Claiborne and Millers Ferry Locks and Dams Fish Passage Study

Appendix B-1: Environmental

Modeling, Monitoring, and Adaptive Management

May 2023

US Army Corps of Engineers

The Nature Conservancy

APPENDIX B-1: Environmental Modeling, Monitoring, and Adaptive Management

US Army Corps of Engineers®

Claiborne and Millers Ferry Locks and Dams Fish Passage Study

Appendix B-1: Environmental Modeling, Monitoring, and Adaptive Management

April 2023

B.1. Habitat Modeling

B.1.1. *Conceptual Ecological Model*

On January 10-11, 2022, U.S. Army Corps of Engineers (USACE) Engineering Research and Development Center (ERDC) facilitated an ecological modeling workshop with Mobile District to engage project stakeholders and develop a set of Conceptual Ecological Models (CEMs) to inform decision-making for the Claiborne and Millers Ferry Locks and Dams Fish Passage Feasibility Study. Approximately 22 workshop participants from USACE Mobile District, USACE Headquarters, U.S. Environmental Protection Agency, The Nature Conservancy, Alabama Rivers Alliance, and Auburn University with multiple backgrounds (e.g., biology, engineering, fisheries, project planning, regulatory, economics) worked together to discuss the major ecosystem drivers and components that were relevant to the fish passage feasibility study. The final product is shown in **Figure B**.1-2.

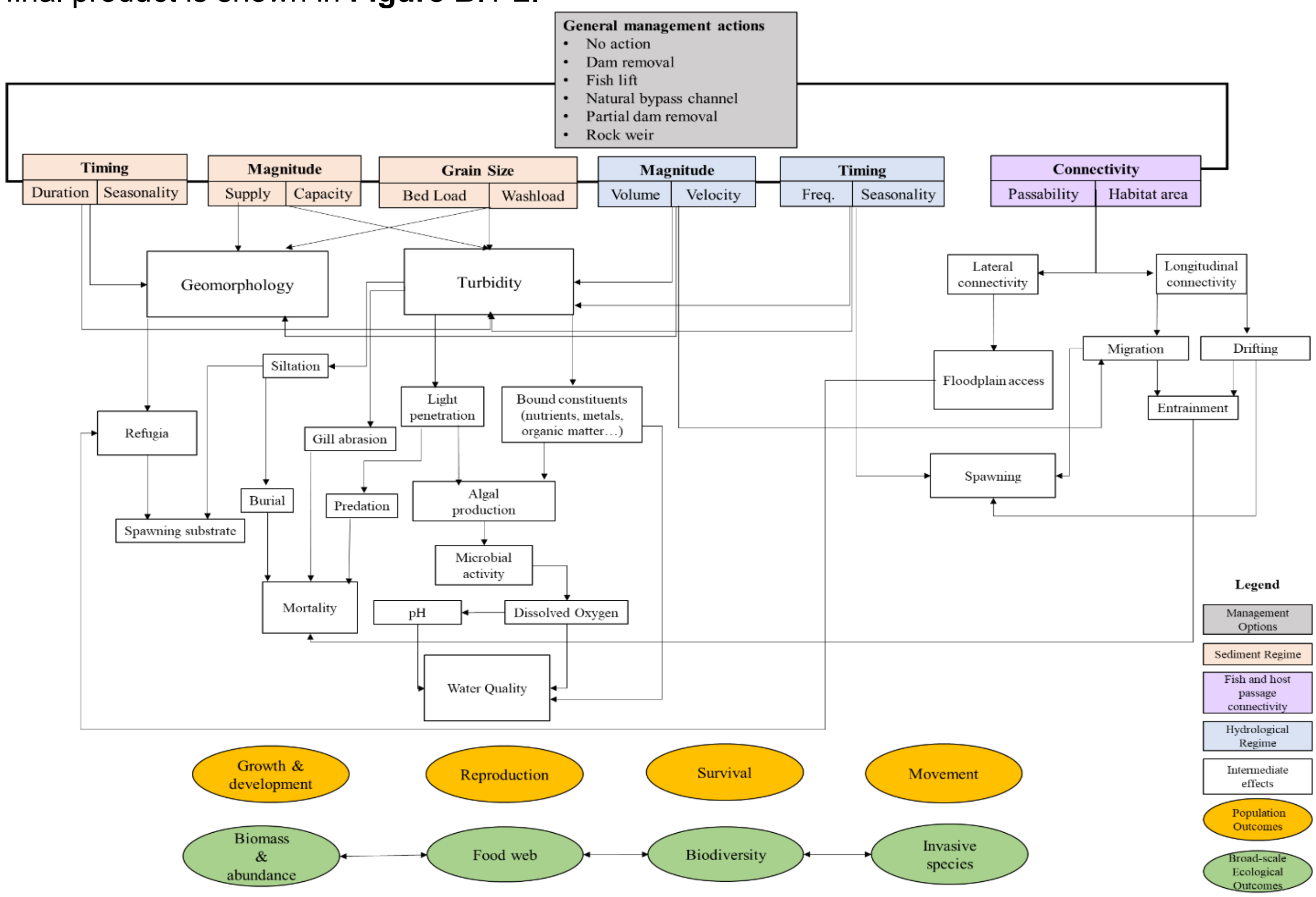


Figure B.1-1: Conceptual Ecological Model

B.1.2. *Fish Passage Connectivity Index*

B.1.2.1. *Model Application*

B.1.2.1.1. *Model Inputs*

Model inputs include movement periods for each migratory species, likelihood of species to encounter fishway entrance based on location, species potential to use passage route, and availability of suitable passage conditions during movement and spawning periods.

The result is a 0-1 FPCI value that represents the suitability of the fish passage alternative measure to a given species. The FPCI is multiplied by the linear feet of connected, upstream habitat types that are suitable to the individual migratory species to obtain Habitat Units for use in Cost Effectiveness/Incremental Cost Analysis.

The model formula is as follows:

$$\epsilon = \frac{\Sigma_{i \dots n}[E_i \text{x} U_i \text{x} D_i]/25}{n}$$

Where,

Є = Fish Passage Connectivity Index

i = a migratory fish species that occurs in pool or reach below the dam

n = number of fish species included in the index

E_i = Chance of encountering the fishway entrance

U_i = Potential for species “i” to use the fish passage pathway or fishway

D_i = Duration of availability

A total of 19 species were included in the index (n). The chance of encountering the fishway entrance was determined via expert elicitation. The potential for a species to use the passage was based on known critical swim speeds and the duration of availability was based on available flows. Thus, if a migratory species encounters the passageway and there is sufficient evidence the fish will utilize the passageway and flows are sufficient to support that use, connectivity is achieved.

Furthermore, the model evaluates three flow rates at 5,000 cfs, 50,000 cfs, and 150,000 cfs to capture variances in fish behavior which affects their abilities to locate the passageways. Each flow rate is weighted based on Annual Percent Probability of occurring where 5,000 cfs is estimated at 75%, 50,000 cfs is estimated at 20%, and 150,000 cfs is estimated at 5%. Expert elicitation was used to determine the F_1 value based on expected fish behavior at each flow rate.

Additionally, because the study evaluates two locks and dams separated by several river miles, each connectivity index focuses on each location separately before averaging into Habitat Unit calculation.

Figure B.1-2: Species cohort and available habitat

Migratory Fishes Known to Occur in the Alabama River below the mouth of the Cahaba River

i	Common Name	Scientific Name	Swimming Behavior	Relative Size	Swimming Speed (Ucrit) cm/sec	Swimming Speed (Ucrit) ft/sec	Swimming Burst Speed ft/sec	Habitat Preference	Benthic A	Pelagic B	Available Littoral Habitat below Cahaba River[1] C1 Soil Substrate and Woody Debris (0-30° slope)	C2 Soil Substrate and Woody Debris (61-90° slope)	C3 Conglomeration of unusual types	C4 Bluff	C5 Gravel / Sand Bar	Total Available Preferred Habitat below Cahaba River
									(linear feet)	(linear feet)	(linear feet)	(linear feet)	(linear feet)	(linear feet)	(linear feet)	(linear feet)
									1,092,527.798	*1,092,527.798*	*828,593.704*	*828,593.704*	*196,240.805*	*120,968.487*	*210,658.896*	*4,370,111.191*
1	Mobile Logperch*	*Percina kathae*	Benthic	Small	32.80	1.0761	3.7664	B, C5		1,092,527.798					210,658.896	1,303,186.693
2	Gulf Logperch*	*Percina suttkusi*	Benthic	Small	32.80	1.0761	3.7664	B, C5		1,092,527.798					210,658.896	1,303,186.693
3	Blacktail Shiner	*Cyprinella venusta*	Benthic	Small	23.17	0.7602	2.6606	B, C5		1,092,527.798					210,658.896	1,303,186.693
4	Freshwater Drum	*Aplodinotus grunniens*	Benthic	Medium	64.80	2.1260	7.4409	B, C1, C2, C4		1,092,527.798	828,593.704	828,593.704		120,968.487		2,870,683.693
5	Chain Pickerel	*Esox niger*	Littoral	Medium	126.68	4.1562	14.5466	C1			828,593.704					828,593.704
6	Largemouth Bass	*Micropterus salmoides*	Littoral	Medium	21.08	0.6916	2.4206	C1, C2, C5			828,593.704	828,593.704			210,658.896	1,867,846.304
7	Skipjack Herring	*Alosa chrysochloris*	Pelagic	Medium	41.80	1.3714	4.7999	B, C2, C4, C5		1,092,527.798		828,593.704		120,968.487	210,658.896	2,252,748.885
8	Alabama Shad	*Alosa alabamae*	Pelagic	Medium	72.60	2.3819	8.3366	B, C2, C4, C5		1,092,527.798		828,593.704		120,968.487	210,658.896	2,252,748.885
9	Striped Bass	*Morone saxatilis*	Pelagic	Large	128.00	4.1995	14.6982	B, C2, C4, C5		1,092,527.798		828,593.704		120,968.487	210,658.896	2,252,748.885
10	Crystal Darter*	*Crystallaria asprella*	Benthic	Small	32.80	1.0761	3.7664	A, C1, C2, C5	1,092,527.798			828,593.704			210,658.896	2,131,780.398
11	River Redhorse	*Moxostoma carinatum*	Benthic	Medium	64.80	2.1260	7.4409	A, C1, C2, C5	1,092,527.798			828,593.704			210,658.896	2,131,780.398
12	Southeastern Blue Sucker**	*Cycleptus meridionalis*	Benthic	Medium	128.00	4.1995	14.6982	A, C1, C2, C5	1,092,527.798			828,593.704			210,658.896	2,131,780.398
13	Alabama Sturgeon	*Scaphirhynchus suttkusi*	Benthic	Large	19.48	0.6391	2.2369	A, C1, C2, C5	1,092,527.798		828,593.704	828,593.704			210,658.896	2,960,374.102
14	Gulf Sturgeon	*Acipenser oxyrinchus desotoi*	Benthic	Large	25.00	0.8202	2.8707	A, C1, C2, C5	1,092,527.798		828,593.704	828,593.704			210,658.896	2,960,374.102
15	Mississippi Silvery Minnow	*Hybognathus nuchalis*	Littoral	Small	52.50	1.7224	6.0285	C5							210,658.896	210,658.896
16	Northern Walleye	*Sander vitreus*	Littoral	Medium	78.50	2.5755	9.0141	C1, C2, C3, C4, C5			828,593.704	828,593.704	196,240.805	120,968.487	210,658.896	2,185,055.596
17	American Eel	*Anguilla rostrata*	Pelagic	Medium	62.00	2.0341	7.1194	B, C1, C2, C3, C4, C5		1,092,527.798	828,593.704	828,593.704	196,240.805	120,968.487	210,658.896	3,277,583.394
18	Smallmouth Buffalo	*Ictiobus bubalus*	Pelagic	Large	64.80	2.1260	7.4409	B, C1, C2, C4		1,092,527.798	828,593.704	828,593.704		120,968.487		2,870,683.693
19	Paddlefish	*Polyodon spathula*	Pelagic	Large	52.20	1.7126	5.9941	B		1,092,527.798						1,092,527.798

[1]Field data collected by NFS

red indicates habitat emphasis for knowledge only

Figure B.1-3: Duration Period at Claiborne

Approximate upriver movement and spawning periods of AL River migratory fishes that may occur below Millers Ferry

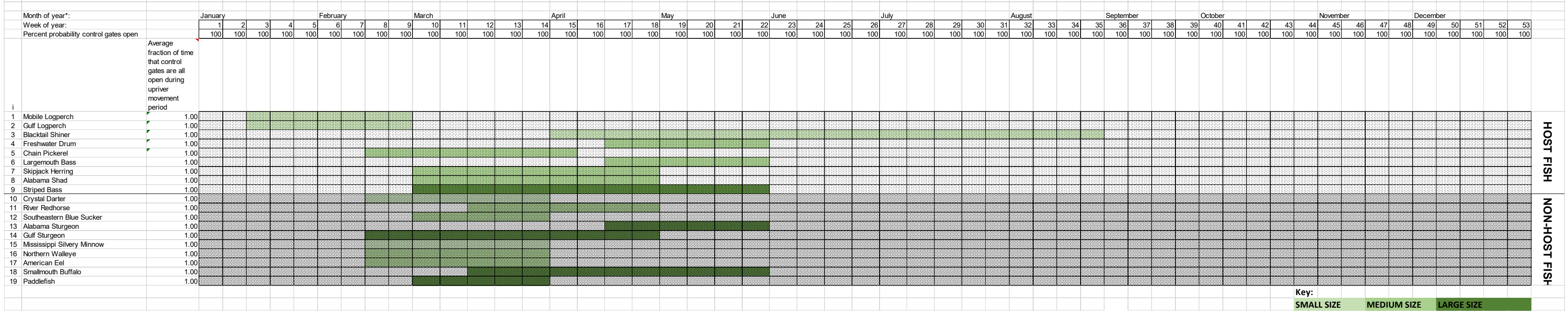
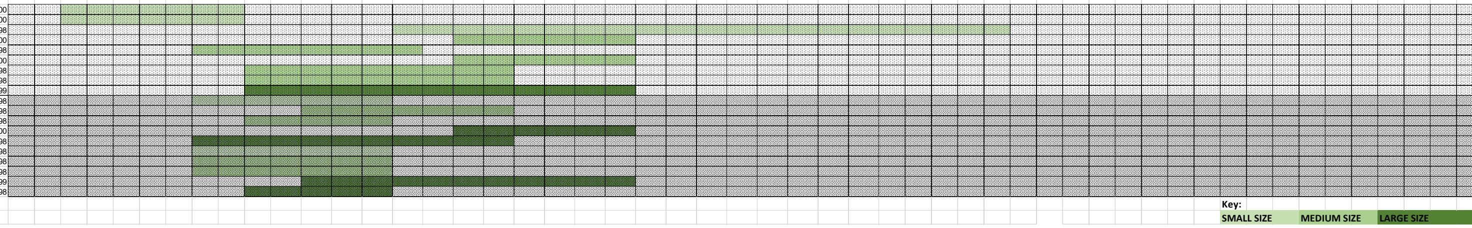


Figure B.1-4: Duration Period at Millers Ferry

Approximate upriver movement and spawning periods of AL River migratory fishes that may occur below Cahaba River

Month of year*:	January					February				March					April				May				June				July					August				September				October					November				December				
Week of year:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53
Percent probability control gates open	100	100	99	100	100	100	100	100	100	99	97	97	99	96	97	96	100	100	100	100	100	100	100	99	99	97	100	99	97	99	99	96	97	96	96	96	93	93	93	96	95	92	96	97	97	97	99	100	99	96	100	100	100

i		Average fraction of time that control gates are all open during upriver movement period	
1	Mobile Logperch	1.00	HOST FISH
2	Gulf Logperch	1.00	
3	Blacktail Shiner	0.98	
4	Freshwater Drum	1.00	
5	Chain Pickerel	0.98	
6	Largemouth Bass	1.00	
7	Skipjack Herring	0.98	
8	Alabama Shad	0.98	
9	Striped Bass	0.99	
10	Crystal Darter	0.98	NON-HOST FISH
11	River Redhorse	0.98	
12	Southeastern Blue Sucker	0.98	
13	Alabama Sturgeon	1.00	
14	Gulf Sturgeon	0.98	
15	Mississippi Silvery Minnow	0.98	
16	Northern Walleye	0.98	
17	American Eel	0.98	
18	Smallmouth Buffalo	0.99	
19	Paddlefish	0.98	



B.1.2.1.2. *Model Results*

The outcomes from the FPCI model for each of the alternatives in the final array are presented in Figure B.1-8. below. Alternative 5d, with a natural bypass channel at both Claiborne and Millers Ferry Locks and Dams, has the highest average connectivity index and average HUs of the final array.

Figure B.1-5: Connectivity Indices for Claiborne Focus

Alternative 1: "No Action" (CL focus) — Minimum Current Velocity at Hydraulic Steps (ft/sec): X; Fs - Size of Fishway: 5; Discharge: 5,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	E_i x U_i x D_i	Є = Fish Passage Connectivity
1	Mobile Logperch	5	5	0	1.00	0.0	0.000
2	Gulf Logperch	5	5	0	1.00	0.0	0.000
3	Blacktail Shiner	5	5	0	1.00	0.0	0.000
4	Freshwater Drum	5	5	0	1.00	0.0	0.000
5	Chain Pickerel	5	5	0	1.00	0.0	0.000
6	Largemouth Bass	5	5	0	1.00	0.0	0.000
7	Skipjack Herring	5	5	0	1.00	0.0	0.000
8	Alabama Shad	5	5	0	1.00	0.0	0.000
9	Striped Bass	5	5	0	1.00	0.0	0.000
10	Crystal Darter	5	5	0	1.00	0.0	0.000
11	River Redhorse	5	5	0	1.00	0.0	0.000
12	Southeastern Blue Sucker	5	5	0	1.00	0.0	0.000
13	Alabama Sturgeon	5	5	0	1.00	0.0	0.000
14	Gulf Sturgeon	5	5	0	1.00	0.0	0.000
15	Mississippi Silvery Minnow	5	5	0	1.00	0.0	0.000
16	Northern Walleye	5	5	0	1.00	0.0	0.000
17	American Eel	5	5	0	1.00	0.0	0.000
18	Smallmouth Buffalo	5	5	0	1.00	0.0	0.000
19	Paddlefish	5	5	0	1.00	0.0	0.000
						Avg.	0.000

Alternative 3: "Fixed Weir Rock Arch – Both Dams" (CL focus) — Minimum Current Velocity at Hydraulic Steps (ft/sec): X; Fs - Size of Fishway: 5; Discharge: 5,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	E_i x U_i x D_i	Є = Fish Passage Connectivity
1	Mobile Logperch	5	5	3	1.00	15.0	0.600
2	Gulf Logperch	5	5	3	1.00	15.0	0.600
3	Blacktail Shiner	5	5	1	1.00	5.0	0.200
4	Freshwater Drum	3	4	3	1.00	12.0	0.480
5	Chain Pickerel	1	3	3	1.00	9.0	0.360
6	Largemouth Bass	1	3	3	1.00	9.0	0.360
7	Skipjack Herring	3	4	1	1.00	4.0	0.160
8	Alabama Shad	3	4	3	1.00	12.0	0.480
9	Striped Bass	3	4	3	1.00	12.0	0.480
10	Crystal Darter	5	5	3	1.00	15.0	0.600
11	River Redhorse	3	4	3	1.00	12.0	0.480
12	Southeastern Blue Sucker	3	4	3	1.00	12.0	0.480
13	Alabama Sturgeon	3	4	1	1.00	4.0	0.160
14	Gulf Sturgeon	3	4	1	1.00	4.0	0.160
15	Mississippi Silvery Minnow	5	5	3	1.00	15.0	0.600
16	Northern Walleye	3	4	3	1.00	12.0	0.480
17	American Eel	5	5	3	1.00	15.0	0.600
18	Smallmouth Buffalo	3	4	3	1.00	12.0	0.480
19	Paddlefish	5	5	3	1.00	15.0	0.600
						Avg.	0.440

Alternative 5d: "Natural Bypass Channel – Both Dams" (CL focus) — Minimum Current Velocity at Hydraulic Steps (ft/sec): X; Fs - Size of Fishway: 5; Discharge: 5,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	E_i x U_i x D_i	Є = Fish Passage Connectivity
1	Mobile Logperch	5	5	3	1.00	15.0	0.600
2	Gulf Logperch	5	5	3	1.00	15.0	0.600
3	Blacktail Shiner	5	5	1	1.00	5.0	0.200
4	Freshwater Drum	3	4	3	1.00	12.0	0.480
5	Chain Pickerel	3	4	5	1.00	20.0	0.800
6	Largemouth Bass	3	4	1	1.00	4.0	0.160
7	Skipjack Herring	3	4	3	1.00	12.0	0.480
8	Alabama Shad	3	4	3	1.00	12.0	0.480
9	Striped Bass	3	4	5	1.00	20.0	0.800
10	Crystal Darter	5	5	3	1.00	15.0	0.600
11	River Redhorse	3	4	3	1.00	12.0	0.480
12	Southeastern Blue Sucker	3	4	5	1.00	20.0	0.800
13	Alabama Sturgeon	3	4	1	1.00	4.0	0.160
14	Gulf Sturgeon	3	4	1	1.00	4.0	0.160
15	Mississippi Silvery Minnow	5	5	3	1.00	15.0	0.600
16	Northern Walleye	3	4	3	1.00	12.0	0.480
17	American Eel	5	5	3	1.00	15.0	0.600
18	Smallmouth Buffalo	3	4	3	1.00	12.0	0.480
19	Paddlefish	5	5	3	1.00	15.0	0.600
						Avg.	0.503

Alternative 12b: "Fixed Weir - CL and Bypass - MF" (CL focus) — Minimum Current Velocity at Hydraulic Steps (ft/sec): X; Fs - Size of Fishway: 5; Discharge: 5,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	E_i x U_i x D_i	Є = Fish Passage Connectivity
1	Mobile Logperch	5	5	3	1.00	15.0	0.600
2	Gulf Logperch	5	5	3	1.00	15.0	0.600
3	Blacktail Shiner	5	5	1	1.00	5.0	0.200
4	Freshwater Drum	3	4	3	1.00	12.0	0.480
5	Chain Pickerel	1	3	3	1.00	9.0	0.360
6	Largemouth Bass	1	3	3	1.00	9.0	0.360
7	Skipjack Herring	3	4	1	1.00	4.0	0.160
8	Alabama Shad	3	4	3	1.00	12.0	0.480
9	Striped Bass	3	4	3	1.00	12.0	0.480
10	Crystal Darter	5	5	3	1.00	15.0	0.600
11	River Redhorse	3	4	3	1.00	12.0	0.480
12	Southeastern Blue Sucker	3	4	3	1.00	12.0	0.480
13	Alabama Sturgeon	3	4	1	1.00	4.0	0.160
14	Gulf Sturgeon	3	4	1	1.00	4.0	0.160
15	Mississippi Silvery Minnow	5	5	3	1.00	15.0	0.600
16	Northern Walleye	3	4	3	1.00	12.0	0.480
17	American Eel	5	5	3	1.00	15.0	0.600
18	Smallmouth Buffalo	3	4	3	1.00	12.0	0.480
19	Paddlefish	5	5	3	1.00	15.0	0.600
						Avg.	0.440

Alternastive 13b: "Fixed Weir — MF and Bypass - CL" (CL focus) — Minimum Current Velocity at Hydraulic Steps (ft/sec): X; Size of Fishway (Fs): 5; Discharge: 5,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	E_i x U_i x D_i	Є = Fish Passage Connectivity
1	Mobile Logperch	5	5	3	1.00	15.0	0.600
2	Gulf Logperch	5	5	3	1.00	15.0	0.600
3	Blacktail Shiner	5	5	1	1.00	5.0	0.200
4	Freshwater Drum	3	4	3	1.00	12.0	0.480
5	Chain Pickerel	3	4	5	1.00	20.0	0.800
6	Largemouth Bass	3	4	1	1.00	4.0	0.160
7	Skipjack Herring	3	4	3	1.00	12.0	0.480
8	Alabama Shad	3	4	3	1.00	12.0	0.480
9	Striped Bass	3	4	5	1.00	20.0	0.800
10	Crystal Darter	5	5	3	1.00	15.0	0.600
11	River Redhorse	3	4	3	1.00	12.0	0.480
12	Southeastern Blue Sucker	3	4	5	1.00	20.0	0.800
13	Alabama Sturgeon	3	4	1	1.00	4.0	0.160
14	Gulf Sturgeon	3	4	1	1.00	4.0	0.160
15	Mississippi Silvery Minnow	5	5	3	1.00	15.0	0.600
16	Northern Walleye	3	4	3	1.00	12.0	0.480
17	American Eel	5	5	3	1.00	15.0	0.600
18	Smallmouth Buffalo	3	4	3	1.00	12.0	0.480
19	Paddlefish	5	5	3	1.00	15.0	0.600
						Avg.	0.503

Alternative 1: "No Action" (CL focus) — Minimum Current Velocity at Hydraulic Steps (ft/sec): X; Fs - Size of Fishway: 5; Discharge: 50,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	E_i x U_i x D_i	Є = Fish Passage Connectivity
1	Mobile Logperch	5	5	0	1.00	0	0.000
2	Gulf Logperch	5	5	0	1.00	0	0.000
3	Blacktail Shiner	5	5	0	1.00	0	0.000
4	Freshwater Drum	5	5	0	1.00	0	0.000
5	Chain Pickerel	5	5	0	1.00	0	0.000
6	Largemouth Bass	5	5	0	1.00	0	0.000
7	Skipjack Herring	5	5	0	1.00	0	0.000
8	Alabama Shad	5	5	0	1.00	0	0.000
9	Striped Bass	5	5	0	1.00	0	0.000
10	Crystal Darter	5	5	0	1.00	0	0.000
11	River Redhorse	5	5	0	1.00	0	0.000
12	Southeastern Blue Sucker	5	5	0	1.00	0	0.000
13	Alabama Sturgeon	5	5	0	1.00	0	0.000
14	Gulf Sturgeon	5	5	0	1.00	0	0.000
15	Mississippi Silvery Minnow	5	5	0	1.00	0	0.000
16	Northern Walleye	5	5	0	1.00	0	0.000
17	American Eel	5	5	0	1.00	0	0.000
18	Smallmouth Buffalo	5	5	0	1.00	0	0.000
19	Paddlefish	5	5	0	1.00	0	0.000
						Avg.	0.000

Alternative 3: "Fixed Weir Rock Arch – Both Dams" (CL focus) — Minimum Current Velocity at Hydraulic Steps (ft/sec): X; Fs - Size of Fishway: 5; Discharge: 50,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	E_i x U_i x D_i	Є = Fish Passage Connectivity
1	Mobile Logperch	5	5	5	1.00	25	1.000
2	Gulf Logperch	5	5	5	1.00	25	1.000
3	Blacktail Shiner	5	5	3	1.00	15	0.600
4	Freshwater Drum	3	4	5	1.00	20	0.800
5	Chain Pickerel	3	4	5	1.00	20	0.800
6	Largemouth Bass	3	4	3	1.00	12	0.480
7	Skipjack Herring	5	5	5	1.00	25	1.000
8	Alabama Shad	5	5	5	1.00	25	1.000
9	Striped Bass	5	5	5	1.00	25	1.000
10	Crystal Darter	5	5	5	1.00	25	1.000
11	River Redhorse	5	5	5	1.00	25	1.000
12	Southeastern Blue Sucker	5	5	5	1.00	25	1.000
13	Alabama Sturgeon	3	4	3	1.00	12	0.480
14	Gulf Sturgeon	3	4	3	1.00	12	0.480
15	Mississippi Silvery Minnow	5	5	5	1.00	25	1.000
16	Northern Walleye	5	5	5	1.00	25	1.000
17	American Eel	5	5	5	1.00	25	1.000
18	Smallmouth Buffalo	5	5	5	1.00	25	1.000
19	Paddlefish	5	5	5	1.00	25	1.000
						Avg.	0.876

Alternative 5d: "Natural Bypass Channel – Both Dams" (CL focus) — Minimum Current Velocity at Hydraulic Steps (ft/sec): X; Fs - Size of Fishway: 5; Discharge: 50,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	E_i x U_i x D_i	Є = Fish Passage Connectivity
1	Mobile Logperch	5	5	3	1.00	15	0.600
2	Gulf Logperch	5	5	3	1.00	15	0.600
3	Blacktail Shiner	5	5	3	1.00	15	0.600
4	Freshwater Drum	5	5	5	1.00	25	1.000
5	Chain Pickerel	5	5	5	1.00	25	1.000
6	Largemouth Bass	3	4	3	1.00	12	0.480
7	Skipjack Herring	3	4	5	1.00	20	0.800
8	Alabama Shad	3	4	5	1.00	20	0.800
9	Striped Bass	3	4	5	1.00	20	0.800
10	Crystal Darter	5	5	3	1.00	15	0.600
11	River Redhorse	3	4	5	1.00	20	0.800
12	Southeastern Blue Sucker	3	4	5	1.00	20	0.800
13	Alabama Sturgeon	3	4	3	1.00	12	0.480
14	Gulf Sturgeon	3	4	3	1.00	12	0.480
15	Mississippi Silvery Minnow	5	5	5	1.00	25	1.000
16	Northern Walleye	5	5	5	1.00	25	1.000
17	American Eel	5	5	5	1.00	25	1.000
18	Smallmouth Buffalo	3	4	5	1.00	20	0.800
19	Paddlefish	5	5	5	1.00	25	1.000
						Avg.	0.771

Alternative 12b: "Fixed Weir - CL and Bypass - MF" (CL focus) — Minimum Current Velocity at Hydraulic Steps (ft/sec): X; Fs - Size of Fishway: 5; Discharge: 50,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	E_i x U_i x D_i	Є = Fish Passage Connectivity
1	Mobile Logperch	5	5	5	1.00	25	1.000
2	Gulf Logperch	5	5	5	1.00	25	1.000
3	Blacktail Shiner	5	5	3	1.00	15	0.600
4	Freshwater Drum	3	4	5	1.00	20	0.800
5	Chain Pickerel	3	4	5	1.00	20	0.800
6	Largemouth Bass	3	4	3	1.00	12	0.480
7	Skipjack Herring	5	5	5	1.00	25	1.000
8	Alabama Shad	5	5	5	1.00	25	1.000
9	Striped Bass	5	5	5	1.00	25	1.000
10	Crystal Darter	5	5	5	1.00	25	1.000
11	River Redhorse	5	5	5	1.00	25	1.000
12	Southeastern Blue Sucker	5	5	5	1.00	25	1.000
13	Alabama Sturgeon	3	4	3	1.00	12	0.480
14	Gulf Sturgeon	3	4	3	1.00	12	0.480
15	Mississippi Silvery Minnow	5	5	5	1.00	25	1.000
16	Northern Walleye	5	5	5	1.00	25	1.000
17	American Eel	5	5	5	1.00	25	1.000
18	Smallmouth Buffalo	5	5	5	1.00	25	1.000
19	Paddlefish	5	5	5	1.00	25	1.000
						Avg.	0.876

Alternastive 13b: "Fixed Weir — MF and Bypass - CL" (CL focus) — Minimum Current Velocity at Hydraulic Steps (ft/sec): X; Size of Fishway (Fs): 5; Discharge: 50,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	E_i x U_i x D_i	Є = Fish Passage Connectivity
1	Mobile Logperch	5	5	3	1.00	15	0.600
2	Gulf Logperch	5	5	3	1.00	15	0.600
3	Blacktail Shiner	5	5	3	1.00	15	0.600
4	Freshwater Drum	5	5	5	1.00	25	1.000
5	Chain Pickerel	5	5	5	1.00	25	1.000
6	Largemouth Bass	3	4	3	1.00	12	0.480
7	Skipjack Herring	3	4	5	1.00	20	0.800
8	Alabama Shad	3	4	5	1.00	20	0.800
9	Striped Bass	3	4	5	1.00	20	0.800
10	Crystal Darter	5	5	3	1.00	15	0.600
11	River Redhorse	3	4	5	1.00	20	0.800
12	Southeastern Blue Sucker	3	4	5	1.00	20	0.800
13	Alabama Sturgeon	3	4	3	1.00	12	0.480
14	Gulf Sturgeon	3	4	3	1.00	12	0.480
15	Mississippi Silvery Minnow	5	5	5	1.00	25	1.000
16	Northern Walleye	5	5	5	1.00	25	1.000
17	American Eel	5	5	5	1.00	25	1.000
18	Smallmouth Buffalo	3	4	5	1.00	20	0.800
19	Paddlefish	5	5	5	1.00	25	1.000
						Avg.	0.771

Alternative 1: "No Action" (CL focus) — Minimum Current Velocity at Hydraulic Steps (ft/sec): X; Fs - Size of Fishway: 5; Discharge: 150,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	E_i x U_i x D_i	Є = Fish Passage Connectivity
1	Mobile Logperch	5	5	1	1.00	5	0.2
2	Gulf Logperch	5	5	1	1.00	5	0.2
3	Blacktail Shiner	5	5	1	1.00	5	0.2
4	Freshwater Drum	5	5	0	1.00	0	0
5	Chain Pickerel	5	5	0	1.00	0	0
6	Largemouth Bass	5	5	1	1.00	5	0.2
7	Skipjack Herring	5	5	1	1.00	5	0.2
8	Alabama Shad	5	5	0	1.00	0	0
9	Striped Bass	5	5	1	1.00	5	0.2
10	Crystal Darter	5	5	0	1.00	0	0
11	River Redhorse	5	5	1	1.00	5	0.2
12	Southeastern Blue Sucker	5	5	1	1.00	5	0.2
13	Alabama Sturgeon	5	5	0	1.00	0	0
14	Gulf Sturgeon	5	5	1	1.00	5	0.2
15	Mississippi Silvery Minnow	5	5	0	1.00	0	0
16	Northern Walleye	5	5	0	1.00	0	0
17	American Eel	5	5	1	1.00	5	0.2
18	Smallmouth Buffalo	5	5	1	1.00	5	0.2
19	Paddlefish	5	5	1	1.00	5	0.2
						Avg.	0.126

Alternative 3: "Fixed Weir Rock Arch – Both Dams" (CL focus) — Minimum Current Velocity at Hydraulic Steps (ft/sec): X; Fs - Size of Fishway: 1; Discharge: 150,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	E_i x U_i x D_i	Є = Fish Passage Connectivity
1	Mobile Logperch	5	3	5	1.00	15	0.6
2	Gulf Logperch	5	3	5	1.00	15	0.6
3	Blacktail Shiner	5	3	5	1.00	15	0.6
4	Freshwater Drum	5	3	5	1.00	15	0.6
5	Chain Pickerel	5	3	5	1.00	15	0.6
6	Largemouth Bass	5	3	5	1.00	15	0.6
7	Skipjack Herring	5	3	5	1.00	15	0.6
8	Alabama Shad	5	3	5	1.00	15	0.6
9	Striped Bass	5	3	5	1.00	15	0.6
10	Crystal Darter	5	3	5	1.00	15	0.6
11	River Redhorse	5	3	5	1.00	15	0.6
12	Southeastern Blue Sucker	5	3	5	1.00	15	0.6
13	Alabama Sturgeon	5	3	5	1.00	15	0.6
14	Gulf Sturgeon	5	3	5	1.00	15	0.6
15	Mississippi Silvery Minnow	5	3	5	1.00	15	0.6
16	Northern Walleye	5	3	5	1.00	15	0.6
17	American Eel	5	3	5	1.00	15	0.6
18	Smallmouth Buffalo	5	3	5	1.00	15	0.6
19	Paddlefish	5	3	5	1.00	15	0.6
						Avg.	0.600

Alternative 5d: "Natural Bypass Channel – Both Dams" (CL focus) — Minimum Current Velocity at Hydraulic Steps (ft/sec): X; Fs - Size of Fishway: 3; Discharge: 150,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	E_i x U_i x D_i	Є = Fish Passage Connectivity
1	Mobile Logperch	5	4	5	1.00	20	0.8
2	Gulf Logperch	5	4	5	1.00	20	0.8
3	Blacktail Shiner	5	4	3	1.00	12	0.48
4	Freshwater Drum	5	4	5	1.00	20	0.8
5	Chain Pickerel	5	4	5	1.00	20	0.8
6	Largemouth Bass	5	4	3	1.00	12	0.48
7	Skipjack Herring	5	4	5	1.00	20	0.8
8	Alabama Shad	5	4	5	1.00	20	0.8
9	Striped Bass	5	4	5	1.00	20	0.8
10	Crystal Darter	5	4	5	1.00	20	0.8
11	River Redhorse	5	4	5	1.00	20	0.8
12	Southeastern Blue Sucker	5	4	5	1.00	20	0.8
13	Alabama Sturgeon	5	4	3	1.00	12	0.48
14	Gulf Sturgeon	5	4	3	1.00	12	0.48
15	Mississippi Silvery Minnow	5	4	5	1.00	20	0.8
16	Northern Walleye	5	4	5	1.00	20	0.8
17	American Eel	5	4	5	1.00	20	0.8
18	Smallmouth Buffalo	5	4	5	1.00	20	0.8
19	Paddlefish	5	4	5	1.00	20	0.8
						Avg.	0.733

Alternative 12b: "Fixed Weir - CL and Bypass - MF" (CL focus) — Minimum Current Velocity at Hydraulic Steps (ft/sec): X; Fs - Size of Fishway: 1; Discharge: 150,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	E_i x U_i x D_i	Є = Fish Passage Connectivity
1	Mobile Logperch	5	3	5	1.00	15	0.6
2	Gulf Logperch	5	3	5	1.00	15	0.6
3	Blacktail Shiner	5	3	5	1.00	15	0.6
4	Freshwater Drum	5	3	5	1.00	15	0.6
5	Chain Pickerel	5	3	5	1.00	15	0.6
6	Largemouth Bass	5	3	5	1.00	15	0.6
7	Skipjack Herring	5	3	5	1.00	15	0.6
8	Alabama Shad	5	3	5	1.00	15	0.6
9	Striped Bass	5	3	5	1.00	15	0.6
10	Crystal Darter	5	3	5	1.00	15	0.6
11	River Redhorse	5	3	5	1.00	15	0.6
12	Southeastern Blue Sucker	5	3	5	1.00	15	0.6
13	Alabama Sturgeon	5	3	5	1.00	15	0.6
14	Gulf Sturgeon	5	3	5	1.00	15	0.6
15	Mississippi Silvery Minnow	5	3	5	1.00	15	0.6
16	Northern Walleye	5	3	5	1.00	15	0.6
17	American Eel	5	3	5	1.00	15	0.6
18	Smallmouth Buffalo	5	3	5	1.00	15	0.6
19	Paddlefish	5	3	5	1.00	15	0.6
						Avg.	0.600

Alternastive 13b: "Fixed Weir — MF and Bypass - CL" (CL focus) — Minimum Current Velocity at Hydraulic Steps (ft/sec): X; Size of Fishway (Fs): 3; Discharge: 150,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	E_i x U_i x D_i	Є = Fish Passage Connectivity
1	Mobile Logperch	5	4	5	1.00	20	0.8
2	Gulf Logperch	5	4	5	1.00	20	0.8
3	Blacktail Shiner	5	4	3	1.00	12	0.48
4	Freshwater Drum	5	4	5	1.00	20	0.8
5	Chain Pickerel	5	4	5	1.00	20	0.8
6	Largemouth Bass	5	4	3	1.00	12	0.48
7	Skipjack Herring	5	4	5	1.00	20	0.8
8	Alabama Shad	5	4	5	1.00	20	0.8
9	Striped Bass	5	4	5	1.00	20	0.8
10	Crystal Darter	5	4	5	1.00	20	0.8
11	River Redhorse	5	4	5	1.00	20	0.8
12	Southeastern Blue Sucker	5	4	5	1.00	20	0.8
13	Alabama Sturgeon	5	4	3	1.00	12	0.48
14	Gulf Sturgeon	5	4	3	1.00	12	0.48
15	Mississippi Silvery Minnow	5	4	5	1.00	20	0.8
16	Northern Walleye	5	4	5	1.00	20	0.8
17	American Eel	5	4	5	1.00	20	0.8
18	Smallmouth Buffalo	5	4	5	1.00	20	0.8
19	Paddlefish	5	4	5	1.00	20	0.8
						Avg.	0.733

SPECIES AVERAGE FPCI

	Species	Alt. 1	Alt. 3	Alt. 5d	Alt. 12b	Alt. 13b
1	Mobile Logperch	0.010	0.680	0.610	0.680	0.610
2	Gulf Logperch	0.010	0.680	0.610	0.680	0.610
3	Blacktail Shiner	0.010	0.300	0.294	0.300	0.294
4	Freshwater Drum	0.000	0.550	0.600	0.550	0.600
5	Chain Pickerel	0.000	0.460	0.840	0.460	0.840
6	Largemouth Bass	0.010	0.396	0.240	0.396	0.240
7	Skipjack Herring	0.010	0.350	0.560	0.350	0.560
8	Alabama Shad	0.000	0.590	0.560	0.590	0.560
9	Striped Bass	0.010	0.590	0.800	0.590	0.800
10	Crystal Darter	0.000	0.680	0.610	0.680	0.610
11	River Redhorse	0.010	0.590	0.560	0.590	0.560
12	Southeastern Blue Sucker	0.010	0.590	0.800	0.590	0.800
13	Alabama Sturgeon	0.000	0.246	0.240	0.246	0.240
14	Gulf Sturgeon	0.010	0.246	0.240	0.246	0.240
15	Mississippi Silvery Minnow	0.000	0.680	0.690	0.680	0.690
16	Northern Walleye	0.000	0.590	0.600	0.590	0.600
17	American Eel	0.010	0.680	0.690	0.680	0.690
19	Smallmouth Buffalo	0.010	0.590	0.560	0.590	0.560
20	Paddlefish	0.010	0.680	0.690	0.680	0.690
	TOTAL FPCI AVERAGE	0.006	0.535	0.568	0.535	0.568

Steady State Flow through Model (cfs)	MF Right Bypass Channel Est Flows (cfs)	MF Rock Weir Est Flows (cfs)	CL Right Bypass Channel Est Flows (cfs)	CL Rock Weir Est Flows (cfs)
5,000	1,150	1,400	550	950
50,000	1,600	2,200	800	1,900
150,000	1,800	2,250	6,500	2,800

*These flows occur when pool is much higher than fixed crest weir

Fs Values	MF Right Bypass Channel Est Flows (cfs)	MF Rock Weir Est Flows (cfs)	CL Right Bypass Channel Est Flows (cfs)	CL Rock Weir Est Flows (cfs)	
5,000	23.000	28.000	11.000	19.000	all over 10% which equals a value of 5
50,000	3.200	4.400	1.600	3.800	all under 5% but more than 2% which equals a value of 3
150,000	1.200	1.500	4.333	1.867	all but CL bypass get value of 1 and CL bypass gets value of 3

Figure B.1-6: Connectivity Indices for Millers Ferry Focus

Discharge: 5,000 cfs

Alternative 1: "No Action" (MF Focus)
Minimum Current Velocity at Hydraulic Steps (ft/sec): X
Fs - Size of Fishway: 5
Discharge: 5,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	$E_i \times U_i \times D_i$	Є = Fish Passage Connectivity
1	Mobile Logperch	3	4	0	1.00	0.0	0.000
2	Gulf Logperch	3	4	0	1.00	0.0	0.000
3	Blacktail Shiner	3	4	0	0.98	0.0	0.000
4	Freshwater Drum	3	4	0	1.00	0.0	0.000
5	Chain Pickerel	3	4	0	0.98	0.0	0.000
6	Largemouth Bass	3	4	0	1.00	0.0	0.000
7	Skipjack Herring	3	4	0	0.98	0.0	0.000
8	Alabama Shad	3	4	0	0.98	0.0	0.000
9	Striped Bass	3	4	0	0.99	0.0	0.000
10	Crystal Darter	3	4	0	0.98	0.0	0.000
11	River Redhorse	3	4	0	0.98	0.0	0.000
12	Southeastern Blue Sucker	3	4	0	0.98	0.0	0.000
13	Alabama Sturgeon	3	4	0	1.00	0.0	0.000
14	Gulf Sturgeon	3	4	0	0.98	0.0	0.000
15	Mississippi Silvery Minnow	3	4	0	0.98	0.0	0.000
16	Northern Walleye	3	4	0	0.98	0.0	0.000
17	American Eel	3	4	0	0.98	0.0	0.000
18	Smallmouth Buffalo	3	4	0	0.99	0.0	0.000
19	Paddlefish	3	4	0	0.98	0.0	0.000
						Avg.	0.000

Alternative 3: "Fixed Weir Rock Arch – Both Dams" (MF Focus)
Minimum Current Velocity at Hydraulic Steps (ft/sec): X
Fs - Size of Fishway: 5
Discharge: 5,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	$E_i \times U_i \times D_i$	Є = Fish Passage Connectivity
1	Mobile Logperch	3	4	1	1.00	4.0	0.160
2	Gulf Logperch	3	4	1	1.00	4.0	0.160
3	Blacktail Shiner	5	5	1	0.98	4.9	0.197
4	Freshwater Drum	3	4	3	1.00	12.0	0.480
5	Chain Pickerel	3	4	3	0.98	11.8	0.471
6	Largemouth Bass	3	4	1	1.00	4.0	0.160
7	Skipjack Herring	3	4	1	0.98	3.9	0.157
8	Alabama Shad	3	4	3	0.98	11.7	0.470
9	Striped Bass	3	4	3	0.99	11.8	0.473
10	Crystal Darter	3	4	1	0.98	3.9	0.157
11	River Redhorse	3	4	3	0.98	11.7	0.470
12	Southeastern Blue Sucker	3	4	3	0.98	11.7	0.468
13	Alabama Sturgeon	3	4	1	1.00	4.0	0.160
14	Gulf Sturgeon	3	4	1	0.98	3.9	0.157
15	Mississippi Silvery Minnow	3	4	3	0.98	11.8	0.472
16	Northern Walleye	1	3	3	0.98	8.8	0.354
17	American Eel	5	5	3	0.98	14.7	0.590
18	Smallmouth Buffalo	3	4	3	0.99	11.8	0.473
19	Paddlefish	5	5	3	0.98	14.6	0.586
						Avg.	0.348

Alternative 5d: "Natural Bypass Channel – Both Dams" (MF Focus)
Minimum Current Velocity at Hydraulic Steps (ft/sec): X
Fs - Size of Fishway: 5
Discharge: 5,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	$E_i \times U_i \times D_i$	Є = Fish Passage Connectivity
1	Mobile Logperch	5	5	3	1.00	15.0	0.599
2	Gulf Logperch	5	5	3	1.00	15.0	0.599
3	Blacktail Shiner	5	5	1	0.98	4.9	0.197
4	Freshwater Drum	3	4	3	1.00	12.0	0.480
5	Chain Pickerel	3	4	5	0.98	19.6	0.785
6	Largemouth Bass	3	4	1	1.00	4.0	0.160
7	Skipjack Herring	3	4	3	0.98	11.7	0.470
8	Alabama Shad	3	4	3	0.98	11.7	0.470
9	Striped Bass	3	4	5	0.99	19.7	0.788
10	Crystal Darter	5	5	3	0.98	14.7	0.590
11	River Redhorse	3	4	3	0.98	11.7	0.470
12	Southeastern Blue Sucker	3	4	5	0.98	19.5	0.781
13	Alabama Sturgeon	3	4	1	1.00	4.0	0.160
14	Gulf Sturgeon	3	4	1	0.98	3.9	0.157
15	Mississippi Silvery Minnow	5	5	3	0.98	14.7	0.590
16	Northern Walleye	3	4	3	0.98	11.8	0.472
17	American Eel	5	5	3	0.98	14.7	0.590
18	Smallmouth Buffalo	3	4	3	0.99	11.8	0.473
19	Paddlefish	5	5	3	0.98	14.6	0.586
						Avg.	0.496

Alternative 12b: "Fixed Weir - CL and Bypass - MF" (MF Focus)
Minimum Current Velocity at Hydraulic Steps (ft/sec): X
Fs - Size of Fishway: 5
Discharge: 5,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	$E_i \times U_i \times D_i$	Є = Fish Passage Connectivity
1	Mobile Logperch	5	5	3	1.00	15.0	0.599
2	Gulf Logperch	5	5	3	1.00	15.0	0.599
3	Blacktail Shiner	5	5	1	0.98	4.9	0.197
4	Freshwater Drum	3	4	3	1.00	12.0	0.480
5	Chain Pickerel	3	4	5	0.98	19.6	0.785
6	Largemouth Bass	3	4	1	1.00	4.0	0.160
7	Skipjack Herring	3	4	3	0.98	11.7	0.470
8	Alabama Shad	3	4	3	0.98	11.7	0.470
9	Striped Bass	3	4	5	0.99	19.7	0.788
10	Crystal Darter	5	5	3	0.98	14.7	0.590
11	River Redhorse	3	4	3	0.98	11.7	0.470
12	Southeastern Blue Sucker	3	4	5	0.98	19.5	0.781
13	Alabama Sturgeon	3	4	1	1.00	4.0	0.160
14	Gulf Sturgeon	3	4	1	0.98	3.9	0.157
15	Mississippi Silvery Minnow	5	5	3	0.98	14.7	0.590
16	Northern Walleye	3	4	3	0.98	11.8	0.472
17	American Eel	5	5	3	0.98	14.7	0.590
18	Smallmouth Buffalo	3	4	3	0.99	11.8	0.473
19	Paddlefish	5	5	3	0.98	14.6	0.586
						Avg.	0.496

Alternastive 13b: "Fixed Weir — MF and Bypass - CL" (MF Focus)
Minimum Current Velocity at Hydraulic Steps (ft/sec): X
Size of Fishway (Fs): 5
Discharge: 5,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	$E_i \times U_i \times D_i$	Є = Fish Passage Connectivity
1	Mobile Logperch	3	4	1	1.00	4.0	0.160
2	Gulf Logperch	3	4	1	1.00	4.0	0.160
3	Blacktail Shiner	5	5	1	0.98	4.9	0.197
4	Freshwater Drum	3	4	3	1.00	12.0	0.480
5	Chain Pickerel	3	4	3	0.98	11.8	0.471
6	Largemouth Bass	3	4	1	1.00	4.0	0.160
7	Skipjack Herring	3	4	1	0.98	3.9	0.157
8	Alabama Shad	3	4	3	0.98	11.7	0.470
9	Striped Bass	3	4	3	0.99	11.8	0.473
10	Crystal Darter	3	4	1	0.98	3.9	0.157
11	River Redhorse	3	4	3	0.98	11.7	0.470
12	Southeastern Blue Sucker	3	4	3	0.98	11.7	0.468
13	Alabama Sturgeon	3	4	1	1.00	4.0	0.160
14	Gulf Sturgeon	3	4	1	0.98	3.9	0.157
15	Mississippi Silvery Minnow	3	4	3	0.98	11.8	0.472
16	Northern Walleye	1	3	3	0.98	8.8	0.354
17	American Eel	5	5	3	0.98	14.7	0.590
18	Smallmouth Buffalo	3	4	3	0.99	11.8	0.473
19	Paddlefish	5	5	3	0.98	14.6	0.586
						Avg.	0.348

Discharge: 50,000 cfs

Alternative 1: "No Action" (MF Focus)
Minimum Current Velocity at Hydraulic Steps (ft/sec): X
Fs - Size of Fishway: 5
Discharge: 50,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	$E_i \times U_i \times D_i$	Є = Fish Passage Connectivity
1	Mobile Logperch	3	4	0	1.00	0	0.000
2	Gulf Logperch	3	4	0	1.00	0	0.000
3	Blacktail Shiner	3	4	0	0.98	0	0.000
4	Freshwater Drum	3	4	0	1.00	0	0.000
5	Chain Pickerel	3	4	0	0.98	0	0.000
6	Largemouth Bass	3	4	0	1.00	0	0.000
7	Skipjack Herring	3	4	0	0.98	0	0.000
8	Alabama Shad	3	4	0	0.98	0	0.000
9	Striped Bass	3	4	0	0.99	0	0.000
10	Crystal Darter	3	4	0	0.98	0	0.000
11	River Redhorse	3	4	0	0.98	0	0.000
12	Southeastern Blue Sucker	3	4	0	0.98	0	0.000
13	Alabama Sturgeon	3	4	0	1.00	0	0.000
14	Gulf Sturgeon	3	4	0	0.98	0	0.000
15	Mississippi Silvery Minnow	3	4	0	0.98	0	0.000
16	Northern Walleye	3	4	0	0.98	0	0.000
17	American Eel	3	4	0	0.98	0	0.000
18	Smallmouth Buffalo	3	4	0	0.99	0	0.000
19	Paddlefish	3	4	0	0.98	0	0.000
					Avg.		0.000

Alternative 3: "Fixed Weir Rock Arch – Both Dams" (MF Focus)
Minimum Current Velocity at Hydraulic Steps (ft/sec): X
Fs - Size of Fishway: 3
Discharge: 50,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	$E_i \times U_i \times D_i$	Є = Fish Passage Connectivity
1	Mobile Logperch	3	3	1	1.00	2.996	0.120
2	Gulf Logperch	3	3	1	1.00	2.996	0.120
3	Blacktail Shiner	5	4	1	0.98	3.937	0.157
4	Freshwater Drum	5	4	3	1.00	12.000	0.480
5	Chain Pickerel	3	3	3	0.98	8.831	0.353
6	Largemouth Bass	5	4	1	1.00	4.000	0.160
7	Skipjack Herring	5	4	1	0.98	3.916	0.157
8	Alabama Shad	5	4	3	0.98	11.747	0.470
9	Striped Bass	5	4	3	0.99	11.825	0.473
10	Crystal Darter	3	3	1	0.98	2.949	0.118
11	River Redhorse	5	4	3	0.98	11.743	0.470
12	Southeastern Blue Sucker	5	4	3	0.98	11.712	0.468
13	Alabama Sturgeon	3	3	1	1.00	3.000	0.120
14	Gulf Sturgeon	3	3	1	0.98	2.948	0.118
15	Mississippi Silvery Minnow	3	3	3	0.98	8.846	0.354
16	Northern Walleye	3	3	3	0.98	8.846	0.354
17	American Eel	5	4	3	0.98	11.794	0.472
18	Smallmouth Buffalo	5	4	3	0.99	11.836	0.473
19	Paddlefish	5	4	3	0.98	11.712	0.468
						Avg.	0.311

Alternative 5d: "Natural Bypass Channel – Both Dams" (MF Focus)
Minimum Current Velocity at Hydraulic Steps (ft/sec): X
Fs - Size of Fishway: 3
Discharge: 50,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	$E_i \times U_i \times D_i$	Є = Fish Passage Connectivity
1	Mobile Logperch	5	4	3	1.00	11.983	0.479
2	Gulf Logperch	5	4	3	1.00	11.983	0.479
3	Blacktail Shiner	5	4	3	0.98	11.811	0.472
4	Freshwater Drum	3	3	3	1.00	9.000	0.360
5	Chain Pickerel	3	3	5	0.98	14.719	0.589
6	Largemouth Bass	3	3	1	1.00	3.000	0.120
7	Skipjack Herring	3	3	3	0.98	8.810	0.352
8	Alabama Shad	3	3	3	0.98	8.810	0.352
9	Striped Bass	3	3	5	0.99	14.781	0.591
10	Crystal Darter	5	4	3	0.98	11.794	0.472
11	River Redhorse	3	3	3	0.98	8.807	0.352
12	Southeastern Blue Sucker	3	3	5	0.98	14.640	0.586
13	Alabama Sturgeon	3	3	1	1.00	3.000	0.120
14	Gulf Sturgeon	3	3	1	0.98	2.948	0.118
15	Mississippi Silvery Minnow	5	4	3	0.98	11.794	0.472
16	Northern Walleye	3	3	3	0.98	8.846	0.354
17	American Eel	5	4	3	0.98	11.794	0.472
18	Smallmouth Buffalo	3	3	3	0.99	8.877	0.355
19	Paddlefish	5	4	3	0.98	11.712	0.468
					Avg.		0.398

Alternative 12b: "Fixed Weir - CL and Bypass - MF" (MF Focus)
Minimum Current Velocity at Hydraulic Steps (ft/sec): X
Fs - Size of Fishway: 3
Discharge: 50,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	$E_i \times U_i \times D_i$	Є = Fish Passage Connectivity
1	Mobile Logperch	5	4	3	1.00	11.983	0.479
2	Gulf Logperch	5	4	3	1.00	11.983	0.479
3	Blacktail Shiner	5	4	3	0.98	11.811	0.472
4	Freshwater Drum	3	3	3	1.00	9.000	0.360
5	Chain Pickerel	3	3	5	0.98	14.719	0.589
6	Largemouth Bass	3	3	1	1.00	3.000	0.120
7	Skipjack Herring	3	3	3	0.98	8.810	0.352
8	Alabama Shad	3	3	3	0.98	8.810	0.352
9	Striped Bass	3	3	5	0.99	14.781	0.591
10	Crystal Darter	5	4	3	0.98	11.794	0.472
11	River Redhorse	3	3	3	0.98	8.807	0.352
12	Southeastern Blue Sucker	3	3	5	0.98	14.640	0.586
13	Alabama Sturgeon	3	3	1	1.00	3.000	0.120
14	Gulf Sturgeon	3	3	1	0.98	2.948	0.118
15	Mississippi Silvery Minnow	5	4	3	0.98	11.794	0.472
16	Northern Walleye	3	3	3	0.98	8.846	0.354
17	American Eel	5	4	3	0.98	11.794	0.472
18	Smallmouth Buffalo	3	3	3	0.99	8.877	0.355
19	Paddlefish	5	4	3	0.98	11.712	0.468
					Avg.		0.398

Alternastive 13b: "Fixed Weir — MF and Bypass - CL" (MF Focus)
Minimum Current Velocity at Hydraulic Steps (ft/sec): X
Size of Fishway (Fs): 3
Discharge: 50,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	$E_i \times U_i \times D_i$	Є = Fish Passage Connectivity
1	Mobile Logperch	3	3	1	1.00	2.996	0.120
2	Gulf Logperch	3	3	1	1.00	2.996	0.120
3	Blacktail Shiner	5	4	1	0.98	3.937	0.157
4	Freshwater Drum	5	4	3	1.00	12.000	0.480
5	Chain Pickerel	3	3	3	0.98	8.831	0.353
6	Largemouth Bass	5	4	1	1.00	4.000	0.160
7	Skipjack Herring	5	4	1	0.98	3.916	0.157
8	Alabama Shad	5	4	3	0.98	11.747	0.470
9	Striped Bass	5	4	3	0.99	11.825	0.473
10	Crystal Darter	3	3	1	0.98	2.949	0.118
11	River Redhorse	5	4	3	0.98	11.743	0.470
12	Southeastern Blue Sucker	5	4	3	0.98	11.712	0.468
13	Alabama Sturgeon	3	3	1	1.00	3.000	0.120
14	Gulf Sturgeon	3	3	1	0.98	2.948	0.118
15	Mississippi Silvery Minnow	3	3	3	0.98	8.846	0.354
16	Northern Walleye	3	3	3	0.98	8.846	0.354
17	American Eel	5	4	3	0.98	11.794	0.472
18	Smallmouth Buffalo	5	4	3	0.99	11.836	0.473
19	Paddlefish	5	4	3	0.98	11.712	0.468
						Avg.	0.311

Discharge: 150,000 cfs

Alternative 1: "No Action" (MF Focus)
Minimum Current Velocity at Hydraulic Steps (ft/sec): X
Fs - Size of Fishway: 5
Discharge: 150,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	$E_i \times U_i \times D_i$	Є = Fish Passage Connectivity
1	Mobile Logperch	3	4	0	1.00	0	0.000
2	Gulf Logperch	3	4	0	1.00	0	0.000
3	Blacktail Shiner	3	4	0	0.98	0	0.000
4	Freshwater Drum	3	4	0	1.00	0	0.000
5	Chain Pickerel	3	4	0	0.98	0	0.000
6	Largemouth Bass	3	4	0	1.00	0	0.000
7	Skipjack Herring	3	4	0	0.98	0	0.000
8	Alabama Shad	3	4	0	0.98	0	0.000
9	Striped Bass	3	4	0	0.99	0	0.000
10	Crystal Darter	3	4	0	0.98	0	0.000
11	River Redhorse	3	4	0	0.98	0	0.000
12	Southeastern Blue Sucker	3	4	0	0.98	0	0.000
13	Alabama Sturgeon	3	4	0	1.00	0	0.000
14	Gulf Sturgeon	3	4	0	0.98	0	0.000
15	Mississippi Silvery Minnow	3	4	0	0.98	0	0.000
16	Northern Walleye	3	4	0	0.98	0	0.000
17	American Eel	3	4	0	0.98	0	0.000
18	Smallmouth Buffalo	3	4	0	0.99	0	0.000
19	Paddlefish	3	4	0	0.98	0	0.000
					Avg.		0.000

Alternative 3: "Fixed Weir Rock Arch – Both Dams" (MF Focus)
Minimum Current Velocity at Hydraulic Steps (ft/sec): X
Fs - Size of Fishway: 1
Discharge: 150,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	$E_i \times U_i \times D_i$	Є = Fish Passage Connectivity
1	Mobile Logperch	3	2	3	1.00	5.991	0.240
2	Gulf Logperch	3	2	3	1.00	5.991	0.240
3	Blacktail Shiner	5	3	3	0.98	8.859	0.354
4	Freshwater Drum	5	3	5	1.00	15.000	0.600
5	Chain Pickerel	5	3	5	0.98	14.719	0.589
6	Largemouth Bass	5	3	3	1.00	9.000	0.360
7	Skipjack Herring	5	3	3	0.98	8.810	0.352
8	Alabama Shad	5	3	5	0.98	14.683	0.587
9	Striped Bass	5	3	5	0.99	14.781	0.591
10	Crystal Darter	3	2	3	0.98	5.897	0.236
11	River Redhorse	5	3	5	0.98	14.679	0.587
12	Southeastern Blue Sucker	5	3	5	0.98	14.640	0.586
13	Alabama Sturgeon	5	3	3	1.00	9.000	0.360
14	Gulf Sturgeon	5	3	3	0.98	8.845	0.354
15	Mississippi Silvery Minnow	5	3	5	0.98	14.743	0.590
16	Northern Walleye	5	3	5	0.98	14.743	0.590
17	American Eel	5	3	5	0.98	14.743	0.590
18	Smallmouth Buffalo	5	3	5	0.99	14.795	0.592
19	Paddlefish	5	3	5	0.98	14.640	0.586
						Avg.	0.473

Alternative 5d: "Natural Bypass Channel – Both Dams" (MF Focus)
Minimum Current Velocity at Hydraulic Steps (ft/sec): X
Fs - Size of Fishway: 1
Discharge: 150,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	$E_i \times U_i \times D_i$	Є = Fish Passage Connectivity
1	Mobile Logperch	5	3	5	1.00	14.979	0.599
2	Gulf Logperch	5	3	5	1.00	14.979	0.599
3	Blacktail Shiner	5	3	3	0.98	8.859	0.354
4	Freshwater Drum	5	3	5	1.00	15.000	0.600
5	Chain Pickerel	5	3	5	0.98	14.719	0.589
6	Largemouth Bass	5	3	3	1.00	9.000	0.360
7	Skipjack Herring	5	3	5	0.98	14.683	0.587
8	Alabama Shad	5	3	5	0.98	14.683	0.587
9	Striped Bass	5	3	5	0.99	14.781	0.591
10	Crystal Darter	5	3	5	0.98	14.743	0.590
11	River Redhorse	5	3	5	0.98	14.679	0.587
12	Southeastern Blue Sucker	5	3	5	0.98	14.640	0.586
13	Alabama Sturgeon	5	3	3	1.00	9.000	0.360
14	Gulf Sturgeon	5	3	3	0.98	8.845	0.354
15	Mississippi Silvery Minnow	5	3	5	0.98	14.743	0.590
16	Northern Walleye	5	3	5	0.98	14.743	0.590
17	American Eel	5	3	5	0.98	14.743	0.590
18	Smallmouth Buffalo	5	3	5	0.99	14.795	0.592
19	Paddlefish	5	3	5	0.98	14.640	0.586
					Avg.		0.542

Alternative 12b: "Fixed Weir - CL and Bypass - MF" (MF Focus)
Minimum Current Velocity at Hydraulic Steps (ft/sec): X
Fs - Size of Fishway: 1
Discharge: 150,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	$E_i \times U_i \times D_i$	Є = Fish Passage Connectivity
1	Mobile Logperch	5	3	5	1.00	14.979	0.599
2	Gulf Logperch	5	3	5	1.00	14.979	0.599
3	Blacktail Shiner	5	3	3	0.98	8.859	0.354
4	Freshwater Drum	5	3	5	1.00	15.000	0.600
5	Chain Pickerel	5	3	5	0.98	14.719	0.589
6	Largemouth Bass	5	3	3	1.00	9.000	0.360
7	Skipjack Herring	5	3	5	0.98	14.683	0.587
8	Alabama Shad	5	3	5	0.98	14.683	0.587
9	Striped Bass	5	3	5	0.99	14.781	0.591
10	Crystal Darter	5	3	5	0.98	14.743	0.590
11	River Redhorse	5	3	5	0.98	14.679	0.587
12	Southeastern Blue Sucker	5	3	5	0.98	14.640	0.586
13	Alabama Sturgeon	5	3	3	1.00	9.000	0.360
14	Gulf Sturgeon	5	3	3	0.98	8.845	0.354
15	Mississippi Silvery Minnow	5	3	5	0.98	14.743	0.590
16	Northern Walleye	5	3	5	0.98	14.743	0.590
17	American Eel	5	3	5	0.98	14.743	0.590
18	Smallmouth Buffalo	5	3	5	0.99	14.795	0.592
19	Paddlefish	5	3	5	0.98	14.640	0.586
					Avg.		0.542

Alternastive 13b: "Fixed Weir — MF and Bypass - CL" (MF Focus)
Minimum Current Velocity at Hydraulic Steps (ft/sec): X
Size of Fishway (Fs): 1
Discharge: 150,000 cfs

i	Family Common Name	F_1 Fishway Location at CL	E_i Potential to Encounter at CL	U_i Potential for Species to Use at CL	Di Duration of migration period passable	$E_i \times U_i \times D_i$	Є = Fish Passage Connectivity
1	Mobile Logperch	3	2	3	1.00	5.991	0.240
2	Gulf Logperch	3	2	3	1.00	5.991	0.240
3	Blacktail Shiner	5	3	3	0.98	8.859	0.354
4	Freshwater Drum	5	3	5	1.00	15.000	0.600
5	Chain Pickerel	5	3	5	0.98	14.719	0.589
6	Largemouth Bass	5	3	3	1.00	9.000	0.360
7	Skipjack Herring	5	3	3	0.98	8.810	0.352
8	Alabama Shad	5	3	5	0.98	14.683	0.587
9	Striped Bass	5	3	5	0.99	14.781	0.591
10	Crystal Darter	3	2	3	0.98	5.897	0.236
11	River Redhorse	5	3	5	0.98	14.679	0.587
12	Southeastern Blue Sucker	5	3	5	0.98	14.640	0.586
13	Alabama Sturgeon	5	3	3	1.00	9.000	0.360
14	Gulf Sturgeon	5	3	3	0.98	8.845	0.354
15	Mississippi Silvery Minnow	5	3	5	0.98	14.743	0.590
16	Northern Walleye	5	3	5	0.98	14.743	0.590
17	American Eel	5	3	5	0.98	14.743	0.590
18	Smallmouth Buffalo	5	3	5	0.99	14.795	0.592
19	Paddlefish	5	3	5	0.98	14.640	0.586
						Avg.	0.473

Average FPCI

	AVERAGE FPCI (Alternative 1)	
1	Mobile Logperch	0.000
2	Gulf Logperch	0.000
3	Blacktail Shiner	0.000
4	Freshwater Drum	0.000
5	Chain Pickerel	0.000
6	Largemouth Bass	0.000
7	Skipjack Herring	0.000
8	Alabama Shad	0.000
9	Striped Bass	0.000
10	Crystal Darter	0.000
11	River Redhorse	0.000
12	Southeastern Blue Sucker	0.000
13	Alabama Sturgeon	0.000
14	Gulf Sturgeon	0.000
15	Mississippi Silvery Minnow	0.000
16	Northern Walleye	0.000
17	American Eel	0.000
18	Smallmouth Buffalo	0.000
20	Paddlefish	0.000
	TOTAL FPCI AVERAGE	0.000

	AVERAGE FPCI (Alternative 3)	
1	Mobile Logperch	0.156
2	Gulf Logperch	0.156
3	Blacktail Shiner	0.197
4	Freshwater Drum	0.486
5	Chain Pickerel	0.453
6	Largemouth Bass	0.170
7	Skipjack Herring	0.166
8	Alabama Shad	0.476
9	Striped Bass	0.479
10	Crystal Darter	0.153
11	River Redhorse	0.476
12	Southeastern Blue Sucker	0.474
13	Alabama Sturgeon	0.162
14	Gulf Sturgeon	0.159
15	Mississippi Silvery Minnow	0.454
16	Northern Walleye	0.366
17	American Eel	0.566
18	Smallmouth Buffalo	0.479
19	Paddlefish	0.562
	TOTAL FPCI AVERAGE	0.347

	AVERAGE FPCI (Alternative 5d)	
1	Mobile Logperch	0.575
2	Gulf Logperch	0.575
3	Blacktail Shiner	0.260
4	Freshwater Drum	0.462
5	Chain Pickerel	0.736
6	Largemouth Bass	0.162
7	Skipjack Herring	0.452
8	Alabama Shad	0.452
9	Striped Bass	0.739
10	Crystal Darter	0.566
11	River Redhorse	0.452
12	Southeastern Blue Sucker	0.732
13	Alabama Sturgeon	0.162
14	Gulf Sturgeon	0.159
15	Mississippi Silvery Minnow	0.566
16	Northern Walleye	0.454
17	American Eel	0.566
18	Smallmouth Buffalo	0.456
19	Paddlefish	0.562
	TOTAL FPCI AVERAGE	0.478

	AVERAGE FPCI (Alternative 12b)	
1	Mobile Logperch	0.575
2	Gulf Logperch	0.575
3	Blacktail Shiner	0.260
4	Freshwater Drum	0.462
5	Chain Pickerel	0.736
6	Largemouth Bass	0.162
7	Skipjack Herring	0.452
8	Alabama Shad	0.452
9	Striped Bass	0.739
10	Crystal Darter	0.566
11	River Redhorse	0.452
12	Southeastern Blue Sucker	0.732
13	Alabama Sturgeon	0.162
14	Gulf Sturgeon	0.159
15	Mississippi Silvery Minnow	0.566
16	Northern Walleye	0.454
17	American Eel	0.566
18	Smallmouth Buffalo	0.456
19	Paddlefish	0.562
	TOTAL FPCI AVERAGE	0.478

	AVERAGE FPCI (Alternative 13b)	
1	Mobile Logperch	0.156
2	Gulf Logperch	0.156
3	Blacktail Shiner	0.197
4	Freshwater Drum	0.486
5	Chain Pickerel	0.453
6	Largemouth Bass	0.170
7	Skipjack Herring	0.166
8	Alabama Shad	0.476
9	Striped Bass	0.479
10	Crystal Darter	0.153
11	River Redhorse	0.476
12	Southeastern Blue Sucker	0.474
13	Alabama Sturgeon	0.162
14	Gulf Sturgeon	0.159
15	Mississippi Silvery Minnow	0.454
16	Northern Walleye	0.366
17	American Eel	0.566
18	Smallmouth Buffalo	0.479
19	Paddlefish	0.562
	TOTAL FPCI AVERAGE	0.347

Steady State Flow through Model (cfs)	MF Right Bypass Channel Est Flows (cfs)	MF Rock Weir Est Flows (cfs)	CL Right Bypass Channel Est Flows (cfs)	CL Rock Weir Est Flows (cfs)
5000	1150	1400	550	950
50000	1600	2200	800	1900
150000	1800	2250	6500	2800

*These flows occur when pool is much higher than fixed crest weir

Fs Values	MF Right Bypass Channel Est Flows (cfs)	MF Rock Weir Est Flows (cfs)	CL Right Bypass Channel Est Flows (cfs)	CL Rock Weir Est Flows (cfs)	
5000	23	28	11	19	all over 10% which equals a value of 5
50000	3.2	4.4	1.6	3.8	all under 5% but more than 2% which equals a value of 3
150000	1.2	1.5	4.333333333	1.866666667	all but CL bypass get value of 1 and CL bypass gets value of 3

Figure B.1-7: Habitat Units per Species per Alternative

i	Migratory Fish Species Family Common Name	Total Available Preferred Habitat below Cahaba River (linear feet)	Alternative 1: No Action Є = Fish Passage Connectivity	Alternative 1: No Action Habitat Units (Є X lf)	Alternative 3: Fixed Weir Rock Arch – Both Dams Є = Fish Passage Connectivity	Alternative 3: Fixed Weir Rock Arch – Both Dams Habitat Units (Є X lf)	Alternative 5d: Natural Bypass Channel – Both Dams Є = Fish Passage Connectivity	Alternative 5d: Natural Bypass Channel – Both Dams Habitat Units (Є X lf)	Alternative 12b: Fixed Weir Rock Arch at Claiborne and Natural Bypass Millers Ferry Є = Fish Passage Connectivity	Alternative 12b: Fixed Weir Rock Arch at Claiborne and Natural Bypass Millers Ferry Habitat Units (Є X lf)	Alternastive 13b: Fixed Weir -– MF and Bypass - CL Є = Fish Passage Connectivity	Alternastive 13b: Fixed Weir -– MF and Bypass - CL Habitat Units (Є X lf)
1	Mobile Logperch	1,303,186.693	0.005	6,516	0.418	544,587	0.593	772,254	0.628	817,865	0.383	498,975
2	Gulf Logperch	1,303,186.693	0.005	6,516	0.418	544,587	0.593	772,254	0.628	817,865	0.383	498,975
3	Blacktail Shiner	1,303,186.693	0.005	6,516	0.248	323,749	0.277	360,886	0.280	364,795	0.245	319,839
4	Freshwater Drum	2,870,683.693	0.000	0	0.518	1,487,014	0.531	1,524,333	0.506	1,452,566	0.543	1,558,781
5	Chain Pickerel	828,593.704	0.000	0	0.457	378,393	0.788	652,906	0.598	495,473	0.647	535,826
6	Largemouth Bass	1,867,846.304	0.005	9,339	0.283	528,601	0.201	375,437	0.279	521,129	0.205	382,908
7	Skipjack Herring	2,252,748.885	0.005	11,264	0.258	581,672	0.506	1,140,169	0.401	903,630	0.363	818,211
8	Alabama Shad	2,252,748.885	0.000	0	0.533	1,200,422	0.506	1,140,169	0.521	1,173,960	0.518	1,166,631
9	Striped Bass	2,252,748.885	0.005	11,264	0.534	1,203,978	0.770	1,733,534	0.665	1,496,995	0.639	1,440,517
10	Crystal Darter	2,131,780.398	0.000	0	0.417	888,234	0.588	1,253,621	0.623	1,328,233	0.382	813,621
11	River Redhorse	2,131,780.398	0.005	10,659	0.533	1,135,797	0.506	1,078,787	0.521	1,110,764	0.518	1,103,821
12	Southeastern Blue Suck	2,131,780.398	0.005	10,659	0.532	1,134,465	0.766	1,632,944	0.661	1,409,107	0.637	1,358,302
13	Alabama Sturgeon	2,960,374.102	0.000	0	0.204	603,916	0.201	595,035	0.204	603,916	0.201	595,035
14	Gulf Sturgeon	2,960,374.102	0.005	14,802	0.203	599,774	0.200	590,893	0.203	599,774	0.200	590,893
15	Mississippi Silvery Minn	210,658.896	0.000	0	0.567	119,452	0.628	132,307	0.623	131,254	0.572	120,505
16	Northern Walleye	2,185,055.596	0.000	0	0.478	1,044,045	0.527	1,151,612	0.522	1,140,686	0.483	1,054,970
17	American Eel	3,277,583.394	0.005	16,388	0.623	2,042,140	0.628	2,058,528	0.623	2,042,140	0.628	2,058,528
18	Smallmouth Buffalo	2,870,683.693	0.005	14,353	0.535	1,534,915	0.508	1,457,877	0.523	1,500,937	0.520	1,491,855
19	Paddlefish	1,092,527.798	0.005	5,463	0.621	678,556	0.626	684,019	0.621	678,556	0.626	684,019
			Avg.	6,513	Avg.	872,331	Avg.	1,005,661	Avg.	978,402	Avg.	899,590

Figure B.1-8: Habitat Unit Summary

Summary - Connectivity Rank of Fish Passage Alternatives		
Measures	**Є = Fish Passage Connectivity (Avg.)**	**Avg. Habitat Units**
Alternative 1: No Action	**0.003**	**6,513**
Alternative 3: Fixed Weir Rock Arch – Both Dams	**0.441**	**872,331**
Alternative 5d: Natural Bypass Channel – Both Dams	**0.523**	**1,005,661**
Alternative 12b: Fixed Weir Rock Arch at Claiborne and Natural Bypass Millers Fe	**0.507**	**978,402**
Alternastive 13b: Bypass at Claiborne and Fixed Weir at Millers	**0.457**	**899,590**

B.1.2.2. *Model Approval*

B.1.2.2.1. *Regional Certification*

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

REPLY TO
ATTENTION OF

CECW-P

16 September 2011

MEMORANDUM FOR Director, National Ecosystem Restoration Planning Center of Expertise (ECO-PCX)

SUBJECT: Fish Passage Connectivity Index (FPCI), Upper Mississippi River (UMR) System Fish Passage Improvement Ecosystem Restoration Projects – Regional Certification

The FPCI, which evaluates ecosystem outputs of alternative measures for fish passage improvements for cost effectiveness and incremental analysis, is certified for regional use. Adequate technical reviews have been accomplished and the model meets the certification criteria contained in EC 1105-2-412. The FPCI is an arithmetic index that incorporates characteristics of migratory fishes present at Lock and Dam 22 on the UMR and characteristics of fish passage alternative measures. While originally intended for use for the Lock and Dam 22 project, it is applicable to fish passage projects at other dams on the UMR and has the potential for application to fish passage projects on other river systems. Subject to a demonstration by the ECO-PCX that use of the model is applicable to other river systems, the regional certification will be expanded. This regional certification is based on the decision of the HQUSACE Model Certification Panel which considered the ECO-PCX assessment of the model.

APPLICABILITY: This regional certification is limited to fish passage projects at other dams on the UMR with possible application on other river systems.

EXPIRES: 30 September 2018

HARRY E. KITCH, P.E.
Deputy Chief, Planning and Policy Division
Director of Civil Works

Printed on Recycled Paper

B.1.2.2.2. *Single-Use Approval*

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
MISSISSIPPI VALLEY DIVISION
1400 WALNUT STREET
VICKSBURG MS 39180-3262

CEMVD-PDP 27 February 2023

MEMORANDUM FOR Commander, Mobile District, U.S. Army Corps of Engineers (Attn: Ms. Jennifer Jacobson, CESAM-PD)

SUBJECT: Single Use Approval of the Fish Passage Connectivity Index for the Claiborne and Millers Ferry Locks and Dams Fish Passage Feasibility Study

1. References:
   a. Engineer Circular 1105-2-412: Assuring Quality of Planning Models, 31 March 2011.

   b. US Army Corps of Engineers. Assuring Quality of Planning Models - Model Certification/Approval Process: Standard Operating Procedures. Feb 2012.

   c. Memorandum to Directors of National Planning Centers of Expertise – Subject: Modification of the Model Certification Process and Delegation of Model Approval for Use, 04 December 2017.

   d. Memorandum from the Director of Civil Works to MSC Commanders – Subject: Delegation of Model Certification, 11 May 2018.

   e. Memorandum to Director of the Ecosystem Restoration Planning Center of Expertise - Subject: Recommend Single Use Approval of the Fish Passage Connectivity Index for the Claiborne and Millers Ferry Locks and Dams Fish Passage Feasibility Study, 27 February 2023.

2. An independent review team managed by the Ecosystem Restoration Planning Center of Expertise evaluated the subject model. The model was found to be technically sound, computationally correct, usable for Civil Works planning, and policy compliant using appropriate functional assessment procedures.

3. The Fish Passage Connectivity Index is approved for single use in the Claiborne and Millers Ferry Locks and Dams Fish Passage Feasibility Study. Independent technical review is complete and the model meets the criteria contained in References 1.a. and 1.b. There are no unresolved issues stemming from the review.

4. This approval expires 27 February 2030. Given that several years may pass before the expiration all users of the model are expected to consult with relevant subject experts before its use, with respect to the appropriateness of the modeling method and ecological information being used in the model before its use. The consult should include discussion of whether the modeling method and ecological

information are still right for the study and current enough for responsible use of the model.

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Kelly J. Keefe, PhD
Chief, MVD Planning and Policy and
Director, Ecosystem Restoration
Planning Center of Expertise

CF
CEMVD-PDP (Lawton, Mallard, Mickal)
CEMVP-PD-C (Jordan, Cyphers, Hoster)
CEMVP-PD-P (Stefanik, Runyon)
CEMVP-PD-F (Opsahl)
CESAM-PD (Bulger, Rickey, White, Malsom, Mroczko, Jacobson)

B.1.2.2.3. *Model Documentation Addendum*

Fish Passage Connectivity Index
Model Documentation Addendum
for
Approval of Model for Single Use on the
Claiborne and Millers Ferry Locks and Dams Fish Passage Feasibility Study

Background

This document is intended to provide justification for use of the Fish Passage Connectivity Index (FPCI) model for the Claiborne and Millers Ferry Locks and Dams Fish Passage Study (also referred to as the Alabama River Fish Passage Study). The study focuses on linear movement of fish species at two Locks and Dams along the Alabama River: Claiborne and Millers Ferry. All action-alternatives include measures at each location to achieve a key Study Objective: connectivity restoration of the Cahaba River which is located upstream of Millers Ferry to the Lower Alabama River and ultimately Mobile Bay. Both Claiborne and Millers Ferry are impediments to this Study Objective and are viewed as one Study Area. The FPCI model is appropriate for deriving habitat units due to the similarity in river systems. The FPCI model was created for the Lock 22 study on the Mississippi River which is a large riverine system with linear migration for several fish species. Likewise, the Alabama River is a large riverine system, and the study focuses on 19 fishes grouped into guilds based on size/speed.

The Alabama River is part of the Alabama Coosa Tallapoosa (ACT) River Basin and is impounded by several federal locks and dams. Impoundment of this system significantly impacts the ability for migratory fishes to reach historic spawning grounds. Additionally, the Alabama River is The Nature Conservancy's (TNC) top priority nationwide due to its rich biodiversity.

The FPCI model was originally developed by the Navigation and Ecosystem Sustainability Program, Lock and Dam 22 Fish Passage Ecosystem Restoration Project Delivery Team which included fisheries biologists and hydraulic engineers from USACE, US Fish and Wildlife Service, Illinois Department of Natural Resources, Illinois Natural History, Missouri Department of Conservation, and Iowa Department of Natural Resources. The model calculates Habitat Units (HU) for each migratory fish species and averages HU for all migratory fish species for each fish passage alternative. Model inputs include movement periods for each migratory species, likelihood of species to encounter fishway entrance based on location, species potential to use passage route, and availability of suitable passage conditions during movement and spawning periods. The result is a 0-1 index that represents the suitability of the fish passage alternative measure to a given species. The fish passage connectivity index is multiplied by the acres of connected, upstream habitat types that are suitable to the individual migratory species to obtain Habitat Units for use in Cost Effectiveness/Incremental Cost Analysis (CE/ICA). CE/ICA outputs will be used in selection of a Tentatively Selected Plan.

The FPCI was previously certified for regional use in the Upper Mississippi River System (UMRS), with possible application on other river systems, by the Ecosystem Restoration National Planning Center of Expertise (ECO-PCX). The FPCI was subsequently approved for single use for the purposes of evaluating the suitability of various fish passage alternatives for the Lower Yellowstone Intake Diversion Dam Fish Passage Project.

Modifications to the model equation are discussed in the **Proposed Modifications to the FPCI** and **Quantification Sections**. Changes include updated species and their habitat types (see discussion below).

Conceptual Ecological Model

This Conceptual Ecological Model (CEM) (**Figure 1**) was developed using input from Cooperating Agencies obtained during a two-day meeting on 10-11 January 2022.

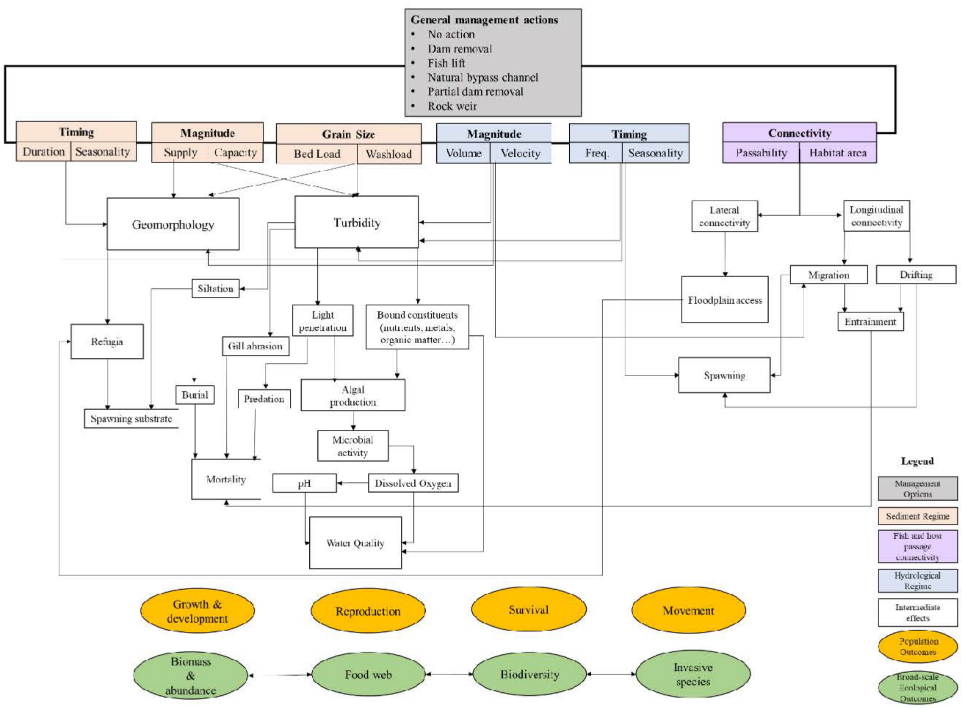

Figure 1: Conceptual Ecological Model

Mr. Todd Swannack (ERDC) and his team facilitated the meeting and developed the CEM based on Miro boards used during the meeting. Agencies represented were

Alabama Department of Environmental Management, Alabama Department of Conservation and Natural Resources, and U.S. Fish and Wildlife Service.

Model Selection

Consideration was given to the ERDC-developed Watershed Upstream Connectivity Toolkit (WUCT) model due to the ecological complexity as shown in the CEM; however, the WUCT model is more useful when encountering braided or branch riverine systems. The Alabama River has no major tributaries between the study area and the Cahaba River and so both the FPCI and the WUCT model would have identified the same result. Additionally, similar species and project complexity were involved with the FPCI; therefore, the FPCI was chosen for the Fish Passage study on the Alabama River due to its similarities with the study area. No changes to the model calculations and formulas are necessary. Only modifications needed include updating species and critical swimming speeds (see discussion below).

Section I.A. of the FPCI model approval documentation for the UMRS Lock 22 states: "The model is applicable to fish passage improvement projects at other navigation dams on the UMRS. The model is applicable to UMRS tributaries and to other large rivers with appropriate modifications." The Alabama River is a similar large riverine system with many of the same target species as well as authorized project purposes. Therefore, the applicability of the FPCI use for the Alabama River Fish Passage Study is established. The same restraints identified in the Lock 22 study apply to the Alabama River study in that the model does not evaluate downstream migration.

The FPCI model is proposed for use for the Alabama River Fish Passage Study and will be used by the PDT for single use only to rank alternatives within the Final Array based on habitat units. The Economist will then apply those results in the CE/ICA which will be used to select the Tentatively Selected Plan.

Proposed Modifications to the FPCI

The Alabama River Fish Passage Study species cohort are listed in **Table 1**. Their migration and spawning periods are shown in **Figure 2**. These species are representative of the diversity within the Alabama River and are not an exhaustive list. The selection of each species was for the purpose of capturing biodiversity, which is a key objective to the study. Furthermore, the cohort is separated into host fish and non-host fish to capture ancillary benefits to federally listed and common freshwater mussel species.

Table 1: Alabama River Species Cohort

Benthic	Littoral	Pelagic
Host Fish		
Freshwater Drum	Chain Pickerel	Striped Bass

Benthic	Littoral	Pelagic
Aplodinotus grunniens	*Esox niger*	*Morone saxatilis*
Mobile Logperch *Percina kathae*	Largemouth Bass *Micropterus salmoides*	Skipjack Herring *Alosa chrysochloris*
Gulf Logperch *Percina suttkusi*		Alabama Shad *Alosa alabamae*
Blacktail Shiner *Cyprinella venusta*		
Non-Host Fish		
Gulf Sturgeon *Acipenser oxyrinchus desotoi*	Northern Walleye *Sander vitreus*	Paddlefish *Polyodon spathula*
Alabama Sturgeon *Scaphirhynchus suttkusi*	Mississippi Silvery Minnow *Hybognathus nuchalis*	Smallmouth Buffalo *Ictiobus bubalus*
Southeastern Blue Sucker *Cycleptus meridionalis*		American Eel *Anguilla rostrata*
River Redhorse *Moxostoma carinatum*		
Crystal Darter *Crystallaria asprella*		

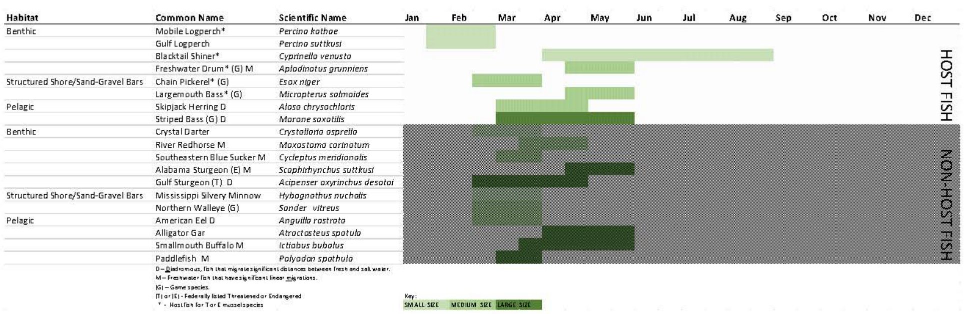

Figure 2: Spawning Seasons

The littoral zone within the Alabama River differs from the UMRS and was surveyed during May 2022 to delineate and group sub-habitat types. These sub-habitat groups are shown in see **Figure 3** and are specific for the needs of the species cohort.

Because the Study Area is comprised of two separate locations, the FPCI equation is calculated for each location separately and averaged to determine a single value for use in the Habitat Unit calculation. Additionally, due to the varying velocities throughout the measures an approach to evaluate each alternative using three steady-state flow rates is used. The values are then averaged per species. Further explanation is provided below in the **Quantification Section**.

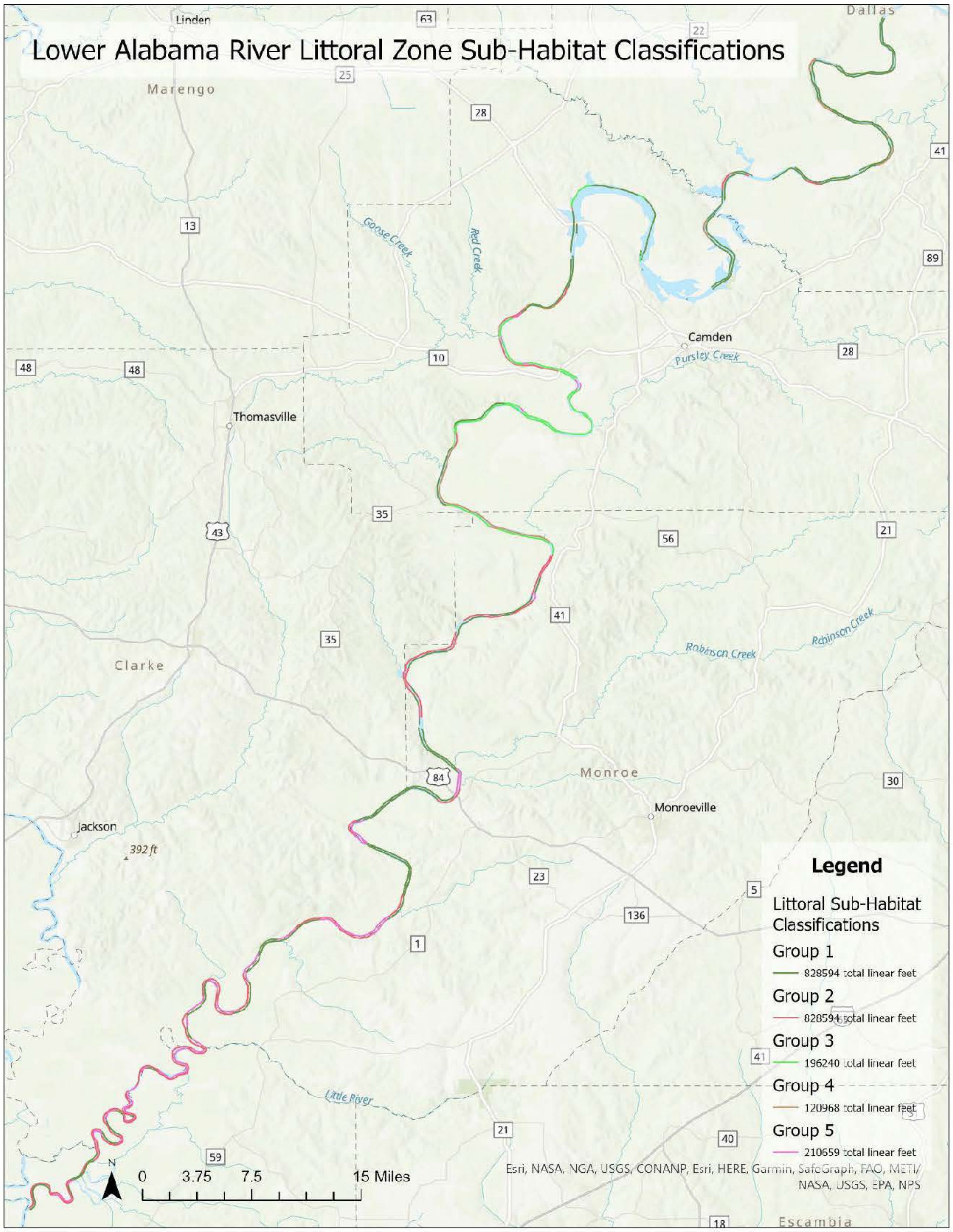

Figure 3: Littoral Sub-Habitat Classifications in the Lower Alabama River

Quantification

The Model application spreadsheet will be used for the Alabama River Fish Passage Study with slight modifications. Updates to the spreadsheet include revising the species list, their habitat types and quantification, as well as expanding some aspects of the workbook. A detailed explanation is included below.

- The Study Area has three main habitat types: benthic, littoral, and pelagic. The littoral zone was classified further into 5 sub-habitat groups: "Soil Substrate and Woody Debris (0-30° slope)", "Soil Substrate and Woody Debris (61-90° slope)", "Conglomeration of unusual types", "Bluff", and "Gravel / Sand Bar". Due to schedule and budget constraints, linear feet is used as a proxy to quantify habitat area Estimation of widths using satellite imagery to convert to acreage would result in a greater margin of error with unknown potential, and is not a Study Risk the Project Delivery Team (PDT) is willing to accept. The Fishes and Habitats sheet was updated to reflect this information.

- Swimming Speeds were provided by the NFS in centimeters per second and a column was added to automatically convert to feet per second in order to compare with the velocity heat maps. Additionally, a burst speed column was added to easily reference for determining the U_i value.

- Additionally, due to the complexity of the Study Area the spreadsheet was modified to analyze each location, Claiborne and Millers Ferry, for the Movement Period and Connectivity Index sheets. The average of the two Connectivity Indices is calculated in the Habitat Units sheet in order to obtain one value.

- Because the velocity outputs show a great amount of variation in inundation and velocity, each Connectivity Index sheet was expanded to analyze three events at 5,000 cubic feet per second (cfs), 50,000 cfs, and 150,000 cfs. This is due to the influence the events would have on species behavior and thus affecting the F_1 and U_i values. Additionally, inclusion of low and high flow events is necessary to capture more accurate Future Without and With Project Conditions (FWOP and FWP). The three events are then weighted based on annual percent probability using ResSIM modeling and then added for a singular Connectivity Index. The weights are as follows: 75% for 5,000 cfs, 20% for 50,000 cfs, and 5% for 150,000 cfs.

- The additional explanation for determining U_i values was defined as "If velocities did not exceed Ucrit speed for the majority of the hydraulic step area but exceeded burst speeds in small areas, the U_i was scored a 3."

- Other minor modifications include removing unnecessary and/or redundant data such as relative abundance, swimming performance, pre and post spawning distinction, average water temperature, and Minimum Current Velocity at Hydraulic Steps (ft/sec). Since the pre-spawning and post-spawning Movement Periods per species for each location is weighted equally, no distinction was made in the timetable graphic. The movement periods for each species were provided as part of work-in-kind services; therefore, the average water temperature data was removed from the sheet as that information was inherent in the provided services. Extraneous information to separate the species cohort into host-fish/non-host fish and color coding by size class was included for knowledge purposes. For each Connectivity Index, the U_i value was calculated using velocity heat maps provided by Engineering and evaluated wholistically. The "Minimum Current Velocity at Hydraulic Steps (ft/sec)" data was removed from these tables as it provided no use to the calculations.

- Because the study goal is to achieve fish passage between the Gulf of Mexico to the watershed above Millers Ferry the model was modified to include the expression =IF('Connectivity Index CL'!I86=0,0,IF('Connectivity Index MF'!I86=0,0,('Connectivity Index CL'!I86+'Connectivity Index MF'!I86)/2)) this required both dams to be transversed before a non zero connectivity or habitat unit score is given.

- The time passage available was changed to allow a 53 week year as opposed to a 52 to allow for HEC RAS data to be inputted.

Data Needs for Model Application
Data necessary to run the model include
1. velocity outputs,
2. estimated cfs through passageways at a steady state flow rate
3. habitat quantification,
4. critical swimming speeds,
5. percent probabilities of passageway gates fully open; and
6. expert elicitation

1. Engineering has provided three velocity outputs for each structural measure. The three outputs are 5,000 cfs, 50,000 cfs, and 150,000 cfs events to show low, average, and high anticipated flowage. These flow events are weighted (75% for 5,000 cfs, 20% for 50,000 cfs, and 5% for 150,000 cfs) based on ResSIM analysis showing annual percent probabilities.

2. Engineering also provided estimated cfs per measure per location for each of the three outputs of 5,000 cfs, 50,000 cfs, and 150,000 cfs. This was used to determine the F_2 value for each Alternative. Using ResSIM to determine annual percent probabilities, the flow events are weighted at 75% for 5,000 cfs, 20% for 50,000 cfs, and 5% for 150,000 cfs to provide more accurate FWOP and FWP conditions.

3. The Nature Conservancy classified and quantified the littoral zone using bathymetry during field work conducted May 2022. The field data which was captured in linear feet as a proxy to acreage due to schedule and budget constraints. Estimation of widths to convert to acreage would result in a greater margin of error with unknown potential that the PDT is unwilling to accept. The habitat model was modified to reflect the change from acreage to linear feet.

4. Critical swimming speeds have been determined through literature research.

5. Engineering will provide a percent probability for each week of the year that the passageway control gates will be open at each location.

6. Expert elicitation was conducted on 14 September 2022. Cooperating Agencies were convened to determine the F_1 value (location of fishway entrance in relation to the expected fish guild behavior) used in the calculation for E_i (potential for fish to encounter fishway entrance). This step is necessary due to the limited existing data showing where fish species congregate within the Alabama River. The agencies used their best professional judgement compared with the velocity outputs provided from Engineering to determine the appropriate values for each species, per alternative, per flow event (5,000 cfs, 50, 000 cfs, and 150, 000 cfs).

B.1.2.2.4. *Model Peer Review*

Model Approval Review

Comment and Evaluation Responses

Fish Passage Connectivity Index for the

Claiborne and Millers Ferry Locks and Dams Fish Passage Feasibility Study

January 2023

Elliot Stefanik, St. Paul District
Joe Jordan, St. Paul District
Trevor Cyphers, St. Paul District
Bethany Hoster, St. Paul District

Comment #1
The available habitat (linear feet of river), in some cases, is being counted more than once for some fish species.
Relevant Assessment Criteria
Technical Quality
Basis for Comment
The study area or habitat that is being applied to the model is the linear habitat from the Cahaba River to the Mobile River, which appears to be roughly 1.09 million linear feet. Fish species that occupy multiple habitat types (i.e., freshwater drum, gulf sturgeon, etc.) are having the linear stretch of the study area counted more than once, which would be considered double counting. I don't think it is appropriate for a fish species to get benefits of reconnecting the channel more than once, as the habitat unit being used is one dimensional.
Significance –
Medium, as this practice is inflating the overall habitat units, but not impacting the evaluation of the alternatives.
Recommendation for Resolution
The maximum habitat a species can be evaluated for should be capped at 1.09 million linear feet or the stretch of river in the study area.
USACE Evaluator Response
____Concur ___X__Non-Concur Though they overlap, each habitat type is unique based on criteria such as slope, depth, substrate, etc. which is necessary to individual species in differing ways. Both FWP and FWOP account for the same total length for all habitat types, and the model teases apart benefits based on these zones. Additionally, individuals within species populations are occupying multiple habitat types at the same time based on life

cycle requirements, refuge, foraging, etc. Finally, though the habitat unit alternative ranking remains the same capping the total available habitat affects the incremental benefits between alternatives and limits our capabilities to do more detailed sensitivity analyses necessary for the "is it worth it" argument. Any double counting of benefits or river length would be parametric since we treated the FWOP and FWP the same. The only difference in the conditions is the change in passability of fish based on alternative design parameters. Quantification of these habitat types uses linear feet as a proxy to acreage due to schedule and budget constraints. Field measurements were conducted which resulted in linear feet units and estimation of widths to convert to acreage would result in a greater margin of error with unknown potential. This is a Study Risk the PDT is unwilling to accept.
Reviewer BackCheck Response
Based on the evaluator response above, the panel provides the following response: __X__Concur ____Non-Concur Though multiple transects of linear feet is not the best way to quantify different habitat types associated with fish passage on the same stretch of river, we acknowledge the inability for the PDT to use acreage outright. In this case, we understand that linear feet is being used as a proxy to quantify benefits for fish species that have multiple habitat preferences throughout the river. Also, this decision does not have an overall impact on alternative selection.

Comment #2
The breakdown of littoral habitat is two times longer than the length of the study area.
Relevant Assessment Criteria
Technical Quality
Basis for Comment
This comment can be linked with comment one. If a one-dimensional habitat is used in the model, having a length greater than the study area wouldn't make sense.
Significance –
Low
Recommendation for Resolution
If littoral habitat is going to be carried through, I suggest the total sub-habitats be no longer than the total study area.
USACE Evaluator Response
____Concur __X___Non-Concur The Littoral Zones account for both left bank and right bank. Therefore, the benthic and pelagic zones are half that available space. See response to comment #1 for importance of littoral zone breakdown.
Reviewer BackCheck Response
Based on the evaluator response above, the panel provides the following response: __X__Concur ____Non-Concur

Comment #3
The F1 variable or the location of the fishway is changing with different velocities for each fish species, where the F1 variable remained constant through alternatives in the original model.
Relevant Assessment Criteria
Technical Quality
Basis for Comment
The UMRS Model states that F1 should be "the location of fishway entrance in relation to the expected behavior of the fish guild". Changing this variable based on different velocities would insinuate that the fish species behavior and fishway location is changing with river velocity. In the original model, the Fs variable was driving the differences between alternatives. This change in fish behavior is already accounted for in the Ui variable. Changing the F1 variable may be making the model more subjective than originally intended.
Significance –
Medium. It doesn't appear that this is impacting the evaluation of the alternatives but assigning higher F1 values as velocity increases appears to be inflating habitat units.
Recommendation for Resolution
Keep the F1 variable constant throughout each alternative (i.e., natural bypass, fixed weir), regardless of velocity.
USACE Evaluator Response
____Concur __X___Non-Concur As a result of expert elicitation to determine F1 values (5 being the highest likelihood of encountering), velocity was used as a surrogate to account for river inundation, which would directly influence fish behavior. Greater inundation leads to a better chance of the fish species finding the entranceway of each measure. We used data provided from Engineering to determine the Fs values using the methodology in the UMRS documentation: "A value of 5 was assigned to fishway designs that pass 10 percent of the low flow discharge, 4 = 8 percent, 3 = 5 percent, 2 = 2 percent, and 1 = less than 2 percent." The Fs values are calculated on each Connectivity Index sheet in cells D115-I124. After conferring with Engineering, each flow parameter was weighted based on ResSIM analysis for annual percent probability. It is important to capture high flow events even though the annual occurrence is low due to baseline passage above Claiborne. It's also important to capture low flow events due to spawning occurring during those events later in the season.
Reviewer BackCheck Response
Based on the evaluator response above, the panel provides the following response: __X__Concur ____Non-Concur This explanation is sufficient as to why the F1 values were changed with different velocities.

Comment #4
The breakdown of littoral sub-habitats should be explained.
Relevant Assessment Criteria
Technical Quality, Information
Basis for Comment
Within the model cert addendum and the model, the five sub-habitats of the littoral zone are not explained or labelled. The only two specifically called out are gravel/sandbar and bluff habitat.
Significance –
Low, mostly important for background information and for the reader to understand what preferred fish habitat was used.
Recommendation for Resolution
Provide the five sub-habitat labels in the model and addendum.
USACE Evaluator Response
__X__Concur _____Non-Concur Habitat names of the sublittoral zones were added based on field criteria. Those names are "Soil Substrate and Woody Debris (0-30° slope)", "Soil Substrate and Woody Debris (61-90° slope)", "Conglomeration of unusual types", "Bluff", and "Gravel / Sand Bar"
Reviewer BackCheck Response
Based on the evaluator response above, the panel provides the following response: __X__Concur ____Non-Concur

Comment #5
Would changing from linear feet to acres be a possibility?
Relevant Assessment Criteria
System Quality
Basis for Comment
The UMRR model utilized acres, so it makes sense to maintain that for this model. Also, acres would be easier to assess habitat preference of fish, as their behavior is more two dimensional than one dimensional.
Significance –
Low
Recommendation for Resolution
If not too much effort, try to utilize acres over linear feet.
USACE Evaluator Response
____Concur __X___Non-Concur This was considered but ruled against due to the large assumption of standard width to apply to each habitat zone. It would result in significant inaccuracies and assumed risk due to the inability to conduct field measurements or accurately estimate widths using satellite imagery.
Reviewer BackCheck Response
Based on the evaluator response above, the panel provides the following response: __X__Concur ____Non-Concur

Comment #6
The Total FPCI average for Alternative 12b and 13b look lower than they should be based on the overall habitat units.
Relevant Assessment Criteria
Technical Quality
Basis for Comment
The Average for each alternative is being divided by 30 instead of 19, thus lowering the average and not impacting the overall habitat units.
Significance –
Low, as it is only impacting the summary average and not the habitat units.
Recommendation for Resolution
Make the fix in the spreadsheet.
USACE Evaluator Response
_X___Concur _____Non-Concur This was corrected.
Reviewer BackCheck Response
Based on the evaluator response above, the panel provides the following response: __X__Concur ____Non-Concur

Comment #7
Some more information on the velocities and how frequent those happen would be helpful.
Relevant Assessment Criteria
Technical Quality
Basis for Comment
The three velocities being used by the model are being averaged or weighted equally. Do these three velocities tend to have a similar frequency? For example, if the 150,000 cfs is a 10-year event, it may be having too much impact of the model for how infrequent it happens.
Significance –
Low
Recommendation for Resolution
Provide flow frequencies for these events. If it makes sense, weight out the overall average in the model to reflect these frequencies.
USACE Evaluator Response
__X__Concur _____Non-Concur After conferring with Engineering, each flow parameter was weighted based on ResSIM analysis for annual percent probability. It is important to capture high flow events even though the annual occurrence is low due to baseline passage above Claiborne. It's also important to capture low flow events due to spawning occurring during those events later in the season. Therefore, the applied weights are 75% at 5,000 cfs, 20% at 50,000 cfs, and 5% at 150, 000 cfs. These weights are included in the formulas in rows 84-103 per spp of each FPCI sheet as well as rows 106 of each FPCI sheet. The weighted averages are then added to obtain a single FPCI value.
Reviewer BackCheck Response
Based on the evaluator response above, the panel provides the following response: __X__Concur ____Non-Concur

Comment #8
The way the model is set up with the two connectivity tabs for each dam makes it confusing to figure out which fish passage measure is being analyzed.
Relevant Assessment Criteria
Information
Basis for Comment
The way the spreadsheet is set up, it makes it hard to determine which dam and fish passage measure is being analyzed.
Significance –
Low
Recommendation for Resolution
State the Alternative and what dam and measure is being analyzed (i.e., Alternative 12b, Fixed Weir CL) instead of including the other that isn't being analyzed.
USACE Evaluator Response
__X__Concur _____Non-Concur The Alternative names are put in quotations within each tab for consistency purposes with Report Writing; however, a project specific focus is provided in parenthesis for each alternative to differentiate connectivity indices.
Reviewer BackCheck Response
Based on the evaluator response above, the panel provides the following response: __X__Concur ____Non-Concur

Comment #9
The model addendum or spreadsheet does not describe how HSI values are assigned. In the Excel spreadsheet, tab Connectivity Index CL, D63, Where did the 5 come from? Is 5 a high score or a low score?
Relevant Assessment Criteria
Technical Quality, System Quality, and Usability
Basis for Comment
Without the original model documentation, I can't repeat your analysis.
Significance –
Medium
Recommendation for Resolution
Include how the HSI scoring is assigned. Is it a 1/3/5 (Low/Medium/High) or is the score based on habitat criteria such as percent chance of finding the ramp entrance or velocity at the ramp?
USACE Evaluator Response
__X__Concur _____Non-Concur To determine F1 values (5 being the highest likelihood of encountering the entranceway), velocity was used as a surrogate to account for river inundation, which would directly influence fish behavior. Expert elicitation was used to determine the F1 values and a common finding was that greater inundation leads to a better chance of the fish species finding the entranceway of each measure. We used data provided from Engineering to determine the Fs values using the methodology in the UMRS documentation: "A value of 5 was assigned to fishway designs that pass 10 percent of the low flow discharge, 4 = 8 percent, 3 = 5 percent, 2 = 2 percent, and 1 = less than 2 percent." The Fs values are calculated on each Connectivity Index sheet in cells D115-I124. After conferring with Engineering, each flow parameter was weighted based on ResSIM analysis for annual percent probability. It is important to capture high flow events even though the annual occurrence is low due to baseline passage above Claiborne. It's also important to capture low flow events due to spawning occurring during those events later in the season.
Reviewer BackCheck Response
Based on the evaluator response above, the panel provides the following response: __x__Concur ____Non-Concur Please update your model documentation accordingly. Thank you.

Comment #10
Spreadsheet, Tab Connectivity Index CL, cell D63 – There is no control over what number I can put into this cell. I can put a negative number; I can put a huge number.
Relevant Assessment Criteria
Technical Quality
Basis for Comment
HSI scores should be limited to a specific score. - 0 -1 -3- 5? Better yet, they should be tied to an environmental value the spreadsheet converts to an HSI score. That way the model input is not biased.
Significance –
Medium
Recommendation for Resolution
Convert the model input from an HSI score to an environmental value. Lock or limit the input cells.
USACE Evaluator Response
_X___Concur _____Non-Concur See response to comment 1 for F1 explanation. These cells were updated to use data validation rather than manual input.
Reviewer BackCheck Response
Based on the evaluator response above, the panel provides the following response: __x__Concur ____Non-Concur Thank you!

Comment #11
The model documentation does not describe the No Action Alternative. The spreadsheet shows there is no habitat value currently (Tab Habitat Units). Is this true? Is there fish passage through the locks? During high water events?
Relevant Assessment Criteria
Technical Quality, System Quality
Basis for Comment
Generally, there is some habitat value under the No Action Alternative. Even is there is no benefit, this assumption should be added to the model documentation.
Significance –
Medium
Recommendation for Resolution
Please describe why the No Action Alternative is assumed to have no habitat value.
USACE Evaluator Response
__X__Concur _____Non-Concur The NAA formulation was changed to the same calculation as the other alternatives. Baseline conditions do result in fish passage only above Claiborne at high flow events and do result in minimal benefits.
Reviewer BackCheck Response
Based on the evaluator response above, the panel provides the following response: __x__Concur ____Non-Concur Thank you!

Comment #12

Page 6, Quantification, 3rd bullet: The habitat model should not be averaged between the 2 reaches. The lower reach is independent to the upper reach. Wouldn't there be a benefit if you only passed fish at the lower dam? Are there more pelagic benefits from removing the lower dam? If so, the two reaches should be separated.

Relevant Assessment Criteria

Technical Quality, System Quality, Usability, and/or Policy

Basis for Comment

The model should not be used to validate a whole project but used to separate out alternatives.

Significance –

<High

Recommendation for Resolution

More detail is needed to show dependence of the features. If you continue to average, you need to justify why both dams are interrelated to each other – they cannot work by themselves. You may have each with different or equal values but together there is a synergy.

USACE Evaluator Response

____Concur ___X__Non-Concur

The study objectives are to restore connection to the Cahaba River from the Lower AL River. Limited fish passage exists at high flow events but is not significant enough to maintain biodiversity and species abundance. Therefore, though the two locations are managed independently of each other this study is only concerned with "all or nothing" and no action alternatives include "no action" at either location.

Reviewer BackCheck Response

Based on the evaluator response above, the panel provides the following response:

__x__Concur ____Non-Concur Please update our model documentation to explain the "all or nothing approach.

B.2. Monitoring and Adaptive Management Plan

B.2.1. *Introduction*

August 2009 guidance from USACE Headquarters, implementing Section 2039 of Water Resources and Development Act (WRDA) of 2007, requires that ecosystem restoration projects include plans for monitoring success and adaptively managing ecosystem restoration projects.

Section 2039 of WRDA 2007 directs the Secretary of the Army to ensure, that when conducting a feasibility study for a project (or component of a project) under the USACE ecosystem restoration mission, that the recommended project includes a monitoring plan to measure the success of the ecosystem restoration.

B.2.2. *Authority*

Section 2039 of WRDA 2007 Monitoring Ecosystem Restoration

"(a) In General - In conducting a feasibility study for a project (or a component of a project) for ecosystem restoration, the Secretary shall ensure that the recommended project includes, as an integral part of the project, a plan for monitoring the success of the ecosystem restoration.

(b) Monitoring Plan - The monitoring plan shall--

(1) include a description of the monitoring activities to be carried out, the criteria for ecosystem restoration success, and the estimated cost and duration of the monitoring; and

(2) specify that the monitoring shall continue until such time as the Secretary determines that the criteria for ecosystem restoration success will be met.

(c) Cost Share - For a period of 10 years from completion of construction of a project (or a component of a project) for ecosystem restoration, the Secretary shall consider the cost of carrying out the monitoring as a project cost. If the monitoring plan under subsection (b) requires monitoring beyond the 10-year period, the cost of monitoring shall be a non-Federal responsibility."

Purpose of Monitoring. Monitoring of an ecosystem restoration project provides information with which to gauge the success of the restoration. Monitoring includes the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, and whether adaptive management may be needed to attain project benefits.

Purpose of Adaptive Management. The USACE implementation guidance for Section 2039 also directs that a contingency plan (an adaptive management plan) be developed for all ecosystem restoration projects. Adaptive management is intended to increase the ability to make timely responses based on new information from monitoring to maximize the objectives of the restoration effort. An adaptive management plan considers the planned restoration activities and establishes a framework for evaluation of the ecosystem performance; and it identifies uncertainties that will be addressed through monitoring. As monitoring data is collected and assessed, the management plan guides decision to a) continue the restoration plan implementation without modification, b) to modify the restoration plan implementation, or c) to change the restoration plan objectives.

The monitoring and adaptive management plan (MAMP) was developed in accordance with the following guidance:

a. USACE. 31 August 2009. Planning Memorandum. Implementation Guidance for Section 2039 of the Water Resources Development Act of 2007 (WRDA 2007) - Monitoring Ecosystem Restoration.

b. USACE. 22 April 2000. ER 1105-2-100, Planning, Planning Guidance Notebook.

c. USACE. 01 May 2003. EC 1105-2-404. Planning Civil Work Projects under the Environmental Operating Principles.

B.2.3. *Objectives and Scope*

The objective of the project is to restore the connectivity of the Cahaba River to Mobile Bay. Monitoring and, if necessary, adaptive management, would occur for a period of 10 years as evidence for successful establishment of the project. Monitoring efforts would be conducted by The Nature Conservancy (TNC) and USACE personnel.

The scope of monitoring and adaptive management was developed for the project's restoration objectives. Monitoring and adaptive management cost and duration were based on the Tentatively Selected Plan, Alternative 5d. This plan is based on currently available data and information. Uncertainties remain regarding the exact project features, monitoring elements, and adaptive management opportunities. Components of the MAMP, including costs, were estimated using a similar ecosystem restoration project as a model. Uncertainties would be addressed during preconstruction engineering and design of the recommended plan. A more detailed MAMP, including cost breakdown, would be included in the design documentation report (DDR).

This feasibility level MAMP identifies and describes the monitoring and adaptive management activities proposed for the project and estimates their cost and duration.

B.2.4. *Management and Restoration Actions*

The project delivery team (PDT) performed a thorough plan formulation process to identify potential management measures and restoration actions that address the project objective. Alternatives were considered, evaluated, and screened to produce a final array of alternatives. One plan, Alternative 5d, was identified as the National Ecosystem Restoration plan and was recommended for implementation. Alternative 5d would restore connectivity of the Cahaba River to Mobile Bay. In total, the plan would reconnect over 230 miles of the Alabama and Cahaba Rivers to the Mobile River Delta into the Gulf of Mexico for migration, spawning, foraging, and nurseries for native fish and mussel species.

The Tentatively Selected Plan includes the following ecosystem restoration components, which would be implemented in two phases on the Alabama River:

• Millers Ferry Natural Bypass Channel;

- Claiborne Natural Bypass Channel;
- Vehicular Bridge Crossing; and
- Control Gate Structures.

Additional figures of each feature are shown in the Engineering Appendix to the main report.

B.2.5. *Implementation*

Each natural bypass channel is likely to be implemented in two stages. Stage 1 would include design and construction of any cofferdams, gate structures, and bridges. Stage 2 would include the design and construction of the bypass channels. Monitoring and adaptive management would occur prior to construction (pre-construction monitoring) and after construction is complete (post-construction monitoring and adaptive management).

Monitoring would be initiated before construction, would continue during construction, and would continue for up to ten years after the completion of construction of each restored area. A monitoring and adaptive management team (MAMT) composed of the USACE and TNC staff would conduct the data acquisition. The MAMP would be implemented in a phased approach as each separable element in the project is constructed. Monitoring and adaptive management would be initiated at the end of the construction of each restoration area, and a ten-year clock for each separable element would start at that time.

Monitoring would focus on evaluating project success and guiding adaptive management actions by determining if the project has met performance standards (**Table B.2-1**). Validation monitoring would involve various degrees of monitoring with quantitative metrics aimed at verifying that restoration objectives have been achieved for biological resources. Effectiveness monitoring would be implemented to confirm that project construction elements perform as desired. Monitoring would be carried out until the project has been determined to be successful. Monitoring would occur for up to 10 years or less depending on when success criteria are met. Monitoring objectives have been tied to original baseline measurements that were performed during site characterization field visits. Adaptive management measures would be considered upon first instance or indication of failure to meet a performance standard. Metrics and specific adaptive management triggers would be further developed during preconstruction engineering and design.

Table B.2-1: Modeling criteria, performance standards, and adaptive management

Measurement	Performance Standard	Adaptive Management
Temperature	60-70 degree F	Implement aeration device(s)/measures
Dissolved Oxygen	>5 ppm	
Velocity	>80% Ucrit per cohort grouping	Perform, modify, or maintain operations and maintenance
Pool Depth	>5’ at Claiborne during GS migration and	

	spawning and >2’ during normal flow conditions >5<6’ at Millers Ferry US end with gates open	
Species Diversity	>60% of Representative Surroundings	Modify or maintain slope/pool/tiered dimensions to accommodate for ideal assemblage
Invasive Species	<10% of Species Diversity	
Federally Protected Species	Presence/Absence	

Preconstruction Monitoring

The USACE Engineering Research and Design Center (ERDC) will establish targeted Vemco arrays and tag sample Gulf sturgeon to establish baseline conditions. Existing literature and surveys will be used to develop baseline conditions for other species assemblage.

B.2.6. *Reporting*

The Project is expected to be constructed as a phased project over a two and a half year period. Evaluation of the success would be assessed annually until all performance standards are met for each phase of the study. Site assessment would be conducted annually by the MAMT and an annual report would be submitted to the U.S. Fish and Wildlife Service, Alabama Department of Environmental Management, Alabama Department of Conservation and Natural Resources, and USACE by January 30 following each monitoring year for up to ten years after the last phase is constructed.

B.2.7. *Monitoring and Adaptive Management Costs*

As shown in **Table B.2-2**, the total estimated cost for Monitoring and Adaptive Management is approximately $9,250,000. The PED Phase is estimated to take two years and construction is estimated for two and a half years. Cost estimates are based on similar adaptive management projects, estimated full-time-equivalent hours, and draft Scopes-of-Work for species monitoring.

Table B.2-2: Preliminary Cost Estimates

Category	Activities	PED Set-up & Data Acquisition	Construction	10-year Post Construction	Total
Monitoring: Planning and Management	Monitoring workgroup, drafting detailed monitoring plan, working with PDT on performance measures	200,000	200,000	--	400,000
Monitoring: Data Collection	Data collection	500,000	500,000	5,000,000	6,000,000
Data Analysis	Assessment of monitoring data and performance standards	200,000	200,000	1,000,000	1,400,000
Adaptive Management Program Phase I	Detailed adaptive management plan and program	100,000	100,000	--	200,000
Adaptive Management Program Phase II	Establishment of adaptive management program	--	--	1,000,000	1,000,000
Database Management	Database development, management, and maintenance	100,000	50,000	100,000	250,000
Total		**1,100,000**	**1,050,000**	**7,100,000**	**9,250,000**