MAUMELLE RIVER, PULASKI COUNTY, ARKANSAS SECTION 206 AQUATIC ECOSYSTEM RESTORATION FEASIBILITY STUDY

Appendix B: Socioeconomics and CEICA

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SOCIOECONOMICS AND CEICA

INTRODUCTION

This appendix presents the socioeconomic setting and cost effective—incremental cost analysis (CEICA) for the Maumelle River, Arkansas, Continuing Authorities Program (CAP) 206 aquatic ecosystem restoration feasibility study. The information presented here has been prepared to support the formulation, evaluation, and recommended plan selection . The study area is located on lands owned by the non-Federal sponsor, Central Arkansas Water (CAW), and is shown in Figure 1.

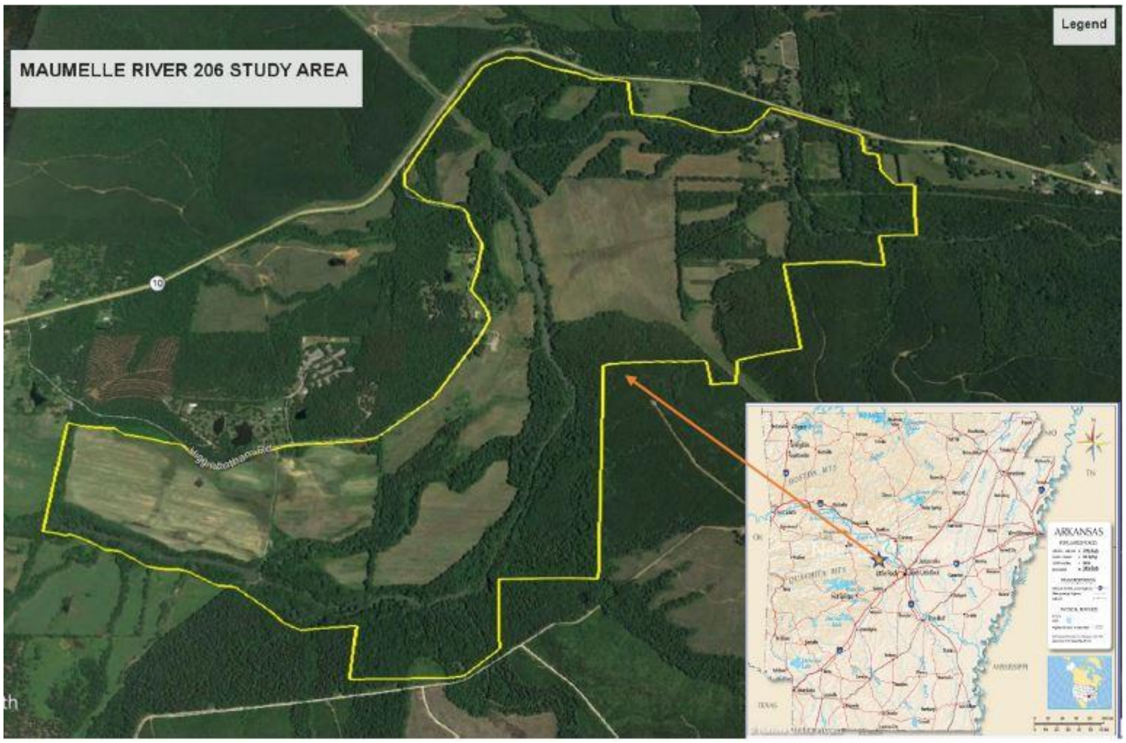

Figure 1. Study Area (outlined in yellow)

DEMOGRAPHIC SETTING

The study area lies completely within Pulaski County, Arkansas, approximately 30 miles west of the city of Little Rock on the Maumelle River. The area immediately around the study area is rural and agricultural. The study area is within the Little Rock-North Little Rock-Conway Metropolitan Statistical Area (MSA), which is comprised of six counties: Faulkner, Grant, Lonoke, Perry, Pulaski, and Saline. The study area is also located in Central Arkansas, one of the six regions of Arkansas. Central Arkansas encompasses eight counties: Conway, Faulkner, Grant, Lonoke, Perry, Pulaski, Saline and White. The city of Little Rock is the most populous city (197,312 as of 2019) in Arkansas and is both the state capital and the Pulaski County seat. While the study area lies within these larger political boundaries, given the small scale of the project, the description of the demographic setting will focus on Pulaski County.

POPULATION

Currently, the population of Pulaski County is estimated to be 392,967, approximately 13 percent of the population of Arkansas. The county's population has seen continuous growth from 2000 to 2019, as shown in Table 1. The county's population is projected to continue to increase through 2065 to 551,833, an annual rate of 0.74 percent. This is just slightly slower than the overall state's projected growth rate of 0.86 percent.

Table 1. Population Estimates and Projections

Geography	2000	2010	2019	2065
Arkansas	2,763,400	2,915,919	2,990,370	4,437,622
Pulaski County	361,474	382,748	392,967	551,833

Sources:
2000 Decennial Census, U.S. Census Bureau
2010 Decennial Census, U.S. Census Bureau
2019 – American Community Survey, 5 Year Estimates, U.S. Census Bureau
2065 – Arkansas Economic Development Institute

GENDER

Approximately 49.1 percent of the county's population is male, and 50.9 percent is female, which is similar to the state's distribution of 47.8 percent male and 52.2 percent female.

RACE

Table 2 shows the distribution of the populations by race and ethnicity. Approximately 52 percent of the population in Pulaski County is White, 37 percent is Black, and 6 percent is Hispanic. Asian and persons of two or more races make up approximately 2 percent each of the total population, with Native American and Alaskan and Some other race making up less than 1 percent each. By comparison, the state overall is approximately 72 percent White, 15 percent Black, and 8 percent Hispanic, with the remaining population distribution similar to that of the county.

Table 2. Population by Race and Ethnicity

Race and Ethnicity	Arkansas	Pulaski County
Total population	2,999,370	392,967
Hispanic or Latino (of any race)	224,130	24,171
White alone	2,172,453	205,386
Black or African American alone	456,899	144,099
American Indian and Alaska Native alone	17,652	931
Asian alone	44,927	8,650
Native Hawaiian and Other Pacific Islander alone	8,614	132
Some other race alone	4,858	935
Two or more races	69,837	8,663

2019 American Community Survey, 5 Year Estimates, U.S. Census Bureau

AGE

As shown in Figure 2, the general distribution of the population by age groups is very similar for Pulaski County and Arkansas, with Pulaski County only slightly younger overall. About 40 percent of the population of Pulaski County is between 25 and 54 years old, 14 percent is under 10 years of age, and 15 percent is 65 years of age or older.

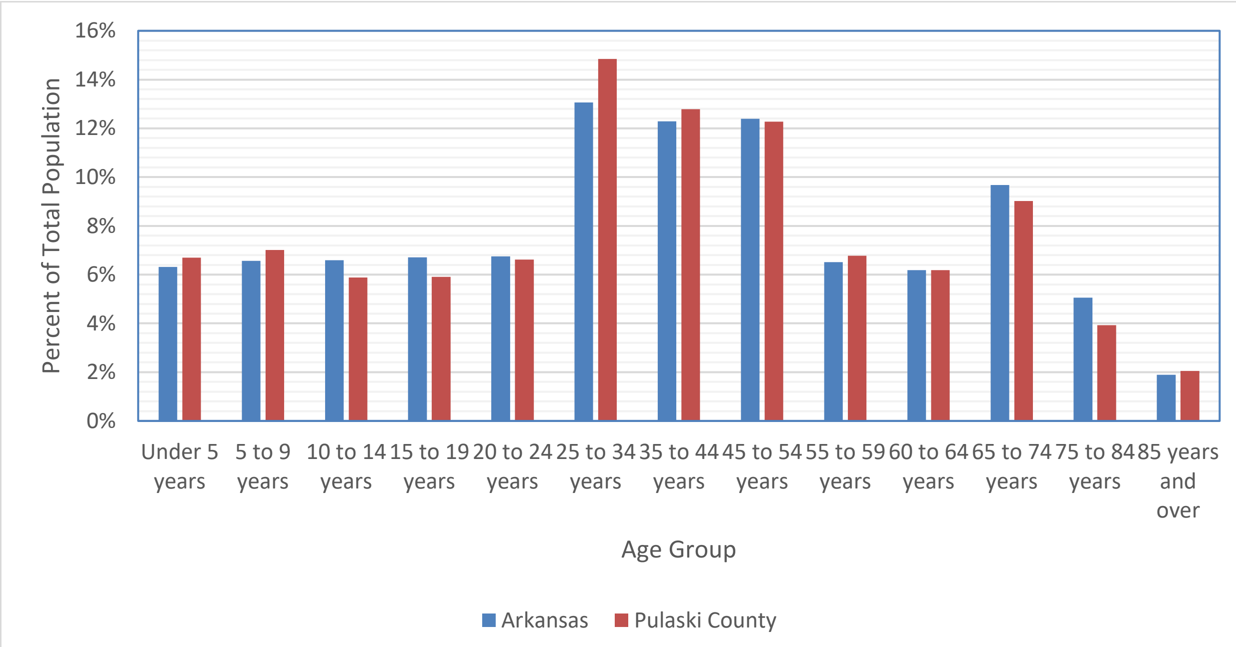

Figure 2. Age Group Distribution

EMPLOYMENT

The employment by sector is shown in Table 3. In Pulaski County, the largest employment sector is Educational, Health Care and Social Services, with 27 percent of the employment. Retail trade makes up about 12 percent of total employment and professional, scientific and management makes up approximately 10 percent. Approximately 9 percent are employed in the Arts, Entertainment, Recreation, Accommodation and Food Services sector. The Manufacturing, Finance/Insurance/Real Estate, and Public Administration sectors make up about 7 percent each of the employment. The remaining sectors make up 5 percent or less each, of total employment.

Table 3. Employment by Sector

Sector	Arkansas	Pulaski County
Civilian employed population 16 years and over	1,303,490	184,202
Agriculture, forestry, fishing and hunting, and mining	36,635	737
Construction	86,816	9,663
Manufacturing	178,324	13,038

Sector	Arkansas	Pulaski County
Wholesale trade	31,705	4,965
Retail trade	172,638	21,346
Transportation and warehousing, and utilities	74,808	9,564
Information	19,541	5,283
Finance and insurance, and real estate and rental and leasing	61,690	12,757
Professional, scientific, and management, and administrative and waste management services	98,757	18,370
Educational services, and health care and social assistance	318,671	50,245
Arts, entertainment, and recreation, and accommodation and food services	104,600	16,560
Other services, except public administration	61,304	9,462
Public administration	58,001	12,212

2019 American Community Survey, 5 Year Estimates, U.S. Census Bureau

INCOME

Based on the 2019 American Community Survey (5-year estimate), the median household income for Pulaski County is approximately $51,749, slightly higher than for the state of Arkansas overall, at $41,229. Similarly, the per capital income for Pulaski County ($32,692) is greater than the state overall ($26,577).

Although the two income measures are greater for Pulaski County than for the state, the proportion of the two populations below the poverty level are similar, with 16.8 percent of all persons in Pulaski County below the poverty level compared to 17.0 percent for Arkansas. This is higher than the national level, which is 13.4 percent.

ENVIRONMENTAL JUSTICE

Executive Order (EO) 12898 "Federal Actions to Address Environmental Justice in Minority Populations and Low- Income Populations" dated February 11, 1994, requires all Federal agencies to identify and address disproportionately high and adverse effect of its programs, policies, and activities on minority and low-income populations. Data were compiled to assess the potential impacts to minority and low-income populations within the study area. Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Minorities account for a large portion (48 percent) of the county's total population and the low-income population is above the national level but comparable to the state level. However, because the project site is in a relatively isolated and rural area, construction of the proposed alternatives would not have a disproportionately high or adverse impact on these populations. No environmental justice concerns are anticipated, and the recommended plan would be consistent with EO 12898.

COST EFFECTIVE AND INCREMENTAL COST ANALYSIS (CEICA)

Comparing benefits and costs for ecosystem restoration provides a challenge to planners and decision makers because benefits and costs are not measured in the same units. Environmental restoration outputs can be measured in habitat units or some other physical unit, while costs are measured in dollars.

Therefore, benefits and costs cannot be directly compared. Two analyses are conducted to help planners and decision makers identify plans for implementation, though the analyses themselves do not identify a single ideal plan. These two techniques are cost effectiveness and incremental cost analysis. Use of these techniques are described in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resource Implementation Studies* (U.S. Water Resources Council 1983).

Cost effectiveness compares the average annual costs and environmental outputs of plans under consideration to identify the least cost plan for each possible level of environmental output, and for any level of investment, the maximum level of output is identified.

Incremental cost analysis of the cost-effective plans is then conducted to reveal changes in costs as output levels are increased. Results from both analyses are presented graphically to help planners and decision makers select plans. For each of the best buy plans identified through incremental cost analysis, an "is it worth it?" analysis is then conducted for each incremental measure or plan to justify the incremental cost per unit of output to arrive at a recommended plan.

For this study, the environmental output is the average annual habitat unit (AAHU). The development of the AAHU is discussed in detail in the environmental technical appendix.

A number of management measures were considered for this study, including removal of low water river crossings, notching of low water river crossings, channel modification, planting of riparian vegetation and bottom-land hardwoods. Because there were separable areas within the study area for ecosystem restoration, these measures were combined to create alternatives, with each alternative addressing a different area or two different alternatives addressing the same area. The ten alternatives would be combined to create fully formed plans for evaluation and comparison. The alternatives are shown in Table 4.

Table 4. List and Description of Alternatives

Alternative Label	Alternative Name	Description
A	Remove River Crossing 1 (RC1)	Remove all concrete and dispose of off CAW property
B	Notch RC1	Notch in main channel; width should be same as width of Maumelle River above the impounded pool. Concrete removed from notch to be disposed of of]f CAW property.
C	Remove River Crossing 2 (RC2)	Remove all concrete and dispose of off CAW property.
D	Notch RC2	Notch in main channel; width should be same as width of Maumelle River above the impounded pool. All concrete to be disposed of off CAW property.
E	Open Side Channel 1 (SC1)	Notch levee adjacent to RC1. Material can be used to create microtopography across sod farm (PFP H) or disposed of off CAW property. Remove culverts (metal) in old road (road not needed). Dispose of off CAW Property. Remove culverts (concrete) in old road (road not needed). Dispose of off CAW Property.
F	Open Side Channel 2 (SC2)	Notch levee between Maumelle River and SC2. Width of opening should be approximately equal to average width of SC2. Material can be used for microtopography across sod farm or disposed of off CAW property. Remove road crossing on SC2.
G	Restore Tributary A	Block channelized ditch on west end of field.

Alternative Label	Alternative Name	Description
		Excavate/Restore Tributary A. Dirt can spread across fields in low level mounds (pimple mounds) and/or elongated ridges (goal is to create microtopography across field). Remove culvert from road (leave gravel low water crossing for CAW access to river). Block channelized ditch. Notch levee (to reconnect Tributary. A to existing channel). Plug ditch to direct Tributary A flow into existing channel through woods). Plant riparian area with native bottomland hardwood tree species (for riparian restoration).
H	Sod Farm Reforestation	Plant sod fields to bottomland hardwood tree species. (for terrestrial reforestation).
I	Repair River Crossing 3 (RC3)	Construct rock vanes at a 20º angle upstream
R	Combinations of River Crossings	This alternative consists of combining the removal and notching of the river crossing alternatives (RC1 and RC2). Because the AAHUs were not additive, requiring separate AAHU calculations to be developed when they were combined. The combinations were treated as four scales: R1 – Notch RC1 and Remove RC2 R2 – Notch RC1 and Notch RC2 R3 – Remove RC1 and Notch RC2 R4 – Remove RC1 and Remove RC2

CEICA INPUTS

AVERAGE ANNUAL HABITAT UNITS

The following tables present the derivation of inputs for the CEICA analysis. To measure the output of the environmental plan, the future without (FWOP and future with-project (FWP) average annual habitat units (AAHU) were calculated from environmental models. The difference between them, net AAHU, then represents the output or gain for that measure. A summary of the AAHUs is shown in Table 5. A full discussion of the underlying modeling and calculations made to derive the AAHUs is presented in the environmental technical appendices.

Table 5. FWOP, FWP and Net Average Annual Habitat Units (AAHUs)s for Alternatives

Alternatives	Description	Future Without Project AAHU	Future With-Project AAHU	Net AAHU	Acres
A	Remove RC 1	232	240	8	290
B	Notch RC 1	232	234	2	290
C	Remove RC 2	232	239	7	290
D	Notch RC 2	232	236	4	290
E	Open SC1	20	33	13	40
F	Open SC2	10	16	6	20
G	Restore Tributary A	4	83	79	66

H	Sod Farm Reforestation	0	44	44	74
I	Repair RC3 Bank Erosion	7	8	1	11
R1	Notch RC1 and Notch RC2	232	243	11	290
R2	Notch RC1 and Remove RC2	232	246	14	290
R3	Remove RC1 and Notch RC2	232	249	17	290
R4	Remove RC1 and Remove RC2	232	252	20	290

COSTS

The second input for CEICA is the average annual cost for each alternative. First costs, including monitoring and adaptive management, were developed. And though the sponsor currently owns all of the needed real estate, and no additional acquisition is required, economic cost for the use of those lands were developed and included as part of first cost. Interest during construction, based on the estimated construction time, for each measure was calculated, and added to the first cost to derive the investment cost for each plan. The investment cost was then amortized over a 50-year period of analysis using the FY 2020 federal discount rate of 2.5%, to get an average annual investment cost and then added to the estimate of average annual operating, maintenance, repair, replacement, and rehabilitation (OMRRR) costs to derive the average annual cost for each alternative. These costs are shown in Table 6. The derivation of the average annual OMRRR costs is shown in Table 7.

Table 6. First Cost and Derivation of Average Annual Cost by Alternative (October 2021 Prices, 2.5% Federal Interest Rate, 50 Year Period of Analysis)

Partially Formed Plan	Description	First Cost	Con-struction Time (months)	Interest During Construction	Investment Cost	Amortized Investment Cost	Interest	Annual OMRRR	Average Annual Cost
A	Remove RC1	$173,000	1	$178	$173,178	$1,776	$4,329	$0	$6,106
B	Notch RC1	104,000	1.5	161	104,161	1,068	2,604	1,141	4,814
C	Remove RC2	202,000	1	208	202,208	2,074	5,055	0	7,129
D	Notch RC2	232,000	1.5	358	232,358	2,384	5,809	1,141	9,334
E	Open SC1	139,000	3	430	139,430	1,430	3,486	0	4,916
F	Open SC2	180,000	3	557	180,557	1,852	4,514	0	6,366
G	Restore Tributary A	685,000	6	4,246	689,246	7,070	17,231	5,434	29,736
H	Sod Farm Reforestation	519,000	6	3,217	522,217	5,357	13,055	6,210	24,622
I	Repair RC3 Bank Erosion	130,000	1	134	130,134	1,335	3,253	0	4,588
R1*	Notch RC1 and Notch RC2	336,000							14,147
R2*	Notch RC1 and Remove RC2	306,000							11,943
R3*	Remove RC1 and Notch RC2	405,000							15,439
R4*	Remove RC1 and Remove RC2	375,000							13,235

*Note: The costs for the four combination scales are additive. The first cost and average annual cost for R1, R2, R3, and R3 are the sums of their respective components.

Table 7. Calculation of Average Annual OMRRR Costs (October 2020 Prices, 2.5% Federal Interest Rate, 50 Year Period of Analysis)

	B - Notch RC1		D - Notch RC2		G - Restore Sod Farm		H - Restore Riparian Forest on Sod Farm	
Period	Outlay	Present Value	Outlay	Present Value	Outlay	Present Value	Outlay	Present Value
0		0.00		0.00		0.00		0.00
1		0.00		0.00		0.00		0.00
2		0.00		0.00		0.00		0.00
3		0.00		0.00		0.00		0.00
4		0.00		0.00		0.00		0.00
5	6,000.00	5,303.13	6,000.00	5,303.13	35,000.00	30,934.90	40,000.00	35,354.17
6		0.00		0.00		0.00		0.00
7		0.00		0.00		0.00		0.00
8		0.00		0.00		0.00		0.00
9		0.00		0.00		0.00		0.00
10	6,000.00	4,687.19	6,000.00	4,687.19	35,000.00	27,341.94	40,000.00	31,247.94
11		0.00		0.00		0.00		0.00
12		0.00		0.00		0.00		0.00
13		0.00		0.00		0.00		0.00
14		0.00		0.00		0.00		0.00
15	6,000.00	4,142.79	6,000.00	4,142.79	35,000.00	24,166.29	40,000.00	27,618.62
16		0.00		0.00		0.00		0.00
17		0.00		0.00		0.00		0.00
18		0.00		0.00		0.00		0.00
19		0.00		0.00		0.00		0.00
20	6,000.00	3,661.63	6,000.00	3,661.63	35,000.00	21,359.48	40,000.00	24,410.84
21		0.00		0.00		0.00		0.00
22		0.00		0.00		0.00		0.00
23		0.00		0.00		0.00		0.00
24		0.00		0.00		0.00		0.00
25	6,000.00	3,236.34	6,000.00	3,236.34	35,000.00	18,878.67	40,000.00	21,575.62
26		0.00		0.00		0.00		0.00
27		0.00		0.00		0.00		0.00
28		0.00		0.00		0.00		0.00
29		0.00		0.00		0.00		0.00
30	6,000.00	2,860.46	6,000.00	2,860.46	35,000.00	16,685.99	40,000.00	19,069.71
31		0.00		0.00		0.00		0.00
32		0.00		0.00		0.00		0.00
33		0.00		0.00		0.00		0.00
34		0.00		0.00		0.00		0.00
35	6,000.00	2,528.23	6,000.00	2,528.23	35,000.00	14,747.99	40,000.00	16,854.84
36		0.00		0.00		0.00		0.00
37		0.00		0.00		0.00		0.00
38		0.00		0.00		0.00		0.00
39		0.00		0.00		0.00		0.00
40	6,000.00	2,234.58	6,000.00	2,234.58		0.00		0.00
41		0.00		0.00		0.00		0.00
42		0.00		0.00		0.00		0.00
43		0.00		0.00		0.00		0.00
44		0.00		0.00		0.00		0.00
45	6,000.00	1,975.05	6,000.00	1,975.05		0.00		0.00
46		0.00		0.00		0.00		0.00
47		0.00		0.00		0.00		0.00
48		0.00		0.00		0.00		0.00
49		0.00		0.00		0.00		0.00
50	6,000.00	1,745.65	6,000.00	1,745.65		0.00		0.00
Present Value		32,375.04		32,375.04		154,115.27		176,131.74
Average Annual OMRR		1,141.48		1,141.48		5,433.81		6,210.06

Table 8 shows the summary of average annual costs and net AAHUs used as inputs in the CEICA analysis.

Table 8. Summary of CEICA Inputs (October 2020 Prices, 2.5% Federal Interest Rate, 50 Year Period of Analysis)

Alternative	Description	Average Annual Cost ($1,000)	Net AAHU
A	Remove RC1	$6	8
B	Notch RC1	5	2
C	Remove RC2	7	7
D	Notch RC2	9	4
E	Open SC1	5	13
F	Open SC2	6	6
G	Restore Trib A	30	79
H	Sod Farm Reforestation	25	44
I	Repair RC3 Bank Erosion	5	1
R1	Notch RC1 and Notch RC2	14	11
R2	Notch RC1 and Remove RC2	12	14
R3	Remove RC1 and Notch RC2	15	17
R4	Remove RC1 and Remove RC2	13	20

To conduct the CE/ICA analysis, environmental restoration outputs (increase in with-project AAHUs) and annual costs (expressed in thousands of dollars) were entered into IWR Planning Suite II software, v. 2.0.9.1. The analysis is in two parts, cost effective analysis and incremental cost analysis. Cost effective analysis identifies all cost-effective plans. The cost-effective plans are incrementally evaluated on incremental cost per incremental output to identify the best buy plans. In combining the alternatives, the two options of addressing the river crossings (removal and notching) were defined as mutually exclusive, which prevents any plan from having both removal and notching of the same river crossing. Additionally, stand-alone river crossing alternatives configures as not combinable with the river crossing combinations. River crossing combinations were treated as scales of the combination measure, and by default, are not combinable with one another.

CEICA Results

Using the IWR Planning Suite plan generator, the various combinations of alternatives resulted in 416 possible plan combinations. Thirty-two of the plans were determined cost effective, with 7 of those being best buys (inclusive of No Action). A scatter plot of the plans is shown in Figure 3. The cost-effective plans are shown as the red triangles, on the leading edge of the plot, and the subset of cost effective plans determined to be best buys are showing as green squares. The best buy plans are:

- No Action
- Restore Tributary A
- Restore Tributary A, Open SC1
- Restore Tributary A, Open SC1, Sod Farm Reforestation
- Restore Tributary A, Open SC1, Sod Farm Reforestation, Remove RC1 and Remove RC2

- Restore Tributary A, Open SC1, Sod Farm Reforestation, Remove RC1 and Remove RC2, Open SC2
- Restore Tributary A, Open SC1, Sod Farm Reforestation, Remove RC1 and Remove RC2, Open SC2, Repair RC3 Bank Erosion

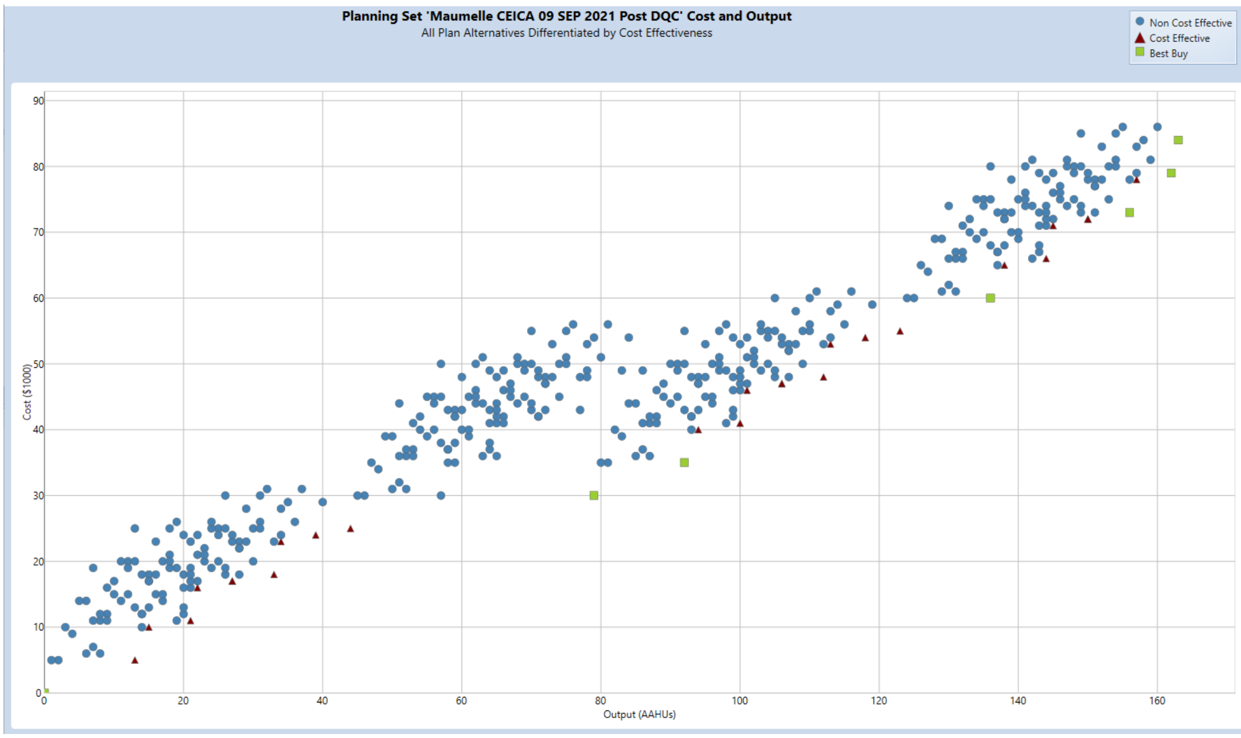

Figure 3. Plot of Pans Showing Cost Effective and Best Buy Plans

The next step in the CEICA analysis is to perform an incremental cost analysis (ICA) on the cost-effective plans. ICA compares the incremental cost per incremental benefit (output or lift in environmental output) among the plans to identify plans that maximize the last dollar spent. Starting with the no action plan, the incremental cost per incremental benefit is calculated from the no action for each cost-effective plan. The plan with the least incremental cost per incremental output is identified as the first of the “with-project” best buy plans. Then starting with that plan, the incremental cost per incremental benefit is calculated between that plan and each remaining cost-effective plan, and the one with the least incremental cost per incremental benefit is identified as the next plan in the array of best buy plans. This iteration continues until there are there are no remaining plans. The last plan in the best buy array, is typically the “kitchen sink” plan, or the plan that contains all the management measures being analyzed.

The array of best buy plans, ordered by ascending incremental cost per incremental output is shown graphically in Figure 4 with the numerical data shown in Table 9.

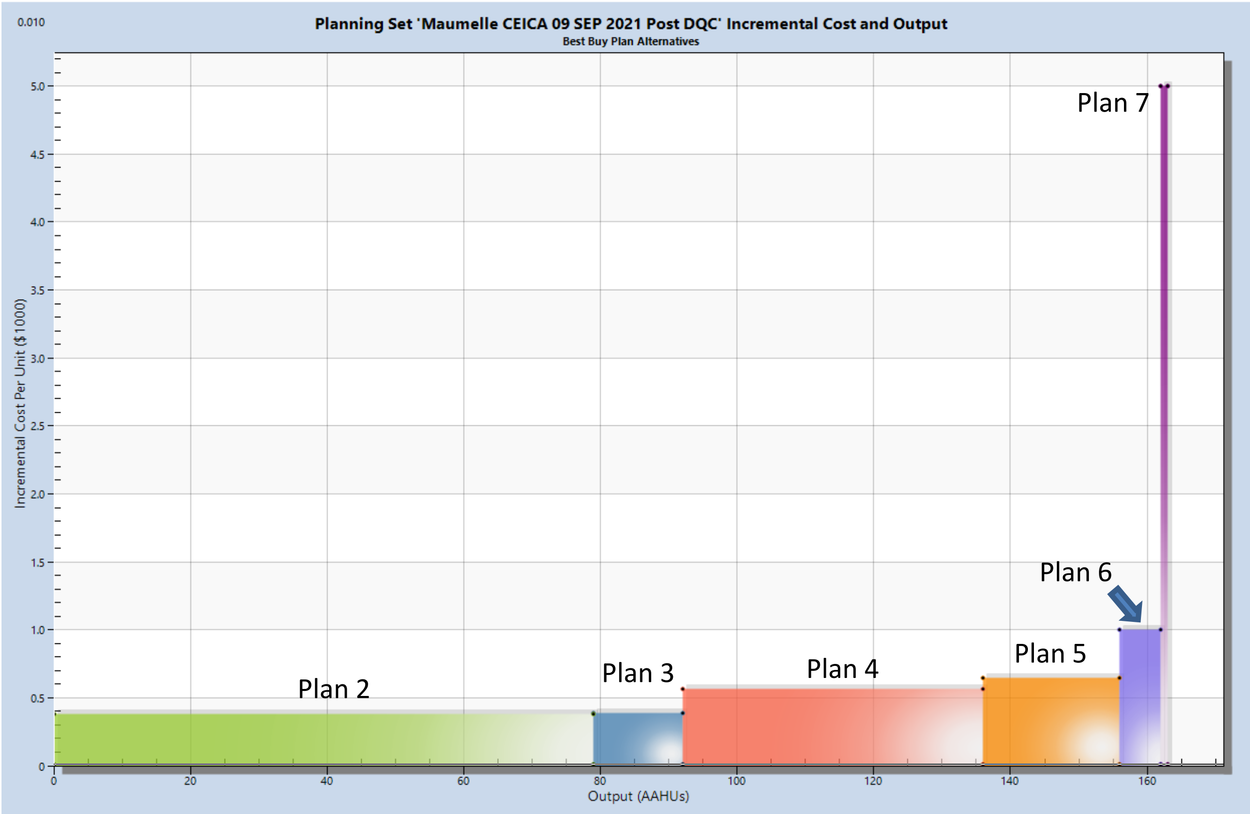

Figure 4. Best Buy Array

Table 9. Results of Incremental Analysis of Best Buy Alternatives (October 2020 Prices)

Plan	Description	Output (AAHU)	Average Annual Cost ($1,000)	Average Cost Per AAHU ($1,000)	Incremental Cost ($1,000)	Incremental Output (AAHU)	Incremental Cost per Incremental Output ($1,000)	First Cost
1	No Action	0	0					
2	Restore Tributary A	79	$30	$0.38	$30	79	$0.380	$685,000
3	Restore Tributary A, Open SC1	92	35	0.38	5	13	0.385	824,000
4	Restore Tributary A, Open SC1, Sod Farm Reforestation	136	60	0.44	25	44	0.568	1,343,000
5	Restore Tributary A, Open SC1, Sod Farm Reforestation, Remove RC1 and RC2	156	73	0.47	13	20	0.650	1,718,000
6	Restore Tributary A, Open SC1, Sod Farm Reforestation, Remove RC1 and RC2, Open SC2	162	79	0.49	6	6	1.000	1,898,000
7	Restore Tributary A, Open SC1, Sod Farm Reforestation, Remove RC1 and RC2, Open SC2, Repair RC3 Bank Erosion	163	84	0.52	5	1	5.000	2,028,000

BEST BUY ARRAY AND "IS IT WORTH IT?" ANALYSIS

The Cost Effective—Incremental Cost Analysis presented in the previous section does not lead to a definitive plan for choosing the recommended plan, but rather serves to inform the selection process. Using the results of the CEICA analysis, the benefits associated with the environmental incremental outputs have to be evaluated against the incremental increase in costs. This analysis, called the "Is It Worth It?" analysis evaluates each plan, its incremental outputs and costs, and the benefits provided by the plan to make a case that the plan is worth the Federal investment to achieve those benefits.

PLAN 1 - NO ACTION

The no action plan represents no federal action to address the degraded aquatic/riparian ecosystem, and the degradation would continue and increase over the 50-year period of analysis.

This plan does not address the identified resource need to remove two low water crossings on the Maumelle River that would restore stream connectivity in the main channel of the river for fish/aquatic organism passage, as well as restore flows through a braided side channel that would flush years of sediment that have destroyed important benthic habitats historically used for spawning and nursery areas. Aquatic biodiversity will continue to be adversely impacted by not allowing populations to mix freely, and the continued degradation of benthic habitats. The natural hydrology will continue to be drastically altered and seasonal variation in river flow below the two river crossings will continue to be diminished. Native plant species will continue to be harmed by the lack of seasonal fluctuations that provide regular depositions of sediment and nutrients, including species of national and regional conservation concern.

This plan does not address the identified resource need to restore floodplain connectivity to provide important spawning and nursery habitat for several aquatic organisms, nor restore flow through side channel riparian habitat important to many riparian dependent species, including neotropical migratory birds.

This plan does not address the identified resource need to restore riparian forest and forested wetland habitat that will restore historic vegetation, provide migration and breeding habitat for several neotropical migratory bird species, reduce "edge" habitat that is detrimental to forest interior breeding birds, provide terrestrial habitat for numerous riparian and forest dependent species, and reduce nutrient and sediment transport into the Maumelle River.

While there is no cost associated with this plan, the PDT does not believe the action is worth the lack of investment, as it does not address any of the planning objectives and leaves the study area in its degraded state

PLAN 2 - RESTORE TRIBUTARY A

Plan 2 will partially restore the natural hydrology and riparian forest habitat that historically existed in the study area. This is accomplished through restoring the natural watershed drainage by reconstructing the tributary stream across the sod farm field that historically existed and planting a riparian corridor along the tributary with native bottomland hardwood species. This restoration will significantly reduce or eliminate the conduit of sediment and nutrients flowing into the Maumelle River and Side Channel 1 (SC1) by blocking channelized ditches that replaced the natural stream. It will also reduce the loss of water supply storage in Lake Maumelle due to sedimentation.

Plan 2 restores important spawning and nursery habitat for many native fish species that require small, shallow, intermittent streams for spawning and nursery habitat (e.g. Orangethroat darter *Etheostoma spectabile*, Pugnose minnow, *Opsopoeodus emiliae*). Many species of salamanders, frogs and toads will likely utilize intermittent pools for reproduction or as summer refugia depending on flow conditions.

The restoration of Tributary A partially restores a Freshwater Forested Wetland that historically existed on the site. Material excavated for this restoration will be used to recreate ridges, swales, small mounds, and alluvial depressions across the sod farm field. LiDAR imagery of reference watersheds will be used to approximate historic topography conditions.

Planting native riparian vegetation as a buffer for Tributary A will provide significant beneficial effects. Appropriate native vegetation (native bottomland hardwood species) will improve water quality by filtering out sediments and chemical constituents. The restored riparian forest corridor will provide forage, cover, and organic inputs to the Maumelle River ecosystem, developing the lower trophic levels utilized by fish and wildlife species. The restored riparian corridor will increase the organic allochthonous material to the aquatic system and provide the energy to the lower trophic organisms that drive and support the Maumelle River ecosystem and reduce the occurrence of invasive species in the study area. The restored riparian corridor will also partially increase habitat diversity for numerous forest-dependent wildlife species, including species of conservation concern (forest interior birds, reptiles and amphibians, and bats [including the federally endangered Northern Long-eared Bat, *Myotis septentrionalis*]), as well as for relatively stable native wildlife species.

While this plan is an improvement over the No Action Plan, it does not fully address all of the planning objectives or capture all of the potential benefits of other plans. The Maumelle River will remain isolated from its floodplain by the manmade levee along the north bank and several important side channels (forested wetlands) will remain isolated from necessary headwater flows that would flush excessive amounts of sediment that have been deposited in them over several decades since levee construction. These side channels historically provided important spawning and foraging habitat for native aquatic species, as well as serve as refugia during flood events. The two river crossings (RC1 and RC2) will remain in place and to disrupt the natural hydrology in the Maumelle River as well as continue to create artificial pool habitat that has replaced natural riffle-pool-run habitats. In addition to the alteration of riverine habitat, the crossings are causing an increase in sedimentation and embeddedness above each of them, thereby degrading benthic habitats (i.e. cobble and gravel substrates) used by many aquatic species.

The restoration of the Tributary A, while requiring no real estate acquisition, does require an economic cost to be associated to the use of sponsor owned lands to achieve the environmental benefits. The economic cost for real estate makes up a large portion of the first cost for this plan.

This plan increases the output by 79 AAHUs at an incremental cost per incremental AAHU of $380. It partially restores 66 acres at a first cost of $685,500. Although the plan only partially addresses one Planning Objective (Restore the Structure and Function of Riparian Wetlands), it is preferred over the no action plan and therefore is worth the Federal Investment.

PLAN 3 – RESTORE TRIBUTARY A, OPEN SIDE CHANNEL 1

Plan 3 builds upon Plan 2 by incrementally adding the Opening of Side Channel 1 (SC1). This restores headwater flow through a Freshwater Forested Wetland. Reduced water elevations from culvert removals will expose the riffle-run habitat currently flooded by artificially impounded pools. The restored headwater flows will flush sediments and reduce embeddedness in the channel.

Opening SC1 restores the flood storage capability of the floodplain, thereby reducing bank erosion and adverse impacts to aquatic habitats caused by restricting high flows to the main river channel. Floodplain connectivity is significantly improved with reconnecting SC1 and the Maumelle River. This connection restores flood frequencies to an average of once every 18 months, from the current condition of once every 15 years (average).

The restored flood frequency, coupled with the restoration of headwater flows through SC1 will significantly increase the quantity, quality, and diversity of aquatic and riparian habitats. Many native fish species utilize tributary streams for spawning and nursery habitat, or as refugia during flood conditions. Similarly, many species of salamanders, frogs, and toads will likely use intermittent pools during the summer as refugia. The increased aquatic biodiversity in the side channel will also benefit many riparian-dependent wildlife species. The reduced water surface elevation will also expose gravel banks/bars that have been inundated by the high water level caused by culverts. This newly-exposed habitat is ideal for several state-sensitive plant species found in the Maumelle River drainage, including one possible new species (discussed in the Environmental Resources Section).

Plan 3 partially addresses a second Planning Objective (Restore Stream Connectivity) and continues to move towards completely addressing the problems and planning objectives and increase the diversity of aquatic and riparian habitat restoration.

This increases the environmental output by 13 AAHUs, for a total of 92 AAHUs. The incremental cost per incremental AAHU is $385, only slightly higher than Plan 2 ($380). It partially restores 106 acres at a first cost of $824,000. Plan 3 partially addresses a second Planning Objective (Restore Stream Connectivity). Given the increase in environmental outputs with only a small increase in incremental costs, this plan is worth the Federal investment.

PLAN 4 – RESTORE TRIBUTARY A, OPEN SIDE CHANNEL 1, SOD FARM REFORESTATION

Plan 4 builds on Plan 3 by incrementally adding reforestation of the land previously used as a sod farm. Restoring the historic Freshwater Forested Wetland (bottomland hardwood forest) will create significant beneficial effects. It will restore a native floodplain bottomland hardwood forest that connects riparian forest communities to higher bottomlands (flood less than a 5-year frequency) and upland forested habitats. The restored forest habitat will reduce forest fragmentation and increase habitat diversity, availability, and connectivity important for numerous native forest-dependent wildlife species, including species of conservation concern (forest interior birds, reptiles and amphibians, and bats [including one federally listed species]), as well as for relatively stable native wildlife species. Reforestation of the sod farm with native hardwood tree species will help to reduce the spread of invasive species that threaten native habitats.

Plan 4 will maximize water quality benefits started in Plan 2 by filtering out sediments and chemical constituents caused by the commercial sod operation. It would further reduce the loss of water supply storage in Lake Maumelle due to sedimentation. It also maximizes the organic allochthonous material input to the aquatic system started in Plan 2, increasing the energy to the lower trophic organisms that drive and support the Maumelle River ecosystem.

Plan 4 provides a significant increase in ecosystem health in the study area by maximizing the restoration potential on the sod farm. Environmental outputs increase by 44 AAHUs over Plan 3, for a total of 136 AAHUs. The incremental cost per AAHU is $568. It partially restores 180 acres at a first cost of $1.3 million. While the incremental cost per incremental output is slightly higher than Plan 3 ($568 compared to $385), Plan 4 provides a comparatively moderate lift in output. Plan 4 is the first to fully address one Planning Objective (Restore the Structure and Function of Riparian Wetlands) by completing the restoration of riparian bottomland hardwoods. Given this, this plan is worth the Federal investment.

PLAN 5 - RESTORE TRIBUTARY A, OPEN SIDE CHANNEL 1, SOD FARM REFORESTATION, REMOVE RIVER CROSSING 1 AND RIVER CROSSING 2

The removal of both river crossings (RC1and RC2) maximizes the restoration of the main-stem Maumelle River to a free-flowing system downstream to Lake Maumelle, fully restores fish/aquatic organism passage in the Maumelle River within the study area to its natural state, and restores the natural hydrology of the river. Channel sinuosity will be greatly improved by the lowered water levels above each crossing location. Sediment and energy transport will be restored to natural conditions. Dissolved oxygen concentrations will improve because of increased water flow. The removal of the impounded pools will improve water quality by restoring natural water temperature regimes and reduce suspended sediments.

Removal of RC1 and RC2 restores approximately 7.7 miles of stream connectivity and aquatic organism passage in the main-stem Maumelle River, from a partial barrier upstream of the study area, downstream to Lake Maumelle. Removal of the crossings will expose several riffle-run-pool habitat complexes (3+ above each crossing location based on USGS survey data) that have been inundated since construction of the crossings. This restoration of historic habitats and the increased connectivity will beneficially impact numerous native aquatic organisms by increasing access to quality habitat for foraging and reproduction. The increased connectivity will also improve aquatic biodiversity by allowing populations to mix freely.

Removal of RC1 and RC2 will stop the deposition of sediments and resultant embeddedness that occurred above them. The reestablished natural flow conditions will aid in flushing sediments out of the newly exposed riffle-run-pool habitat complexes and reduce embeddedness in the cobble/gravel substrate. Bank scouring caused by the crossings will be eliminated by their removal.

Removal of RC1 reconnects a 0.5-mile Freshwater Forested Wetland (braided side-channel) located downstream of the river crossing, restoring headwater flows that will flush excess sediment from heavily impacted riffle and pool habitat and reduce embeddedness, thereby increasing habitat diversity and productivity for native aquatic species.

The reduced water surface elevations will expose gravel banks/bars that have been inundated by the high water level created by the river crossings. This newly-exposed habitat is ideal for several state-sensitive plant species found in the Maumelle River drainage, including one possible new species (discussed in the Environmental Resources Section).

Plan 5 increases environmental outputs by 20 AAHUs over Plan 4, for a total of 156 AAHUs. The incremental cost per incremental AAHU is $650. It partially restores 470 acres (290-acre increase over Plan 4) at a first cost of $1.7 million. Plan 5 is the first to fully address the majority of the Planning Objectives (fully addresses Restore Stream Connectivity and Restore the Structure and Function of Riparian Wetlands); and partially address the third (Restore Floodplain Connectivity in the Study Area). Given the added benefits associated with this plan and a full restoration of the mainstem of the Maumelle River, this plan is worth the Federal Investment.

PLAN 6 - RESTORE TRIBUTARY A, OPEN SIDE CHANNEL 1, SOD FARM REFORESTATION, REMOVE RIVER CROSSING 1 AND RIVER CROSSING 2, OPEN SIDE CHANNEL 2

This plan builds on Plan 5 by incrementally adding the Opening of Side Channel 2. This reconnection would restore headwater flow through a second Freshwater Forested Wetland. The headwater flows created by the opening would maximize aquatic and riparian habitat diversity and productivity by flushing years of sediment deposition that has accumulated and embedded in a natural gravel substrate that historically occurred in the channel. Environmental benefits will be similar to those gained with the opening of SC1 (Plan 3).

This plan increases the environmental output by 6 AAHUs, for a total of 162 AAHUs. The incremental cost per AAHU is $1,000. It partially restores 490 acres at a first cost of $1.9 million. While opening Side Channel 2 increases important side channel habitat for aquatic species (and maximizes all three Planning Objectives), it only provides an additional 6 AAHUs for a considerably large incremental cost per incremental output over Plan 5 ($1,000 compared to $650). The PDT feels that this alternative is not worth the investment of Federal dollars for the limited habitat gains.

PLAN 7 - RESTORE TRIBUTARY A, OPEN SIDE CHANNEL 1, SOD FARM REFORESTATION, REMOVE RIVER CROSSING 1 AND RIVER CROSSING 2, OPEN SIDE CHANNEL 2, REPAIR RIVER CROSSING BANK EROSION

This plan would incrementally add Bank Erosion Repair at River Crossing 3 (RC3) to Plan 6. The repair of bank erosion at RC3 (site of a former low water river crossing) will significantly reduce or eliminate active erosion occurring at the site. The bank restoration will reduce the amount of fine sediments entering the Maumelle River, thus improving benthic habitat diversity downstream. It would also assist in reducing the loss of water supply storage in Lake Maumelle due to sedimentation.

Plan 7 would increase the environmental output by only 1 AAHUs over Plan 6, for a total of 163 AAHUs. The incremental cost per incremental AAHU is $5,000, five times that of Plan 6 ($1,000). It partially restores 501 acres at a first cost of $2 million. While the repair of on-going bank erosion at River Crossing 3 would provide a reduction in sediments entering the river and lake, it results in an increase of only 1 AAHUs for a significantly large increase in incremental cost per incremental output. The PDT feels that this alternative is not worth the investment of Federal dollars for the limited habitat gain.

NATIONAL ECOSYSTEM RESTORATION AND RECOMMENDED PLAN

As outlined in ER-1105-2-100, an aquatic ecosystem restoration study must identify the National Ecosystem Restoration (NER) Plan. The NER plan is the justified alternative and scale having the maximum excess of monetary and non-monetary beneficial effects over monetary and non-monetary costs. It is the plan where the incremental beneficial effects is just equal to the incremental, or alternatively stated, where the extra environmental value is just worth the extra costs.

Upon comparing and evaluating the nine best-buy plans, performing an incremental cost analysis on those plans, and evaluating those incremental costs against the against the incremental benefits through the “Is It Worth It Analysis?”, Plan 5 Removing River Crossing 1 And 2, Restoring Tributary A, Opening Side Channel 1, And Sod Farm Reforestation, has been identified as the NER Plan, and as such, is the recommend plan.

PLAN DESCRIPTION

The Recommended Plan for the Maumelle River Aquatic Ecosystem Restoration Study incorporates several measures that will restore the structure and function of the aquatic and riparian ecosystem in the study area.

The Maumelle River reach in the study area is heavily degraded due in part to severe pooling and sedimentation. This pooling, caused by RCs 1 and 2, has decreased the efficiency of natural pool-riffle-run features that historically existed above the crossings and negatively impacting aquatic habitat. The Recommended Plan incorporates the removal of the low water crossings which will allow for open flow of the river, improve sediment transport, decrease erosion, and improve overall aquatic connectivity of the Maumelle River. Once the crossings have been removed, water will be allowed to flow unimpeded, including through a braided Freshwater Forested Wetland that has been isolated by one of the structures. A more natural river flow will allow for natural processes to return such as sediment transport and connectivity which have significant controls over habitat characteristics for flora and fauna. Animals that have evolved based on the natural processes of the river will greatly benefit through the implementation of this plan as well as native plant seed dispersal.

The Recommended Plan includes the restoration of a historic Freshwater Emergent Wetland (Tributary A) that existed in the western part of the study area, and plugging several channelized ditches that are currently serving as conduits for sediments, nutrients, and herbicides from a commercial sod farm operation in the study area. Runoff from the sod farm is being directed into the Maumelle River upstream of RC1 and into a side channel that was historically connected to the Maumelle River. Benthic habitats in these areas have been subjected to decades of excess sedimentation, resulting in gravel and cobble substrates being heavily embedded. Restoring Tributary A will provide important spawning and nursery habitat for native fish species that require small, shallow, intermittent streams for spawning and nursery habitat. Many species of salamanders, frogs and toads will likely utilize intermittent pools for reproduction or as summer refugia depending on flow conditions.

The Recommended Plan includes the reforestation of approximately 140 acres of native bottomland hardwood species to restore the historic forested ecosystem that once existed in the study area. Planting native riparian vegetation as a buffer for Tributary A will provide significant beneficial effects. Riparian species will assist ecosystem restoration in several ways 1) roots of vegetation will hold in the soil and slow down runoff, decreasing the amount of erosion and effectively decreasing the amount of sedimentation buildup within the stream, 2) additional vegetation will provide shade within the stream, improving the temperature, 3) increase biodiversity of insects and microorganisms near the stream that improves foraging opportunities for aquatic and terrestrial wildlife, 4) provide a multitude of cover for aquatic and terrestrial wildlife through their various features, such as roots and limbs, 5) increase the organic allochthonous material to the aquatic system and provide the energy to the lower trophic organisms that drive and support the Maumelle River ecosystem, and 6) reduce the occurrence of invasive species in the study area.

As part of the Recommended Plan, a portion of a man-made levee adjacent to the Maumelle River will be breached to restore floodplain connectivity in the study area, and to allow flows to once again nourish a side channel that has been isolated for decades. This side channel has received runoff from the adjacent sod farm for years, resulting in several inches of silt and muck covering what once was a pristine gravel substrate that provided important spawning areas for native aquatic species. The restored flows through the side channel will flush the sediments out of the side channel over time and once again expose the gravel substrate. The restored benthic habitat will not only benefit numerous aquatic species inhabiting the Maumelle River, but also increase the abundance of riparian-dependent wildlife that will once again utilize the area.

COST ESTIMATE OF THE RECOMMENDED PLAN

Upon the determination of the recommended plan, an abbreviated risk assessment was made on the risk to cost and scope, which result in a more risk informed estimate of the project first costs. The estimated first cost for the recommended plan is $1,410,000, as shown in Table 10. This includes $869,000 for construction, including monitoring and adaptive management, $283,000 for land and damages, and $258,000 for pre-engineering design and construction management.

Table 10. Project First Costs (October 2021 Prices)

Feature	First Cost
Construction	$869,000
Lands and Damages	283,000
PED and Construction Mgmt	258,000
Total	$1,410,000

Table 11 shows the derivation of average annual costs, based on a 2.5% Federal interest rate and a 50 year period of analysis. The average annual cost of the recommended pan is $62,000, which provides a total lift of 156 average annual habitat units.

Table 11. Derivation of Average Annual Costs (October 2021 Prices, 2.5% Federal Interest Rate, 50 Year Period of Analysis)

Cost Element	Cost
Project First Cost	$1,410,000
Interest During Construction	9,000
Investment Cost	1,419,000
Amortization	15,000
Interest	35,000
Annual OMRRR	12,000
Average Annual Cost	**$62,000**
Average Annual Habitat Units	**156**
Acres	**470**