APPENDIX H

ECONOMICS

APPENDIX H
Lower Cache River Ecosystem Restoration
Section 1135 DPR
Cost Effectiveness & Incremental Cost Analyses

Introduction:

Ecosystem Restoration: The primary goal of this project is the restoration of the ecosystem at several meander sites located within the Lower Cache River Basin. The mussel and fish enhancement at these sites will improve the environment by improving the quantity and quality of the habitat to more closely resemble the historic ecosystem.

According to the *Planning Guidance Notebook* ER 1105-2-100, the types of improvements recommended for USACE involvement in ecosystem restoration include improving degraded ecosystem structure and function. Of particular interest to the USACE are restoration projects involving wetlands, floodplains, and aquatic systems. USACE restoration policy focuses on engineering and water control solutions rather than land acquisition. Possible improvements recommended by USACE policy include, but are not limited to: restoring tidal creeks and tidal pond habitat; restoring tidal hydrology and native wetland vegetation; using dredged material to restore wetlands; and, restoring conditions conducive to native species establishment (USACE, 2000).

In order to comply with the requirements of ER 1105-2-100, a Cost Effectiveness and Incremental Cost Analyses (CE/ICA) must be conducted for ecosystem restoration projects to identify the Cost Effective or "Best Buy" solutions for each possible level of environmental output.

The tasks required to conduct the National Ecosystem Restoration (NER) analysis for the Lower Cache River study are described in terms of the seven steps listed in ER 1105-2-100, E-36. In these steps, the CE/ICA are identified separately and begin after the outputs and costs have been determined. The software program IWR-PLAN, developed for the Institute for Water Resources (IWR), was used in performing these steps.

The costs utilized in the CE/ICA analyses were based on order of magnitude costs of the construction, design & specifications, performance monitoring, operation, maintenance, repair, rehabilitation, and replacement (OMRR&R), and real estate of the conceptual plans. As a result, the real estate costs presented in this section are only lands that have a financial cost to the project that were included under the Lands and Damages account in the Cost Appendix. Only actual project implementation costs are to be included in the total project cost calculations for the Cost Effectiveness and Incremental Cost Analyses, per Corps policy.

Since project benefits are not measured in dollars, the CE/ICA analyses offer the next-best approach to value. The (CE/ICA) cost analyses of alternative plans may not identify a unique or optimal solution, they can lead to a more-informed choice from among alternatives during the decision making process.

Step 1 - Display outputs and costs: Calculate average annual outputs (not discounted) and equivalent annual costs (discounted) based on inputs over a 50-year period of analysis. Output values or the average annual change in Habitat Units were calculated by subtracting the Without-Project value from the With-Project value ("With-&-Without Analysis"), and the difference is the net benefit. All costs were calculated in terms of present worth and annualized.

Outputs:

Habitat Units: The Average Annual Habitat Units (AAHU) was the output benefit category that was used for this study. There were 4 Alternatives that were analyzed. Alternative 2 was considered to meet project objectives, and all other alternatives were dropped from further analysis, because they were not functional. Alternative 2 was then analyzed and sized by the number of meanders that would be constructed for different plans. Such as, for Alternative 2a was the largest plan that would unplug 6 meanders and build 7 weirs, and the smallest was Alternative 2c that would unplug 3 meanders and build 4 weirs.

Total Habitat Units in the project area ranged from a low of 54 Average Annual Habitat Units for No Action (Without-Project) conditions, to a high of 16,254 AAHU With-Project conditions for Alternative 2a which produced the most net benefits of 16,200 AAHU. Total annual Habitat Units for Without and With Project are presented in Table 1 and Figure 1. Total annual net Habitat Units (benefits With-Project) for Alternative 2 is presented in Table 2 and Figure 2. These are the habitat unit parameters used in the Cost Effectiveness Analysis.

TABLE 1

LOWER CACHE RIVER ECOSYSTEM RESTORATION

AVERAGE ANNUAL HABITAT UNITS FOR NO ACTION & ALTERNATIVE 2

Col. 1 Alternatives	Col. 2 Meanders	Col. 3 Mussels AAHU	Col. 4 Riverine Fish AAHU		Col. 5 Total Average Annual Habitat Units 1/ (Col. 3+4)
No Action	1 - 6	54	0		54
Alt. 2a	1, 2, 3, 4, 5, & 6	16,143	111		16,254
Alt.2b	1, 3, 5, & 6	12,470	91		12,561
Alt. 2c	1, 2, & 3	7,961	56		8,017

1/ Average Annual Habitat Units were derived from Appendix C.

FIGURE 1
LOWER CACHE RIVER - SECTION 1135
AVERAGE ANNUAL HABITAT UNITS
FOR WITHOUT AND WITH- PROJECT CONDITIONS

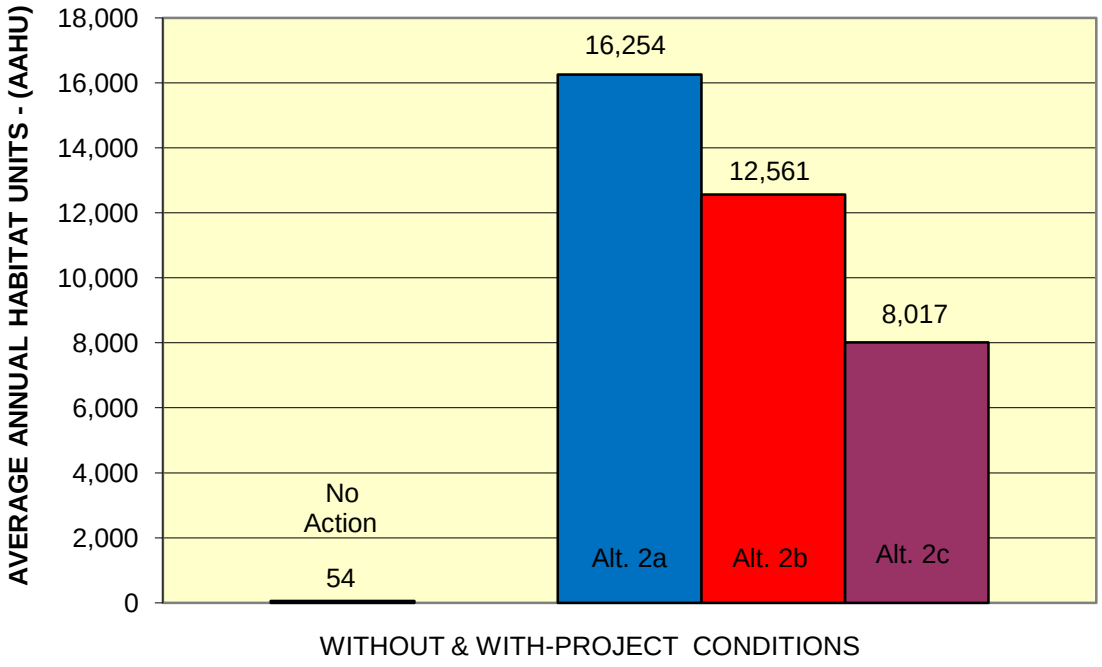


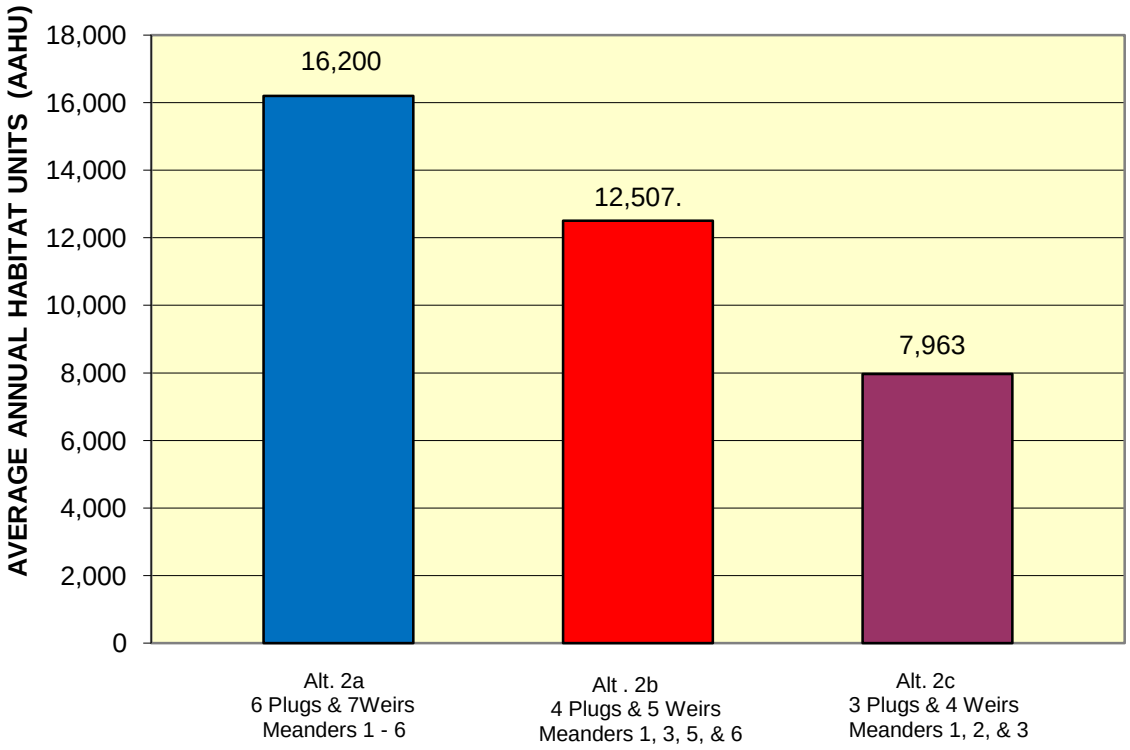
TABLE 2

LOWER CACHE RIVER ECOSYSTEM RESTORATION

AVERAGE ANNUAL HABITAT UNIT NET BENEFITS FOR ALTERNATIVE 2

Col. 1 Alternatives	Col. 2 Meanders	Col. 3 Mussels Habitat Units	Col. 4 Riverine Fish Habitat Units		Col. 5 Total Net Benefits Habitat Units (Col. 3+4)
Alt. 2a	1, 2, 3, 4, 5, & 6	16,089	111		16,200
Alt. 2b	1, 3, 5, & 6	12,416	91		12,507
Alt. 2c	1, 2, & 3	7,907	56		7,963

FIGURE 2
LOWER CACHE RIVER ECOSYSTEM RESTORATION
AVERAGE ANNUAL HABITAT UNIT NET BENEFITS FOR ALTERNATIVE 2



Cost Estimates:

First Costs: The detailed project construction first costs for Alternative 2 are presented in the Costs Appendix and Table 3. Real estate costs are included in project first costs. Real estate cost estimates and the conditions to which they are subject are presented in the Real Estate Appendix.

Average Annual Equivalent Costs: The average annual equivalent (AAE) costs are based on November 2010 price levels, the current FY11 Federal discount rate of 4.125 percent, and a 50-year period of analysis. This interest rate, as specified in the Federal Register, is to be used by Federal agencies in the formulation and evaluation of water and land resource plans. For the purpose of discounting, all costs are set to a common reference period, which is assumed to occur at the end of the year during which they are expended.

Average Annual Costs: The average annual costs ranged from a low of $0 for No Action, to a high of $643,000 for Alternative 2a. Average annual total cost includes annual OMRR&R costs, and average annual performance monitoring costs are presented in Table 3 for Alternative 2.

TABLE 3

LOWER CACHE RIVER ECOSYSTEM RESTORATION

AVERAGE ANNUAL TOTAL PROJECT COST FOR ALTERNATIVE 2,

(November 2010 Price Level @ 4 1/8% Interest Rate)

Col. 1 Alternatives	Col. 2 Project Construction First Cost	Col. 3 Average Annual Cost 1/	Col. 4 Annual OMRR&R Cost 2/	Col. 5 Average Annual Monitoring 3/	Col. 6 Average Annual Total Cost ® (Col. 3+4+5)
No Action	N/A	N/A	N/A	N/A	N/A
Alt. 2a	$13,054,000	$634,000	$6,000	$3,000	$643,000
Alt. 2b	$9,868,000	$479,000	$6,000	$3,000	$488,000
Alt. 2c	$8,271,000	$393,000	$6,000	$3,000	$402,000

1/ Project construction will take place over a 2-year period for Alt. 2a & 2b, and a 1-year period for Alt. 2c. Average annual cost includes Interest During Construction (IDC). Common reference period is end of year.

2/ OMRR&R costs are for inspection, weir maintenance, and minor repairs at the 25th year after construction.

3/ Performance monitoring of the project site will take place after construction.

In general, the cost for unplugging 3 meanders for Alternative 2c is relatively about 63% of the costs of Alternative 2a, which will unplug and restore 6 meanders.

Step 2 - Identify combinable management measures: In this step, several possible combinations of management measures and scales were formulated for Alternative 2. Each measure and scale was combined with the cost and output of each part being summed. As a result, each combination had an associated total cost and total output. Each possible combination was considered an alternative/plan.

Alternative/Plan:

No Action plan: No Federal action would be undertaken to restore the degraded conditions in the project area with the No Action plan.

Alternative 2a: This alternative includes the removal of channel plugs in 6 meanders (1, 2, 3, 4, 5, & 6), and the building of 7 low water weirs in the main channel.

Alternative 2b: This alternative includes the removal of channel plugs in 4 meanders (1, 3, 5, & 6), and the building of 5 low water weirs in the main channel. This alternative is not exactly comparable to the other alternatives in that by building weirs below meanders 2 and 4, this eliminates the possibility of opening meanders 2 and 4 in the future. Therefore, the net benefits for meanders 2 and 4 would be lost. The other alternatives are connected to each other in meander order as a system.

Alternative 2c: This alternative includes the removal of channel plugs in 3 meanders (1, 2, & 3), and the building of 4 low water weirs in the main channel.

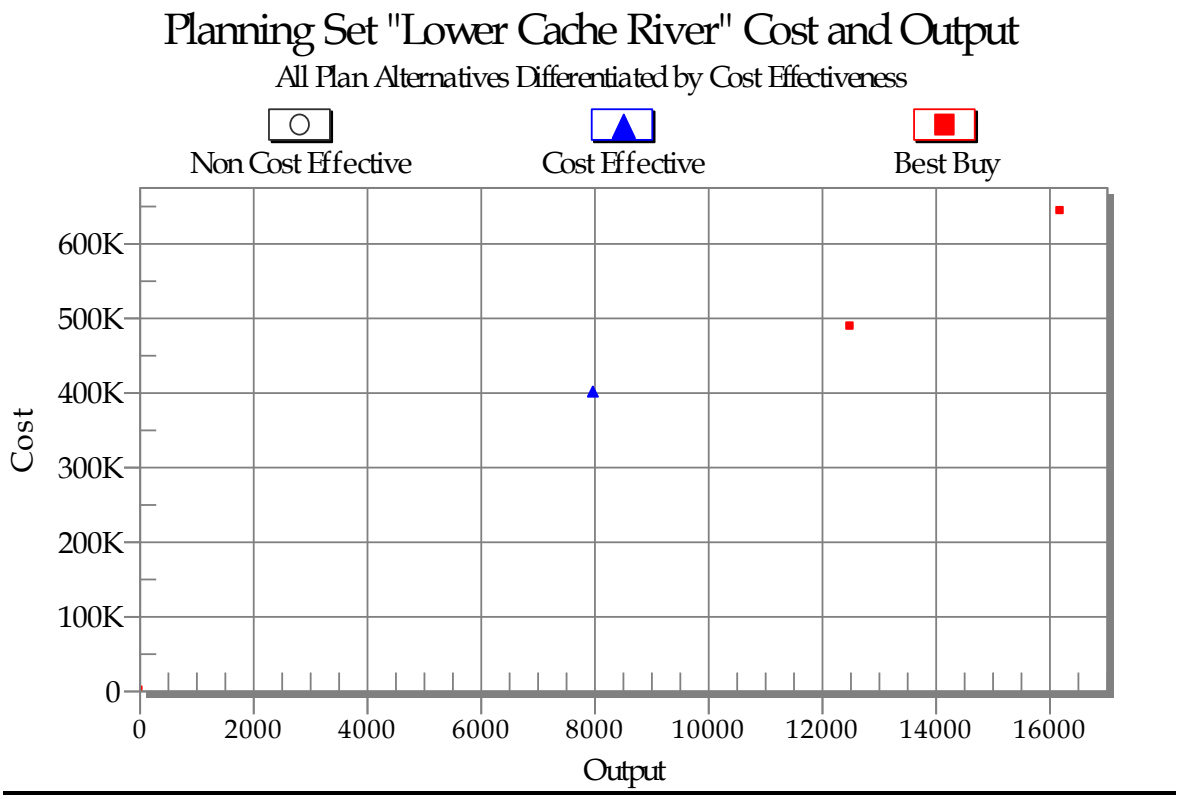
Step 3 - Calculate outputs and costs of combinations: All combinations of management measures and scales were sorted in terms of increasing output. This provided the basis for developing a supply curve. All environmental outputs were measured in terms of average annual Habitat Units. As indicated in Table 1 and discussed in Step 1 of the previous report section, Alternative 2a provides the most net Habitat Units (16,200 AAHU).

Step 4 - Conduct cost effectiveness analysis: A plan is cost effective if no other plan provides the same level of output for less cost and if no other plan provides more output for the same or less cost. This step identifies the least-cost or best solution plan for a given amount (or range) of outputs. This essentially creates a supply curve and eliminates economically ineffective solutions. Alternative/plans identified through this comparison are the "cost effective" plans.

Alternative 2 provides relatively similar outputs with increasing higher construction costs when increasing the number of meanders being unplugged. Alternative 2c with 3 meanders costs $402,000 per year and produce 7,963 AAHU. Alternative 2a with 6 meanders average $643,000 per year and produce the highest 16,200 AAHU. Alternatives 2a, 2b, & 2c were all determined to be cost effective plans.

Figure 3 shows that Alternative 2c is a cost effective plan, whereas Alternative 2a and 2b were cost effective plans and also determined to be "Best Buy" plans.

FIGURE 3



Alt. 2c (7,963 AAHU) | **Alt. 2b (12,507 AAHU)** | **Alt. 2a (16,200 AAHU)**

FIGURE 3 DATA & RESULTS

Name	Average Annual Cost	Average Annual Output (HU)	Cost Effective
No Action Plan	0	0	-
Alt. 2a - Meanders 1, 2, 3, 4, 5, & 6	$643,000	16,200	Best Buy
Alt. 2b - Meanders 1, 3, 5, & 6	$488,000	12,507	Best Buy
Alt.2c - Meanders 1, 2, & 3	$402,000	7,963	Yes

Step 5 - Incremental cost analysis: The ICA identifies the subset of cost effective plans that offer the greatest increases in output for the least increases in cost (the plans that have the lowest incremental costs per unit of output for successively larger levels of output) are those plans that are most efficient in production and superior financial investments are called the "Best Buy" plans. "Best Buy" plans are the most efficient plans at producing the output variable (Habitat Units). They provide the greatest increase in the value of the output parameter variable for the least increase in the value of the cost parameter variable. The first best buy plan is the most efficient plan, producing the most output at the lowest incremental cost per unit. If a higher level of output is desired than that provided by the first best buy plan, the second best buy plan is the most efficient plan for producing additional output, and so on.

That is the same as identifying the plans with the lowest incremental cost per habitat unit, also known as a marginal cost analysis. This step considers the most cost effective plans by scale of output, beginning with No Action. It eliminates plans that are smaller in scale than the first "Best Buy" plan. The incremental costs and outputs are first measured against the No Action to determine what is referred to as the first "Best Buy."

Finally, the additional costs for the additional amounts of output (incremental cost) produced by the "Best Buy" alternative plans were calculated for Alternative 2. The results of all the calculations and comparisons of costs and outputs provided a basis for addressing the decision question of whether the additional outputs are worth the costs incurred to achieve them.

The incremental cost analysis examined how the costs of additional units of environmental output increase as the level of environmental output increases. For this analysis, the environmental outputs are measured in average annual habitat units. The plan is to improve environmental conditions in the Lower Cache River which includes restoring the river meanders and building low water weirs in the main channel. The project construction costs of each alternative were compared with the environmental benefits, within the framework of an incremental cost analysis, to identify the most cost effective Alternatives. This analysis identified the "Best Buy" plans for decision makers to consider. Project cost, and the number of net habitat units created by each Alternative are shown in Table 4. Table 4 displays the incremental cost of all "Best Buy" plans relative to No Action.

TABLE 4

LOWER CACHE RIVER ECOSYSTEM RESTORATION

INCREMENTAL COST OF BEST BUY PLAN COMBINATIONS

(November 2010 Price Level @ 4 1/8% Interest Rate)

Col. 1 Alternative	Col. 2 Project Construction First Cost	Col. 3 Average Annual Cost	Col. 4 Change in Incremental Cost	Col. 5 Total Habitat Units	Col. 6 Net Restored Habitat Units	Col. 7 Change in Incremental Restored HU	Col. 8 Average Cost/HU (Col.3/Col.6)	Col. 9 Incremental Cost/HU (Col.4/Col.7)
No Action	N/A	N/A	0	54	0	0	N/A	N/A
Alt. 2b	$9,868,000	$488,000	$488,000	12,561	12,507	12,507	$39.02	$39.02
Alt. 2a	$13,054,000	$643,000	$155,000	16,254	16,200	3,693	$39.69	$41.97

Table 4 shows that Alternative 2b with an incremental cost of $39.02 per habitat unit, results in restoring a total of 12,507 average annual habitat units, has the lowest incremental cost and is the first "Best Buy" plan beyond No Action.

Step 6 - Recalculate incremental costs: This step uses iterative incremental cost analysis to identify plans where there is a significant change in incremental costs and identify the potential NER plans. The first step in this process looks at the incremental costs and outputs for plans larger than the first "Best Buy" plan. Plans larger (i.e. providing more output) than the last "Best Buy" plan are iteratively considered with the incremental costs and outputs relative to that last plan.

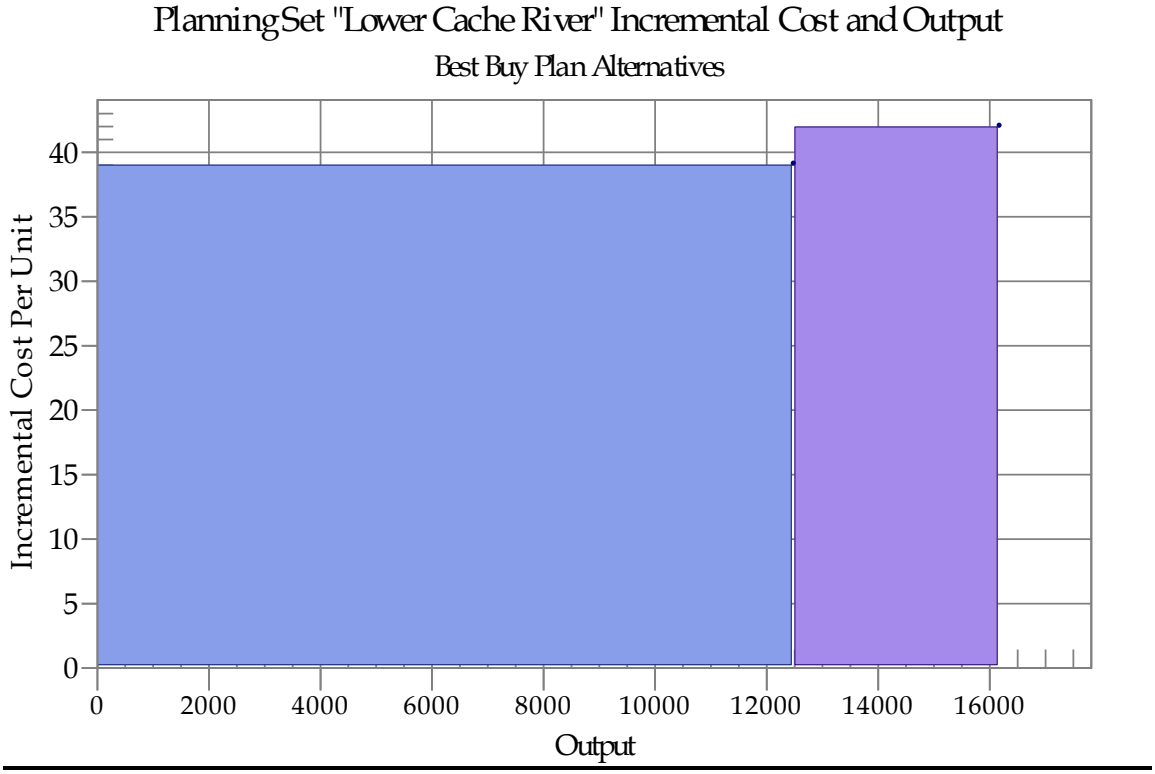
As is indicated in Table 4, Alternative 2a delivers an additional 3,693 average annual habitat units at an incremental cost of $41.97 per habitat unit is the second "Best Buy" plan. Alternative 2a results in the most cost-effective plan that maximizes ecosystem restoration benefits as compared to costs. Although it does not result in the least costly plan per HU, it does provide the maximum amount of environmental benefits (16,200 HUs) which is 30 percent more in outputs than the next smaller plan.

Step 7 – Tabulate and graph incremental costs: This is the last step that displays a summarized table of the pertinent incremental cost and output information associated with the increasing size (in terms of output) of the "Best Buy" plans.

Figure 4: Incremental Cost of Best-Buy Plans compared to Habitat Unit outputs.

Figure 4 shows the "Best Buy" plans that comprise the incremental cost curve. The horizontal axis represents Output or Habitat Units created by each project. The vertical axis represents the incremental cost per incremental output as output increases with project size. All "Best Buy" plans are a subset of cost effective plans. For each "Best Buy" plan there are no other plans that will give the same level of output at a lower incremental cost. There are two "Best Buy" plans. They are Alternative 2b with 12,507 AAHU and Alternative 2a with 16,200 AAHU.

FIGURE 4



Alt. 2b **(12,507 AAHU)** | **Alt. 2a** **(16,200 AAHU)**

National Ecosystem Restoration Plan:

The identified NER plan will be the ecosystem restoration plan of the desired scale that maximizes the monetary and non-monetary beneficial effects/outputs (AAHU) as compared to the monetary and nonmonetary costs. The (CE/ICA) cost analyses do not provide a discrete decision criterion for plan selection, however, the incremental cost analysis does provide for the explicit comparison of the relevant changes in costs and outputs on which such decisions may be based. The question that decision makers must

ask themselves at each increment of output: "Is it worth it?" They must decide whether the additional gain in environmental benefit is worth the additional cost. To help with this process, the Lower Cache River Project Delivery Team determined that the alternative plan that would be selected as the NER plan would be based on the following criteria:

— Results of the cost-effectiveness and incremental cost analyses;
— Significance of ecosystem outputs produced by the project;
— Improvement in quantity and/or quality of desired ecosystem resources;
— Significance of ecosystem outputs produced by the project in terms of institutional, public, and technical recognition;
— Acceptability, completeness, effectiveness, and efficiency of the plan; and,
— Risk and uncertainty associated with the costs and outputs of the alternative restoration plans.

Based on the results of the (CE/ICA) cost analysis and the criteria presented above, it was determined that Alternative 2a (Meanders 1-6) was considered to be the NER Plan or "Best Buy" Plan for restoring the ecosystem with the greatest outputs (AAHU) at the optimal cost. Because of a constraint of funds, the NER Plan is not implementable.

If implementation funds are a constraint, then the non-Federal sponsor decision makers can review both the cost effectiveness curve and the incremental cost curve for information that will help them judge the "best investment" for the funds available.

For example, if only $5,700,000 is available for project construction, then, by examining the Project First Costs in Table 3 and the Cost Effective Plans in Figure 3, the decision makers would see that no plan alternatives are cost effective with the existing weir designs. Under these conditions, a decision was made to reduce costs by changing the weir design at Meander 3. Since the weir design at Meander 3 was not comparable to the existing weir designs for Alternative 2, plus the funding constraint, a new Cost Effectiveness Analysis was performed and is shown in the Locally Preferred Plan (LPP) appendix.