APPENDIX I

INCREMENTAL COST ANALYSIS

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RIP RAP LANDING HABITAT REHABILITATION AND ENHANCEMENT PROJECT

APPENDIX E
INCREMENTAL COST ANALYSIS (ICA)

1. PURPOSE

Corps of Engineers guidance requires a cost effectiveness analysis and an incremental cost analysis for recommended environmental restoration and mitigation plans. A cost effectiveness analysis is conducted to ensure that the least cost solution is identified for each possible level of environmental output. An incremental cost analysis of the solutions is conducted to reveal changes in costs for increasing levels of environmental outputs. In the absence of a common measurement unit for comparing the nonmonetary benefits with the monetary costs of environmental plans, cost effectiveness and incremental cost analysis are valuable tools to assist in decision making. This appendix presents the results of the cost effectiveness analysis and incremental cost analysis of the Rip Rap Landing Habitat Rehabilitation and Enhancement Project, Calhoun County, Illinois.

2. METHOD

The project was evaluated using guidance documents and software prepared by the Corps of Engineers' Institute for Water Resources (IWR). IWR –Planning Suite Software (Version 1.0.11.0, Sept 24, 2008) was used to automate steps in the cost effectiveness and incremental cost analysis. Much of the text of this appendix was borrowed from IWR Report (IWR 94-PS-2), *Cost Effectiveness Analysis for Environmental Planning: Nine EASY Steps* (Orth, 1994). The cost effectiveness and incremental cost analysis procedures are presented in nine steps, which are grouped into four tasks listed below.

A. Formulation of Combinations

Step 1 Display outputs and costs
Step 2 Identify combinable management features
Step 3 Calculate outputs and costs of combinations

B. Cost Effectiveness Analysis

Step 4 Eliminate economically inefficient solutions
Step 5 Eliminate economically ineffective solutions

C. Development of Incremental Cost Curve

Step 6 Calculate average costs
Step 7 Recalculate average costs for additional outputs

D. Incremental Cost Analysis

Step 8 Calculate incremental costs
Step 9 Compare successive outputs and incremental costs

The results of these analyses are displayed as graphs and tables at the end of this appendix. They allow the decision makers to progressively compare alternative levels of environmental

outputs and ask if the next level is "worth it" – that is, is the additional environmental output in the next level worth its additional monetary costs. It is important to note that these analyses will not usually lead, and are not intended to lead, to a single best solution as in economic cost-benefit analyses. They will improve the quality of decision making by ensuring that a rational, supportable, focused and traceable approach is used for considering and selecting alternative methods to produce environmental outputs.

A. Formulation of Combinations

Step 1. Display outputs and costs. Table E-1 at the end of this appendix displays the outputs and costs of potential management features. Outputs were determined using Habitat Evaluation Procedures and are presented as net Average Annual Habitat Units. Costs were annualized over a 50-year period of analysis at an interest rate of 3.75% based on Economic Guidance Memorandum, 10-1, Federal Interest Rates for Corps of Engineers Projects for Fiscal Year 2012. These costs include initial construction (with mobilization & demobilization (5%), contingency (25%), engineering fees (15%), and construction management (10%) above the actual estimated cost for construction) and the cost of replacing each management feature during the 50-year period of analysis.

Step 2. Identify combinable management features. The management features were reviewed to determine which were dependent on other features and which were logically combinable into functional alternatives (Table E-2), either by the zone within the project area where the proposed features would impact, or by the type of feature being proposed, such as vegetation conversion. Outputs were determined using Habitat Evaluation Procedures and are presented as net Average Annual Habitat Units. On this project, each of the alternatives was evaluated separately because they each provide unique conditions that are not duplicated by other alternatives.

Step 3. Calculate output and costs of combinations. Step 3 calculates the outputs and costs of each of the possible alternatives. ICA generated 506 plans. For features with only one possible alternative other than No Action, incremental cost analysis is not necessary.

B. Cost Effectiveness Analysis

Steps 4 and 5. Eliminate economically inefficient solutions and economically ineffective solutions. Steps 4 and 5 were carried out using the IWR-Planning Suite software. Step 4 eliminates economically inefficient solutions and identifies the least cost solution for each level of output. For example, if two plans produce two AAHUs and one costs $3,000 while the other costs $4,000, the more expensive plan is eliminated.

Step 5 eliminates the economically ineffective solutions by identifying and deleting those solutions that will produce less output at equal or greater cost than subsequently ranked solutions. For example, if one plan produces 2 AAHUs for $8,000 and the next plan produces 4 AAHUs for $6,000, the first plan would be eliminated because it is not economically effective.

Of the 506 generated plans, 40 were considered cost effective.

C. Development of Incremental Cost Curve

Step 6. Calculate average costs. Average costs for each least-cost, cost-effective plan are determined by dividing the cost of the plan by the output (AAHUs). Average costs are expressed in cost per AAHU ($/AAHU). The plan with the lowest average cost is identified. Plans with less output at a higher average cost are eliminated.

Step 7. Recalculate average costs for additional outputs. This step asks the question: "of the remaining levels of output, which has the lowest additional cost for additional output?" Using levels of output from Step 6, the average annual costs for additional output are calculated. The previous step's lowest average cost level of output is used as the "zero level." Levels of output less than the lowest average cost level are dropped from further analysis, while levels of output greater than the lowest average cost level advance to the next recalculation. Recalculations are then made using the new lowest average cost level as the "zero level" until the highest level of output is reached. The incremental costs for additional outputs were applicable to alternatives in groups D and L as these alternatives represented lengthening or extensions of a specific feature. Steps 6 and 7 were carried out using the IWR-Planning Suite software.

D. Incremental Cost Analysis

Step 8. Calculate incremental costs. Step 8 was carried out using the IWR-Planning Suite software. The 10 plans listed in Table E-3 are the "best buys," meaning these plans produce the most AAHUs per dollar. The incremental costs shown in Table E-3 are calculated by dividing the difference between the different plans output. Figure E-1 is a graph of the incremental costs of alternatives as listed in Table E-3. As shown in the chart, there are seven "best buy" combinations. Table E-3 and Figure E-1 are included at the end of this appendix.

Step 9. Compare successive outputs and incremental costs. Table E-3 and Figure E-1 were used as decision making tools by progressively proceeding through available levels of output and determining if the next level is worth its additional monetary costs. This step examined the additional habitat value, as measured by increased AAHU output, for an increase in monetary costs. Federal planning for water resources development is conducted in accordance with the requirements of the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G). The P&G provides a decision rule for selecting a tentatively selected plan where both outputs and costs are measured in dollars. This rule states: "The alternative plan with the greatest net economic benefit consistent with protecting the Nation's environment (National Economic Development Plan, NED Plan) is to be selected… (Paragraph 1.10.2)". There is no similar rule for plan selection where the outputs are not measured in dollars, as is the case in planning for restoration and mitigation. In the absence of such a decision-making rule, cost-effectiveness and incremental cost analyses helps to better understand the consequences of the preferred plan in relation to other choices.

E . ICA Conclusions & Selection of Tentatively Selected Plan.

The best buy alternatives presented provide the information necessary to make well-informed decisions regarding desired project scale (Table E-3, Figure E-1). Progressing through the increasing levels of output for the alternatives in Table 7 helps determine whether the increase in Net AAHUs is worth the additional cost. As long as decision makers consider a level of output to be "worth it", subsequent levels of output are considered. When a level of output is

determined to be “not worth it”, then subsequent levels of output will also likely be “not worth it”, and the final decision regarding desired project scale for environmental restoration planning will have been reached.

Typically in the evaluation of Best Buy Alternatives, ‘break points’ are identified in either the last column in Table E-3, or in the stair step progression from left to right in Figure E-1. Break points are defined as significant increase or ‘jumps’ in incremental cost per output, such that subsequent levels of output may/may not be considered ‘worth it’. Identification of such breakpoints can be subjective. For Rip Rap Landing, the breakpoints are subjectively identified as occurring between Alternatives 2 and 3; Alternative 8 and 9. Alternative 3 generates substantially higher levels of output at 199 incremental AAHUs making the decision to continue elevating and considering Best Buy Alternatives beyond this breakpoint logical.

Alternative 8 generates a total of 431 AAHUs at an average cost of $1,648 per output. Alternative 9 only generates an additional 1 AAHU at an incremental cost of $48,000 per output. This considerable higher incremental cost per unit was deemed “not worth it”. Therefore, Alternative 8, generating a total 431 Net AAHUs, is identified as the desired project scale.

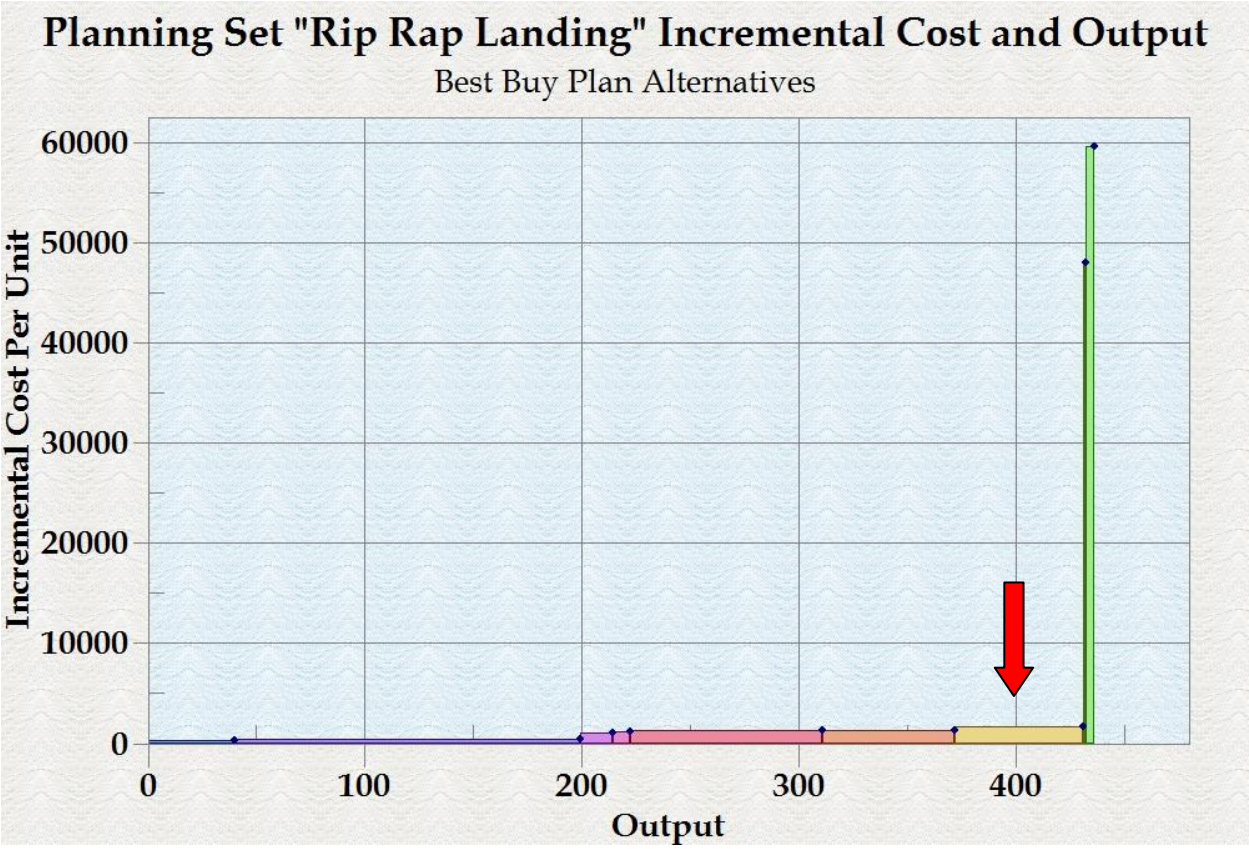

Figure E.1 Rip Rap Landing Best Buy Alternatives. The Recommeded Plan (Alternative 8) is highlighted by red arrow.

Table E-1. Total Costs (FY12) and Design Life of Environmental Enhancement Features

Code	Description	Design Life (yr)	Total Cost[1] ($)
Zone 1 – Sny Island Drainage and Levee District			
1A	Water Control Structure	30	$44,052
1B	2,500 gpm Well	20	$349,852
1C	Tree Planting	50	$207,689
1D	Channel to Goose Pasture Lake	30	$27,245
Zone 3 – Roadside Lake and Waverly Lake Wetland Management Areas			
3A	Channel to Waverly Lake	30	$232,220
3B	Water Control in Pump Station Channel	30	$44,521
3C	WCS in North Units	30	$195,761
3D	Sny Creek Excavation from Sny Levee to Bridge	30	$2,002,965
3E	43% of Pump Station	30	$195,444
3F	43% Pump Channel Widening	30	$32,480
3G	43% Pump Station Pipe and Concrete for Road	30	$6,780
3H	WCS Pipes Under Sand Levee	30	$82,569
3I	Conversion of Crop to Bottomland hardwoods	50	$120,519
3J	Roadside Lake Channel from Sny Creek	30	$13,943
3K	Portable pump and water control structure for Roadside Lake	30	$79,583
Zone 4 – Rust Land Company - WRP			
4A	Sny Creek Excavation Bridge-Old Levee End	30	$1,115,856
4B1	Sny Creek Excavation Old Levee to Roadside Lake Channel	30	$628,953
4B2	Sny Creek Excavation Roadside to Dog Island	30	$277,043
4C2	River Ridge Scour Embankments	30	$230,625
4D	South Spillway	30	$535,996
4E	WCS South Spillway	30	$43,689
4G	57% of Pump Station	30	$259,076
4H	57% Pump Channel Widening	30	$43,055
4I	57% Pump Station Pipe and Concrete for Road	30	$8,987

Code	Description	Design Life (yr)	Total Cost[1] ($)
4J	WCS Pipes Under Road	30	$61,977
4K	Tree Planting	50	$905,932
Zone 5 – Dog Island			
5B	Sny Creek Excavation @ Dog Island	30	$765,692

[1]Total Costs includes Contingency, Engineering Fees, Construction Management, Construction Cost, Present Worth of Replacements, and OMRR&R costs

Table E-2. Cost and Outputs (FY12) for Alternatives Analyzed during ICA.

ICA Code	Feature Code	Brief Description	Output (AAHU)	Average Annual Cost[1] ($)
A1	1A+1B+1D	Zone 1 Water Control	116	$61,000
A2	1C+(1A+1B+1D)	Zone 1 Water Control + Zone 1 Trees	159	$71,000
B1	1C	Zone 1 Trees	43	$19,000
W1	3A + 3B + 3C + (3E, 3F, 3G, 3H) + (4G, 4H, 4I)	Zone 3 Water Control	90	$129,000
W2	4D, 4E + (4G, 4H, 4I, 4J)+ (3E, 3F, 3G)	Zone 4 Water Control	97	$123,000
W3	3A + 3B + 3C + (3E, 3F, 3G, 3H) + 4D, 4E + (4G, 4H, 4I, 4J)	Zones 3 and 4 Water Control	147	$214,000
W4	3A + 3B + 3C + (3E, 3F, 3G, 3H) + (4G, 4H, 4I), 3I	Zone 3 Water Control + Zone 3 Trees	98	$136,000
W5	3A + 3B + 3C + (3E, 3F, 3G, 3H) + 4D, 4E + (4G, 4H, 4I, 4J), 3I	Zones 3 and 4 Water Control + Zone 3 Trees	156	$220,000
C1	3I	Zone 3 Trees Only	8	$10,000
S1	4C2	Zone 4 Scour embankment	15	$16,500
D1	5B	Sny Creek Excavation at Dog Island	29	$58,000
D2	5B, 4B2	Sny Creek Excavation at Roadside to Dog Island and Sny Dredging @ Dog Island	59	$80,000
D3	5B, 4B2, 4B1	Sny Creek Excavation at Levee to Roadside L. Channel , Sny Excavation Roadside to Dog Island, and Sny Excavation @ Dog Island	60	$128,000
D4	5B, 4B2, 4B1, 4A	Sny Creek Excavation Bridge-Levee, Sny Excavation Levee to Roadside L. Channel , Sny Excavation Roadside to Dog Island, and Sny Excavation @ Dog Island	61	$213,000
D5	5B, 4B2, 4B1, 4A, 3D	Sny Creek Excavation to Bridge, Sny Excavation Bridge-Levee, Sny Excavation Levee to Roadside L. Channel , Sny Excavation Roadside to Dog Island, and Sny Excavation @ Dog Island	64	$366,000

ICA Code	Feature Code	Brief Description	Output (AAHU)	Average Annual Cost[1] ($)
R1	3K, 3J	Roadside Lake Water Control	40	$12,000
R2	3K, 3J, 5B, 4B2	Roadside Lake Water Control, Sny Excavation Roadside to Dog Island and Sny Excavation @ Dog Island	101	$92,000
R3	3K, 3J, 5B, 4B2, 4B1	Roadside Lake Water Control., Sny Excavation Levee to Roadside L. Channel , Sny Excavation Roadside to Dog Island, and Sny Excavation g @ Dog Island	102	$140,000
R4	3K, 3J, 5B, 4B2, 4B1, 4A	Roadside Lake Water Control, Sny Excavation Bridge-Levee, Sny Excavation Levee to Roadside L. Channel , Sny Excavation Roadside to Dog Island, and Sny Excavation @ Dog Island	103	$225,000
R5	3K, 3J, 5B, 4B2, 4B1, 4A, 3D	Roadside Lake Water Control Sny Creek Excavation to Bridge, Sny Excavation Bridge-Levee, Sny Excavation Levee to Roadside L. Channel , Sny Excavation Roadside to Dog Island, and Sny Excavation @ Dog Island	106	$378,000

[1]Average Annual Costs includes Contingency, Engineering Fees, Construction Management, Construction Cost, Present Worth of Replacements, LERRDS, and OMRR&R costs

Table E-3. Incremental Costs of Best Buy Plans. Price Level July 2012.

Alt #	Alternative Symbol	Description – Additional Group Added	Output[1]	Annualized Cost[2]	Average Cost ($/AAHU)	Incremental Cost ($)	Incremental Output (AAHU)	Incremental Cost/Output ($/AAHU)	Acreages Required (Acres)	Real Estate Costs
1	No Action	None	0	0	0	0	0	0	0	0
2	A0B0W0C0S0D0R1	Zone 3 Roadside Lake Water Control	40	$12,000	$300	$12,000	40	$300	99	$125,235
3	A2B0W0C0S0D0R1	Zone 1 Water Control and Vegetation	199	$83,200	$418	$71,200	159	$448	259	$702,259
4	A2B0W0C0S1D0R1	Zone 4 Scour Protection	214	$99,700	$466	$16,500	15	$1,100	269	$714,909
5	A2B0W0C1S1D0R1	Zone 3 Vegetation	222	$109,300	$492	$9,600	8	$1,200	306	$800,009
6	A2B0W2C0S1D0R1	Water Control Zone 4	311	$222,300	$715	$113,000	89	$1,270	1062	$1,718,054
7	A2B0W2C0S1D0R2	Roadside Lake Reconnection	372	$302,200	$812	$79,900	61	$1,310	1072	$1,730,704
8	**A2B0W5C0S1D0R2**	**Water Control Zones 3 and 4**	**431**	**$399,400**	**$927**	**$97,200**	**59**	**$1,648**	**1618**	**$2,886,000**
9	A2B0W5C0S1D0R3	Sny Creek to Levee	432	$447,400	$1,036	$48,000	1	$48,000	1622	$2,991,817

10	A2B0W5C0S1D0R5	Sny Creek to Bridge	436	$685,900	$1,573	$238,500	4	$59,625	1641	$3,015,852

[1]Outputs are calculated as Average Annual Habitat Units (AAHUs)
[2]Annualized cost (FY12) includes initial construction, monitoring, and OMRR&R costs based on a 50-year period of analysis, 3.75% interest rate