ARKANSAS RIVER CORRIDOR

Appendix F: CE/ICA

ARKANSAS RIVER CORRIDOR, TULSA COUNTY, OKLAHOMA

Introduction

The Arkansas River is a water resource serving numerous nationally significant purposes. The river has historically served as a nationally significant resource for aquatic and terrestrial habitat of the nation's wildlife that live, breed, and migrate through the Arkansas River ecosystem. This includes federally endangered Interior Least Tern (Least Tern, *Sterna antillarum*), a nationally significant resource, and one federally threatened bird species, the Piping Plover (*Charadrius melodus*) as well as a plethora of native species and migratory waterfowl that support a healthy and functional riverine ecosystem. Keystone Lake and its dam located along the Arkansas River play vital roles in supporting the continued provision for these species, as well as many other purposes. In particular, the lake and dam provide flood risk management benefits, contribute to the eleven reservoir system operation of the McClellan-Kerr Arkansas River Navigation System, provide clean and efficient power through the associated hydropower plant, and provide a source of water for municipal and industrial uses. However, construction, operation, and maintenance of the Keystone Dam, lake, associated hydropower operations and other multi-purposes have significantly degraded the riverine ecosystem structure, function, and dynamic processes below Keystone Dam on the Arkansas River within Tulsa County, Oklahoma.

Purpose

This study is in response to the Section 3132 authorization of the 2007 WRDA. The purpose of this study is to evaluate the aquatic ecosystem restoration components of the October 2005 Arkansas River Corridor Master Plan (ARC Master Plan) and determine if there is a Federal Interest that aligns with the Corps of Engineers' ecosystem restoration mission.

Study Authority

The Arkansas River Corridor study is authorized in the Water Resources Development Act (WRDA) of 2007, Section 3132.

Section 3132. Arkansas River Corridor.

(a) IN GENERAL. – The Secretary is authorized to participate in the ecosystem restoration, recreation, and flood damage reduction components of the Arkansas River Corridor Master Plan dated October 2005. The Secretary shall coordinate with appropriate representatives in the vicinity of Tulsa, Oklahoma, including representatives of Tulsa County and surrounding communities and the Indian Nations Council of Governments.

(b) AUTHORIZATION OF APPROPRIATIONS. – There is authorized to be appropriated $50,000,000 to carry out this section.

Non-Federal Sponsor

Tulsa County is the non-federal sponsor for the Arkansas River Corridor feasibility study. An amended feasibility cost-sharing agreement was executed in May 2015.

Recommended Plan

Alternative 5 is the National Ecosystem Restoration (NER) Plan and includes construction of a pool structure at River Mile 530 to regulate flow in the Arkansas River, a rock riffle feature associated wetland plantings at Prattville Creek, and construction of a sandbar island near Broken Arrow, OK. With the implementation of the NER plan, more natural river flow would return to 42 river miles of the Arkansas River within the study area. The NER plan would provide approximately 2,144 acres of additional riverine habitat, nearly doubling the amount of currently available habitat under low flow conditions. Also five acres of restored wetlands, and three acres of reliable sandbar island habitat where none currently succeed, would be restored as part of the NER plan. Shoreline, river, backwater, slackwater, wetland, and sandbar island habitat quality would all be improved generating an overall increase in the ecosystem quality and carrying capacity of the corridor. Current operation of Keystone Dam would not be changed. Additional water and flow would remain within the existing banks of the river and would not increase the flood elevation, nor downstream or backwater flooding.

INTRODUCTION

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 benefits 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 annual costs and benefits of plans under consideration to identify the least cost plan alternative 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 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.

MEASURES AND PLANS

Management measures were formulated incrementally for each of the study. These measures included flow regime pool structures, constructed islands for nesting habitat, rock riffle structures, riparian plantings and wetland plantings. A flow regime (pool structures) measure was determined to be a prerequisite for all other management measures. In addition to the sites for flow regime and island nesting habitat, two additional sites (Prattville Creek and I-44/Riverside) were identified for rock riffle structures as well as riparian and wetland plantings. A brief description of the measures are presented below with a summary presented in Table 1. More detailed information can be found in the Environmental technical appendix.

FLOW REGIME MANAGEMENT MEASURE – POOL CONTROL STRUCTURE (TWO POTENTIAL LOCATIONS)

The flow regime management measure consisted of a pool control structure constructed using state-of-the art technology. The pool control structure storage would have a capacity that could provide a flow of 1,000 cubic feet per second (cfs) approximately 80% of the time between periods of hydropower releases. There are two candidate sites for pool control structures. River mile 531 is the site of the Lake Keystone Project reregulating dam that was removed in 1985. Another potential site is at river mile 530. This site was identified during development of the Arkansas River Corridor (ARC) Master Plan. A pool control structure is a prerequisite for all other management measures.

CONSTRUCTED LEAST TERN ISLAND

This management measure increases nesting habitat for the Interior Least Tern. The nesting area would be approximately three acres in size, circular to oblong in shape with maximum surface area and a surface height above water to exceed 18 inches at nest initiation that is usually in May or June. The nesting substrates for the constructed island consist of well-drained particles ranging in size from fine sand to small stones. The

anticipated design will be similar to that developed by Oklahoma State University for the USACE-Tulsa District in May 2003. Based on consultation with the U.S. Fish and Wildlife Service and information from USACE Least Tern surveys, the most desirable reach in the study area is upstream of the Tulsa County line where the river more closely resembles a braided prairie stream. The current proposed location is in the Arkansas River just south of the Indian Springs Sports Complex in Broken Arrow, Oklahoma.

PRATTVILLE CREEK MANAGEMENT MEASURES

Prattville Creek is a right-bank tributary to the Arkansas River downstream of the Highway 97 Bridge at Sand Springs, Oklahoma. An engineered rocked riffle placed at the mouth of Prattville Creek would create a wetland. The wetland increases the area of open water and provides an opportunity for the incorporation of additional management measures consisting of aquatic and riparian plant communities. The control structure and associated wetland would also restore low flows in the original Prattville Creek channel. Riparian areas bounding the wetland include 2.24 acres in two sections (0.88 acres & 1.36 acres). Plantings proposed are live-staked brush willow, and red-osier dogwood. Wetland plantings around the perimeter of the created wetland (~3,000 feet excluding the rock riffle) include rushes, reeds, and bulrushes. The rock riffle structures are prerequisites for the riparian and wetland plantings.

I-44/RIVERSIDE

This area is located on the left bank Arkansas River just upstream of the Interstate-44 (I-44) Bridge. During hydropower releases from Keystone Dam, this area provides important slackwater habitat for aquatic species and waterfowl but has been degraded due to reservoir operations. Proposed restoration measure include rocked riffles to create small wetlands, and re-vegetation. Re-vegetation would consist of aquatic and riparian plant communities. Two (2) rock riffle (grade control) structures are proposed to create sustainable slackwater habitat. Restoration plantings proposed for the area include three areas of riparian planting (0.67, 0.35, and 0.57 acres). Riparian plantings proposed include live-stake plantings of brush willow/red-osier dogwood. Wetland area plantings proposed at the site include three area immediately downstream (0.07, 0.09, and 0.13 acres), and the perimeters of two pooled areas generated by grade control features. Proposed plantings include a combination of reeds, rushes, and bulrushes. Rock riffle structures are a prerequisite for riparian and wetland plantings.

Table 1. List of Plans

Management Measure Area	Plans
Flow Regime	Pool structure located at Lake Keystone Project reregulating dam (river mile 531) Pool structure located at river mile 530 (Sand Spring)
Nesting Habitat	Constructed Least Tern Island
Prattville Creek	Rock Riffles Structures Rock Riffles Structures + Wetland Plantings Rock Riffles Structures + Riparian Planting Rock Riffles Structures + Wetland Plantings + Riparian Plantings
I-44/Riverside	Rock Riffles Structures Rock Riffles + Wetland Plantings Rock Riffles + Riparian Plantings Rock Riffles + Wetland Plantings + Riparian Plantings

ANNUAL AVERAGE HABITAT UNITS AND COSTS

EXISTING AND FUTURE WITHOUT-PROJECT AAHU

In order to determine benefits of an environmental restoration plan, future with-project environmental outputs are compared to future without-project outputs. The difference between the two represents the benefits from project implementation. For this study, future without-project conditions are assumed to be the same as existing conditions, given the existing habitat quality.

FUTURE WITH-PROJECT

ENVIRONMENTAL OUTPUTS

Environmental restoration benefits are calculated by subtracting the future without-project AAHU from the with-project AAHU. For the comparison of measures, both environmental outputs and costs were annualized over a 50 year planning horizon. The resulting benefits are then used, along with annual costs, to identify cost effective plans and perform incremental cost analysis. The calculation of benefits (outputs) are shown in Table 2.

COSTS

Annual costs were calculated using the annualizer in IWR Planning Suite. A period of analysis of 50 years was used, along with a federal discount rate of 3.125% (per EGM16-01 dated 14 OCT 2015). Prices are expressed in October 2015 dollars. First costs for the flow regime pool structures were adopted from similar structures presented in the *Arkansas River Low Water Dams and Public Access/Recreational Improvements* (April 2015) prepared for Tulsa County. The Tulsa District Cost Engineering section prepared independent government estimates for the measures, including contingencies. Details of the development of costs can be found in the Cost Engineering Appendix. Table 3 provides first costs (inclusive of real estate), interest during construction,

and average annual costs for the measure combinations. First costs ranged from $1.4 million ($89,000 annual cost) for the Least Tern Island to $105 million ($4.5 million annual cost) for the pool structure at Sand Spring.

Table 2. Annual AAHU Benefits

Management Measure Area	Plans	Future Without Project AAHU	With Project AAHU	Annual Benefits AAHU	Future With Project Acres
Flow Regime	Pool structure located at Lake Keystone Project reregulating dam (river mile 531)	481.78	1305.83	824.05	3,614
	Pool structure located at river mile 530 (Sand Spring)	481.78	1349.35	867.57	3,735
Nesting Habitat	Constructed Least Tern Island	2.00	4.97	2.97	3
Prattville Creek	Rock Riffle Structures	0.002	2.578	2.576	5.34
	Rock Riffle Structures + Wetland Plantings	0.002	5.118	5.116	5.34
	Rock Riffle Structures + Riparian Planting	0.002	2.598	2.596	7.58
	Rock Riffle Structures + Wetland Plantings + Riparian Plantings	0.002	5.138	5.316	7.58
I-44 / Riverside	Rock Riffle Structures	0.066	0.268	0.202	0.55
	Rock Riffle Structures + Wetland Plantings	0.066	0.543	0.477	0.55
	Rock Riffle Structures + Riparian Plantings	0.066	0.282	0.216	2.13
	Rock Riffle Structures+ Wetland Plantings + Riparian Plantings	0.066	0.683	0.617	2.13

Table 3. Annual Costs for Plans (October 2015 Prices, 3.125% Federal Discount Rate)

Management Measure Area	Plans	Construction Cost	Real Estate Cost	First Cost	Interest During Construction	Investment Cost	Annual Investment Cost	OMRR&R	Total Annual Cost
Flow Regime	Pool structure located at Lake Keystone Project reregulating dam (river mile 531)	$78,722,700	$11,206,000	$89,928,700	$1,515,776	$91,444,476	$3,638,850	$235,672	$3,874,522
	Pool structure located at river mile 530 (Sand Spring)*	91,075,312	13,533,000	104,608,312	1,763,205	106,371,517	4,232,842	235,672	4,468,514
Nesting Habitat	Constructed Least Tern Island	1,025,185	336,000	1,361,185	3,497	1,364,682	54,305	34,500	88,805
Prattville Creek	Rock Riffle Structures	726,762	1,002,000	1,728,762	6,668	1,735,430	69,058	35,000	104,058
	Rock Riffle Structures + Wetland Plantings	1,056,934	1,002,000	2,058,934	7,941	2,066,875	82,247	43,000	125,247
	Rock Riffle Structures + Riparian Planting	1,703,529	1,002,000	2,705,529	13,925	2,719,454	108,215	107,200	215,415
	Rock Riffle Structures + Wetland Plantings + Riparian Plantings	1,871,907	1,002,000	2,873,907	25,950	2,899,857	115,394	130,000	245,394
I-44 / Riverside	Rock Riffle Structures	158,379	3,155,000	3,313,379	4,254	3,317,633	132,019	7,200	139,219
	Rock Riffle Structures + Wetland Plantings	507,367	3,155,000	3,662,367	18,849	3,681,216	146,487	40,000	186,487
	Rock Riffle Structures + Riparian Plantings	935,030	3,155,000	4,090,030	26,335	4,116,365	163,803	77,000	240,803
	Rock Riffle Structures + Wetland Plantings + Riparian Plantings	1,339,289	3,155,000	4,494,289	46,418	4,540,707	180,688	82,481	263,169

* Includes $1 million to address HTRW concerns

COST EFFECTIVENESS AND INCREMENTAL COST ANALYSIS

To conduct the CE/ICA analysis, environmental restoration benefits (increase in with-project AAHUs) and annual costs (expressed in thousands of dollars) were entered into IWR Planning Suite. This data is presented in Table 4. Using the 11 partially-formed measures, the plan generator in the software was used to create all possible combinations of the measures. Each final measure required one of the pool structures for flow regime, and the plantings required the rock riffle structures at Prattville Creek and I-44/Riverside. This resulted in 101 plans.

Table 4. Inputs for IWR Planning Suite CE/ICA Analysis

Management Measure Area	Plans	Annual Benefits AAHU	Annual Cost ($1,000) October 2015 Prices
Flow Regime	Pool structure located at Lake Keystone Project reregulating dam (river mile 531)	824.05	$3,874.522
	Pool structure located at river mile 530 (Sand Spring)	867.57	4,468.514
Nesting Habitat	Constructed Least Tern Island	2.97	88.805
Prattville Creek	Rock Riffle Structures	2.576	104.058
	Rock Riffle Structures + Wetland Plantings	5.116	125.247
	Rock Riffle Structures + Riparian Planting	2.596	215.415
	Rock Riffle Structures + Wetland Plantings + Riparian Plantings	5.316	245.394
I-44/Riverside	Rock Riffles Structures	0.202	139.219
	Rock Riffles Structures + Wetland Plantings	0.477	186.487
	Rock Riffles Structures + Riparian Plantings	0.216	240.803
	Rock Riffles Structures + Wetland Plantings + Riparian Plantings	0.617	263.169

COST EFFECTIVENESS

Using the generated plans, their costs and benefits, a cost effective analysis was performed using the IWR Planning Suite Software. Cost effective plans are defined as the least expensive plan for a given set of benefits, or environmental output. In other words, no other plan would provide the same or more benefits for a lower cost. Of the 101 plans, 22 were identified as cost effective plans (including no action). The cost

effectiveness results are shown graphically in Figure 1. Note that cost effective plans (those identified as blue triangles) include those identified as “Best Buy” plans (red squares), which will be discussed in the next section. Figure 2 displays a zoomed in view of the clusters of plans, more clearly showing the cost effective and best buy plans. Since the CE/ICA analysis was made with a flow regime (pool structure) measures as a perquisite, it can be seen in the figure that the plans are grouped into two clusters, the left most cluster representing the less expensive pool structure at the old reregulating dam site and the right most cluster representing the more expensive pool structure at Sand Spring. The frontier, or leading edge of these two clusters represent the collection of cost effective plans – that is no plan provides greater benefits at the same cost.

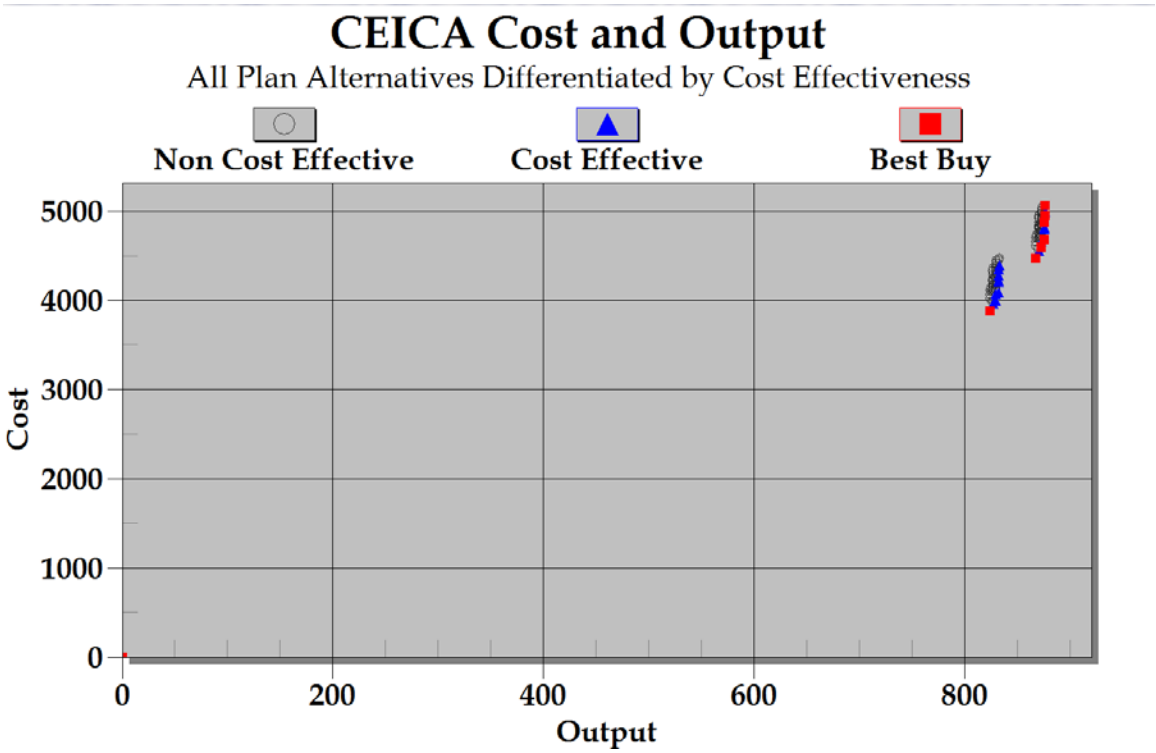

Figure 1. Cost Effective Results (Cost expressed in $1,000, Output in AAHU)

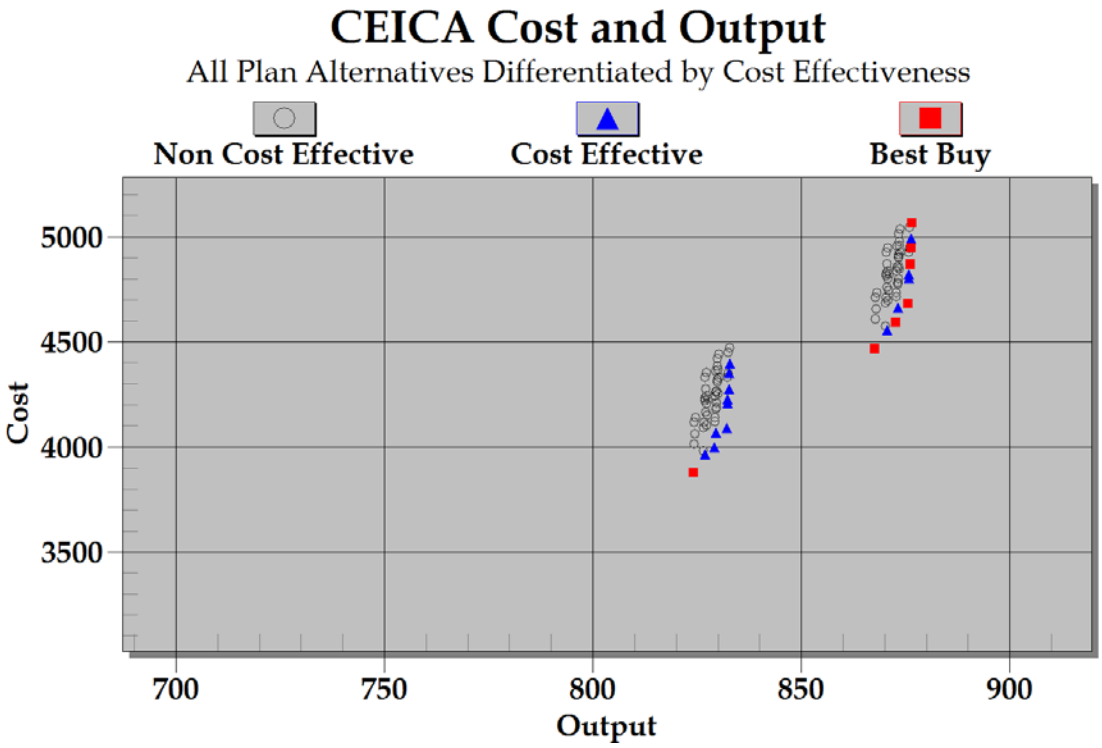

Figure 2. Adjusted Display of Effective Results (Costs are annual incremental costs per output in $1,000, Output in AAHUs)

INCREMENTAL COST ANALYSIS AND BEST BUY PLANS

The next step in the CE/ICA 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 of the management measures being analyzed.

From the cost effective alternatives, eight (including the no action plan) were identified as "Best Buy" plans. The results of the analysis is shown graphically in Figure 3 and Figure 4. Due to the significant increases in incremental cost per incremental benefit, it is difficult to distinguish plans in Figure 3. By shifting the origin away from 0 as shown in Figure 4, more distinction can be made among the last plans in the array. However, note that this also truncates the visual benefits from Alternative 2. For this particular alternative in this graphic, the output endpoint is more meaningful than the visual length of the bar. Detailed numerical output from the ICA is presented in Table 5.

The alternatives best buy plans are:

Alternative 1: No Action

Alternative 2: Pool structure located at Lake Keystone Project reregulating dam (river mile 531).

Alternative 3: Pool structure located at river mile 530 (Sand Spring)

Alternative 4: Alternative 3 + Prattville Creek Rock Riffles and Wetland Plantings

Alternative 5: Alternative 4 + New Least Tern Island.

Alternative 6: Alternative 5 + Riverside/I44 Rock Riffles and Wetland Plantings

Alternative 7: Alternative 6 + Riverside/I44 Riparian Plantings

Alternative 8: Alternative 7 + Prattville Riparian Plantings

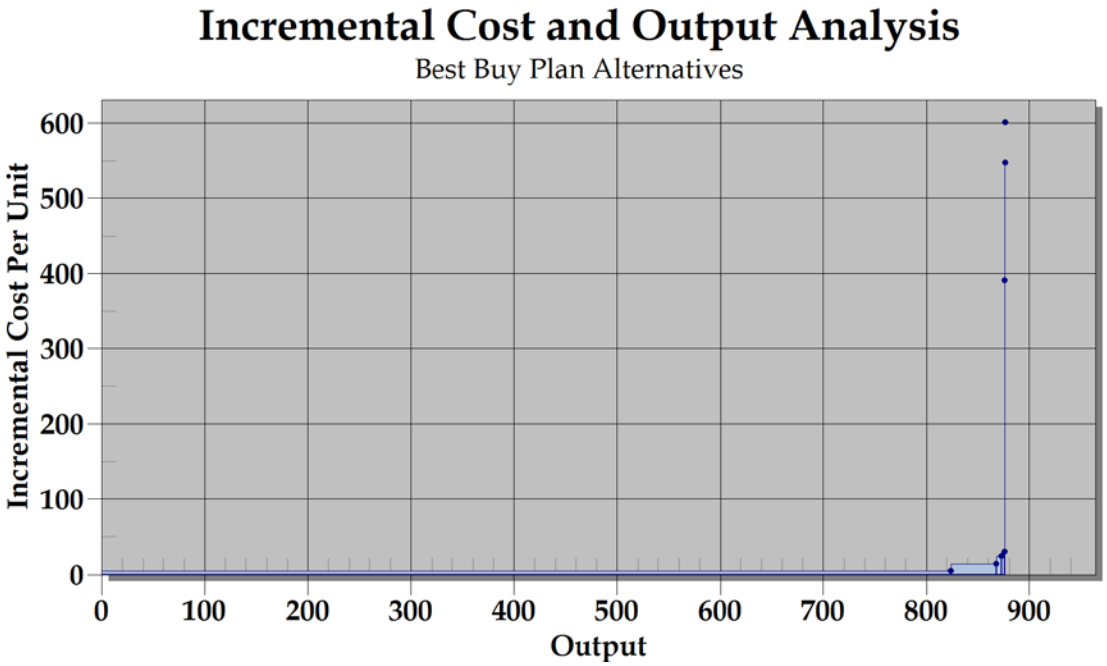

Figure 3. Incremental Cost Analysis Results (Costs are annual incremental costs per output in $1,000, Output in AAHUs)

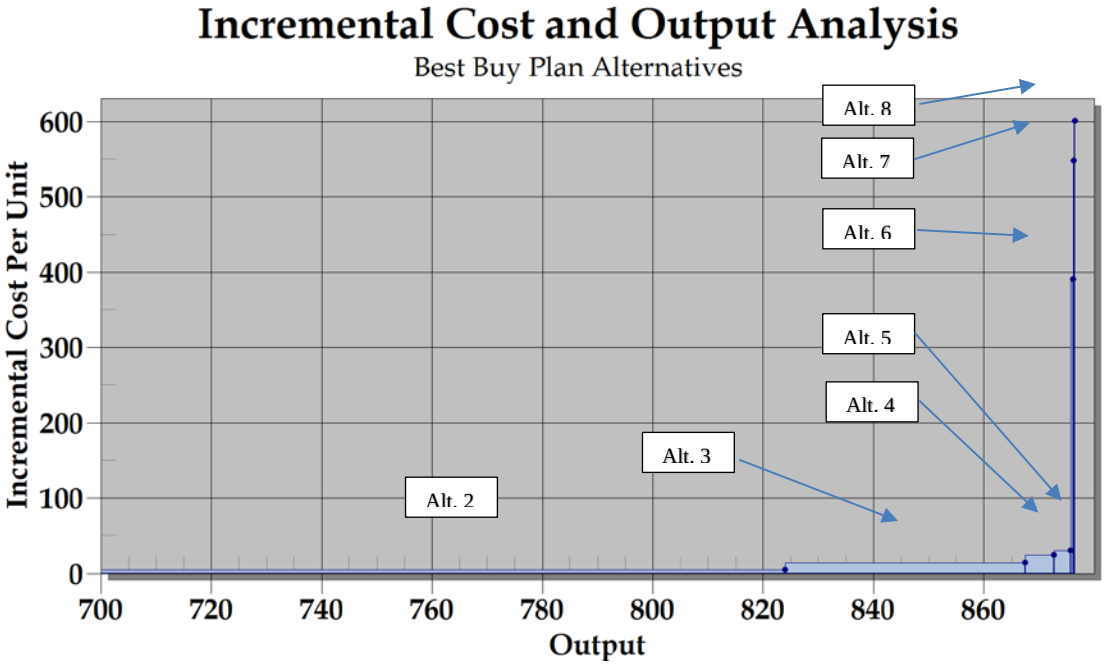

Figure 4. Adjusted View of Incremental Cost Analysis Results (Costs are annual incremental costs per output in $1,000, Output in AAHUs)

Table 5. Best Buy Plans

No	Plan Alternative	Output (AAHU)	Annual Cost ($1000)	Average Annual Cost ($1000/AAHU)	Incremental Annual Cost ($1000)	Incremental Output (AAHU)	Incremental Annual Cost per Output ($1000)	Alternative First Cost	Acres
1	No Action	0	0						
2	Pool structure located at Lake Keystone Project reregulating dam (river mile 531)	824.050	$3,874.85	$4.702	$3,874.852	824.050	$4.702	$89,928,700	3,614.00
3	Pool structure located at river mile 530 (Sand Spring)	867.570	4,468.51	5.151	593.662	43.520	13.641	104,608,312	3,735.00
4	Pool structure located at river mile 530 (Sand Spring) + Prattville Rock Riffle and Wetland Plantings	872.690	4,593.76	5.264	125.247	5.116	24.481	106,667,246	3,740.34
5	Pool structure located at river mile 530 (Sand Spring), Prattville Rock Riffle and Wetland Plantings +New Least Tern Island	875.660	4,682.57	5.348	88.805	2.970	29.901	108,028,431	3,743.34
6	Pool structure located at river mile 530 (Sand Spring), Prattville Rock Riffle and Wetland Plantings, New Least Tern Island + Riverside Rock Riffle and Wetland Plantings	876.130	4,869.05	5.557	186.487	0.477	390.958	111,690,798	3,743.89
7	Pool structure located at river mile 530 (Sand Spring), Prattville Rock Riffle and Wetland Plantings, New Least Tern Island, Riverside Rock Riffle and Wetland Plantings +Riverside Riparian Plantings	876.270	4,945.74	5.644	76.682	0.140	547.729	112,522,720	3,745.47
8	Pool structure located at river mile 530 (Sand Spring), Prattville Rock Riffle and Wetland Plantings, New Least Tern Island, Riverside Rock Riffle and Wetland Plantings, Riverside Riparian Plantings + Prattville Riparian Plantings	876.470	5,065.88	5.780	120.147	0.200	600.735	113,337,693	3,747.71

FINAL ARRAY OF ALTERNATIVES

Upon reviewing the best buy array, the PDT decided an additional cost effective measure should be evaluated alongside of the best buy array leading to the NER plan. In order for a plan to be considered an NER plan, it must be cost effective, but does not have to be a best buy plan. In reviewing the best buy plans, only one plan that includes the upstream pool structure is included. This occurs because the two pool structures are mutually exclusive, and not additive, along with their significant cost and benefits, compared to the other measures. Once the incremental cost analysis moves to the downstream pool structure, there is no further consideration of any plan based on the upstream structure. By restricting the array of plans to be evaluated to the best buy plans, should the cost or any other issues related to the downstream pool structure screen out plans that include it, the only remaining plan would be only the upstream structure, without additional measures. This could leave some of the planning objectives and benefits unaddressed. Based on additional CEICA analysis considering that included only one of the pool structures in each run, based on total cost and incremental costs per output, it was decided to include in the evaluation an alternative that consisted of the upstream pool structure, rock riffles and wetland plantings at Prattville and the new Least tern island. Based in the total output (AAHUs) this alternative falls between Alternatives 2 and 3 from the Best Buy array, and has been inserted into the array as Alternative 2a, to keep the numbering consistent throughout this document. Figure 5 shows this plan's relative relationship to output and cost among other alternatives. The comparison of total costs, output, incremental cost and output and incremental cost per incremental output for each of the final array alternatives is presented in Table 6. Finally, a bar chart diagram comparing the incremental output and incremental costs per incremental output is shown in Figure 6.

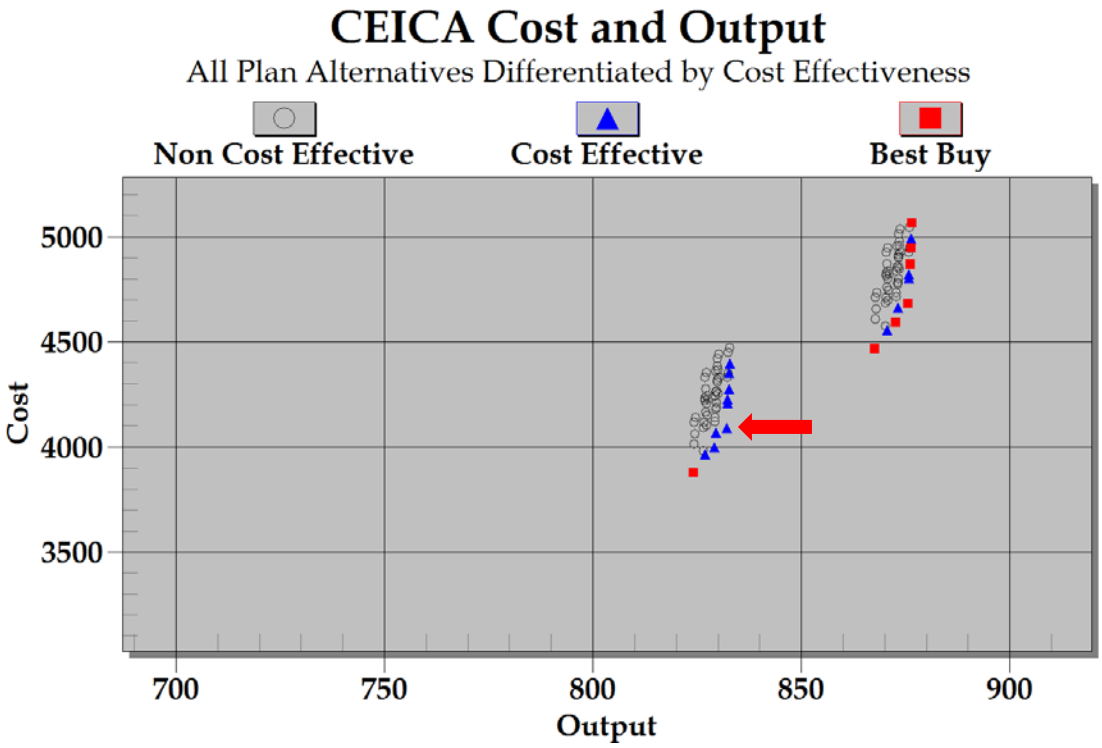

Figure 5. Additional Cost Effective Plan Included in the "Is It Worth It" Analysis (Costs are expressed in $1,000, Output in AAHUs)

Table 6. Final Array of Plans for Selection of the NER Plan

No	Plan Alternative	Output (AAHU)	Annual Cost ($1000)	Average Annual Cost ($1000/AAHU)	Incremental Annual Cost ($1000)	Incremental Output (AAHU)	Incremental Annual Cost per Output ($1000)	Alternative First Cost	Acres
0	No Action	0	0						
2	Pool structure located at Lake Keystone Project reregulating dam (river mile 531)	824.05	$3,874.85	4.702	$3,874.85	824.05	$4.70	$89,928,700	3,614.00
2A	Pool structure located at Lake Keystone Project reregulating dam (river mile 531) + Prattville Rock Riffle and Wetland Plantings +New Least Tern Island	832.136	$4,088.90	4.914	$214.05	8.086	$26.47	93,348,819	3,622.34
3	Pool structure located at river mile 530 (Sand Spring)	867.57	4,468.51	5.151	$379.61	35.434	$10.71	104,608,312	3,735.00
4	Pool structure located at river mile 530 (Sand Spring) + Prattville Rock Riffle and Wetland Plantings	872.69	4,593.76	5.264	125.247	5.116	24.481	106,667,246	3,740.34
5	Pool structure located at river mile 530 (Sand Spring), Prattville Rock Riffle and Wetland Plantings +New Least Tern Island	875.66	4,682.57	5.348	88.805	2.97	29.901	108,028,431	3,743.34
6	Pool structure located at river mile 530 (Sand Spring), Prattville Rock Riffle and Wetland Plantings, New Least Tern Island + Riverside Rock Riffle and Wetland Plantings	876.13	4,869.05	5.557	186.487	0.477	390.958	111,690,798	3,743.89
7	Pool structure located at river mile 530 (Sand Spring), Prattville Rock Riffle and Wetland Plantings, New Least Tern Island, Riverside Rock Riffle and Wetland Plantings +Riverside Riparian Plantings	876.27	4,945.74	5.644	76.682	0.14	547.729	112,522,720	3,745.47
8	Pool structure located at river mile 530 (Sand Spring), Prattville Rock Riffle and Wetland Plantings, New Least Tern Island, Riverside Rock Riffle and Wetland Plantings, Riverside Riparian Plantings + Prattville Riparian Plantings	876.47	5,065.88	5.780	120.147	0.2	600.735	113,337,693	3,747.71

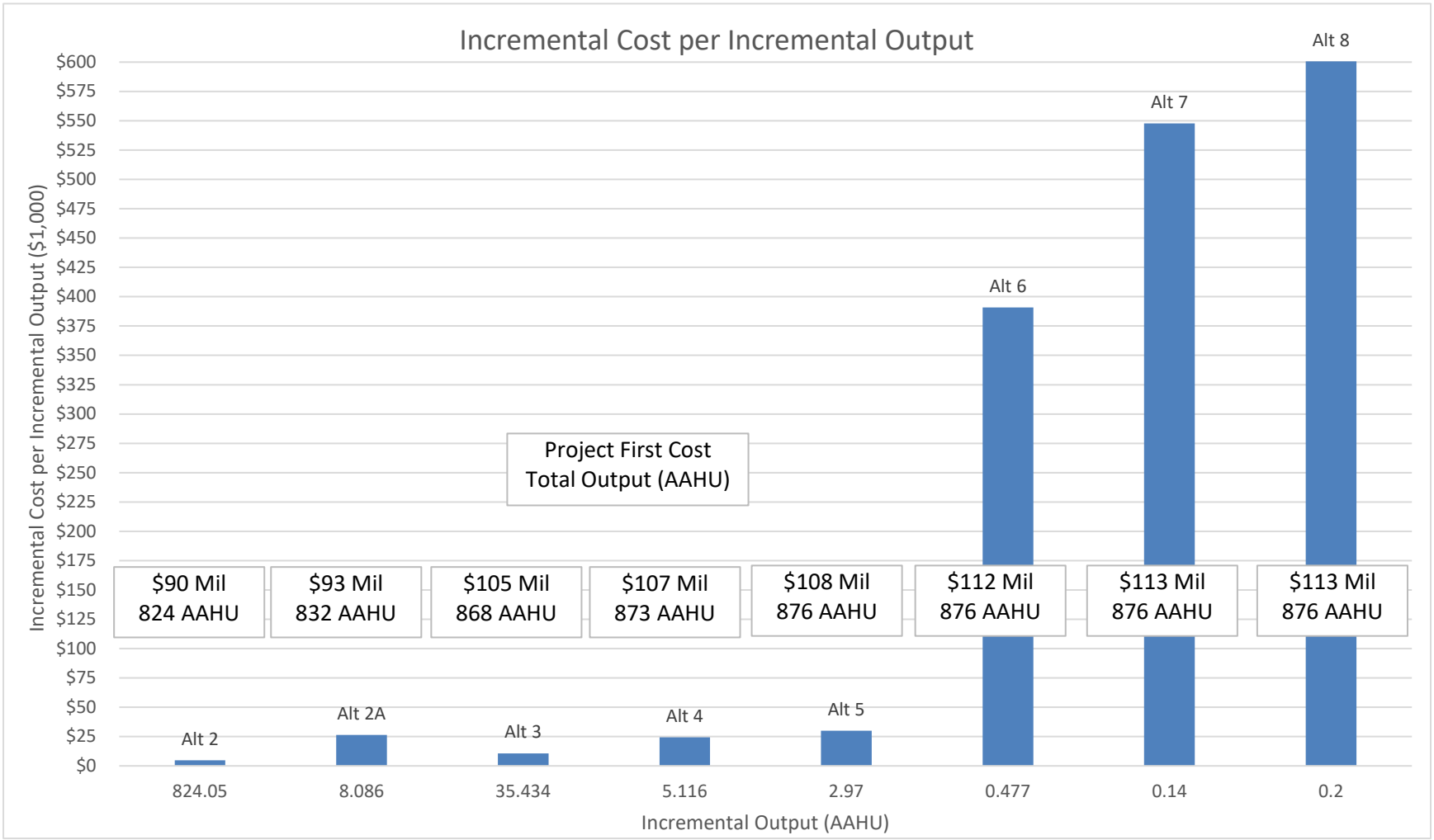

Figure 6. Comparison of Final Array of Alternatives

ALTERNATIVE 1

This is the no action plan. With this alternative, the degradation to the riverine ecosystem will continue. While there are no cost to this alternative, there are also no benefits and likely a decline in AAHUs over time. It is represented as the single point origin in Figure 3.

ALTERNATIVE 2

This plan consists of a pool structure located at Lake Keystone Project reregulating dam (river mile 531. It increases the AAHUs by 824.1 units over the no action plan with an incremental cost per incremental output of $4,700. It is represented by the first bar in Figure 4. Given that the largest plan in the array would restore a total of 876.5 AAHUs and 3,748 acres, this plan restores 94 percent of the possible AAHUs and 96 percent (3,614 acres) of the possible acres. The alternative's first cost is approximately $90 million, an annual cost of $3.9 million.

ALTERNATIVE 2A

The additional cost effective plan chosen to be considered alongside the best buy array includes the upstream pool structure at river mile 531, the rock riffles and wetland plantings at Prattville, and the new Least Tern Island. Among the mix of other plans, in the Cost Effective Analysis, this plan is identified in Figure 5. While the plan does not easily insert itself into the best buy array based on incremental costs, it would be a plan considered as one providing greater benefits than the upstream pool structure alone (Alternative 2) and but fewer benefits and lower costs than Alternative 3, which brings the downstream pool structure into the best buy array. For that reason, this added alternative was named Alternative 2a, to keep prior numbering consistent and identify a place in the list of final alternatives to be evaluated where it fits best. This alternative would create 832 AAHUs over the no action plan, and 8.1 over Alternative 2. The incremental cost per incremental output is approximately $26,000, significantly higher that Alternative 2, but at the same level as Alternatives 4 and 5. The first cost of the alternative is approximately $93.3 million, an increase of $3.4 million over Alternative 2 and $11.3 million less than Alternative 3. It would provide 94.9% of the potential AAHUs and 96.6% of the maximum acres.

ALTERNATIVE 3

This alternative places a pool structure near Sand Spring instead of at the former reregulation site. Since the two pool structures were mutually exclusive, that is one or the other, but not both, this alternative provided the next least incremental cost per incremental output compared to Alternative 2 and 2a. This alternative provides a total benefit of 867.6 AAHUs, or 35.4 additional AAHUs over Alternative 2a. This alternative restores 99 percent of the maximum possible AAHUs and 99.7 percent of the maximum possible acreage. The incremental cost per incremental output is approximately $10,700, an increase of $6,000 per incremental output over Alternative 2 but a decrease of $16,200 over Alternative 3. As can be seen in Figure 4, the incremental increase in cost per output gained is relatively small compared to other alternatives. The first cost is approximately $105 million, an annual cost of $4.5 million.

ALTERNATIVE 4

This alternative adds rock riffle structures and aquatic plantings to Alternative 3 to restore approximately 5.3 acres of wetland habitat near Prattville. The alternative provides a total benefit of 872.7 AAHUs, an increase of approximately 5.1 AAHUs over Alternative 3, with an incremental cost per incremental output of $24,500, almost double that of Alternative 3. With this alternative, approximately 99.6 percent of the total possible AAHUs are restored and 99.8 percent of the total acreage. As can be seen in Figure 4, there is a small increase in incremental costs as incremental output begins to decline. The total cost for this alternative is approximately $107 million, an annual cost of $4.6 million.

ALTERNATIVE 5

This alternative adds a new Least Tern Island to Alternative 4, creating new nesting habitat for the Federally listed endangered species during higher flows created with the pool structures. The effective nesting area is approximately 3 acres. The total benefit of this alternative is approximately 875.7 AAHUs, an increase of approximately 3 AAHUs over Alternative 4, and an incremental cost per incremental output of approximately $29,900, an increase of $5,400. As can be seen in Figure 4, this increase in incremental cost per output is less than with Alternative 4. Approximately 99.9 percent of the total possible AAHUs are restored with this alternative, along with 99.9% of the total acres. The first cost of this alternative is approximately $108 million, an annual cost of $4.7 million.

ALTERNATIVE 6

This alternative adds rock riffle structures and aquatic plantings at Riverside/I-44 to Alternative 5 to restore 0.55 acres of wetland habitat. The total AAHUs for this alternative are approximately 876.1 AAHUs, an increase of approximately 0.4 AAHUs and an incremental cost per incremental output of $391,000. Just over 99.9% of the total possible AAHUs are restored, along with 99.9% of total possible acres. As shown in Figure 4, this is the first alternative with a dramatic increase in incremental cost per incremental output, almost 10 fold over Alternative 5. This dramatic spike is a signal that increases in cost are increasing by larger or faster amounts than benefits. The first cost for this alternative is approximately $112 million, an annual cost of $4.9 million.

ALTERNATIVE 7

This alternative adds 1.58 acres of riparian plantings at the wetlands created in Alternative 6. The alternative has a total benefit of 876.2 AAHUs, an increase of approximately 0.1 AAHUs over Alternative 6, and an incremental cost per incremental output of $547,700, an increase of $156,800 over Alternative 6. Again, as seen in Figure 4, the incremental cost has a significant spike relative to incrementally output, largely due to small gains in output. With this alternative, almost 100% of both potential AAHUs and acreages have been restored. The first cost for this alternative is approximately $113 million, an annual cost of $5.0 million.

ALTERNATIVE 8

This alternative adds 2.24 acres of restored riparian plantings at Prattville to Alternative 7. The alternative has a total benefit of 876.5 AAHUs, an increase of 0.3 AAHUs over Alternative 7, with an incremental cost per incremental output of $600,700. Again, as shown in Figure 4, the incremental increase in cost is relatively larger than the incremental gain in output. It represents an increase in incremental cost per incremental out of $53,000,000 over Alternative 7. With this alternative, 100% of the potential AAHUs and acres have been restored. The alternative's first cost is approximately $113 million, an annual cost of $5.1 million.

"IS IT WORTH IT" ANALYSIS

The CE/ICA analysis provides a framework to identify cost effective and best buy plans, to aid with informed decision making, but the analysis alone cannot alone identity an optimal plan that meets the planning objectives. Modeling limitations do not always allow all potential benefits to be quantified. The CE/ICA results, along with additional qualitative and quantitative information must be used to complete an "Is It Worth It" analysis to step through the best buy array and make a rational case as to why a particular measure is worth the Federal and local investment for the benefits gained. This "Is It Worth It" analysis is presented in the main report.