SKOKOMISH RIVER BASIN
MASON COUNTY, WASHINGTON
ECOSYSTEM RESTORATION

APPENDIX G

ECONOMICS

Integrated Feasibility Report and Environmental Impact Statement

US Army Corps of Engineers
Seattle District

This page was intentionally left blank to facilitate double sided copying.

TABLE OF CONTENTS

Tables

Figures

1. Overview

This appendix describes the cost effectiveness and incremental cost analysis (CE/ICA) performed for the Skokomish River Basin General Investigation (GI) integrated feasibility report and environmental impact statement (FR/EIS, or feasibility report). This process helps in the formulation of efficient and effective restoration solutions in the Skokomish River Basin. Because there is no currently accepted method for quantifying environmental benefits (or environmental outputs) in monetary terms, it is not possible to conduct a traditional benefit-cost analysis for the evaluation of project alternatives. Cost effectiveness and incremental cost analyses offer approaches that are consistent with the Principles and Guidelines (U.S. Water Resources Council, 1983; referred to as the "P&G") planning paradigm. Cost effectiveness will ensure that the least cost solution is identified for each possible level of environmental output. Subsequent incremental cost analysis will reveal changes in cost for increasing levels of environmental outputs. While these analyses will usually not lead, and are not intended to lead, to a single best solution (as in economic benefit-cost analysis), they will improve the quality of decision making by ensuring that a rational, supportable, focused and traceable approach is used for considering and selecting alternatives for environmental restoration.

This report briefly summarizes some of the plan formulation and modeling of environmental outputs that focused the scope and inputs of the cost effectiveness and incremental cost analyses. The contents of this appendix are as follows:

- Section 2, Plan Formulation and Identification of Restoration Projects
- Section 3, Evaluation of Project Benefits
- Section 4, Evaluation of Project Costs
- Section 5, IWR Planning Suite Model Inputs
- Section 6, Cost Effectiveness and Incremental Cost Analysis (CE/ICA) Alternatives Evaluation
- Section 7, Final Array of Alternatives
- Section 8, Sensitivity Analysis
- Section 9, Recommended Plan
- Section 10, References

2. Plan Formulation and Identification of Restoration Projects

The planning process which includes the identification of problems, opportunities, objectives and constraints, as well as the identification of management measures, siting of management measures, and screening is documented in Chapter 2 of feasibility report.

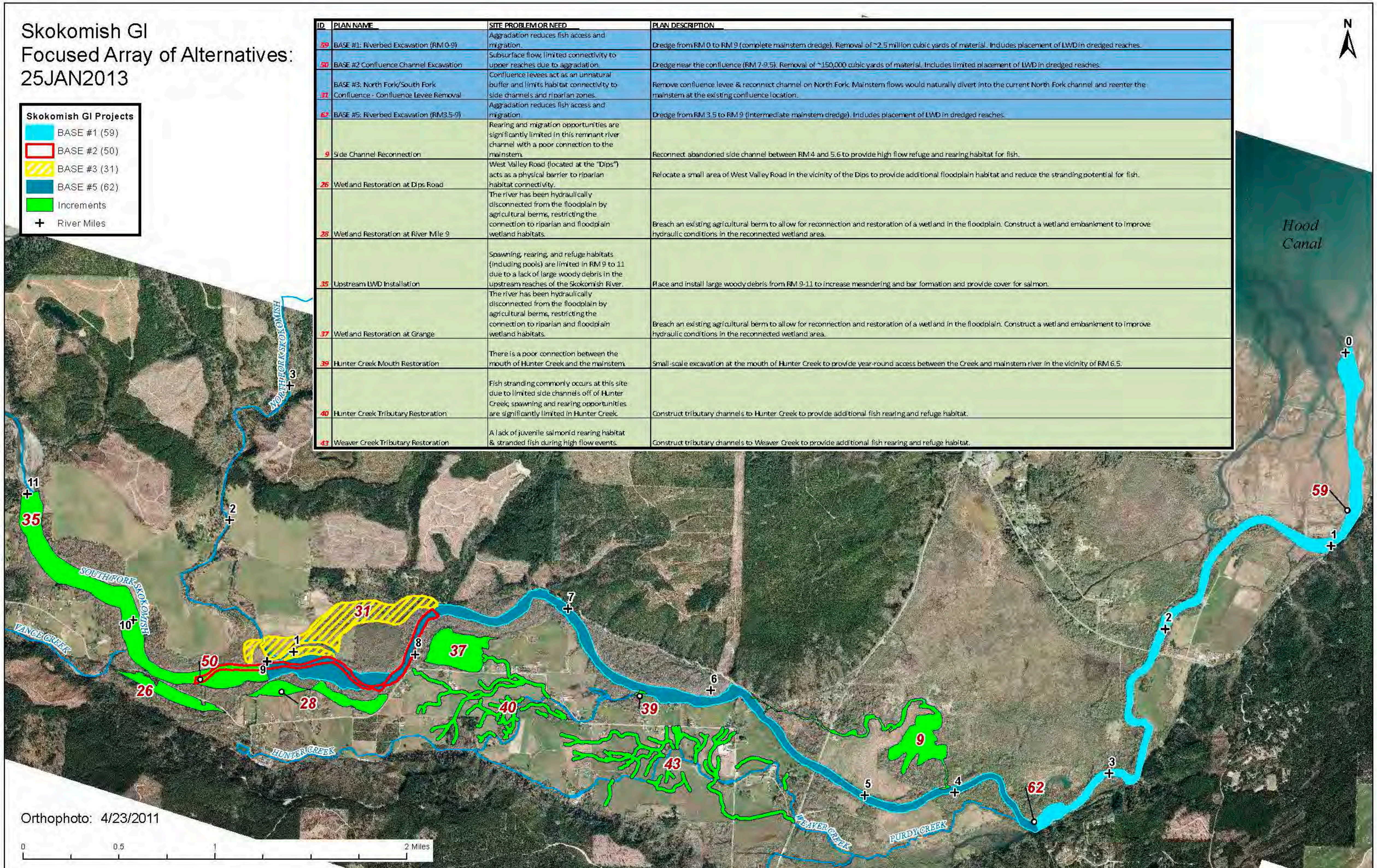
Based on the problems identified in the study area, planning objectives include the following:

- Provide year-round passage for fish species around the confluence of the North Fork and South Fork Skokomish River for the 50-year period of analysis.
- Reconnect and restore the spawning, rearing, and refuge habitats in the study's side channel and tributary networks including Hunter and Weaver Creeks for the 50-year period of analysis.
- Improve the quantity, quality, and complexity of native riparian and floodplain habitats in the study area for the 50-year period of analysis.
- Improve the quantity, quality, and complexity of pools in the Skokomish River to promote spawning and rearing success, as well as reduce stranding of ESA-listed salmonid species for the 50-year period of analysis.

The initial array of alternatives was formulated based on initial data collection and best professional judgment. This exercise led to the development of alternatives that include a "base" measure. The bases are key measures at specific sites or reaches of the river that address the highest priorities of the study area (improve the quantity, quality, and complexity of pools and provide a year-round channel for fish passage). The bases are large projects with no separable elements; they are also mutually exclusive from other bases. Developing alternatives around these base measures ensures the critical needs of the study area are addressed. An alternative cannot be considered complete, acceptable, efficient, or effective unless one of these bases is included. The bases include two large-scale sediment removal options that reach across multiple river reaches plus two smaller-scale restoration projects within specific reaches of the river.

Increments will be added to the focused array of four bases to capture supplementary benefits associated with restoration of additional channel and floodplain habitat features. These increments are generally smaller and can be combined with any of the base alternatives. Increments include in-channel habitat improvements which address the highest study priorities (increasing channel capacity and restoring year-round passage near the confluence). Finally, floodplain habitat increments were considered as lower priority restoration features. Potential floodplain increments include removal of blockages at the mouths of tributaries, restoration of side channel habitat, creation of new side channels, and levee setbacks.

Of the approximately 60 potential restoration sites, eight sites were identified by the study team as high priority in-channel or floodplain increments that in combination with one of the bases would address restoration needs in the basin. Key information about the bases and increments are described in the feasibility report. A map of the focused array of bases and potential increments is shown in Figure 2-1.



ID	PLAN NAME	SITE PROBLEM OR NEED	PLAN DESCRIPTION
59	BASE #1: Riverbed Excavation (RM 0-9)	Aggradation reduces fish access and migration.	Dredge from RM 0 to RM 9 (complete mainstem dredge). Removal of ~2.5 million cubic yards of material. Includes placement of LWD in dredged reaches.
50	BASE #2 Confluence Channel Excavation	Subsurface flow, limited connectivity to upper reaches due to aggradation.	Dredge near the confluence (RM 7-9.5). Removal of ~150,000 cubic yards of material. Includes limited placement of LWD in dredged reaches.
31	BASE #3: North Fork/South Fork Confluence - Confluence Levee Removal	Confluence levees act as an unnatural buffer and limits habitat connectivity to side channels and riparian zones.	Remove confluence levee & reconnect channel on North Fork. Mainstem flows would naturally divert into the current North Fork channel and reenter the mainstem at the existing confluence location.
62	BASE #5: Riverbed Excavation (RM3.5-9)	Aggradation reduces fish access and migration.	Dredge from RM 3.5 to RM 9 (intermediate mainstem dredge). Includes placement of LWD in dredged reaches.
9	Side Channel Reconnection	Rearing and migration opportunities are significantly limited in this remnant river channel with a poor connection to the mainstem.	Reconnect abandoned side channel between RM 4 and 5.6 to provide high flow refuge and rearing habitat for fish.
26	Wetland Restoration at Dips Road	West Valley Road (located at the "Dips") acts as a physical barrier to riparian habitat connectivity.	Relocate a small area of West Valley Road in the vicinity of the Dips to provide additional floodplain habitat and reduce the stranding potential for fish.
28	Wetland Restoration at River Mile 9	The river has been hydraulically disconnected from the floodplain by agricultural berms, restricting the connection to riparian and floodplain wetland habitats.	Breach an existing agricultural berm to allow for reconnection and restoration of a wetland in the floodplain. Construct a wetland embankment to improve hydraulic conditions in the reconnected wetland area.
35	Upstream LWD Installation	Spawning, rearing, and refuge habitats (including pools) are limited in RM 9 to 11 due to a lack of large woody debris in the upstream reaches of the Skokomish River.	Place and install large woody debris from RM 9-11 to increase meandering and bar formation and provide cover for salmon.
37	Wetland Restoration at Grange	The river has been hydraulically disconnected from the floodplain by agricultural berms, restricting the connection to riparian and floodplain wetland habitats.	Breach an existing agricultural berm to allow for reconnection and restoration of a wetland in the floodplain. Construct a wetland embankment to improve hydraulic conditions in the reconnected wetland area.
39	Hunter Creek Mouth Restoration	There is a poor connection between the mouth of Hunter Creek and the mainstem.	Small-scale excavation at the mouth of Hunter Creek to provide year-round access between the Creek and mainstem river in the vicinity of RM 6.5.
40	Hunter Creek Tributary Restoration	Fish stranding commonly occurs at this site due to limited side channels off of Hunter Creek; spawning and rearing opportunities are significantly limited in Hunter Creek.	Construct tributary channels to Hunter Creek to provide additional fish rearing and refuge habitat.
43	Weaver Creek Tributary Restoration	A lack of juvenile salmonid rearing habitat & stranded fish during high flow events.	Construct tributary channels to Weaver Creek to provide additional fish rearing and refuge habitat.

Figure 2-1. Focused Array of Bases and Potential Increments

3. Evaluation of Project Benefits

The study team developed an environmental outputs model (EO Model) to estimate benefits of proposed restoration actions in the Skokomish GI. This model was approved for one-time use approval in October 2013. The model documentation, including the biological and ecological rationale and quantification of benefits can be found in Appendix F, Ecosystem Benefits Model Documentation.

For each proposed restoration action, it was first determined whether the project assessment area for that action would result in measureable change to the channel capacity, in-channel habitat, or floodplain habitat limiting factors. After determining applicable limiting factor(s) for a project assessment area, the without project and with project habitat quality index scores for relevant assessment metrics were estimated. Two assessment metrics were used for in-channel habitat: woody debris (V1) and pools (V2). Two assessment metrics were used for floodplain habitat: connectivity (V3) and riparian cover (V4). Finally, channel capacity was measured using a flow capacity (V5) assessment metric. Three equations were used to estimate habitat quality indices based on the applicable limiting factors. A project that would address in-channel habitat only would be evaluated using the in-channel habitat assessment metrics for woody debris and pools. The bases address both in-channel habitat and channel capacity limiting factors. Figure 3-1 includes a flow diagram of which assessment metrics (labeled V1 to V5) are considered in the computation of HQI for a restoration action based on the assessment area limiting factor(s).

HQI is equal to one of three equations depending on the limiting factor(s) that apply to a given assessment area:

- $HQI = \frac{V1+V2+V5}{3}$ for assessment areas which evaluate both channel capacity and in-channel habitat limiting factors;
- $HQI = \frac{V1+V2}{2}$ for assessment areas which evaluate the in-channel habitat limiting factor only; and
- $HQI = \frac{V3+V4}{2}$ for assessment areas that evaluate the floodplain habitat limiting factor only.

AAHUs are computed for an assessment area by multiplying the HQI given the applicable limiting factor(s) and the affected acres as follows:

$$AAHU = HQI \; x \; Affected\ Area$$

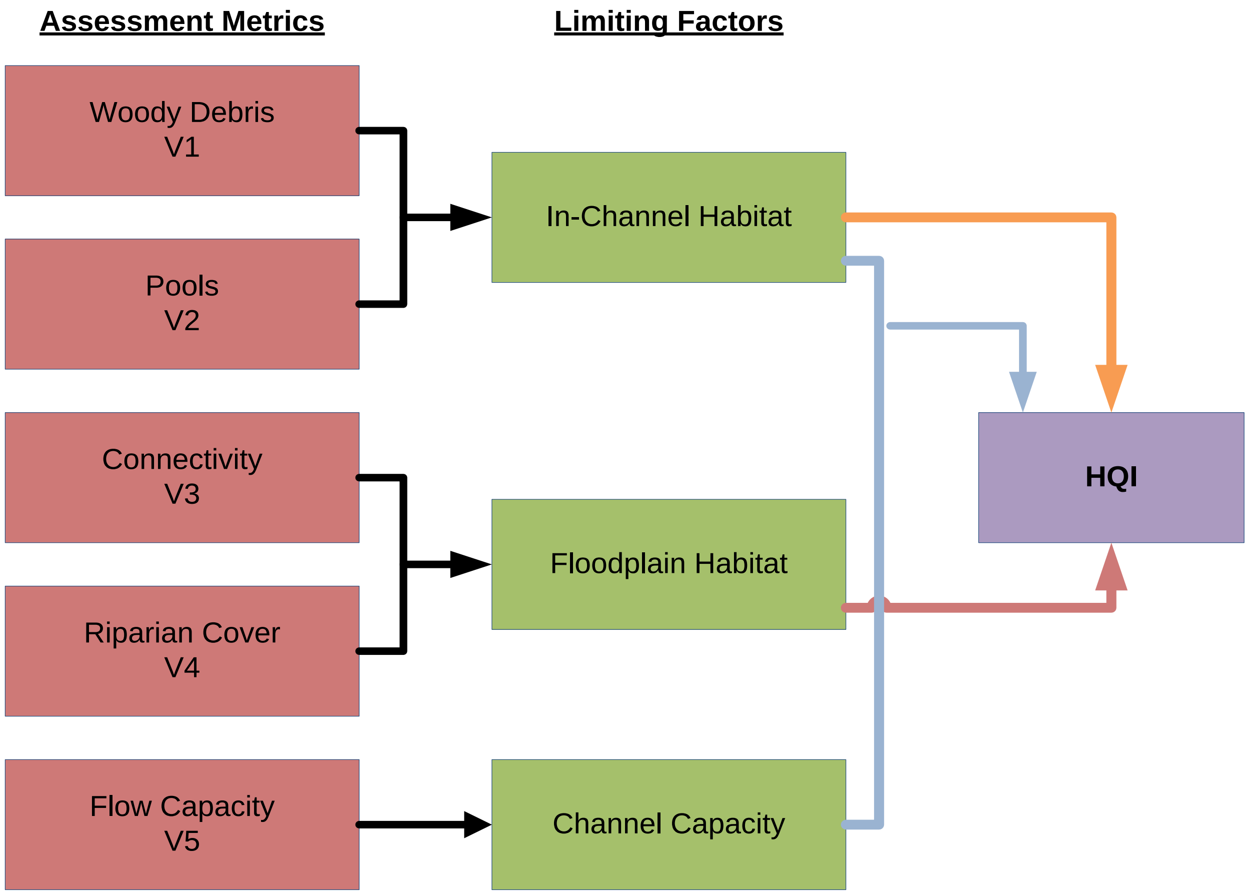


Figure 3-1. Flow Diagram of HQI Computation Based on Assessment Area Limiting Factor(s) and Assessment Metrics

Table 3-1 displays the evaluation of assessment areas by the limiting factor(s) the proposed project increments address. For each assessment area, three evaluations are presented. The first line is the evaluation of the without project condition for the assessment areas and is denoted by a letter followed by 0. It is scored based on the applicable limiting factor(s) and HQI is computed using the applicable HQI equation. The second line is for the project increment (with-project action) and is denoted with the same project letter followed by 1. It evaluates the habitat quality associated with the proposed action and is scored using the same assessment metrics used in the without project condition. Lastly, the third line presents the benefits of the proposed action. The benefits are taken as the change in HQI score multiplied by the affected area of the project.

$$Benefits\ (in\ AAHU) = Change\ in\ HQI\ Score\ (With\ Project - Without\ Project)\ x\ Affected\ Area$$

Table 3-1. EO Model Benefits for Assessment Areas with Channel Capacity and In-Channel Habitat Limiting Factors (Bases)

Quality Index Scores for Applicable Variables									
Project Number	**Project ID**	**Affected Acres**	**V1 - Woody Debris**	**V2 - Pools**	**V3 - Connectivity**	**V4 - Riparian Cover**	**V5 - Capacity**	**HQI**	**AAHU (Affected Acres * HQI)**
Bases: Limiting Factors for Assessment Area = Channel Capacity and In-Channel Habitat HQI = (V1 + V2 + V5)/3									
59	K0	219	0.1	0.21	N/A	N/A	0.03	0.11	24.5
59	K1	219	0.93	0.93	N/A	N/A	1	0.95	208.7
59	***K1***	***219***	***0.83***	***0.72***	***N/A***	***N/A***	***0.97***	***0.84***	***184.2***
50	L0	26	0.1	0.21	N/A	N/A	0.03	0.11	*2.9*
50	L1	26	0.93	0.93	N/A	N/A	0.5	0.79	20.4
50	***L1***	***26***	***0.83***	***0.72***	***N/A***	***N/A***	***0.47***	***0.67***	***17.5***
31	M0	68	0.1	0.21	N/A	N/A	0.03	0.11	*7.6*
31	M1	68	0.93	0.93	N/A	N/A	0.5	0.79	*53.5*
31	***M1***	***68***	***0.83***	***0.72***	***N/A***	***N/A***	***0.47***	***0.67***	***45.9***
62	N0	132	0.1	0.21	N/A	N/A	0.03	0.11	*14.8*
62	N1	132	0.93	0.93	N/A	N/A	1	0.95	*125.8*
62	***N1***	***132***	***0.83***	***0.72***	***N/A***	***N/A***	***0.97***	***0.84***	***111***
In-Channel Increments: Limiting Factors for Assessment Area = In-Channel Habitat HQI = (V1 + V2) / 2									
35	F0	107	0.1	0.21	N/A	N/A	N/A	0.16	16.6
35	F1	107	0.93	0.93	N/A	N/A	N/A	0.93	99.5
35	***F1***	***107***	***0.83***	***0.72***	***N/A***	***N/A***	***N/A***	***0.77***	***82.9***
43	J0	25	0.1	0.21	N/A	N/A	N/A	0.16	3.9
43	J1	25	0.93	0.93	N/A	N/A	N/A	0.93	23.2
43	***J1***	***25***	***0.83***	***0.72***	***N/A***	***N/A***	***N/A***	***0.77***	***19.4***
Floodplain Increments: Limiting Factors for Assessment Area = Floodplain Habitat HQI = (V3 + V4) / 2									
9	B0	45	N/A	N/A	-	0.68	N/A	0.34	15.3
9	B1	45	N/A	N/A	0.94	0.88	N/A	0.91	41
9	***B1***	***45***	***N/A***	***N/A***	***0.94***	***0.94***	***N/A***	***0.57***	***25.7***
26	C0	17	N/A	N/A	-	0.4	N/A	0.2	3.4
26	C1	17	N/A	N/A	0.94	0.95	N/A	0.95	16.1
26	***C1***	***17***	***N/A***	***N/A***	***0.94***	***0.94***	***N/A***	***0.75***	***12.7***
28	D0	23	N/A	N/A	-	0.55	N/A	0.28	6.3
28	D1	23	N/A	N/A	0.94	0.79	N/A	0.87	19.9
28	***D1***	***23***	***N/A***	***N/A***	***0.94***	***0.94***	***N/A***	***0.59***	***13.6***
37	G0	34	N/A	N/A	-	0.61	N/A	0.31	10.4
37	G1	34	N/A	N/A	0.94	0.76	N/A	0.85	28.9
37	***G1***	***34***	***N/A***	***N/A***	***0.94***	***0.94***	***N/A***	***0.54***	***18.5***
39	H0	0.5	N/A	N/A	-	0.81	N/A	0.41	0.2
39	H1	0.5	N/A	N/A	0.94	0.88	N/A	0.91	0.5
39	***H1***	***0.5***	***N/A***	***N/A***	***0.94***	***0.94***	***N/A***	***0.51***	***0.3***
40	I0	29	N/A	N/A	-	0.1	N/A	0.05	1.5
40	I1	29	N/A	N/A	0.94	0.54	N/A	0.74	21.5
40	***I1***	***29***	***N/A***	***N/A***	***0.94***	***0.94***	***N/A***	***0.69***	***20.1***

With any attempt to quantify environmental benefits, the method will have inherent uncertainties and limitations. These model limitations and uncertainties are described in Appendix F, Ecosystem Benefits Model Documentation.

As the study team developed conceptual designs and cost estimates for the bases, a number of disposal options were identified for the riverbed excavation bases. Placement of dredged material in the estuary and nearshore area of the Skokomish River was identified as the most likely disposal option (other options included disposal in a nearby quarry or open-water disposal). Placement of dredged material in approximately 800 acres of the estuary would create high quality shellfish habitat (e.g., hard substrate for oyster attachment) and would significantly reduce costs associated with transportation and disposal of up to 2.5 million cubic yards of dredged material outside of the study area.

It should be noted that the environmental benefits model did not formally account for the benefits associated with placing dredged material in the estuary for shellfish attachment; the model only captures benefits related to channel habitat quality, floodplain habitat connectivity, and mainstem river channel capacity. To capture the approximate benefits associated with placement of hard substrate in the estuary for shellfish habitat, the study team developed a conservative estimate for the habitat quality change in the estuary and nearshore (0.25) that would result from placement of dredged material. This habitat quality score was multiplied by the affected area shown in Table 3-2 (511 acres for Base #5 and 843 acres for Base #1). These outputs are presented as “AAHU (Shellfish Substrate)” in Table 3-3.

Table 3-2. Base Benefits

Base	Affected Area Benefits (Channel Benefits)	Approximate Affected Area for Beneficial Use for Shellfish Substrate (Shellfish Benefits)	Improvement of Egg-to-Fry Survival (+/-%)
No Action	0 acres	0 acres	No Change
Base #2	26 acres	0 acres	No Change
Base #3	68 acres	0 acres	No Change
Base #5	132 acres	511 acres	+30%
Base #1	219 acres	843 acres	+52%

Average annual habitat units (AAHU’s) calculated by the environmental benefits model (presented as “AAHU (EO Model)” in Table 3-3) were added to habitat units calculated outside of the EO model (shellfish substrate) to determine total habitat units. The total outputs are presented as “Total AAHU” in Table 3-3.

It should also be noted that the sediment excavation bases (Bases #1 and #5) improve egg-to-fry survival by reducing the frequency of flooding from four or more times annual to once every one to two years. Over the 50 year period of analysis, Base #1 and Base #5 are expected to show 52 percent and 30 percent improvement in egg-to-fry survival, respectively, as shown in Table 3-2. These benefits were not directly incorporated in to the cost effectiveness and incremental cost analyses. Rather, channel capacity improvements are included in the EO model which examines changes to flood flow capacity.

For the purposes of comparing and evaluating alternatives, the AAHU's presented in Table 3-3 will be used in IWR Planning Suite (USACE certified version 2.0.6.0) to evaluate the cost effectiveness and incremental cost of the bases in combinations with the additional incremental projects. Total AAHU's for incremental projects are equal to the difference in AAHU's for the without-project condition and the with-project condition for a given assessment area.

Table 3-3. Revised Environmental Outputs by Restoration Project

Project Number	Base Combinability	Project ID	Project Name	Total Acres Affected	AAHU (EO Model)	AAHU (Shellfish Substrate)	Total AAHU
59	1	K1	Base #1: Riverbed Excavation (RM 0-9)	219 + 843 shellfish = 1,062	184.2	210.8	395.0
50	2	L1	Base #2: Confluence Channel Excavation	26	17.5	n/a	17.5
31	3	M1	Base #3: Confluence Levee Removal	68	45.9	n/a	45.9
62	5	N1	Base #5: Riverbed Excavation (RM 3.5-9)	132 + 219 shellfish = 643	111.0	127.8	238.8
9	all	B1	Side Channel Reconnection	45	25.7	n/a	25.7
26	all	C1	Wetland Restoration at Dips Road	17	12.7	n/a	12.7
28	all	D1	Wetland Restoration at River Mile 9	23	13.6	n/a	13.6
35	all	F1	Upstream LWD Installation	107	82.9	n/a	82.9
37	all	G1	Wetland Restoration at Grange	34	18.5	n/a	18.5
39	2 and 3	H1	Hunter Creek Tributary Mouth Restoration	0.5	0.3	n/a	0.3
40	all	I1	Hunter Creek Tributary Reconnection	29	20.1	n/a	20.1
43	all	J1	Weaver Creek Tributary Reconnection	25	19.4	n/a	19.4

4. Evaluation of Project Costs

Table 4-1 shows the present value construction and real estate costs, computed interest during construction (IDC), periodic operations and maintenance (O&M) costs, and total investment costs and annualized costs for each base and increment at the October 2013 price level. O&M was assumed to be minimal for each of the increments, with exception of the excavation bases (Bases #1, #2, and #5). Periodic sediment excavation would be required to maintain channel capacity and is estimated to occur every 20 years for Bases #1 and #5, or for two cycles during the period of analysis (in years 20 and 40), and every 10 years for Base #2, or five cycles during the period of analysis (in years 10, 20, 30, 40, and 50). Planning level cost estimates were developed for the purposes of alternative formulation and comparison using October 2013 prices. Additional cost information can be found in Appendix K, *Cost Estimate*. Costs were annualized using the IWR Planning Suite Annualization Tool (USACE certified version 2.0.6.0) using the construction cost, real estate cost, construction period (in months) for IDC computations, estimated O&M, the current discount rate (the fiscal year 2013 discount rate is 3.75 percent), and a 50 year period of analysis.

Table 4-1. Average Annual Cost of Bases and Increments (Oct 2013 price level, 3.75% discount rate)

Project Number	Project Name	Construction Cost (1,000s)	Real Estate Cost Estimate ($1,000s)	Interest During Construction ($1,000s)	Total Investment Cost ($1,000s)	Cost for periodic O&M / Frequency	Total Average Annual Cost ($1,000s)
59	Base #1: Riverbed Excavation (RM 0-9)	$141,391	$2	$7,173	$148,567	$43.4 M / Every 20 years (2x)	$8,035
50	Base #2: Confluence Channel Excavation	$14,017	$2	$65	$14,084	$6.2 M / Every 10 years (5x)	$1,153
31	Base #3: Confluence Levee Removal	$6,721	$741	$62	$7,525		$335
62	Base #5: Riverbed Excavation (RM 3.5-9)	$94,756	$2	$2,816	$97,575	$38.0 M / Every 20 years (2x)	$5,548
9	Side Channel Reconnection	$1,024	$2,069	$3	$3,096		$138
26	Wetland Restoration at Dips Road	$5,148	$97	$40	$5,285		$236,
28	Wetland Restoration at River Mile 9	$2,250	$101	$14	$2,365		$105
35	Upstream LWD Installation	$870	$2,357	$3	$3,229		$144
37	Wetland Restoration at Grange	$2,722	$538	$17	$3,277		$146
39	Hunter Creek Tributary Mouth	$11	$193	$0	$204		$9
40	Hunter Creek Tributary Reconnection	$4,190	$1,100	$13	$5,303		$236
43	Weaver Creek Tributary Reconnection	5,318	$2,261	$25	$7,603		$339

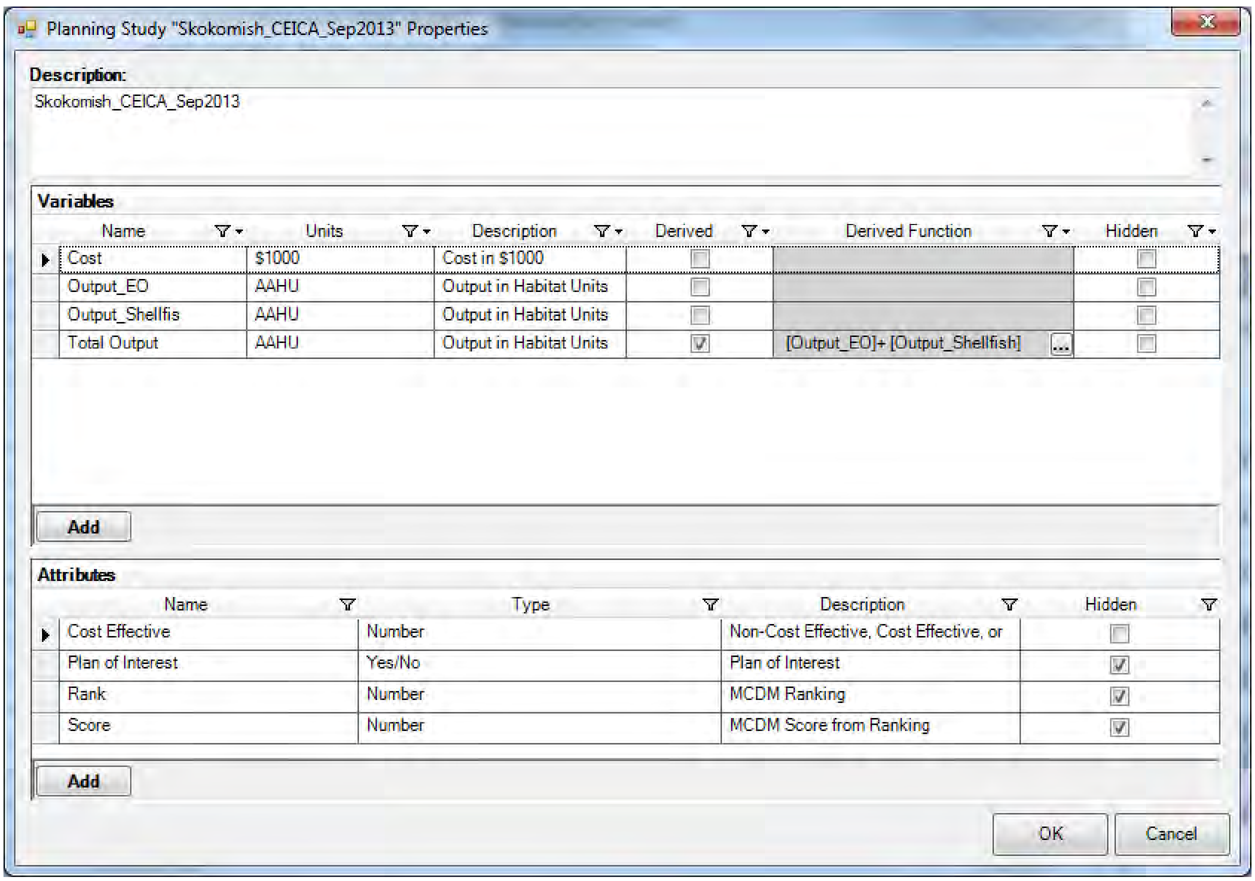
5. IWR Planning Suite Model Inputs for Cost Effectiveness and Incremental Cost Analyses

This section describes the model inputs for performing the cost effectiveness and incremental cost analyses using the IWR Planning Suite, version 2.0.6.0 (USACE certified model). The USACE Institute for Water Resources (IWR) developed this software to assist with the formulation and comparison of alternative plans. The software can assist with plan formulation by combining solutions to planning problems and calculating the additive effect of each combination, or "plan", by utilizing inputs on outputs (AAHU's), costs, and rules (combinability and dependency relationships) for combining solutions into plans. Plans are then compared in IWR Planning Suite by conducting cost effectiveness and incremental cost analyses (CE/ICA), identifying the plans which are the best financial investments, and displaying the effects of each on a range of decision variables. The cost effectiveness and incremental cost analyses are presented in Section 6.

5.1 Planning Study Properties

Figure 5-1 displays the study variables for the cost effectiveness and incremental cost analysis. Cost is input as an annual cost in $1,000s. Two output scores are input Average Annual Habitat Units (AAHU), one for the Environmental Outputs Model AAHU's ("Output_EO") and one for shellfish substrate ("Output_Shellfis"). Total output ("Total Output") is derived by adding together two output scores ("[Output_EO] + [Output_Shellfish]"), and is also measured in AAHU's.

Figure 5-1. Planning Study Properties



Planning Study "Skokomish_CEICA_Sep2013" Properties

Description:
Skokomish_CEICA_Sep2013

Variables

Name	Units	Description	Derived	Derived Function	Hidden
Cost	$1000	Cost in $1000	☐		☐
Output_EO	AAHU	Output in Habitat Units	☐		☐
Output_Shellfis	AAHU	Output in Habitat Units	☐		☐
Total Output	AAHU	Output in Habitat Units	☑	[Output_EO]+ [Output_Shellfish]	☐

Add

Attributes

Name	Type	Description	Hidden
Cost Effective	Number	Non-Cost Effective, Cost Effective, or	☐
Plan of Interest	Yes/No	Plan of Interest	☑
Rank	Number	MCDM Ranking	☑
Score	Number	MCDM Score from Ranking	☑

Add

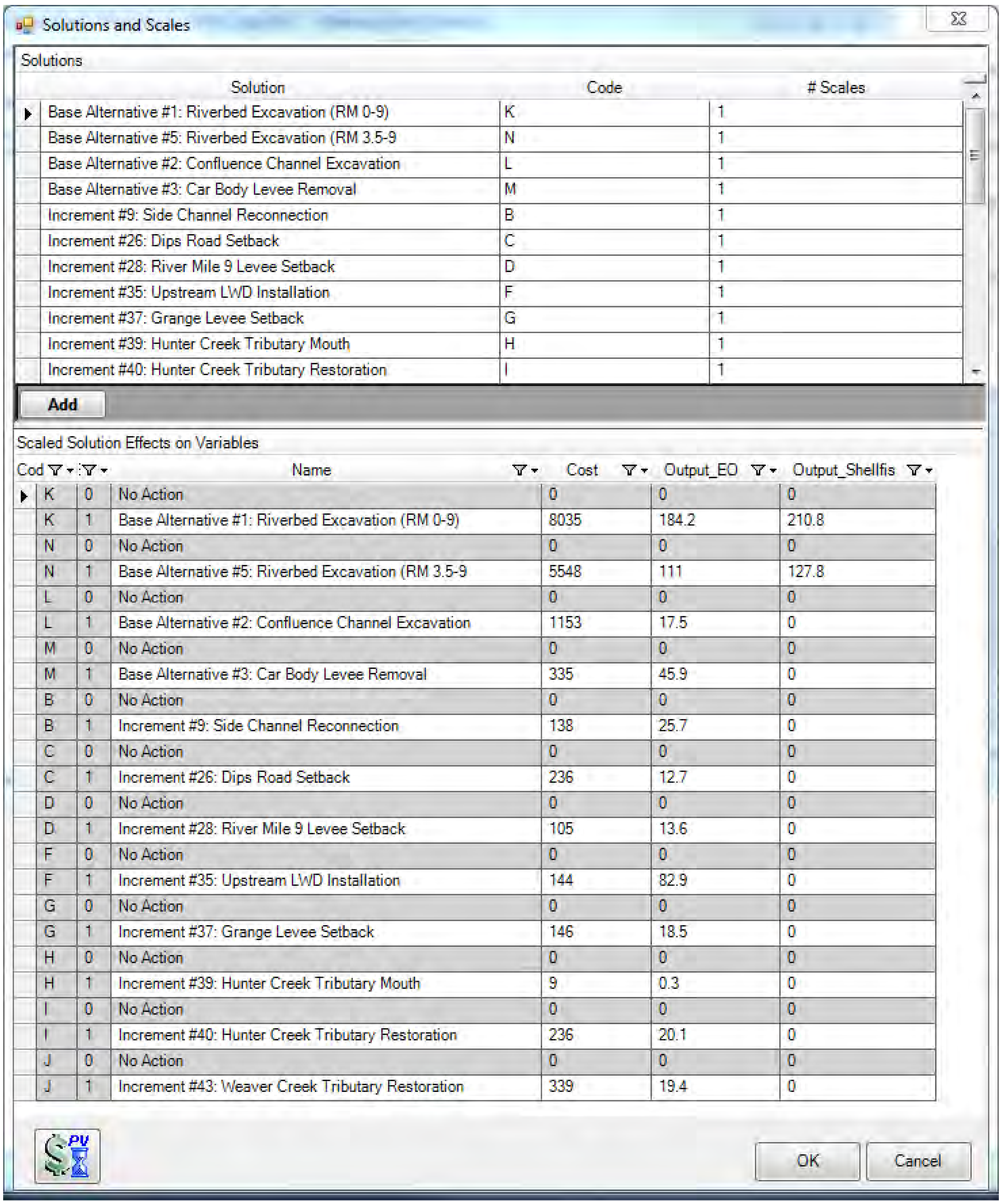
OK Cancel

5.2 Solutions and Scales

Four bases and eight project increments were input into IWR Planning Suite as shown in Figure 5-2. Along with the project name, other inputs for the bases and project increments include the average annual cost ("Cost" column, derived using the Annualizer in IWR Planning Suite), AAHU's derived from the Environmental Outputs Model ("Output_EO"), and AAHU's estimated for shellfish substrate associated with dredged material placement for Bases #1 and #5 ("Output_Shellfis"). Each unique project is assigned a code letter (i.e. Base #1 is code "K"). Each project has a No Action cost and output equal to zero. The output for the action is gain in output (AAHU's) to be realized with implementation of the proposed project as compared to the No Action.

At the time that IWR Planning Suite was used to evaluate potential alternatives, the project team was using local site names to refer to each site where measures could be combined and evaluated as alternatives. During the project's feasibility-level design phase, site names were formalized in the Final Feasibility Report and Environmental Impact Statement; therefore, some site names presented in the figures below have changed, but no new sites were added to the analysis.

Figure 5-2. Solutions and Scales



Solutions and Scales

Solutions

Solution	Code	# Scales
Base Alternative #1: Riverbed Excavation (RM 0-9)	K	1
Base Alternative #5: Riverbed Excavation (RM 3.5-9	N	1
Base Alternative #2: Confluence Channel Excavation	L	1
Base Alternative #3: Car Body Levee Removal	M	1
Increment #9: Side Channel Reconnection	B	1
Increment #26: Dips Road Setback	C	1
Increment #28: River Mile 9 Levee Setback	D	1
Increment #35: Upstream LWD Installation	F	1
Increment #37: Grange Levee Setback	G	1
Increment #39: Hunter Creek Tributary Mouth	H	1
Increment #40: Hunter Creek Tributary Restoration	I	1

Add

Scaled Solution Effects on Variables

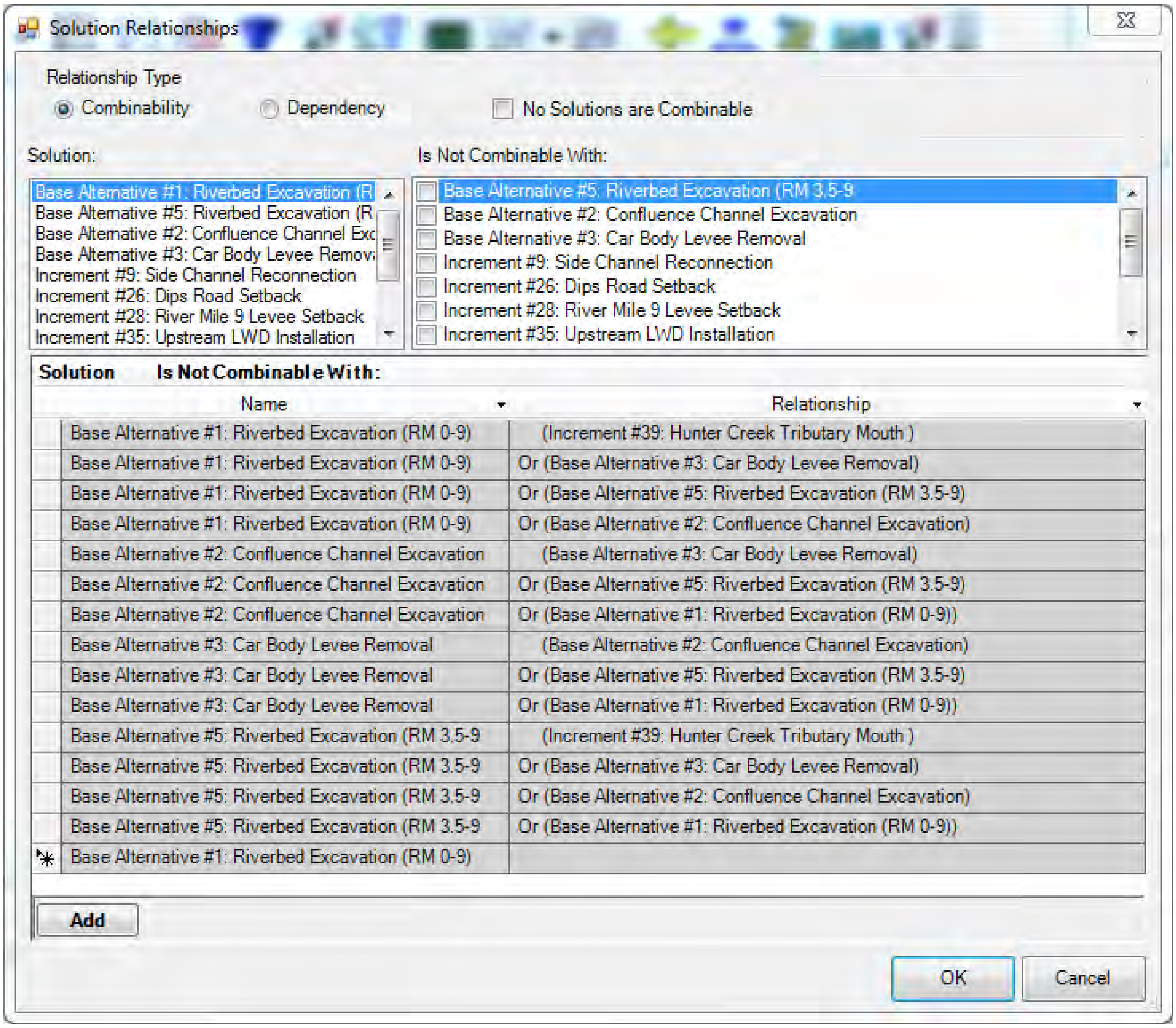
Cod	:	Name	Cost	Output_EO	Output_Shellfis
K	0	No Action	0	0	0
K	1	Base Alternative #1: Riverbed Excavation (RM 0-9)	8035	184.2	210.8
N	0	No Action	0	0	0
N	1	Base Alternative #5: Riverbed Excavation (RM 3.5-9	5548	111	127.8
L	0	No Action	0	0	0
L	1	Base Alternative #2: Confluence Channel Excavation	1153	17.5	0
M	0	No Action	0	0	0
M	1	Base Alternative #3: Car Body Levee Removal	335	45.9	0
B	0	No Action	0	0	0
B	1	Increment #9: Side Channel Reconnection	138	25.7	0
C	0	No Action	0	0	0
C	1	Increment #26: Dips Road Setback	236	12.7	0
D	0	No Action	0	0	0
D	1	Increment #28: River Mile 9 Levee Setback	105	13.6	0
F	0	No Action	0	0	0
F	1	Increment #35: Upstream LWD Installation	144	82.9	0
G	0	No Action	0	0	0
G	1	Increment #37: Grange Levee Setback	146	18.5	0
H	0	No Action	0	0	0
H	1	Increment #39: Hunter Creek Tributary Mouth	9	0.3	0
I	0	No Action	0	0	0
I	1	Increment #40: Hunter Creek Tributary Restoration	236	20.1	0
J	0	No Action	0	0	0
J	1	Increment #43: Weaver Creek Tributary Restoration	339	19.4	0

OK Cancel

5.3 Solution Relationships – Combinability

Combinability relationships were input in IWR Planning Suite as shown in Figure 5-3. Generally all solutions are combinable, with exception to the bases. No bases may be combined with any other base.

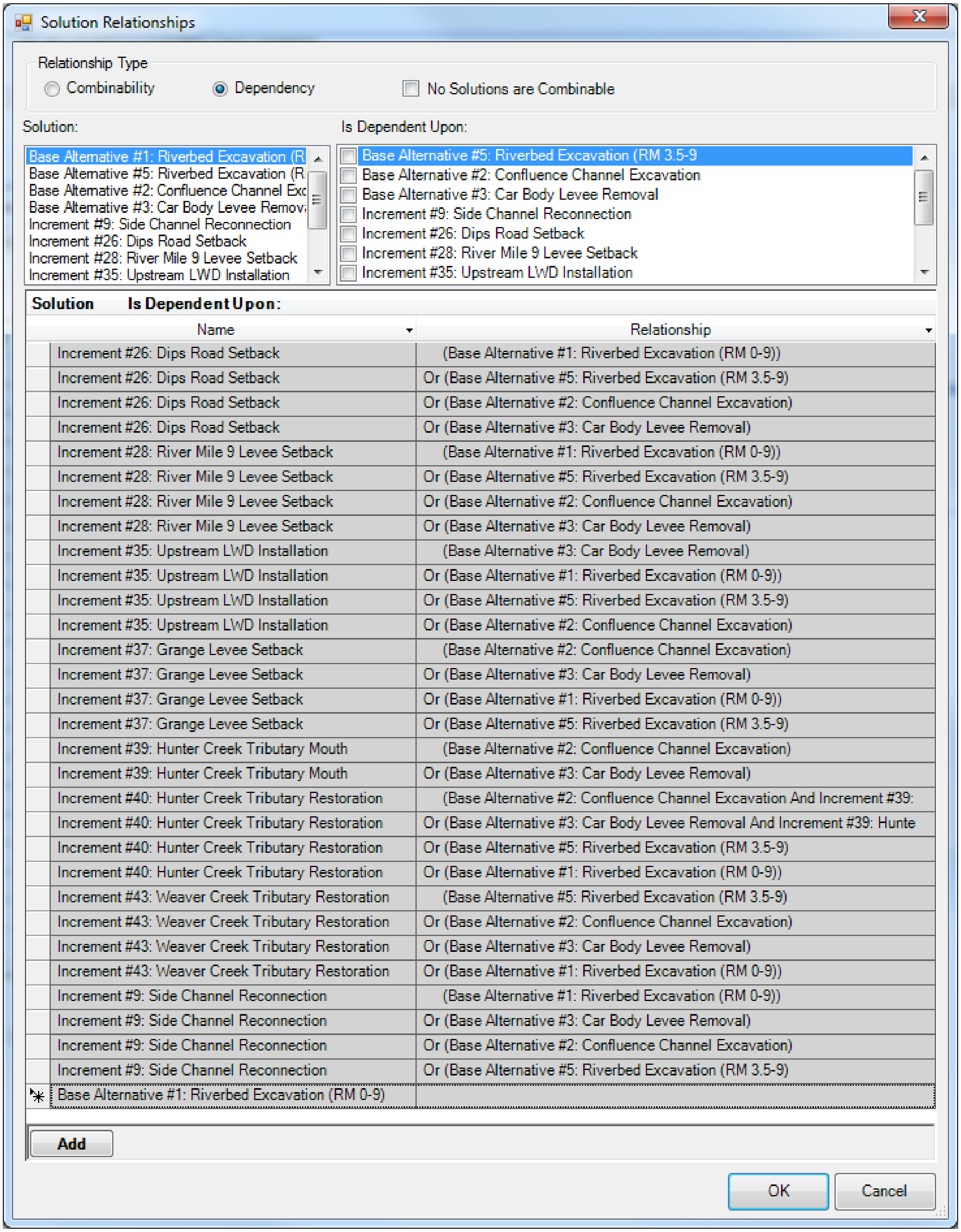
Figure 5-3. Solution Relationships – Combinability



5.4 Solution Relationships – Dependency

Dependency relationships were input in IWR Planning Suite as shown in Figure 5-4. Each incremental project is dependent on a base. Increment #40, Weaver Creek Tributary Restoration, is dependent on Increment #39, Hunter Creek Tributary Mouth, when combined with Base #2, Confluence Channel Excavation, and Base #3, Confluence Levee Removal. The mouth of Hunter Creek Tributary is assumed to be addressed by the excavation associated with Bases #1, Riverbed Excavation (River Mile 0-9), and #5, Riverbed Excavation (RM 3.5-9).

Figure 5-4. Solution Relationships – Dependency



6. Cost Effectiveness and Incremental Cost Analysis (CE/ICA) Alternatives Evaluation

Traditional benefit-cost analysis is not possible for this restoration study because costs and benefits are expressed in different units. Rather, cost effectiveness and incremental cost analysis (CE/ICA) was used to assist the process of determining what project features and design alternatives should be built based on comparison of quantified habitat benefits (outputs) and estimated costs of alternative feature designs. Cost effectiveness analysis is conducted to ensure that the least cost plan is identified for each possible level of environmental output; and that for any level of investment, the maximum level of output is identified. Subsequent incremental cost analysis of the cost effective plans is conducted to reveal changes in costs as output levels are increased.

Given the IWR Planning Suite inputs described in Section 5, a total of 705 plans were generated. Of these, 60 plans (including the No-Action Alternative) were identified as being cost effective using the cost effectiveness analysis. Cost effective plans are listed in Table 6-1 and all possible plans are displayed in Figure 6-1 as those plans which provide a given level of output at the lowest cost denoted by blue triangles and red squares. Those plans which are not cost effective are denoted by circles. Table 6-1 shows "best buy" plans in bold font, and plans that were carried forward into the final array of alternatives are highlighted in different colors. The process used to carry these plans forward is described in Section 7.

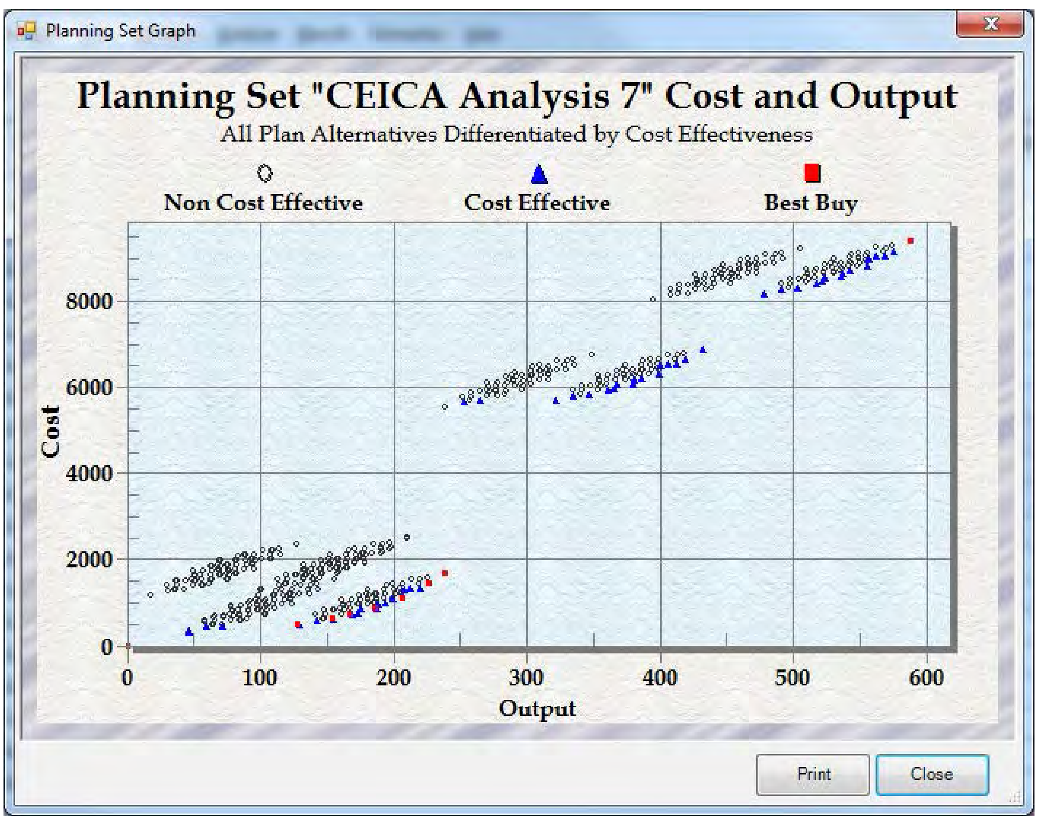


Figure 6-1. Plot of Plan Costs and Output

Table 6-1. Cost Effective Plans* (Oct 2013 price level, 3.75% discount rate)

Alternative # (Original #)	Plan Components	AAHU (In-Channel, Floodplain, and Capacity)	AAHU (Shellfish Substrate)	Total AAHU	Total Average Annual Cost ($1,000s)	Average Annual Cost/ AAHU
1	**No Action Plan**	**0.0**	**0.0**	**0.0**	**0**	
2	Base 3	45.9	0.0	45.9	335	7.30
3	Base 3+ Increment 39	46.2	0.0	46.2	344	7.45
4	Base 3+ Increment 28	59.5	0.0	59.5	440	7.39
5	Base 3+ Increments 28+39	59.8	0.0	59.8	449	7.51
6	Base 3+ Increment 9	71.6	0.0	71.6	473	6.61
7	**Base 3+ Increment 35**	**128.8**	**0.0**	**128.8**	**479**	**3.72**
8	Base 3+ Increments 35+39	129.1	0.0	129.1	488	3.78
9	Base 3+ Increments 35+28	142.4	0.0	142.4	584	4.10
10	Base 3+ Increments 35+28+39	142.7	0.0	142.7	593	4.16
11	**Base 3+ Increments 35+9**	**154.5**	**0.0**	**154.5**	**617**	**3.99**
12	Base 3+ Increments 35+9+39	154.8	0.0	154.8	626	4.04
13	**Base 3+ Increments 35+9+28**	**168.1**	**0.0**	**168.1**	**722**	**4.30**
14	Base 3+ Increments 35+9+28+39	168.4	0.0	168.4	731	4.34
15	Base 3+ Increments 35+9+37	173.0	0.0	173.0	763	4.41
16	Base 3+ Increments 35+9+37+39	173.3	0.0	173.3	772	4.45
17	Base 3+ Increments 35+9+39+40	174.9	0.0	174.9	862	4.93
18	**Base 3+ Increments 35+9+28+37**	**186.6**	**0.0**	**186.6**	**868**	**4.65**
19	Base 3+ Increments 35+9+28+37+39	186.9	0.0	186.9	877	4.69
20	Base 3+ Increments 35+9+39+40+28	188.5	0.0	188.5	967	5.13
21	Base 3+ Increments 35+9+37+39+40	193.4	0.0	193.4	1,008	5.21
22	Base 3+ Increments 35+9+28+37+26	199.3	0.0	199.3	1,104	5.54
23	**Base 3+ Increments 35+9+28+37+39+40**	**207.0**	**0.0**	**207.0**	**1,113**	**5.38**
24	Base 3+ Increments 35+9+28+39+40+43	207.9	0.0	207.9	1,306	6.28
25	Base 3+ Increments 35+9+37+39+40+43	212.8	0.0	212.8	1,347	6.33
26	Base 3+ Increments 35+9+28+37+39+40+26	219.7	0.0	219.7	1,349	6.14
27	**Base 3+ Increments 35+9+37+39+40+43+28**	**226.4**	**0.0**	**226.4**	**1,452**	**6.41**
28	**Base 3+ Increments 35+9+37+39+40+43+28+26**	**239.1**	**0.0**	**239.1**	**1,688**	**7.06**
29	Base 5+ Increment 28	124.6	127.8	252.4	5,653	22.40
30	Base 5+ Increment 9	136.7	127.8	264.5	5,686	21.50
31	Base 5+ Increment 35	193.9	127.8	321.7	5,692	17.69
32	Base 5+ Increments 35+28	207.5	127.8	335.3	5,797	17.29
33	Base 5+ Increments 35+9	219.6	127.8	347.4	5,830	16.78
34	Base 5+ Increments 35+9+28	233.2	127.8	361.0	5,935	16.44
35	Base 5+ Increments 35+9+37	238.1	127.8	365.9	5,976	16.33
36	Base 5+ Increments 35+9+40	239.7	127.8	367.5	6,066	16.51
37	Base 5+ Increments 35+9+28+37	251.7	127.8	379.5	6,081	16.02
38	Base 5+ Increments 35+9+28+40	253.3	127.8	381.1	6,171	16.19
39	Base 5+ Increments 35+9+40+37	258.2	127.8	386.0	6,212	16.09
40	Base 5+ Increments 35+9+40+37+28	271.8	127.8	399.6	6,317	15.81
41	Base 5+ Increments 35+9+28+40+43	272.7	127.8	400.5	6,510	16.25
42	Base 5+ Increments 35+9+28+40+43+37	277.6	127.8	405.4	6,551	16.16
43	Base 5+ Increments 35+9+40+37+28+26	284.5	127.8	412.3	6,553	15.89
44	Base 5+ Increments 35+9+40+37+28+43	291.2	127.8	419.0	6,656	15.89
45	Base 5+ Increments 35+9+40+37+28+43+26	303.9	127.8	431.7	6,892	15.96

Alternative # (Original #)	Plan Components	AAHU (In-Channel, Floodplain, and Capacity)	AAHU (Shellfish Substrate)	Total AAHU	Total Average Annual Cost ($1,000s)	Average Annual Cost/ AAHU
46	Base 1+ Increment 35	267.1	210.8	477.9	8,179	17.11
47	Base 1+ Increments 35+28	280.7	210.8	491.5	8,284	16.85
48	Base 1+ Increments 35+9	292.8	210.8	503.6	8,317	16.52
49	Base 1+ Increments 35+9+28	306.4	210.8	517.2	8,422	16.28
50	Base 1+ Increments 35+9+37	311.3	210.8	522.1	8,463	16.21
51	Base 1+ Increments 35+9+40	312.9	210.8	523.7	8,553	16.33
52	Base 1+ Increments 35+9+28+37	324.9	210.8	535.7	8,568	15.99
53	Base 1+ Increments 35+9+28+40	326.5	210.8	537.3	8,658	16.11
54	Base 1+ Increments 35+9+40+37	331.4	210.8	542.2	8,699	16.04
55	Base 1+ Increments 35+9+40+37+28	345.0	210.8	555.8	8,804	15.84
56	Base 1+ Increments 35+9+28+40+43	345.9	210.8	556.7	8,997	16.16
57	Base 1+ Increments 35+9+28+40+43+37	350.8	210.8	561.6	9,038	16.09
58	Base 1+ Increments 35+9+40+37+28+26	357.7	210.8	568.5	9,040	15.90
59	Base 1+ Increments 35+9+40+37+28+43	364.4	210.8	575.2	9,143	15.90
60	**Base 1+ Increments 35+9+40+37+28+43+26**	**377.1**	**210.8**	**587.9**	**9,379**	**15.95**

*Plans in bold represent "Best Buy" plans.

Incremental cost analysis identified nine of the cost effective plans as "Best Buy" plans, defined as those cost effective plans which provide the greatest incremental increase in output (benefits) for the lowest incremental increase in cost. These best buy plans are listed in Table 6-2 and include total output, total average annual cost, average cost per output, and incremental cost per incremental output. The incremental costs of the best buy plans are displayed as a bar graph in Figure 6-2. The first best buy plan is the No Action Plan. Seven of the remaining eight best buy plans are combinations of increments with Base #3 Confluence Levee Removal. The last best buy (Alternative #60/Best Buy 9) is Base #1 Riverbed Excavation RM 0-9 with all combinable increments. The incremental cost per output of the last best buy is $22,000 per AAHU, or an approximate $3,500 incremental cost per unit than the previous best buy (Alternative #28/Best Buy 8). The study team included a smaller scale sediment excavation plan (Base #5 Riverbed Excavation RM 3.5-9) in the final array of alternatives due to the high cost and scale of Base #1 Riverbed Excavation RM 0-9. The Base #5 plan carried forward is Alternative #45 from the cost effective plans. The incremental cost per output for this plan is estimated at $27,000 per AAHU, which has a higher incremental cost per output than the large scale riverbed excavation plan (Alternative #60/Best Buy 9).

Table 6-2. Best Buy Plans and Increment Cost per Incremental Output (Oct 2013 price level, 3.75% discount rate)

Alternative #	Plan Components	Total Output in AAHU's	Total Average Annual Cost (AAC in $K)	AAC/ AAHU ($K)	Incremental Cost/Incremental Output ($K)	Total Present Value Cost ($K)	Cost Effective and/or Best Buy?	Improves Egg-to-Fry Survival?
1	No Action Plan	0.0	0				Best Buy 1	No
7	Base #3: Confluence Levee Removal +35	128.8	479	$3.71	$3.71	$10,754	Best Buy 2	No
11	Base #3: Confluence Levee Removal +35+9	154.5	617	$3.99	$5.37	$13,850	Best Buy 3	No
13	Base #3: Confluence Levee Removal +35+9+28	168.1	722	$4.30	$7.72	$16,215	Best Buy 4	No
18	Base #3: Confluence Levee Removal +35+9+28+37	186.6	868	$4.65	$7.89	$19,492	Best Buy 5	No
23	Base #3: Confluence Levee Removal +35+9+28+37+39+40	207.0	1,113	$5.38	$12.01	$24,999	Best Buy 6	No
27	Base #3: Confluence Levee Removal +35+9+37+28+39+40+43	226.4	1,452	$6.41	$17.47	$32,602	Best Buy 7	No
28	Base #3: Confluence Levee Removal +35+9+37+28+39+40+43+26	239.1	1,688	$7.06	$18.58	$37,887	Best Buy 8	No
45	Base #5: Riverbed Excavation RM 3.5-9 +35+9+37+28+40+43+26	431.7	6,892	$15.96	$27.02	$154,623	Cost Effective	Yes
60	Base #1: Riverbed Excavation RM 0-9 +35+9+37+28+40+43+26	587.9	9,379	$16.00	$22.05	$210,434	Best Buy 9	Yes

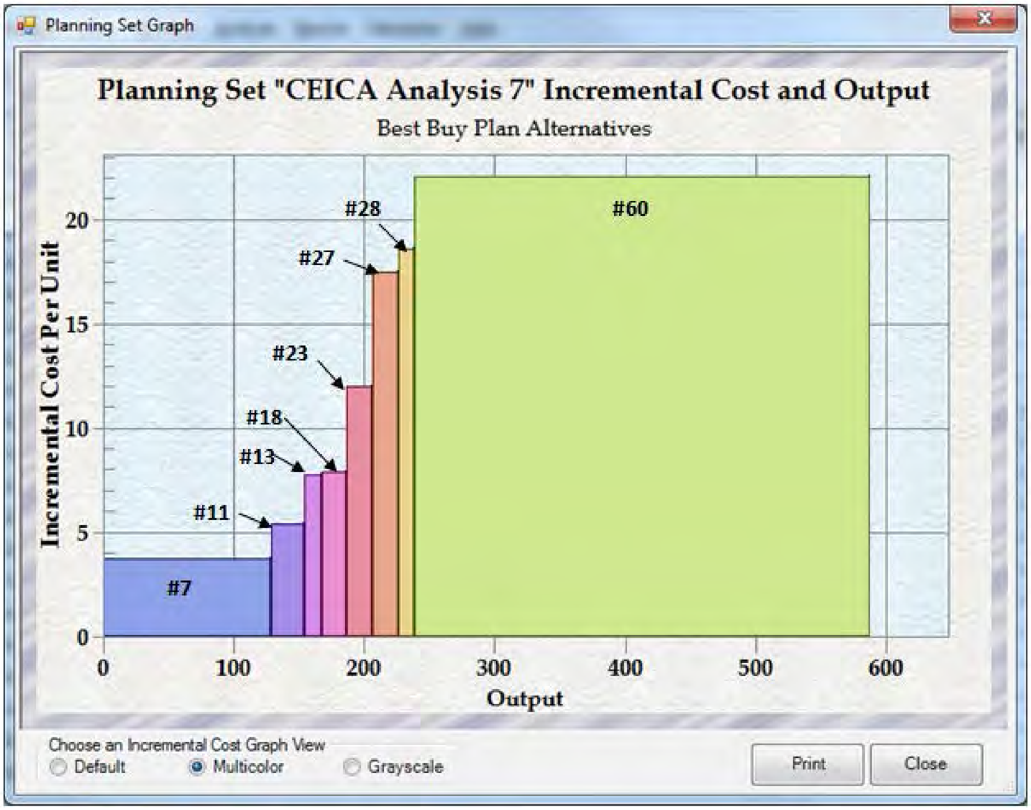


Figure 6-2. Incremental Cost and Output

7. Final Array of Alternatives

The alternatives carried forward for detailed evaluation in the final array were chosen based on CE/ICA results, total cost, incremental cost, and ecological value added between increments. This step resulted in carrying forward six alternatives into the final array of alternatives. The final array of alternatives includes the No-Action Alternative, three Confluence Levee Removal alternatives, and two Riverbed Excavation alternatives.

Logic for screening was based on habitat types restored by each alternative. Side channel or tributary increments provide rearing and refuge habitats in an active channel setting. In contrast, the wetland restoration increments (located at River Mile 9 and the Grange) reconnect floodplain and riparian zones but do not directly provide an active channel habitat in the reconnected zone. Both of these types of increments provide important but slightly different ecosystem restoration benefits.

Alternative #11 was carried forward because it is the first alternative that includes reconnection of a side channel, identified as critical rearing and refuge habitat in the study area. Alternative #18 was carried forward because it includes two wetland restoration increments at River Mile 9 and the Grange; these increments improve floodplain habitat connectivity in critical forested riparian zones of the study area, providing benefits to all riverine life stages of salmonids by increasing available spawning, incubation, rearing, and over-wintering habitats as well as high flow refuge for flood survival, and improving and expanding wetlands. Alternative #27 was carried forward because it represents one of the largest-scale Confluence Levee Removal alternatives with all but one increment (a road relocation) included in the plan. While Alternative #45 is cost effective only, it was carried forward into the final array of alternatives because it meets the critical needs of the study area while requiring a smaller extent of dredging compared to Alternative #60. Alternative #60 was carried forward because it is the largest-scale Best Buy Plan and represents the most significant Federal investment for the study.

Alternatives #7, #13, #23, and #28 were not carried forward into the final array of alternatives. While Alternative #7 represents the least cost best buy plan, it was not carried forward because it does not include side channel reconnections, wetland restoration increments or tributary restorations, which are all critical habitat types requiring restoration in the study area. Although Alternative #13 includes a side channel reconnection, it was not carried forward because it only includes a single wetland restoration increment (Wetland Restoration at River Mile 9); restoration and reconnection of floodplain habitat in two riparian zone wetlands represents a more complete alternative. Similarly, Alternative #23 was not carried forward because it only includes one of two tributary restoration increments, significantly limiting the area of tributary restoration in the study area. Hunter Creek and Weaver Creek are the only two perennial groundwater-fed streams in the lower Skokomish Basin and restoration of fluvial and biological processes in both tributaries represents a more complete alternative.

Finally, Alternative #28 was not carried forward into the final array of alternatives. The only difference between Alternative #27 (carried forward into the final array) and Alternative #28 is the inclusion of wetland restoration at Dips Road, a road relocation increment which is not a feature that could be cost-shared as part of a proposed National Ecosystem Restoration Plan. This individual increment may be constructed by the non-Federal sponsors but was not carried forward as a best buy plan (Alternative #28) in the final array of alternatives. While the CE/ICA analysis presented in this report includes the Dips Road increment, Section 8.2 of the Economics Appendix (Appendix G) presents the results of a sensitivity analysis of CE/ICA that does not include the Dips Road increment. This sensitivity run removed the Dips Road increment and re-ran CE/ICA to determine whether the cost effective and incremental analysis results would change significantly without this feature. The analysis indicates that the final array of alternatives presented in this report are still considered to be cost effective and best buy plans.

Each alternative included in the final array meets the purpose and need for action. The best buy plans carried forward into the final array of alternatives is shown in Figure 7-1. As noted above, Alternative #45 is cost effective only and does not appear as a best buy plan in this figure. Descriptions of the final array of alternatives are included in the feasibility report.

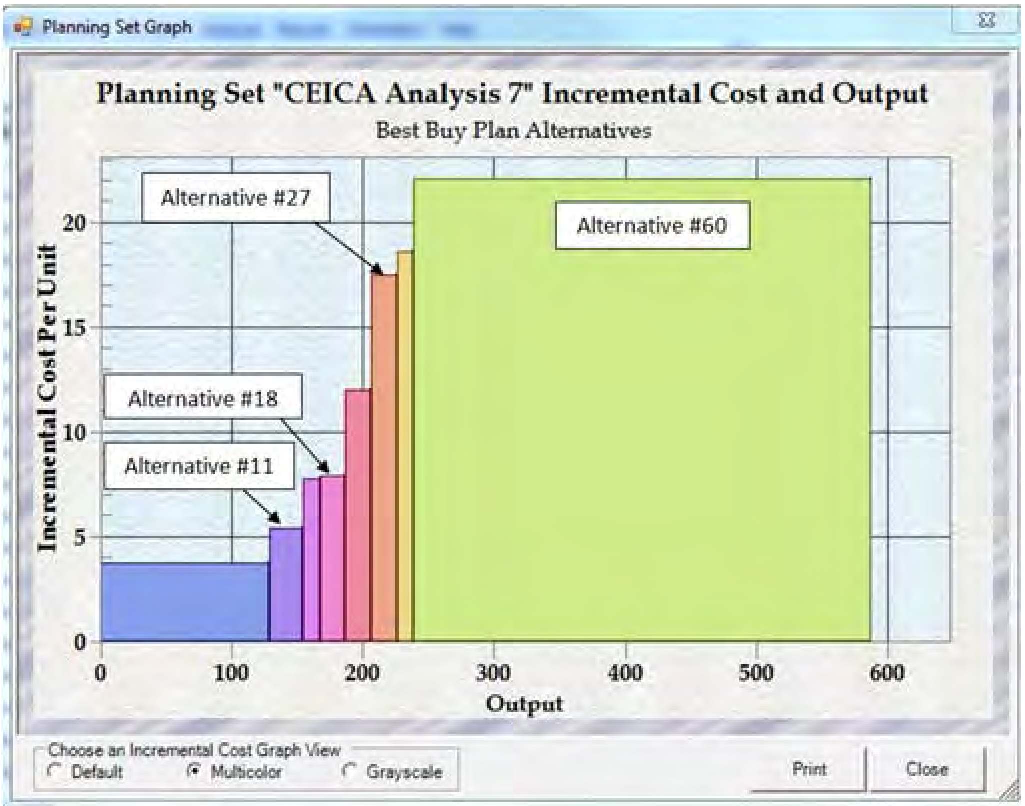


Figure 7-1. Best Buy Plans Carried Forward into Final Array of Alternatives

Table 7-1 summarizes the habitat benefit (AAHU's), acres restored, and average annual cost of the final array of alternatives. The total AAHU's and average annual cost of the alternatives are plotted in Figure 7-2. A plot of the incremental cost per output which includes cost effective Alternative #45 is shown in Figure 7-3. Alternative #45 is approximately $5,000 per incremental output greater than Alternative #60.

Table 7-1. Habitat Outputs and Costs of Final Array of Alternatives (Oct 2013 price level, 3.75% discount rate)

Alternative #	Plan Components	Habitat Units (In-Channel, Floodplain, and Capacity)	Habitat Units (Shellfish Substrate)	Total Habitat Units	Total Acres Restored	Total Annual Cost ($1,000s)
No Action Alternative						
1	No Action Plan	0	n/a	0	0	$0
Confluence Levee Removal Alternatives						
11	Alternative #11 Confluence Levee Removal: *Base #3: Confluence Levee Removal* Increment 35 – Upstream LWD Increment 9 – Side Channel Reconnection	154.5	n/a	154.5	220 In-Channel and Floodplain	$617
18	Alternative #18 Confluence Levee Removal: Base #3: Confluence Levee Removal Increment 35 – Upstream LWD Increment 9 – Side Channel Reconnection Increment 37 – Wetland Restoration at Grange Increment 28 – Wetland Restoration at River Mile 9	186.6	n/a	186.6	277 In-Channel and Floodplain	$868
27	Alternative #27: Confluence Levee Removal: *Base #3: Confluence Levee Removal* Increment 35 – Upstream LWD Increment 9 – Side Channel Reconnection Increment 37 – Wetland Restoration at Grange Increment 28 – Wetland Restoration at River Mile 9 Increment 39 – Hunter Creek Tributary Mouth Increment 40 – Hunter Creek Tributary Restoration Increment 43 – Weaver Creek Tributary Restoration	226.4	n/a	226.4	331.5 In-Channel and Floodplain	$1,452
Riverbed Excavation Alternatives						
45	Alternative #45 Riverbed Excavation: *Base #5: Riverbed Excavation (RM 3.5-9)* Increment 35 – Upstream LWD Increment 9 – Side Channel Reconnection Increment 37 – Wetland Restoration at Grange Increment 28 – Wetland Restoration at River Mile 9 Increment 40 – Hunter Creek Tributary Restoration Increment 43 – Weaver Creek Tributary Restoration Increment 26 – Wetland Restoration at Dips Road	303.9	127.8	431.7	412 In-Channel & Floodplain + 511 Shellfish = 923 Total Acres Restored	$6,892

Alternative #	Plan Components	Habitat Units (In-Channel, Floodplain, and Capacity)	Habitat Units (Shellfish Substrate)	Total Habitat Units	Total Acres Restored	Total Annual Cost ($1,000s)
60	Alternative #60 Riverbed Excavation: *Base #1: Riverbed Excavation (RM 0-9)* Increment 35 – Upstream LWD Increment 9 – Side Channel Reconnection Increment 37 – Wetland Restoration at Grange Increment 28 – Wetland Restoration at River Mile 9 Increment 40 – Hunter Creek Tributary Restoration Increment 43 – Weaver Creek Tributary Restoration Increment 26 – Wetland Restoration at Dips Road	377.1	210.8	587.9	499 In-Channel & Floodplain + 843 Shellfish = 1,342 Total Acres Restored	$9,379

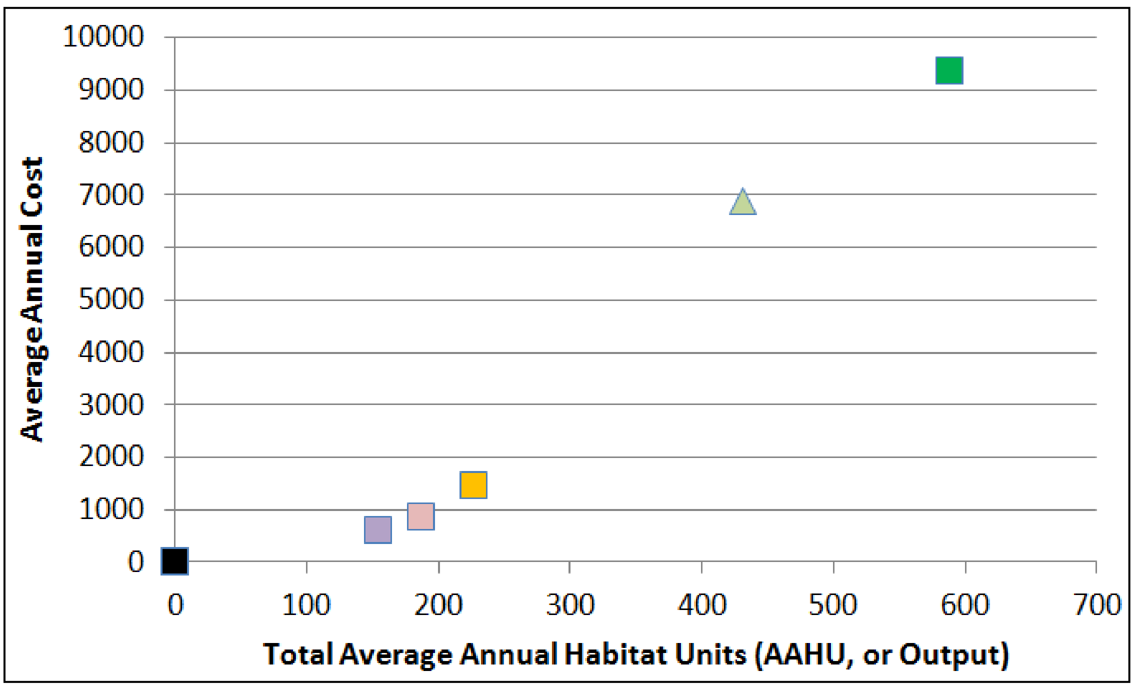


Figure 7-2. Outputs and Costs of Final Array of Alternatives Plot* (Oct 2013 price level, 3.75% discount rate)

*Square denotes “Best Buy” plan; triangle denotes “Cost Effective” plan

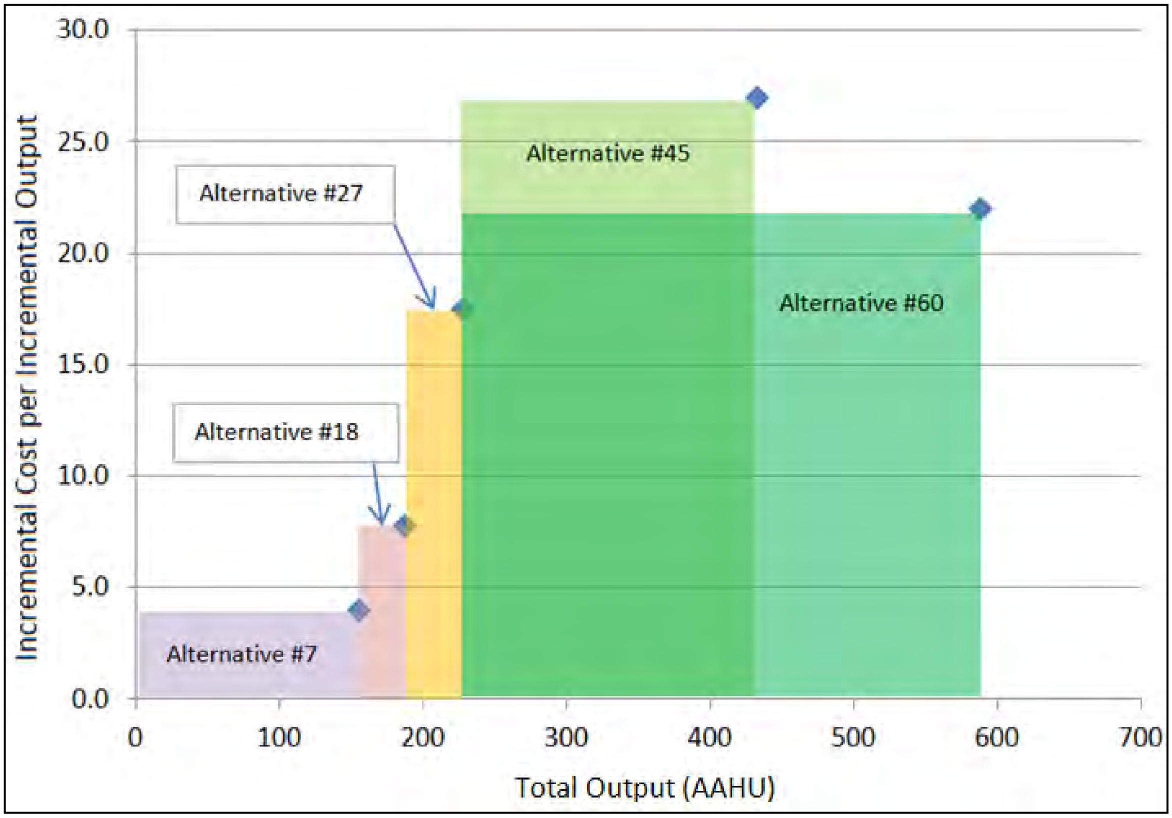


Figure 7-3. Incremental Costs for Final Array of Alternatives (Oct 2013 price level, 3.75% discount rate)

8. Sensitivity Analysis

8.1 CE/ICA With EO Model Outputs Only

A sensitivity run of the cost effectiveness and incremental analysis was performed on the EO Model outputs only, with benefits for shellfish substrate not included in this model. This sensitivity analysis was conducted once designs were refined for those increments carried forward. There were several disposal options considered for the large-scale riverbed excavation. The most feasible and cost effective disposal option was placement of material in the estuary. This placement of material would have benefits to shellfish. These incidental benefits were not accounted for in the development of the EO Model and were added after the fact assuming a moderate quality benefit for shellfish without use of an existing shellfish model. A sensitivity analysis was conducted to determine changes to the cost effectiveness and incremental cost analysis for not including these incidental shellfish benefits.

Costs for the base alternatives and increments did not change with changes to the benefits. Outputs for Bases #1 and #5 were reduced from 395.0 and 238.8 to 184.2 and 111.0, respectively. Figure 8-1 shows a plot of costs and outputs for each possible plan combination. There were 705 possible plan combinations, 50 of which were cost effective plans, and 9 of which were best buy plans. The best buy plans for this run of incremental cost analysis were the same as the best buy plans identified from the incremental cost analysis that included the shellfish benefits. Incremental costs for Best Buy 9 (Base #1 with each combinable increment) increased from $22.05 to $55.73 per incremental output. The best buy incremental costs are displayed in Figure 8-2, and the incremental costs of the best buy plans are included in Table 8-1. The final array of alternatives is highlighted in Table 8-1. Without inclusion of the shellfish substrate benefits, total AAHU's are reduced from 587.9 to 377.1 which results in a steeper and narrower bar for the last best buy plan (Best Buy 9, green bar) as the bar graph shown in Figure 8-2.

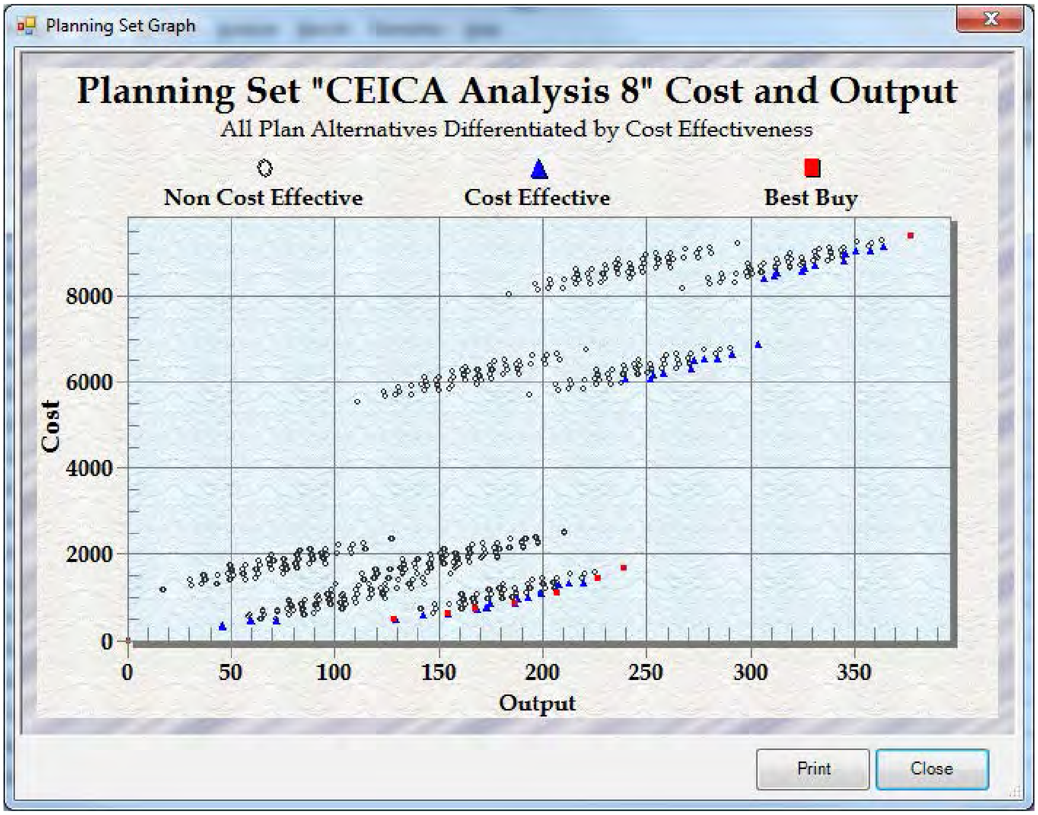


Figure 8-1. Plot of Plan Costs and Outputs, EO Model Benefits Only

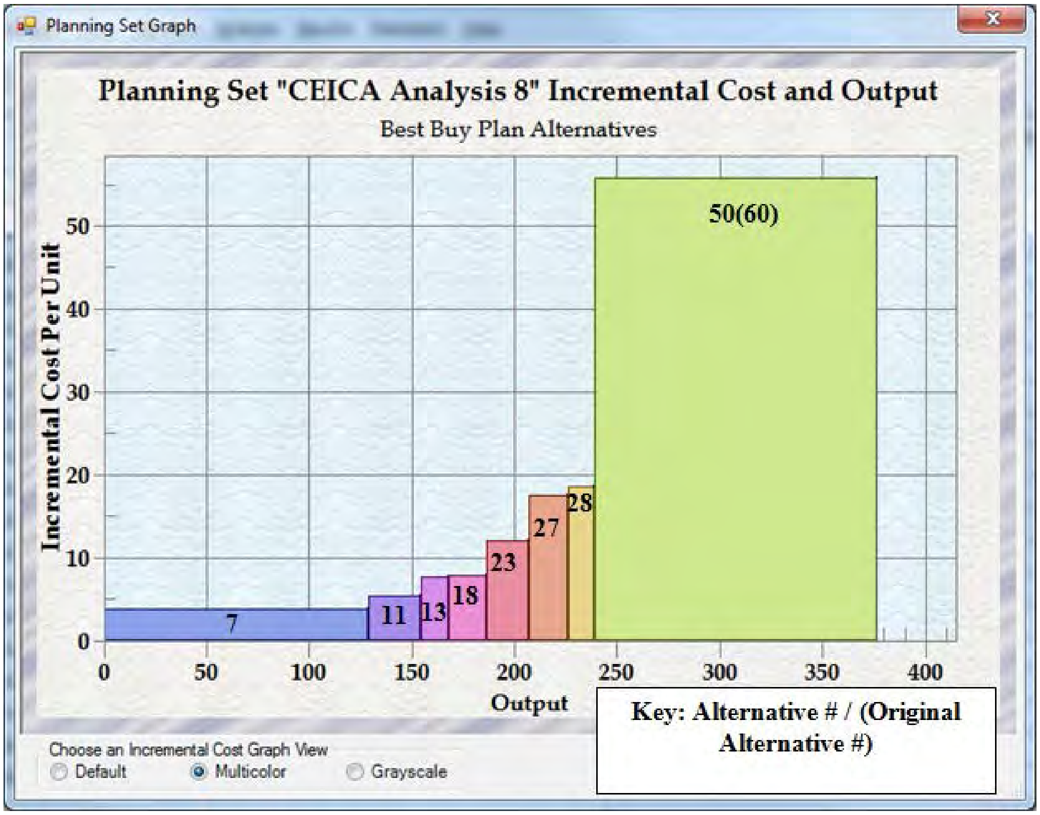


Figure 8-2. Incremental Cost and Output, EO Model Benefits Only

Table 8-1. Best Buy Plans, EO Model Benefits Only (Oct 2013 price level, 3.75% discount rate)

Alternative # (Original Alternative #)	Plan Components	Total Output in AAHU's (EO Model)	Total Average Annual Cost (AAC in $K)	AAC/ AAHU ($K)	Incremental Cost/Incremental Output ($K)	Total Present Value Cost ($K)	Cost Effective and/or Best Buy?	Improves Egg-to-Fry Survival?
1	No Action Plan	0.0	0				Best Buy	No
7	Base #3: Confluence Levee Removal +35	128.8	479	$3.72	$3.72	$10,754	Best Buy	No
11	Base #3: Confluence Levee Removal +35+9	154.5	617	$3.99	$5.37	$13,850	Best Buy	No
13	Base #3: Confluence Levee Removal +35+9+28	168.1	722	$4.30	$7.72	$16,215	Best Buy	No
18	Base #3: Confluence Levee Removal +35+9+28+37	186.6	868	$4.65	$7.89	$19,492	Best Buy	No
23	Base #3: Confluence Levee Removal +35+9+28+37+39+40	207.0	1,113	$5.38	$12.01	$24,999	Best Buy	No
27	Base #3: Confluence Levee Removal +35+9+37+28+39+40+43	226.4	1,452	$6.41	$17.47	$32,602	Best Buy	No

Alternative # (Original Alternative #)	Plan Components	Total Output in AAHU's (EO Model)	Total Average Annual Cost (AAC in $K)	AAC/ AAHU ($K)	Incremental Cost/Incremental Output ($K)	Total Present Value Cost ($K)	Cost Effective and/or Best Buy?	Improves Egg-to-Fry Survival?
28	Base #3: Confluence Levee Removal +35+9+37+28+39+40+43 +26	239.1	1,688	$7.06	$18.58	$37,887	Best Buy	No
38(45)	Base #5: Riverbed Excavation RM 3.5-9 +35+9+37+28+40+43+26	303.9	6,892	$22.68	$71.09	$154,623	Cost Effective	Yes
50(60)	Base #1: Riverbed Excavation RM 0-9 +35+9+37+28+40+43+26	377.1	9,379	$24.87	$55.73	$210,434	Best Buy	Yes

8.2 CE/ICA without Increment #26 – Wetland Restoration at Dips Road

A sensitivity run of the cost effectiveness and incremental analysis was performed with removal of Increment #26, Wetland Restoration at Dips Road. Increment #26 is a road setback that is considered to be a relocation and would be funded solely by the non-Federal sponsor(s). The study team also identified this feature to be an increment that could only be included as a Locally Preferred Plan (LPP). The evaluation and comparison of alternatives led the study team to originally recommend Alternative #28 as the TSP which includes Increment #26. The next smallest best buy alternative, Alternative #27, includes the same project features as Alternative #28 with the exception of the Wetland Restoration at Dips Road, Increment #26. This alternative achieves similar benefits as the larger Alternative #28 without any large-scale relocations. Alternative #27 was identified as the tentatively selected plan (TSP). A sensitivity analysis was completed to confirm whether the proposed TSP is still a cost effective and best buy plan. The results of this analysis are below and indicate the proposed TSP is a cost effective, best buy plan.

Figure 8-3 shows a plot of costs and outputs for each possible plan combination. There were 321 possible plan combinations, 55 of which were cost effective plans, and 8 of which were best buy plans. The best buy plans for this run of incremental cost analysis were slightly different than the best buy plans identified from the incremental cost analysis that included Increment #26, with removal of Alternative #28, or the best buy plan for Base #3 which included all increments. The last best buy plan for Base #3 is now Alternative #27, which does not include Increment #26. The best buy which includes Base 1 and the cost effective plan which includes Base 5 did not include benefits and costs for Increment #26. Outputs for Bases #1 and #5 were reduced from 587.9 and 431.7 to 575.2 and 419, respectively. Incremental costs for the Base #1 best buy (original Alternative #59, now Alternative #55) and Base #5 cost effective plan (original Alternative #44, now Alternative #41) did not change from the evaluation presented in Chapter 6. The best buy incremental costs are displayed in Figure 8-4, and the incremental costs of the best buy plans are included in Table 8-2.

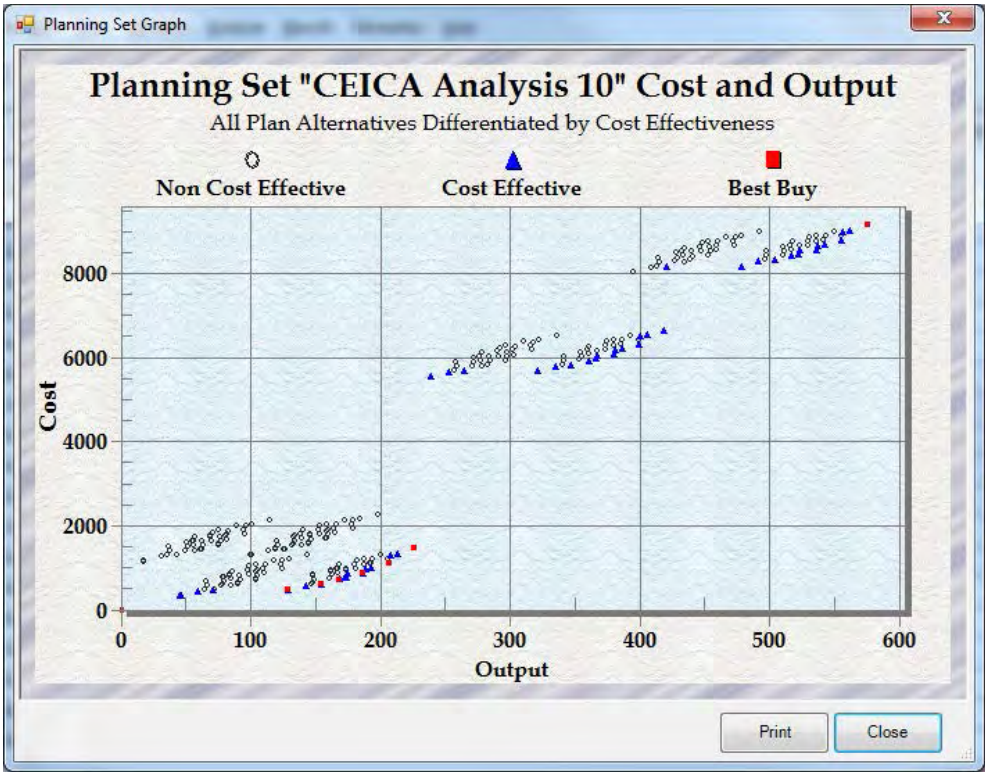


Figure 8-3. Plot of Alternative Costs and Outputs, Without Increment #26 – Dips Road

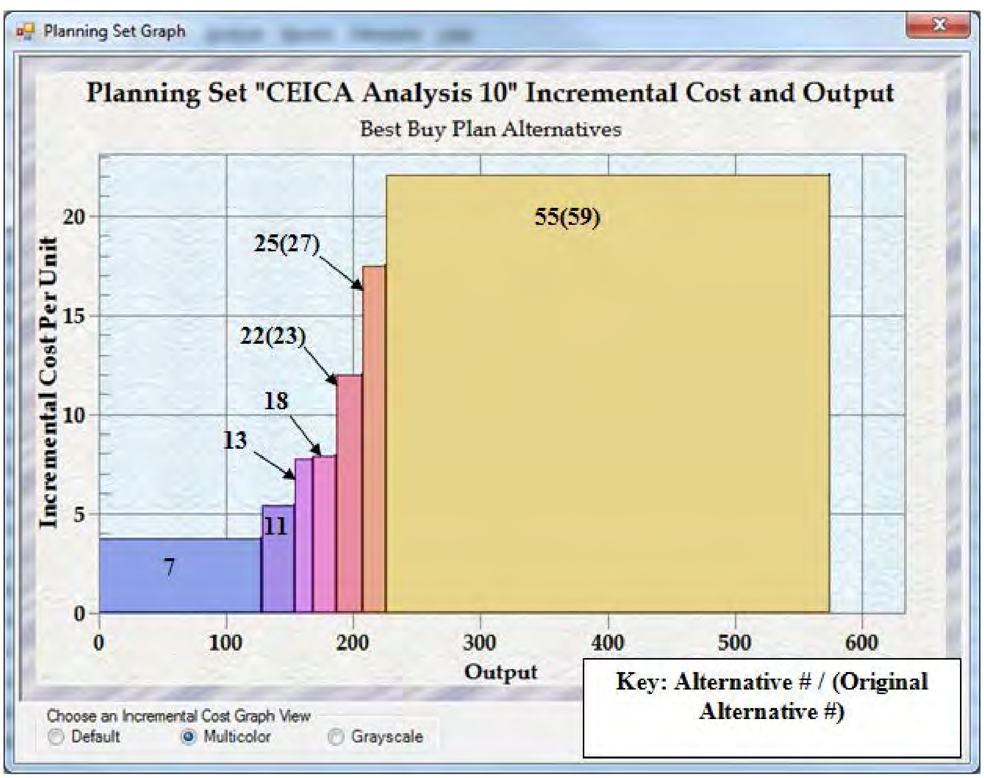


Figure 8-4. Incremental Cost and Output, Without Increment #26 – Wetland Restoration at Dips Road

Table 8-2. Best Buy Plans, Without Increment #26 – Wetland Restoration at Dips Road (Oct 2013 price level, 3.75% discount rate)

Alternative # (Original Alternative #)	Plan Components	Total Output in AAHU's (EO Model)	Total Average Annual Cost (AAC in $K)	AAC/ AAHU ($K)	Incremental Cost/Incremental Output ($K)	Total Present Value Cost ($K)	Cost Effective and/or Best Buy?	Improves Egg-to-Fry Survival?
1	No Action Plan	0.0	0				Best Buy	No
7	Base #3: Confluence Levee Removal +35	128.8	479	$3.72	$3.72	$10,754	Best Buy	No
11	Base #3: Confluence Levee Removal +35+9	154.5	617	$3.99	$5.37	$13,850	Best Buy	No
13	Base #3: Confluence Levee Removal +35+9+28	168.1	722	$4.30	$7.72	$16,215	Best Buy	No
18	Base #3: Confluence Levee Removal +35+9+28+37	186.6	868	$4.65	$7.89	$19,492	Best Buy	No
22(23)	Base #3: Confluence Levee Removal +35+9+28+37+39+40	207.0	1,113	$5.38	$12.01	$24,999	Best Buy	No
25(27)	Base #3: Confluence Levee Removal +35+9+37+28+39+40+43 +26	226.4	1,452	$6.41	$17.47	$32,602	Best Buy	No
41(44)	Base #5: Riverbed Excavation RM 3.5-9 +35+9+37+28+40+43+26	419.0	6,656	$15.89	$27.02	$154,623	Cost Effective	Yes
55(59)	Base #1: Riverbed Excavation RM 0-9 +35+9+37+28+40+43+26	575.2	9,143	$15.90	$22.05	$210,434	Best Buy	Yes

9. Recommended Plan

The Corps' objective in ecosystem restoration planning is to contribute to national ecosystem restoration (NER). Contributions to NER (outputs) are increases in the net quantity and/or quality of desired ecosystem resources. The NER Plan must reasonably maximize ecosystem restoration benefits compared to costs, consistent with the Federal objective. The selected plan must be shown to be cost effective and justified to achieve the desired level of output.

The evaluation and comparison of alternatives led the study team to initially recommend Alternative #27 as the Tentatively Selected Plan (TSP) as well as the environmentally preferable alternative. Alternative #27 is environmentally preferable because it has the greatest quantity of Average Annual Habitat Units without the significant temporary construction impacts and environmental risk to salmon spawning habitat of Alternatives #45 and #60.

The TSP presented in the Draft FR/EIS (January 2014) included the removal of Confluence Levee, the installation of large woody debris, reconnection of a side channel, wetland restoration at two sites, and restoration of two tributaries. In subsequent coordination efforts between the Corps, the non-Federal sponsors, and local landowners in the study area, three increments that were originally included in the TSP are no longer being carried forward. The Hunter Creek Mouth (Increment #39), Hunter Creek Tributary Restoration (Increment #40), and Weaver Creek Tributary Restoration (Increment #43) are no longer included in the recommended plan due to a lack of landowner willingness. As the feasibility-level design phase was completed, these increments were determined to have insurmountable real estate and access issues that had not manifested earlier the analysis.

As described in the previous section, the TSP presented the Draft FR/EIS has been modified following agency, technical, and public review of the report as well as completion of feasibility-level design efforts. While the Draft FR/EIS presented the Corps' tentative proposal for a selected plan, this Final FR/EIS presents the Corps' recommended NER plan. Based on subsequent coordination efforts between the Corps, the non-Federal sponsors, and local landowners in the study area, Alternative #18 is presented as the recommended plan. This best buy plan includes the same increments as the original TSP (Confluence Levee removal, installation of large woody debris, reconnection of a side channel, and two wetland restoration increments) but does not include the Hunter and Weaver Creek tributary restorations. While less comprehensive than the original recommended plan, Alternative #18 is still considered complete, acceptable, efficient, and effective, and it restores the critical needs of the study area (restores year-round flow for fish passage). Alternative #18 is a best buy plan, is economically justified, and is more acceptable in terms of landowner willingness/support. Additionally, supplemental analyses of the two wetland embankments (RM 9 and Grange) were conducted to optimize these features for ecosystem benefit versus cost. This evaluation is presented as an addendum to this appendix. This analysis led to the reduced scale of embankments heights for each site, referred to as the small-scale scenarios. Costs have been revised to reflect the cost of the small scale wetland embankments. There were no changes to the benefits for these features.

The annual costs and benefits of the each of the components included in the recommended plan are shown in Table 9-1 based on feasibility-level costs developed following the cost effectiveness and incremental cost analyses. The recommended plan results in 277 acres of restoration with 186.6 average annual habitat units (AAHU's) with in-channel and floodplain benefits in the Lower Skokomish Watershed.

Table 9-1. Recommended Plan Components (Oct 2014 price level, 3.375% discount rate)

Alternative #	Plan Components	Habitat Units (In-Channel, Floodplain, and Capacity)	Habitat Units (Shellfish Substrate)	Total Habitat Units	Total Acres Restored	Total Annual Cost ($1,000s)
18	Base #3: Confluence Levee Removal	45.9	0	45.9	68	$177
	Increment 35 – Upstream LWD	82.9	0	82.9	107	261
	Increment 9 – Side Channel Reconnection	25.7	0	25.7	45	79
	Increment 37 – Wetland Restoration at Grange	18.5	0	18.5	34	154
	Increment 28 – Wetland Restoration at River Mile 9	13.6	0	13.6	23	153
	Totals for Recommended Plan	**186.6**	**0**	**186.6**	**277**	**$824**

Project costs underwent a cost and schedule risk analysis to develop contingencies for the alternatives considered. Table 9-2 summarizes the refined project first costs at the October 2014 price level for the recommended plan. The estimated project first costs are $19,343,000, which includes monitoring costs of $374,000 and adaptive management costs of $127,000.

Table 9-2. Recommended Plan Cost Summary (October 2014 price level)

	Project First Cost (October 2014 price level)
Construction Item	
01 Lands & Damages (LERRD)	$1,687,000
Elements	
06 Fish & Wildlife Facilities	$12,806,000
06 Monitoring	$374,000
06 Adaptive Management	$127,000
Subtotal	***$14,994,000***
30 Planning, Engineering and Design (PED)	$2,545,000
31 Construction Management	$1,804,000
Total Estimated Cost	**$19,343,000**

Table 9-3 provides an economic summary of the recommended plan. Interest during construction was computed using project first costs at current price levels (October 2014 price level), anticipated construction duration (construction duration ranges from three to 14 months for the three sites, with overall construction assumed over a 32-month period), and the current Federal discount rate (3.375% for fiscal year 2015), bringing total investment costs to $20,197,000. Minimal operations, maintenance, repair, rehabilitation or replacement (OMRR&R) expenses are estimated to be $10,000 per year. Monitoring for this alternative is estimated over a 10-year period with a cost of $374,000, and adaptive management is estimated at $137,000. Annual costs were updated using the feasibility-level first costs at current price levels to include interest during construction. Average annual cost, included annual OMRR&R is estimated at $852,000, with an average annual cost of $4,600 per AAHU.

Table 9-3. Economic Summary for Recommended Plan (October 2014 price level)

	Cost and Benefit Summary of the Recommended Plan (October 2014 price level)
Interest Rate (Fiscal Year 2015)	3.375%
Interest Rate, Monthly	0.28%
Construction Period, Months	32
Period of Analysis, Years	50
Estimated Cost (Oct 2014 price level)	$19,343,000
Interest During Construction	$854,000
Investment Cost	$20,197,000
Average Annual Cost	
Amortized Cost	$842,000
OMRR&R	$10,000
Total Average Annual Cost	$852,000
Average Annual Benefits	
Average Annual Habitat Units (AAHUs)	186.6
Average Annual Cost/AAHU	$4,600
Average Annual Cost/Acre Restored	$3,100

Table 9-4 summarizes the cost sharing for the recommended plan. Lands, easements, right-of-ways, relocations, and disposals (LERRDs) are credited towards the non-Federal sponsor's 35 percent cost share responsibility. The Federal and non-Federal shares of the total estimated cost is $12,573,000 and $6,770,000, respectively.

Table 9-4. Project Cost Share of the Recommended Plan (October 2014 price level)

	Federal ($1,000s)	Non-Federal ($1,000s)	Total ($1,000s)
Ecosystem Restoration			
Lands & Damages		$1,687	$1,687
Fish & Wildlife Facilities	$12,806		12,806
Monitoring & Adaptive Management	501		501
Planning, Engineering & Design	2,545		2,545
Construction Management	1,804		1,804
Cash Contribution/Reimbursement	-5,083	5,083	0
Total Project Cost Share	**$12,573**	**$6,770**	**$19,343**
Total Project Cost Share (%)	***65%***	***35%***	***100%***

10. References

USACE (U.S. Army Corps of Engineers). 2012. Economic Guidance Memorandum, 13-01, Federal Interest Rates for Corps of Engineers Projects for Fiscal Year 2013. Available online: http://planning.usace.army.mil/toolbox/library/EGMs/EGM13-01.pdf (Accessed 25 September 2013).

USACE. 2000. ER 1105-2-100: Planning Guidance Notebook, CECW-P, 22 April 2000, as amended. Available online: http://140.194.76.129/publications/eng-regs/ER_1105-2-100/toc.htm (Accessed 25 September 2013).

USACE, Institute for Water Resources. 1994. Cost Effectiveness Analysis for Environmental Planning: Nine EASY Steps, IWR Report 94-PS-2, October 1994. Available online: http://www.iwr.usace.army.mil/Portals/70/docs/iwrreports/94-PS-2.pdf (Accessed 25 September 2013).

USACE, Institute for Water Resources. 1995. Evaluation of Environmental Investments Procedures Manual - Interim: Cost Effectiveness and Incremental Cost Analyses, IWR Report 95-R-1, 31 May 1995. Available online: http://www.iwr.usace.army.mil/Portals/70/docs/iwrreports/95-R-1.pdf (Accessed 25 September 2013).

USACE, Institute for Water Resources. 2006. IWR Planning Suite User's Guide, November 2006. Available online: http://www.pmcl.com/iwrplan/IWR%20Planning%20Suite%20Users%20Guide.pdf (Accessed 25 September 2013).

U.S. Water Resources Council. 1983. Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G), 10 March 1983. Available online: http://planning.usace.army.mil/toolbox/library/Guidance/Principles_Guidelines.pdf (Accessed 25 September 2013).

Addendum

Skokomish Supplemental Analyses of Optimization of Wetland Embankment Sites

In July 2015, a supplemental analysis was conducted to provide additional evaluation and optimization of two wetland embankment sites included in the Skokomish recommended plan—Wetland Restoration at River Mile 9 and Wetland Restoration at Grange. These embankments were evaluated at two additional elevations (one lower and one higher which reasonably bracket the range of elevations to consider for optimization), as well as a "breach only" scenario (no embankment) for a total of 5 increments for each wetland site. For each site, a habitat model output score was derived using the methods outlined in Appendix F, Ecosystem Benefits Model Documentation. While the "breach only" scenario was evaluated for ecosystem outputs, these scenarios were not carried forward for cost effectiveness and incremental cost analysis (CE/ICA) because they did not meet the purpose and need, planning objectives. This rationale is described further in the evaluation of benefits below. For the remaining scenarios, costs were estimated and CE/ICA analyses were conducted to determine cost effective and best buy alternatives. The following scenarios were evaluated for each site:

- Without project
- With project original recommended plan scale scenario (original design, or average height of 5 ft for River Mile 9 and 6 ft for Grange)
- With project "breach only" scenario (evaluated for benefits only but not carried to CE/ICA)
- With project small scale scenario (based on 6,000 cfs flow containment at each embankment site; approximate 2-3ft reduction in average height for each embankment)
- With project large scale scenario (approximate 1 ft increase in average height for each embankment)

Benefit and Cost Inputs for the CE/ICA Sensitivity Analyses

Ecosystem Benefits

In order to conduct a cost effectiveness and incremental analysis, benefits for the three new scenarios were evaluated for habitat value using the same methodology as outlined in the approved for one-time use Skokomish environmental output model, specifically determining floodplain habitat values using average annual habitat units (AAHUs). The following summarizes the assumptions used to evaluate the three new scenarios for each of the wetland embankment sites. No changes were made to the analysis completed for the without project condition or the original recommended plans for each of the embankment sites.

- Acreage assumptions:

  - Acreage for without project and wetland embankment scales is the same as for the original recommended plan.
  - Greater acreage is associated with the “breach only” scenarios. Wetland Restoration at River Mile 9 acreage increased from 23 acres to 58 acres and Wetland Restoration at Grange acreage increased from 34 acres to 43 acres, rounded to the nearest acre. This assumption is based on GIS spatial analysis of hydraulic model results at the 6,000 cfs flow showing greater wetted area, where 6,000 cfs is the approximate capacity provided by the existing agriculture berms in the without project condition which is significantly less than the 50% annual chance of exceedance flow of approximately 17,000 cfs. Modeling results show that water would flow across a county road in the “breach only” scenario; however, for the purposes of estimating an acreage footprint, the boundary ends at the road alignment and does not extend beyond the road.

- Connectivity assumptions:
  - Connectivity HQI score assumed to be 0 for “breach only” scenario due to no reconnection to the mainstem (because flood flows would move south across the valley and there are no tributaries that feed back in to the main channel in the area flooded).
  - Connectivity HQI score for the larger scale wetland embankment scenarios assumed to be the same as for the original recommended plan scenario because they would provide year-round two-way connectivity of flood flows into the riparian zone and receding flows back into the river.
  - Connectivity HQI score for the smaller scale wetland embankments is the same as the original recommended plan due to uncertainty in comparable functionality. The approved EO Model states that an action gets 100% score if it provides a year-round connection. The smaller embankments would not contain a 1-year event; however, the EO model was not designed to be sensitive to various elevations of embankments because it was assumed the embankments would be designed to not overtop until greater than the 1-year flow event to achieve the needed two-way connectivity and therefore the 100% HQI.

- Riparian cover assumptions:
  - No additional riparian vegetation is gained with the “breach only” scenario. With the breaches, there is a bigger perimeter around the water and a less percent buffer around the riparian area. GIS analysis was conducted on the larger wetted areas to determine the proportion of perimeter with the buffer around the riparian area using the same methodology described in Appendix F, Ecosystem Benefits Model Documentation. The score for this scenario is assumed to be constant throughout the period of analysis. This results in a reduced score from the future without project condition of approximately 0.46 for Wetland Restoration at River Mile 9 and 0.46 for the Wetland Restoration at Grange. See Figures 2 and 3 for “breach only” riparian cover scores over a 50-year period of analysis.

- o Small and large scale scenarios are assumed to have the same riparian cover HQI scores as the original recommended plan scenario given no expected change to the percent area of 150-foot buffer with continuous vegetation.

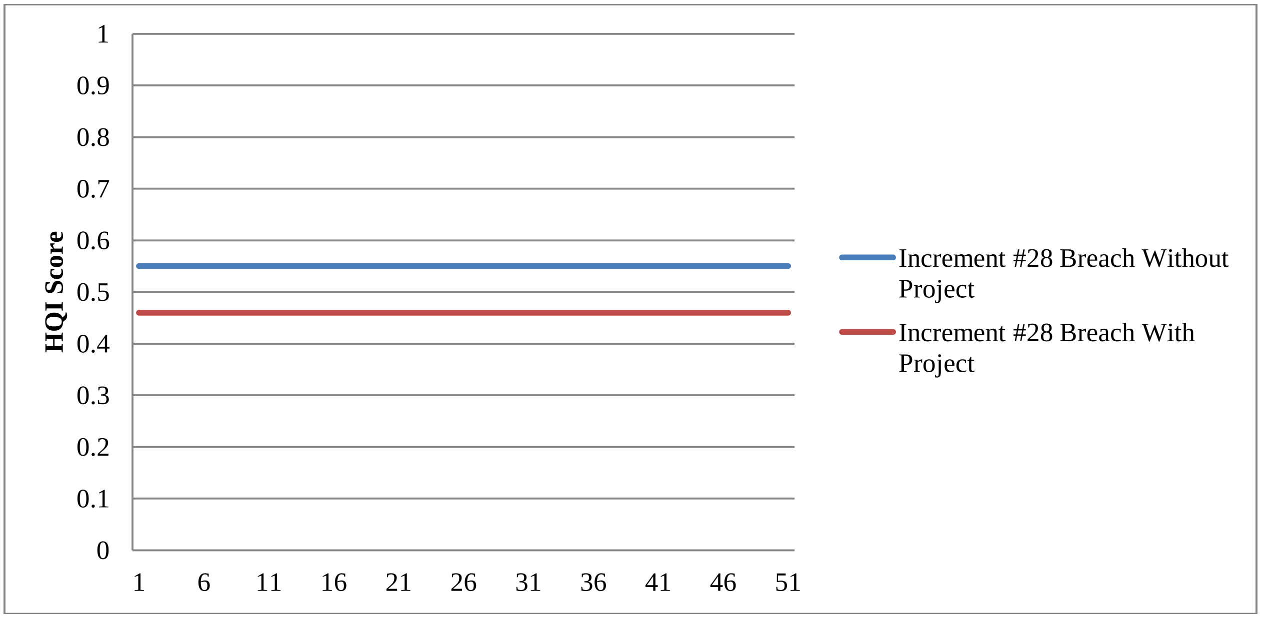


Figure 5 - Floodplain Habitat - Riparian Cover; Increment #28: Wetland Restoration at River Mile 9 "Breach Only" Scenario

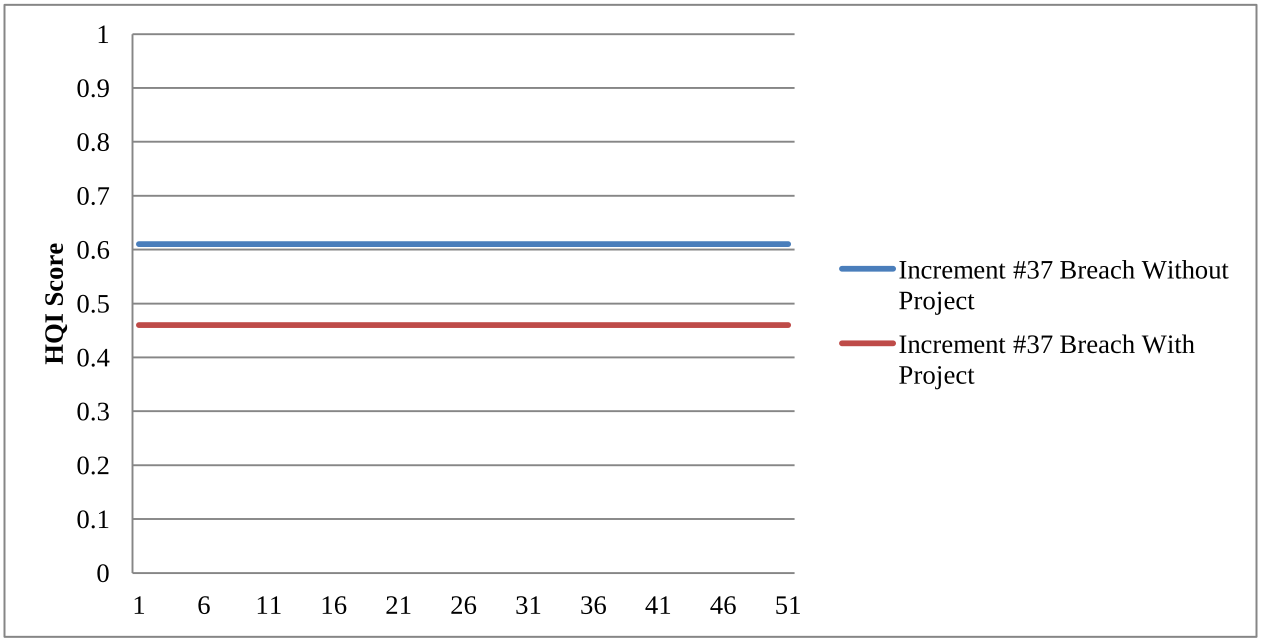


Figure 6 - Floodplain Habitat - Riparian Cover; Increment #38: Wetland Restoration at Grange "Breach Only" Scenario

The following tables summarize the benefit information that was used to evaluate River Mile 9 (Table 1) and Grange (Table 2) in CE/ICA analyses. It should be noted that while acreage increases for the “breach only" scenario for each embankment, the riparian cover score is lower than the without project condition score and this scenario does not achieve floodplain connectivity as reflected in connectivity scores of 0. Therefore, the "breach only" scenarios provide an increase in acreage of low quality habitat that is not of a habitat type identified as a problem or in need of restoration in this area and does not achieve the project goals and objectives. While the breach only scenario shows a benefit for River Mile 9, this is due to the additional acreage that is gained but results in lower quality habitat than in the existing and future without project condition. The breach scenarios are problematic because in not achieving floodplain connectivity, ESA-listed fish would be stranded and killed in the floodplain more frequently than in the existing condition, resulting in "take" and a jeopardy opinion from the Services. The local sponsors and natural resource agencies would voice opposition to a breach-only design. Additionally, there would be a monetary cost associated with achieving this detrimental impact. If this site were designed to meet the purpose and need of the project, additional plantings and a side channel to achieve connectivity would be needed in addition to the breaches; however, no plantings could be established where the water meets the road, so it is not possible to achieve the same riparian buffer as existing conditions. Therefore, while benefits were quantified for the "breach only" scenarios, these scenarios were screened for reasons already described and were not carried forward in the cost effectiveness and incremental cost analysis for these 2 sites.

Table 5 – Increment 28 Wetland Restoration at River Mile 9 Benefits

Scale	Acres	Riparian Cover HQI	Connectivity HQI	HQI Score [(Riparian Cover + Connectivity) / 2]	AAHUs (Acres * HQI Score)	Benefits (With-Without AAHU)
Without Project	23	0.55	0	0.28	6.3	N/A
With Project – original scale scenario /original recommended plan	23	0.79	0.94	0.87	19.9	13.6
With Project – breach only scenario	58 (+)	0.46 (-)	0 (-)	0.23 (-)	13.3	7.0
With Project – small scale scenario	23	0.79	0.94	0.87	19.9	13.6
With Project – large scale scenario	23	0.79	0.94	0.87	19.9	13.6

Table 6 – Increment 37 Wetland Restoration at Grange Benefits

Scale	Acres	Riparian Cover HQI	Connectivity HQI	HQI Score [(Riparian Cover + Connectivity) / 2]	AAHUs (Acres * HQI Score)	Benefits (With-Without AAHU)
Without Project	34	0.61	0	0.31	10.4	N/A
With Project – original scale scenario / original recommended Plan	34	0.76	0.94	0.85	28.9	18.5
With Project – breach only scenario	43 (+)	0.46 (-)	0 (-)	0.23 (-)	9.9	-0.5
With Project – small scale scenario	34	0.76	0.94	0.85	28.9	18.5
With Project – large scale scenario	34	0.76	0.94	0.85	28.9	18.5

Costs

Parametric costs were developed for the two additional scales for each of the wetland embankment sites. The following summarizes the assumptions and methodology used to develop those additional cost estimates.

- Cost assumptions:
  - Construction costs at the October 2014 price level were developed for the small scale and large scale scenarios by computing new material quantities for those scales.
  - Construction management costs varied for each of the scales by applying the same percentages of construction cost to each scale.
  - PED costs are assumed to be the same regardless of scale.
  - Real estate costs are assumed to be the same regardless of scale.
  - Construction durations were approximated using estimated construction duration in days and assuming 22 working days per month for interest during construction (IDC) computation.
  - Annual operations and maintenance (O&M) estimates are assumed to be the same regardless of scale.
  - Average annual costs for each site and scale were computed using the certified cost annualizer and interest during construction spreadsheet tool in IWR PLAN suite using the total estimated cost, construction duration in months, and estimated annual O&M over a 50-year period of analysis. All costs shown in the analysis are at the October 2014 price level and utilize the current fiscal year 2015 Federal discount rate of 3.375 percent.

The following tables summarize the cost inputs to the CE/ICA analysis for River Mile 9 (Table 3) and Grange (Table 4).

Table 7 – Increment 28 Wetland Restoration at River Mile 9 Costs (Oct 2014 price level)

Scale	Construction Cost ($1,000s)	Total Cost ($1,000s)	Annual O&M ($1,000s)	Construction Duration (Months)	Average Annual Cost ($1,000s, including IDC and O&M, @3.375%)
Without Project	N/A	N/A	N/A	N/A	N/A
With Project – original scale scenario / original recommended plan	$3,049	$4,415	$5	3	$193
With Project – small scale scenario	$2,161	$3,333	$5	3	$144
With Project – large scale scenario	$4,349	$5,890	$5	4	$252

Table 8 – Increment 37 Wetland Restoration at Grange Costs (Oct 2014 price level)

Scale	Construction Cost ($1,000s)	Total Cost ($1,000s)	Annual O&M ($1,000s)	Construction Duration (Months)	Average Annual Cost ($1,000s, including IDC and O&M, @3.375%)
Without Project	N/A	N/A	N/A	N/A	N/A
With Project – original scale scenario / original recommended plan	$3,620	$5,143	$5	3	$223
With Project – small scale scenario	$2,196	$3,408	$5	3	$147
With Project – large scale scenario	$4,224	$5,871	$5	4	$251

Wetland Restoration at River Mile 9 Cost Effectiveness and Incremental Analysis Results

Cost and benefit information for Wetland Restoration at River Mile 9 was input into IWR Planning Suite and evaluated for cost effectiveness and incremental cost analysis. The results indicated two best buy plans (No Action/without project and small scale scenario). The original recommended plan and large scale scenarios are not cost effective as they provide the same benefits as the small scale scenario, but at an additional cost. Table 5 summarizes the results of the cost effectiveness and incremental cost analysis. Figure 3 displays the incremental costs and benefits of the best buy plans, and Figure 4 displays the costs and benefits for each of the scenarios evaluated for cost effectiveness and incremental cost.

There is still a degree of uncertainty in the scale of the wetland embankments as originally recommended. Existing terrain data was utilized to inform designs based on risk-informed SMART planning principles.

This data was evaluated to include greater uncertainty but was considered to be appropriate for this phase of study. This uncertainty exists due to use of multiple terrain data sets with accuracy ranging approximately 6 to 10 feet. The elevation change of 2 to 3 feet, on average, between the previously recommended embankment height and the lower scale embankment height is within the margin of error of this existing terrain data. Additional survey data obtained during PED phase, as well as additional hydraulic modeling, will help refine the optimum elevation. Cost schedule risk analysis performed on the project and resulting cost contingencies reflect the uncertainty in height and material needed for construction, and PED costs include additional survey and analysis to refine the elevation.

Table 9 – Increment 28 Wetland Restoration at River Mile 9 Cost Effectiveness and Incremental Analysis (Costs at Oct 2014 price level)

Scale	Output (AAHU)	Average Annual Cost ($1,000s, Oct 2014 price level)	Average Cost ($1,000s /AAHU)	Cost Effective and/or Best Buy Plan?	Incremental Cost ($1,000s)	Incremental Output (AAHU)	Inc Cost / Output ($1,000s)
Without Project	0	0		Best Buy			
With Project – original scale scenario / original recommended plan	13.6	$193	$14.2	Not Cost Effective			
With Project – large scale scenario	13.6	$252	$18.5	Not Cost Effective			
With Project – small scale scenario	13.6	$144	$10.6	Best Buy	$144	13.6	$10.6

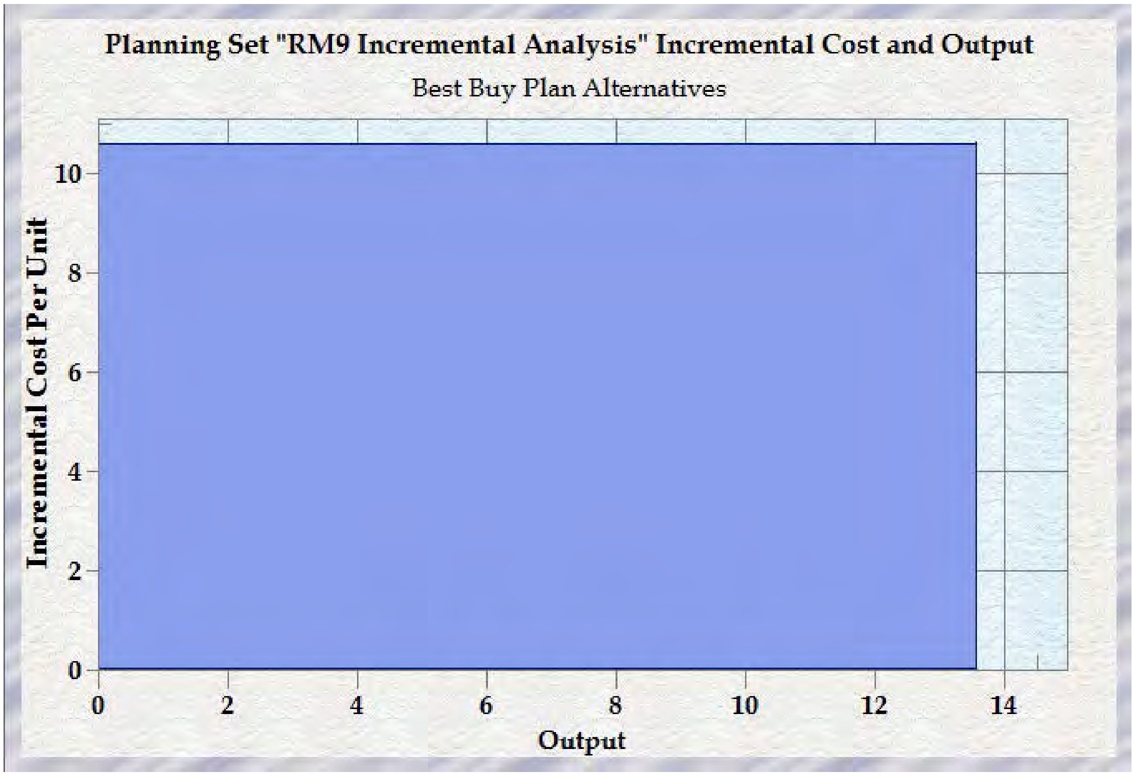


Figure 7 - River Mile 9 Incremental Costs and Incremental Benefits

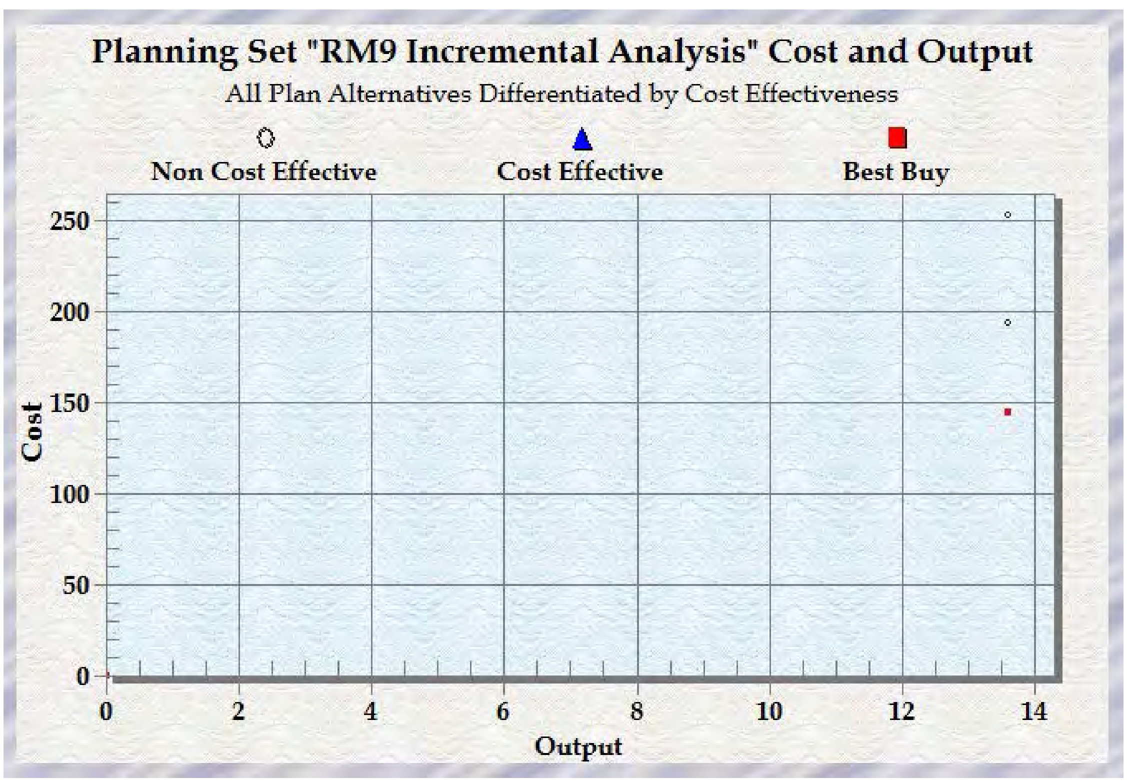


Figure 8 - River Mile 9 Plot of Costs and Benefits

Wetland Restoration at Grange Cost Effectiveness and Incremental Analysis Results

Cost and benefit information for Wetland Restoration at Grange was input into IWR Planning Suite and evaluated for cost effectiveness and incremental cost analysis. The results indicated two best buy plans (No Action/without project and small scale scenario). The original recommended plan and large scale scenarios are not cost effective as they provides the same benefits as the existing recommended plan, but at an additional cost. Table 6 summarizes the results of the cost effectiveness and incremental cost analysis. Figure 6 displays the incremental costs and benefits of the best buy plans, and Figure 7 displays the costs and benefits for each of the scenarios evaluated for cost effectiveness and incremental cost. Similar to the River Mile 9 wetland embankment, there are key uncertainties that will be addressed during PED phase to optimize and refine the wetland embankment height.

Table 10 – Increment 37 Wetland Restoration at Grange Cost Effectiveness and Incremental Analysis (Costs at Oct 2014 price level)

Scale	Output (AAHU)	Average Annual Cost ($1,000s)	Average Cost ($1,000s /AAHU)	Cost Effective and/or Best Buy Plan	Incremental Cost ($1,000s)	Incremental Output (AAHU)	Inc Cost / Output ($1,000s)
Without Project	0	0		Best Buy			
With Project – original scale scenario /original recommended plan	18.5	$223	$12.1	Not Cost Effective			
With Project – large scale scenario	18.5	$251	$13.6	Not Cost Effective			
With Project – small scale scenario	18.5	$147	$7.9	Best Buy	$147	18.5	$7.9

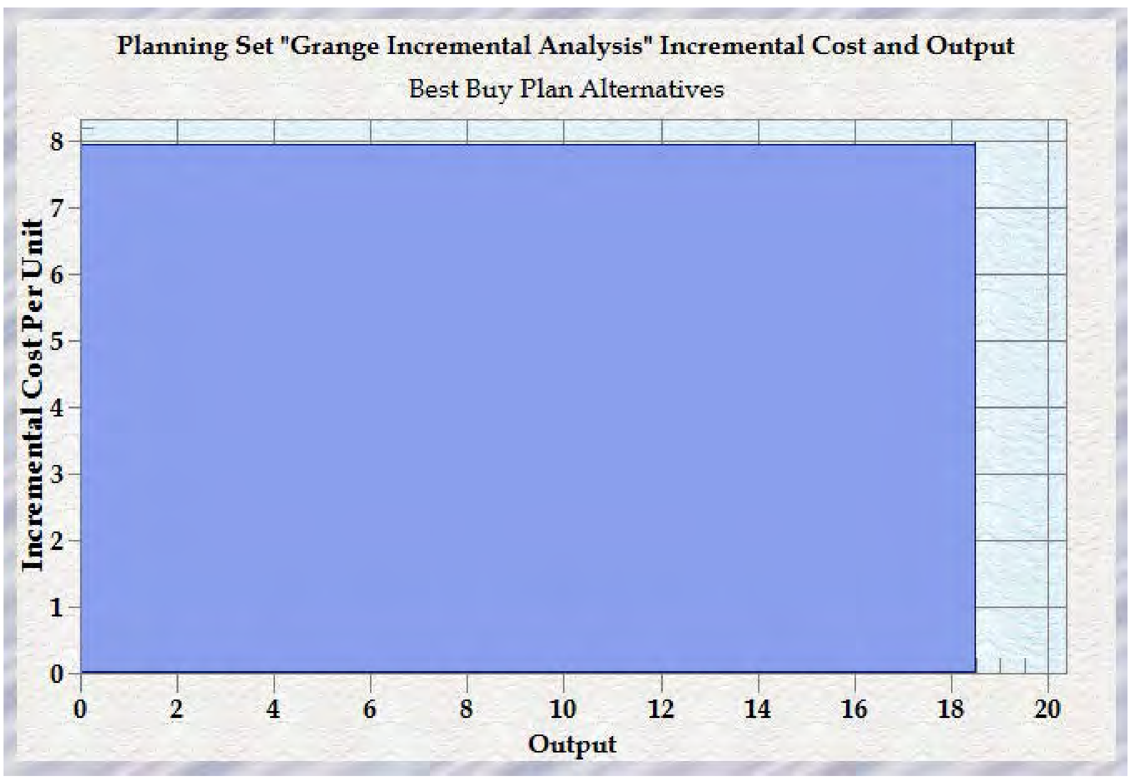


Figure 9 - Grange Incremental Costs and Incremental Benefits

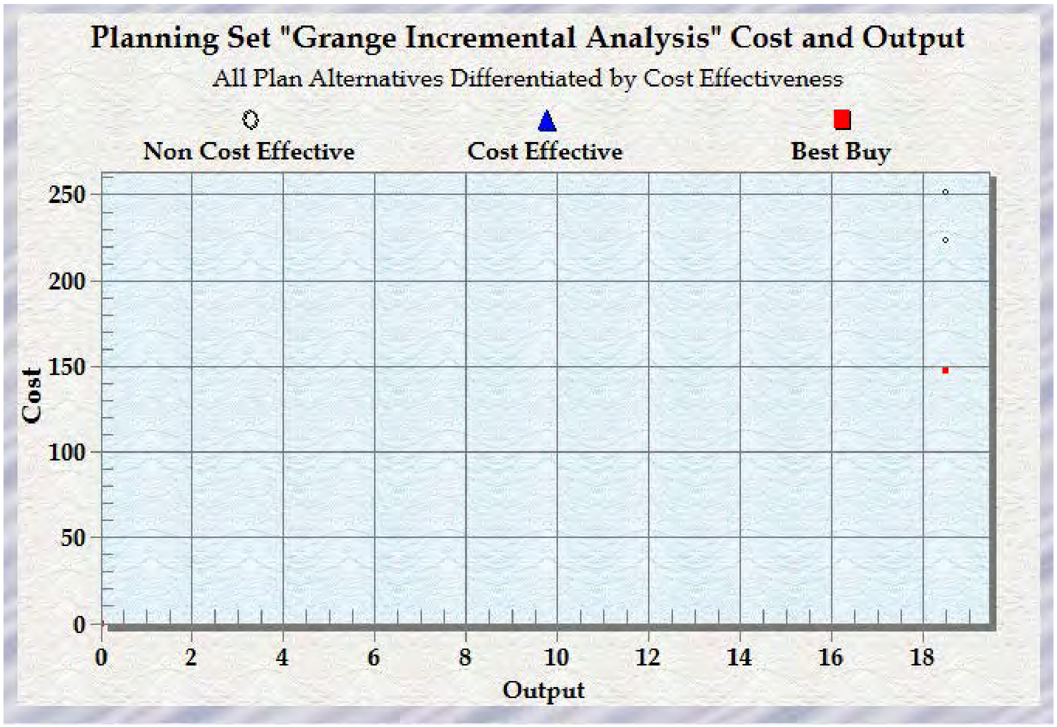


Figure 10 - Grange Plot of Costs and Benefits

Outstanding Risks and Uncertainties

The previously recommended plan for each site has been thoroughly evaluated and there is high confidence that they would perform as designed. There is less confidence in the performance and intended ecosystem benefits for the lower embankments given the frequency of overtopping during flows between 6,000 cfs and 12,500 cfs (approximately a 1-year event). Additionally, since the LiDAR and topography data have substantial uncertainty, it is not possible to tell whether the ecosystem benefit of 1-3 feet of water can be achieved across the entire length of the wetland embankments at the smaller scale elevation until more data is collected in PED. Smaller embankments will have a greater risk for allowing water and therefore fish to escape the riparian zone out toward the farm fields and county road compared to the original recommended plan and the existing conditions. Without additional survey work and engineering analysis, the benefits and costs for the lower embankments have greater associated risks and uncertainty than for the recommended plans. Cost contingencies for the smaller scale wetland embankments will be evaluated to reflect the degree of risk for these key uncertainties and the scope for PED phase will address these outstanding uncertainties to optimize embankment heights.

Outcome / Recommendation

An In-Progress Review was held with members of the Vertical Team on 29 July 2015. The results of the supplemental analysis were briefed by Seattle District and the Vertical Team recommended moving forward with the small scale wetland embankment scenario for both wetland restoration sites. The Final FR/EIS and PGM have been updated with the results of this analysis and continued coordination, and the final recommended plan reflects the smaller-scale embankments at the River Mile 9 and Grange sites.

Additionally, costs of the recommended plan presented in Section 9 of this appendix have been revised to reflect the costs of the smaller-scale wetland embankments.