Countyline Levee Setback Project
30% Design Alternatives Analysis

October 2012

King County
Department of
Natural Resources and Parks
Water and Land Resources Division

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30% Design Alternatives Analysis

FINAL REPORT

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Cover image

Flood waters flowing south from the left bank wetland over agricultural land and toward 8th Street E. during the January 2009 flood event.

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1.0 INTRODUCTION

This report is an informational summary of the alternatives analysis conducted during the 30% design phase of the Countyline Levee Setback project. The purpose of this report is to document that effort, which focused on selecting a preferred project concept. Two options for levee removal were explored: 1) an extensive removal of the existing left bank levee that would entail removing all but a short segment of the existing levee, and 2) a notching approach, which would breach the existing levee at four locations. Other key project elements incorporated into this alternatives analysis include a setback levee, a biorevetment, planting and maintaining a wide riparian corridor in the current wetland buffer, engineered logjams, and other types of log structures (e.g. biorevetment, small channel forming structures, and floodplain roughening features). All supporting work for this analysis was conducted in 2008. This report provides formal documentation of the analysis for the project files and for the incorporation into the Basis of Design report that will document the final design process.

Additional conceptual design work for the engineered logjams and biorevetments included in the project was conducted by Herrera Environmental Consultants and is available in a separate technical memorandum (Herrera 2011).

1.1 Project Overview

The White River Countyline Levee Setback project is located between river miles (RMs) 4.92 and 6.05) and involves reconnecting a currently disconnected portion of the White River floodplain for both flood protection and habitat restoration. The Countyline project features a combination of property acquisition, levee removal, setback levee construction, and floodplain restoration along the left bank of the Lower White River between the A Street and 8th Street (Stewart Road) bridges in the cities of Pacific and Sumner and a portion of unincorporated Pierce County. The project is identified as a priority in the adopted 2006 King County Flood Hazard Management Plan, as well as in the Salmon Habitat Protection and Restoration Strategy for the Puyallup and Chambers/Clover Creek Watersheds (Water Resource Inventory Area 10/12), which is a chapter of the National Marine Fisheries Service's (NMFS) Puget Sound Salmon Recovery Plan (Pierce County 2008). The construction of the setback levee will reduce the extent of overbank flooding and damages that impact the surrounding communities. This project directly addresses limiting factors identified in the recovery plan by restoring and providing off-channel rearing habitat for fall and spring Chinook, coho, and steelhead. The alternatives analysis was used to develop a preferred conceptual design that will be carried forward into later design phases.

1.2 Existing Conditions

The project site encompasses approximately 115 acres (Figure 1). The footprint of the existing levee prism and revetment occupy approximately 16 acres and are composed of river alluvium with rock facing along portions of the riverward side. Although the analysis of the alternatives predated the January 2009 flood event, increased flood risks to right bank properties and increased deposition in this depositional reach were noted in the 2006 Flood Plan. The Draft Lower White River Summary of Sediment Trends (Herrera 2009) summarizes historical trends in aggradation and degradation in the lower White River between RMs 4.4 to 10.6 and how

these trends relate to historical flood control measures and other projects implemented within the study reach.

As indicated above, the existing site conditions used in this alternatives analysis pre-date the January 2009 flood. Increased flood risk resulting from continued deposition in the Countyline reach became even more apparent during and after the January 2009 flood event. The flood data from that event, coupled with new bathymetric survey and hydraulic modeling of conveyance capacity in the project reach, indicate that ongoing sediment aggradation is reducing the conveyance capacity. Following the January 2009 flood, King County installed HESCO flood barriers on the right bank to provide temporary flood protection as an interim measure. The HESCO flood barriers and any future planned right bank flood protection measures post-date the analysis and therefore were not considered in the alternatives analysis.

Salmonid performance in the Lower White River is largely limited by the loss of floodplain habitat caused by the historical channelization of the river (Pierce County 2008). The Countyline levee currently disconnects approximately 85 acres of historical floodplain from the mainstem. The wetland on the landward side of the levee currently provides bird, amphibian, and small mammal habitat. Despite occasional levee overtopping near the King-Pierce county line, no salmonids have been documented in the open water wetlands by fish surveys conducted by King County. Additionally, the floodplain provides little to no rearing habitat or flood refuge for salmonids. There is moderate native and nonnative vegetation on the existing levee, which provides minimal shade and wood/leaf litter recruitment to the river. The higher floodplain ground east of the wetland has only sparse vegetation along the wetland edge and is dominated by agricultural crops and tilled soils, which are assumed to provide no habitat or water quality benefits to the wetland complex.

1.3 Project Considerations

Background

The lower White River in the vicinity of the cities of Auburn, Pacific, and Sumner is a highly modified system. Revetments and levees have been placed along both river banks to control floodwaters and to protect private and public properties. This reach of the White River is a depositional alluvial fan. Prior to the mid-1980s, this reach was actively dredged of sand and gravel to maintain flow conveyance through this corridor. Since the cessation of dredging activities in the mid 1980s, sediment deposition in the project reach has decreased the conveyance capacity of the active channel and simultaneously increased the flood risks to the surrounding communities.

The County proposes to address the existing flood risks by increasing the flood storage and sediment depositional capacity of the White River downstream of the A Street bridge. The County proposes to do this through land acquisitions (or flood easement purchase) and by implementing capital improvement projects to reconnect the river to its historical floodplain.

One such project is the Countyline project, identified in the County's 2006 Flood Hazard Management Plan as the Countyline to A-Street Flood Conveyance Improvement project (King County 2007). The goal of this project is to reduce flood-related risk to residential areas by purchasing flood-

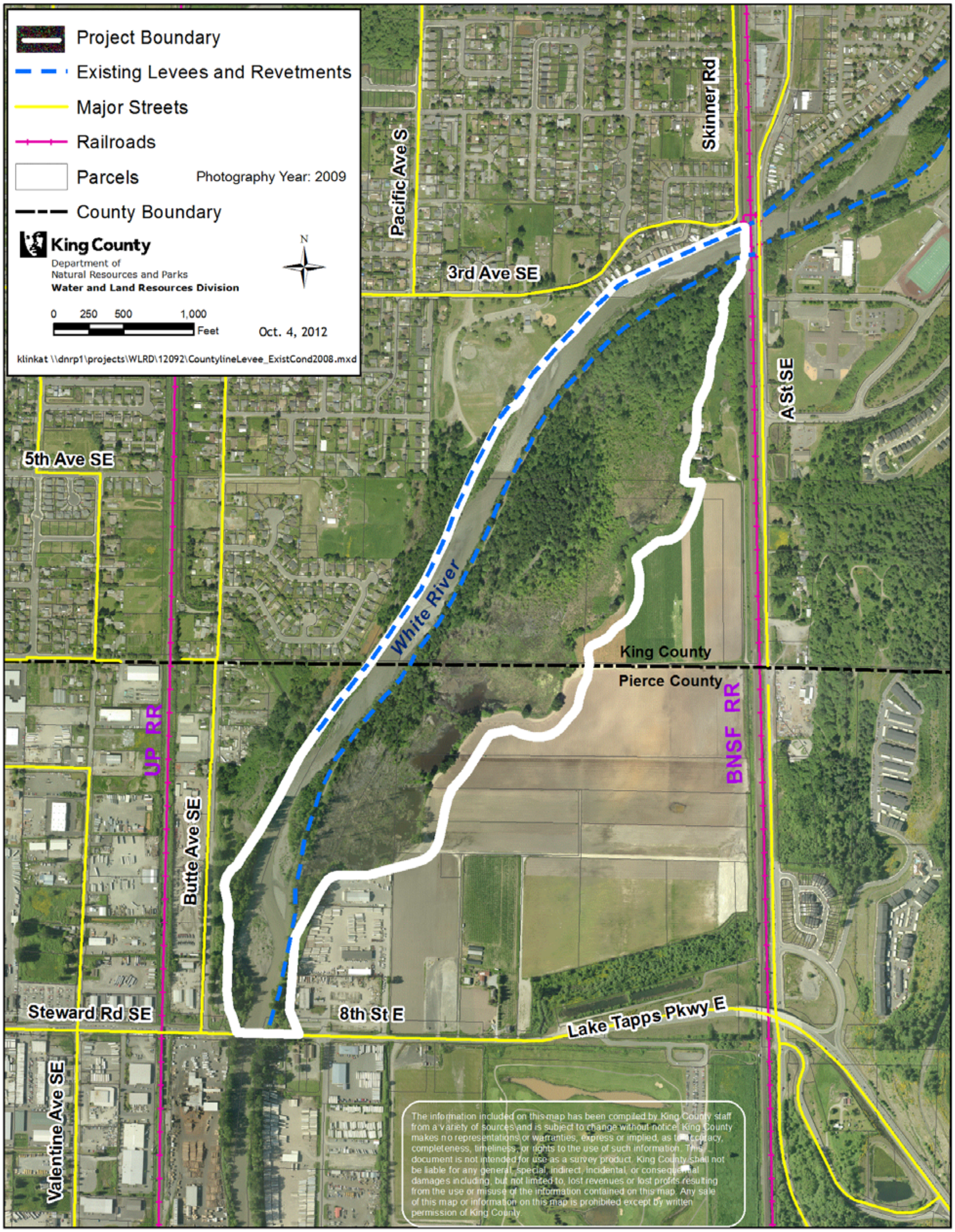

Figure 1. Existing site conditions in 2008 used for the alternatives analysis.

prone property and by providing conveyance through the existing left bank floodplain and wetland area. An additional project goal is to provide increased sediment storage. The project will also benefit salmonids habitat by improving floodplain connectivity and function.

As outlined in the County's 2006 Flood Plan (King County 2007), the Countyline project proposes to reduce the following identified risks:

- Risk to Public Safety due to residents entering and re-entering flooded areas and rescue personnel unable to help or evacuate residents.
- Damage to public infrastructure (including streets, drainage systems, and a flood protection facility).
- Damage to private structures (including numerous housing developments and trailer parks along the right bank).

Project Impacts

Project impacts will be assessed both on-site and off-site. A detailed hydraulic model will be created for the project site and the surrounding vicinity. This hydraulic model will analyze the existing and the proposed project conditions (including floodplain development scenarios for the preferred project alternative). This hydraulic assessment will quantitatively assess the changes in flood inundation areas, water depths, and water velocities throughout the project area for a wide range of flood scenarios.

In addition to the hydraulic modeling, sediment deposition scenarios will be analyzed for the preferred alternative. This analysis will evaluate potential sediment deposition throughout the project area based on potential channel evolution scenarios anticipated after construction of the Countyline (left bank) project. These scenarios may include a full avulsion of the White River through the left bank floodplain area and extensive side-channel and gravel bar development in the wetland. These geomorphic changes are expected to be limited to the project site where the levee modifications would occur. Project design will limit off-site channel and floodplain geomorphic changes. Thes sediment and channel surfaces developed to characterize the geomorphic response will also serve as the surfaces for proposed conditions hydraulic modeling scenarios to determine the full range of on-site and off-site impacts.

Model results will be used to quantify these changes as a result of the proposed project both on-site and off-site. Results of the various project analyses will be summarized and presented in project reports. When completed, these results will be presented in public meeting(s) with the local community and the general public. Based on the results of the hydraulic and sediment modeling, the County may need to mitigate for the potential adverse, off-site impacts. This may be accomplished through land acquisition or the acquisition of floodplain easements or other proposed actions and measures.

Bioengineered Design

The proposed project alternatives utilize bioengineered elements in their designs. Bioengineering incorporates the use of live plants and vegetative materials (e.g., large woody debris) in the engineered structures as an alternative to the use of more traditional materials

such as rock and steel. There has been an increase in the use of bioengineered materials in structural designs throughout the Pacific Northwest, particularly in riverine environments. This has mostly been in support of improving habitat conditions for ESA-listed salmonid species. Bioengineered materials can provide bank protection in riverine environments that is comparable or superior to traditional engineering materials, but have an added habitat benefit and function and can thus self-mitigate most adverse impacts of levee and revetment projects.

The project alternatives incorporate a combination of the following bioengineered design features:

- Biorevetment. This revetment would incorporate large wood and live vegetation in its design and be constructed along the eastern edge of the wetland.
- Vegetated buffer. An area between the bio-revetment and setback levee plnated with native vegetation.
- Engineered Logjams. Wood structures that would mimic natural logjams to promote habitat diversity and hydraulic complexity in the newly activated floodplain.
- Other bioengineered features. Channel and floodplain roughening features typically made of large wood to promote additional habitat and hydraulic complexity.

Landowner/Stakeholder negotiations

The project site straddles the King-Pierce county line and is surrounded by diverse land uses, numerous land owners with varying interests, and several jurisdictions. The right bank is mostly residential land use, whereas the left bank consisting of agricultural and light industrial land uses. The adjacent agricultural lands are not within an Agricultural Production District or Farmland Preservation Program. The County plans to acquire the land necessary for project implementation through fee-simple real estate transactions. Flood easements will be secured where necessary. Detailed hydraulic modeling will be completed for the project to determine the extent of proposed project impacts both on-site and in the project vicinity.

2.0 PROJECT ALTERNATIVES ANALYSIS

2.1 Project Goals, Objectives, and Metrics

The goals and objectives for the project were defined at the beginning of the 30% design process. The project goals were purposely broad and encapsulate three central desired project outcomes relating to flood hazards, habitat, and project implementation. Objectives were more specific than goals and were defines so that each could be used to guide project design and gauge post-project monitoring results. Lastly, metrics were assigned to each project objective to provide criteria by which to measure each objective and to support the evaluation of project alternatives. The metrics developed during discussions by the project team in 2008 were used specifically to evaluate project alternatives. At the time (in 2008), various project metrics were included that could be also be used to evaluate the project during different design phases and after project construction. These metrics helped to inform the development of the Countyline monitoring plan, but were not a complete or final list of performance measures that were used in the monitoring plan. The Project goals, objectives, and metrics developed in December 2008 are listed below.

Project Goal 1: Restore riverine processes and functions to the lower White River and its floodplain within the project area (inside the levees) in order to enhance salmonid rearing habitat, in particular for spring and fall Chinook, coho, and steelhead. (Salmonid Habitat)

Objectives:

1.1 Allow natural channel movement within the project area by removing and setting back the existing levee along the left bank.

- **A.** 30% Metric. Change in the relative likelihood for the main river channel to re-occupy the floodplain complex immediately following project completion.

1.2 Encourage the formation of off-channel rearing habitat (pool complexes and side-channels), such as through installation and future natural recruitment of large wood, that will promote the return of the complexity, diversity, and morphology found in an unconstrained floodplain.

- **A.** 30% Metric. Change (increase or decrease) in edge habitat (complexity) following project completion.

1.3 Provide off-channel flood refuge for salmonids by allowing a more natural frequency of inundation of the floodplain complex during flood events within the project boundaries.

- **A.** 30% Metric. Flood frequencies for which salmonids have access to the floodplain complex.

1.4 Protect existing mature riparian buffer areas and restore a corridor of mature riparian vegetation within the project boundaries to provide shoreline and stream channel shading, invertebrate prey supply, and large wood recruitment.

- **A.** 30% Metric. Difference in number of mature trees preserved (not necessary to be cut during construction).
- **B.** 30% Metric. Change in aerial amount of native riparian corridor established along terrace buffer.

Project Goal 2: Prevent an increase in flood hazards outside of the project area due to this restoration project and, if possible, reduce existing flood hazard. (Flood Hazards)

Objectives:

2.1 Design the project to ensure flood hazards (on private property or public infrastructure) outside of the project area does not increase due to the project.

A. 30% Metric: Change in base flood elevations upstream, downstream, and left and right banks along margins of the project area as compared to the Draft White River floodplain maps for Zone 2 King County, Washington (created by NHC), and the Pierce County DFIRM for the White River (predates Zone 2 study).

B. 30% Metric: Change in flood elevations upstream, downstream, and left and right banks along margins of the project area as compared to the project existing conditions model.

C. 30% Metric: Compare containment flows for existing and post-project conditions.

D. 30% Metric: Compare estimated flood hazard, including erosion hazard or scour (especially along the right bank armor) for post project to existing conditions.

2.2 Increase flood storage along the length of the project, which will also have a net benefit on reducing flood elevations in the immediate vicinity of the project, particularly the right bank.

A. 30% Metric: Change in floodplain storage volume and conveyance for the 2-, 10-, 50-, 100-, and 500-yr events as compared to project existing conditions model.

2.3 Avoid or minimize the need for sediment management actions.

A. 30% Metric: Predict the post project vertical rates of aggradation for coarse sediment within and downstream of the project area. Compare post project rates to existing information on vertical aggradation rates for coarse sediment for existing and historic conditions.

Project Goal 3: Design and construct a project that best meets the goals and objectives of the project using the most cost-effective means. (Cost Effectiveness)

Objectives:

3.1 Evaluate individual and collective project components based on cost-effectiveness and ability to achieve the goals and objectives for salmonid habitat (primarily) and flood hazards.

A. 30% Metric: Estimated costs for individual components

B. 30% Metric: Individual project component benefits for habitat and flood hazard objectives.

3.2 Avoid or minimize the need for remedial actions (habitat restoration or construction to avoid or repair public damage) by incorporating self-sustaining habitat restoration and flood hazard reduction components in the design.

A. 30% Metric: Minimize the need for long term maintenance.

B. 30% Metric: Estimated design life

- Note: High scoring alternative(s) would have a relatively long design life, with low maintenance requirements and cost.

3.3 Work with landowners to negotiate acquisitions or conservations easements.

3.4 Work with all stakeholders, including the City of Pacific, City of Sumner, Pierce County, Washington State Department of Fish and Wildlife, the Puyallup Tribe, and the Muckleshoot Tribe throughout the project to foster project support and a clear understanding of any needs or issues.

2.2 Project Alternatives

Four alternative project design concepts were developed and evaluated against no action being taken in the reach. Reach characteristics for the "no action" alternative that Alternatives 1 through 4 were compared against were defined by using historical information and existing reach conditions (Figure 1). Specific project components were also evaluated individually. Specific project components of project design alternatives are presented in Table 1.

Table 1. Proposed White River Countyline project components

Project Alternative Components	Description
Extended Left Bank Levee Removal	Remove 2,880 lineal feet of existing levee and revetment. This more extensive (and more expensive) removal alternative was included as an alternative that would encourage riverine processes to reshape the channel and promote floodplain evolution over a shorter time scale by removing as much of the length of the current barrier as practical.
Four Notch Levee Removal	Remove the existing levee and revetment at four locations. The total length removed would be 1,000 lineal feet. This less-extensive (and less-expensive) removal alternative was included to assess the potential for natural riverine processes and floodplain evolution to occur over a longer time frame.
Biorevetment along Eastern Wetland Edge	This project component would include a biorevetment incorporating wood along the left bank of the irregularly shaped wetland edge. The purpose of this feature would be to prevent erosion and channel migration along the east edge of the wetland after the existing left bank levee is removed.
Vegetated Riparian Buffer Landward of Wetland Edge	A vegetated buffer east of the wetland would include native vegetation equal in width to the current regulatory wetland buffer (about 50 to150 feet depending on jurisdiction). The vegetated buffer would serve to provide shade and additional inputs of invertebrate food sources to salmonids when aquatic invertebrate prey is scarce.
Setback Berm	This project component would include a berm “set back” from the edge of the left bank wetland edge to provide additional flood containment to properties on the left bank. In 2009, the left bank overtopped at the southeast end of the wetland and flowed south over 8th Street E. (Stewart Road E.) (see cover image). This event post-dates the analysis of the alternatives metrics.
Engineered Logjams	Engineered logjams in the form of large, stand-alone apex type structures located in the interior of the wetland were included as elements to provide additional rearing habitat for salmonids and to provide flow deflection away from the biorevetment.
Other Bioengineered Features	This project element included other small-scale bioengineered features (e.g., channel-roughening structures, debris catchers, and live flood fences) that could be incorporated into project design, as needed, to promote channel processes.

The four project alternatives comprise various configurations of the project components listed above and are presented in Table 2.

Table 2. Project alternatives and corresponding components.

Alternative	Project Components
No. 1	Extended levee removal; biorevetment, vegetated buffer, ELJs, and other bioengineered features, (Figure 2)
No. 2	Extended levee removal, biorevetment, vegetated buffer, setback berm, ELJs, and other bioengineered features, (Figure 3)
No. 3	Four notch removal; biorevetment, vegetated buffer, ELJs, and other bioengineered features, (Figure 4)
No. 4	Four notch removal; biorevetment, vegetated buffer, setback berm, ELJs, and other bioengineered features, (Figure 5)

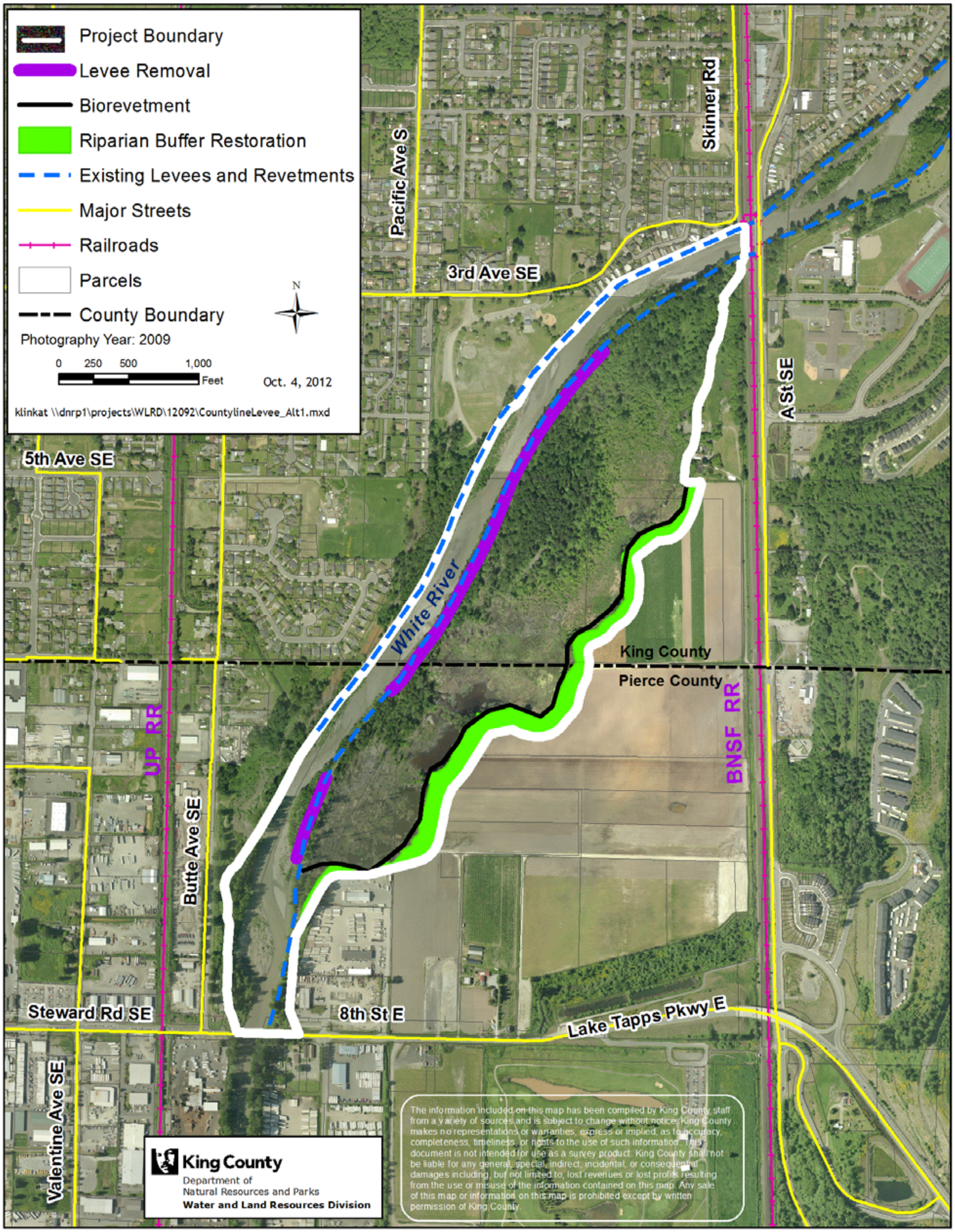

Figure 2. Alternative 1: extended levee removal including biorevetment, vegetated buffer, ELJs, and other bioengineered features.

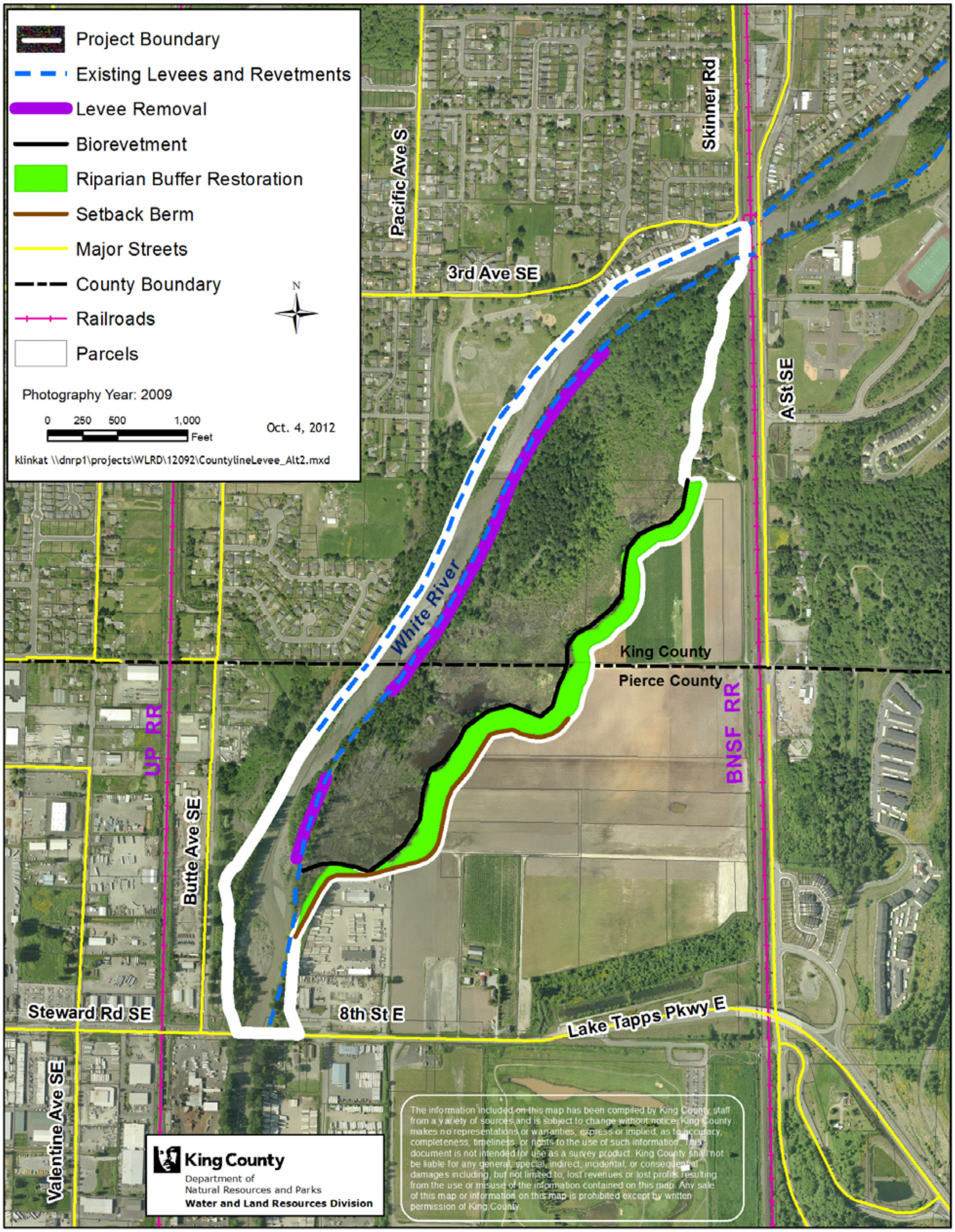

Figure 3. Alternative 2: extended levee removal including biorevetment, vegetated buffer, setback berm, ELJs, and other bioengineered features.

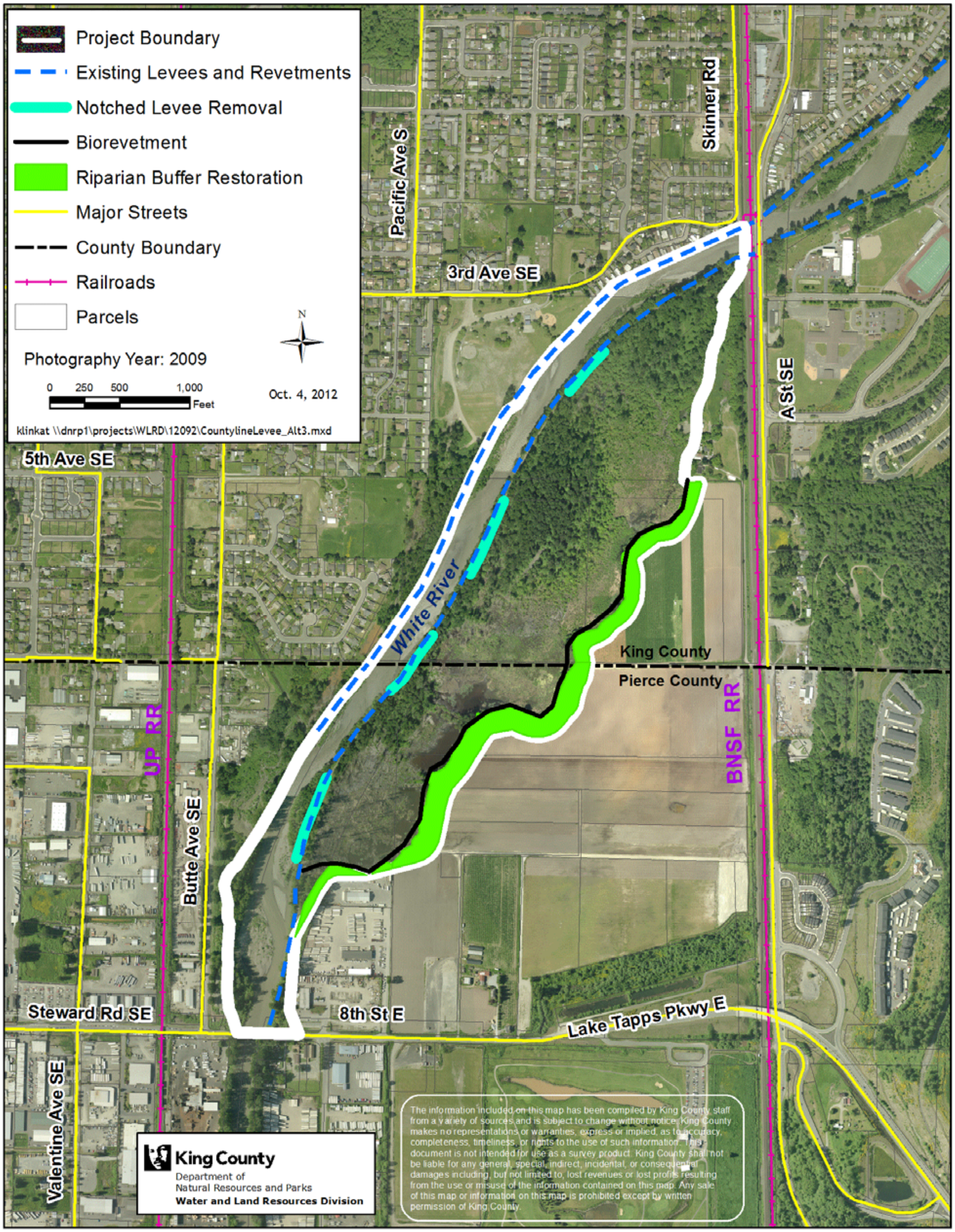

Figure 4. Alternative 3: four-notch levee removal including biorevetment, vegetated buffer, ELJs and other bioengineered features.

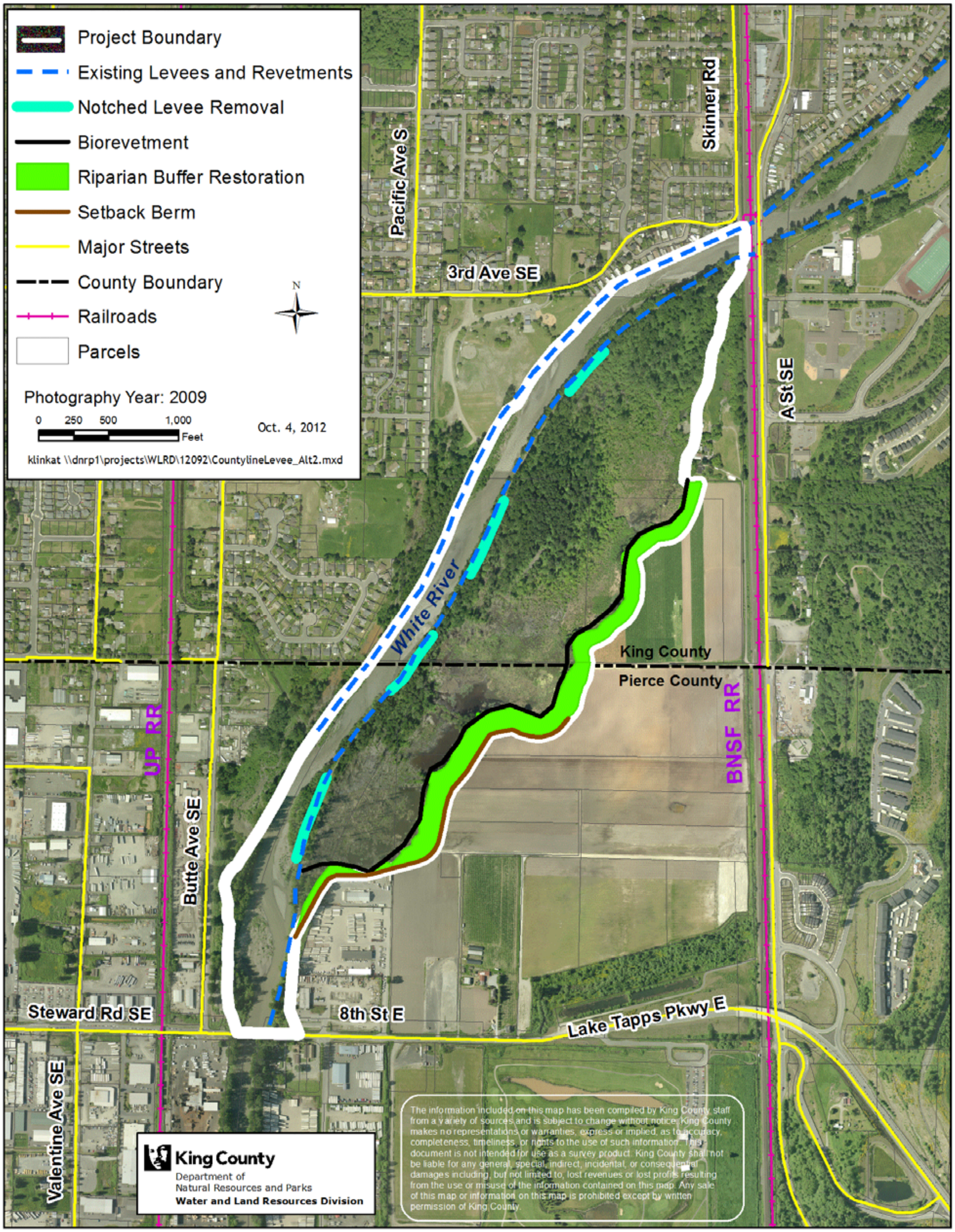

Figure 5. Alternative 4: four-notch levee removal including biorevetment, vegetated buffer, setback berm, ELJs and other bioengineered features.

3.0 METRICS EVALUATION METHODS

This section describes the methods used to evaluate metrics for each of the objectives. These are grouped here by the project goal and objective to which they relate. Some of the project goal and objective statements have been abridged in these sections.

Comparison values (scores) for project benefits and risks were developed to evaluate and rate the alternatives according to the 30 percent metrics (Table 3). The scores for each project alternative component were used to determine whether any one project component (e.g., ELJs, setback berm, biorevetment, etc.) resulted in a substantially more or less beneficial project. Individual score tables with ranges are provided in each section, but each follows the approach shown in Table 3 below.

Table 3. Scoring comparison keys for the alternatives analysis.

A. Physical Feature Benefits Comparison Key	
Score Value	**Benefits of Alternative Compared to No Action**
-7	Much worse than no project
-4	Moderately worse
-2	Slightly worse
0	No change
2	Low benefits
4	Moderate benefits
7	Very high benefits
B. Physical Feature Risk Comparison Key	
Score Value	**Risks of Alternative Compared to No Action**
-7	Much more risk
-4	Moderately more risk
-2	Slightly more risk
0	Same risk
2	Slightly less risk
4	Moderately less risk
7	Much less risk

The scores for Goals 1, 2, and 3 were normalized to allow for the addition of the three total scores. This sum (considered the alternative benefit) was compared to the total project cost from Goal 3 (construction cost plus the estimated maintenance and remedial action costs) to compare total project benefits to cost. The alternative with the highest project benefit to cost ratio was considered the preferred alternative.

Scores were assigned to each metric using a combination of quantitative and qualitative analyses that were based on available data. The existing data allowed the design team to objectively evaluate each alternative and draw defensible conclusions. Though additional information and data sets would be needed to thoroughly evaluate project impacts, the existing data sets were assumed to be sufficient for formulating a conceptual level design for the overall project. This alternatives analysis did not include the development of detailed conceptual designs for individual components such as the ELJs, biorevetment, and setback levee, which are to be developed during the 40% design phase.

3.1 Salmonid Habitat (Goal #1)

Metrics under Goal #1 focus on measuring changes in riverine processes and functions in the project area that are crucial for providing rearing and flood refuge habitat used by salmonids.

Objective 1.1 Allow natural channel movement within project area by removing and setting back the existing levee along the left bank.

Metric 1.1A Change in relative likelihood of floodplain reoccupation

This metric was quantified by computing the area of levee or revetment removal, which factors in the extent to which the current barrier to floodplain reoccupation is removed. Score values were assigned such that more acres of fill removed equated to a higher score value. Topographic survey imported into GIS was used to estimate areas of removal. The maximum amount of removal area possible was estimated to be approximately 8 acres. Scores were assigned values across this range (Table 4).

Table 4. Metric 1.1.A – Score values for area of levee and revetment removed

Score Value	Area (in acres)
0	0
1	>0 to 1.0
2	1.1 to 2.2
3	2.3 to 3.3
4	3.4 to 4.5
5	4.6 to 5.6
6	5.7 to 6.8
7	6.9 to 8.0

Objective 1.2 Encourage formation of off-channel habitat

Metric 1.2.A Change in edge habitat at project completion

Edge habitat (a surrogate measure for habitat complexity) under existing conditions was compared to predicted post-project edge habitat in order to evaluate Objective 1.2. Polygons were drawn in ArcGIS outlining the expected edge of water during modeled 2-year flows. The increase in edge habitat over existing conditions was calculated and used to assign a score based on the values in Table 5.

Table 5. Metric 1.2.A – Score values for increase in edge habitat over existing conditions.

Score Value	Percent (%) Increase
0	0-11
1	12-24
2	25-37
3	28-40
4	41-53
5	54-66
6	67-89
7	90-100

Objective 1.3 Provide off-channel flood refuge for salmonids by allowing a more natural frequency of inundation of the floodplain complex during flood events within the project boundaries.

Metric 1.3.A. Flood frequencies allowing access to floodplain.

This metric evaluates two options for reconnecting the main stem to the left bank floodplain, the four-notch approach or the extended removal approach. Floodplain access was defined for this metric as the length over the footprint of the existing levee and revetment (that currently blocks access by salmonids to the left bank floodplain) allowing access to flood refugia in the left overbank during a particular flood recurrence interval (e.g., 1.01, 2-, 10-, 50-, 100-, and 500-year recurrence intervals).

The estimated length of the revetment and levee blocking access between the main channel and the left floodplain is 5,720 lineal feet. The lengths of inundation across the footprint of the revetment and levee were quantified for each recurrence interval and compared with the maximum potential length of connection of 5,720 lineal feet. The lengths of inundation were derived from the results of HEC-RAS hydraulic modeling. Score values were assigned based on the percent of total length inundated for each recurrence interval, where higher percent inundation equated to higher score values as shown in Table 6 below. These scores were then normalized for each recurrence interval and summed to come up with a relative score for each alternative and for no action (in this case equal to existing conditions). For simplicity and to assign greater weight to alternatives with immediate benefits versus long-term benefit, this metric only evaluated conditions immediately after construction and did not consider future channel migration which could be expected to occur over time and increase floodplain connectivity if the notching approach were taken.

Table 6. Metric 1.3.A – Score values for percent total length of accessible floodplain.

Score Value	Percent (%) Increase
0	0
1	1-13
2	14-28
3	29-42
4	43-56
5	57-70
6	71-85
7	86-100

Objective 1.4 Protect existing mature riparian buffer areas and restore a corridor of mature riparian vegetation within the project boundaries to provide shoreline and stream channel shading, invertebrate prey supply, and large wood recruitment.

Two analyses were conducted in order to evaluate Objective 1.4. First, mature tree density on the existing levee prism was compared to predicted construction-related tree removal. Second, the amount of the total regulatory buffer that would be revegetated was compared to existing conditions.

<u>1.4.A. Difference in number of existing mature trees preserved in construction footprint</u>

Mature trees along the riverward and landward sides of the existing levee prism were counted in the field. A representative section of the levee was selected (417 feet in length) and all trees

over 4-inch diameter at breast height (dbh) were counted. The number of trees per linear foot was calculated and multiplied by the disturbance area for each levee removal alternative. All trees within the disturbance area were assumed to be removed during construction. Because all of the alternatives included face rock removal along the entire "extended removal" footprint, both notched and extended removal alternatives included removal of all trees along the riverward side of the levee. Estimates of the number of trees that would be removed for ELJ construction were not done for this level of analysis. The number of trees removed under each alternative was compared to the total number of trees on the levee, resulting in percent of total trees removed as the evaluation metric. The range of estimated tree removal was binned equally for all components and assigned a score of 0 to 7 (Table 7).

Table 7. Metric 1.4.A – Score values for percent of trees removed during construction.

Score Value	Percent (%) Trees Removed
0	88-100
1	75-87
2	63-74
3	50-62
4	38-49
5	25-37
6	13-24
7	0-13

1.4.B. Area of native riparian corridor created

An estimate of revegetation area was calculated by determining the area of the riparian buffer to be planted and using aerial photos to examine the current vegetation in this area. At the time this analysis was done, the Salmon Recovery Funding Board grant agreement specified a 100-foot wide planted buffer. The total (100-foot wide) area that would be revegetated was compared to the total regulatory buffer to calculate the percent of the total regulatory buffer that would be revegetated; this percent increase was multiplied by 7 to obtain a score between 0 and 7 (Table 8).

Table 8. Metric 1.4.B – Score values for percent revegetated buffer area.

Score Value	Percent (%) Increase
0	0-11
1	12-24
2	25-37
3	28-40
4	41-53
5	54-66
6	67-89
7	90-100

3.2 Flood Hazards (Goal #2)

Goal 2: Prevent an increase in flood hazards outside of the project area due to this restoration project and, if possible, reduce existing flood hazard.

Evaluation tools used for the metrics addressing flood hazard objectives included the use of 1-D Hydraulic Modeling (HEC-RAS Version 3.1.3) and qualitative consideration of available existing information. The existing 1-D hydraulic model for the Lower White River 2008 Flood Study was used along with flood elevation information from the Pierce County Preliminary Draft Flood Insurance Rate Maps for the Lower White River. Recurrence intervals used were those developed for the 2008 Flood Study and are summarized below in Table 9.

Table 9. Recurrence interval flows for the White River at A Street from the 2008 Flood Study.

Recurrence Interval (years)	Flow (cfs)
1.01	2,058
2	9,692
10	14,000
50	15,300
100	15,500
500	19,000

Modifications were made to the flood study model to represent each alternative at construction completion. This analysis did not included hydraulic modeling based on future projections of sediment aggradation in the reach or on any sediment transport modeling. These changes did not include the addition of engineered logjams in the models because roughness values in the left overbank were already high due to the existing forest. Furthermore, a conceptual design for the number and placement of ELJs had not yet been conducted. Lastly, it was acknowledged that there were inherent limitations in using a 1-D model to analyze the complex flow patterns that would likely occur when the left bank levee is removed; however, the 1-D model served its purpose in comparing and selecting a preferred project design for the overall project. It was acknowledged that a 2-D model would better serve the purpose of analyzing project hydraulics for later project design purposes.

Changes in the regulatory base flood elevations were modeled for each alternative by removing the left bank levee and revetment prisms from the model to reflect the fill removal. Levee cards were added to models used to estimate physical changes (assuming existing fill prisms would not fail) in flood elevations and containment flows immediately after construction. Lateral weirs and a split flow channel were added to the four-notch alternative models at each notch location to model flow distribution in the main channel and in left overbank.

Objective 2.1 Design the project to ensure flood hazards (on private property or public infrastructure) outside of the project area does not increase due to the project.

Metric 2.1.A Change in base flood elevation (ft) in immediate vicinity of the right and left banks, and upstream and downstream of the project area:

Changes in base flood elevation were analyzed for the right bank, left bank, and upstream and downstream reaches in the immediate vicinity of the project. Modeled flood elevations for each alternative were compared with base flood elevations from the 2008 King County Flood Study (NHC 2008) and the Pierce County Preliminary DFIRMs, and then averaged to come up with an average change for each area. Results were also reviewed for maximum increase and decrease in water surface elevations. Since both alternatives resulted in reductions in base flood elevations at all but one cross-section, an averaging approach was felt to be appropriate to represent project effects. This was especially true on the right bank and upstream of the project since the regulatory maps indicate higher flood elevations on the right bank, in the main channel, and upstream assuming the left bank levee is not breached. Since the project would intentionally breach the left bank levee and remove revetment fill, the combination would in theory result in large-scale reductions in flood elevations in these areas immediately after project construction. The one outlier was a localized increase in flood elevations at one cross section due to a sharp transition from confined flow to expanded flow created by the levee removal. The actual project design would create a smoother transition and largely dampen this effect.

A total score for each alternative was derived by assigning one-third of the total score to the upstream and downstream areas (lumping upstream and downstream together since the downstream segment was a short segment between the project and 8th Street Bridge), one-third to the right bank, and one-third to the left bank (Table 10).

These four areas correlate to the following river mile segments:

- Upstream, from RM 6.145 to 7.511 (Upstream end of left bank levee excavation to upstream model limit)
- Downstream, from RM 4.978 to 5.197 (Downstream edge of the 8th Street Bridge to just downstream of existing wetland outlet culvert)
- Right bank, from RM 5.292 to 6.145 (Near wetland outlet culvert to upstream end of left bank levee excavation)
- Left overbank (flood elevations along left bank terrace), from RM 5.292 to 6.077 (Near wetland outlet culvert to upstream of the left bank levee excavation)

Table 10. Metric 2.1.A – Score values for changes in base flood elevation.

Score Value	Average Change (ft)
-7	> 2
-6	0.75 to 2
-5	0.5 to 0.75
-4	0.25 to 0.5
-3	0.1 to 0.25
-2	0.01 to 0.1
-1	0 to 0.01
0	0
1	0 to -0.01
2	-0.01 to -0.1
3	-0.1 to -0.25
4	-0.25 to -0.5
5	-0.5 to -0.75
6	-0.75 to -2
7	< -2

Metric 2.1.B Change in flood elevations in immediate vicinity of the right and left banks, and upstream and downstream of the project area:

Physical changes in post-project flood elevations were analyzed using HEC-RAS for the extended alternative and for the four-notch alternative with no setback berm in place, for the right bank, left bank, and upstream and downstream reaches in the immediate vicinity of the project (as listed in Metric 2.1.A.). This metric evaluated potential project effects of levee removal on flood elevations outside the project limits at various flood frequencies. The impacts on flood elevations of adding a setback levee were evaluated qualitatively in the alternative scores, but no detailed modeling of the setback levee was conducted for this alternatives analysis. Alternatives were modeled assuming the segment(s) of the left bank levee kept in place do not fail. The levee/revetment prism was removed from the model where the project would remove levee or revetment fill. Lateral weirs were used in the four-notch alternative to model flow across each of the notches.

Modeled flood elevations for each alternative were compared against existing conditions flood elevations. Maximum, minimum, and average change in water surface elevations were

summarized for each cross-section. Metric 2.1.B included analyses of the 2-, 10-, 50-, 100-, and 500- year recurrence interval flows. Scoring used the same approach as shown in Table 10 for Metric 2.1.A. Total scores for each of the reaches was calculated by assigning one-fifth of the total point value to each of the 5 recurrence intervals. Individual points for each recurrence interval were then totaled to derive the total score for the reach. Total scores for each alternative were then calculated the same as for Metric 2.1.A, where one-third of the total point value was assigned to the left and right banks, and two-thirds was assigned to the downstream and upstream reaches (the upstream and downstream reaches were lumped).

Metric 2.1.C. Change in containment flow frequency

The change in containment flow frequency or flow quantile was measured as the difference in containment flow frequency between each alternative and existing conditions immediately after project construction. No future projections incorporating changes in channel capacity due to sediment aggradation was included in this metric evaluation. HEC-RAS output from metric 2.1.B, with the addition of the 1.01-year recurrence interval flow was used to assess changes in flood containment. This analysis focused on the eastern edge of the wetland bank since removal of the existing levee would result in the greatest change in containment flow frequency. Model cross-sections with the greatest change in flood containment (identified as flow contained below the top of bank) relative to existing conditions were identified and scored according to Table 11. The cross-section with the lowest score was used for scoring this metric. The flood frequencies analyzed included the 1.01-, 2-, 10-, 50-, 100-, and 500- year recurrence intervals.

Table 11. Metric 2.1.C – Score values for change in containment flow frequency.

Score Value	Increments of Change in Containment Flow Frequency
0	No change
-1	<1 (e.g. reduced from 50 yr to 30 yr)
-2	1 (e.g. reduced from 500 yr to 100 yr)
-3	2 (e.g. reduced from 500 yr to 50yr)
-4	3 (e.g. reduced from 500 yr to 10yr)
-5	4 (e.g. reduced from 500yr to 2yr)
-6	5 (e.g. reduced from 500yr to 1.01yr)
-7	> 5 (e.g. reduced from 500yr to <1.01yr)

2.1.D. Change in estimated erosion hazard or scour

The technical analysis used to evaluate the project alternatives against metric 2.1.D was to compare the channel-averaged basal shear stress values calculated by the HEC-RAS hydraulic model under existing conditions to those with project alternatives in place. In addition, a qualitative characterization of the likely hydraulic response due to the project alternatives also

was considered in evaluating the alternatives. No scour calculations were performed at this 30% stage. The score values for this metric are presented in Table 12.

It was assumed that there would be no difference between the extended levee removal Alternative 1 (no setback berm) and extended levee removal Alternative 2 (setback berm) and no difference between notched levee removal Alternative 3 (no setback berm) and notched levee removal Alternative 4 (setback berm) with regard to this metric. This approach assumes that the likelihood for hydraulics in main channel to induce scour or erosion, especially along the right bank, would be unaffected by the presence or absence of a setback berm on the left bank terrace. Therefore, Alternatives 1 and 2 were rated the same and Alternatives 3 and 4 were rated the same in evaluation against this metric.

Table 12. Metric 2.1.D – Score values for change in erosion hazard or scour.

Score Value	Risk of Erosion or Scour Relative to Existing Conditions
-7	Very high
-4	High
-2	Moderately High
0	Moderate
2	Moderately Low
4	Low
7	Very low

Objective 2.2 Increase flood storage along the length of the project which will also have a net benefit on flood elevations in the immediate vicinity of the project, particularly the right bank.

2.2.A. Change in floodplain storage volume for the 2-, 10-, 50-, 100, 500-yr Recurrence Intervals

Flood storage volumes calculated from flood water cross-sectional areas over the project length under existing conditions were compared to predicted post-project flood storage volumes calculated from flood water cross-sectional areas over the project length using hydraulic modeling.

Increases to flood storage area within the study area were determined by using the HEC-RAS hydraulic model to calculate changes in the cross-sectional area of inundation. Calculations were completed for the 2-, 10-, 50-, 100-, and 500-year events. Flood storage volumes were then calculated as the product of the cross-sectional area of inundation and the length of channel between cross-sections. Volume calculations were completed for the extended removal and four-notch alternatives. Floodplain storage volumes did not include any landward areas of flooding on the left bank floodplain east of the wetland. Consequently, scores for the with- and

without berm alternatives were the same for the extended removal and for the four-notch alternatives. The score values for the percent change in floodplain storage volume are presented in Table 13.

The total score for this metric was derived by scoring each flood frequencies separately based on the table below, and then averaging the score for all recurrence intervals to calculate an overall score. All recurrence intervals were given equal weight.

Table 13. Metric 1.3.A – Score values for percent change in floodplain storage volume.

Score Value	Percent (%) Change in Floodplain Storage
0	No change
1	1-13
2	14-28
3	29-42
4	43-56
5	57-71
6	72-85
7	86-100

Objective 2.3 Avoid or minimize the need for sediment management actions.

<u>Metric 2.3.A. Evaluate post project vertical rates of aggradation for coarse sediment within and downstream of the project area.</u>

No quantitative analyses were conducted to evaluate the project alternatives against this metric. The likely responses of coarse sediment deposition to the project alternatives were considered qualitatively. As with Metric 2.1.D, it was assumed that there would be no difference between extended levee removal Alternative 1 (no setback berm) and extended levee removal Alternative 2 (setback berm) and no difference between notched levee removal Alternative 3 (no setback berm) and notched levee removal Alternative 4 (setback berm) with regard to this metric. Therefore Alternatives 1 and 2 were rated the same and Alternatives 3 and 4 were rated the same in evaluation against this metric.

Table 14. Metric 2.3.A – Score values for rates of aggradation of coarse sediment within and downstream of the project.

Score Value	Risk of Increased Sediment Aggradation Relative to Existing Conditions
-7	Very high
-4	High
-2	Moderately High
0	Moderate
2	Moderately Low
4	Low
7	Very low

3.3 Cost Effectiveness (Goal #3)

Project Goal 3: Design and construct a project that best meets the goals and objectives of the project using the most cost-effective means.

This goal specifically addresses the need to design and construct the project using the most efficient and cost-effective means. Efficiency and effectiveness were measured by cost, project benefit in terms of flood hazards and habitat, the likely frequency of maintenance and repair, and project longevity or estimated design life.

Objective 3.1 Evaluate individual and collective project components based on cost-effectiveness and ability to achieve the goals and objectives for salmonid habitat (primarily) and flood hazards.

<u>Metric 3.1A. Individual component costs</u>

Costs for individual components were developed using comparable projects, such as the Tolt River Floodplain Reconnection project, Newaukum Creek engineered logjam installations, and Green River levee and revetment repair projects. Rather than assigning a score to this metric, the cost was compared to the overall project alternative scores to evaluate cost effectiveness in terms of dollars spent per benefit score and benefit score per $1,000 spent. All costs are in 2008 dollars and include materials, labor, mobilization, and construction oversight. Numerical scoring was not assigned to each of the component costs.

Metric 3.1.B Individual component benefits

This number represents the sum of the individual component benefit ranking for each project objective that was determined by the alternatives analysis presented in Section 4.0 of this document. Each individual project component received a score for each project objective.

Objective 3.2 Avoid or minimize the need for remedial actions (habitat restoration or construction to avoid or repair public damage) by incorporating self-sustaining habitat restoration and flood hazard reduction components in the design.

Metric 3.2A. Minimize the need for long term maintenance

This metric was qualitative and compared each alternative relative to No Action, based on relative maintenance frequency, cost of repair, vegetation maintenance, and inspection requirements over a timeframe of 50-years. Scores for each alternative were based on past project experience from comparable project elements (e.g. setback levees, engineered log jams, biorevetments) as compared to the current and likely future maintenance needs of the current left bank levee and revetment in the project reach (Table 15).

Table 15. Metric 3.2.A – Score values for long-term maintenance.

Score Value	Long-term Maintenance Relative to Existing Conditions
-7	Very high
-4	High
-2	Moderately High
0	Moderate
2	Moderately Low
4	Low
7	Very low

Metric 3.2B. Estimated Design Life

This metric assigned score values based on the relative project service life, where a design life of 50 years was considered a long design life based on similar projects (Table 16). Sources reviewed included assumed decay rates of Douglas fir, comparable service lives of similar levee projects in King County's inventory, large engineered logjams (designed to resist scour, overturning, and other typical modes of failure for a 100-year design event), native woody vegetation comprising the vegetated buffer, and small-scale bioengineered structures (e.g

channel forming structures and flood fences). No score was assigned to either levee removal alternative since this metric is not applicable to excavation type.

Table 16. Metric 3.2.B – Score values for approximate life span.

Score Value	Approximate Life Span (years)
0	0-1
1	2-6
2	7-13
3	14-20
4	21-28
5	29-35
6	36-42
7	43-50

4.0 RESULTS: EFFECTS OF PROJECT ALTERNATIVES

A summary scoring sheet for project components each of the alternative analyzed is included in Appendix A. Results of metric analyses are summarized below.

4.1 Salmonid Habitat (Goal #1)

Objective 1.1 Allow natural channel movement within project area by removing and setting back the existing levee along the left bank.

Metric 1.1.A. Change in relative likelihood of floodplain reoccupation

Alternatives 1 and 2 received the same score (6) because both alternatives are extended levee removal where 5.7 to 6.8 acres of levee are removed (Table 17). Alternative #3 and #4 received the same score (2) because the 4-notch levee removal where 1.1 to 2.2 acres of levee are removed (Table 17).

Table 17. Metric 1.1.A – Results for levee and revetment fill removal.

Alternative	Acres of levee/revetment fill removed	Score
No Action	0	0
1	6.3	6
2	6.3	6
3	2.8	2
4	2.8	2

Objective 1.2 Encourage formation of off-channel habitat

Metric 1.2.A Change in edge habitat at project completion

There were minor differences in percent increase of edge habitat (wetted length) among the alternatives. The extended removal alternatives had a 36% increase in edge habitat over existing conditions compared to a 31% increase for the notched alternatives (Table 18).

Table 18. Metric 1.2.A - Results of percent change in edge habitat.

Alternative	Percent (%) Change in Edge Habitat	Score
No Action	0	0
1	31	2
2	31	2
3	36	2
4	36	2

Objective 1.3 Provide off-channel flood refuge for salmonids by allowing a more natural frequency of inundation of the floodplain complex during flood events within the project boundaries.

Metric 1.3.A. Flood frequencies allowing access to floodplain.

The two levee scenarios will increase the flood frequencies within the project area. Alternatives 1 and 2 have the same score because the same amount of levee is removed under these alternatives (extended levee removal) (Table 19). Alternatives 3 and 4 have the same score because the same amount of levee is removed under these alternatives (4-notch removal) (Table 19).

Table 19. Metric 1.3.3 – Results of comparisons of flood frequencies allowing access to floodplain.

Recurrence Interval (years)	Alternative	Length of connectivity to wetland (feet)	Difference between Existing Conditions and Alternative	Percent ot Total Length Inundated (total possible=5720 feet)	Score	Normalized Score (Score/7)
1.01	3 and 4	503	0	9	1	0.17
	1 and 2	503	0	9	1	0.17
	No Action	503	--	9	1	0.17
2	3 and 4	837	196	15	2	0.33
	1 and 2	3224	2584	56	4	0.67
	No Action	641	--	11	1	0.17
10	3 and 4	2099	638	37	3	0.50
	1 and 2	3309	1849	58	4	0.67
	No Action	1461	--	26	2	0.33
50	3 and 4	2175	650	38	3	0.50
	1 and 2	3333	1808	58	4	0.67
	No Action	1525	--	27	2	0.33
100	3 and 4	2180	652	38	3	0.50
	1 and 2	3335	1806	58	4	0.67
	No Action	1528	--	27	2	0.33
500	3 and 4	2356	682	41	3	0.50
	1 and 2	3378	1704	59	4	0.67
	No Action	1674	--	29	2	0.33

Table 20. Metric 1.3.A – Total of normalized scores for all recurrence intervals.

Alternatives	Score
No Action	2
1	4
2	4
3	3
4	3

Metric 1.4.A. Difference in the number of existing mature trees preserved within the construction footprint

The extended levee removal alternatives required more tree removal and therefore scored lower than the levee notching alternatives (Table 21). Alternatives 1 and 2 require trees to be removed from the riverward side of the "extended removal" footprint as well as the landward side of the "notched removal" areas. Alternatives 3 and 4 require trees to be removed from both the riverward and landward side of the "notched removal" areas.

Table 21. Metric 1.4.A – Scores for estimates of levee tree removal.

Alternative	# Trees Removed	Score
No Action	0	7
1	677	3
2	677	3
3	562	4
4	562	4

Metric 1.4.B. Total Area of native riparian corridor created

Because the existing regulatory buffer is either developed as light industrial or maintained as agricultural fields, the riparian buffer planting will provide an increase in the riparian area relative to existing conditions. Alternatives 1-4 had identical riparian buffer planting plans with 77% of the total area being revegetated, such that all of the alternatives received the same score (Table 22).

Table 22. Metric 1.4.B – Scores for estimated percent of the regulatory buffer to be revegetated following construction, as compared to existing conditions.

Alternative	Percent (%) Regulatory Buffer Revegetated	Score
No Action	0	0
1	77	6
2	77	6
3	77	6
4	77	6

4.2 Flood Hazards (Goal #2)

Metric 2.1.A Change in base flood elevation (ft) in immediate vicinity of the right and left banks, and upstream and downstream of the project area:

Although both projects reduced flood elevations for each area analyzed, the extended levee removal alternatives resulted in greater reductions in base flood elevations than the four-notch alternatives (Table 23). The most effective reductions were on the right overbank. One outlier on the four-notch alternatives was a localized, 0.78-foot increase in flood elevations at a sharp transition between confined and expanded flow that only occurred at one model cross section of the HEC-RAS model. Project design would actually create a smooth transition; therefore, this localized anomaly was not considered during scoring. Since scores were rounded to whole numbers, all alternatives scored a 4 (Table 23). Normalized scores of predicted changes in base flood elevations are presented in Table 24.

Table 23. Metric 2.1.A – Scores for change in base flood elevations.

Extended Removal						4-Notch Alternative					
Upstream (channel) XS 6.145 and above					Score	Upstream (channel) XS 6.145 and above					Score
Maximum Change (ft)	HEC-RAS Model Station	Minimum Change (ft)	HEC-RAS Model Station	Average Change (ft)		Maximum Change (ft)	HEC-RAS Model Station	Minimum Change (ft)	HEC-RAS Model Station	Average Change (ft)	
-3.23	6.15	0.00	6.65	-0.60	4	-1.98	6.22	0.01	6.76	-0.37	3
Downstream (channel) XS 5.197 and below						Downstream (channel) XS 5.197 and below					
Maximum Change (ft)	HEC-RAS Model Station	Minimum Change (ft)	HEC-RAS Model Station	Average Change (ft)		Maximum Change (ft)	HEC-RAS Model Station	Minimum Change (ft)	HEC-RAS Model Station	Average Change (ft)	
-1.11	4.98	-0.51	5.20	-0.81	5	-1.00	4.98	-0.43	5.20	-0.73	5
Right Overbank Channel (XS 6.145-5.292)						Right Overbank Channel (XS 6.145-5.292)					
Maximum Change (ft)	HEC-RAS Model Station	Minimum Change (ft)	HEC-RAS Model Station	Average Change (ft)		Maximum Change (ft)	HEC-RAS Model Station	Minimum Change (ft)	HEC-RAS Model Station	Average Change (ft)	
-4.09	6.01	-0.07	5.52	-1.91	7	-1.60	5.59	0.78	5.52	-1.01	7
Left Overbank Channel (left bank terrace XS 6.077-5.292)						Left Overbank Channel (left bank terrace XS 6.077-5.292)					
Note: Only at XS's where left bank terrace floods						Note: Only at XS's where left bank terrace floods					
Maximum Change (ft)	HEC-RAS Model Station	Minimum Change (ft)	HEC-RAS Model Station	Average Change (ft)		Maximum Change (ft)	HEC-RAS Model Station	Minimum Change (ft)	HEC-RAS Model Station	Average Change (ft)	
--		--		--	0	--		--		--	0

Table 24. Metric 2.1.A – Normalized scores for change in base flood elevations.

Alternative	Score
No Action	0
1	4
2	4
3	4
4	4

Metric 2.1.B Change in flood elevations (ft) in immediate vicinity of the right and left banks, and upstream and downstream of the project area:

Results of the changes in flood elevations for the alternatives are shown in Tables 25 through 28. Both the four-notch and extended removal alternatives showed similar trends in model results for most of the recurrence intervals modeled. Flood elevations were reduced immediately upstream of the project between the upstream end of the excavation and the A Street bridge. Increases in flood elevations occurred on the left overbank terrace between cross sections 5.517 and 5.292. Downstream flood elevations did not change noticeably.

The greatest reductions in flood elevations occurred on the right overbank, and the greatest increases occurred at the south end of the left overbank terrace. Maximum changes in the left overbank (Table 27) only reflect increase in flood elevations outside of the project area (i.e., the agricultural fields east of the wetland). Table 29 summarizes the normalized scores for the four areas of concern. The final scores for Metric 2.1.B are shown in Table 30.

Table 25. Predicted changes in water surface elevations in the upstream channel (RM 6.145 to 7.511).

Flood Recurrence Interval	Alternative	Upstream (channel) XS 6.145 and above						
		Maximum Change (ft)	HEC-RAS Model Station	Minimum Change (ft)	HEC-RAS Model Station	Average Change (ft)	Score	Normalized Score
2-yr	3 and 4	0.00	6.482	-0.29	6.145	-0.02	3	0.60
	1 and 2	0.03	7.087	-0.42	7.001	-0.03	3	0.60
10-yr	3 and 4	0.00	6.569	-0.39	6.145	-0.04	3	0.60
	1 and 2	0.15	7.087	-0.58	7.252	-0.11	4	0.80
50-yr	3 and 4	0.00	6.647	-0.40	6.145	-0.04	3	0.60
	1 and 2	0.01	7.087	-0.36	7.252	-0.08	4	0.80
100-yr	3 and 4	0.00	6.647	-0.40	6.145	-0.04	3	0.60
	1 and 2	0.18	7.087	-0.66	7.252	-0.12	4	0.80
500-yr	3 and 4	-0.66	7.001	-1.56	6.39	-0.93	6	1.20
	1 and 2	0.27	7.087	-0.73	7.252	-0.08	4	0.80

Note: Minimum change used for scoring since the greatest impact is just upstream of the left bank levee excavation sta

Table 26. Predicted changes in water surface elevations in the downstream channel (RM 4.978 to 5.197).

Flood Recurrence Interval	Alternative	Downstream (channel) XS 5.197 and below						
		Maximum Change (ft)	HEC-RAS Model Station	Minimum Change (ft)	HEC-RAS Model Station	Average Change (ft)	Score	Normalized Score
2-yr	3 and 4	0.00	5.00	0.00	4.98	0.00	0	0.00
	1 and 2	0.00	4.98	0.00	5.00	0.00	0	0.00
10-yr	3 and 4	0.00	4.98	0.00	5.00	0.00	0	0.00
	1 and 2	0.00	4.98	-0.01	5.00	0.00	0	0.00
50-yr	3 and 4	0.01	5.00	0.00	4.98	0.00	0	0.00
	1 and 2	0.00	5.00	0.00	4.98	0.00	0	0.00
100-yr	3 and 4	0.01	5.00	0.00	4.98	0.00	0	0.00
	1 and 2	0.00	5.00	0.00	4.98	0.00	0	0.00
500-yr	3 and 4	0.01	5.00	0.00	4.98	0.00	0	0.00
	1 and 2	0.00	5.00	0.00	4.98	0.00	0	0.00

Note: Minimum change used for scoring since the greatest impact is just upstream of the left bank levee excavation star

Table 27. Predicted changes in water surface elevations in the left overbank (RM 6.077-5.295).

Flood Recurrence Interval	Alternative	Left Overbank (XS 6.6577-5.292)			
		Maximum Change (ft)	HEC-RAS Model Station	Score	Normalized Score
2-yr	3 and 4	2.04	5.374	-7	-1.40
	1 and 2	0.00	5.46	0	0.00
10-yr	3 and 4	2.16	5.374	-7	-1.40
	1 and 2	0.39	5.46	-3	-0.60
50-yr	3 and 4	1.95	5.374	-6	-1.20
	1 and 2	0.74	5.46	-4	-0.80
100-yr	3 and 4	1.92	5.374	-6	-1.20
	1 and 2	0.84	5.374	-5	-1.00
500-yr	3 and 4	1.37	5.517	-6	-1.20
	1 and 2	0.39	5.46	-4	-0.80

Table 28. Predicted changes in water surface elevations in the right overbank (RM 6.145-5.292).

Flood Recurrence Interval	Alternative	Right Overbank (XS 6.145-5.292)						
		Maximum Change (ft)	HEC-RAS Model Station	Minimum Change (ft)	HEC-RAS Model Station	Average Change (ft)	Score	Normalized Score
2-yr	3 and 4			-2.72	6.06577*	-1.00	6	1.20
	1 and 2	-0.13	5.374	-2.77	5.712	-1.16	6	1.20
10-yr	3 and 4			-2.80	6.06577*	-0.83	5	1.00
	1 and 2	0.06	5.292	-2.82	6.06577*	-1.21	6	1.20
50-yr	3 and 4			-2.98	6.06577*	-1.24	6	1.20
	1 and2	0.13	5.374	-2.86	6.06577*	-1.19	7	1.40
100-yr	3 and 4			-3.01	6.013	-1.23	6	1.20
	1 and 2	0.12	5.374	-2.87	6.06577*	-1.18	7	1.40
500-yr	3 and 3	-0.87	6.145	-4.07	6.06577*	-1.81	7	1.40
	1 and 2	0.46	5.374	-3.02	6.06577*	-1.02	7	1.40

Table 29. Metric 2.1.B – Normalized scores for changes in water surface elevations.

Reach Location	Four-notch removal (Alternatives 3 and 4) Score	Four-notch removal Normalized Score	Extended Removal (Alternatives 1 and 2) Score	Extended Removal Normalized Score
Left Overbank	-6.4	-2	-3.2	-1
Right Overbank	6.6	2	6.6	2
Upstream	3.6	1	3.8	1
Downstream	0.0	0	0.0	0
Total Score	3.8	1	7.2	2

Table 30. Metric 2.1.B - Scores for changes in water surface elevations.

Alternative	Score
1	2
2	3
3	1
4	3

Metric 2.1.C. Change in containment flow frequency (match cfs and recurrence interval)

Though both the extended removal and four-notch levee removal alternatives resulted in lower containment flow frequencies on the left bank for alternatives not including a setback berm, the four-notch levee removal alternative lowered containment flow frequency slightly more than the extended removal alternative. Though modeling with a setback berm was not conducted, it was assumed for the purposes of this level of evaluation that reductions in containment flow frequency on the left overbank would be compensated for by the placement of a setback berm, if needed. Alternatives incorporating a setback berm were scored with a zero (or no change since the level of service of the setback berm had not been identified), while those that did not incorporate a setback berm were given negative scores since flood elevations were increased such that flooding on the left overbank terrace did occur more frequently than under existing conditions. Table 31 below identifies the maximum change in containment flow frequency, the cross-section this occurred at and the score.

Table 31. Metric 2.1.C – Scores for maximum change in containment flow frequency at HEC-RAS cross-section 5.46.

Existing Conditions (Baseline Flow)	Extended Removal (Alternatives 1 and 2, Without Setback Berm)	Score	Four-notch Removal (Alternatives 3 and 4, Without Setback Berm)	Score
100-year	10-year	-3	2-year	-4

Metric 2.1.D. Change in estimated erosion hazard or scour

HEC-RAS results showed negligible or no differences in basal shear stress values between existing conditions, extended levee removal alternatives (1 and 2) and notched levee removal alternatives (3 and 4). This finding held true for flows ranging from the 2-year to the 100-year flows. Although these results suggest that all four project alternatives should be rated the same as existing conditions, it is recognized that the HEC-RAS model is not capable of calculating local shear stress along a cross-section.

Qualitatively, it was determined that the extended removal of the levee will result in more of a decrease in channel confinement, and therefore a lowering of basal shear stress relative to existing conditions. Under this assumption, Alternatives 1 and 2 would be somewhat less likely to result in scour or erosion than existing conditions. The notched project alternatives (3 and 4)

would retain of the some levee prism and therefore were rated the same as existing conditions. Alternative ranking scores form Metric 2.1.D are presented in Table 32.

Table 32. Metric 2.1.D – Scores for estimated erosion hazard or scour.

Alternative	Score
No Action	0
1	1
2	1
3	0
4	0

<u>Metric 2.2.A. Change in floodplain storage volume for the 2-, 10-, 50-, 100, 500-yr Recurrence Intervals</u>

Increases to flood storage volume within the study area were calculated using methods described in the previous section to estimate change in flood storage volume for the 2-, 10-, 50-, and 100- year events. These were compared to Existing Conditions (or No Action) (Table 33).

Table 33. Metric 2.2.A – Scores for change in simulated flood storage volume for each alternative relative to existing conditions.

	Percent increase in flood storage volume and Individual and Total Score (% change/individual score)					
Alternative	**2-yr**	**10-yr**	**50-yr**	**100-yr**	**500-yr**	**Score**
1 and 2	100/7	51/4	42/3	41/3	30/3	4
3 and 4	100/7	36/3	29/3	27/2	19/2	3

Objective 2.3 Avoid or minimize the need for sediment management actions.

<u>Metric 2.3.A. Evaluate post-project rates of sediment aggradation within and downstream of the project area.</u>

Information considered in this qualitative evaluation includes several assumptions. It was assumed that the existing levees are composed of river alluvium, which is consistent with typical construction methods for levees built in the early 1900s. The notched levee removal alternatives (3 and 4) would leave some distances of unarmored levee prism material onsite, where it would be eroded by river flows, contribute that alluvial material to the channel, and thereby result in greater vertical aggradation than would the extended levee removal alternatives (1 and 2). By this reasoning, Alternatives 3 and 4 would have a greater impact (and lower rating) on channel aggradation than would Alternatives 1 and 2 (Table 34). It was assumed that the extended removal alternatives (1 and 2) would rate equally to existing conditions (Table 34).

Table 34. Metric 2.3.A – Scores for Sediment Management Actions.

Alternative	Score
No Action	0
1	0
2	0
3	-1
4	-1

4.3 Cost Effectiveness (Goal #3)

Objective 3.1 Evaluate individual and collective project components based on cost-effectiveness and ability to achieve the goals and objectives for salmonid habitat (primarily) and flood hazards.

Metrics 3.1.A and 3.1.B. Individual component costs and component benefit scores

Unit costs and quantities were derived for each of the project components as summarized below. Costs do not include

Biorevetment – Based on recent WLRD projects incorporating bioengineered elements, the unit cost was assumed to be $500 per lineal feet, a planning-level estimate. The length of the biorevetment was measured as the length the left overbank (east of the wetland).

Setback Berm – Unit costs for the setback berm was assumed to be $1,000/lf, a planning level estimate based on comparable WLRD levee repair and construction projects. For proper comparison with typical planning level estimates, the berm was assumed to be 5 feet high, have a 12 ft top width, and 2:1 riverward and landward slopes.

Extended and Four-notch Levee Removal – Unit costs for excavation were assumed to be $40/CY based on recent WLRD projects. This is a conservative value and given the volume of the extended levee removal (43,500 CY) this value could decrease depending on haul distance and disposal vendor costs. It was estimated that the removal volume for the four-notch levee removal alternative would be around 19,000 CY. It was assumed that the project would likely be a multi-year undertaking and that the existing levee would be removed in the second year of construction or after interior project elements had been constructed. It was also therefore conservatively assumed, that none of the existing levee prism fill would be reused. Volumes of existing fill removal were based on preliminary volume calculations using surveyed cross-sections and the end-area volume computation method.

Engineered Logjams (ELJs) – Project costs for engineered log structures constructed for the Tolt River Floodplain Reconnection and Newaukum Creek projects were reviewed. Since a preliminary design to select the types and number of ELJs had not yet been conducted, a

planning level assumption was made that the project should accommodate at least three large ELJs, where the unit cost for one large ELJ from the Tolt River project was $180,000.

Other Bioengineered Features - A planning-level assumption was made that the project could incorporate a range of these types of elements, but that a conservative budget value could be based on the cost of three channel-forming structures similar to those constructed for the Tolt River project, where the unit cost of one channel-forming structure was $21,000.

Vegetated Buffer – A conservative cost of $50,000 was estimated for the lump sum cost to vegetate the regulatory wetland buffer. This cost was based on planting costs from recent WLRD projects.

Table 34 summarizes the project component costs and the total individual component flood hazard and habitat scores. It should be noted that the scores shown in Table 35 also include individual component scores for metrics 3.2.A and 3.2.B described in the next section.

Table 35. Metric 3.1.A and 3.1.B – Individual component cost and total metric scores.

Project Component	Cost	Score
Biorevetment	$1,745,000	11
Setback Berm	$1,222,000	11
Extended Removal	$1,740,000	40
Four-notch Levee Removal	$760,000	29
Engineered Logjams	$540,000	11
Other Bioengineered Features	$63,000	8
Vegetated Buffer	$50,000	19

Objective 3.2 Avoid or minimize the need for remedial actions (habitat restoration or construction to avoid or repair public damage) by incorporating self-sustaining habitat restoration and flood hazard reduction components in the design.

<u>Metric 3.2A. Minimize the need for long-term maintenance.</u>

Project components were evaluated for their need for long-term maintenance throughout their anticipated design life. Each component was assigned a design life based on the 30% design assumptions. Assigned scores are summarized in Table 36 for each project component.

Table 36. Metric 3.2.A – Scores for long-term maintenance.

Project Component	Relative Long Term Maintenance	Score
No Action	HIGH to VERY HIGH - Frequent monitoring and channel surveys required, continued aggradation likely to increase the frequency of repair, potential flood fighting and maintenance needs	N/A
Biorevetment	LOW to VERY LOW - Annual, flood patrol, and post flood monitoring required, may require occasional repair as a "first line of defense" project element. Assumes no vegetation requiring maintenance.	5
Setback Berm	LOW - Annual, flood patrol, and post flood monitoring required, may require occasional repair. Side slope vegetation and access road requires maintenance.	4
Extended Removal	LOW to VERY LOW - Continued monitoring and occasional repair and maintenance of remaining permanent levee segment required. Current maintenance and repair need is very low.	6
4-Notch Levee Removal	LOW to VERY LOW - Continued monitoring and occasional repair and maintenance of remaining permanent levee segment required. Current maintenance and repair need is very low.	6
Engineered Logjams	LOW to VERY LOW - Annual, flood patrol, and post flood monitoring required, may require occasional repair as a "first line of defense" project element. Assumes no vegetation requiring maintenance.	6
Other Bioengineered Features	LOW to VERY LOW - Annual, flood patrol, and post flood monitoring required. Not expected to be repaired due to lower life span. Assumes no vegetation requiring maintenance.	6
Vegetated Buffer	LOW to VERY LOW – Initially maintenance of plantings will require weeding, watering and mulching till established. Once established, vegetation can be self-maintaining (assuming effective management of invasive vegetation) and maintenance expected to be very low.	6

<u>Metric 3.2B. Estimated Design Life</u>

Project components were evaluated based on the methods described in the methods section for this metric. Scores are tabulated in Table 37. The projected lifespan Douglas fir key members was a significant factor in estimating design life for ELJs, biorevetment, and other bioengineered features incorporating wood. This was estimated to be between 35 and 50 years. The estimated design life of the biorevetment was given a range assuming that sections could be rebuilt to increase its life span, whereas failing timbers in an ELJ would most likely require the entire

assemblage to be replaced. Levees in King County have been in place for more than 50 years and continue to function with continued maintenance. Other bioengineered features are expected to serve a function over a shorter time period in order to promote natural riverine processes, but would not be actively maintained as their functional need over time would be reduced as riverine processes are restored. Once established, the vegetated riparian buffer, planted with native woody vegetation would likely have an expected life of 50 years, but would more likely outlast the rest of the project elements.

Table 37. Metric 3.2.B. Scores for estimated design life.

Project Component	Estimated Design Life	Score
Biorevetment	~35-50 years	6
Setback Berm	~50 years	7
Extended Removal	N/A	0
4-Notch Levee Removal	N/A	0
Engineered Logjams	35 years	5
Other Bioengineered Features	10	2
Vegetated Riparian Buffer	>50	7

5.0 EVALUATION OF ALTERNATIVES

5.1 Scoring Summary

A summary scoring sheet for project components each of the alternative analyzed is included in Appendix A. The project benefit compared with total cost for each alternative is listed in Table 38, along with benefit score/$100,000. Alternative #2 - Extended removal alternative with the setback levee alternative had the highest benefit to cost ratio of all the alternatives analyzed. The Flood Hazard metric analyses also indicated that excavation of the left bank levee without some type of containment structure on the left bank terrace would result in an increase in flood hazards on the left bank terrace. Looking at the habitat and flood hazard goals separately, Alternative #2 had the highest total metric scores for each, and tied with Alternative #4 for the highest project effectiveness total metric score.

Table 38. Alternative Evaluation Benefits Compared to Total Project Costs.

Alternative	Total Score	Total Estimated Cost	Benefit/ $100,000
#1 Extended Levee Removal, biorevetment, vegetated buffer, ELJs, and other bioengineered features	49	$4,138,000	2,027
#2 Extended Levee Removal, biorevetment, vegetated buffer, setback berm, ELJs, and other bioengineered features	51	$5,360,000	2,709
Four-notch Removal, biorevetment, vegetated buffer, ELJs, and other bioengineered features	35	$3,158,000	1,101
Four-notch Removal, biorevetment, vegetated buffer, setback berm, ELJs, and other bioengineered features	38	$4,380,000	1,677

5.2 Recommendations

The results of this analysis of four alternatives conducted during the 30% design phase of the Countyline Levee Setback project indicate that Alternative 2 (extended levee removal, biorevetment, vegetated buffer, setback berm, ELJs, and other bioengineered features) is the most preferred alternative. This finding is based on the highest total score and the greatest benefit to cost ratio calculated for the alternatives. It is recommended that Alternative 2 be carried forward for design refinement.

6.0 REFERENCES

Herrera. 2009. White River Sediment Trends Report, December 2009 Check Draft. Prepared for King County River and Floodplain Management Section. Seattle, Washington.

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7.0 APPENDIX A

Metric Score Sheet

Appendix A – Table A.1

Countyline Project Metrics Score Sheet - Near-term, post-construction metrics

Goal/Metric	Project components							Project Alternatives			
	Extended Removal	Four-notch Removal	Biorevetment along wetland	Vegetated buffer	Setback berm	ELJs	Other features: Channel roughening feature/debris catchers	Alternative #1: Extended removal; biorevetment, vegetated buffer, no berm, ELJs, and other features	Alternative #2: Extended removal, biorevetment, vegetated buffer, berm, ELJs, and other features	Alternative #3:Four-notch removal; biorevetment, vegetated buffer, no berm, ELJs, and other features	Alternative #4: Four-notch removal; biorevetment, vegetated buffer, berm, ELJs, and other features
Goal 1. Restore riverine processes and functions within the project area.											
Objective 1.1 Allow natural channel movement within project area											
1.1A Change in relative likelihood of floodplain reoccupation. (sf or acres of newly accessible floodplain 2-YR)	6	2	0	0	0	0	0	6	6	2	2
Objective 1.2 Encourage formation of off-channel habitat											
1.2.A Change in edge habitat at project completion (2-yr floodplain perimeter length)	2	2	0	0	0	0	0	2	2	2	2
Objective 1.3 Provide off-channel flood refuge											
1.3.A. Change in extent of access to floodplain a flow frequencies >1.01 yr	4	3	0	0	0	0	0	4	4	3	3
Objective 1.4 Riparian buffer preservation/creation											
1.4.A. Difference in number of existing mature trees preserved in construction footprint	3	4	0	0	0	0	0	3	3	4	4
1.4.B. Area of native riparian corridor created	0	0	0	6	0	0	0	6	6	6	6
							Subtotal of Columns	32	32	26	26
							Total Possible	49	49	49	49
							Normalized Total	50	50	50	50
							Normalized Scores	33	33	27	27

Appendix A – Table A.1 (continued)

Goal/Metric	Project components							Project Alternatives			
	Extended Removal	Four-notch Removal	Biorevetment along wetland	Vegetated buffer	Setback berm	ELJs	Other features: Channel roughening feature/debris catchers	Alternative #1: Extended removal; biorevetment, vegetated buffer, no berm, ELJs, and other features	Alternative #2: Extended removal, biorevetment, vegetated buffer, berm, ELJs, and other features	Alternative #3:Four-notch removal; biorevetment, vegetated buffer, no berm, ELJs, and other features	Alternative #4: Four-notch removal; biorevetment, vegetated buffer, berm, ELJs, and other features
Goal 2. Prevent an increase in flood hazards outside of the project area, if possible reduce exisiting flood hazard.											
Objective 2.1 Ensure no increase in flood hazards											
2.1.A Change in base flood elevation (ft) in immediate vicinity of:											
Right bank	2.33	2.33	0	0	0	0	0	2	2	2	2
Left bank	0.00	0.00	0	0	0	0	0	0	0	0	0
Upstream	0.67	0.50	0	0	0	0	0	1	1	1	1
Downstream	0.83	0.83	0	0	0	0	0	1	1	1	1
							Subtotal of Columns	4	4	4	4
2.1.B. Change in flood elevations for the 2-,10-, 50-,100-, and 500-yr RIs											
Right bank	2	2	0	0	0	0	0	2	2	2	2
Left bank	-1	-2	0	0	0	0	0	-1	-1	-2	-2
Upstream	1	1	0	0	0	0	0	1	1	1	1
Downstream	0	0	0	0	0	0	0	0	0	0	0
							Subtotal of Columns	2	2	1	1
2.1.C. Change in containment flow frequency (match cfs and Q freq)	-3	-4	0	0	0	0	0	-3	-3	-4	-4
2.1.D. Change in estimated erosion hazard or scour	1	0						1	1	0	0
Objective 2.2. Increase flood storage											
2.2.A. Change in floodplain storage volume for the 2-,10-, 50-, 100-, 500-yr RIs	4	3	0	0	0	0	0	4	4	3	3
Objective 2.3. Avoid/minimize sediment management actions											
2.3.A. Change in vertical aggradation rates for coarse sediment within and downstream of project.	0	-1						0	0	-1	-1
							Subtotal of Columns	8	8	3	3
							Total Possible	42	42	42	42
							Normalized Total	50	50	50	50
							Normalized Scores	9	9	3	3

Appendix A – Table A.1 (continued)

Goal/Metric	Project components							Project Alternatives			
	Extended Removal	Four-notch Removal	Biorevetment along wetland	Vegetated buffer	Setback berm	ELJs	Other features: Channel roughening feature/debris catchers	Alternative #1: Extended removal; biorevetment, vegetated buffer, no berm, ELJs, and other features	Alternative #2: Extended removal, biorevetment, vegetated buffer, berm, ELJs, and other features	Alternative #3:Four-notch removal; biorevetment, vegetated buffer, no berm, ELJs, and other features	Alternative #4: Four-notch removal; biorevetment, vegetated buffer, berm, ELJs, and other features
Project Goal 3: Design and construct a project that best meets the goals and objectives of the project using the most cost-effective means.											
Objective 3.1 Cost versus project benefit/risk reduction effectiveness											
3.1.A. Estimated cost (2008)	$ 1,740,000	$ 760,000	$ 1,745,000	$ 50,000	$1,222,000	$ 540,000	$ 63,000	$ 4,138,000	$ 5,360,000	$ 3,158,000	$ 4,380,000
3.1.B. Individual component benefits	40	29	11	19	11	11	8				
Objective 3.2 Avoid/minimize need for remedial actions											
3.2.A. Long-term maintenance requirements based on frequency and cost of repair, vegetation maintenance, and inspection	6	6	5	6	4	6	6	29	33	23	33
3.2.B. Estimated design life	0	0	6	7	7	5	2	20	27	13	27
							Subtotal of Columns	49	60	36	60
							Total Possible	98	98	98	98
							Normalized Total	14	14	14	14
							Normalized Scores	7	9	5	9
							Grand Total Project Benefit Score	49	51	35	38
							Estimated Construction Cost	$ 4,138,000	$ 5,360,000	$ 3,158,000	$ 4,380,000
							Benefit Score/$100,000	2,027	2,709	1,101	1,677