APPENDIX C

Skagit River Big Bend Reach Habitat Restoration Feasibility Study Excerpts Relating to Johnson Bar, major site in vicinity

Skagit River Big Bend Reach Habitat Restoration Feasibility Study

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December 20, 2004

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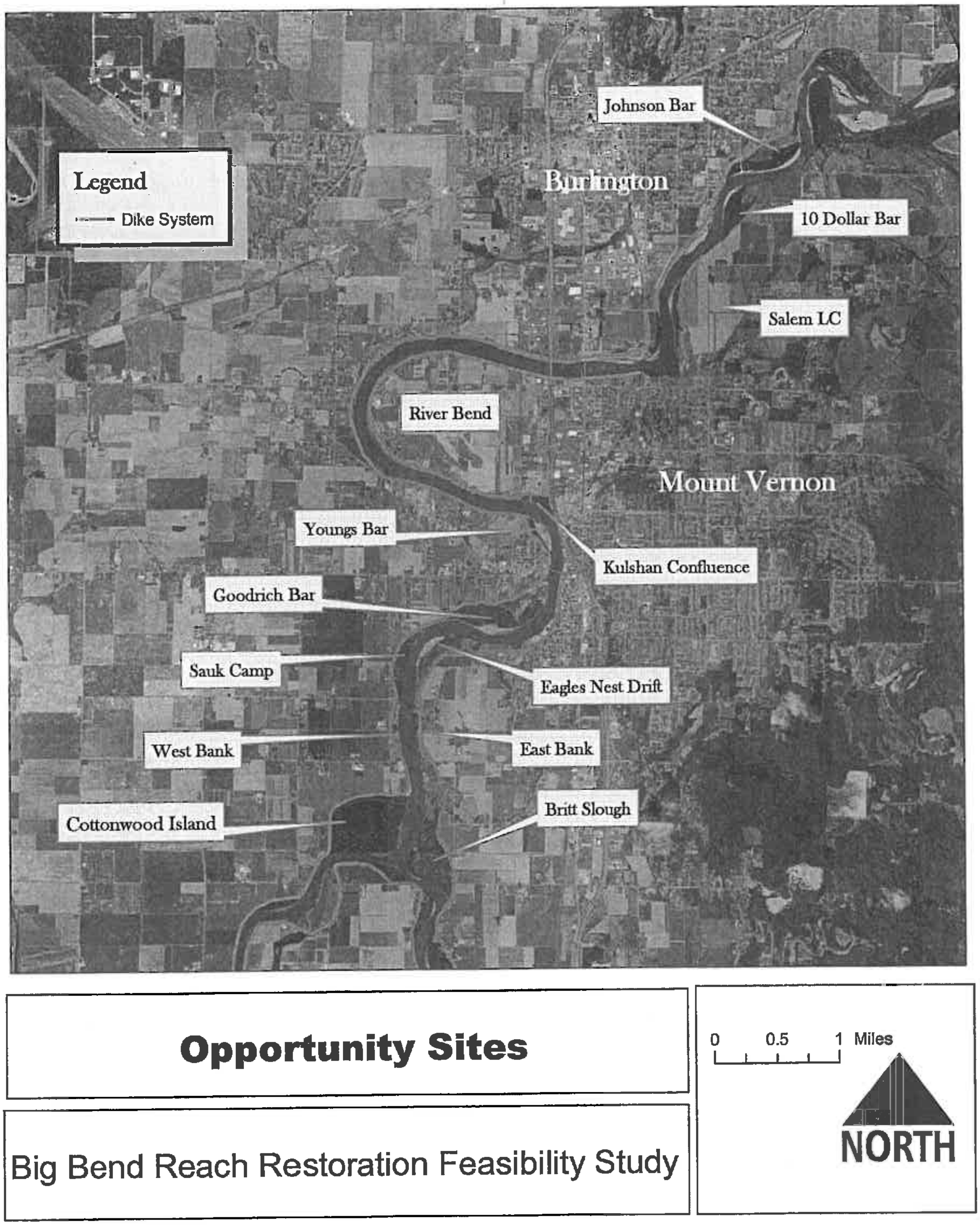

Figure 14 - Opportunity Sites

5.1 Site 1 - Johnson Bar (Figure 15)

LOCATION: This site is located at RM 19-20 on the right bank across from the confluence of Nookachamps Creek.

AREA: The site is 72 acres in size.

EDGE HABITAT: The site is framed by the levee protecting the City of Burlington. At the upstream end of the site, the riverbank is armored for approximately 1538feet. The remainder of the site is classed as bar habitat (3547 lineal feet).

TOPOGRAPHY: Based on our methods of defining zones relative to mean water level we identified three representative zones at this site. Zone one comprising the bar area is approximately 12.3 acres in size. Zone two with elevations generally 5-10 feet above mean water level constitutes 35.9 acres or nearly 50% of the floodplain. The remainder are fields higher than the forested area by approximately 5 to 10 feet, and received zone four designation. Some low elevation wetlands parallel the inside edge of the dike. These are possibly a relic from fill borrowed for construction of the levees.

OFF CHANNEL HABITAT: A persistent network of ephemeral side channels were identified at the site. The side channel network appears to be well interconnected, however heavy off-road vehicle (ORV) use made it difficult to determine which channels were self sustaining and natural. It also appears that ballast rock was dumped in one of the relic channels to make it a road bed. A very rough estimate of 5,477 lineal feet of persistent channel was identified. There appears to be one low-elevation outlet that drains the primary channel network, however, another shallow channel crosses underneath the boat ramp access road, and exits the site at the far downstream end.

FOREST CONDITION: Four plots were sampled at this site. Floodplain forests at Johnson Bar are generally even aged, ranging from 40 - 52 yrs. The number of live overstory trees ranges from 138-160 stems per acre with a basal area of 203-213 square feet per acre. This is consistent with what you would expect of a moderately aged forest, although cottonwoods drive up the basal somewhat because of their large size. (Young forests generally have more trees per acre but less volume, in the 100 sq feet/ac range and old growth forests often have less stems and closer to 300-400 sq feet/ac).

Of the forest at Johnson Bar, roughly 30% of the trees are > 20" in diameter. These trees make up more than half the basal area on the site. The rest of the trees are in the 8-20" category and account for the other half of the basal area. This site is heavily dominated by Black Cottonwood which makes up 85% of the tree-per-acre count, the balance being Red Alder. No conifers were identified in the sampled plots although some conifers exist on site.

The most notable LWD accumulation on this site occurs adjacent to the boat ramp access road. LWD apparently piles up against the road grade where it blocks the primary side channel on the site. Small accumulations of LWD are observed within side channels not impacted by ORV use. None of the wood observed was in diameter classes greater than 60 cm in size.

OWNERSHIP: Ownership is distributed between the City of Burlington (South and West end), Dike District #12 (East End along the river) and private (North side along the levee).

LAND USE: Surrounding land uses include the Burlington Sewage Treatment Plant to the west and expanding residential development on agricultural lands to the north. The river forms the East and South boundaries of the site. The site is a public access site under the jurisdiction of the City of Burlington and features the Gardner Road Boat Ramp located in the downstream (West) end of the site. About a third to half the site is grass field located adjacent to the levee, while the remainder contains young, mostly deciduous, riparian forest. A paved road, leading to the boat ramp, bisects the lower third of the site. The levee forms the boundary of the site to the north and the west. The site also features a network of channels, which have been emphasized and impacted by ORV use. ORV trails appear to follow the network of side channels (or alternately, overbank flow forms side channels through the ORV trail network during high flow periods).

GEOMORPHOLOGY: Johnson Bar is on the inside of a broad, curving river meander. Within the forested portion of the site, fine sand is intercalated with the vegetation mat on the ground. This indicates repeated deposition during high water. In addition, sediment deposition occurs along the river's edge upstream of the boat ramp. Sediment size was measured during the 2002 Skagit River study (Pentec Environmental, 2003). The gravel bar surface at the site contains about 50 percent gravel, suggesting a weakly developed pavement surface. Three sediment samples were collected on the bar surface. Two of the samples included the pavement layer, while the third consisted of two separate components, the surface and subsurface. The mean particle diameter D_{50} was highly variable among the samples. The D_{50} of the two bulk samples were 2.9 and 7.0 mm. Surprisingly, the D_{50} of the subsurface sample was even larger, at 11.0 mm. The surface D_{50} was 27 mm.

SITE EVOLUTION: The site has been present in its current configuration for at least 80 years. The site was not present in the late 1800s (Meehan 1894); the river migrated west to approximately its current location sometime in the early 1900s.

SITE POTENTIAL: This area was regarded as having a high degree of potential. Natural process appear to be expressing itself at the site but could be limited by a number of factors, including, but not limited to, the interruption of ephemeral flows by the boat ramp, rip rap armoring and heavy ORV use.

6.6 Full Restoration

This alternative would maximize the restoration of side channel and backwater sloughs at the opportunity sites. Archival data from surveys conducted by the Army Corps of Engineers in 1897, 1908 and 1961 in conjunction with historic aerial photos will clearly indicate the presence of multiple channels in the vicinity of the various sites. Stable wood debris structures may be required at the entrance and exit of the side channel to divert water from the river into the channel and maintain the channel pattern. Smaller distributary channels may be added across the floodplain to vary the channel elevations and create complexity in the vegetation patterns and drainage pathways.

6.7 Other Elements

There are several historic alterations (such as levees, riprap, tide gates or boat launches) that occur at the opportunity sites. These may require modification or removal in order to meet the objectives of restoration. Levees have limited river processes and separate the river from its floodplain, impacting habitat areas and fish use. Riprap has been used at the toe of levees and separately to prevent bank erosion. Riprap has been a major cause of limiting development of a riparian corridor. Tide or flood gates have been used to regulate water flow on several tributaries and have impeded fish passage to upstream refuge, spawning and rearing areas. Boat launches are found at several of the sites and may require a change in design or location to allow full function of the restoration process.

7.0 Analysis Process

A qualitative and quantitative assessment of the alternatives for each site was performed by: 1) using a set of restoration objectives that support the goal of the study and 2) determining the benefits to habitat values and fish production. These methods are discussed below with the results presented in Section 8 – Analysis Results.

7.1 Restoration Objectives

Objectives for meeting the study goal, which is to understand what the opportunities are for improving the quality and quantity of habitat at opportunity sites, were developed by the study team. The objectives generally were grouped around three themes: habitat, engineering and public infrastructure. The objectives were used to determine the potential effectiveness of the restoration alternatives at each of the opportunity sites.

The objectives are listed below.

1. Reduce the risk of fish stranding in isolated relic side channels and other low-lying areas;
2. Increase off-channel low velocity refugia habitat during high river flows;
3. Increase edge habitat and habitat complexity;
4. Provide habitat restoration for multiple species;
5. Increase habitat availability through a wider range of the river hydrograph;
6. Minimize construction costs;
7. Minimize long-term operations and maintenance requirements;
8. Create sustainable habitat within the opportunity site;
9. Minimize grading and earthwork by using relic and historic channels;
10. Minimize stable wood debris structures for hydraulic control;
11. Minimize risk to existing levee system;
12. Minimize risk to existing drainage system;
13. Minimize disturbance to existing infrastructure and facilities;
14. Provide restored features that present limited risk to landowners during normal river flow;
15. Create artificial and natural barriers to illegal off-road vehicle use in the restored habitat area; and
16. Maximize the use of public property.

7.2 Objectives Analysis Method

For each opportunity site, the restoration objectives (Section 7.1) were combined with the alternative restoration actions (Section 6.0) to form an evaluation matrix. The matrix (Table 5 – Evaluation Matrix) serves as an indicator of how successful each alternative is in meeting each objective at a particular site. An example of the matrix is provided below.

Table 5 – Evaluation Matrix

Opportunity Site:	Objective 1	Objective 2	Objective 3	Objective 4	Objective 5	Objective 6	Objective 7	Objective 8	Objective 9	Objective 10	Objective 11	Objective 12	Objective 13	Objective 14	Objective 15	Objective 16	
No Action																	
Backwater/Blind Sough																	
Perennial Side Channel																	
Ephemeral Side Channel																	
Riverine Wetland																	
Full Restoration																	
Removal of: Dike, Riprap, Tidegate Boatramp																	

Range of 0 to 4, with 0 representing objective not being met and 4 representing objective being well met.

Study team members developed the matrices individually prior to a team meeting at which time a consensus matrix was developed for each site. The importance of various objectives were discussed and added to the assessment process. For example; all the sites have good access, being paralleled by the levee and in most instances by local roads. Therefore, accessibility was not a particularly significant factor. Maintenance is one factor that is considered very important by organizations and jurisdictions. Maintenance is directly related to sustainability. Thus the propensity for side channel sedimentation became one of the more important parameters in assessing a site. Size of a restoration site is an important factor as well. Generally, as size increases, the economy of scale comes into play. The larger the restoration site, the less expensive the habitat is per linear foot or acre restored. Presence of existing side channels is also important. This reduces the cost of excavation and helps increase the chances of stability. Habitat created in existing or historic channels is more likely to remain stable than in completely new side channels. Minimizing disturbance of or disruption to existing infrastructure and facilities and maximizing use of public lands are also desired outcomes.

7.3 Potential Restoration Actions at each Opportunity Site

Based on the application of the criteria to the various restoration actions at each opportunity site, a list of appropriate and most likely restoration actions at each site was determined. The result of this analysis is shown below in **Table 6**.

As shown on the table, the "No Action" alternative is common to all, except Salem LC. It is assumed that some action related to development of a wetland mitigation bank at this site will restore some level of habitat function to this site in the future, In addition, five of the sites displayed little or no opportunity for any restoration activities. Therefore, five of the thirteen sites were eliminated from further analysis. The sites eliminated from consideration are: Kulshan Confluence, sites displayed little or no opportunity for any restoration activities. Therefore, five of the thirteen sites were eliminated from further analysis. The sites eliminated from consideration are; Kulshan Confluence, Young's Bar, Sauk Camp, and East and West Banks.

Table 6 – Restoration Actions for each Opportunity Site

The inventory information, objectives and benefits analysis determined the possible actions appropriate for each opportunity site. The study team felt that it would be possibly meaningless to try to prioritize a particular restoration action for a site. Future actions at a site will be dependent on political will, available funding, partnership interest, size of a project and willingness of land owners to participate and would probably prove to be opportunistic. Rather, this study

Opportunity Sites / **Alternative Restoration Strategies**	Cottonwood Island	Britt Slough	West Bank	East Bank	Sauk Camp	Eagle Nest Drift	Goodrich Bar	Youngs Bar	Kulshan Confluence	Salem LC	10 – Dollar Bar	Johnson Bar	Riverbend
No Action	XX	XX	XX	XX	XX	XX	XX	XX	XX		XX	XX	XX
Backwater/Blind Sough		XX				XX	XX			XX	XX	XX	XX
Perennial Side Channel	XX					XX						XX	
Ephemeral Side Channel	XX	XX				XX	XX			XX	XX	XX	XX
Riverine Wetland	XX	XX					XX			XX			XX
Full Restoration	XX									XX			
Change To:													
Levee (or setback)	XX	XX											XX
Riprap,	XX	XX				XX				XX	XX	XX	XX
Tidegate										XX			
Boat ramp	XX												

provides an assessment of a range of potential actions associated with each of the restoration opportunity sites and an analysis of potential benefits. The study is a blueprint for future restoration actions within the Big Bend Reach of the Skagit River; actions ready to be implemented by County or City governments, state agencies, Dike Districts, or other organizations active in open space conservation or habitat and salmon restoration activities.

The following is a narrative of the opportunities presented at each site.

Site 1 – Johnson Bar - The concept at this site is to restore an ephemeral or perennial channel(s) with an upstream hydraulic connection to recreate side channel habitat. This would entail removal of riprap at the upstream end and excavation in existing and historic side channels. A backwater or blind channel is possible but is a less desirable option. The site is currently used by off-road vehicles which, if not limited, would damage restoration efforts. Redesign of the boat launch and access road would have to occur to allow water passage through the channels.

Site 2 – 10-Dollar Bar - The concept at this site is to restore an ephemeral channel(s) that is wetted for most of the time that juvenile salmon are migrating out to the estuary and ocean. The forested backwater channel currently floods during high water events. An upstream hydraulic connection to recreate side channel habitat would require introducing water by excavating a channel, constructing a control structure or installing a pipe. Several of these options entail removal of riprap at the upstream end and excavation in existing and historic side channels. A backwater or blind channel is possible but is a less desirable option.

Site 3 – Salem LC - This site is currently under detailed investigation in a separate project proposal as a wetland mitigation bank. The City of Mount Vernon will be responsible for review and approval. The study team decided to evaluate the ideal habitat goals for this site, but not to get involved in project development because it is assumed that the property owner will likely instigate habitat restoration activities in the future.

The concept is to provide better fish access to the site through removal or reworking the existing dike/floodgate system. This would open up off-channel rearing habitat with blind sloughs into the site. In addition the riparian buffer could be widened along the river. Options include removal of the floodgate, breaching the dike, moving the dike inland or removing the dike and tidegate altogether. Wetland creation may require control structures and some site grading. There is also an opportunity to create a flow through channel by introducing water onto the site from an upstream control structure or pipe. Fully restoring this site to the river processes is also feasible at considerable cost.

Site 4 – Kulshan Confluence - This site was eliminated from further analysis due to its high bank, limited size, and the location of existing infrastructure (dike, roadway, creek outfall) in close proximity to the river. There is a possibility of adding additional structure to existing historic pilings enhancing shoreline structure.

Site 5 – Young's Bar - This site was eliminated from further analysis because it is functioning as well as would be expected given its limited size, high bank, the constraints of transportation functions on the opposite bank and proximity of the dike to the river.

Site 6 – Goodrich Bar - The site is adjacent to and downstream from Edgewater Park. The concept at this site is to add to the current efforts to restore off-channel habitat at the park. This could entail connecting to restored historic channels at the park site or a more likely scenario involves a blind backwater channel originating at the downstream end of the site. The site is currently used by off-road vehicles which, if not limited, would damage any future restoration efforts.

Site 7 – Eagles Nest Drift - The concept at this site is to restore an ephemeral channel(s) that is wet for much of the time that juvenile salmon are in the main stem of the river. The forested backwater channel currently floods during high water events. Minor excavation would need to take place to create an ephemeral channel. A more intense upstream hydraulic connection through a riprap bank would be required to recreate a perennial side channel. Several of these options entail removal of riprap at the upstream end and excavation in existing and historic side channels. A backwater or blind channel is possible but is a less desirable option.

Site 8 – Sauk Camp - This site was eliminated from further analysis due to its high bank, the location of existing dikes and riprap in close proximity to the river, its limited size, and the lack of habitat areas suitable for restoration.

Site 9 – West Bank - This site was eliminated from further analysis due to its high bank, the location of existing dikes and riprap in close proximity to the river, its limited size, and the lack of habitat areas suitable for restoration.

Site 10 – East Bank - This site was eliminated from further analysis due to the location of existing dikes and riprap in close proximity to the river and the lack of habitat areas suitable for restoration.

Site 11 – Britt Slough - The concept at this site is to reconnect a large, isolated wetland to the river at the southern (downstream) end of the site with a backwater/ blind channel. This channel would be located just below the forks of the Skagit on the North Fork. The channel would not only respond to high water conditions, but would be influence by tidal actions as well.

A large scale, process-based option involves setting back a section of dike to Dike Road, north of the Hickox Road intersection, and excavating a side channel on the river side that has an upstream connection, either with a direct connection or control structure. This channel would connect to a portion of the downstream end of the historic Britt Slough restoring an ephemeral or perennial channel to recreate side channel habitat. This would entail buying several properties, relocation of a section of dike, removal of riprap at the upstream end and new excavation of a side channel.

Site 12 – Cottonwood Island - The concept at this 165-acre site is to restore a more consistent water flow into an existing 1500-foot long channel. There are several options for accomplishing this. One option requires excavation of the inlet and portions of the existing channel and the construction of a log jam to deflect 50 to 100 cfs flow into the channel. A second option calls for setting back a portion of the dike upstream of the inlet, allowing the river to move into the area in a more natural manner. This option would also entail excavation at the inlet and along portions of the existing side channel. There is some off-road vehicle use which, if not limited, would damage restoration efforts. Redesign, relocation or removal of the existing boat launch and access road would have to occur with either option to allow water passage through the channel. This is an important bank fishing access point dedicated to Frank J. Nelson. This public access point would need to be maintained in some fashion. Combining the dike setback option for this site with the dike setback option for the Britt Slough site on the opposite river bank would create a large scale, river process-based alternative for the entire Skagit Forks area.

Site 13 - River Bend - Conceptual restoration actions at this site focused on taking advantage of the low topographic depressions, classic oxbow shape and position in the river continuum. River Bend is an area that is extremely prone to flooding and regionally recognized as a high hazard area during large scale flood events. This high hazard exposure to river forces generally deters development in the area, and marginalizes agricultural productivity in low lying areas, making this location uniquely situated to offer substantial opportunity for fish, wildlife, and open space uses.

7.4 Habitat and Fish Benefits Analysis Method

An analysis of the benefits to habitat and fish was undertaken for each of the opportunity sites and results are presented in Section 8. The following describes the method for determining these benefits based on the habitat units developed following restoration actions.

Fish Potential

Production values were calculated for habitat units developed following restoration actions using density dependent production estimates derived from published values specific to the Skagit basin. Two tools were employed, one estimates potential coho smolt production for each floodplain feature, the other estimates chinook production along mainstem edge habitat. The method to estimate coho smolt production in off channel floodplain features relies on values reported in Beechie et al. (1994) and are presented in **Table 7** below. This model provides the basis for an estimate of coho smolt production under a density dependent condition assuming full seeding of all available habitat.

Table 7 - Habitat Unit Equivalents for Skagit Basin coho

The basis for these estimates are from census data collected in the Skagit River basin by SRSC over the course of five years used in conjunction with the predictive model developed by Reeves et. al. (1989). Lacking specific data on off channel habitat use in the lower river by chinook we believe this estimate of coho production by habitat type provides a useful tool for site potential within the various floodplain habitat units at each of the opportunity sites. Albeit a crude estimate, until more data becomes available we believe it provides a suitable surrogate. It is important to note that production numbers derived from these equations are estimates of the maximum smolt production potential in an environment that is limited by density dependence. Because values will differ depending on how conditions limit the availability of summer or winter rearing habitat for coho, potential production values will be shown as a range of low to high, with the low value representing the maximal summer limited habitat production and the higher value showing the maximal winter rearing potential.

With regard to mainstem production, there are more specific numbers regarding use, density and preferences for juvenile chinook based on data collected and reported in Hayman et. al. (1996). While chinook use of edge habitats will vary based on total outmigration, any given year preference coefficients were derived for lower river reaches using the mean 0+ chinook density observed through the outmigration season. Using the formula described in Hayman et al. (1996) habitat preference coefficients were derived for four habitat types within the mainstem; natural banks, hydro-modified banks, bars and backwaters. We applied each of these tools in the manner described below.

Mainstem Bank Edge Habitat Unit Production

Using the values and assumptions described in Beechie et al. (1994) we applied the same mainstem values for potential smolt production at 600/KM under natural bank conditions. Preference coefficients were then applied derived from Hayman et al. (1996) and normalized to natural bank conditions. The length of each of the four habitat types described for the mainstem; natural, hydromodified, bar and backwater were then calculated using GIS tools. Each calculated value was adjusted based on the preference coefficient. Normalized to natural banks (Value=1), backwaters received a coefficient of 1.88, hydro-modified banks .75 and bars a coefficient of .07.

Perennial Channel Unit Production

Lacking specific data on chinook use of off channel habitat in this section of the lower river we applied values from Beechie et al. (1994) to estimate use of these habitats by coho rather than chinook. Our key assumption is that usable area for side channel or distributary sloughs by juvenile coho is similar to those of large beaver pond habitats described by Reeves et al. (1989). Usable area factors for this habitat type were 0.75 units of habitat per square meter in the summer and 0.5 units per square meter in the winter (Reeves et al. 1989). The number of coho smolts produced from these areas during the summer is then extrapolated from an average rearing density of 1.7 parr per unit of habitat and a density-independent survival to smoltification of 0.25 (Reeves et al: 1989). Winter, smolt production was estimated with a rearing density of 5.0 parr/unit and a survival to smoltification of 0.31 (Reeves et al. 1989).

Ephemeral Channel Unit Production

While being appropriate for perennial channels, these formulas provide less predictive power when applied to ephemeral channels. Seasonality of flow will affect smolt production values, in particular for values related to limitations in summer rearing habitat. To compensate for this difference, values for ephemeral channel smolt production were first calculated using the methods described above. These numbers were then adjusted by applying a coefficient derived from an estimate of flow availability at the site based on an average flow rating over the last 10 water years.

Wetland Unit Production

To estimate the smolt production in summer pond habitat, a usable area equivalent of 1.0 units/m^2, a rearing density of 1.5 parr per unit of habitat area, and a survival of 0.25 was applied (Reeves et al. 1989). Therefore, estimated smolt production was 0.375 smolts/m^2 for summer habitat (Beechie et.al.1994). For winter rearing a useable area equivalent of 0.75 units/m^2, a rearing density of 5.0 parr per unit of habitat area and a survival of 0.31 was applied (Reeves et al. 1989). Therefore estimated smolt production was 1.163 smolts/m^2 (Beechie, et al. 1994).

8.0 Analysis Results

8.1 Overview

The field reconnaissance and research into the historic and current character of the geomorphic, habitat and land use attributes for each of the opportunity sites and the application of the analysis methods described previously resulted in the study team understanding the restoration potential of each site. In addition, the objectives criteria and the benefits analysis were combined into several additional assessments. These assessments are grouped into three themes: 1) the geomorphic sustainability of restoration actions (or how well a side channel or blind slough will be able to function over time); 2) the biological benefits of a restoration action (or how available new habitat is to juvenile salmon and how productive it will be); and 3) the level of effort required to acquire and restore a site (or the expected ease in implementing a project).

8.2 Geomorphic Sustainability Assessment

Side channels form and evolve as a result of geomorphic processes. The changing environment that forms these features also obliterates them sometimes rapidly and sometimes gradually over time. The geomorphic sustainability assessment evaluates the anticipated longevity of restored or created off channel habitat features by comparing the habitat forming processes with the location, orientation, and configuration of off channel habitat features. The types of off channel habitat features considered in this evaluation include blind sloughs (connected to the main river at the outlet), side channels (connected to the main river at both the inlet and outlet), and riverine wetlands. Geomorphic processes that form these features derive from overbank flooding, which drives side channel hydrology, sediment deposition, erosion, and accumulation of LWD. The geomorphic sustainability assessment focuses on side channels and blind sloughs.

For side channels, the channel gradient has a direct effect on sediment deposition within the channel. To provide a simple means of comparing channel gradient at candidate restoration sites, the analysis uses the ratio of side channel length (Ls) to main channel length (Lm). Larger values of Ls/Lm reflect a flatter channel that would be subject to a higher likelihood of sediment accumulation than comparable channels with higher gradient.

The sustainability of both side channels and blind sloughs is affected by the configuration and location of the channel outlet with respect to the main river channel. Positioned upstream of a meander and on the outside bank, a side channel outlet would be subject to erosion more than sedimentation. Positioned on the inside of a meander bend downstream of the apex of the bend, a side channel entrance would likely receive substantial sediment delivery during and after flood events. This is in the zone of accretion of point bars. We developed a Meander Position (MP) metric to represent the effects of channel outlet location on side channel sustainability. The MP ratio is determined by the ratio of distance from upstream bend apex to the side channel outlet divided by the distance between adjacent bend apices. Larger MP values reflect a greater distance from the primary zone of sediment deposition and indicate that long-term point bar migration would have a reduced effect on the side channel outlet. Conversely, s smaller MP value reflects a channel outlet located within or close to the primary zone of sediment accretion and indicates point bar migration would directly impact the channel outlet.

Blind sloughs remain connected at their outlet to the main river channel. Over time, blind sloughs become isolated from the main river channel as accumulated sediment blocks the outlet of the slough. There are a few processes that can sustain an open slough outlet and offset the normal accumulation of sediment. The first is a source of perennial flow from a tributary. One example on the Skagit River is Red Cabin Creek, which flows into the slough that forms Cockreham Island near Hamilton. There are no good examples of this process within the Big Bend Study Area. In the absence of surface water, clean water derived from hyporheic flow can feed a blind slough and provide a source of flow to flush sediment from the channel outlet. This process requires sufficient groundwater surface gradient to drive hyporheic flow through subsurface gravel that connects the river to off channel features. In situations where perennial flow is absent, sediment is flushed from the mouth of a blind slough typically as flood water temporarily stored on the floodplain drains back to the main river channel through the slough. Larger off channel storage areas have greater potential for flushing sediments than smaller storage areas. The present analysis used drainage area estimates to evaluate the sustainability of blind sloughs.

The results of the Geomorphic Sustainability Analysis are shown in **Table 8 – Opportunity Site Geomorphic Sustainability Indicators.** For each opportunity site, the table reports the calculated values of the geomorphic indicator metrics described previously. Based on these values, we ranked each opportunity site according to its geomorphic sustainability. Among candidate side channel sites, the Eagles' Nest site ranked highest based on favorable side channel gradient and outlet position. Although the Cottonwood Island site ranked lowest among the four candidate side channel sites, this ranking is relative to the other opportunity sites and does not mean the site should be eliminated from consideration. For all of the candidate sites, the side channel gradient is steeper than the gradient of the main river channel. The negative affects of unfavorable outlet position can be overcome by a source of perennial flow provided either by lowering the channel inlet position or establishing a hyporheic flow connection between the side channel and the main river channel. Among candidate blind slough sites, the Lower Britt Slough opportunity site ranked highest based on a relatively large drainage area and a favorable outlet position.

Table 8 - Opportunity Site Geomorphic Sustainability Indicators

	RM	D50	Ls/Lm*	A**	MP***

		(mm)		(acres)	
Johnson	19.5	0.6	0.8	n/a	0.9
10-dollar	19	0.6	0.9	n/a	1.0
Goodrich	11.7	0.7	n/a	32.1	0.6
Eagles' Nest	11.2	0.7	0.7	n/a	0.9
Cottonwood	10	0.6	0.9	n/a	0.7
Britt Slough (lower)	9.1	0.5	n/a	43.6	0.9
River Bend	13.6	-	n/a	83.6	-

*Ratio of side channel length (Ls) to main channel length (Lm); applicable only to potential ephemeral or perennial side channels.

**drainage area - only applicable to potential blind sloughs

***Meander Position (measured as a ratio of distance from upstream bend apex to channel/ slough outlet divided by distance between adjacent bend apices).

Notes:

1) only bed material size was used for D50; there is virtually no difference between sites.
2) the lower Ls/Lm, the more likely the side channel will be flushed of sediment after the hydrograph peak.
3) the greater A is, the more return flow would be available to flush the slough after the hydrograph peak.
4) the higher MP is, the less likely that long-term aggradation (point bar migration) would affect the slough/channel outlet.
5) of the potential blind slough sites, Britt Slough Lower has the advantage of daily tidal action to flush the outlet.
6) River miles are from the Corps of Engineers' UNET model

Overall Sustainability Ranking

Rank	Side channels	Blind sloughs
1	Eagle's Nest	Lower Britt Slough
2	Johnson Bar	Goodrich Bar
3	10-dollar bar	River Bend
4	Cottonwood Id.	

8.3 Estimated Habitat and Fish Benefits

Estimated Edge Habitat Production

Table 9 – Estimated Edge Habitat Production Potential by Unit summarizes edge habitat designations for each of the opportunity sites and each unit's respective production potential expressed as number of smolts based on the assumptions described. This value was also expressed on the basis of production per foot.

Table 9 – Estimated Edge Habitat Production Potential by Unit

Opportunity Site	Total	Natural Bank	Bar Edge	Hardened Bank	Natural Bank Production	Bar Production	Hardened Bank Prod.	Total Production Pot.	Production/foot
Kulshan	2296	1755	0	541	324	0	72	396	0.17
East Bank	2750	1678	0	1072	306	0	149	455	0.17
Britts Slough	5786	5220	566	0	954	7	0	961	0.17
Cottonwood Island	1275	0	1275	0	726	16	0	742	0.14
West Bank	2513	0	0	2513	0	0	347	347	0.14
Sauk Camp	4344	0	0	4344	0	0	594	594	0.14
10 Dollar Bar	6525	2634	968	2923	480	13	401	894	0.14
River Bend	16240	0	3153	13087	0	40	1795	1835	0.11
Salem LC	6476	2028	3300	1148	372	42	158	572	0.09
Eagles Nest	6470	0	3320	3150	0	42	432	474	0.07
Johnson Bar	5092	0	3550	1542	0	45	212	257	0.05
Youngs	2319	0	2319	0	0	29	0	29	0.01
Goodrich	2743	0	2743	0	0	35	0	35	0.01

Estimated Off Channel Habitat Production

Table 10 - Estimated Off Channel Unit Production shown below summarizes the results of the analysis of existing off channel habitat conditions at each opportunity site. The table also examines site potential based on some applied restoration assumptions.

Table 10. Estimated Off Channel Unit Production

Opportunity Site	Existing Ephemeral Channel Area in square meters	Existing Trib/Backwater Channel area in square meters	Riverine Wetland area	Smolt Production Potential	Adult Equiv. @3% survival	Adult equiv. w/restoration	Delta	Notes
Johnson Bar	113,500	0	0	13,126	393	499	106	1
10 Dollar Bar	72,000	0	0	8,327	250	915	665	2
Salem LC	0	110,625	0	8,573	257	6,839	6,582	3

River Bend	0	0	0	0	0	27,450	27,450	4
Kulshan	0	6,750	0	523	15			5
Goodrich	0	0	0	0	0	705	705	6
Eagles Nest	52,500	0	0	10,119	303	1,457	1,154	7
Britts Slough	0	212,700	0	16,484	494	2,216	1,722	8
Cottonwood Island	329,000	97,138	553,212	90,989	2,730	3,495	765	9

Notes: 1) Assumed constructed ephemeral channel adds 2000 feet X 24 feet with 45% as opposed to 15% flow availability.
2) Assumed constructed ephemeral channel deepens 2000 X 24 feet of channel with 75% flow availability as opposed to 15%.
3) Assumed 45 acre constructed riverine wetland
4) Assumed 170 acre constructed riverine wetland
5) No change/not evaluated
6) Assumed five acre Backwater channel
7) Assume constructed ephemeral channel 24 X 3500 feet long 75% flow availability.
8) Assume 2 acre backwater channel and 10 acre constructed riverine wetland,
9) Assume 4700 feet of channel is restored to perennial flow.
East bank, West Bank, and Youngs Bar were not evaluated since no existing off channel habitat exists and restoration potential is low.

In summary this analysis indicates significant population gains could potentially be realized by developing restoration projects at all of the sites. The larger the site, the more potential habitat gains can be made. The opportunities for riverine wetland connections in those areas that have that riverine wetland potential is a prospect that is an important priority.

8.4 Level of Effort Assessment

The Level of Effort Assessment is meant to address property and land use issues that normally accompany the acquisition and/or restoration of a site for habitat values. Criteria such as; 1) current ownership, public or private, 2) the number of properties and landowners that would be included, 3) costs to acquire sites and costs to restore natural processes and 4) current land use, all go into determining the relative ease or difficulty of implementing a habitat restoration project. These four criteria serve as good indicators for determining the level of effort required to implement a restoration project. For each of the opportunity sites, the criteria have been applied with the results presented below in the **Table 11 – Level of Effort Assessment.**

The results of this assessment allows for a relative ranking of the opportunity sites based on the degree of difficulty in implementing a restoration project at each site. This ranking is displayed below.

Table 11 - Level of Effort Assessment

OpportunitySite	Ownership (1)	# of Properties (2)	Relative Cost (3) (Acquire & Restore)	Current Land Use (4)
Johnson Bar	Mostly Public some Private	3 - City, Private, Dike District 12	Moderate $700K	Forested floodplain & pasture
10-Dollar Bar	Mostly Private some Public	4 - Private: 3 City: 1	Moderate $700K	Forested floodplain & pasture
Goodrich Bar	Private	2 - Private	Low $400K	Forested floodplain & sand bar
Eagles Nest Drift	Private	several	Moderate $700K	Forested floodplain & pasture
Britt Slough	Private	several	High $400K - $1.5M.	Mostly forested floodplain
Cottonwood Island	Majority Public some Private	several	High $500K - $1.5M	Forested floodplain, some field crops
River Bend	Private	20+ properties	Highest	Scattered houses, active agriculture

Notes:

1) Public or Private - assumes that to restore on public land is more desirable than on private land and that no acquisition is required on public land.

2) Assumes that the fewer the number of properties, the easier the transaction.

3) General costs for comparison between the opportunity sites.

4) Assumes developed sites are more difficult to restore; active farmland more difficult than pasture, all uses more difficult than current habitat lands.

Overall Level of Effort Ranking	
Less Difficult	
1	Johnson Bar
	Goodrich Bar
2	10-Dollar Bar
	Eagles Nest Drift
	Cottonwood Island
3	Britt Slough
4	River Bend
More Difficult	

Not surprisingly, the smaller sites and simpler projects (such as Goodrich Bar or Eagles Nest Drift) would be expected to be less difficult to implement. The larger and more complicated projects, particularly if it involves setting back dikes (such as at Britt Slough or River Bend) would be more difficult to implement. It should be noted that a smaller project at Britt Slough involving a backwater/ blind slough could be more manageable to implement in a phased program of restoration. Restoration efforts at River Bend may also be implemented before some of the other apparently less difficult projects as they may be to the political desire of the City of Mount Vernon to develop other portions of the River Bend area for commercial and transportation uses.

8.5 Combined Outcome from Assessments

The results of the three assessments: Overall Geomorphic Sustainability, Fish Production Potential and Level of Effort to Implement, are combined and presented below in summary form. Higher ranking opportunity sites within each assessment category start at the top and lower ranked sites are at the bottom.

Table – 12 - Summary of Assessments.

Ranking	**Overall Sustainability**		**Fish Production Potential**		**Level of Effort**
	Side Channels	Blind Channels	Edge Habitat	Off-Channel Habitat	**to Implement**
Highest 1	Eagles' Nest	Lower Britt Slough	River Bend	River Bend Salem LC	Johnson Bar Goodrich Bar
2	Johnson Bar	Goodrich Bar	Britt Slough 10-Dollar Bar Cottonwood Is.	Britt Slough Cottonwood Is.	10-Dollar Bar Eagles' Nest Cottonwood Is.
3	10-Dollar Bar	River Bend	Salem LC Eagles' Nest	Eagles' Nest 10-Dollar Bar	Britt Slough
4 **Lowest**	Cottonwood Is.		Johnson Bar Goodrich Bar	Goodrich Bar Johnson Bar	River Bend

Reviewing the results of the table above allows for some discussion regarding the sustainability, benefits and potential for implementation of restoration actions at the opportunity sites.

- River Bend offers clear habitat and fish benefits with some amount of effort required to remain sustainable. The high level of effort required to implement a project at this site is due to its size, being in private ownership and acquisition and restoration costs.

- Britt Slough ranks high with respect to providing habitat and fish benefits and would remain geomorphically stable. However its cost to implement are high and it would occur on land in private ownership.

- Cottonwood Island also ranks high with respect to providing habitat and fish benefits as well as ease of implementation because it is land owned by WDFW. However, in order for it to be sustainable, changes to dike location and other physical modifications to the site would be required. Some of these changes would occur on privately owned land.

- 10-Dollar Bar would provide moderate fish benefits, would need some effort to make it sustainable and could be implemented somewhat easily due to its smaller size, limited ownership (some of which is public) and moderate cost.

- Johnson Bar would provide off-channel habitat at a moderate cost and is sustainable. It is located on mostly public land. Modifications to the existing boat ramp would be required.

- Eagles Nest would provide edge habitat in a sustainable environment at a moderate cost.

- Goodrich Bar would create negligible habitat value, would remain sustainable and would likely be implementable. This site could be connected to the restoration efforts currently underway at Edgewater Park, at which time the benefits to habitat and fish could increase and would have to be reanalyzed.

- The Salem LC site is currently under detailed investigation in a separate project proposal as a wetland mitigation bank in the

City of Mount Vernon. The study team decided to evaluate the ideal habitat goals for this site, but not to get involved in project development because it is assumed that the property owner will likely instigate habitat restoration activities in the future.

- There are several locations were projects at different sites could be combined into a larger river process-based alternative. One example is at the forks area were the dike setback option for the Britt Slough site combined with the Cottonwood Island restoration efforts on the opposite river bank would create a large scale alternative for the entire Skagit Forks area.

9.0 Conceptual Designs

9.1 Overview

The final task of the feasibility study was to develop, in more detail, conceptual designs of priority implementation sites. The study team investigated three sites that provide a range of restoration recommendations and different benefits. The Britt Slough Site has two restoration options or phases: 1) a backwater/ blind channel connection to riverine wetland at the southern end and/or 2) a flow-through channel connecting remnants of lower Britt Slough requiring a dike set back. The Eagles Nest Site epitomizes a site capable of sustaining a flow-through perennial or ephemeral side channel. The River Bend Site recognizes the scarcity of riverine floodplain and wetlands and the habitat potential of the topographically submerged areas in the bend area.

The remainder of this section provides conceptual design and preliminary cost estimates for these habitat restoration opportunity sites.

9.2 Conceptual Design: Britt Slough Restoration

The proposed project has two phases. The first phase requires excavation of a backwater channel to re-connect the river to a low-lying wetland area as shown previously in **Figure 26 – Britt Slough LIDAR Topography.** This phase would initiate tidal flushing, directly