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MEMORANDUM

To: Technical Oversite Group Members

CC: Jeff Breckel; Amelia Johnston, LCFRB

From: Technical Team: Paul Kolp and Keith Marcoe, Lower Columbia Estuary Partnership & Gardner Johnston, Inter-Fluve

Subject: Ridgefield Pits Restoration Project

Date: July 8, 2020

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## Overview

This memo summarizes efforts completed to date by the Technical Oversite Group (TOG), including the Technical Team, for the Ridgefield Pits Restoration Design project (project ID #17-1070). The TOG was formed in 2018 to provide guidance for the Ridgefield Pits project. With over 20 stakeholders from state, federal, county, Native American Tribes conservation, private citizen, regional fisheries, and non-profit entities that are interested in restoring and preserving the East Fork Lewis River (EFLR), the TOG constitutes an extensive source of knowledge and expertise that the Technical Team has been able to draw on to inform this project. The Technical Team is comprised of staff from the Lower Columbia Estuary Partnership (LCEP) and Inter-Fluve, Inc. The skills represented by the Technical Team include river engineering, GIS mapping, hydrology and hydraulics, numerical modeling, ecology and geomorphology. The memo documents findings from a series of TOG meetings, analysis by the technical team and development of draft Restoration Goals and Design Alternatives.

Between June 2018 and January 2020, a series of five TOG meetings were held. The initial four meetings focused largely on physical and biological elements of the EFLR and specifically the Ridgefield and Daybreak project reaches, while also capturing important land use and human considerations. The Ridgefield Pits reach (Appendix A) includes the eight pits (Appendix B) as well as the mainstem EFLR, beaver ponds and adjacent alcoves and is located at River Mile 8. The Daybreak reach includes two project sites: Mill Creek confluence with EFLR (located at River Mile 9.5) and two upstream side-channels (located at River Mile 9- Appendix A).

During the fifth meeting, the Technical Team summarized prior meeting results and presented a series of example restoration goals and actions intended to initiate a discussion of restoration options with the TOG. The Technical Team believes that one of the most critical components of the project is developing consensus with the TOG on the restoration goals for the two project

reaches. During and after the meeting, TOG members provided recommendations to the Technical Team on refining the example goals and objectives into a series of draft restoration goals and alternatives.

These draft goals and objectives are presented herein, along with the summary of conditions and the individual TOG recommendations. Example goals and actions initially presented by the Technical Team at the fifth TOG meeting can be found at http://s458607291.onlinehome.us/FTP/RidgefieldPits_Working_Group/meetings/Ridgefield%20Pits%20TOG_Example%20Goals_%20Actions_Targets%20.pdf

The following visuals are included as Appendices to aid in reading this memo:

- Project area map including the Ridgefield Pits and Lower Daybreak reaches of the EFLR (Appendix A)
- Aerial photo of the Ridgefield Pits with individual Pit IDs (Appendix B)
- Table of draft restoration Goals and Actions (Appendix C)
- References (Appendix D)

### Next Steps

At this time the technical team is requesting feedback from the TOG that will help us refine the draft alternatives presented here into a final set of alternatives that will best address the goals and objectives. Concurrently, the technical team is evaluating the draft alternatives and will incorporate TOG feedback into this analysis, which includes the following components:

- Spreadsheet & hydrodynamic modeling to evaluate hydraulics, sediment transport, channel stability and temperature.
- Comparison of model results to empirical data to further validate model predictions.
- Uncertainty and risk analysis

Upon completion the technical team will review results of the alternatives analysis with the TOG and together select a preferred design alternative for each project sites and project reach. Preliminary design drawings will then be developed for the selected alternatives.

### Historical & Current Conditions- Ridgefield and Daybreak Project Reaches

Establishing meaningful restoration goals and objectives requires a critical understanding of how a project site has evolved over time and the forces and events that have shaped it. To develop this understanding of the Ridgefield Pits project area, the technical team reviewed existing literature and data, independently and with the TOG, and convened a series of discussions with the TOG which provided additional insight. Input from TOG members, and numerous existing studies and data sources, provided the basis for describing historical and current conditions. The following sections summarize the primary conditions of the project area in its historical and current state, and how these conditions have evolved and continue to evolve. The ramifications of these changes for how the project site currently supports, and may continue to support, multiple life stages of native salmon and steelhead sets the foundation for

the restoration goals, objectives and alternatives. Findings for the geomorphic conditions that resulted from this effort have been documented in the Geomorphology Report (LCEP 2020), currently available at:

http://s458607291.onlinehome.us/FTP/RidgefieldPits_Working_Group/meetings/EFLR%20Ridgefield%20Geomorph%20Report%20012720.pdf

For our analysis we consider 'historical' conditions to be the relatively pristine state of the river that existed prior to extensive development due to European settlement. In fact, the EFLR, including the project site, has been evolving constantly both naturally and due to human activity, and this continuum must be considered when analyzing changes over time. In the following sections we summarize how the river has changed from the time of the earliest data sources that describe it to its current condition, and how it is continuing to change presently.

*Historical Conditions*

To assess the earliest known condition of the project area and changes that occurred over the next several decades we relied on cadastral survey plots completed by the General Land Office (now part of BLM) in the 1850's, aerial photos dating back to the 1930's, Washington Department of Fish & Wildlife (WDFW) spawning survey data, geologic and topographic data, historical records from existing reports, and other anecdotal information. The following list summarizes the condition of the river in the project reach, dating back to the early data sources:

- Extensive spawning and rearing occurred for multiple salmonid species, including Chinook, steelhead and coho, with some records indicating it was also important for chum (personal communication with WDFW and Lower Columbia Fish Recovery Board). The vitality of these focal species to the East Fork Lewis ecosystem, and their precipitous decline over the last century leading to current threatened and endangered status, is well documented, including in the Lower Columbia Fish Recovery Board's LCFRB) 2010 Lower Columbia Salmon and Steelhead Recovery Sub Basin Plan. The plan estimates that historical populations of Chinook, coho and steelhead for the East Fork Lewis River subbasin ranged from 1,000 to 40,000 fish depending on species, and historical populations of chum ranged from 100,000 to 320,000 fish, for the combined Lewis and East Fork Lewis subbasins. Washington Department of Fish & Wildlife spawning survey data show use of the entire project reach by all these species from the 1940's through the 2010's, highlighting its importance.
- The Ridgefield Pits (and Daybreak Pits) reach was a depositional zone with an anabranching (multi-thread) planform, multiple side-channels and oxbows, and an abundant supply of gravels and wood.
- The channel migration zone (CMZ) encompassed both the current day Ridgefield and Daybreak Pits, over a wide floodplain area of approximately 1,300 acres (sum of acres within EDT Reaches 6A-8A called out in the Recovery Plan, which overlap with the project area), stretching up to 1 mile across the valley floor at its widest.

- The large wood in the channel, and large and robust riparian and floodplain vegetation, likely resulted in relative stability of the channel during regularly recurring floods (i.e. annual to 5-year event).
- Channel adjustments, via scrolling and avulsions, likely occurred during the larger, less common events (> Q5 flood event). These events likely created a complex mosaic of highly productive instream and floodplain aquatic habitats.
- High complexity and a highly connected floodplain and water table likely led to a diversity of habitat types and areas of groundwater intrusion that provided several cold-water inputs.
- Significant changes in land use, including agricultural development and river confinement, were already occurring as early as the 1930's.

*Current Conditions*

In addition to some of the same sources used to assess historical conditions, numerous existing reports and data sources (Appendix D) provided background for describing present day conditions of the project area. Many of these have been produced in response to environmental degradation, development, and species decline that have occurred within the project reach and throughout the EFLR. The Estuary Partnership and Inter-Fluve also conducted site investigations (from 2017-2019) as part of this project to fill existing data gaps. These included snorkel surveys, water temperature and stage monitoring, sediment sampling, and topographic and bathymetric surveys. Site investigations inform subsequent mapping and analysis, including: juvenile fish distribution, hydraulic, sediment transport and temperature modeling and the geomorphic analysis and report. The following list summarizes the present-day condition of the river, that has resulted from natural and human-derived activity over the past several decades:

- Spawning is occurring for multiple species, but the amount of spawning habitat has been greatly reduced in the Ridgefield Pits area. According to the 2009 Lower East Fork Lewis River Habitat Restoration Plan (LCFRB), "approximately 3,200 feet of lineal riffle habitat was eliminated as a result of the Ridgefield Pits avulsion, and over 50% of off-channel habitat and wetlands in the historical lower river floodplain are no longer accessible to spawning fish as a result of hydromodifications". WDFW no longer samples in this area for adults due to lack of suitable spawning habitat (a summary of spawning surveys conducted by WDFW can be found here-http://s458607291.onlinehome.us/FTP/Ridgefield%20Pits_Working_Group/Fish/).
- Cold-water inputs from groundwater still exist throughout the project area. Cold water was found in and around: Ridgefield Pits 1,2,8 and 9; the upper side channel at RM 9.0; and within some floodplain beaver ponds. Recorded water temperatures in these areas were 2–7 degrees colder than the mainstem during summer months.
- Our observations suggest that juvenile fish continue to use the Ridgefield Pits area throughout the summer. These findings suggest much greater usage by juvenile salmon

and steelhead than was documented in the aquatic study of the Ridgefield Pits and East Fork Lewis River (CM-10, R2 Consultants 2013). Our surveys also confirm findings from the 2013 report that there are a large number of predatory fish in the area.

- Despite summertime mainstem temperatures that commonly exceed recommended and lethal temperatures for salmon and steelhead (18 and 24 C°, Ecology), snorkel surveys conducted by the Estuary Partnership (2018) in June (see Meeting #2 presentation on juvenile fish use- http://s458607291.onlinehome.us/FTP/Ridgefield%20Pits_Working_Group/meetings/TOG%202-presentation.pdf ) and August (when mainstem water temp's exceeded 24 C°) showed juveniles present. In summer months fish were found around cold water seeps, around habitat structure, riffles and cut banks.
- According to the 2009 Lower East Fork Lewis River Habitat Restoration Plan (LCFRB 2009), temperatures in the mainstem commonly exceed the 64°F (18°C) State standard, and occasionally exceed 73.4°F (23°C) in the project reach, which is above the 22°C level considered lethal to rearing salmon and trout. Additional data collected from 2010-2020 suggests that temperatures exceed the water quality standard regularly during summer months (Estuary Partnership, Fish First and WDFW). Estuary Partnership data collected in 2018 showed average daily maximum temperatures ranging from 21–25 °C throughout the mainstem and Ridgefield Pits, with instantaneous values reaching as high as 28°C, from mid-July through mid-September.
- Mill Creek is an important source of cold water, particularly now that summertime temperatures in the mainstem are regularly exceeding TMDL limits. Data collected in 2018 by the Estuary Partnership at the confluence of Mill Creek showed average daily maximum temperatures ranging from 13–15 °C from mid-July through mid-September.
- The historical anabranching channel planform has evolved into a single, confined channel throughout most of the Ridgefield Pits reach, with occasional side channels and very limited floodplain connectivity.
- The channel migration zone below Daybreak Bridge, and through the Ridgefield Pits reach, is confined to a much narrower floodplain area relative to the historical condition. The overall area and has declined by approximately 1,300 acres to approximately 660 acres, roughly a 50% decline for EDT reaches 6A–8A (LCFRB, Chapter 4: East Fork Lewis River basin- Habitat Assessment 2005). The reduction in the channel migration zone is largely, but not entirely, due to exclusion from the active Daybreak Pits gravel mining operation.
- Avulsion of the channel into formerly active gravel pits (including the Ridgefield Pits and Mile 9 Pit) created immediate and persistent changes including: relocating the river, interrupting gravel transport, slowing channel velocities, changing channel geometry including depth to width ratios and upstream changes to the longitudinal profile.
- Reduced vegetation presence and reduced hydraulic roughness (i.e. large wood debris) have reduced overall habitat complexity and quantity.

- EFLR flows have potentially become more 'flashy' due to more impervious surfaces, increased development, land use practices and water use which resulted in greater surface water runoff rates and volumes.
- Combined changes in flow patterns and reduced vegetation and hydraulic roughness have likely led to more frequent channel forming events (~annual occurrence) relative to the historic condition (~5-year occurrence or longer). This has potentially contributed to local habitat complexity but may also be causing redd scour and egg burial issues.
- Invasive species introduction, warmer water, and native species habitat degradation has likely increased the abundance of predatory warm water species.
- Sediment has accumulated at the Mill Creek confluence, possibly limiting fish access to cold water refuge in the summer. This may be a result of EFLR flow dynamics and/or upstream land-use practices that have occurred in the headwaters of Mill Creek.
- The future of current mining activity in the Daybreak Pits (adjacent to the Ridgefield Pits), including timelines for termination and transfer of ownership, is unknown.
- It is uncertain whether lands within the Ridgefield Pits that are currently held in private ownership will remain private or be transferred to public holdings. This may potentially impact the scope of possible restoration activity.

The 1996 avulsion of the EFLR into the abandoned Ridgefield Pits, which was mined as early as the 1960's for aggregate, has had substantial negative impacts on aquatic conditions and physical processes. Findings from this project related to biological and physical conditions are summarized below. Some of our findings are consistent with prior studies; however, others are markedly different, in particular the rates of sediment infill for the Ridgefield Pits. Notably, some of these observed differences (that we estimated) are likely due to more recent and improved data resolution.

- Avulsion into the Mile 9 Pit in 1995 resulted in a channel alignment that is causing significant erosion of the bluff along the south bank at this location, threatening private property.
- Upstream migration of the head-cut that developed in response to the 1996 Ridgefield Pits avulsion (described by Norman et al. 1998, and multiple WEST reports) appears to have ceased and the river profile has largely stabilized throughout the project area upstream of the pits, according to our 2019 updated bathymetric profiles.
- Active channel dynamics upstream of Daybreak Bridge (and upstream of the project area) are within the range of historical conditions and do not appear to pose a significant risk to downstream project work (LCEP 2020). It has been noted in TOG discussions however that risk of avulsion in this reach is present, and sediment transport processes have been impaired.
- Trapping of sediment in the Ridgefield Pits has likely reduced sediment transport to downstream reaches, including the transport of spawning gravels. Spawning is known to occur downstream of the pits for several miles.

- Ridgefield Pits 1 and 2 have experienced significant sediment infilling and wood accumulation, much of which occurred within 10 years of the 1996 avulsion. This has resulted in improved habitat diversity, fish use, groundwater intrusion, and channel processes in this area.
- Despite the significant infilling of Ridgefield Pits 1 and 2 that has occurred, our analysis of infilling rates since the 1996 avulsion indicates that overall infilling of the Ridgefield Pits will likely not occur for at least another 50–60 years (2070, minimum). This is considerably slower than prior estimates by WEST and others, which predicted recovery by approximately 2026. Our analysis shows a substantial slowdown in overall filling subsequent to the decade following the avulsion (LCEP 2020). As a result, mainstem habitat below Pits 1 and 2 has remained in a very low-quality state since 1996, characterized by deep, warm pools, slow flow and abundant predatory fish (Estuary Partnership snorkel survey, 2018).
- Ridgefield Pits 8 and 9, which are located off the mainstem EFLR, are subject to groundwater inflows and thus may be providing some thermal refuge for juvenile salmon during summer months. Pit 9 is likely to only be accessible to fish during higher (flood) flows.

## Review of Example Restoration Goals and Objectives – TOG Meeting 5, January 2020

Prior to the January 2020 meeting, a document titled *Goals and Actions* was sent by the Technical Team to the TOG. The document was intended to provide a framework for discussion of restoration options for the Ridgefield Pits project area with the TOG. It lists a series of example goals and restoration actions for the project area within 5 categories: Channel Forming and Related Sediment Processes; Floodplain Connectivity; Vegetation; Biology; and Human Elements. The *Goals and Actions* document can be found at http://s458607291.onlinehome.us/FTP/RidgefieldPits_Working_Group/meetings/Ridgefield%20Pits%20TOG_Example%20Goals_%20Actions_Targets%20.pdf.

After review and discussion of the document, the TOG was asked to provide feedback to the Technical Team on the example goals and actions, which the Technical Team could then use as a basis for formulating a draft set of goals and restoration alternatives. The TOG provided feedback at the end of the meeting and during weeks after, as a series of written and verbal comments. These comments are included below, by category, and have been consolidated where duplicates occurred:

### *Comments on Restoration Goals*

Channel Forming and Related Sediment Processes

- Restore a complex, multi-thread channel network that includes greater channel planform complexity.
- Reestablish natural rates of channel adjustment including the appropriate sediment transport processes and allowing the river to rebuild itself.

- Address upstream sources of sediment, prevent entrainment & improve sediment transport processes through the site and downstream of the project.
- Sediment management should be the #1 priority.
- Create more pools in the project area.

Floodplain Connectivity (lateral and vertical)

- Define the floodway, floodplain and CMZ and then let the river be chaotic within that total area.
- Look at returning the river to the historic CMZ including Daybreak Pits and remove human infrastructure.
- Encourage greater interaction with the historic channel migration zone and remove human barriers to channel migration wherever possible, while maintaining or creating protection of property and infrastructure where needed.

Vegetation

- Include robust riparian area w/ beavers.

Biology

- Attempts to ameliorate summer high temps by tapping into the Daybreak pits or engineering this kind of approach in other areas does not sound sustainable or maintainable. The focus of thermal efforts should remain on process driven approaches and action.
- Identifying and reconnecting cold-water areas should be the #1 priority. Addressing the temperature impairment should be in the top two priorities.
- Maximize side-channel cool water areas and address river warming.
- Map thermal refuge areas/subsurface temperatures to help plan actions that encourage thermal regulation.
- Incorporate cooler water into habitat creation.
- Target locations outside that project area, including where water is being impounded and warm water is being discharged to the East Fork. Coordinate with other agencies to determine ways to reduce impoundments and warm water inputs.
- Restore the full range of habitat types historically present in the reach, at historic ratios.
- Develop the proper mix of habitat features (rocks, riffles, runs).
- Increase extent & quality of thermal refuge without compromising existing refuges.
- Create ways to scour out Mill Creek confluence area with the East Fork to preserve the cold water pool and create more and higher quality cool water rearing opportunities.

Human Elements

- Consider river recreation in all project design concepts.
- Investigate the feasibility of expanding future restoration actions into the Daybreak Pits area.
- Can we acquire the necessary property to allow the river to migrate how it used to?
- Enforce and refer to the Shoreline Management Act- Shoreline Plan and Growth Management Act.

### *Comments on Restoration Actions*

TOG member comments related to potential actions were also divided into the same five categories used above.

Channel Forming and Related Sediment Processes

- Encourage greater stability in some areas and create more dynamic channel in other areas by adding habitat and engineering features.
- Move the channel back to its pre-avulsion alignment.
- Move channel back to where it was located before the avulsion.
- Fill in select pits that are thermal barriers and leave others where there is cooler water to serve as alcoves or oxbows.
- Mill Creek upper portions are problematic due to increases sediment delivery and need to be addressed including restoring ditched portions of Mill Cr. between the EFLR and SR 502.

Floodplain Connectivity (lateral and vertical)

- Reset Pits floodplain and channel to increase rate of stabilization without trying to train the river including using Stage 0/Stage 8 approaches.
- Pipe the cooler water from select pits into the restored channel.
- Grade the floodplain on river left, filling select pits while also creating side-channels, oxbows and off-channel areas.
- Use onsite material to begin to fill pits. We don't have enough material to fill all pits-prioritize warm water Pits.
- Remove levees, riprap, and other hydromodifications impeding natural rates of lateral channel adjustment.

Vegetation

- See what recovers naturally before planting.
- Create a fully functioning riparian buffer zone.

Biology

- Reduce/remove levees and other raised features. Build an extensive network of ELJ anchored, alluvium based, vegetated islands throughout the river and floodplain that cause the river to be split into multiple channels.
- Install habitat features including historic wood loading.
- Deliver LWM to channels to meet LWM volume targets based upon natural wood loading levels.
- Introduce structures to provide habitat and natural channel functions.
- Create a complex channel and allow the cooler water to find its own path.
- Create complex channels with multiple side-channel and oxbows.
- Leave Pits 8 & 9, and other places where there is cooler water, and open it to riverine processes and fill Pits where there is warmer water.

Human Elements

- Need sideboards to guide our ability to realize what we can afford and have the actual capability to pull off.

## Draft Restoration Goals

Based on comments from TOG members the Technical Team developed six restoration goals for the project area. The first two goals listed below received the most comments compared to the other goals. The intent of the goals is to capture important physical, biological and social dimensions critical to advancing restoration efforts at the project sites. The goals also serve as the foundation for the development of the restoration alternatives.

**Goal 1. Restore native vegetation communities**: Restore a patchwork mosaic of age classes and native species that dominate riparian and floodplain areas, with vegetation supported by channel migration processes and high seasonal water table. Restoring native vegetation should ultimately contribute to the recruitment and retention of large wood and sediment, reduce erosion and mobilization of fine sediment, and reduce thermal loading to help improve water temperatures.

**Objectives**

1a. Promote conditions where channels are well-connected to the floodplain and CMZ and are able to self-initiate and self-maintain riparian vegetation through channel scrolling processes and overbank deposition of fines. Decrease the depth to the alluvial aquifer.

1b. Promote a patchwork mosaic of native vegetation communities with a range of age classes consisting of older coniferous forests, cottonwood galleries, willow-dominated shrub communities, and sedges and rushes.

1c. Encourage vegetative growth along stream channels, with persistent vegetation abutting the primary channel and side channels that provides hydraulic roughness, natural stability, shade, and habitat complexity.

**Goal 2. Enhance thermal refuge and incorporate cold water areas into restoration efforts:** Protect and enhance existing cold-water areas in order to decrease thermal loading to the mainstem and provide thermal refuge to benefit pre-spawn holding and spawning for coho, Chinook, steelhead and chum and summer juvenile rearing habitat for coho, Chinook and steelhead.

**Objectives**

2a. Protect, enhance, and expand access to existing known cold-water refugia including at tributary confluences (e.g. Mill and Manley), in north-side side-channels, and in Pits 8 and 9 of the Ridgefield Pits.

2b. Achieve a low flow channel width-to-depth ratio that is below 15 and ideally below 12.

2c. Increase canopy closure from vegetation to greater than 50%.

2d. Increase juvenile salmonid over-summer thermal refugia by creating head gradients that result in strong hyporheic exchange flows – i.e. highly sinuous meanders that create strong gradients across gravel bars where hyporheic flow contributes to backbar alcoves; occasional valley wall contacts with alcoves fed by wall-based channels; and offset riffles around islands.

**Goal 3. Increase the quality and quantity of Chinook, chum, steelhead and coho spawning and rearing habitat:** Create habitat conditions that are consistent with the geomorphic setting. Restore a complex, multi-thread channel network that includes greater channel planform complexity, deep pools with instream cover, riffles for macroinvertebrate production, and pool tail-outs with abundant spawning gravel. Increase floodplain habitat availability and complexity in the form of abandoned oxbows, floodplain wetlands, secondary and side-channel connectivity, and beaver dam complexes that are accessible to fish at a range of flows.

**Objectives**

3a. Achieve a moderate-to-high channel sinuosity (>1.3) to increase planform complexity.

3b. Achieve a pool (and riffle) frequency greater than 10 pools per mile in the main channel, co-dominant channels, and active side-channels.

3c. Increase large wood quantities to exceed the Fox and Bolton (2007) 75$^{th}$ percentile quantities of wood and key pieces that would be expected under undisturbed conditions. A range of wood size classes should be present, with abundant large pieces exceeding the NOAA 'properly functioning condition' threshold of 80 pieces/mi for wood over 24 inches diameter and 50 feet in length. Wood placements to include individual pieces and jams to provide habitat complexity and to encourage structural formation of bars, pools, and other geomorphic features. Where suitable, jams should recruit mobile wood over time. Wood placements should also occur on floodplains, especially where vegetation is sparse or young, to emulate hydraulic roughness found in natural vegetated floodplains.

3d. Increase occurrence of co-dominant and secondary channels (i.e. side-channels) so that 2 to 5 perennial channels (including main channel) occur at any given valley-bottom cross-section.

3e. Achieve a low-flow channel margin length that is at least five times the corresponding valley-bottom length.

3f. Achieve the presence of zero velocity areas during seasonal high flows in order to provide for flood refuge by juvenile salmonids.

3g. Create abundant (>8 acres/mile of stream) connected off-channel wetlands and beaver dam complexes that are accessible to fish throughout the year.

**Goal 4. Restore Channel Migration Zone and Floodplain Connectivity:** Restore portions of the historical channel migration zone and restore natural rates of floodplain inundation, where possible, by 1) removing hydromodifications; and 2) achieving channel and floodplain geometry and elevation that encourage frequent overbank flows and natural rates of channel adjustment. Investigate the feasibility of expanding future restoration actions into the Daybreak Pits area.

**Objectives**

4a. Expand Channel Migration Zone and floodplain inundation extent by removing (or setting back) levees, riprap, fill, and other hydromodifications impeding channel adjustment or flood inundation to the extent possible given private property and infrastructure constraints.

4b. Achieve an active valley width (i.e. extent of intact CMZ and floodplain) that is at least 6 times the active channel width.
4c. Achieve overbank flows and significant floodplain inundation that occurs annually for at least 1 month of the year, on average. Five-year flood should create very large inundation.

**Goal 5. Create a dynamic channel that allows for natural rates of channel adjustment and sediment transport**: Allow for natural rates of channel adjustment in concert with sediment supply and hydrology regime. Maintain depositional conditions, especially within the pits to promote sediment capture and to re-build the grade lost to avulsion, and to restore sediment transport processes into and through the area.

**Objectives**

5a. Achieve slope and channel geometry conditions that are depositional, especially in the Ridgefield Pits segment where net deposition is needed to help build grade lost to gravel mining, but also in other segments that exhibit incision.
5b. Achieve bank erosion at meander bends that occurs at a natural rate. Minor erosion may occur every year (<5 feet), with larger adjustments at the 2- to 5-year event (e.g. scrolling) and more dramatic changes (e.g. chute and neck cut-off avulsions) occurring during large floods (>10-year event).
5c. Achieve a streambed that is composed of a mix of sediment sizes, with channel bed dominated (>70%) by coarse gravel and cobble and floodplains eventually topped with fine sand and silt. Increase substrate patchiness. Decrease fines to less than 15% in potential spawning areas.

**Goal 6. Develop restoration approaches and actions that are consistent with existing land use:** Avoid any increase of flood or erosion risk to public or private infrastructure. Take into consideration the potential for a future avulsion of the EFLR into the Daybreak Pits. Consider the implications of designs for recreation users along the river.

**Objectives**

6a. Do not increase flood damage risk to public or private property or infrastructure unless landowner agreement is obtained.
6b. Decrease, or at minimum avoid increase of, potential avulsion of the EFLR into the Daybreak Pits.
6c. Design actions that adequately address potential risks to river recreational users.

## Draft Restoration Alternatives

To address the goals, baseline findings, and comments summarized above, a range of restoration enhancement alternatives were identified. In conjunction with the geomorphic assessment, restoration alternatives were divided into two reaches (Appendix A) including the Lower Daybreak reach [RM 10.2 (most upstream Asterix) to RM 8.0 (middle Asterix)], which includes the side-channels and Mill Creek, and the Ridgefield Pits reach [RM 8.0 (middle Asterix) to RM 7.1 lower Asterix)]. The Draft Restoration alternatives are also summarized in a table (Appendix C).

Ridgefield Pits Reach

1. **No Action/Passive Recovery of Pits**

   *Description***-** This alternative would allow the river to continue to recover without any outside intervention.

   *Benefits, Limitations & Level of Effort-* The benefit of this approach is to allow the river to restore itself without expending capital to try and restore a complex site. Some of the habitat in the areas around Pits 1 and 2, and upstream around RM 8 (where wood and sediment have accumulated) are already showing signs of recovery. Juvenile coho, chinook and steelhead were found to be using these areas during the summer of 2018 (Estuary Partnership). Several adults were also seen in the area. There are several limitations to the 'no action' approach, however. The primary limitation is that current estimates of the pits recovering to pre-avulsion physical conditions are on the order of 50- 60 (or greater) years. Passive recovery will continue to have negative effects on juvenile and adult salmon and steelhead during this recovery period. In the Pits Reach spawning has almost completely disappeared and overall habitat conditions for juveniles and adults have been substantially impacted. The Pits area also presents a bottleneck to salmonids that migrate through the Reach. There are large amounts of predatory fish that key into deeper areas along the mainstem and several of the pits. The depths exceed 10 ft. in these areas, with lower velocities and warmer temperatures that are conducive to predatory fish. Warmer water in several of the pits also increases thermal loading to the EFLR and impacts native aquatic species. The overall level of effort for the passive recovery alternative is anticipated to be low.

   *Proposed Actions-* No action.

2. **Relocate Main Channel Back Into/near Pre-1996 Avulsion Channel**

   *Description-* This scenario would use channel grading and log jams to relocate the main channel into its former, pool-riffle type, pre-1996 avulsion, channel alignment. LWD supplementation efforts would be focused on increasing LWD density to a level that is typical for an undisturbed stream of this size and climatic region.

   *Benefits, Limitations & Level of Effort-* This effort would likely immediately improve habitat conditions. This alternative would reconnect more than 3,000 ft. of mainstem habitat that was known to be productive in the past. The location of the channel would also potentially benefit from cooler groundwater inputs from the Daybreak Pits. LWD would facilitate gravel trapping, provide hydraulic refuge, cover from predation and a source of detrital material. This would improve spawning and rearing habitat for Chinook, coho, steelhead, and possibly chum, in an area that was known to provide high productivity. Some connected off-channel habitat could be provided in former pit areas.

   This alternative proposes to relocate the channel into its pre-avulsion location; however, this is not necessarily its historical location, which we know from the 1854-5 maps had a much wider CMZ and a multi-thread channel network. To return the channel to its pre-avulsion single-thread channel location, significant fortification would have to occur

along the streambanks to the south (river left- looking downstream) to reduce the risk of avulsion back into the pits. This action would further narrow the CMZ and limit floodplain connectivity and would reduce the gradual filling of the pits by stream-mobilized sediments.

The overall level of effort is anticipated to be moderate- high.

*Proposed Actions*

- Re-locate channel back into its pre-avulsion (e.g. pre-1996) location
- Create berm to reduce potential for river to avulse back into pits
- Remove invasive plants/plant natives to establish a 100 ft. riparian buffer
- Install large wood jams throughout the channel to promote pool formation and sediment retention.
- Increase pool frequency to meet the range of natural variability that would be expected under undisturbed conditions.

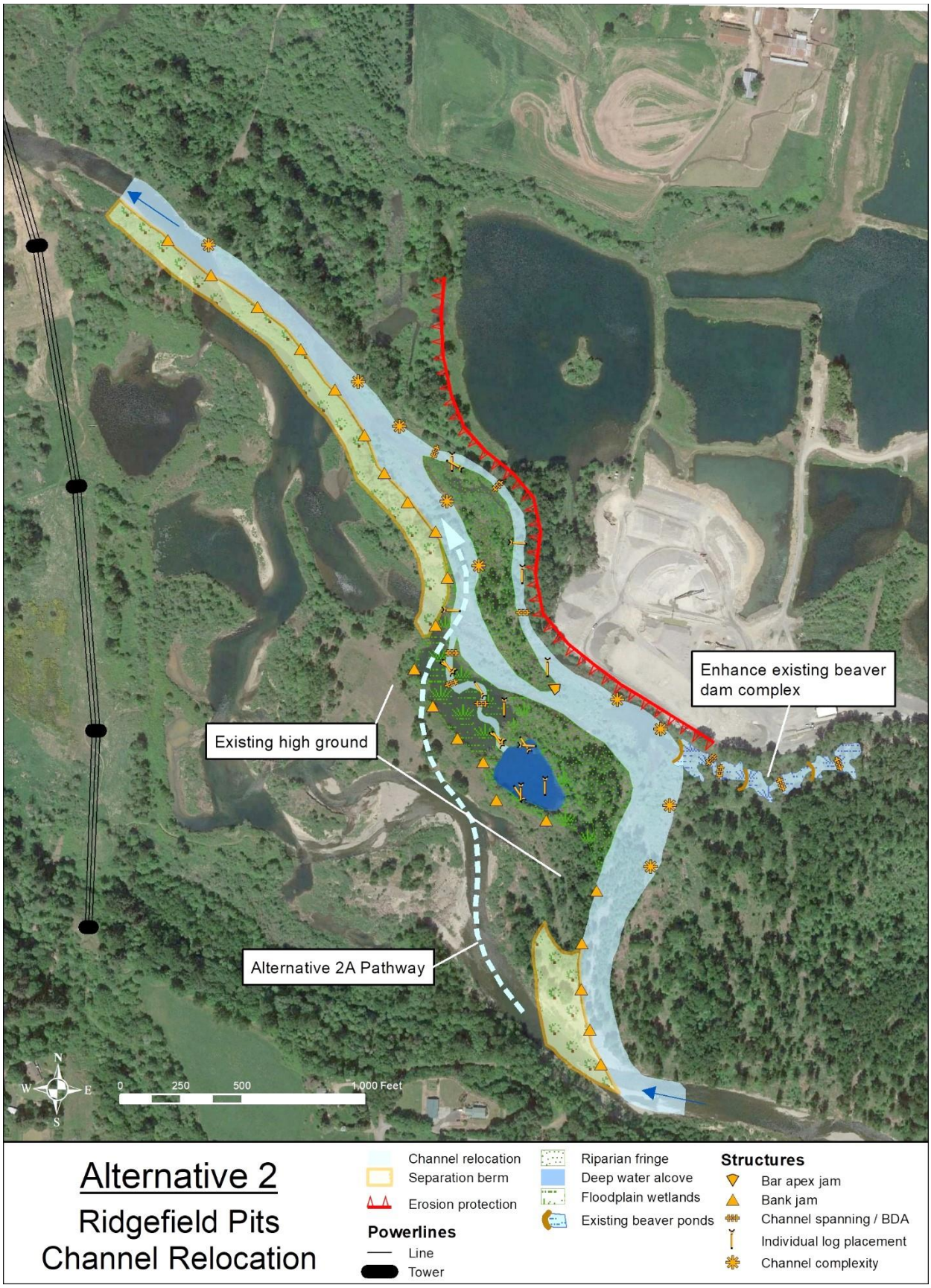


**Figure 1.** Ridgefield Pits Channel Relocation- Alternative 2 and 2A.

**2A. (Sub-Alternative) Create New Flow Path between Pit 8 & EFLR**

*Description-* This scenario would use select grading and log jams to remove land between the river and Pit 8 to relocate the river into a portion of its pre-avulsion flow path, rather than the complete pre-avulsion flow path proposed in Alternative 2. Habitat features, including LWD, would be installed as well as channel grading to create a self-sustaining channel that mimics pre-avulsion conditions including a pool-riffle channel geometry. LWD supplementation efforts would be to increase LWD density to a level similar to an undisturbed stream of this size and climatic region.

*Benefits, Limitations & Level of Effort-* This effort would likely improve habitat conditions immediately. LWD would facilitate gravel trapping, provide hydraulic refuge and provide habitat cover for juvenile and adult fish. This would also improve spawning and rearing habitat in an area that was known to provide high productivity. Juvenile fish would also have access to a series of beaver ponds that could provide important rearing and hydraulic refuge during higher flows. The area around the beaver ponds and portions of Pit 8 and 9 have cooler groundwater inputs from the Daybreak Pits. These areas would likely be used extensively by juvenile fish and could also offer refuge for fish migrating through the pits area.

This alternative has the same limitations as Alternative 2.

The overall level of effort is anticipated to be moderate.

*Proposed Actions*

- Remove high ground between the existing channel and Pit 8, re-locating the channel through Pit 8 and into the downstream portion of the pre-1996 avulsion channel location.
- Remove invasive plants/plant natives to establish a 100 ft. riparian buffer
- Install large wood jams throughout the channel to promote pool formation and sediment retention.
- Increase pool frequency to meet the range of natural variability that would be expected under undisturbed conditions.

**3. Full Floodplain & Pits Re-Grade**

*Description-* This scenario would include grading and filling to re-contour the pits reach into a multi-thread connected channel and floodplain wetland system. The elevation of the new channel/floodplain system would be lower than the pre-avulsion elevation given the amount of material removed by past mining.

*Benefits, Limitations & Level of Effort-* This alternative would restore a broad range of habitat mosaics that were likely found at this site historically, including beaver ponds, alcoves, shallow and deeper areas, wetlands and a multi-thread channel alignment. The multi-thread channel alignment would support channel geometry that would yield a wide range of velocity and depth conditions conducive to the species and different life histories that were historically found here. Coho and chum adults would have access to lower velocity areas and be able to key in on co-dominant channels where cold-water inputs or upwelling exists. Chinook and steelhead adults would be expected to utilize the dominant channels in areas with suitable gravels and higher velocities. Juvenile

salmon and steelhead would be able to utilize the site, particularly in areas with cold-water inputs, wood and deeper holes. This alternative would increase the width of the CMZ in this location to approximately 50% of its historical width, a 20% improvement over the approximate 30% of historical width that it currently occupies. Any changes in the channel alignment could result in subsequent changes after flooding events and the channel would not conform to a single thread layout.

Analysis is needed to determine the amount of fill and grading necessary to achieve meaningful habitat improvement, and to determine whether there is enough material available on or near the site. The lateral extent of grading will also need to be determined, including interface with the BPA powerline towers. Sediment transport modeling will be used to help understand the effects of this alternative on sediment transport and aggradation within the pits reach compared to other alternatives listed above including the No Action (existing conditions) alternative.

The overall level of effort is anticipated to be high.

*Proposed Actions*

- Create anabranching planform with 2-4 co-dominant channels active at low flows, many more channels active at flood flows and abundant oxbows/floodplain wetlands connected during annual high flows.
- Install LWD and habitat features similar to Alternative #2
- Create vegetation buffer similar to Alternative #2
- Support and encourage beaver activity in secondary flow channels and off-channel wetland complexes.
- Evaluate the need for reinforcing existing levee along the Storedahl Haul Road.

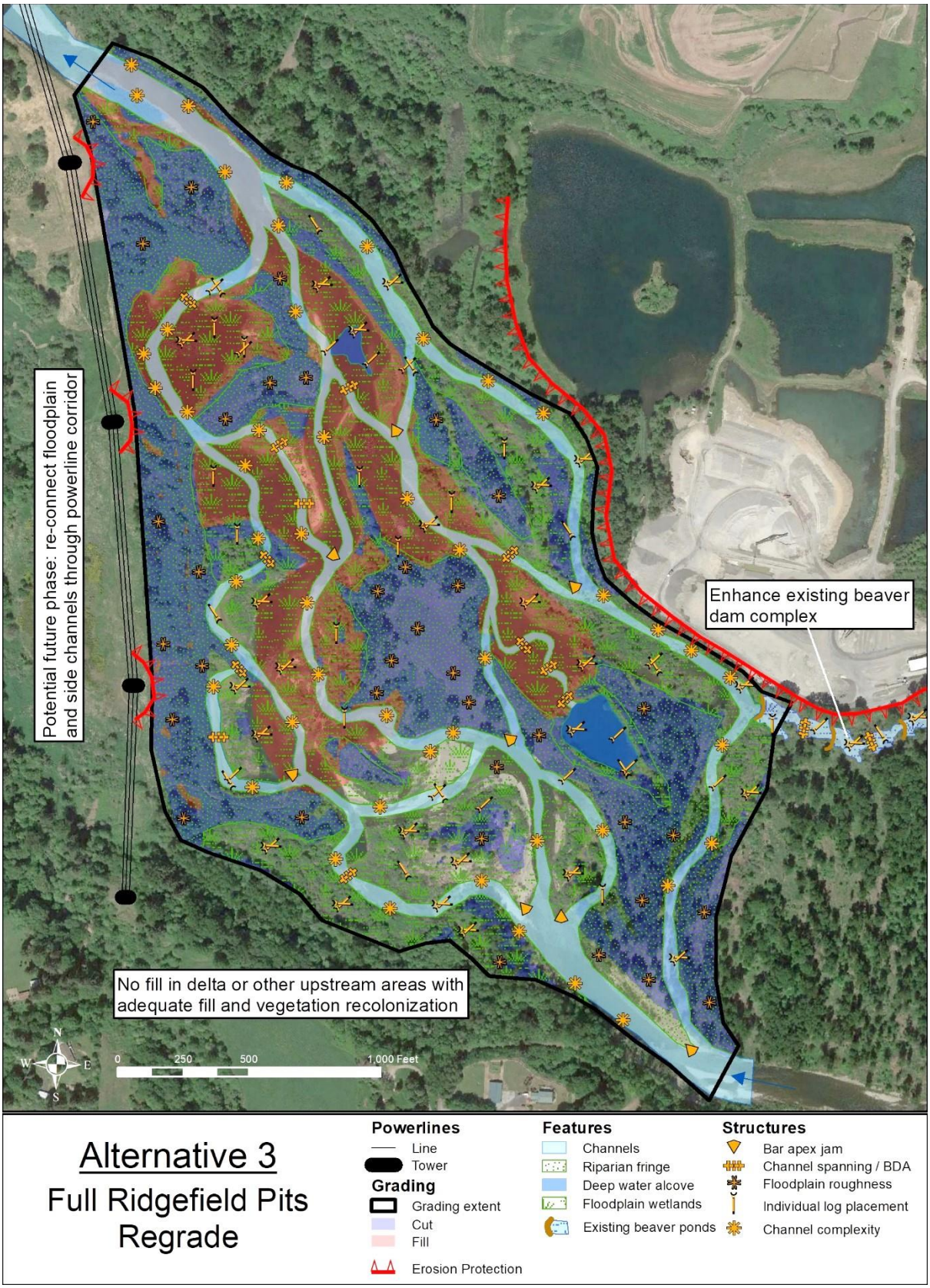


**Figure 2.** Full Pits Regrade- Alternative 3.

**3A. (Sub-Alternative) Select Floodplain & Pits Regrade**

*Description-* This scenario would follow Alternative #3 however pits that have cooler water including Pits 8 & 9 would be largely retained to allow for off-channel thermal refuge, particularly for fish. Grading would focus on river left and areas below Pits 8 & 9. Grading in Pits 8 & 9 could narrow pits substantially to allow for off-channel habitat while also moving towards a more natural river setting.

*Benefits, Limitations & Level of Effort-* Similar to Alternative #3.

The overall level of effort is anticipated to be high.

*Proposed Actions-* Similar to Alternative #3.

**4. Side-Channel Re-Connections**

*Description***-** This scenario would include improving habitat and increasing flow in the two prominent right bank side-channel alignments in the Lower Daybreak reach. Work would include select excavation in the side-channel alignments and placement of new wood structures (or enhancement of existing ones) in the mainstem to help raise/divert water into the side-channels. Wood would also be added throughout both side-channels to improve habitat complexity. Additional analysis is needed to understand the amount of grading and log jam work that would be required to achieve perennial connectivity.

*Benefits, Limitations & Level of Effort-* This alternative would build on the existing sediment and wood accumulation area that has been occurring over the last 5–10 years along the mainstem and at the entrance to the lower side-channel. Existing wood and pool availability within the lower side-channel is almost non-existent. In the upper side-channel there is some good pool habitat (due to beaver activity) but almost no wood. Wood additions would provide habitat complexity, roughness, and a mechanism for gravel retention. Wood could also serve as valuable grade breaks reducing localized steeper slopes. By adding wood along the mainstem, this would help facilitate additional gravel recruitment, rebuild channel bed elevations, and divert more flow into the side-channels over a greater range of months and flow events. This will increase the available habitat and opportunities for both spawning and rearing fish in the mainstem and side-channels. Actions would be expected to benefit juvenile coho, Chinook, and steelhead; and adult (spawning) coho.

There are a few potential considerations with this alternative. The area around the connection to the mainstem at the entrance of the lower side-channel, and the mainstem bar/depositional area, is dynamic and the elevations have changed over the last 5-10 years. This could lead to some uncertainty in terms of determining elevations of the entrance invert to the lower side-channel and the potential for sediment accumulation.

The overall level of effort is anticipated to be moderate.

*Proposed Actions*

- Add wood at side channel confluences to enhance connectivity to the mainstem.
- Selectively grade side channel confluence areas to enhance the frequency and duration of hydrologic connectivity.

- Install large wood jams throughout the channels to promote pool formation and gravel retention.
- Increase pool frequency to meet NOAA requirements for properly functioning alluvial river.

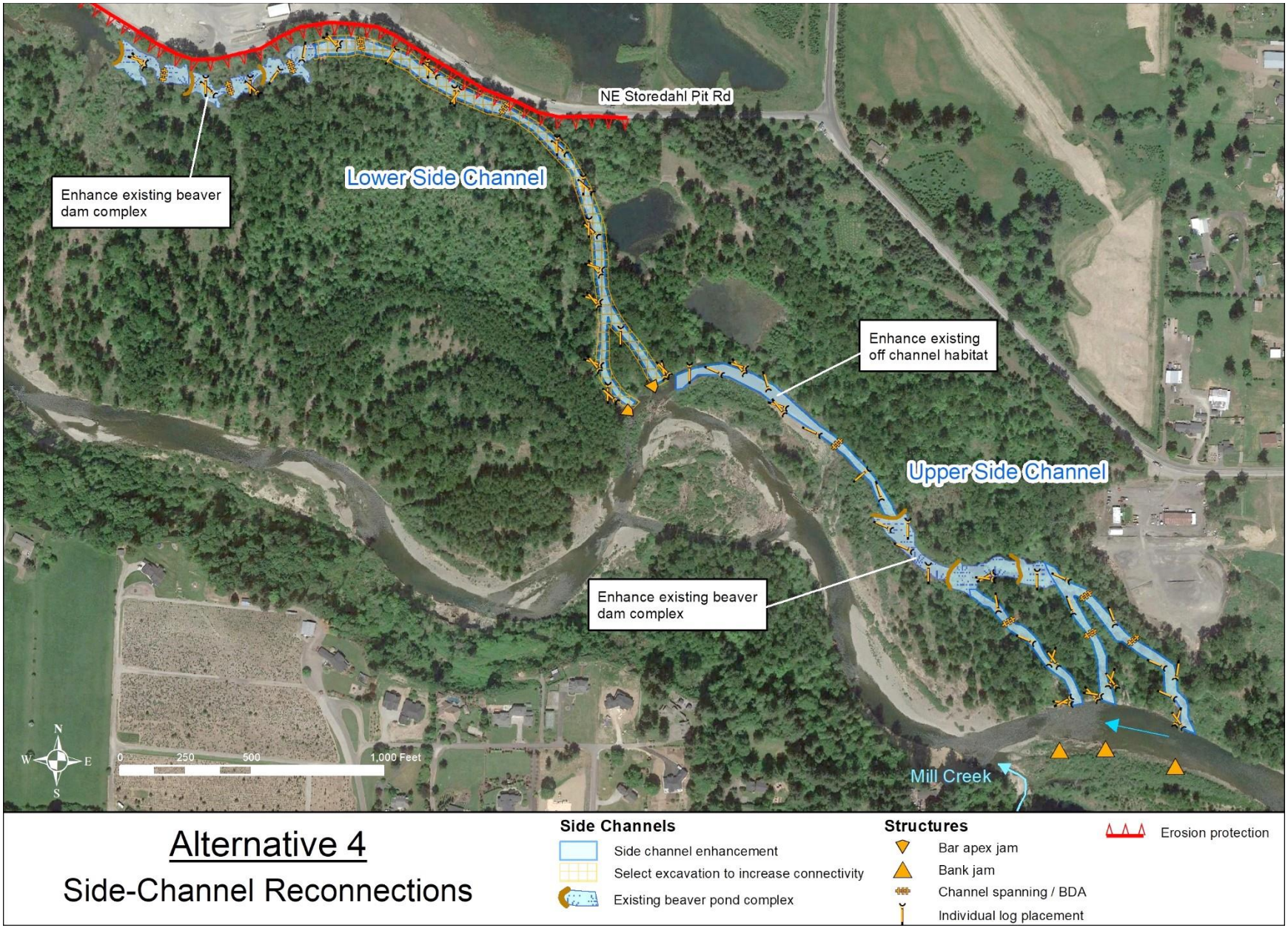


**Figure 3**. Side-Channel Enhancement- Alternative 4.

5. **Mill and Manley Creek Confluence**

*Description***-** Efforts at this location would be focused on improving habitat complexity and creating a self-sustaining thermal refuge area, which is located in a backwater alcove and beaver dam complex that receives flow from Mill and Manley Creeks. This scenario would include increasing higher flows across the point bar and into the downstream end of the backwater alcove near the Mill Creek confluence. The intent would be to promote the periodic scour and evacuation of sediments that have accumulated to fill the pool and limit juvenile salmonid rearing habitat capacity. Direct excavation of sediments to provide an immediate boost in the available rearing space could also be performed. LWD structures would be installed in the mainstem to divert flow into the high flow channel at the confluence area. Select excavation may also be required to create greater flow across the bar. Enhancements would also be made to habitat complexity and passage in an existing beaver dam complex.

*Benefits, Limitations & Level of Effort-* The benefit would primarily be to preserve and enhance a well-documented thermal refuge area that is used heavily by juvenile salmon and steelhead. Over the last several years, sediment has filled in some of the area and has reduced the area available for thermal refuge. Direct excavation of these sediments would increase rearing area. To maintain the pool over time, high seasonal flows across the bar and into this area would be encouraged, and a large wood structure adjacent to the Mill Creek confluence would help maintain a scour pool. The channel would encourage flows to scour out deposited sediment, thereby maintaining sufficient depth and area of the thermal plume. This would be expected to benefit juvenile Chinook, coho and steelhead as well as provide refuge for adult fish moving upstream. Further upstream in the alcove, extending up to and beyond the Manley Creek confluence, there is a beaver dam complex that has been found to have a large number of fish present in the summer (snorkel survey LCEP 2018). Preliminary observations suggest there may be opportunities to would expand the beaver dam complex, add habitat cover, and, improve access to isolated ponds. These actions could benefit juveniles and provide them with an expanded area to hold over during the summer.

There are a few considerations and potential limitations with this alternative. This is a highly dynamic area, with changes every year that affect the position of the mainstem, sediment contributions from the tributaries, and the configuration of the backwater alcove and beaver dam complex. Recent mainstem scrolling patterns suggest that the river is likely to continue to migrate to the north and west away from the area. Over the next several years, this could lead to a natural expansion of the alcove and beaver dam complex that is fed by Mill and Manley Creeks, which could minimize the benefits of scouring out the filled pool at the Mill confluence. Based on input from the TAC, there is also reason to believe that the recent increases in deltaic sediment deposits at the mouth of Mill Creek may be due to changes in flows and associated erosion from activities in the upper Mill Creek watershed – this needs further investigation. There are also potential limitations to installing wood structures and increasing flows into the Mill and Manley confluence areas, including potential effects on the steep bluff between Mill and Manley Creeks and downstream of Mill Creek. Diverting flows from the mainstem could also reduce the rate of down-valley scrolling, which could be counterproductive

since the scrolling is likely to naturally expand the thermal refuge. There are multiple landowners in this area and a high degree of coordination would be needed.

The overall level of effort is anticipated to be moderate-high.

*Proposed Actions*

- Install large wood jams along the mainstem and upstream of the site to promote flow deflection.
- Perform select excavation in the high flow channel across the bar to encourage scouring flows at the Mill Creek confluence area.
- Install large wood structure adjacent to Mill Creek confluence to help maintain scour pool.
- Excavate Mill Creek deltaic deposits to expand cold water pool.
- Encouraging more mainstem flow into the Mill Creek confluence area would require an investigation of potential effects on bluff erosion and possibly the design of mitigation measures to protect property.
- Enhancement and expansion of rearing in the beaver dam complex.

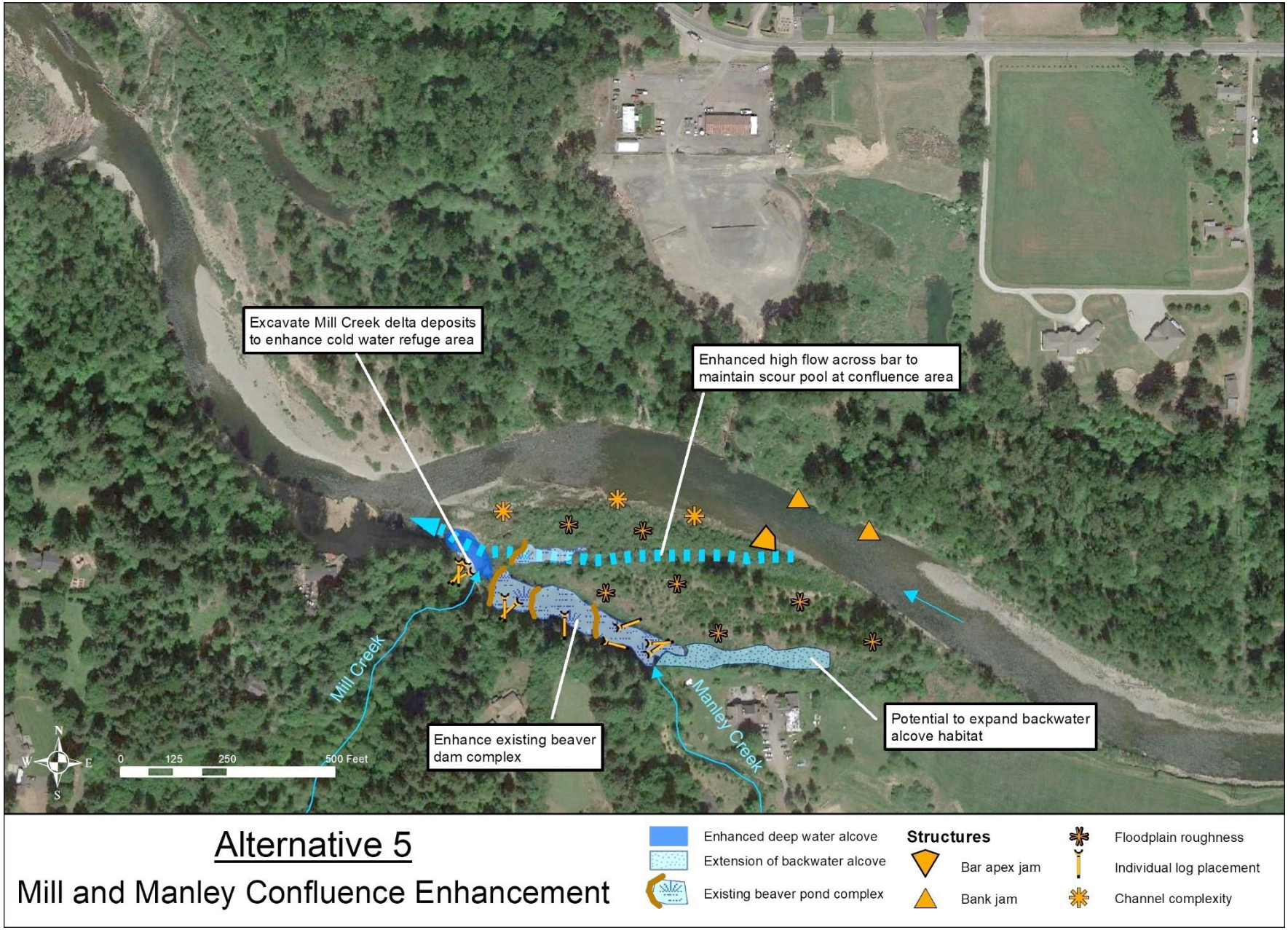


**Figure 4.** Mill-Manley Confluence - Alternative 5.

**6. Mill and Manley Area CMZ Expansion**

*Description***-** This effort would work with the County to explore the potential for expanding the width of the CMZ in the north floodplain across from the Mill and Manley confluences. Currently, due to the County maintenance yard and related hydromodifications (i.e. levees and armor), this area has one of the narrowest CMZs in the lower river (see EF Lewis Habitat Assessment, Cramer Fish Sciences and LCFRB 2005). If the southern portion of the maintenance yard could be relocated, then the CMZ could be expanded by approximately 15 acres. Set-back protections in the form of bank armoring, and a levee if needed, could be provided for the maintenance offices, shop buildings, and other structures. This alternative would also include large wood placements on the bar and channel margin on the south side of the river near the Mill-Manley confluence area. Accumulated bedload at the Mill Creek confluence would be excavated to expand the existing alcove habitat area. Enhancements would be made to the existing beaver dam complex.

*Benefits, Limitations & Level of Effort-* The benefit would be to expand the CMZ in this area and to reduce channel confinement. The confinement would be reduced from an Active Valley Width to Active Channel Width ratio (ACV/ACW) of approximately 3.5 to 5 (~40% reduction in confinement). This would allow for the potential future formation of side-channels in this expanded CMZ as well as creation and fish access to future floodplain habitats including abandoned oxbows, floodplain wetlands, and beaver dam complexes. Wood placements on the river-left (south) bar and channel margin would allow for and encourage the continued down-valley scrolling of the mainstem. Assuming these trends continue, this would be expected to eventually move the mainstem away from the high and actively eroding cliff on the south bank. It would also serve to lengthen the backbar alcove fed by Mill and Manley Creeks, which would provide a natural expansion of an important cold-water refuge area for salmonids. Wood placements in the existing beaver dam complex, and potentially construction of BDAs, would enhance the complexity and expanse of the beaver dam complex that is fed by cool water from Manley Creek.

The overall level of effort is anticipated to be high, particularly given the required coordination with the County and the cost of moving the maintenance yard and providing adequate set-back protections.

*Proposed Actions*

- Remove the existing levee/berm that extends south and west of the maintenance yard.
- Provide set-back protections for office and shop buildings.
- Excavate deposited sediments at Mill Creek confluence to provide immediate expansion of cold-water refuge habitat.
- Place floodplain roughness on bar at Mill-Manley confluence, and habitat complexity jams along mainstem margin. These placements will encourage vegetation growth on bar and will allow for continued downstream scrolling of mainstem.
- Enhance existing beaver dam complex at Mill-Manley confluence by adding large wood and potentially BDAs.

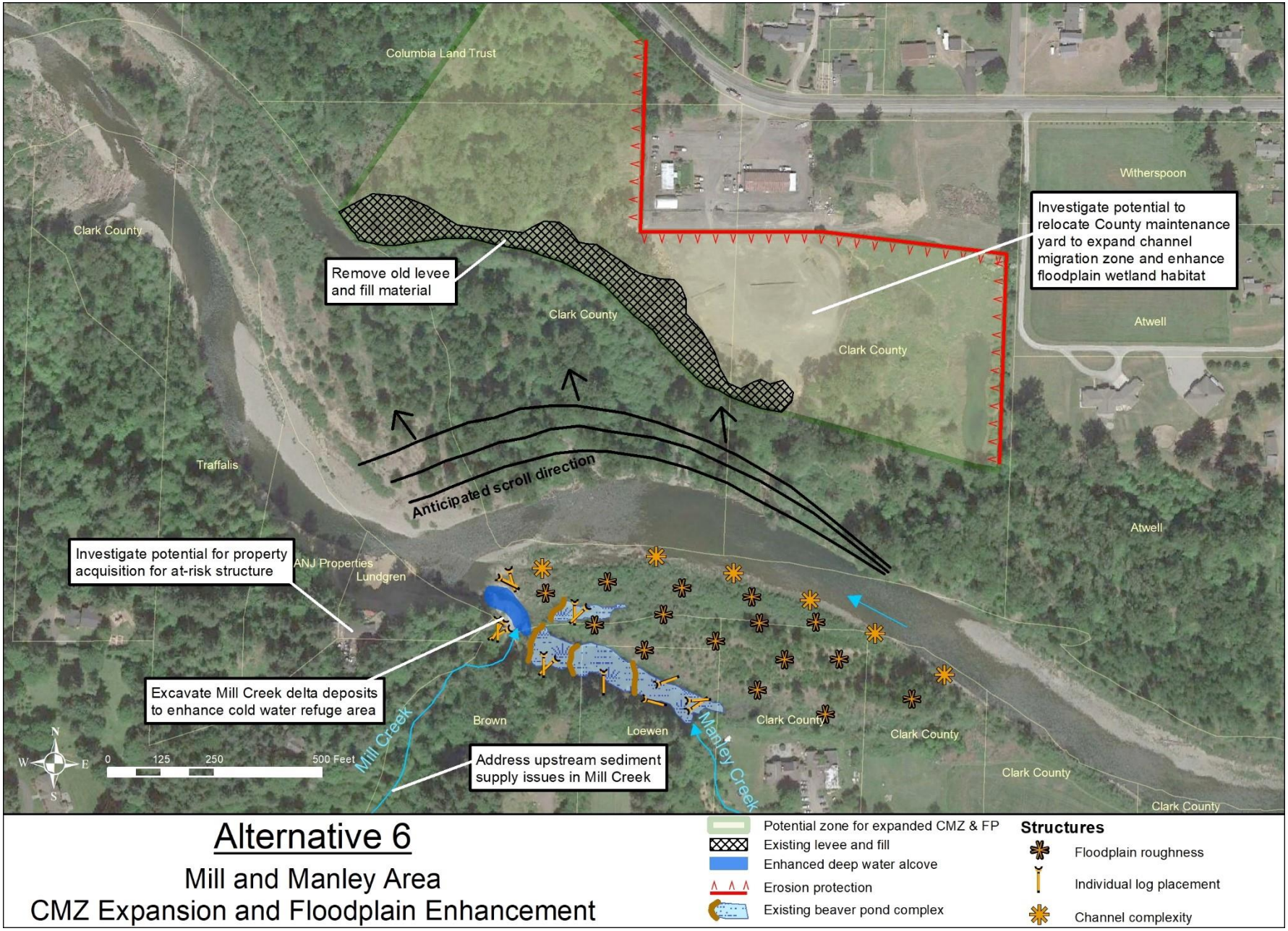


**Figure 5.** Mill-Manley CMZ Enhancement- Alternative 6.

Appendix A- Project Area Map and Reaches

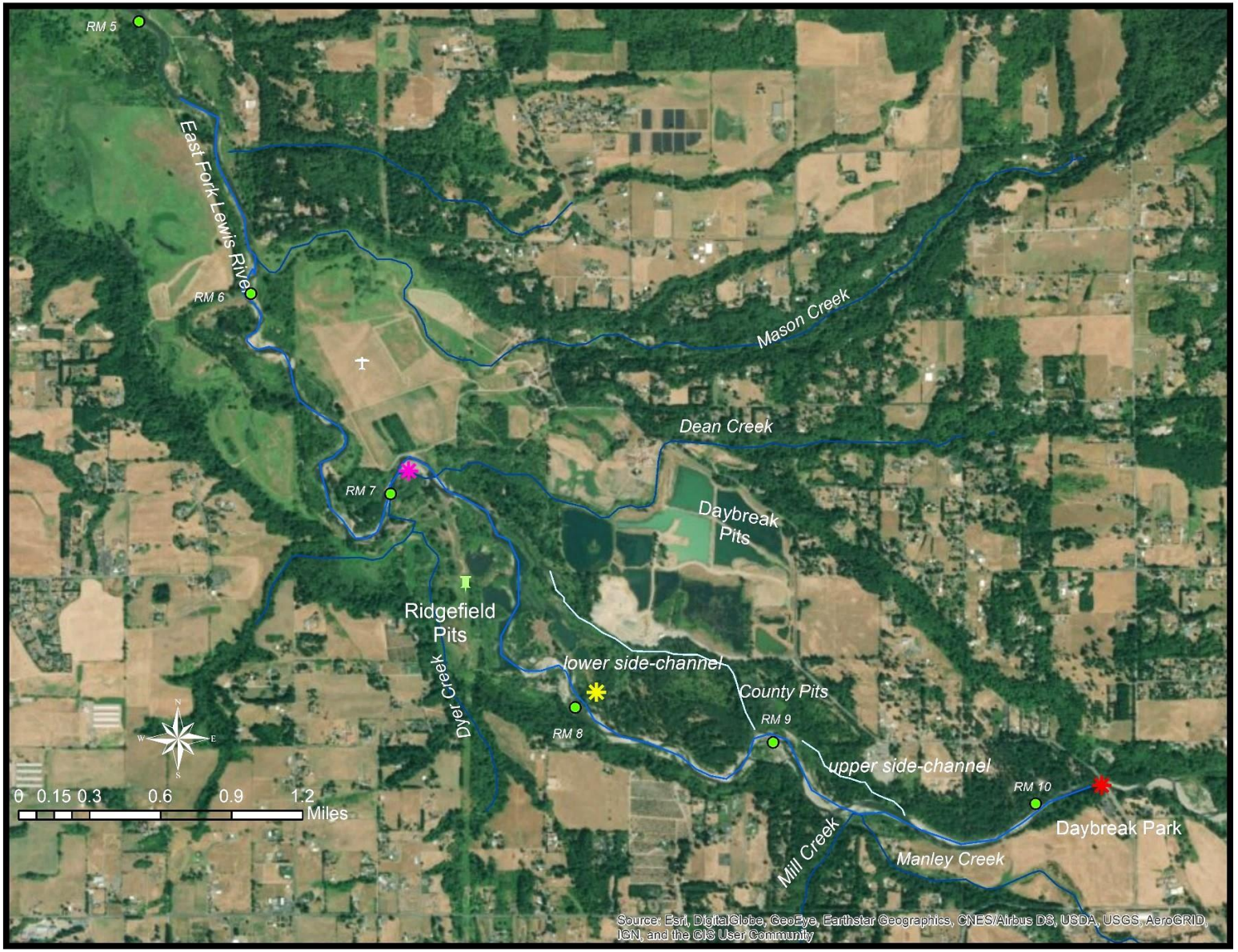


**Figure 1**. Project area map showing the Daybreak Park reach (RM 10.2- RM 8.0- most upstream Asterix to middle Asterix) and Ridgefield Pits Reach (RM 8.0- RM 7.1- middle Asterix to lower Asterix). Project sites include Ridgefield Pits, upper and lower side-channels and the Mill Creek confluence with EFLR.

Appendix B- Ridgefield Pits


**Figure 1**. Aerial oblique view looking downstream at the Ridgefield Pits. Pits are numbered 1- 9. Pits 1 and 2 have different coloration to indicate the approximate locations of the former pits. Note the gravel and wood deposition at Pits 1 and 2.

**Table 1.** Restoration alternatives by reaches. Key for accomplishing restoration objectives is located at the bottom of table.

| | | Restoration Alternatives | | | | | |
|---|---|---|---|---|---|---|---|
| **Goal** | **Objective** | **Alt 1: No action** | **Alt 2/2a: Relocate main channel** | **Alt 3/3a: Full pits regrade** | **Alt 4: Side-channel reconnections** | **Alt 5: Mill-Manley enhancement** | **Alt 6: Mill-Manley area CMZ expansion** |
| **Goal 1: Vegetation** | **1a. Create channel processes that support veg** | No channel processes that support veg in Pits reach. Scour either too frequent/too infrequent to support nat. veg in other rch. | Moderate confinement will limit scrolling. Limited floodplain connectivity. | Multi-thread channels, channel scrolling, shallow water table, frequent floodplain inundation will support native vegetation | Increasing side channel connections will increase dynamic processes within them, supporting native vegetation. | Overbar flow will enhance processes that support veg, but mainstem jams may limit scrolling. | Expanding CMZ will support channel processes that support native veg. |
| | **1b. Create a patchwork mosaic of veg types and ages** | Invasive grasses and shrubs dominate Pits reach. Only a couple of stand types and age classes in other reaches. | Supported mainly in new channel corridor, not across full pits area due to continued process limitations. | Restored channel processes and dynamics will achieve patchwork mosaic over time. | Increasing side channel connections will increase veg diversity in those areas. | Only minor influence on overall vegetation conditions. | Restoring more of the CMZ and related processes will increase veg. types and ages in this area. |
| | **1c. Provide streamside veg for key functions** | Riparian veg. highly degraded in Pits rch. Streamside veg young and sparse in other rchs. | Can achieve robust riparian buffers along new channel but may need to be actively maintained. Armoring may affect river-right side at gravel processing area. | Robust vegetation along riparian stream margins, with abundant margin habitat created. Wide buffers created in pits reach. | Increased connectivity will support robust streamside veg communities. | Assume riparian work along bar occurs, creating more robust buffer in this location. Otherwise no significant impact. | Only minor impact on streamside veg, at least in the near-term. |
| **Goal 2: Thermal Refugia** | **2a. Protect and enhance existing refugia** | No protections or enhancements of existing refugia | Possible to achieve, assuming existing refugia can be accessed by new channel location. | Multi-thread channel network across wide valley footprint will access known (e.g. Pit 9) and potentially unknown areas of thermal refugia | Increasing side-channel connections increases access to and quality of potential thermal refugia. | The goal is to enhance existing refugia at Mill-Manley confluence area, although there are questions about whether mainstem scrolling may enhance on its own. | Down-valley scrolling of mainstem away from Mill confluence is expected to lengthen tributary/backwater refuge area that receives cool flows from Mill-Manley. |
| | **2b. Width-to-depth <12** | width-to-depth >20 | Unlikely to achieve with primarily a single-thread channel. | Multi-thread planform will allow channel sizing for individual channels to be at or below 12. | Achievable in side-channels | Slight reduction in w/d in mainstem due to jams but target not reached. | No significant short-term impact on w/d, except for long-term, where new side-channel development would help reduce overall w/d of channels. |
| | **2c. Canopy closure >50%** | Canopy closure <20% | Unlikely to achieve with primarily a single-thread channel. | Canopy closure >50% can be achieved due to multi-thread channels and robust riparian veg. | Achievable in side-channels | Not likely to achieve | No significant short-term impact on shade, except for long-term, where new side-channel development would help increase overall shade of channels. |
| | **2d. Create new refugia via hyporheic exchange** | Little-to-no refugia created via hyporheic exchange | Only moderate ability to provide hyporheic flow paths given narrower channel corridor, possibly one or two opportunities. | High sinuosity & planform complexity, and transition to coarser substrate will help activate hyporheic flow paths. New alcove and backbar habitats will be created. | Perennial side-channels will help create head gradients that create hyporheic flow paths contributing to thermal refuge areas. | Creating high-flow path is likely to encourage more low flow hyporheic flow contributing to refuge area. | Opening up CMZ will create more possibilities for channels that create hyporheic exchange, and off-channel habitats that receive cool hyporheic flows. But indirect. |
| **Goal 3: Aquatic Habitat** | **3a. Sinuosity >1.3** | Sinuosity ~1.2 | Unlikely to achieve given narrow corridor | Sinuosity will be at or above 1.3 | Sinuosity is likely to remain similar to existing side-channel alignments, which is ~1.2; However, more connectivity will allow greater future planform adjustment. | No impact on sinuosity | No direct effect, but potential long-term effect by allowing channels to more freely form over a wider CMZ. |
| | **3b. Pools per mile >10** | ~1-2 pools/mi in Pits. ~7 pools/mi in upstream reach. | Possible to achieve in primary channel | Possible to achieve >10 pools/mi in primary channel as well as co-dominate and secondary channels due to high planform complexity and LW additions. | Possible to achieve in side-channels | No impact on pools/mi. | No direct effect, but potential long-term effect by allowing channels to more freely form over a wider CMZ. |
| | **3c. Large wood targets (Fox & Bolton, NOAA)** | Does not achieve any of the targets. | LW can be added to achieve targets | LW can be added to achieve targets | LW can be added to achieve targets in side-channels | LW can be added to achieve targets | LW can be added to achieve targets |
| | **3d. Side-channel frequency 2-5 channels per cross-section** | Currently 0-2 perennial channels | 0-1 perennial side-channels | Multi-thread network will result in 3-5 channels per valley cross-section. | Will achieve at least low end of scale (2-3 channels). | Somewhat increases side-channels, but only at high flows. | Widening the CMZ will allow for the potential for more side-channels to form. |
| | **3e. Channel margin length >5 times valley length** | Channel margin length currently and into the future <5 times valley length | Not possible to achieve with primarily single-thread channel. | Multi-thread network will result in channel margin length > 5x valley length. | Likely to achieve or be very close to target. | No significant change in channel margin length. | Widening the CMZ will allow for the potential for more side-channels to form, thus increasing margin length. |
| | **3f. Existence of zero velocity refuge areas** | Few zero velocity areas at high flows | Possible to achieve by taking advantage of existing pits for off-channel high flow refuge. | Complex channel network will result in numerous zero velocity areas during high flows. | Likely to achieve by introducing more flow into off-channel and floodplain areas. | No significant change | Widening CMZ will allow for the potential for more side-channels, backwater channels, alcoves, and floodplain wetlands that retain quiescent water during high flows. |
| | **3g. Floodplain habitats >8 acres/mi** | Currently estimated at ~3 acres/mi, but varies among reaches | Unlikely to be able to achieve given limited floodplain extent. | Possible to achieve floodplain habitats > 8 acres/mi. due to extensive floodplain wetlands & off-channel areas | Is likely to significantly improve access to and occurrence of floodplain habitats but may not fully achieve. | Slight increase from enhancement of beaver dam complex & scouring of Mill confluence, but only minor. Target not achieved. | Widening CMZ will allow for the potential for more side-channels, backwater channels, alcoves, and floodplain wetlands with connectivity to the main channel. |
| **Goal 4: CMZ and Floodplain Connectivity** | **4a. Remove hydromodifications** | Existing hydromodifications remain | Levee would need to be constructed to prevent re-avulsion into pits. Armor needed at gravel processing area. | Berms surrounding pits will be removed. Armor protection of gravel processing area will need to stay and possibly be strengthened. | No hydromodifications will be removed and some armoring, such as at the County maintenance yard and along the Storedahl Pit Rd., may need to be strengthened. | Existing hydromodifications remain | This alternative will remove a levee and create set-back protections to the extent needed depending on landowner participation (TBD). |
| | **4b. AVW/ACW >6** | AVW/ACW<2 in Pits.<br>AVW/ACW ranges 3.5-8.5 in Daybreak rchs; 3.5 in Mill-Manley area. | AVW/ACW = ~1-2 is significantly below target conditions. | AVW/ACW > 6, even with all channels summed, in widest part of pits. Less width downstream due to powerline towers. | No change in channel confinement. Confinement remains high at Mill-Manley but low at downstream side-channel. | No change in channel confinement, which would remain high in this area. | Current AVW/ACW = 3.5; restored would be ~5 |
| | **4c. Overbank flow > 1 mo/yr** | No overbank flow in Pits reach for even large floods. Overbank flow only every 1-2 years for Daybreak reaches | Possible to meet inundation target, but only within the limited new floodplain area. | Designs for channel sizing and floodplain elevation will accomplish overbank flow >1 month per year, on average. | Partially achieves objective by connecting side-channels at lower flows. | Overbank flows across bar likely to increase, but likely not to full extent of target. | Larger floodplain allows for greater inundation, and future side-channels that receive flows more frequently, no significant short-term influence on rates or duration. |
| **Goal 5: Channel Dynamics and Sediment** | **5a. Depositional channels** | Pits are depositional. U and L Daybreak are close to equilibrium, with deposition and transport zones. | Single-thread channel with limited floodplain and with a desire to prevent re-avulsion will need to be approximately at equilibrium (bedload in = bedload out) | Pits reach will remain very depositional due to high sinuosity (therefore low gradient) and high floodplain connectivity. | Side-channels will remain depositional, but no significant increase. | No change in depositional features of channels. Likely more scour at Mill confluence area. Deposition on bar expected to continue. | Allowing for and encouraging mainstem scrolling and side-channel development will somewhat increase depositional conditions. |
| | **5b. Natural bank erosion rates** | No significant bank erosion in Pits.<br>7-8 ft/year in U and L Daybreak reaches. | Natural rates of bank erosion will be limited by confining features on each side of new stream corridor. | Banks will be supported by native vegetation, without incised channels and hydromodifications, except for abutting gravel processing area with armor. | Introduction of more flow into side-channels likely to increase erosion and adjustment rates within side-channels. | Short-term reduction in erosion rates at mainstem jams but possible increase or no-change downstream right bank. Effect on erosion at high cliff is uncertain. | Current scrolling along bank with mature native veg. would be allowed to continue and be encouraged. |
| | **5c. Bed substrate >70% grl-cbl; <15% fines for spawn** | Dominated by fines in Pits reach.<br>>70% gravel-cobble in Daybreak reaches. | Likely to achieve | Likely to achieve | Unlikely to have significant effect on bed substrate. Possible coarsening due to greater flow introduced but also possible more suspended load introduced as well. | No significant change. Substrate assumed to remain coarse. | No significant change. Substrate assumed to remain coarse. |
| **Goal 6: Human Uses and Risks** | **6a. Do not increase property or structure risk** | Existing risk remains | Likely to achieve. May need to supplement armor to protect gravel processing area and downstream private property. | Likely to achieve. May need to supplement armor to protect gravel processing area and downstream private property. | Likely to achieve. May need to supplement armor along County yard and Storedahl Pit Rd. | Effect on high cliff erosion is uncertain. Angle of attack is more parallel, so could be less, but more flow introduced towards upstream side of bank. | Effect on high cliff erosion is uncertain. Allowing for and encouraging down-valley scrolling is expected to eventually move mainstem away from eroding cliff. |
| | **6b. Avoid Daybreak Pits avulsion** | Avulsion is possible in the future; however, in pits reach channel is locked in for the foreseeable future. Overbank flows from up-valley are possible avulsion-source. | This does confine the channel to a location closer to the Daybreak Pits, possibly adding risk of avulsion during very large flood. | Low potential for avulsion- lower overall stream and floodplain elevation & high conveyance of large floods. Overbank up-valley flow still a possible avulsion-source. | No significant impact on Daybreak Pits avulsion risk, unless avulsion were to occur within downstream side-channel. | No increased risk from work in this area. Risk remains the same. | No increased risk from work in this area. Risk may reduce due to greater conveyance at large floods, reducing potential for overbank flows in north floodplain that could enter Pits. |
| | **6c. Consider recreational user risks** | Existing risk from large wood | Possible to achieve | Possible to achieve, though multi-thread network and abundant LW could make for challenging boat navigation. | Possible to achieve | Possible to achieve | Possible to achieve |

**KEY**

| | |
|---|---|
| | Very much accomplishes objective |
| | |
| | Somewhat accomplishes objective |
| | |
| | Does not accomplish objective |

# Appendix D- References


1. Aerial photos (1939-2002) of project area (digital photo library, USACE).
2. Cadastral Survey Plot from 1854 (General Land Office, BLM).
3. Flood Plains, Salmon Habitat, Sand and Gravel Mining (Norman et al., WA DNR 1998)
4. Geomorphic Analysis of the East Fork Lewis River, Appendix C, prepared as part of a Habitat Conservation Plan & Environmental Impact Statement for the proposed Daybreak Mine expansion (WEST Consultants, Inc. 2001).
5. East Fork Lewis River Basin- Habitat Assessment, Chapter 4. (LCFRB 2005).
6. A Regional and Geomorphic reference for quantities and volumes of instream wood in unmanaged forested basins in Washington State (Fox., M and Bolton, S. 2007).
7. Lower East Fork Lewis River Habitat Restoration Plan (LCFRB 2009).
8. CM-10- Monitoring Report: Ridgefield Pits Bathymetric Survey. Prepared as part of a Habitat Conservation Plan & Environmental Impact Statement for the proposed Daybreak Mine expansion (West Consultants, Inc. 2013).
9. CM-10- Investigate water temperature, DO, fish use and geomorphology. Prepared as part of a Habitat Conservation Plan & Environmental Impact Statement for the proposed Daybreak Mine expansion (R2 Resource Consultants 2013).
10. East Fork Lewis River La Center Wetlands Floodplain Restoration Design Report (Estuary Partnership 2015).
11. East Fork Lewis River Watershed Bacteria and Temperature- Source Assessment Report (Washington Department of Ecology 2018).