East Fork Lewis River
Ridgefield Pits Restoration

Basis of Design Report Preliminary Design

Lower Columbia Estuary Partnership & Inter-Fluve

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1 Introduction

1.1 Overview

This report summarizes preliminary designs for aquatic habitat restoration for the Ridgefield Pits reach and adjacent upstream areas on the lower East Fork Lewis River (EF Lewis River). The project aims to restore habitat conditions for ESA-listed salmonids, including winter and summer steelhead, fall Chinook salmon, coho salmon, and chum salmon. The project will restore instream habitat, riparian habitat, and floodplain processes in a section of river that has been heavily impacted by past floodplain gravel mining, gravel mining capture (avulsion into floodplain gravel pits), and a host of past and ongoing land uses that havefilled and encroached on the historical floodplain and channel migration zone.

This report provides background information on the project and serves as a Basis of Design report for the Preliminary Designs. It will be updated as part of subsequent design phases.

1.2 Background

This preliminary design effort was led by the Lower Columbia Estuary Partnership (LCEP) and is funded by theWashington State Salmon Recovery Funding Board as part of Recreation and Conservation Office (RCO) Project #17-1070. The project included planning, data collection, analysis and stakeholder involvement to support the preliminary designs, including:

- Topographic survey (Attachment A)
- Geomorphic analysis (Attachment B)
- Hydraulics analysis (Attachment C)
- Sediment survey and analysis (Attachment D)
- Water temperature analysis (Attachment E)
- Restoration alternatives development and selection of preferred alternative (Attachment F).

Technical support and guidance for the project has been provided by a Technical Oversight Group (TOG) comprised of technical representatives from interested and involved stakeholders and resource agencies. The TOG and stakeholder involvement is further discussed in Section 1.4 and Attachment G.

1.3 Supporting Studies

There has been considerable past analysis of the lower EF Lewis River and preliminary restoration planningfor the project area. The following previous studies have evaluated habitat, land use impacts, and/or restoration opportunities in the study area and have been reviewed as part of this effort.

- Daybreak Mine Expansion Habitat Conservation Plan (HCP) (Storedahl & Sons 2003). Includes the main HCP document as well as the following attachments or follow-up work that are relevant to this effort:
    - Conceptual Restoration Plan for Ridgefield Pits (R2 Resource Consultants 1999) –Appendix B of the HCP
    - Geomorphic Analysis of the East Fork Lewis River (WEST Consultants 2001)-Appendix C of HCP
    - Daybreak Ponds Avulsion Mitigation (WEST Consultants 2001 and Ecological LandServices) – Addendum 1 to Appendix C of HCP
    - CM-10 Monitoring Report-Ridgefield Pits Bathymetric Survey (Tech Memo by WEST Consultants 2013) – monitoring requirement of HCP
- Assessment and Strategic Plan for East Fork Lewis River (Dover Habitat Restoration for Friends of

the East Fork 2003)

- East Fork Lewis River (RM 13 to RM 6), Including West Daybreak Park Project Reach – Fluvial Geomorphology and Erosion and Sediment Evaluation (Frank Reckendorf 2010).
- The Lower East Fork Lewis River Subbasin: A Summary of Habitat Conditions, Salmonid Distribution, and Smolt Production (WDFW 2001)
- East Fork Lewis River Basin – Habitat Assessment (SP Cramer & Associates 2005)
- Lower East Fork Lewis River Habitat Restoration Plan (Inter-Fluve and Cramer Fish Sciences, for LCFRB 2009). This effort identified the need for restoration of the pits reach and provided a coarse-scale description of opportunities and potential costs.

1.4 Project Goals

Project goals were established through the workgroup (TOG) process described above and are listed below. The project objectives and design criteria that fit within these goals are included in Section 4.1.

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.

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. Improve habitat quantity and quality in the existing thermal refuge areas. Assess potential to leave pits that contain cooler water as refuge areas during the design and construction phases of the project.

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, pools with instream cover, riffles for macroinvertebrate production, and 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.

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 channeladjustment. Investigate the feasibility of expanding future restoration actions into the Daybreak Pits area.

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.

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. Considerthe implications of designs for recreation users along the river.

2 Site Conditions

2.1 Site Overview

The study area extends from approximately river mile (RM) 7.3 (downstream of the Ridgefield Pits) to RM 10 (downstream of Daybreak Bridge). An overview map of the project area (Figure 1 and Sheet 5 in the Preliminary Design drawings- Attachment H) and photos of the individual site locations (Figure 2) are shown below. The project study area included four restoration sites, including: Ridgefield Pits (Figure 3); two side channels (referred to as Lower Side Channel and Upper Side Channel) located to the north of the main channel and upstream of the Ridgefield Pits, and the Mill/Manley Creek confluence with the EF Lewis River. The Ridgefield Pits and the Upper Side Channel project locations were identified as high priority sites in the Lower EF Lewis River Habitat Restoration Plan (2009).

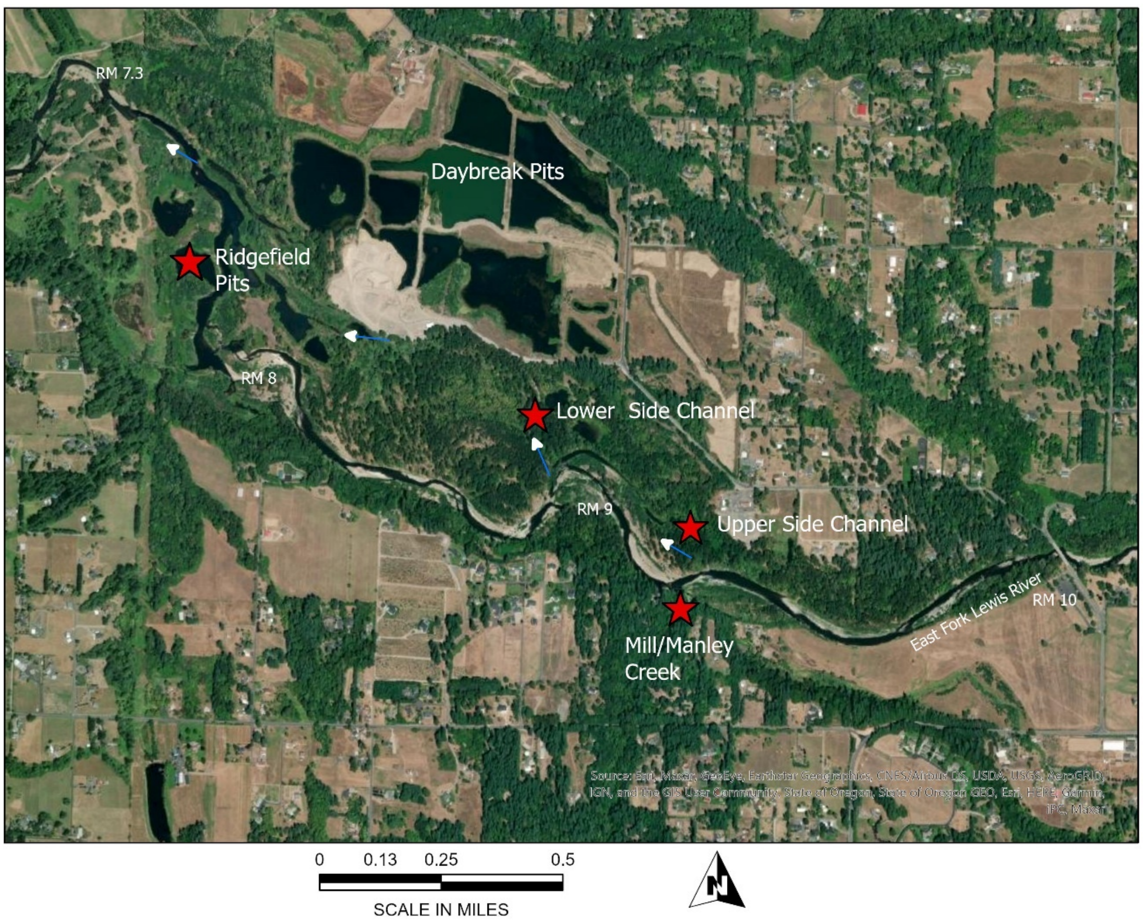

Figure 2. Project area photos including a) Upper Side Channel- confluence (star) with EF Lewis River (located to the right), looking upstream, spring flows; b) Lower Side Channel- confluence with EF Lewis River (background), looking upstream, early summer flows; c) Lower Side Channel- close to Ridgefield Pits, looking upstream, late summer conditions; 4) Mill/Manley Creek- confluence with the EF Lewis River (EF Lewis River in background), looking downstream, late summer flows.

A primary focus of the project is the Ridgefield Pits (RM 7.5-RM 8.0) which were mined for gravel starting in the 1950's (Figure 3). In 1996 the EF Lewis River avulsed into the Ridgefield Pits, which essentially captured the river routing all flow and sediment through the pits. The avulsion caused the abandonment of approximately 4,000 feet of former stream channel and the river still flows through the former gravel mining pits. In the area around Pits 1 and 2 a new delta formed of deposited riverbed material has developed since the avulsion.

Figure 3. Ridgefield Pits current conditions. There are nine pits total. Several of the pits have filled considerably with sediment while the majority have filled very little over the last 25 years The delta forming at Pits 1 and 2 has led to increased habitat complexity. This location has shown some of the highest juvenile fish counts. Flow is towards the top of the image.

There is various infrastructure located adjacent to the project area. In the valley bottom and former floodplain to the north and east of the channel are the Daybreak Pits, some of which are still being actively mined. The processing area for the Daybreak Pits, and two older inactive gravel mine ponds, are located immediately adjacent to the Ridgefield Pits. The processing area is accessed via NE Storedahl Pit Road, which abuts the project area along the river-right side. Bank armoring separates the river and floodplain from the Daybreak Pits mining area and access road along most of project area. At the downstream endof the project area, Bonneville Power Administration (BPA) transmission lines cross the river and valley bottom, with 3 powerline towers located along the river-left (west) margin of the Ridgefield Pits. At the upstream end, on river-right, is a Clark County maintenance yard and an associated levee and armoring.

Landownership of the project area is a combination of private lands, County lands, conservation lands, and state lands (Figure 4). The Ridgefield Pits themselves are owned by CEMEX (formally Pacific Rock Products Environmental Enhancement Group). The majority of the adjoining floodplain lands upstream and downstream are owned by Clark County, with some instances of private ownership. The river channel itself within the Ordinary High-Water line is State-Owned Aquatic Land, managed by the Washington Department of Natural Resources. The primary landowners within and adjacent to the project area are shown in the Preliminary Designs drawings.

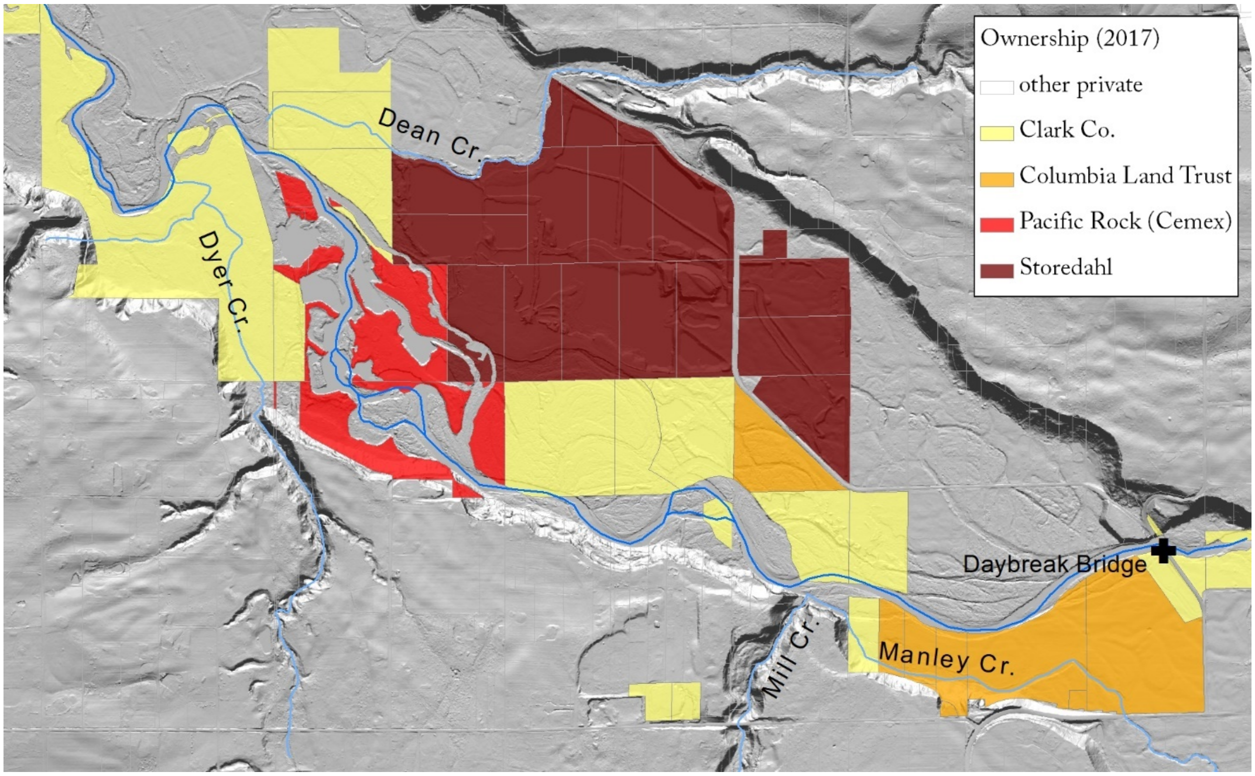

Figure 4. Land ownership (2017) in and adjacent to the East Fork Lewis River Ridgefield Pits restoration site.

2.2 STREAM SURVEYS

Inter-Fluve and LCEP staff collected bathymetric and topographic data in the spring of 2018. This work was performed using a combination of boat-based and ground-based survey techniques. Survey methods and results are described in the Survey Technical Memorandum, included as Attachment 1. The survey data was used in combination with available LiDAR data to support design, modeling, analysis and development of construction quantities.

An existing conditions digital terrain model (DTM), which represents the topographic and bathymetric surface of the project area, was created by LCEP using the field-collected data and LiDAR (Figure 5).

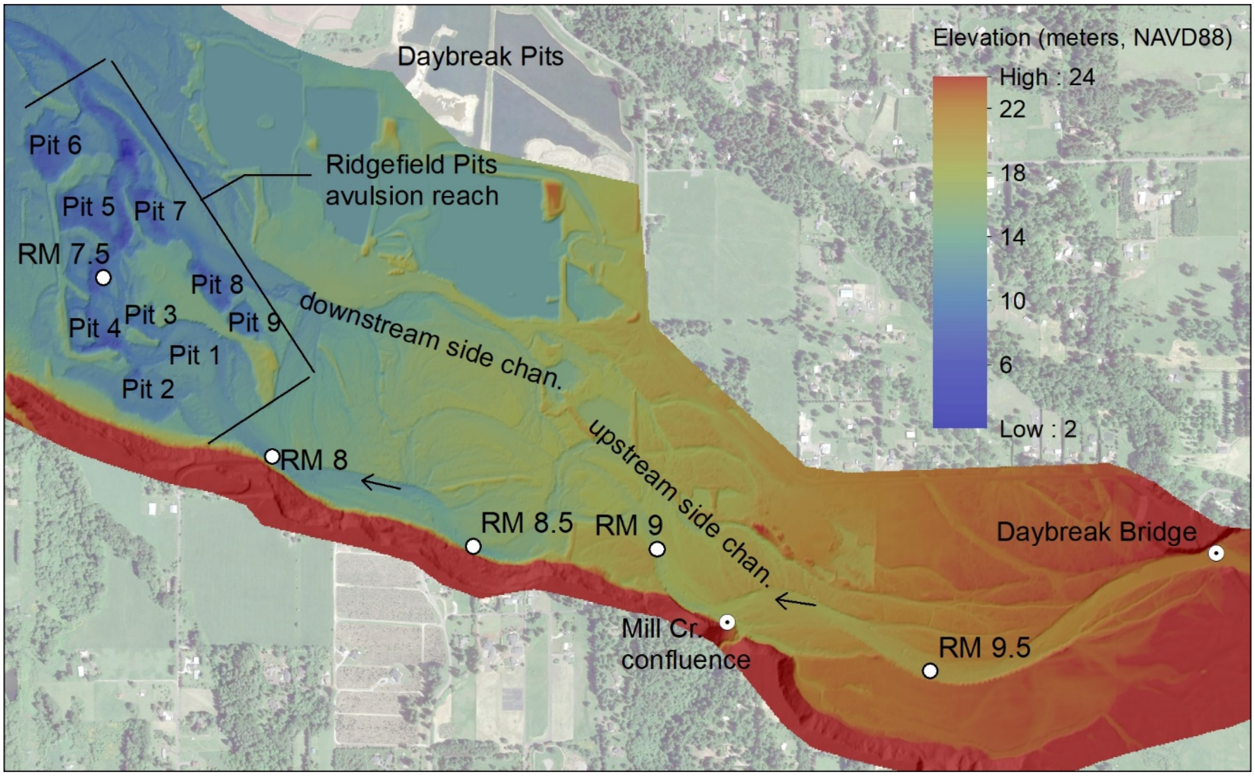

Figure 5. Digital terrain model created for the East Fork Lewis River Ridgefield Pits restoration site.

2.3 GEOMORPHOLOGY

A geomorphic investigation was performed and describes the geomorphic setting, the influence of human actions on geomorphic processes, and anticipated future trends. The geomorphic report is included in Attachment 2. A brief summary of the geomorphic setting is included here.

The headwaters of the EF Lewis River originate in the foothills of the Cascades at an elevation of approximately 4,100 ft. The river flows east to west, entering the lower North Fork Lewis River at sea level. The project site is located just above tidal influence, which extend up to approximately Mason Creek at RM 5.7, which is 1.5 miles downstream of the project area. Within the project area, the river flows through a wide (0.5 - 0.9 mile), unconfined valley with a very low gradient (<0.004 ft./ft). The entire river valley is composed of young (Holocene) alluvial sediments (fines to cobbles-see Attachment 4 for analysis of substrate). The modern river is confined to a narrower floodplain and channel migration corridor due to valley bottom development, fill, roadways, and mining. The river through the project area abuts the high valley wall on river-left in a few locations, causing erosion of the high walls, which are composed of various layers of highly erodible material including fines, gravels, and cobbles.

US Government land office maps from the 1850s indicate that the entire valley bottom was historically well-connected to the hydrology of the river. The valley bottom was labeled as a “low rich bottom subject to inundation” and was illustrated as an extensive wetland area. The river in the vicinity of the Ridgefield Pits was mapped as a multi-threaded channel, with as many as 6 or more interconnected channel threads. Upstream and downstream areas were drawn as highly sinuous with occasional secondary channels (Figure 6). This information suggests that the river through the Ridgefield Pits reach was historically anabranching, characterized by multiple channel threads separated by vegetated islands. Historical presence of this channel type is further supported by a regional (Columbia River Basin) channel typing analysis conducted by

Beechie and Imaki (2014), whose model predicts an anabranching channel type throughout the studyarea. Reckendorf (2010) also concluded that an anabranching channel type was the likely historical condition in the Ridgefield Pits area.

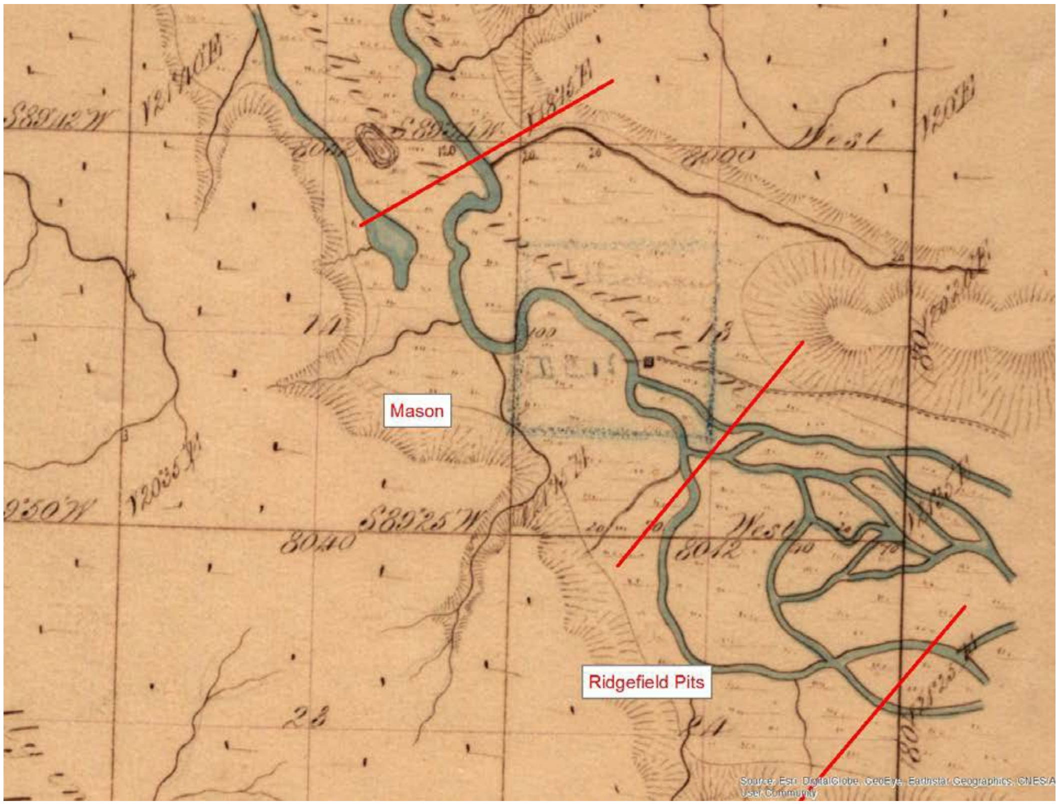

Figure 6. 1854 GLO Map- Ridgefield Pits area (between two red lines at bottom right). GLO map shows an anabranching channel planform in Ridgefield Pits area prior to human disturbances. The channel was highly connected to the adjacent floodplain. Flow is from bottom right to top left.

An aerial photo analysis was performed as part of the geomorphology report, and the imagery, along witha detailed chronology of changes, can be seen in the report (Attachment B). The analysis shows that impacts to the valley bottom were already well underway prior to the first aerial photos in 1939. The 1939 aerials show farms and residences throughout the valley bottom, although the valley bottom, including in the project area, was considerably more vegetated than today. Various episodes of instream and floodplain gravel mining can be seen throughout the lower river in the aerial photos, with mining occurring at least as early as the 1930s and continuing today. With the progression of time and increasing human impacts, the river gradually became more single-threaded, more incised, less complex, and less connected to its floodplain and channel migration zone. Aquatic habitat has suffered accordingly.

The geomorphology analysis also focused on the impact of the Ridgefield Pits avulsion (pit capture) in the mid-1990s and its potential implications to future channel processes and restoration (Figure 7). In summary, previous assessments (WEST Consultants 2001 & 2013) estimated that natural filling of the pits with river bedload and sediments would result in “recovery” (i.e. channel filling back up to a pre-1996 avulsion level) of the pits reach by 2026. Our analysis of pit filing rates, showed that full recovery based on natural filling is not likely to occur until at least the 2070s or later.

Figure 7. Ridgefield Pits avulsion, from Norman et al. (Washington DNR 1998). Flow is from right to left.

2.4 HYDROLOGY AND HYDRAULICS

2.4.1 Hydrologic Setting

The EF Lewis River has a rainfall-dominated hydrograph typical of western Cascades streams. Estimates of average monthly flows for the downstream end of the study area (RM 7.5) are included in Figure 8. An exceedance plot showing the estimated median and the 10 and 90 percent exceedance flows for RM 7.5 is included in Figure 9. These values were obtained by using a basin-area correction of data from the USGS gage at Heisson (RM 20), which is approximately 11 miles upstream of the study area. Note the relatively steady median winter flow of between 1,000 and 2,000 cfs but the wide daily range. This demonstrates the high variation in winter flows. In contrast, summer base flows are very consistent, with an average median daily flow of 89 cfs in August.

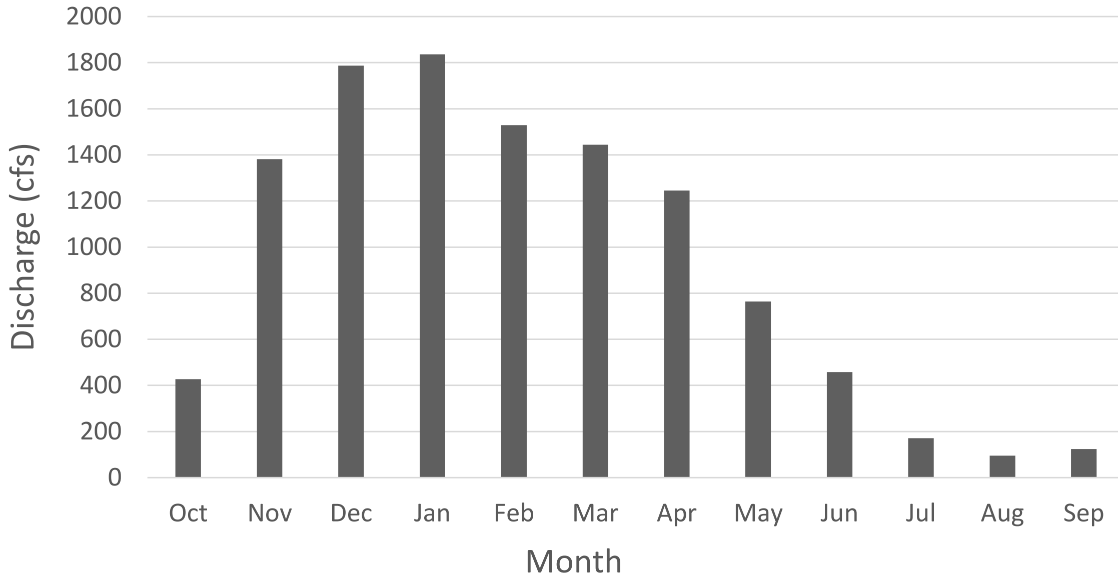

Figure 8. Estimate of monthly average flows for the project area, calculated using a basin-area correction on data from the Heisson Gage (USGS # 14222500) for the past 30 years.

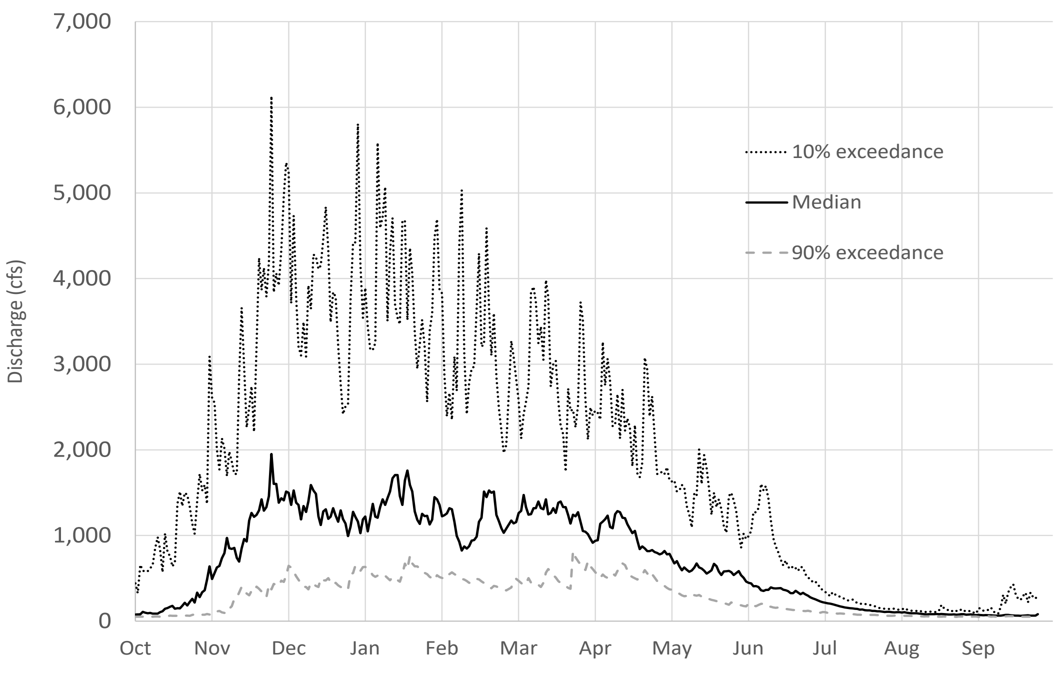

Figure 9. Daily flow exceedance estimated for River Mile 7.5. Based on a basin-area correction from the Heisson Gage (USGS # 14222500) for the past 30 years.

The flood recurrence intervals from the Heisson Gage are provided in Table 1, and a graphical display of annual peaks since the 1930s is provided in 10. As can be seen, three flood events in the past 25 years have met or exceeded the 50-year event; and the February 1996 event, which is the flood of record, is near the 500-year event. From Figure 10, it also appears that since the 1970s, there has been greater variation in the size of peak flows, which is possibly related to basin land use such as increases in the road drainage network, timber harvest, and conversion of forest to other uses.

Table 1. Flood recurrence intervals from Mastin et al. (2016) for the Heisson Gage (USGS #14222500), using 82 years of record.

Flood Recurrence Interval	Discharge (cfs)
2-Year	9,160
5-Year	12,900
10-Year	15,400
25-Year	18,500
50-Year	20,800
100-Year	23,100
200-Year	25,300
500-Year	28,300

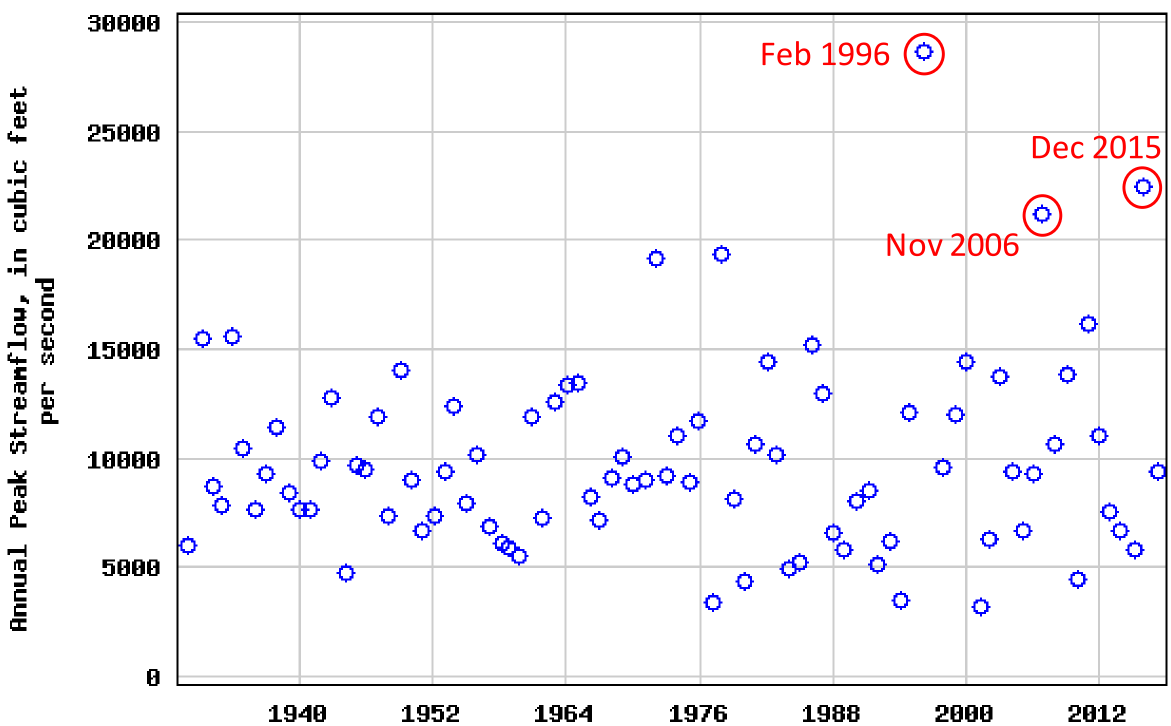

Figure 10 . Annual peak flows for the period of record from the Heisson Gage (USGS #14222500). Recent and prominent flood events over the past 25 years are highlighted.

2.4.2 Hydraulic Analysis

2.4.2.1 Overview

To evaluate surface hydraulics along the EF Lewis River and its floodplain throughout the project site, LCEP developed a 2D hydrodynamic model using the Tuflow FV modeling engine developed by the University of Queensland in Australia (and currently owned by British Maritime Technologies). The model is an upstream extension of an original model that was calibrated and applied as part of the completed EFLR La Center Wetlands project. The hydraulic model was used to evaluate existing hydraulic conditions and aid in the selection of preferred restoration design alternatives. Hydraulic model outputs also provide input to sediment and water quality modules used to evaluate geomorphic changes and water temperatures (see report sections 2.5 and 2.6, respectively). A summary of the hydraulic model analysis is presented below. Full details including model setup and results can be found in Attachment C to this report.

2.4.2.2 Results Summary

The Ridgefield Pits hydraulic model was used to help evaluate restoration Alternative 3 – within the Ridgefield Pits reach proper, and restoration Alternative 5 – the proposed overflow channel upstream of the Mill/Manley confluence with the EFLR. The model also serves as input for extended analyses of sediment transport and water temperature, using add-on modules within the Tuflow modeling package. These analyses are described in Sections 2.5 and 2.6 below, although sediment modeling has not been fully completed at this time. Inputs to the Ridgefield Pits model were derived from an initial model covering the entire EFLR downstream of the project reach, that was developed for the La Center Wetlands restoration project. That model was fully calibrated and validated, however this process has not yet been completed for the Ridgefield Pits model because required field observations are still being collected.

Model simulations of the preferred restoration Alternative 3 for the Ridgefield Pits reach generally show improved hydraulic conditions for the 3-channel hybrid network relative to the Existing Condition (EC). Bed shear and water surface profiles suggest improved sediment transport and channel stability through this reach for the 3-channel network. Currently, the reach shows significant channel instability, and a continued lack of sediment conveyance, as the reach continues to slowly adjust to the 1996 channel avulsion event. Bankfull flow occurrence as predicted by the model is somewhat less than what was predicted by channel calculations for the given channel design parameters. This is expected, as the model is not fully calibrated, and the model grid cell resolution is limited in the ability to fully resolve the relatively small channel widths incorporated in the design. Further grid refinements, and model calibration, will be incorporated into the next design phase to resolve these issues.

Model simulations of the overflow channel proposed in Alternative 5 at the Mill/Manley confluence did not show a significant improvement over the EC, relevant to the restoration objective of promoting scour at this confluence zone. A minor increase in bed shear was obtained after some refinement of the channel geometry, however increased bed shear upstream, as well as other potential concerns associated with this action that were expressed by the TOG, have generally deemed this restoration alternative unfavorable.

2.5 SEDIMENT TRANSPORT

A 2D morpho-dynamic sediment transport model with the capability to dynamically adjust bed elevations in response to hydraulically forced movement of bed and suspended load materials was developed to help characterize current transport conditions and inform the restoration alternatives that were assessed using the hydraulic model. The model used is included in the Tuflow FV modelling package, as an add-on module to the hydraulic modeling engine. LCEP and Inter-Fluve conducted surface and subsurface pebble count surveys at selected floodplain, and mainstem locations within the project reach, to characterization streambed information required by the model. The survey was completed in October 2018.

Preliminary simulations for the Project reach Existing Condition were run, however time did not allow for an analysis of the restoration alternatives that were considered for the Ridgefield Pits reach (preferred Alternative #3 three-channel network, and the Alternative #2 single channel network). Exact details of channel geometries have not yet been determined at the preliminary design stage, and because these will influence model simulation outcomes LCEP will complete the analysis once these have been defined. At that point, results will be analyzed to compare performance of the preferred multi-channel alternative (Alternative #3) to that of the Existing Condition and also to the single-thread channel concept (Alternative #2), which has been requested.

Details of the sediment sampling survey and grain size analysis, as well as model setup and results for the preliminary Existing Conditions simulations, are included in Attachment C.

2.6 Water Temperature

2.6.1 Overview

LCEP completed a water temperature analysis for the Project Reach to analyze factors contributing to the existing summertime temperature profile and predict how water temperature may respond to various restoration alternatives. We relied on previous temperature studies as well as temperature surveys we completed in July of 2018 and August of 2020. These utilized continuous temperature loggers at several locations in the mainstem and floodplain, as well as a single thermal infrared survey completed for several mile of the East Fork Lewis River mainstem in 2020. We also developed a 2D water temperature model to compare temperature performance of restoration alternatives that were developed for the Ridgefield Pits reach, including the preferred Alternative #3 (three-channel network) and Alternative #2 (single-channel network). This model is an advective/dispersive heat transfer add-on module for the Tuflow FV hydraulic model engine, which includes atmospheric inputs for heat exchange at the air-water interface. The complete water temperature analysis is included as Attachment E to this report. A summary of the findings is presented below.

2.6.2 Results Summary

The following bullets summarize water temperature characteristics for the Project reach during low flow summer conditions when temperatures are of concern, as described in the preceding sections:

- EFLR mainstem temperatures already exceed most water quality standards at the upstream extent of the Project reach near RM 10 at Daybreak Park.
- Further degradation of EFLR temperature through the Project reach is minimal.
- EFLR mainstem temperature exhibits large diurnal variation in summer due to atmospheric heating and cooling. This variation is reduced through the Ridgefield Pits, where the high volume of slow-moving water attenuates heating and cooling effects, resulting in lower daily high and higher daily low temperatures relative to upstream and downstream reaches.
- Much of the spatial variation in temperature observed in the vicinity of the Pits can be attributed to the moderating effect of the Pits reach on atmospheric heating and cooling. Temperature modeling supports this conclusion.
- Some groundwater may currently influence water temperature through the Pits reach, but this appears to be a relatively small influence, at least during the period we monitored.
- Groundwater influence is tied to the water table, which fluctuates based on climate and weather patterns. Thus, influence of groundwater on the EFLR mainstem is likely to vary from year to year. This has been evidenced by LCEP's 2021 water temperature monitoring, which showed considerably less cold water in off-channel and side channel areas relative to 2018.

- Little evidence of mixing is observed between the larger Ridgefield Pits #5 and #7 and the EFLR mainstem despite being hydrologically connected throughout the summer. Model results support this conclusion.
- Several off-channel and side channel areas have been observed to hold cold surface water during the summer, presumably due to groundwater intrusion. Most of these however do not remain hydrologically connected to the EFLR mainstem during most summer flows, limiting their potential as thermal refuge for juvenile salmonids.
- The confluence of Mill and Manley creeks with the EFLR mainstem presents the largest area of current thermal refuge within the Project reach.
- Overall, the highly dynamic nature of the project reach results in a complex and dynamic water temperature profile. Restoration actions should retain and enhance positive aspects of this.

2.6.2.1 Implications for Restoration Alternatives

The following bullets summarize implications of the observed and simulated EFLR temperature performance for the restoration alternatives that have been considered for the Pits reach, relative to each other and the Existing Condition.

Existing Condition:

- Slow moving, large volume of water with reduced diurnal temperature variation relative to upstream and downstream. Lower daily maximum and higher daily minimum temperatures.
- No current riparian shading, and not likely to improve due to large channel widths.
- From a temperature standpoint, the larger pits (#5 and #7) which remain connected to the mainstem during summer do not appear to degrade its temperature. Other negative factors such as habitat for predators must also be considered.

Alternatives #2 and #3, relative to Existing:

- Based on modeling, water temperatures for both Alternatives will likely exhibit the larger diurnal temperature variations currently seen upstream and downstream of the Pits reach. Thus, daily peak temperatures will be higher, and daily minimum temperatures will be lower, relative to the Existing condition.
- Overall water temperature may be reduced relative to the Existing Condition due to an anticipated rise in the groundwater table from proposed grading.
- Extensive riparian planting along channels that are considerably narrower than the Existing Condition should provide extensive shading and reduce solar heating of the reach during the day, potentially reducing diurnal temperature variation.

Alternative #2 versus #3

- Model results indicate slight improvement in temperature performance for the hybrid three-channel network in Alternative 3 versus the single channel in Alternative 2. Despite the greater water depth and smaller width-to-depth ratio exhibited by Alternative 2, the corresponding reduction in heating is offset by a greater overnight cooling effect seen in the shallower, smaller Alternative 3 channels.
- Temperature performance in Alternative 3 was seen to be further enhanced by simulated groundwater inputs, which persist longer and have more influence in the shallower, lower volume multi-thread channels relative to the single channel.
- Due to time constraints, channels for the Alternative 3 design were not optimized for low flow. Further iterations of low-flow geometry may be possible to further enhance its temperature performance.

2.7 VEGETATION AND WETLAND RESOURCES

Valley bottom vegetation consists of a complex mosaic of aquatic, wetland, riparian, and upland species. Most of the valley bottom where active riverine processes (flood inundation, channel migration) are still intact contain native species communities; although non-native species are present throughout, especially in more disturbed areas. Some of the most common native plants are willow, cottonwood, alder, Oregon ash, vine maple, Douglas spirea, red osier dogwood, salmonberry, sword fern, and bigleaf maple. Common non-natives are Himalayan blackberry, reed canary grass, and Japanese knotweed. Clark County continues to invest a lot of resources to combat non-native plants along the floodplain adjacent to the pits.

Most of the valley bottom is comprised of wetlands. The National Wetland inventory shows that nearly the entire project area can be characterized as wetlands, consisting of Freshwater Forested/Shrub Wetlands and Freshwater Emergent Wetlands. A wetlands assessment has not been completed for the project area. The approach to evaluating wetlands and project impacts to wetlands will be coordinated with permitting agencies in later design stages.

2.8 FISH USE- SALMONIDS

In 2001 WDFW produced a report (Project # 99- 1113P) that estimated coho and smolt production from the EF Lewis River above RM 6. Estimates of steelhead production in 2001 included hatchery production (prior to the EF Lewis River becoming a wild steelhead gene bank) included 12,481 wild smolts and 106,836 hatchery smolts. Smolt estimates for other species included: 5,716 coho, 2,060 chum and 1,068 sea-run cutthroat. Spawning data has not been collected by WDFW in the pits area (with the exception of the area above Pit 1) due to avulsion and lack of suitable habitat. Historical accounts of the area where the avulsion occurred suggest that it hosted valuable spawning and rearing habitat due to the availability of spawning gravels and suitable depths and velocities.

As part of the HCP (CM-10) R2 Consultants (2013) collected fish data in the Ridgefield Pits. There was no data collected within the EF Lewis River adjacent to the pits, upstream or downstream of the pits. The survey, which included 23 minnow traps and snorkeling, occurred from July 30-31. The results of the R2 survey showed 500 yearling coho around Pit 2 in an area fed by cooler groundwater. No other juvenile salmon or steelhead were observed.

The Estuary Partnership conducted presence/absence surveys for salmonids during the summers of 2018 and 2019. The data collection was accomplished using two teams and using a snorkel survey approach. Data collection occurred in June and August 2018 and again in August in 2019. The surveys began at Daybreak Park and terminated below the Ridgefield Pits. As part of the June 2018 survey we collected presence/absence data from each of the nine pits. Although the Estuary Partnership methodology was different from the R2 survey, the follow-up survey allowed us to validate R2's findings.

The results from our surveys show juvenile fish present in almost every section of the river throughout the project reach. Figure 11 shows results from the June 2018 survey, which includes salmon and steelhead observed within the project area from RM 7.5- 10. Locations of the juvenile fish shown in Figure 11 are approximate. Juveniles that were found included yearling and sub-yearling steelhead, coho and Chinook. Several adult steelhead were also observed (not shown). The juveniles were often found clustered (particularly coho and Chinook) in and around structure (wood), in areas that had cooler water and in tail-outs (primarily steelhead). In the June 2018 survey several of the pits (8 and 9) contained much cooler water and 360 juveniles were found in Pit 8. The 550 fish that were found around Pits 1 and 2 compare favorably to R2's findings and suggest that this is an important area for juveniles. Juvenile salmon and steelhead were also found in and around Pits 1, 2, 8 and 9. In the other pits, and in the river where depths were greater than several feet, warm water species were frequently observed.

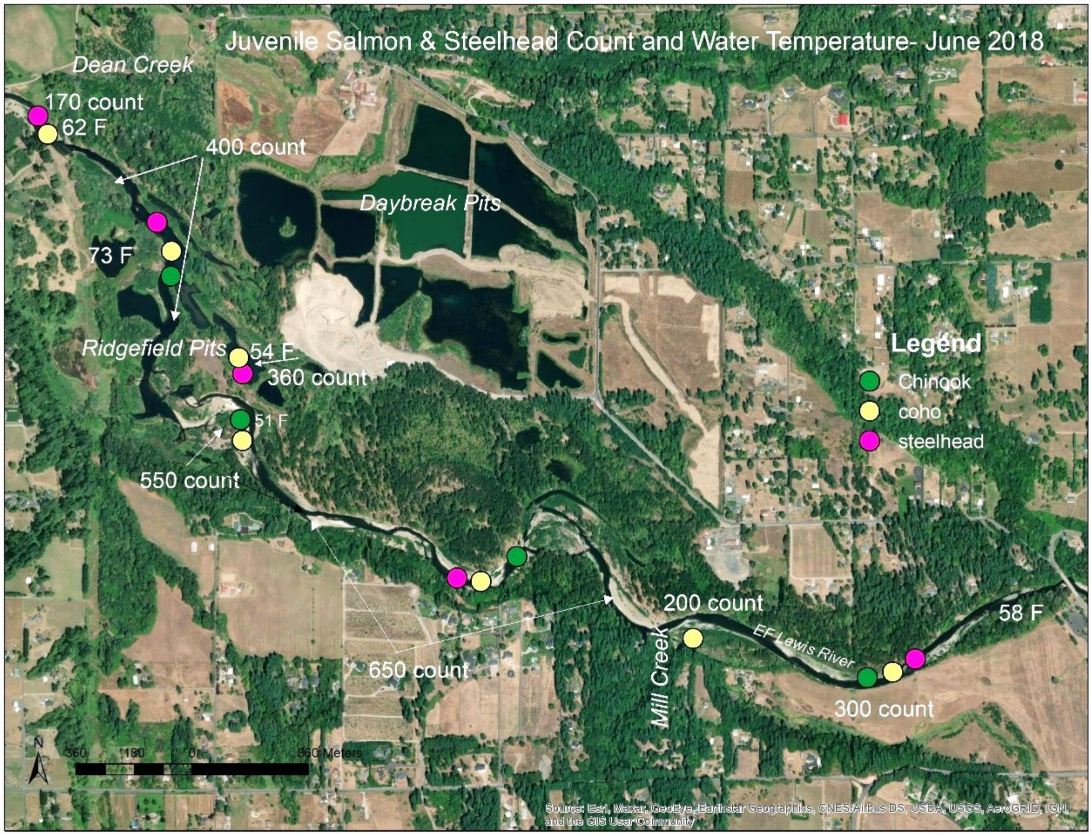

Figure 11. Count estimates for salmon and steelhead and temperature observations based on 2018 snorkel survey. Flow is from right to left.

3 Evaluation of Restoration Alternatives

3.1 Summary of Restoration Alternatives

The goals and objectives were presented to the TOG. The TOG reviewed and commented on the goals and objectives, which provided the foundation for the restoration alternatives. The restoration alternatives and the analysis is summarized in the Restoration Alternatives Analysis report (Attachment 6), which includes concept-level sketches of each alternative. The alternatives analysis involved the development and evaluation of 6 alternatives, including a No Action alternative. Not all of the alternatives were mutually exclusive, allowing for the selection of “a la carte” items that could be grouped together. The restoration alternatives evaluated are listed below:

- Alt. 1 – No action- passive recovery of Ridgefield Pits
- Alt. 2 – Relocate main channel EF Lewis River into pre-avulsion channel (single-thread)
- Alt. 3 – Full Ridgefield Pits re-grade and multi-thread channel network
- Alt. 4 – Side-channel enhancements at upper and lower sites
- Alt. 5 – Mill/Manley Cr. confluence improvements
- Alt. 6 – Mill/Manley Cr. channel migration expansion

Each alternative was evaluated with respect to how well it would be expected to achieve the project goals and objectives. This resulted in the following ordering (most to least) of how well each alternative achieved this: Alternative 3, Alternative 4, Alternative 6, Alternative 2, Alternative 5, Alternative 1.

3.2 Selection of the Preferred Alternative

The Alternatives Analysis was completed in July 2020 and was distributed to the TOG members for their input. A follow-up meeting was held on November 4, 2020 to review and discuss the alternatives and to summarize and review the TOG input. Based on input on the report, discussions at the November 2020 meeting, and multiple follow-up discussions between LCEP and TOG members, further design refinement and analysis was performed. This work was primarily to address suggested edits to Alternative 3 and to further explore a single-thread alternative similar to Alternative 2. Based on this additional analysis, andin consideration of the TOG input and the best approach for accomplishing the project objectives, the following suite of actions were selected to move forward to Preliminary Design:

- Modified Alternative 3 – Full pits re-grade with modifications to reduce the number of channels, reduce grading at the upstream end of the reach were the delta has formed, and to better optimize grading to achieve an approximate cut-fill balance on the site.
- Modified Alternative 4/6 – This includes the side channel enhancements of Alternative 4 plus a partial removal of the levee identified in Alternative 6.

LCEP convened a meeting with the TOG in March 2021 to present the preferred Alternatives described above and the related analyses that were completed. During this time, it was requested that LCEP further explore the single-thread channel concept that was originally defined as Alternative 2. Because this alternative did not score well based on initial feedback from the TOG, LCEP did not do a comprehensive analysis of it prior to the March meeting. At that time some members expressed concern about Alternative 3, primarily related to the water temperature performance of its multi-thread network during low water conditions in the summer, and they suggested that the single channel would remain deeper, thereby reducing potential heating impacts from solar exposure. LCEP agreed to run additional hydraulic, sediment and temperature analysis for Alternative 2. Due to budget and time considerations, LCEP was only able to complete the water temperature assessment in time for this report. Being the main concern, this was prioritized. The full hydraulic and sediment analysis will be completed before final design development commences in winter of 2022. If at that time the analysis suggests that Alternative 2 is a better approach, modifications will be made to the design accordingly.

Table 2 below provides a summary comparison of Alternatives 2, 3, and the Existing Condition, based on all analyses done to date. These include quantitative modeling results as well as qualitative knowledge gained through the Technical Oversight Group process and other data analysis. It should be noted that the Alternative 2 used for comparison assumes a specific set of parameters that were provided by the members who requested the additional analysis. Some of these may differ slightly from the original concept that was presented for consideration early on in the restoration alternatives process. The differences are outlined in Table 2.

Table 2. restoration alternatives comparison matrix for Alt. 1 (Existing Condition), Alt. 2 (single-thread channel), and Alt. 3 (multi-thread channel network).

Performance Factor	Comparison
Channel Stability/Avulsion Risk	The Existing Condition presents no avulsion risk as it has already occurred. Changes in planform are still occurring as the channel continues to adjust to the 1996 avulsion. Alt. 2 would provide channel stability through levees that would be required to fix the channel in place to prevent an avulsion risk into the existing Ridgefield Pits that would not be filled as part of this alternative. Risk of this avulsion occurring would not be eliminated however, as the levees are proposed to overtop flows that are just at or above the 1-year flood magnitude. Alt. 3 by design would have limited channel stability. No levees are included, which would allow channel migration through a reduced (relative to historical) floodplain extent, thereby restoring the dynamic channel network that was characteristic of this reach prior to anthropogenic influence, based on observations of early maps. This is a desired outcome based on feedback throughout the Technical Oversight Group process.
Constructability	Alt. 3 would require the most movement of material because it would fill the Ridgefield Pits. To minimize cost then, its grading plan must be carefully considered, and a significant level of effort went into this during preliminary design. Alt. 2 would be more straightforward since it would not fill the Pits.
Hydraulics	LCEP has not completed this analysis to date. A primary difference between Alts. 2 & 3 is that Alt. 2 is designed with a much lower bankfull elevation relative to Alt. 2 (~2,300 cfs versus ~5300 cfs). We believe that this would provide an overall habitat benefit by allowing greater magnitude and duration of floodplain inundation. Shear stresses would also be reduced at intermediate level flows however it remains to be seen as to whether or not this would have significant implications.
Sediment Conveyance	Channel width to depth ratios would be similar for Alts. 2 & 3, at bankfull conditions. Channel slope is uniform through the Reach for Alt 2, while slope is higher at the upstream end of the reach and lower downstream for the Alt. 3 channels. This is due to the grading required to optimize the cut-fill balance (thereby reducing cost and material requirements associated with filling the Pits) for Alt. 3. LCEP has not completed the analysis to date on what impact the differences in channel slope and geometries would potentially have on sediment conveyance through the reach.
Water Temperature	Complete analysis can be found in the Water Temperature attachment. In summary, both alternatives will likely result in a larger diurnal temperature variation (higher daily maximum temperatures and lower daily minimum temperatures) through the Ridgefield Pits reach than what is currently seen for the Existing Condition. This is because the current high volume and depth of water currently in this slow-moving reach acts to moderate atmospheric heating effects. However, overall mean temperatures may be reduced for the alternatives through groundwater interaction, which currently seems to exhibit minor impact on the large volume of water in this reach. The effects from groundwater would likely be more beneficial for Alt. 3 versus Alt. 2 for two reasons: 1) the multi-thread channel provides more spatial opportunity for interaction; and 2) lower channel volumes in Alt. 3 would result in less dilution. Model results indicate that Alt. 2 does not perform better than Alt 3. with respect to atmospheric heating. In fact, Alt. 3 temperature performance was observed to be better, because the nighttime cooling effect on its respective lower channel volumes exerted a greater effect than daytime heating, which occurs over shorter period. In short, Alt. 3 was shown to have better temperature performance than Alt. 2 from both a groundwater and atmospheric heating perspective, and this was true at the lowest flow modeled (35 cfs). Finally, from a riparian perspective the narrower channels of Alt. 3 may provide improved shade benefits relative to the wider Alt. 2 channel.

4 Description of Preliminary Design

4.1 Design Objectives and Constraints

Design objectives are included below nested under the corresponding goals. These were developed as part of the alternatives analysis process. More information, and additional documentation, is provided in the Restoration Alternatives Analysis report. These design objectives have served as design criteria to guide the development of the Preliminary Designs.

Goal 1. Restore native vegetation communities.

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.

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 9of 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.

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) 75th 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.

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 6times the active channel width.
4c. Achieve overbank flows and significant floodplain inundation that occurs annually for at least1 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.

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.

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.

There are several potential constraints in the project area. These include limitations to the extent of potential channel, floodplain and channel migration zone restoration that can occur at the site. The project area is assumed to be limited by a hard boundary on the river-right side due to the floodplain encroachment starting with the County maintenance yard, then along NE Storedahl Pit Road, the Daybreak Pits processing area, and the downstream-most Daybreak Pit. These constraints limit the ability to restore full channel migration and floodplain inundation to these areas and are not being considered as part of the project area at this time. Another likely constraint to full restoration is the BPA transmission lines and towers at the downstream end of the site and in the river-left floodplain. At the upstream end of the project site, there is bluff erosion on river-left downstream of the Mill Creek confluence. This high bluff erosion is currently threatening a residence, which has already been affected by the erosion. This risk limits the ability to significantly affect channel dynamics in this area. River recreational use is another potential constraint, which could affect the size, location, and configuration of instream log structures. And lastly, the large deficit of coarse riverbed and floodplain material created by the mining of the Ridgefield Pits limits the ability to recover this area to full floodplain connectivity.

4.2 Design Components

The Preliminary Design includes three main components: 1) the Ridgefield Pits, 2) the downstream side-channel, which is located just upstream of the Pits, and 3) the upstream side-channel, which is located just upstream of the downstream side-channel and across the river from the Mill-Manley confluence area.

4.2.1 Ridgefield Pits

At the Ridgefield Pits, the design includes re-grading most of the former gravel mining ponds to create a multi-threaded channel network that is well-connected to an extensive floodplain wetland complex. The objectives/design criteria (Section 4.1) provided the guidelines from which design iterations and decisions were made. In order to accomplish objectives 3d, 3e, and 3f, a 3-channel network was developed with connected alcoves strategically located in existing pond areas. The river-right alcove is located within Pond 9, a known cold-water source from temperature monitoring. In order to accomplish the floodplain connectivity objective (4c), channels were designed to overtop at approximately 2,600 cfs, which is the 10% exceedance flow (flow that is exceeded approximately 10% of the time on average; this equates to channel bank overtopping for a little over one month per year, on average. This resulted in the 3 channels each having a top width of from 60-75 feet and total depths of approximately 6 feet.

A primary feasibility consideration is to achieve an approximate cut-fill balance on the site, in order to avoid the potentially very high cost of importing streambed and floodplain material. Because of the past mining activity that removed over 1 million cubic yards of alluvial material, this will result in a designed floodplain surface that is lower in elevation than the historical floodplain surface, and lower than the floodplain surfaces upstream and downstream of the site. In addition to achieving an on-site cut-fill balance, this configuration also helps to achieve other objectives and constraints, including well-connected floodplains to support native vegetation (1a), small channel width-to-depth ratios to benefit temperature and shading (2b, 2c), presence of off-channel habitat (3f, 3g), greater channel migration zone and floodplain connectivity (4b, 4c), and maintaining depositional conditions (5a). The lower floodplain surface also allows for creating frequent floodplain inundation within the project area while avoiding an increase in flooding to adjacent areas outside the project area that could present a risk to infrastructure or habitat (6a, 6b).

In order to develop the channel and floodplain grading plan, the existing conditions DTM was modified to create a proposed conditions DTM. The proposed conditions DTM was then used in the hydraulic model to evaluate the effects on inundation extents and hydraulic conditions. This was done via an iterative process of repeat DTM refinement and modeling to optimize proposed conditions. For this Preliminary Design stage, the grading plan was developed to a level of detail that confirmed that achieving the objectives and satisfying constraints is possible. It is anticipated that the channel and floodplain geometry will continue to be refined in subsequent design stages. Channel details including pools, riffles, asymmetrical cross-section geometry, and profile complexity have also not been incorporated at this stage, nor has microtopography throughout the floodplain wetland complex to support a range of wetland types and vegetation communities. These details will be added in subsequent design stages.

In addition to the channel and floodplain re-grading, a variety of large wood additions are planned for the channels, alcoves, and floodplain areas. The large wood habitat is designed to primarily accomplish the large wood objective (3c), but will also help support other objectives including pool frequency (3b), high flow refuge (3f), and substrate deposition (5a) and patchiness (5c). Instream wood placements include a variety of wood structure types. These include 1) bar apex log jams at flow splits to support split flow and maintain island vegetation, 2) jams in pools to support pool scour and provide cover, 3) channel-spanning jams in smaller channels or off-channel areas to support sediment deposition and initiate planform changes, 4) general complexity jams to provide juvenile hiding cover and complexity throughout, and 4) floodplain roughness structures that provide hydraulic roughness and high flow refuge habitat throughout the floodplain. Overall, a very high density of in-channel and floodplain wood placements will be necessary to provide hydraulic roughness that will be necessary to support depositional processes, erosion control, and vegetation growth, especially in the first few years immediately following construction due to exposed soils and young vegetation.

Planting of native wetland, riparian, and floodplain vegetation will occur throughout the project site following construction. This will include a patchwork mosaic of species assemblages selected based on the range of elevations, soil conditions, and inundation frequencies. Two primary planting zones have been identified for the preliminary design. These include: 1) a riparian buffer zone, which extends approximately 25 feet from either side of the channels and will primarily include planting of willow and cottonwood live stakes, and 2) a floodplain wetlands zone that includes the remainder of the site and will consist of a wide range of native species found throughout undisturbed portions of the site and listed in the design plans. These will likely be bare root seedlings. Planting plan details including proportions of each species, type of planting stock, browse control, and any irrigation or maintenance needs will be determined in later design stages.

4.2.2 Lower Side-Channel

Enhancements at the lower side-channel include large wood habitat additions and beaver dam analogs. At the upstream end of the side-channel there are multiple entry points. Apex log jams will be placed at these entrances in order to encourage scour and split flow conditions into the side channel. Various log jam types will be placed throughout the side channel. These are the same as the log jam types described above for the Ridgefield Pits site, with the exception of floodplain roughness, which is not necessary due to the already heavily vegetated floodplain. In addition, we anticipate that some riparian trees will be felled into the side-channels, mostly pushed over by machinery to retain the rootwad. This action provides high complexity habitat of whole trees and can also be used to help facilitate access routes.

At the lower end of the side-channel, beaver dam analogs will be installed. These will be post-supported structures racked with small wood and slash. These will be designed to provide immediate functions of off-channel habitat, sediment deposition, vegetation growth, and increasing groundwater tables, but are also anticipated to support additional beaver activity.

At this preliminary design stage, no excavation work is planned in the side-channels to increase hydrologic connectivity. However, this will be re-visited in later design stages and will also partly depend on the eventual channel configuration and degree of connectivity as the main channel connections and the side-channels continue to naturally adjust.

4.2.3 Upstream Side-Channel (Mill-Manley Confluence Area)

Enhancement work in the upstream side-channel will include the same work as described above for the lower side-channel, including habitat wood placements and beaver dam analogs. In addition, the push up levee adjacent to the County maintenance yard will be modified. This levee currently abuts the maintenance yard on its south side and extends westward into the floodplain. Two older, partially in-filled former gravel pits are located to the north of the western half of the levee. This western half of the levee will be removed to increase floodplain connectivity through this area. The eastern portion of the levee (and armoring) will remain where it may be serving to provide some protection to the maintenance yard. The material from the removed portion of the levee could potentially be used to further fill the two former gravel ponds to the north, configured in a way to increase the function of these wetland areas. The material could also be hauled downstream to provide coarse material to the Ridgefield Pits site. The planfor the material will be further refined and developed as part of later design stages.

4.3 Summary of Ecological Benefits

This project will provide a range of aquatic habitat and river process benefits. The primary benefit will be addressing the currently severely degraded conditions in the Ridgefield Pits reach. This work will immediately improve aquatic habitat and floodplain connectivity at the site and will re-set the geomorphic trajectory to support future channel dynamics, stream temperature improvements, establishment of native vegetation, and continued deposition of streambed material to re-build the channel and floodplain elevations lost due to gravel mining. The Alternatives Analysis (Attachment F) identified the degree to which alternatives help to achieve the project goals and objectives. Although somewhat modified since the Alternatives Analysis, the Preliminary Design for the Ridgefield Pits will have essentially the same ecological benefits as Alternative 3. Of the 23 objectives identified, Alternative 3 is expected to “very much” accomplish 19 of them, “very much” to “somewhat” accomplish 3 of them, and “somewhat” accomplish one of them. The one that it only “somewhat” accomplishes is not an ecological objective but a social one – the consideration of river recreational users. This is because the multi-thread channel and high large wood loading may provide challenges for recreational boaters at some flows, a consideration that will need to be factored into the design.

The ecological benefits of the side-channel work include increased habitat complexity and floodplain connectivity. In the Alternatives Analysis, of the 23 objectives, the side-channel alternative “very much” accomplishes 10 of them, “very much” to “somewhat” accomplishes 7 of them, “somewhat” accomplishes 4 of them, and “somewhat” to “does not” accomplish 2 of them. The objectives it only somewhat accomplishes are ones that the side-channel work simply would not have a significant impact on, including sinuosity, sediment deposition, substrate type, and confinement. One of the two lower ranked objectives relates to the removal of hydromodifications; however, the levee removal work was added to this alternative after the alternatives analysis, so it does provide some benefits there. The other lower ranked objective relates to avoiding an avulsion into the Daybreak Pits, which this alternative doesn’t affect one way or the other.

4.4 Construction Considerations

Preliminary considerations have been developed for project construction methods, sequencing, and phasing. Construction methods will be further analyzed as part of later design stages, and will also be affected by the approach taken by the construction contractor. River channel conditions at the time of construction, which are likely to change between now and then, will also affect construction methods. Preliminary access and staging areas have been indicated on the design drawings; however, discussions with landowners and additional site investigation and planning will be necessary to refine those areas.

The greatest construction challenge will be the re-grading of the Ridgefield Pits reach and the construction of the multi-thread channel system, especially with respect to management of water. Management of water will be necessary to facilitate construction and to limit impacts to meet environmental permit requirements. We anticipate that the re-grading of the site will occur using a multi-part work isolation strategy, where river flow is routed to one side of the site to facilitate construction of the other side. Based on the current location of the main channel through the pits, the sequence would likely entail using cofferdams and pumping to isolate and facilitate the construction of the river-right portion of the site first, then re-routing the main channel flow into the newly constructed portion, and again using cofferdams and pumping to facilitate completion of the river-left portion. However, multiple shifting of the main channel flow may be required. We also anticipate that full dewatering will not be possible due to subsurface seepage but that pumping will nevertheless be needed to reduce water levels in active construction areas and to manage turbidity. The use of sheet pile, turbidity curtains, and long pumping distances to land-apply construction water may be necessary.

Construction of the side-channel enhancements is straightforward. Wood additions and construction of BDAs in these areas will be conducted at low flow periods when the side channels are either dry or have very little flow that can easily be managed to facilitate construction and limit environmental impacts. Management of water for the side-channel work will occur via localized cofferdams and pumping, if necessary. In order to limit impacts to the existing riparian and floodplain vegetation along the side-channels, we anticipate using “inside-out” construction where possible, which includes using the channel itself to access the areas for large wood additions. This will only occur in side-channel areas that are dry during construction and will be limited to areas where existing large wood or other habitat conditions in the side-channels would not be significantly impacted by machinery.

In-water work will need to occur during the permitted in-water construction window. This is listed as August 1 – 15 by WDFW. Because this effort will take considerably longer than 2 weeks, it will be necessary to work closely with WDFW and project designers to develop a sequencing plan that works for the permitting agencies and the project. This will likely entail a worksite isolation strategy that allows for significant portions of the project re-grading to occur in isolation from the main channel flow outside of the work window period. It is also possible that all of the work for the project will not be able to occur in one construction season, and that the project will need to be phased over multiple years.

4.5 Opinion of Probable Construction Cost

Opinion of Probable Construction Costs - Preliminary Design				
Lower East Fork Lewis River - Ridgefield Pits Restoration Project				
28-Jun-21				
Note: Costs do not include permitting, final design, fish management/rescue during construction, construction staking, or construction oversight				
ITEM	**UNIT**	**UNIT PRICE**	**QUANTITY**	**SUBTOTAL**
Primary Construction Elements				
Channel and floodplain grading (includes cut and fill)	CY	$ 6	450,000	$2,700,000
Channel shaping and detail work	LF	$ 15	12000	$180,000
Remove/push in levee near County maintenance yard	CY	$ 10	3000	$30,000
Furnish and install logs with rootwads	EA	$ 1,500	526	$789,000
Furnish and install logs without rootwads	EA	$ 1,000	479	$479,000
Furnish and install vertical snags/pilings	EA	$ 800	581	$464,800
Whole trees from on-site	EA	$ 300	85	$25,500
Slash incorporated into jams (haul from off-site)	CY	$ 40	1490	$59,600
Fell riparian trees	EA	$ 500	45	$22,500
Furnish materials and install beaver dam analogs	EA	$ 4,000	9	$36,000
Subtotal				**$4,786,400**
Site Prep, Access, and Environmental Controls				
Environmental controls (SWPPP, hydraulic fluids, erosion control measures, etc.)	LS (2.5%)	$ 119,660	1	$119,660
Temporary access and haul roads (includes temporary culvert and/or bridge crossings)	LS (3%)	$ 143,592	1	$143,592
Cofferdams, diversions, dewatering and water management	LS (6%)	$ 287,184	1	$287,184
Subtotal				**$550,436**
Revegetation				
Seeding and planting - channel banks	AC	$ 5,000	19	$95,000
Seeding and planting - floodplain	AC	$ 3,000	83	$249,000
Subtotal				**$344,000**
Mobilization and demobilization	LS (7%)	$ 397,659	1	**$397,659**
Construction Subtotal				**$6,078,495**
Construction Subtotal with 25% Contingency				***$7,598,118***

Abbreviations: CY = Cubic yard LF = Lineal foot AC = Acre EA= Each

5 Attachments

A. Topographic Survey- Technical Memorandum

(BLANK)

B. Geomorphic Conditions- Technical Memorandum

(BLANK)

C. Hydraulic Modeling

(BLANK)

D. Sediment Sampling

(BLANK)

E. Water Temperature Modeling

(BLANK)

F. Restoration Alternatives Analysis- Memorandum

(BLANK)

G. Technical Oversite Group Written Comments Restoration Alternatives

(BLANK)

H. Preliminary Design Drawings

(BLANK)