Buffalo Flats Project: Little Creek

Design report

Little Creek, Oregon

Columbia Pacific Northwest Region

Mission Statements

The Department of the Interior (DOI) conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Cover Photo: Little Creek existing channel, looking upstream, August 2020.

Acronyms and Abbreviations

Acronym or Abbreviation	Definition
BiOp	Biological Opinion
BPA	Bonneville Power Administration
BPLL	Buffalo Peak Land and Livestock Company
BSR	Biologically Significant Reach
°C	Degrees Celsius
cfs	Cubic Feet Per Second
CRITFC	Columbia River Inter-Tribal Fish Commission
DEQ	Oregon Department of Environmental Quality
DOI	Department of the Interior
ESA	Endangered Species Act
FCRPS	Federal Columbia River Power System
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
GRMW	Grande Ronde Model Watershed
HAWS	Height Above Water Surface
HIP	Habitat Improvement Program
HMI	Holistic Management International
HUD	Department of Housing and Urban Development
LiDAR	Light Detection and Ranging
LWD	Large Woody Debris
m^2	Square Mters
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
ODFW	Oregon Department of Fish and Wildlife
ODOT	Oregon Department of Transportation
OTEC	Oregon Trail Electric Co-Op
OWRD	Oregon Water Resources Department

Acronym or Abbreviation	Definition
POD	Point of Diversion
Reclamation	Bureau of Reclamation
REM	Relative Elevation Modeling
RM	River Mile
RPA	Reasonable and Prudent Alternative
TAC	Technical Advisory Committee
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USWCD	Union Soil and Water Conservation District

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Executive Summary

The United States Bureau of Reclamation is working with Union Soil and Water Conservation District and project partners to design a fish habitat enhancement project at the Buffalo Flats project area, located immediately upstream of the City of Union, Oregon on Little Creek. The project area is 268-acres in size, and is a portion of the larger 628-acre cattle ranch owned by Buffalo Peak Land and Livestock Company. Goals for the project include restoring historical creek and floodplain processes of Little Creek to maximize salmonid habitat benefits and ecological function in collaboration with private agricultural landowners. Little Creek within the project area has been adversely affected by historical modifications associated with transportation infrastructure and land use. The channel has been straightened, leading to floodplain disconnection and reduced in-stream complexity. Project alternatives were developed to improve instream habitat and floodplain connectivity while working within constraints imposed by land use within the project area.

This report describes preliminary designs and follows the BPA HIP format. Future design phases will further refine the designs as described here. Several additional documents have been developed to support design rationale, and include: *Buffalo Flats Project Alternatives Analysis* (Reclamation 2020), *Buffalo Flats Existing Conditions Hydraulic Modeling* Report (Reclamation 2020), *Buffalo Flats 30% Hydraulic Modeling Report* (Reclamation 2022), *Buffalo Flats Revegetation Technical Memorandum* (Inter-Fluve 2022), *Buffalo Flats Wetland Delineation* (Inter-Fluve 2022). Further, a 30% design planset (December 31 2022) accompanies this Basis of Design Report.

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1 Project Background

The United States Bureau of Reclamation (Reclamation) is working with Union Soil and Water Conservation District (USWCD) and project partners to design a fish habitat enhancement project at the Buffalo Flats project area, located immediately upstream of the City of Union, Oregon on Little Creek (Figure 1). The project area is 268-acres in size, and is a portion of the larger 628-acre cattle ranch owned by Buffalo Peak Land and Livestock Company. River channels and floodplains within the project area have been negatively impacted by historical modifications associated with infrastructure and land use. Designs have been developed that enhance in-stream and floodplain habitats for ESA-listed Snake River spring Chinook (*Oncorhynchus tshawytscha,* threatened), steelhead (*Oncorhynchus mykiss,* threatened), and bull trout (*Salvelinus confluentus,* threatened).

Project goals are stated as:

1. Enhance and restore aquatic habitat conditions and increase habitat diversity and complexity for salmonids;
2. Improve water quality conditions (temperature and sediment) for salmonids;
3. Promote conditions for restoring ecological function and improving soil health within the project area;
4. Improve riparian corridor and floodplain vegetative diversity and function within the project area;
5. Reconnect Little Creek with the associated floodplains and expand quality floodplain habitat availability for salmonids within the project boundaries;
6. Increase streambank and floodplain storage of water and ice; thereby, increasing the potential for attenuating flows, and reducing ice formation within the project reach.

The Catherine Creek Subbasin, which includes Little Creek has benefited from extensive planning processes to prioritize habitat enhancement actions for listed species. Documents published in support of restoration planning include the following:

- *The Grande Ronde Subbasin Plan* (Nowak and Kuchenbecker, 2004)
- *Catherine Creek Tributary Assessment* (Reclamation 2012)
- *The Catherine Creek Reach Assessment* (Reclamation 2012)
- *Catherine Creek Atlas*.

The *Catherine Creek Atlas* was developed by BPA in collaboration with local implementation partners in the Grande Ronde Subbasin to create a strategic, prioritization tool for fish habitat restoration. The Atlas utilizes existing scientific data, current research evidence, and local biological knowledge to define the limiting factors for ESA-listed fish, identify opportunities for improvements, and to prioritize reaches for improvement opportunities. The Buffalo Flats project area includes a reach of Catherine Creek that was ranked as having the highest potential for salmonid uplift (tier 1). While the tributaries of Catherine Creek were not evaluated as extensively in the Atlas process, Little Creek is currently being evaluated by the Grande Ronde Model Watershed Implementation Team (Atlas IT) in the context of how it may support habitat goals as a tributary to Catherine Creek within this important reach.

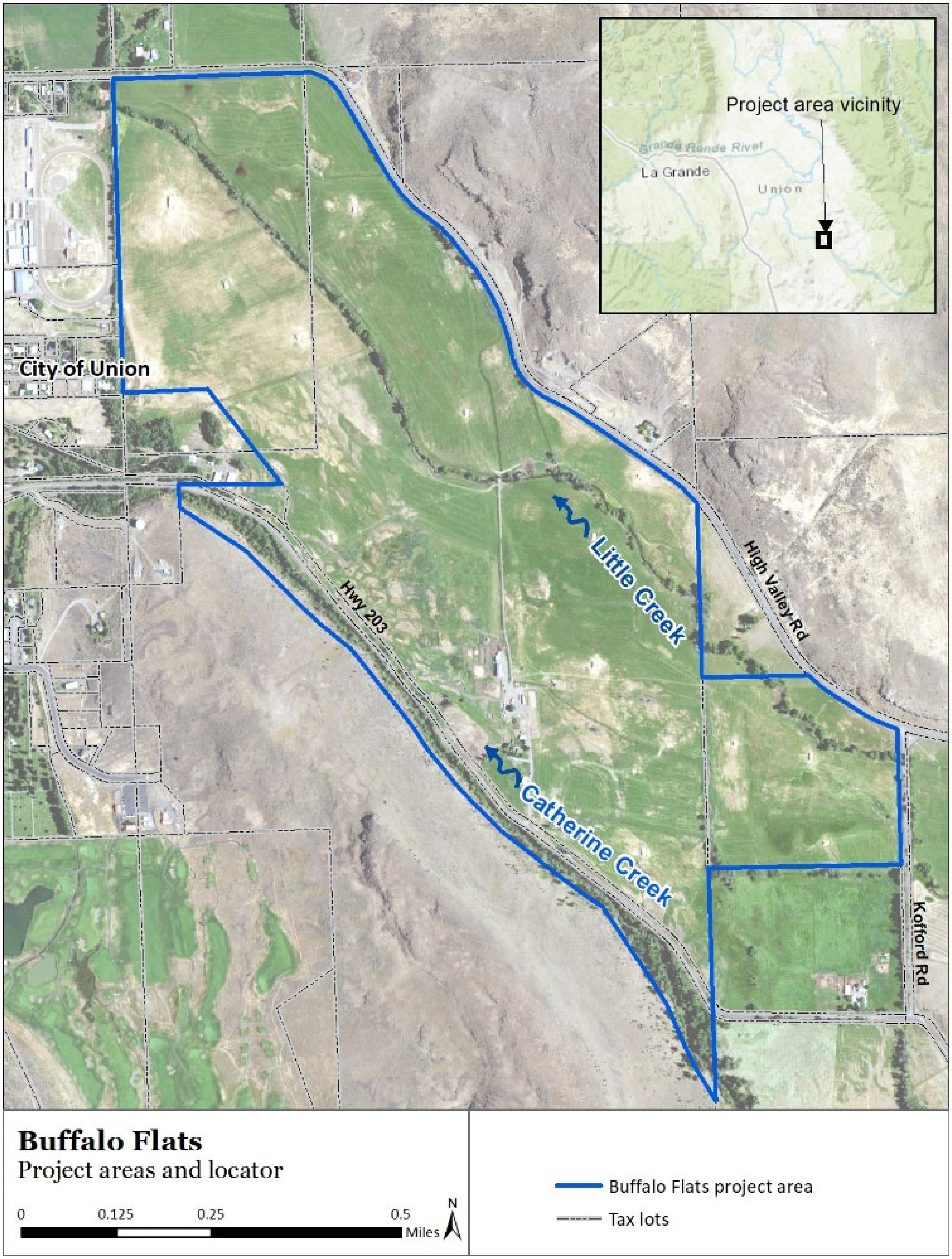


Figure 1. Buffalo Flats project area locator map, showing the project area boundary and Little Creek.

1.1 Name and Titles of Sponsor, Firms, and Individuals Responsible for Design

The project is sponsored by Union Soil and Water Conservation District (USWCD). US Bureau of Reclamation (Reclamation) is providing technical support and funding for design. Inter-Fluve, Inc. is the engineering design firm. Key individuals that are part of the design team are listed in Table 1.

Table 1. Design team members

Name, Title	**Organization**	**Role in this project**	**Contact**
Jim Webster, District Manager	Union Soil and Water Conservation District	Sponsor	jwebster@unionswcd.org
Aaron Bliesner, Project Manager	Union Soil and Water Conservation District	Sponsor	abliesner@unionswcd.org
Brandon Barrow*, Project Manager	US Bureau of Reclamation	Project Manager, Reclamation	bbarrow@usbr.gov
Kira Christensen, Civil Engineer	US Bureau of Reclamation	Project Manager, Reclamation	kchristensen@usbr.gov
Michael Knutson, PE, Hydraulic Engineer	US Bureau of Reclamation	Technical Lead	mknutson@usbr.gov
Matt Cox, PE, Hydraulic Engineer	Inter-Fluve	Engineer of Record	mcox@interfluve.com
Peter Benchetler, PE Hydraulic Engineer	Inter-Fluve	Staff Engineer, Modeling Lead	pbenchetler@interfluve.com
Caitlin Alcott, CE Ecologist	Inter-Fluve	Project Manager, Inter-Fluve	calcott@interfluve.com
Joe Parzych, CFS	Inter-Fluve	Wetland Delineation, Permit Support	

*In September 2022 the role of Reclamation Project Manager shifted from Brandon Barrow to Kira Christensen. Kira has been involved in previous iterations of the Buffalo Flats project.

1.1.1 Coordination with BPA and other Stakeholders

In addition to the design team listed above, BPA, landowners, and other stakeholders have been involved in the design effort thus far, including those listed in Table 2.

Table 2. Additional Stakeholders

Name, Title	**Organization**	**Role in this project**	**Contact**

Thomas Delorenzo, Environmental Protection Specialist	Bonneville Power Administration	Environmental Compliance Lead	tdelorenzo@bpa.gov
Sean Welch, PE Tributary Habitat Policy Lead	Bonneville Power Administration	BPA Technical Lead	spwelch@bpa.gov
Andrea Malmberg	Buffalo Peak Land and Livestock Company	Landowner	andrea@lifeenergy.guide
Tony Malmberg	Buffalo Peak Land and Livestock Company	Landowner	tony@holisticmanagement.guide
Richard Fitzgerald	Oregon Dept of State Lands	Aquatic Resource Coordinator	Richard.W.FITZGERALD@dsl.oregon.gov
Jesse Steele, Executive Director	Grande Ronde Model Watershed	Advisor	jesse@grmw.org
Allen Childs	Confederated Tribes of the Umatilla Indian Reservation	Advisor	allenchilds@ctuir.org

1.2 List of Project Elements that have been Designed by a Licensed Professional Engineer

This Basis of Design report describes the preliminary (30%) level of the preferred alternative identified by the design team. The following proposed project elements are anticipated to be designed by a licensed professional engineer in future design phases. This table uses BPA FY2021 HIP Handbook (BPA 2019).

Description of proposed element	Work element name	HIP category	HIP risk level (estimated)
Grade multi-thread channel and swale network to mimic historical conditions at this site, including increased length, sinuosity, and floodplain connection	Improve secondary channel and floodplain interactions Channel reconstruction	2a, 2f	Medium or high
Install constructed riffles	Headcut and grade stabilization	1c	Medium
Instream habitat wood (likely small trees and/or willow post structures)	Install habitat-forming instream structures	2d	Medium
Riparian and wetland planting	Riparian vegetation planting	2e	Low
Remove existing farm crossing and associated culvert	Bridge and culvert removal or replacement	1f	Medium
Relocate irrigation diversion (state ditch) if needed.	Consolidate or replace existing irrigation diversions	1b	Low

1.3 Identification and Description of Risk to Infrastructure or Existing Resources

Existing infrastructure and resources within the project site include a homesite owned by the participating landowners, an adjacent homesite, ranching infrastructure including existing irrigation and diversion ditches, a primary channel crossing, as well as functioning pasture being used for an active ranching business. The area has been noted for potential cultural resources as well and an initial pedestrian survey was completed by Reclamation. Future cultural resources investigations are anticipated to be coordinated with BPA.

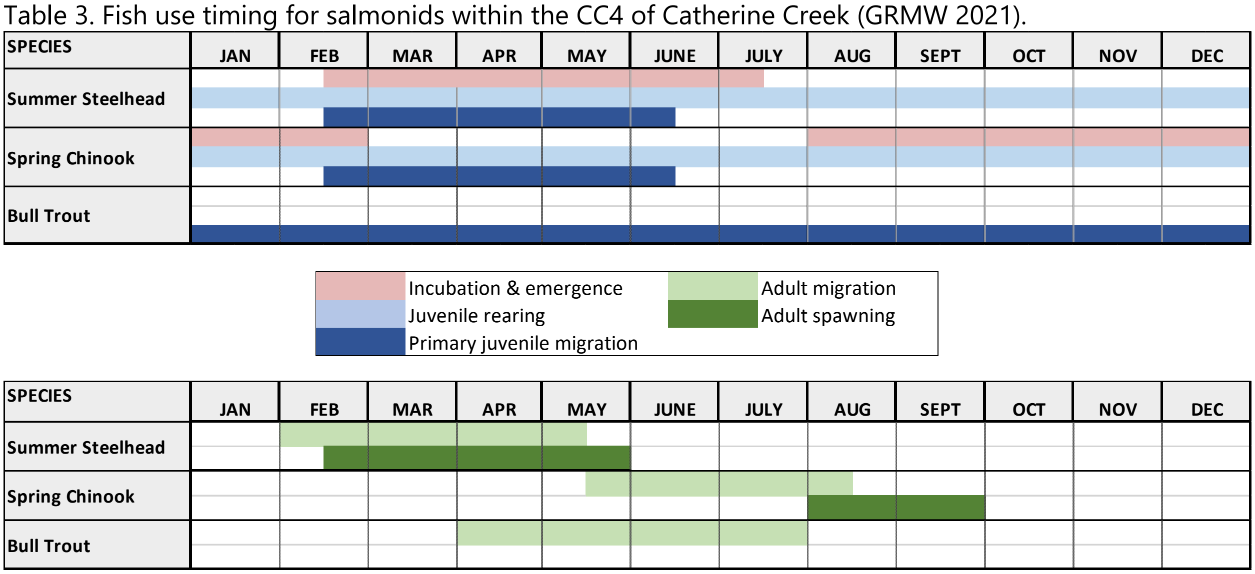
Adjacent infrastructure and resources include the Swackhammer irrigation ditch that is piped across Little Creek at the downstream project boundary, and High Valley Road which runs along the north edge of the property. To gauge potential impacts to these resources, hydraulic modeling was completed early in the design process (at conceptual designs) and has continued throughout the preliminary design. Future design phases will include further refining the hydraulic modeling, and direct coordination with FEMA.

1.4 Explanation and background on fisheries use (by life stage – period) and limiting factors addressed by project

The project area is known to provide habitat for ESA-listed Chinook Salmon (threatened), steelhead (threatened), and bull trout (threatened) at various life stages (Table 3). In 1992, Chinook were listed as threatened under the Endangered Species Act and in 1996 steelhead were also listed as threatened. Habitat degradation in headwater streams has been identified as the significant source of these population declines.

The Little Creek project area is located in the CC2C reach as mapped in the Grande Ronde Atlas. The CC2C reach also includes sections of Lower Catherine Creek, and the Grande Ronde River mainstem near the Catherine Creek confluence. Therefore, salmonid life history timing in Little Creek is believed to be more similar to timing observed in the nearby CC4 reach mapped in Atlas. Timing for CC4 is shown below in Table 3. Note that neither spring Chinook spawning nor emergence have been documented in Little Creek, and the timing is included here because project actions have the potential to improve spawning conditions for these fish.

Table 3. Fish use timing for salmonids within the CC4 of Catherine Creek (GRMW 2021).



1.4.1 Spring Chinook Salmon

Adult spring Chinook have not been documented spawning in Little Creek, however the project is expected to potentially improve habitat conditions in the reach and could lead to spawning in the future. Life history timing is expected to be similar to Chinook Salmon in adjacent Catherine Creek. Chinook Salmon migrate upstream through Catherine Creek near the project reach in late May through early June. Spawning occurs in late August through September, and juvenile emergence occurs in January and February. Most juveniles express a stream-type life history, where they rear in freshwater for one year prior to out-migrating the following spring during spring runoff. Of those stream-type fish, there are two life history strategies that have been identified. Early migrants migrate downstream and overwinter in lower Catherine Creek or the Grande Ronde mainstem before out-migrating the following spring, while Late Migrants rear in headwaters in which they were spawned prior to out-migrating in the spring (Jonasson et al. 2002).

While historical data has documented Chinook spawning in both Catherine Creek and Little Creek in the past, contemporary surveys indicate that current fish use is more limited. Data collected by ODFW indicates that adult Chinook spawning has not been documented in Little Creek within the past 10 years, and juveniles detected from the mouth to RM 1.2 during electroshocking surveys are believed to be fish spawned in Catherine Creek, seeking thermal refuge in Little Creek during hot summer months. Juveniles were not observed upstream of RM 1.2, likely due to a passage barrier downstream of Godley Road (downstream of the project area).

1.4.2 Steelhead

Adult steelhead returning from the ocean appear at the project reach as early as February, with spawning occurring in Little Creek within the project area and upstream from February through May. Juveniles emerge from February through June, and rear for one to several years prior to migrating to the ocean.

Juvenile steelhead have been documented in both Catherine Creek and Little Creek, and steelhead spawning has been observed in Little Creek within the project area.

1.4.3 Bull Trout

Little is known about how bull trout utilize the project reach. The project area most likely functions as a migration corridor for fluvial bull trout between overwintering habitat downstream, and spawning and rearing habitat upstream. Spawning occurs in headwater streams in the fall, and juveniles display an extended rearing period before expressing either a resident life history where they remain in headwater streams as adults, or fluvial life history where they migrate downstream as sub-adults and reside in downstream reaches during winter months or when water temperatures are suitable.

Electroshocking surveys conducted by ODFW did not document bull trout in the project area vicinity, however it is possible these fish primarily use the project area as a seasonal migration corridor and were not present during the time of sampling.

1.4.4 Habitat conditions and limiting factors

Little Creek within the project area has been heavily impaired by a history of agricultural land use, grazing, channel straightening, and road building. In-channel complexity is low, and floodplain connectivity and habitat quality area also impaired. Water temperature in Little Creek has been evaluated by ODFW, and remained within the thermal ranges preferred by salmonids (below 18°C) in all stream reaches, with the exception of the lowest reach where stream temperatures were a few degrees warmer. These findings, along with the detection of juvenile Chinook Salmon in Little Creek despite a lack of spawning in the basin, suggest that Little Creek is an important cool-water refuge for salmonids during hot summer months.

Limiting factors within this reach were identified in the Atlas process, and include the following:

- Reduced instream flows
- High summer temperatures
- Limited instream structural complexity
- Limited availability of peripheral and transitional habitats (side channels, floodplains, and wetlands)

1.5 List of Primary Project Features Including Constructed or Natural Elements

Proposed project features are described below. A detailed alternatives analysis was performed as part of the 15% conceptual designs. Additional design iterations were completed during the preliminary (30%) interval to incorporate observations from adjacent sites, guidance from stakeholders and landowners, and to better meet the ecological objectives of the project.

Grade multi-thread channel and swale complex: The project aims to restore natural floodplain connectivity and in-stream habitat complexity that was likely found in this area historically, and that would be naturally self-sustaining and dynamic. As observed in various other restoration projects and functioning floodplains, raising the water-table to support a robust aquatic and riparian vegetation community was a key determinant of the grading.

The proposed new channel planform and sizing were evaluated extensively at the conceptual and preliminary design stage using a 2D hydraulic model. Attention was paid to existing hydrologic records, observed site conditions during floods, species and life stages likely to use the site, and native vegetation that will interact with the physical processes of the channel to support ongoing habitat complexity.

Constructed riffles: Riffles are proposed in the project area to hold grade in two locations informed by the results from 2D hydraulic modeling. One is at the downstream end of the project area and will manage the flow rate of water at the downstream outlet. The other provides a fish passable diversion structure that provides water to the state ditch diversion.

Instream habitat complexity treatments: Instream habitat complexity will complement the channel grading. The intention is to increase roughness, drive geomorphic dynamism, provide habitat cover for aquatic organisms, support an aquatic and riparian plant community associated with a high water table. The proposed treatments include: post willow structure (in stream), willow trenches (on the floodplain), small whole trees. These habitat features will be located throughout the project area.

Riparian and wetland planting: Woody and herbaceous plants will be installed in the project area based on anticipated inundation patterns. Stream shading, geomorphic function, ecological complexity, and soil regeneration are key objectives guiding the riparian planting. All areas of disturbance will be planted with a native mix of herbaceous and woody plants that are appropriate to the site and post-project inundation patterns.

Remove crossing: Near the middle of the project area an existing farm crossing is causing a constriction and a grade break in the channel. The landowners have suggested that they may be willing to remove this farm access.

Relocate irrigation diversion: The preferred alternative proposes to relocate the State Ditch diversion as shown on the plans. Preliminary discussions between Union SWCD and the water master has indicated that this location may not be an official Point of Diversion (POD), and thus may have fewer restrictions to relocation. Additional investigation is ongoing in collaboration with the Union SWCD.

Land management plan: The landowners operate a ranching operation at the project area. They are also committed to supporting endangered species recovery and overall ecological function on their property. To provide documentation of their proposed operation and its interaction with the designs described here, a land management plan will be completed, including a monitoring and adaptive management plan. Multiple conversations with BPA and landowners have attempted to find acceptable land management strategies and success criteria in the project area.

1.6 Description of Performance/Sustainability Criteria for Project Elements and Assessment of Risk of Failure to Perform, Potential Consequences and Compensating Analysis to Reduce Uncertainty

The primary purpose of this project is to restore natural floodplain processes and improve instream salmonid habitat conditions in Little Creek. Project goals are stated above.

Objectives in support of project goals include:

- Elevate the water table to provide optimal growing conditions for a mosaic of woody and herbaceous vegetation across the floodplain.
- Improve aquatic habitat, with a particular focus on juvenile rearing habitat.
- Reduce solar gain both by using channel geometry where possible (narrow and deeper channels) and by focusing on encouraging conditions for vigorous riparian plant growth.
- Encourage channel evolution processes and lateral channel migration.

Objectives in support of risk reduction include:

- Support flood flows that maintain or improve the current flooding condition, including maintaining the existing flow-split at the downstream end of the project

- Reduce areas in which grazing animals may irrevocably damage restoration features (eg, narrow, deep channels)
- Use in-stream features (post structure and/or whole trees) in Subreach 1 (above new POD location) to create dynamic channel responses and local habitat rather than grading. This approach is intended to limit possibility of flow to bypass the diversion structure.

These objectives will support and be refined in collaboration with a monitoring and adaptive management plan developed in future phases.

In addition to meeting the project's landowner, biological, and ecological goals and objectives for improvements within the project area other important design criteria are discussed as follows:

- **Federal Emergency Management Agency (FEMA) no-rise to base flood conditions**. Within the project area, the current adopted flood hazard zone has been defined by a detailed study within the Little Creek floodplain. For the City of Union, which is immediately downstream of the project area, the flood hazard zone has been defined through detailed study. Hydraulic analysis within the detailed study zones of the City of Union and Little Creek, will document the required FEMA base flood conditions required. Additional coordination with FEMA will be included as the project moves to 80% design.
- **Large Wood Design.** Placement and construction of large wood structures within the project area will be designed following Reclamation - Pacific Northwest Region - Risk-Based Design Guidelines (Reclamation 2014a).
- **Union County Planning Department Land Use Regulations.** All required land use regulations will be followed.
- **State of Oregon Permitting Regulations**, to include Division of State Lands removal-fill permits and wetland evaluations, Department of Environmental Quality permits.
- **Federal regulations**, to include ESA, Section 106 of the National Historic Preservation Act, National Environmental Policy Act, Clean Water Act.

1.7 Description of Disturbance Including Timing and Areal Extent and Potential Impacts Associated with Implementation of Each Element

Areal extents of the project elements are provided in the attached planset. The project is expected to be constructed using excavating equipment and off-road haul trucks. Timing will be dependent on regulatory permitting in-water work windows, which is typically July 1- August 15 for Catherine Creek up to and including Little Creek.

2 Resource Inventory and Evaluation

2.1 Description of Past and Present Impacts on Channel, Riparian and Floodplain Conditions

2.1.1 Historical Land Use

The earliest impacts to the historical channel, riparian, and floodplain conditions were likely the extirpation of beaver beginning in the early 1800s, but also occurring as recently as the late 1930's and early 1940's on the downstream end of Little Creek within the project area (Gildemeister, 1998). With the removal of beaver and beaver dams from the project area, multiple trends of stream and floodplain degradation would have been initiated. Stream degradation would have included increased water velocities and sediment transport and therefore local incision and simplification of channel planform. Stream degradation would have also included reduced frequency and duration of floodplain inundation leading to the lowering of the water table and altered evolution of the local plant community.

While Little Creek was not as heavily impacted by construction of Highway 203 as Catherine Creek to the south, the planform was likely altered within the project area prior to 1937. Analysis of historical aerial images show that prior to channelization, Little Creek had a multithread signature on the landscape. Channelization occurred within the project area through the mid 1950's, which resulted in channel incision, reduced instream roughness, and floodplain disconnection. Extensive conversion of riparian and floodplain vegetation to agricultural fields and pasture had also occurred by 1937 and continued through the mid the late 1950's. Little Creek is currently listed as a Section 303(d) waterbody by the Oregon Department of Environmental Quality due to issues associated with dissolved oxygen, temperature, sediment, nutrients, and flow (DEQ 2010). All water quality issues are likely associated with anthropogenic disturbance from existing and past forest and agricultural practices in the watershed.

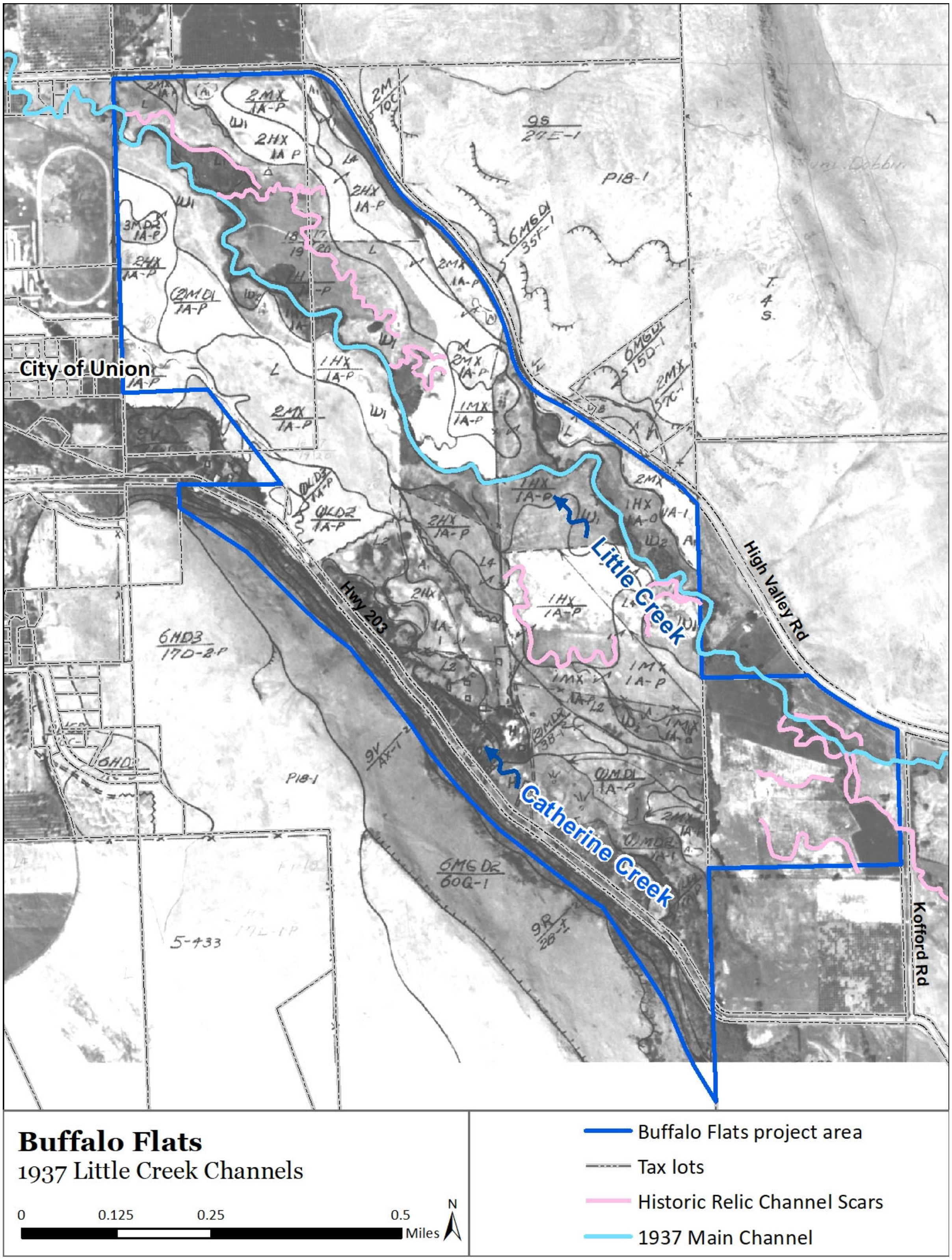


Figure 2: 1937 aerial image showing the digitized historical mainstem Little Creek Channel (light blue) and multiple Little Creek channel relicts (pink).

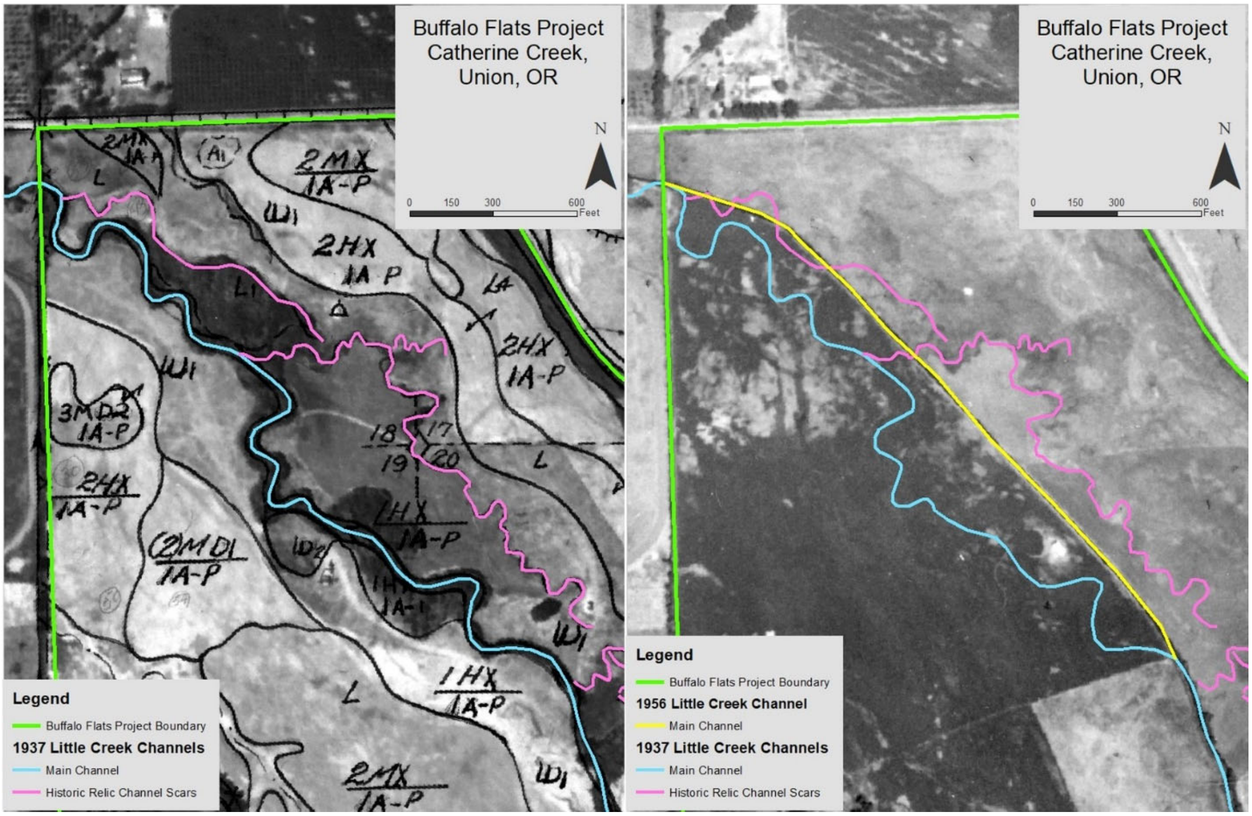


Figure 3: The 1937 aerial image (left) and 1956 aerial image (right) showing the degree of channelization that occurred on Little Creek between 1937 (main channel depicted in blue) and 1956 (main channel depicted in yellow) in the downstream region of the project area.

2.1.2 FEMA modeling of the floodplain within the project area

Hydraulic modeling has been performed near and within the project area as part of the Union County and City of Union Flood Insurance Studies (HUD 1978). For these studies, one dimensional numerical modeling was performed using the U.S. Army Corps of Engineers Hydraulic Engineering Center's HEC-2 model. These historical studies were completed to develop base flood elevations (100-year flood elevations) as represented by currently adopted Flood Insurance Rate Maps (FIRMs) for Union County and the City of Union (HUD 1978). Numerical hydraulic models were developed in "detailed" study areas only. Detailed studies were performed for Little Creek through the project area and downstream through the City of Union. Current Flood Insurance Rate Maps for the project area and adjacent City of Union are shown below in Figure 4.

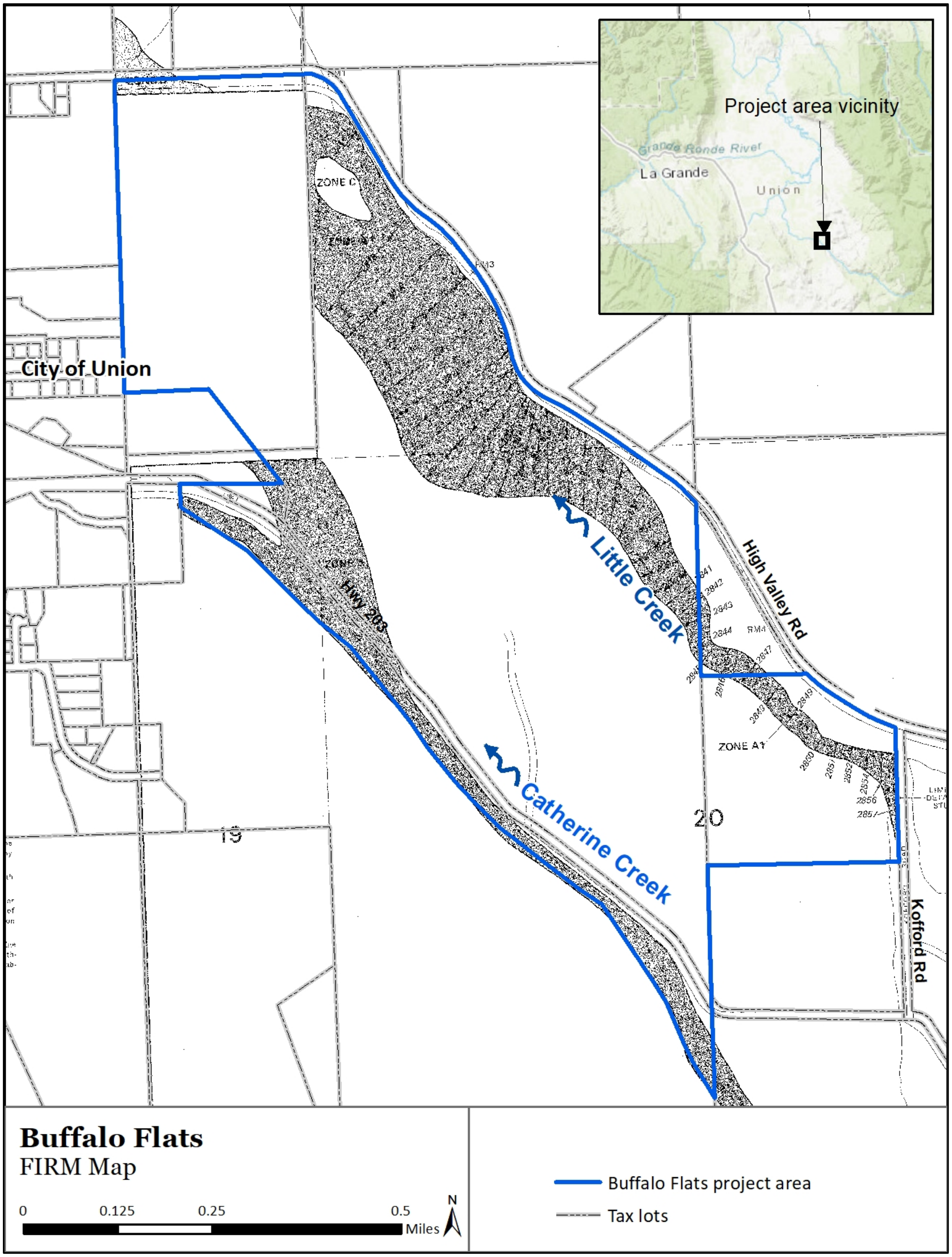


Figure 4. Adopted FEMA Flood Insurance Rate Maps (FIRMs) at project area (100-year flood) - Union County FIRM Map Panel 4102160429B and City of Union FEMA Map Panel 4102230001

2.2 Instream Flow Management and Constraints in the Project Reach

Hydrology within the project area is complex, and is a function of natural stream flows, irrigation ditches, and in the winter, ice can occasionally influence hydrology and sediment transport through the formation of ice dams. Each of these aspects is discussed separately below.

2.2.1 Seasonal hydrology

Little Creek is a major tributary to Catherine Creek with a drainage area of approximately 38.3 square miles. The Little Creek watershed is located within forested areas in the upper reaches and agricultural areas in the valley. The average precipitation for the watershed ranges between approximately 18-inches to 50-inches from downstream to upstream (Reclamation 2013). No daily gage data are available for Little Creek to estimate base flows. Therefore, two stream gages were established by Reclamation in the fall of 2019 at the upper and lower boundaries of the project area. Each gage consists of a pressure transducer and thermometer that measures water surface stage and temperature every 15-minutes.

Little Creek's annual peak hydrology was estimated based upon the Catherine Creek near Union stream gage (USGS #13320000) for the period of record 1912 through 2011. Tributary hydrology was estimated using weighting techniques for drainage area and mean sub-watershed precipitation. Hydrology at the project area was estimated based upon data developed from the CCTA by removing the precipitation-weighted drainage area below the upper project boundary from the overall estimate as shown in the following table.

Table 4: Annual Peak Discharge Frequency for Little Creek at Upstream Project Boundary (Estimated from CCTA, Reclamation 2011).

Return Frequency	Little Creek at Mouth (Reclamation 2013)	Little Creek at Project Upstream Boundary
1.5-year	189 cfs	185 cfs
2-year	223 cfs	218 cfs
5-year	306 cfs	299 cfs
10-year	359 cfs	351 cfs
25-year	427 cfs	417 cfs
50-year	477 cfs	466 cfs
100-year	526 cfs	514 cfs

2.2.2 Diversions

Four major surface water diversions exist within the project reach: State Ditch, Swackhammer Ditch, Guild United Ditch and the Prescott Ditch. Major ditches within the project area are shown in Table 5 below. These diversions have resulted in reduced baseflow within the project area.

Table 5: A summary of surface diversions within the project area vicinity (water right data was downloaded from the OWRD Graphical User Interface).

Surface Diversion	Max Diversion Rate (cfs)
State Ditch	37.93
Swackhammer Ditch	39.28
Guild United Ditch	5.91
Prescott Ditch	4.93

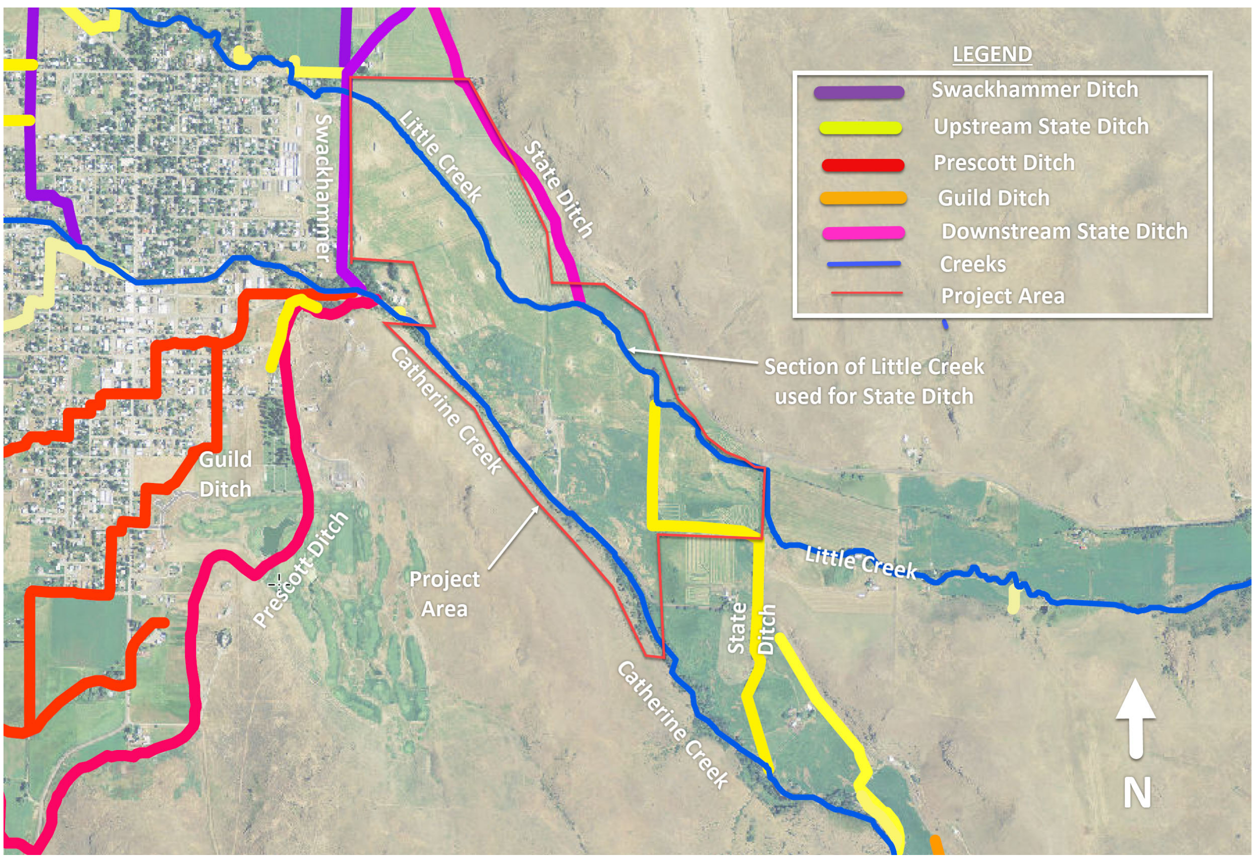


Figure 5: Image showing irrigation infrastructure upstream, within and downstream of the Project Area.

2.2.3 Ice

Ice formation can occur in Little Creek during cold winter periods, as anchor ice or ice jams, which can have a significant impact on flooding and sediment transport. Little Creek through the project subreach is incised and disconnected from its floodplain. In winter months, shallow water flows fast over the planebed substrate, which creates ideal conditions for the formation of anchor ice. Anchor ice forms on the bottom of the channel during subfreezing temperatures through the process of supercooling, where ice particles attach to substrate and build into anchor ice formations. When temperatures warm and surface ice begins to break up, it is rafted in large pieces downstream and can hang up on protruding objects such as downed trees, bridge piers or other anchor ice formations. When rafted ice gets hung up, it can create a jam and water builds up until it can find relief around the blockage. The current Little Creek alignment is incised and lacks a floodplain, and therefore existing flood conditions in Little Creek within the project area are dramatically affected by ice.

In January of 2014, an ice jam occurred in nearby Catherine Creek that temporarily closed Highway 203. The ice jam occurred within the middle sub-reach near the existing BPLL residence. The ice jam appeared to have been caused by break-up of ice sheets that were jammed against a downed cottonwood spanning Catherine Creek. Water and ice eventually flooded the highway and closed it temporarily. The ice that formed in the river during this event is shown below in Figure 6.

Figure 6: Ice jam in Catherine Creek above the City of Union within the Project Area – January 2014 (La Grande Observer).

2.3 Description of Existing Geomorphic Conditions and Constraints on Physical Processes

2.3.1 Historical forms and processes

The Little Creek alluvial fan developed where the stream emerges from a relatively steeper and more confined reach into the open valley, and was heavily influenced by the Pleistocene glacial period. Upon entering the valley, sediment transport capacity rapidly decreases due to increases in channel width, reduction in confinement and reductions in channel gradient. During the formation of the alluvial fan, sediment supply and transport mechanisms would have included debris flow, channelized water flow and sheet-flooding (Schumm et. al, 1996). The Little Creek channel would have been braided, or multithreaded, with lateral and mid channel bars, beginning at the slope inflection where the stream enters the valley.

As the climate warmed and dried following the Pleistocene glacial period, Little Creek discharge decreased, thus lowering sediment transport competency and capacity. This changed the sediment transport regime from depositional to one characterized by channel incision and widening, creating inset surfaces in the upper sections of the fan (Shumm et. al, 1996). After the channel incised into glacial outwash and floodplain surfaces were formed, large scale avulsions initiated by bank overtopping would have occurred on a much less frequent basis, if at all, compared to those experienced during the glacial period. Colonization of banks by vegetation would have further increased bank stability. However, localized reworking of sediment and colonization of vegetation on bars and inset surfaces would have increased levels of hydraulic roughness in certain areas enough to reinitiate divergence of flow between the terraces.

2.3.2 Contemporary forms and processes

Little Creek presently emerges from High Valley and across its Pleistocene-age alluvial fan in a northwest direction. The fan surface slope is approximately 0.8 percent as measured in the stream flow direction. The main channel is a single-thread planform with a riffle-run morphology with a few pools, sinuosity of 1.2, and a bedslope of 0.7 percent.

The sediment transport regime on Little Creek is also transport dominant in approximately the upstream third of the channel segment within the project area. Downstream, there are areas where high flow can overtop the banks and overbank flows can occur in lower lying areas. Sediment transport has not been modeled as part of this design process to date.

2.3.3 Existing conditions of subreaches

For the purposes of analysis, the project site was subdivided into four subreaches. Each subreach is illustrated below with existing geomorphic and habitat characteristics. All photos in this section are from August 2020 during a site visit.

Subreach 1: starts at Kofford Road and extends to the downstream end of the McCrae property.

Subreach 2: starts at the downstream end of the McCrae property and extends to the existing farm crossing.

Subreach 3: starts at the existing farm crossing and extends through the main channelized downstream section.

Subreach 4: includes approximately 1000 feet of channel above the downstream property boundary and is characterized by somewhat more floodplain connectivity.

Subreach	**Channel Slope**	**Valley Slope**	**Thalweg to top of bank**
Subreach 1	– 0.64%	– 0.8%	3-4 ft and consistent
Subreach 2	– 0.61%	– 0.9%	2-4ft. Lower banks immediately upstream of bridge

Subreach 3	– 0.72%	– 0.75%	3-6ft. More entrenched in downstream direction
Subreach 4	– 0.54%	– 0.75%	3-6ft. Less entrenched in downstream direction

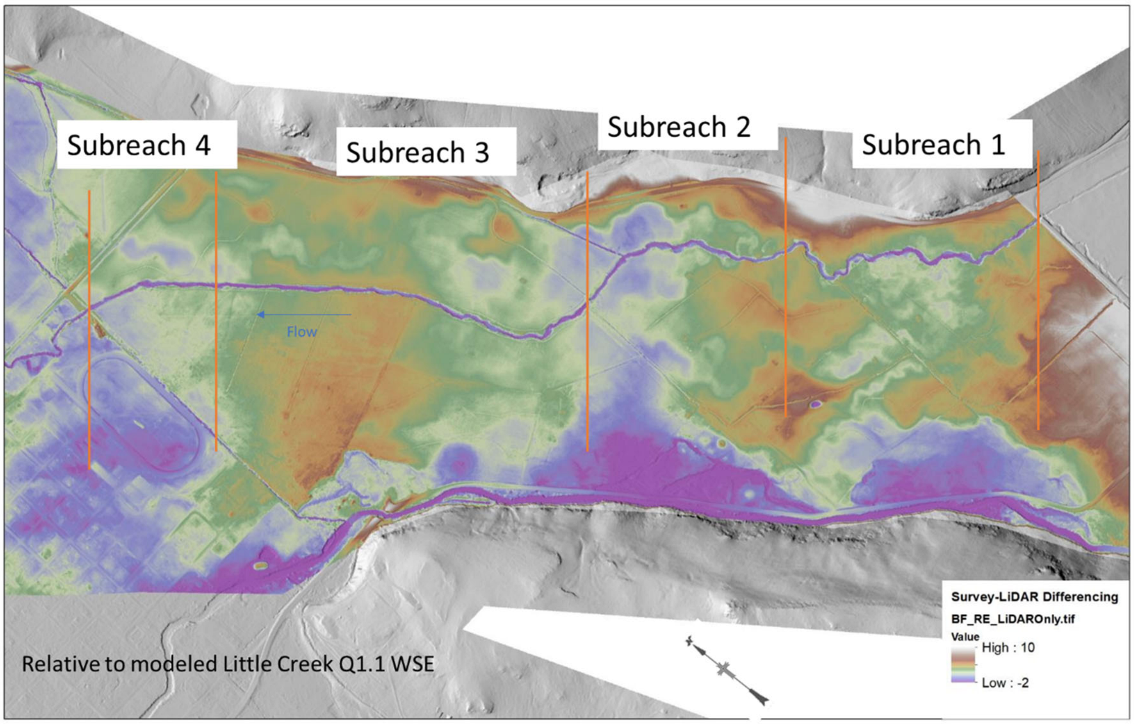


Figure 7. Approximate subreaches within the project area displayed on a relative elevation map

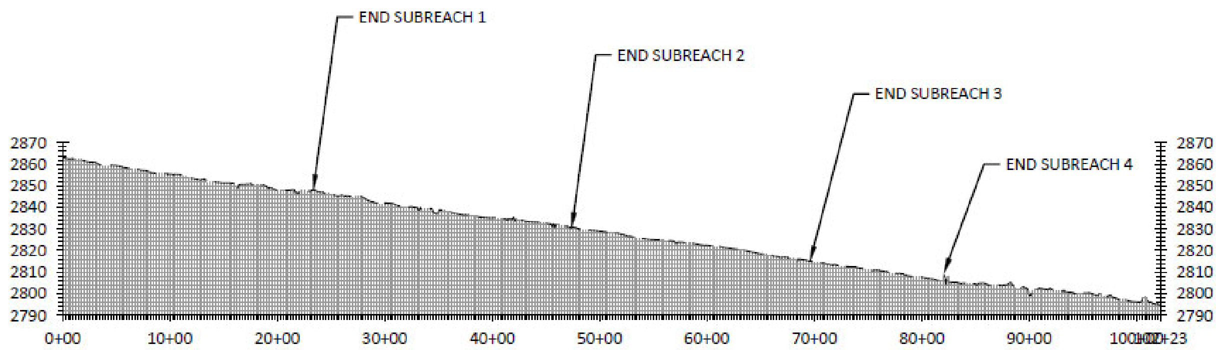


Figure 8. Longitudinal profile of the Little Creek channel with subreach breaks called out.

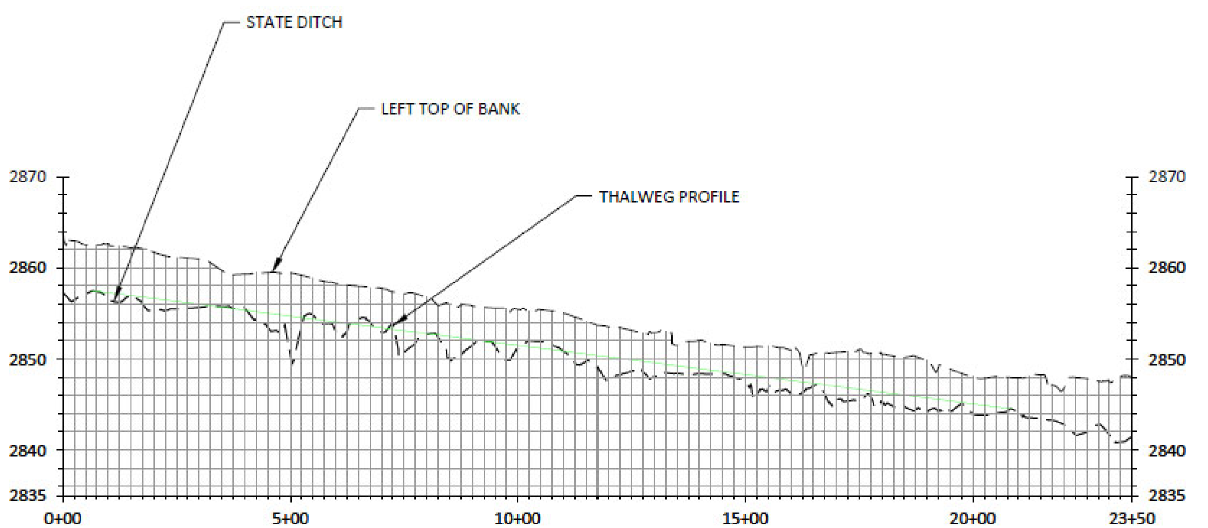


Figure 9. Subreach 1 profile (vertical exaggeration of 20:1)

Figure 10. Subreach 1 characteristic photos

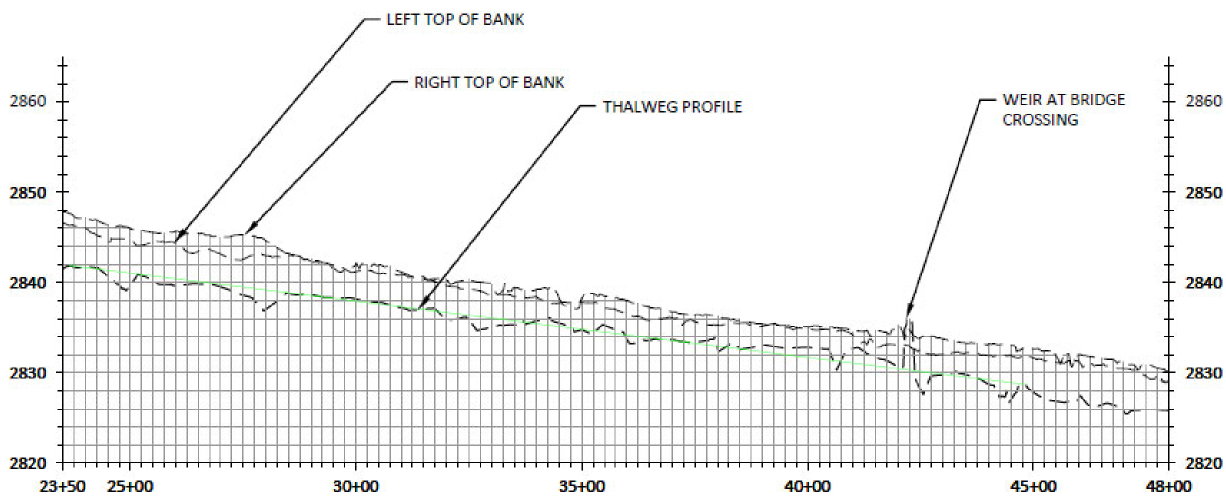


Figure 11. Subreach 2 profile (vertical exaggeration of 20:1)

Figure 12. Subreach 2 characteristic photos.

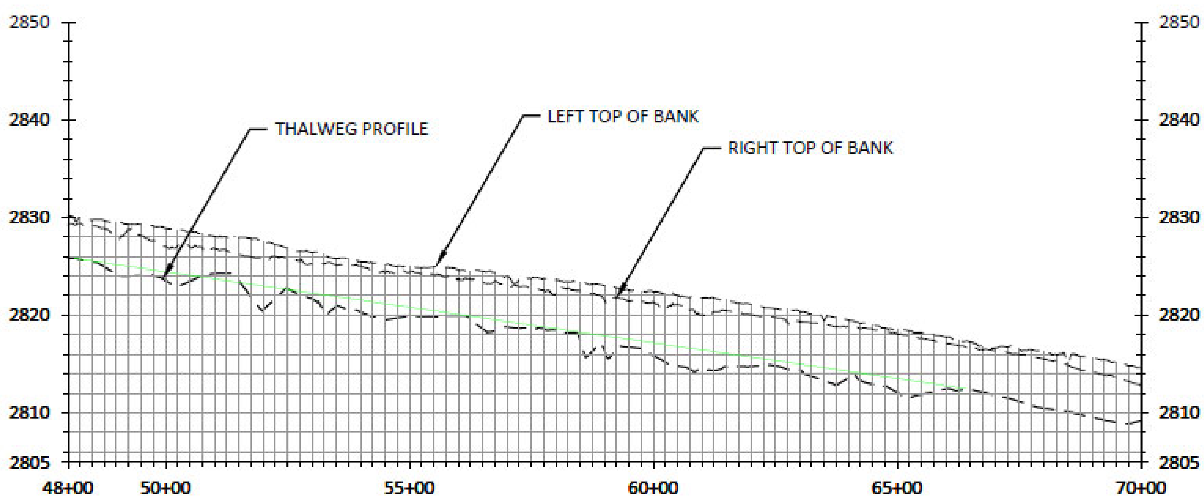


Figure 13. Subreach 3 profile (vertical exaggeration 20:1).

Figure 14. Subreach 3 characteristic photos.

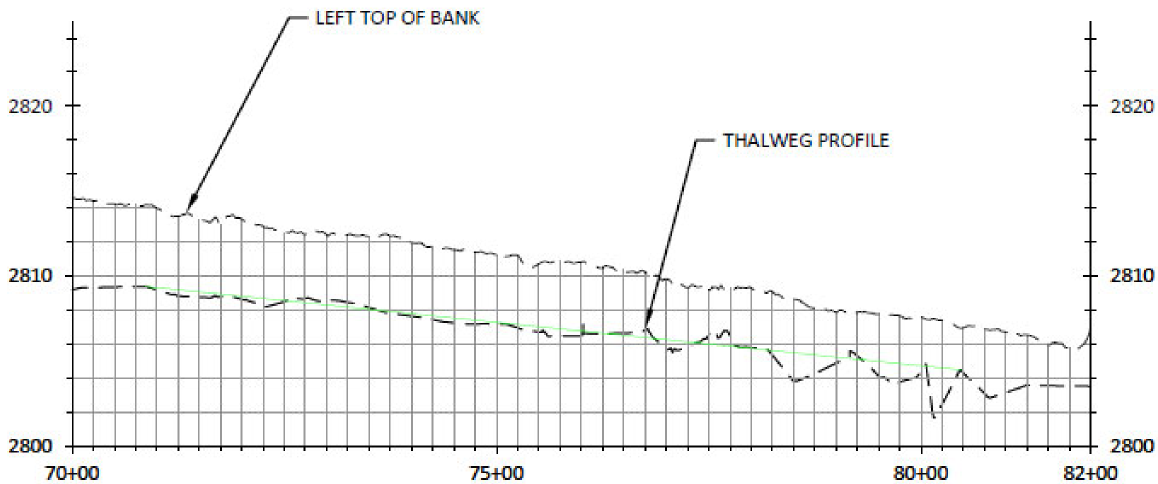


Figure 15. Subreach 4 profile (20:1 vertical exaggeration).

Figure 16. Subreach 4 characteristic photos.

2.3.4 Analog sites desktop analysis

Several potential analog sites were identified via personal communication with local staff and desktop analysis. While none of these sites is an ideal "analog", there are elements of each site that help inform project design as well as start the process toward a shared expectation of project outcomes. The projects are described

Table 6 – Buffalo Flats Little Creek Project Site, existing description

Site	Drainage Area (mi^2)	Valley Slope	Valley Width (ft)	Sinuosity	Lateral Migration	Notes
Little Creek, OR	*37.5*	*0.008*	*2,000*	*1.07*	*Almost no lateral migration 1990s-present; confined by human alteration for agriculture. Currently high ground separating Little Creek and Catherine Creek. Large alluvial fan within the town of Union and downstream. Likely very complex in the past.*	*Valley bottom represents both Little Creek and Catherine Creek. Actual Little Creek bottom width 1000-1500 ft, approximately.*

	representative valley cross section and aerial:  

Table 7 - Potential analog location – Hall Ranch Side Channel

Site	Drainage Area (mi^2)	Valley Slope	Valley Width (ft)	Sinuosity	Lateral Migration	Notes
Hall Ranch Side Channel, OR	n/a	0.015	1,500	1.13	Recently developed side channel (2011-present); confined on LB by road; blocked from extensive floodplain to the SW. Beaver are active in Catherine Creek, but	This valley is almost double the slope of the Little Creek project site. Hydrology may be similar depending on the flow split. The floodplain soils at this location are

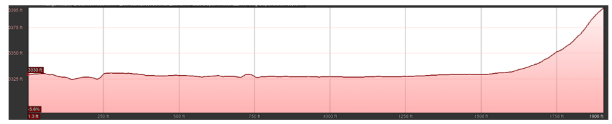
<table>
<tr><td></td><td></td><td></td><td></td><td></td><td>no recent beaver activity in this channel has been observed</td><td>shallow and gravel is present on the surface throughout.</td></tr>
<tr><td colspan="5"></td><td colspan="2">representative valley cross section shape and aerial:

</td></tr>
</table>

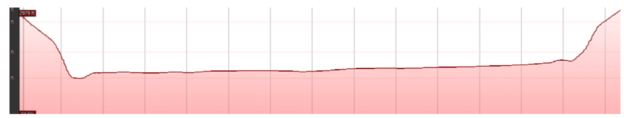
Table 8 - Potential analog location – Badger Creek, Warm Spring Reservation.

Site	Drainage Area (mi^2)	Valley Slope	Valley Width (ft)	Sinuosity	Lateral Migration	Notes
Badger Ck., OR	37.8	0.008	750-1,000	1.28	Wide valley bottom with one to two main channels and many of small side channels & low relief areas in between. Large wood is present in valley bottom despite limited LW recruitment potential locally. Beaver are active. Limited anthropogenic disturbance visible, other than road crossings. No visible cut banks. Deep narrow channels.	Valley width is higher upstream of HWY26 crossing; CIR image (2011) captures plant growth in valley well. The ”green line” spans the valley, with large shrubs dominant. Slope and drainage area are very similar to Little Creek (although hydrology differs on eastern flanks of Mt Jefferson and valley is narrower. Fringe herbaceous vegetation along channel, gives way to robust woody vegetation on most of the floodplain.

representative valley cross section shape and aerial:

Table 9. Potential analog site - Catherine Creek Southern Cross Swale Complexes

Site	Drainage Area (mi^2)	Valley Slope	Valley Width (ft)	Sinuosity	Lateral Migration	Notes
Catherine Creek., OR	108	0.015	750-1,200	Imposed by channel construction	Increased lateral activity and sediment deposition due to increased planform complexity. Woody vegetation is thriving on the floodplain and in	Location in the upstream portion of the project identified as an analog for vegetative response to restoration. Wetland fringe and woody establishment similar

<table>
<tr><td></td><td></td><td></td><td></td><td></td><td>freshly deposited/sorted sediments.</td><td>to Badger Creek. More detailed field observations and data collection in the downstream reach of the site is included in the Vegetation Tech Memo 12/31/2022</td></tr>
<tr><td colspan="5"></td><td colspan="2">representative valley cross section shape and aerial:

</td></tr>
</table>

2.4 Description of Existing Riparian Condition and Historical Riparian Impacts

The existing Little Creek riparian vegetation within the project area is also a narrow, discontinuous strip along the top of the banks (Figure 17). As previously described, floodplain and upland vegetation has been removed for agricultural use and grazing practices.

Figure 17: A 2009 aerial image showing the discontinuous strip of riparian vegetation along the bank and conversion of floodplain vegetation to agricultural.

2.5 Description of Lateral Connectivity to Floodplain and Historical Floodplain Impacts

As described above in Section 2.3 existing lateral connectivity to the floodplain has been reduced through bank armoring, channel straightening and incision.

3 Technical Data

3.1 Incorporation of HIP IV Specific Activity Conservation Measures for all Included Project Elements

HIP conservation measures will be included throughout the project design process. The preliminary designs are currently believed to be able to meet all HIP conservation measures for each activity category included in the project.

3.2 Summary of Site Information and Measurements (Survey, Bed Material, Etc.) Used to Support Assessment and Design

3.2.1 Digital Terrain Model

3.2.2 Aerial Photography and Historical Survey Records

3.2.3 Fish Use Data

3.2.4 Vegetation Data

3.2.5 Topographic and Bathymetric Survey

3.2.6 Soils Data

3.3 Summary of Hydrological Analyses Conducted, Including Data Sources and Period of Record Including a List

of Design Discharge (Q) and Return Interval (RI) for Each Design Element

See Appendix, Hydraulic Modeling and Alternatives Analysis Report.

3.4 Summary of sediment supply and transport analyses conducted, including data sources including sediment size gradation used in streambed design

Sediment analyses have not been completed for this project yet.

3.5 Summary of hydraulic modeling or analyses conducted and outcomes – implications relative to proposed design

See Appendix, Hydraulic Modeling and Alternatives Analysis Report.

3.6 Stability Analyses and Computations for Project Elements, and Comprehensive Project Plan

Stability analyses and other project element computations will be completed in future design phases.

3.7 Description of How Preceding Technical Analysis has been Incorporated into and Integrated with the Construction – Contract Documentation.

Integration of design analyses into the construction and contract documentation will be described in future design phases.

4 Decision-making process for the Buffalo Flats Little Creek project

The project has been developed in a careful and stepwise process as project partners and funders assessed feasibility of the effort and the ability of the work to support habitat in this important region. Foundational efforts included the following, and Table 10 includes key milestones in the Buffalo Flats Little Creek effort since January 2020:

- Building upon the regional studies described in the first section, US Bureau of Reclamation studied both Catherine Creek and Little Creek for potential habitat project opportunities.
- The landowners of BPLL and USWCD have collaborated on ways to develop a habitat project at this site.
- Discussions between the design team and ODOT have been underway to understand whether moving Highway 203 is feasible and potentially include co-benefits to the community.

Table 10. Project milestones since 2020.

Date	Milestone
January 30, 2020	Public Meeting, Union, Oregon
July 2020	Alternatives Analysis (Little Creek and Catherine Creek)
September 2020 (approx.)	Cultural Resources pedestrian survey and report completed
November 2020	Existing Conditions Hydraulic Modeling completed
July 2021	Conceptual (15%) Design Plans, BDR, Hydraulic Modeling completed
April 29, 2022	Conceptual Review comments received from BPA
July 20, 2022	15% Site visit with Sean Welch (BPA) and design team
August 2022	Wetland Delineation field work
October 12, 2022	Vegetation Analogue site visit (BPA, sponsor, landowners).

December 2022	Preliminary (30%) Design Plans, BDR, Hydraulic Modeling, Wetland Delineation completed

After BPA reviews the preliminary (30%) designs, the next steps in the design process include:

- Complete geotechnical investigation and optional groundwater wells
- Finalize grading and habitat features designs
- Advance permitting discussions with agency staff including DSL, USACE, DEQ, SHPO, FEMA, Union County as well as consult with federal agencies and tribes.
- Secure implementation funding
- Develop permitting, and final design at intervals as required by BPA review.
- Continue public outreach

References

Citation in Text	Bibliographic Reference
Anderson Perry 2010	(*To be completed; referenced in Section 3.2*).
Anderson Perry 2011	(*To be completed; referenced in caption to Figure 36*).
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Reclamation (*?*)	(*To be completed; various references to Catherine Creek assessments/Atlas, etc.; one is dated 2015 in the Executive Summary; two are dated 2004 and 2017 in Section 1.4.1; and one is dated 2017 in the caption for Figure 2*)
Reclamation 2012	Bureau of Reclamation. 2012. *The Catherine Creek Tributary Assessment, Grande Ronde River Basin, Tributary Habitat Program, Oregon*. Pacific Northwest Region, Boise, Idaho.
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