4 REACH 10 CONCEPTUAL PROJECTS

Reach 10 is located from the mouth of Panjab Creek at RM 50.2 to the downstream end of Big Four Lake (RM 44.0; Figure 2). The reach is within the Umatilla National Forest and the Wenaha-Tucannon Wilderness area and includes both public (WDFW) and private holdings such as the Camp Wooten natural resources learning center. Reach 10 is an important reach for spring Chinook, steelhead, and bull trout. Spring Chinook spawn and rear in Reach 10, with a high density of juvenile rearing in the lower portion of Reach 10. Steelhead rearing and spawning also occurs in the reach. Reach 10 and the adjacent tributaries (especially Panjab Creek) are significant areas for bull trout spawning and rearing.

The valley is forested with conifers that increase in density upstream of Panjab Creek (RM 50.2). The reach contains several perennial tributaries that drain the headwater areas, as well as several spring sources; a majority of Reach 10 was identified as a gaining reach except for a small section between approximately RM 47.7 and 46 (HDR 2006). A majority of the subbasin areas between the Little Tucannon River (RM 48.0) and the downstream end of Reach 10 were affected by the 2005 School Fire; the most severely burned areas were the Hixon and Grub Canyon basins (USFS 2008).

Confinement in the reach is variable; confinement in the lower reach downstream of the Little Tucannon River is typically influenced by anthropogenic features and entrenchment, whereas confinement in the upper reach is associated with alluvial fans, debris flow deposits, and natural narrowing of the valley width. Channel pattern in Reach 10 transitions from a primarily single-thread channel near Panjab Creek into a more diverse channel network with some side channels and braided sections toward the lower end of the reach. Floodplain connectivity in Reach 10 is slightly impacted by infrastructure and strongly impacted by channel incision in many places.

Nine conceptual project areas were identified in Reach 10. The primary restoration strategy presented within Reach 10 focuses on addition of LWD, with a lesser number of projects that identify off-channel habitat opportunities. LWD addition is consistent with the limiting factors identified in the EDT analysis of key habitat quantity and increasing riparian function (Appendix J, CCD 2004). LWD will provide a greater quantity of holding areas by initiating

pools and will contribute to reversing the incised condition of much of the channel, which will eventually lead to better connectivity of riparian vegetation with water table and bank overtopping.

4.1 Project Area 1 (River Mile 50 to 48.9)

Project Area 1 (PA-1) is located from the Panjab Creek Bridge (RM 50) to just upstream of the campground near RM 48.9.

Table 4-1
Restoration Recommendations for Project Area 1

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Maintain natural channel and floodplain processes throughout the project area, particularly the ground water at RM 49.5.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	No significant infrastructure was identified that impairs natural processes.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout 1.3 river miles; supplement existing rock structure (weirs) with LWD.

4.1.1 Site Description

4.1.1.1 Channel Characterization

The channel through PA-1 is characterized as a single-thread, plane-bed channel with local rapid sections (Photograph 4-1). This area is located in a relatively steep, narrow section of the valley. Five rock weirs are located within the project area and likely contribute to grade control of the channel profile. Multiple rock-rootwad restoration features were also observed throughout. Several minor side channels were observed during site reconnaissance, although many of these features are likely dry during the low-flow period. At approximately RM 49.05, a spring originates south of the campground and flows parallel to the river for approximately 0.1 miles.

Photograph 4-1
PA-1 near RM 49.6, looking downstream

The quality of instream habitat is limited by the lack of hydraulic and bedform complexity in the channel. Very few key logs were observed, so pools and instream cover were generally limited to the locations of man-made structures and small side channels. Overall, woody debris retention and temporary sediment storage was low.

4.1.1.2 Floodplain Characterization

Floodplain connectivity appears to be unaffected by infrastructure, although remnant alluvial fan and hillslope deposits create moderately high surfaces that restrict the area of the low floodplain throughout much of the project area. Small sections of remnant levees and sections of riprap are located in a few places; however, the influence of these features to natural processes appears to be minor.

The riparian zone is generally in a moderately healthy condition, with local areas that have been degraded by recreational use, development, and fire. Riparian trees are mixed deciduous and conifer, dominated by Ponderosa pine, willow, alder, and dogwood. Understory vegetation includes groundcover, shrubs, and small trees that provide overhanging vegetation. Species are moderately diverse but contain many invasive plants, including Robert geranium, reed canarygrass, oxeye daisy, and creeping buttercup that are dominant in local areas of the floodplain and the active channel.

4.1.2 Conceptual Project Actions

Restoration actions would involve placing large woody debris structures throughout the project area and supplementing existing rock structures with wood for added complexity (Figure B-1). LWD may include a range of treatments, from placing single logs in side channels and alcoves to engineered log jams (ELJs) in plane-bed sections of the main channel.

4.1.2.1 Geomorphic Implications

Addition of LWD will initiate a geomorphic response resulting in bank erosion, bed scour, and sorting of sediment, which form critical habitat features (e.g., pools, cover, and spawning gravels). Because the channel profile is controlled by man-made features, the larger ELJs are not expected to significantly affect the channel grade on a reach scale. However, the ELJs will influence the development of pool-riffle morphology through what is a mostly simplified, plane-bed channel. In addition, large wood structures will promote development of a more complex channel network by splitting flow, initiating island development, and promoting channel migration.

4.1.2.2 Biological Benefits

Adding complexity to the channel via LWD will provide hydraulic diversity and refuge in the mainstem significantly improving habitat conditions for juveniles. In the short term, the pools that form at the structures will increase the available area for holding in the project area. Increased hydraulic diversity will provide high-flow refuge and low-flow cover for juveniles. The structures will also increase sediment retention enhancing the size and quality of spawning areas. In the long term, ELJs will promote channel complexity by

splitting flow and encouraging natural processes driving the formation of habitat elements such as pools and side channels. Diversification of available habitats will increase the carrying capacity of juvenile salmonids and increase the number of pools for holding adults.

4.1.2.3 Potential Challenges

The project area covers more than 1 river mile and multiple access routes will be required to place LWD. Some trees and other existing vegetation may be disturbed in the process of gaining access to and placing the LWD structures.

4.2 Project Area 2 (River Mile 49.1 to 48.65)

Project Area 2 (PA-2) is located within the channel and floodplain on public land from an undeveloped campground at RM 49.1 to approximately RM 48.65.

Table 4-2
Restoration Recommendations for Project Area 2

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Maintain natural channel and floodplain processes primarily in the lower half of the mainstem and through the existing channel in the right floodplain.
2. Reconnect isolated habitats	Reconnect an approximately 1,410-linear foot channel with a 200 linear foot excavation, and supplement with groundwater.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	No significant infrastructure was identified that impairs natural processes.
4. Restore riparian processes	Install supplemental plantings as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout 0.2 river miles as needed when associated with other restoration actions in the project area.

4.2.1 Site Description

4.2.1.1 Channel Characterization

The channel through PA-2 is characterized as a single-thread, plane-bed channel from RM 49.1 to 48.95. Downstream of RM 48.65 the channel contains a moderate amount of LWD that initiates an anastamosing channel with multiple pathways and a high amount of temporary sediment storage. Two rock weirs are located at the downstream end of the project area. Multiple side channels were observed during site reconnaissance. A large side channel diverts from the main channel near RM 48.85 and flows along the southwest valley wall. Instream habitat in the project area is generally good due to multiple off-channel areas that provide excellent juvenile rearing habitat and LWD that provides large holding pools, cover, and hydraulic refuge.

4.2.1.2 Floodplain Characterization

Floodplain connectivity appears to be unaffected by infrastructure in the project area. Remnant alluvial fan and hillslope deposits create a moderately high floodplain surface at the upstream end of the site. More recent alluvium composes the low floodplain downstream of approximately RM 49.0. A groundwater channel was identified in the floodplain, originating at approximately RM 49.05 at the toe of the high terrace. Because the water surface elevation in this channel was perched 1 to 2 feet above the water surface in the main channel, the source of the water was assumed to be a groundwater spring. The spring water flows parallel to the river along the base of the terrace and through the floodplain for approximately 550 feet until it meets the main channel near RM 48.95.

Two additional low-flow paths were identified in the floodplain. The first is a low depression just north of the spring channel near RM 48.95 that was dry at the time of observation. The second is located at the toe of the northern valley wall between approximately RM 48.95 and 48.7 and contained swampy flowing water with no clear source. The channel may be supplied by groundwater, hyporheic exchange, or more likely by water from narrow ephemeral drainages that outlet beneath Tucannon Road.

The riparian zone is generally in a moderately healthy condition, with local areas that have been degraded by development. Riparian trees are mixed deciduous and conifer, dominated

by Ponderosa pine and dogwood. Understory vegetation is generally thick and healthy, containing fern and saplings that provide overhanging shade in the spring channel (Photograph 4-2). Species are moderately diverse, but contain many invasive plants, including reed canarygrass, St. John's wart, teasel, and creeping buttercup.

Photograph 4-2
Vegetation on the floodplain at the existing spring channel near RM 49.0

The spring-fed wetland adjacent to the northeast valley wall is in moderately good health with ample shade and wood. The overstory is composed of a mixture of mature deciduous and conifer trees and several saplings. The understory is generally healthy and dominated by rushes, sedges, and ferns. Vegetation diversity is high and disturbance is low. At RM 48.8, there is another wetland with dense, healthy vegetation that provides shade and cover.

4.2.2 Conceptual Project Actions

Restoration actions in PA-2 involve routing the existing spring-fed channel north through the floodplain and into the roughly 1,400-foot channel along the northern edge of the valley (Figure B-2). The realigned channel may be supplemented with additional LWD or plantings at the time of construction. The two rock weirs at the downstream end of the project area would be supplemented with LWD.

4.2.2.1 Geomorphic Implications

The project is not expected to have significant geomorphic implications. Placing LWD in the main channel will promote local channel expansion and hydraulic complexity.

4.2.2.2 Biological Benefits

Increasing the quantity and duration of flow in the side channel will provide additional off-channel habitat area for rearing juveniles. The groundwater spring will supply cool, flowing, and clean water through the channel that is currently slow-moving and swampy. The thick vegetation growing along the channel will provide greater cover and complexity than the channel in its current configuration, which will likely reduce predation. Placing LWD in the main channel and supplementing the weirs with LWD will provide cover and complexity and may create better juvenile passage.

4.2.2.3 Potential Challenges

A short but relatively deep excavation would be required to connect the spring source to the tributary-fed channel, although the spoiled materials could be easily distributed atop the floodplain. Some trees and other existing vegetation may be disturbed in the process of excavation. Because the tributary channel is located near the toe of the road prism, the impacts of road runoff should be considered during the design process.

4.3 Project Area 3 (River Mile 48.65 to 46.8)

Project Area 3 (PA-3) is located within the active channel from one-quarter mile upstream of Cow Camp Bridge (RM 48.65) to the upstream end of the Camp Wooten Environmental Learning Center (RM 46.8).

Table 4-3
Restoration Recommendations for Project Area 3

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Maintain natural channel and floodplain processes throughout the project area.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 380 feet of riprap to re-establish floodplain connectivity of approximately 0.59 acres of low floodplain.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout 1.3 river miles; supplement the existing rock structure (weir) with LWD.

4.3.1 Site Description

4.3.1.1 Channel Characterization

The channel through PA-3 is characterized as a single-thread channel containing both plane-bed, and forced pool-riffle sections. Local steep rapids are present; in these sections, the thalweg is typically deep with high velocities. One rock weir and multiple rock and rootwad restoration features were identified in the project area. Other than rock armor along the Cow Camp Bridge abutments and an approximately 350-foot riprap bank downstream of the bridge near RM 48.3, no other significant infrastructure was identified in the channel. Only a few side channels were observed that appeared to provide minimal habitat benefit.

The availability and quality of instream habitat is limited by lack of complexity and hydraulic conditions that prevent the retention of sufficient volumes of LWD and sediment. The spatial distribution of existing LWD is limited. Large jams and sediment deposits are present but sporadic (Photograph 4-3); the log jams that were observed were typically associated with local areas of high temporary sediment storage, split flow, and side channels. However, the majority of the project area is made up of long, straight, plane-bed stretches that lack any adequate cover or hydraulic complexity.

Photograph 4-3
A channel-spanning log jam near RM 47.5

4.3.1.2 Floodplain Characterization

Throughout a majority of the project area, the channel is moderately entrenched between the bedrock valley wall and remnant alluvial fan and hillslope deposits, resulting in a relatively high floodplain surface. Thus, much of the valley floor is not within the low floodplain.

The influence of the riprap at RM 48.3 to floodplain connectivity does not appear to be significant, although the armoring likely prevents channel migration and transfers energy downstream along the left bank. A relatively low former channel position is located in the western portion of the floodplain between RM 48.2 and RM 48.1. Flowing water was

observed through the channel, although it was unclear if it was supplied by hyporheic exchange or a groundwater spring. No fish use was observed within this feature.

The riparian zone is in a moderately healthy condition, with local areas that have been degraded by infrastructure, fire, and development. Riparian trees are mixed deciduous and conifer, dominated by Ponderosa pine, alder, and dogwood. The banks upstream of the Little Tucannon River (RM 48.1) are dominated by alder saplings, grasses and other emergent vegetation, buttercup, and other invasive species. Downstream of RM 48.1, understory vegetation is thick and healthy and contains fern and saplings that provide overhanging shade in the channel. Species are moderately diverse but contain many invasive plants, including reed canarygrass, St. John's wart, teasel, and creeping buttercup.

4.3.2 Conceptual Project Actions

Restoration actions would involve placing LWD throughout the project area and supplementing the existing rock weir with wood (Figure B-3). Large woody debris may include a range of treatments, from placing single logs in side channels and alcoves to ELJs in plane-bed sections of the main channel. Additionally, the riprap bank between RM 48.3 and 48.2 would be removed to allow channel migration to occur through this area of the floodplain. Long-term planning should consider reconfiguration or replacement of the Cow Camp Bridge with a longer spanning bridge that would allow for better connectivity and ability to migrate across the low floodplain. The bridge is currently in disrepair.

4.3.2.1 Geomorphic Implications

Addition of LWD will initiate a geomorphic response resulting in bank erosion, bed scour, and sorting of sediment, which form critical habitat features (e.g., pools, cover, and spawning gravels). Over time, the large ELJs will promote retention of bedload sediment throughout the project area, reversing some of the effects of channel entrenchment. Log jams will also promote development of a more complex channel network by splitting flow, initiating island development, and promoting channel migration. Removal of the riprap bank will additionally allow natural channel processes such as migration to occur.

4.3.2.2 Biological Benefits

Adding complexity to the reach via LWD will provide hydraulic diversity and refuge in the mainstem, significantly improving habitat conditions for juveniles. In the short term, the pools that form at the structures will increase the available area for holding in the project area. Increased hydraulic diversity will provide high-flow refuge and low-flow cover for juveniles. The structures will also increase sediment retention, enhancing the size and quality of spawning areas. In the long term, ELJs will promote channel complexity by splitting flow and encouraging natural processes that drive the formation of habitat elements such as pools and side channels. Diversification of available habitats will increase the carrying capacity of juvenile salmonids and increase the number of pools for holding adults. Riprap removal will decrease velocities along the face of the bank and promote natural channel processes.

4.3.2.3 Potential Challenges

The project area is approximately 2 river miles long and multiple access routes will be required to place the LWD. Some trees and other existing vegetation may be disturbed in the process of gaining access to the riprap removal and LWD placement sites, particularly within the more heavily wooded area upstream of the Little Tucannon River. Downstream of this location, the lack of understory will make for easier access, although some existing vegetation will likely be disturbed. Any wood that must be removed for access may be incorporated into the LWD placements or used to decommission access routes.

4.4 Project Area 4 (River Mile 46.8 to 46.4)

Project Area 4 (PA-4) is located within the active channel and in the floodplain adjacent to the Camp Wooten Environmental Learning Center between RM 46.8 and 46.4.

Table 4-4
Restoration Recommendations for Project Area 4

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Maintain natural channel processes occurring upstream of RM 46.6 and the tributary/floodplain channel habitat on the south side of the floodplain.
2. Reconnect isolated habitats	Excavate approximately 260 linear feet to reconnect 820 linear feet of additional side channel; enhance 1,970 feet of existing channel by increasing flow in the side channel for a greater time period.
3. Address roads, levees, other anthropogenic infrastructure impairing processes	Set back approximately 670 feet of the levee (includes the gravel road) to reconnect approximately 1.6 acres of low floodplain.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout 0.45 river miles in the project area.

4.4.1 Site Description

4.4.1.1 Channel Characterization

In the upper portion of the project area from RM 46.8 to 46.65, the river contains multiple rapid/run channels separated by forested islands. Downstream of RM 46.65, the river and floodplain are highly confined between a levee and the road grade, which has resulted in a single-thread, high-velocity channel with large armor substrate and angular riprap banks (Photograph 4-4). The levee on the right bank currently serves as an access road to the upstream side of the Camp Wooten facilities, including Donnie Lake. The lake outfall channel flows along the toe of the road, meeting the main channel at approximately RM 46.55. Several juvenile fish were observed in the outfall channel. It is not clear if the pond itself is spring-fed or receives water via diversion from the river.

Photograph 4-4
PA-4 near RM 46.5, looking downstream from the right bank levee

The quality of instream habitat in this project area is limited by the lack of hydraulic and bedform complexity in the channel. In the upper multiple-thread channel, some mobile debris has accumulated at the apex of islands and along the channel margins. The different flow paths create variable hydraulic conditions that are likely to be active year-round. Although a few trees were observed in the lower portion of the channel, the high-velocity conditions likely prevent any retention of mobile debris or sediment deposition, and these trees likely will be transported downstream during the next high-flow event.

4.4.1.2 Floodplain Characterization

Floodplain connectivity is greatly limited by the right bank road levee, which confines the channel to the left side of the valley and cuts off a majority of the floodplain to the right. A

large amount of low floodplain area and low-lying channel paths exist within the cutoff portion of the floodplain. One of these channels originates on the downstream side of the levee near RM 46.6 and flows through the camp on the southeast side of the valley. During field observation, the channel was dry at the upstream end and became wetted where a tributary meets the main valley at approximately RM 46.5; this tributary may be spring-fed, as indicated on U.S. Geological Survey (USGS) topographic maps (cite), although it was unclear if the flow is perennial due to the unusually wet conditions at the time of observation. The floodplain channel continues through the floodplain and does not flow into the main channel until approximately 0.9 RM downstream of the project area, gaining additional tributary flow along the way.

The riparian zone is generally in a moderately healthy condition, where it has not been cleared or disturbed for development of the Camp Wooten site and for other recreational use. The most notable area of disturbance is associated with the levee near RM 46.5. Riparian trees are predominantly immature deciduous trees, with very few mature or coniferous trees in the area. Understory vegetation upstream of the levee contains shrubs such as flowering dogwood that provide overhanging shade and leaf drop. Downstream of the levee where the channel is more confined, the riparian zone narrows to approximately 5- to 10-feet wide and vegetation limited with little overhang. In the overall project area, species are moderately diverse. The levee zone contains a high number of invasive species, including St. John's wart, common teasel, Himalayan blackberry, and Robert's geranium, Mullein and reed canarygrass grow atop much of the open area in the active channel.

4.4.2 Conceptual Project Actions

Upon discussion with several stakeholders, including the entities that operate and maintain Camp Wooten, it is understood that removal or significant modification of the facilities are not desired at this time. Restoration actions in PA-4 involve re-establishing a side channel through the disconnected floodplain, setting back a portion of the levee between RM 46.6 and 46.4 to ease channel confinement, and placing LWD (Figure B-4). Flow to the floodplain channel would be achieved by re-routing outfall of the pond. A culvert would be placed through the levee to connect the upstream and downstream ends of the side channel. The northwest corner of the road and levee around the camp would be set back to the edge of the

floodplain terrace. This action would require four portable cabins and a few small outbuildings to be relocated elsewhere on the site.

4.4.2.1 Geomorphic Implications

Widening the floodplain corridor via levee setback would significantly increase the width of the floodplain corridor and remove confining features that affect instream hydraulics and geomorphic processes. During high flows, dispersion of floodwaters over this area would significantly decrease velocities in the main channel and allow for dispersion of overbank sediments and mobile debris. Over time, the channel will have a greater capacity to establish a more natural channel configuration and ability to retain wood and store sediment. Establishing the side channel through the floodplain is not expected to have significant geomorphic implications.

4.4.2.2 Biological Benefits

Biological benefits include decreased instream velocities and increased complexity. Increased flow in the approximately 2,000-linear-foot side channel will increase the juvenile carrying capacity. In the long term, re-establishing and enhancing floodplain processes via levee setback will promote wood and sediment retention and increase the presence of side channels and diverse instream complexity.

4.4.2.3 Potential Challenges

Implementing this project will require some modifications to Camp Wooten and will cause disturbance during construction activities. The project would require a significant amount of earthwork, though much of the excavated material would be re-used to build the setback levee or dispersed on site. Trees and other vegetation on the portion of the levee that is setback would be removed, but the material may be incorporated into other habitat features. Because the current levee was built and is maintained by the U.S. Army Corp of Engineers (USACE), the setback levee will likely require USACE consultation and adherence to their standards. Some trees and other existing vegetation in the floodplain may be disturbed in the process of gaining access to the channel to place LWD at the upstream end of the site.

4.5 Project Area 5 (River Mile 46.4 to 45.95)

Project Area 5 (PA-5) is located within the active channel from the downstream end of the Camp Wooten Environmental Learning Center (46.4) to the Tucannon Campground Bridge at RM 45.95.

Table 4-5
Restoration Recommendations for Project Area 5

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Maintain natural channel and floodplain processes through naturally functioning areas. Protect the existing side channel along the SE valley wall.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, other anthropogenic infrastructure impairing processes	Remove approximately 2,330 feet of roadway that separates the main channel from approximately 9.27 acres of low floodplain and establish alternate bridge access to Camp Wooten. Remove approximately 990 feet of levees and riprap banks between RM 46.4 and 46.2 to reconnect approximately 1.5 acres of low floodplain; approximately 95 feet of levee will be set back along the Camp Wooten loop.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout 0.5 river miles.

4.5.1 Site Description

4.5.1.1 Channel Characterization

Throughout the project area, the river is characterized by multiple channels separated by unvegetated gravel bars or forested islands. This portion of the channel is located downstream of a tightly confined section (PA-4). The active channel area is relatively wide and wood and sediment is more likely to deposit resulting in a relatively dynamic reach with a greater volume of LWD, temporary sediment storage, and channel migration than has been observed in upstream reaches (Photograph 4-5). Steady migration of meander bends was observed in many of the outside meander bends, most notably at RM 46 along the left bank. Side channels ranging from perennial to high-flow were observed with variable depths and

presence of LWD. Many side channels, however, were relatively wide, shallow, and lacking complexity.

Photograph 4-5
A secondary flow path within PA-5 near RM 46.1, looking downstream

The variety of hydraulic conditions created by channel processes, wood, and sediment in this project area create relatively good instream habitat conditions. Overall, however, the project area is lacking in sufficient volume and size of LWD. The log jams observed did not appear substantial enough to persist and retain additional LWD over time.

4.5.1.2 Floodplain Characterization

Floodplain connectivity in this project area is highly affected by the presence of infrastructure. Approximately half of the low floodplain area, including a major former

channel position along the southeast valley wall, is cut off from the river by the road connecting the Tucannon Campground to Camp Wooten. The side channel was flowing at the time of field observation, which was likely from tributary inputs (Hixon and Grub canyons).

A hyporheic- or groundwater-fed channel was identified in the right floodplain near RM 46.4. At the time of observation, the channel flowed downstream to a dry side channel at approximately RM 46.3, where it became subsurface. The flow from this channel may be supplementing some standing water pools within the dry side channel, where several isolated juvenile salmonids were observed.

The riparian zone is generally in a moderately healthy condition, with local areas that have been disturbed by recreational use and development, such as the Tucannon Campground. There are very few mature or coniferous trees adjacent to the main channel. Understory vegetation includes groundcover, shrubs, and small trees that provide overhanging vegetation along the banks. Species are moderately diverse and contain only a moderate amount of invasive plants. Mullein and reed canarygrass grow atop a majority of the open areas in the active channel.

The vegetation surrounding the tributary-fed channel along the southeast valley wall downstream of Camp Wooten is generally in good health. Riparian trees are a mixture of deciduous and conifer species, including Ponderosa pine and cottonwood. Understory vegetation includes groundcover, shrubs, and small trees that provide ample overhanging vegetation. Species are diverse and contain few invasive plants. Several juvenile salmonids were observed in the channel.

4.5.2 Conceptual Project Actions

Restoration actions in PA-5 involve reconnecting the low floodplain via road removal and enhancing instream habitat by LWD placement (Figure B-5). These actions are independent from each other and may be implemented in phases. Road removal would occur from the intersection of the Camp Wooten loop (RM 46.4) to the intersection of the Tucannon Campground loop (RM 46.0). A new bridge crossing to Camp Wooten will be required

upstream. The location of the bridge may be affected by project actions associated with PA-4 (see Section 4.4).

4.5.2.1 Geomorphic Implications

Widening the floodplain corridor by removing the roadway would approximately double the accessible floodplain through the project area and allow natural floodplain and channel processes to occur. During high flows, dispersion of floodwaters over this area would decrease velocities in the main channel and allow for distribution of overbank sediments and mobile debris. Over time, the functionality of channel, floodplain, and riparian processes will be increased, in turn leading to ecosystem benefits. Addition of LWD will initiate pool scour, provide cover, retain sediment, maintain existing side channels, and increase hydraulic complexity. In the long term, large wood structures will form a complex channel network by maintaining and creating additional islands and promoting channel migration.

4.5.2.2 Biological Benefits

Biologic benefits include decreased channel velocities, better connectivity with the floodplain, and increased complexity and refuge related to LWD placement. Over time, greater floodplain connectivity will lead to a healthier riparian zone and in turn drive floodplain ecosystem processes. The LWD will promote channel complexity by splitting flow and initiating a geomorphic response that will create habitat elements such as pools and side channels. The diversification of available habitats will increase the carrying capacity of juvenile salmonids in the project area and increase the holding area for adults.

4.5.2.3 Potential Challenges

Road removal will require a significant amount of material be hauled off site. Implementing this project as shown requires the construction of a new bridge, which is expected to be a high-cost effort.

4.6 Project Area 6 (River Mile 45.95 to 45.3)

Project Area 6 (PA-6) is located within the active channel from the weir upstream of the Tucannon Campground Bridge (RM 49.95) to the former U.S. Forest Service (USFS) Road 140 crossing at RM 45.3.

Table 4-6
Restoration Recommendations for Project Area 6

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Protect natural channel and floodplain processes between RM 45.7 and 45.3, and within the tributary-fed channel along the southeast valley wall.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove the access road and bridge to the campground. Retire the campground and remove any infrastructure (including approximately 145 feet of levee) that may impact habitat conditions or impede natural processes.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD within approximately 0.2 RM; supplement existing rock structures (weirs) with LWD.

4.6.1.1 Channel Characterization

In the upper portion of the project area from RM 45.95 to 45.7, the channel is a single-thread, plane-bed channel with little complexity (Photograph 4-6a). Two vortex weirs between RM 46.0 and 45.8 hold the channel grade and form deep pools on the downstream end. This portion of the channel contains very little LWD or other hydraulic complexity, other than the pools at the weirs. Very little suitable habitat for juvenile fish was observed except near the channel margins. Habitat conditions may also be affected in the summer months by recreational use as this portion of the river is adjacent to the campground.

Photograph 4-6a
The plane-bed section of the channel during low flow near RM 45.8, looking upstream

Between RM 45.7 and 45.3, the channel is a more complex, multi-channel configuration with forced pools and riffles at LWD and along the bedrock valley wall (Photograph 4-6b). Instream habitat conditions in the main channel are generally good, due to the presence of large LWD that retains additional mobile wood and forces deep pools. Two large side channels that meet the main river at approximately RM 45.5 and RM 45.3 provide good off-channel rearing habitat with ample cover, depth, and low velocities.

Photograph 4-6b
A side channel with moderate woody debris near RM 45.4, looking downstream

4.6.1.2 Floodplain Characterization

Floodplain connectivity in this project area is adversely affected by the presence of the bridge and campground, which cut off approximately half of the low floodplain area. A major former channel position along the southeast valley wall is separated from the river by the campground area. Floodplain connectivity is less impacted from RM 45.8 through the downstream end of the project area, where no infrastructure is present. The portion of the floodplain between RM 45.5 and 45.3 is somewhat naturally confined by remnant alluvial fan and hillslope deposits from the northwest side of the valley.

The riparian zone is generally in moderate to poor health, with many dead or dying plants in the upstream end of the project area. Riparian trees are generally immature and sparse; some

larger deciduous shrubs are present, including flowering dogwood and vine maple. The understory is in moderate health but provides little overhanging vegetation. The dry exposed areas contain many invasive plants, including St. John's wart, reed canarygrass, and common teasel.

Towards the downstream end of the project area, the riparian zone is in moderately healthy condition. Riparian trees are mixed coniferous and deciduous, including Ponderosa Pine, alder, and dogwood. Understory vegetation includes groundcover, shrubs, and small trees that provide overhanging vegetation along the banks. Species are moderately diverse and contain a moderate amount of invasive plants such as reed canarygrass.

4.6.2 Conceptual Project Actions

Between RM 45.95 and 45.7, proposed restoration actions include retiring the campground, supplementing the existing weirs with LWD, and adding instream habitat and complexity with LWD placements (Figure B-6). Implementing this project in conjunction with PA-5 should be considered for optimum habitat and physical benefits; implementing both projects would allow the bridge to the campground to be removed. No active restoration is proposed within the project area between RM 45.7 and 45.3; this area should be protected as natural processes continue to create and maintain relatively good habitat conditions.

4.6.2.1 Geomorphic Implications

Retiring the campground is not expected to have significant geomorphic implications related to floodplain connectivity, unless the campground is removed as a part of road removal described in PA-5 (see Section 5.5). Implementing the two projects together would allow floodplain connectivity without risk to infrastructure. If the campground and bridge are removed, in addition to road removal, the benefits of the project to natural processes would be considerable. The channel would no longer be constricted at the bridge crossing and the channel would be able to freely migrate through the campground area, decreasing velocities and leading to more natural distribution of wood and sediment. Addition of LWD will develop instream complexity in the wide, shallow portions of the project area by initiating bed scour and sediment deposition and developing pools and velocity shadows. In the long

term, large wood structures will initiate formation of a more complex channel network by creating islands and promoting channel migration.

4.6.2.2 Biological Benefits

Immediate biological benefits of the project include decreased channel velocities during high flows from better connectivity with the floodplain, additional instream complexity, and pool development via LWD placement. Over time, greater floodplain connectivity will lead to a healthier riparian zone and, in turn, drive many ecosystem processes. The LWD will promote channel complexity by splitting flow and encouraging processes such as pool scour to create hydraulic complexity where it is lacking in the plane-bed portion of the channel. Over time, the LWD will promote channel migration and other processes that drive the formation of habitat elements (e.g., pools and side channels), leading to a more complex channel network. The availability of more and diverse habitats will increase the carrying capacity for juvenile salmonids.

4.6.2.3 Potential Challenges

The Tucannon Campground is highly popular and generates a significant amount of revenue for the USFS; retiring the campground may not be desired. However, an alternate action would be to convert the campground to a primitive walk-in site with access from Camp Wooten or from another location downstream. This would allow removal of infrastructure (including removal of the bridge if combined with PA-5), while maintaining revenue and promoting diverse use of USFS properties. Retiring or conversion of the campground may require relocation of the facility or other means of assurance that lost revenue can be recovered.

4.7 Project Area 7 (River Mile 45.3 to 44.85)

Project Area 7 (PA-7) is located within the active channel and floodplain from the former USFS Road 140 crossing at RM 45.3 to the Curl Lake intake structure at RM 44.85.

Table 4-7
Restoration Recommendations for Project Area 7

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Natural processes are impaired in this project area.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 2,700 feet of Tucannon Road and relocate approximately 2,470feet of the road between RM 45.3 and 44.85; remove approximately 340 linear feet of riprap and other infrastructure.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout approximately 0.5 river miles.

4.7.1 Site Description

4.7.1.1 Channel Characterization

Within this project area, the channel is a single-thread, plane-bed channel with local rapid sections. Between RM 45.2 and 45, the channel is entrenched and incised between alluvial fan deposits and Tucannon Road, which appears to be built mostly on remnant fan deposits. An approximately 10-foot high bank between RM 44.9 and the Curl Lake intake also indicates an incised condition (Photograph 4-7). The section of the channel between RM 45.3 and RM 44.9 contains multiple rock and rootwad restoration features that force pools along the margin of the channel. Immobile boulders in the channel bed also provide a minor amount of pool formation and hydraulic complexity. Some riprap is present along the channel banks between RM 45.1 and 45.05, although it likely has no effect on channel migration in its currently entrenched state. At the Curl Lake intake, the channel is roughened with boulders and cobbles.

Photograph 4-7
An incised section of the main channel near RM 44.9, looking upstream

Between RM 45.3 and 44.9, the channel contains a moderate amount of LWD that provides some cover and hydraulic complexity to the channel in addition to the restoration structures. However, the confined condition of the channel through the project area results in a lack of side channels and likely concentrates velocities during high flows. Juvenile rearing habitat is severely limited by the lack of hydraulic refuge (e.g., off-channel areas and secondary flow paths). In addition, the hydraulic conditions likely prevent suitable spawning gravels from accumulating in the project area.

4.7.1.2 Floodplain Characterization

The limited floodplain connectivity in this project area is a product of the incision and high floodplain surfaces in this portion of the valley. However, Tucannon Road and the riprap present in the project area may limit the ability of the channel to migrate and develop low-lying floodplain areas, exacerbating the confined conditions. One potential side channel is present on the far southeast side of the valley that appears to have little connectivity to the channel; it is likely a drainage pathway for tributaries. A former mill pond located in the left floodplain between the channel and Tucannon Road at RM 45.3 contains wetland vegetation and standing water. Small trees are growing within the pond bottom and around the margins.

The riparian zone is generally in a moderately healthy condition. Riparian trees are a mixture of coniferous and deciduous species, predominantly young to mature Ponderosa pines, and alder and other hardwoods. The understory is in moderate health, dominated by immature trees and woody shrubs that provide some amount of overhang. A few local exposed areas contain many invasive plants, primarily reed canarygrass and other weedy species.

4.7.2 Conceptual Project Actions

Restoration actions would involve relocating Tucannon Road to the west side of the Tucannon Guard Station between approximately RM 45.3 and 44.85 and removing any riprap or other infrastructure in the project area (Figure B-7). A former road grade is located up the hillslope that may be an ideal location to relocate the road alignment. LWD would be placed throughout the channel and would likely need to be placed in large, stable complexes to withstand hydraulic forces and initiate a geomorphic response.

4.7.2.1 Geomorphic Implications

While road removal will not reconnect low-lying floodplain, the channel will have the ability to migrate into the floodplain material and adjust its planform to a more natural configuration. Installing LWD complexes will initiate a geomorphic response by scouring pools, promoting channel migration, and expanding the width of the active channel. As additional LWD material is retained in the project area, the active channel will be widened

and the bed elevation will increase, promoting improved connectivity with the floodplain through time.

4.7.2.2 Biological Benefits

Immediate biological benefits of the project include high-flow refuge, low-flow cover, and pool development from LWD placement. Over time, the LWD will promote the formation of habitat elements (e.g., pools and side channels), leading to the development and maintenance of diverse habitats that will support salmonids throughout various life stages. Reversing the incised condition of the channel will lead to better floodplain connectivity, in turn creating a healthier riparian zone and distribution of water and sediment across the floodplain that drives many ecosystem processes.

4.7.2.3 Potential Challenges

Road realignment will likely be an involved process with several stakeholders and regulatory agencies. Road and building relocation associated with the Guard Station may be not be desired by forest and recreational managers. Implementation may be a long process and should be initiated early. This portion of Tucannon Road has been considered by the USFS for relocation in the past; the cost-benefit analysis was determined to be inadequate to complete the project.

4.8 Project Area 8 (River Mile 44.85 to 44. 4)

Project Area 8 (PA-8) is located within the active channel and floodplain from Curl Lake intake structure at RM 44.85 to downstream of Curl Lake at RM 44.4.

Table 4-8

Restoration Recommendations for Project Area 8

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Natural processes are impaired in this project area.
2. Reconnect isolated habitats	Establish a better connection between the spring, the wetland, and the river with a shallow excavation to create a total of approximately 990 linear feet of spring-fed side channel; reposition the outfall through the floodplain channel to provide 546 feet of additional off-channel habitat.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 680 feet, and setback approximately 330 feet, of rock and levee material to re-establish floodplain connectivity of approximately 1.01 acres of low floodplain.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout approximately 0.3 river miles of the mainstem.

4.8.1 Site Description

4.8.1.1 Channel Characterization

Throughout the project area, the single-thread channel is typically wide, shallow, and plane-bed. A few local high-velocity areas occur along the toe of the bedrock valley wall (Photograph 4-8). Levees are present along much of the left bank, confining the active channel and low floodplain to the far side of the valley. No side channels or secondary flow paths were identified. A large ELJ is present on the right bank at RM 44.8 and provides some cover and pool habitat. The channel contains little other LWD except small, transient material. Although juvenile fish may use the shallow margins of the channel, the lack of cover, complexity, and pools results in generally poor habitat conditions throughout this section of the river.

Photograph 4-8
The mainstem channel near RM 44.7, looking downstream

4.8.1.2 Floodplain Characterization

Floodplain connectivity in this project area is poor due the incised condition of the channel and the presence of infrastructure that confines and disconnects the channel from a majority of the low-lying floodplain. A narrow corridor of low floodplain is present from approximately RM 44.8 to the Curl Lake outfall at RM 44.55, but it is cut off from the channel by levees. A groundwater spring located near RM 44.85 appears to originate west of Tucannon Road, where several wetland plants were observed but no flowing water. East of the road, the spring becomes a surface water channel, eventually flowing into a wetland near RM 44.75. The channel is lined with ferns, sedges, and rushes that provide good shading and cover. The spring flows into a portion of the disconnected low floodplain, consisting of a

muddy to ponded wetland area vegetated with rushes, sedges, ferns, and cattails. Several dead or dying trees are present in this area. The spring channel has a poor downstream connection with the river and no fish were observed in the channel.

Adjacent to Curl Lake, another disconnected floodplain area is present that is fed by seepage through the lake berm. The water accumulates into a small side channel and meets the river near RM 44.6, providing a minor amount of off-channel habitat. Downstream of Curl Lake, a ponded wetland dominated by cattails and grasses makes up a majority of the floodplain. Trees and other cover or shading is sparse.

In general, the riparian zone is in a moderately healthy condition, but conditions adjacent to the main channel provide little cover or shading. Few mature riparian trees are present along the channel margins. Riparian trees in the project area consist of young to moderately mature Ponderosa pines, dogwood, and alder. The understory is moderately dense and dominated by emergent vegetation that provides little overhang. Understory species are moderately diverse but contain several invasive plants, including St. John's wart, common teasel, Himalayan blackberry, sulfur cinquefoil, and reed canarygrass.

4.8.2 Conceptual Project Actions

Restoration actions in the project area involve creating a better connection between the spring flow, wetlands, and river to optimize the quantity of available off-channel habitat (Figure B-8). Levees and bank armoring will be removed to reconnect the low-lying floodplain and materials will be placed along the Curl Lake berm. LWD placement in the main channel is recommended. In addition, the outfall may be re-positioned so that the flow is routed out through the floodplain downstream of the lake, creating additional off-channel area. Because of the lack of cover in this area, LWD (single logs or similarly small placements) should be placed to provide cover, and willows or other shrubs should be planted to shade the channel.

4.8.2.1 Geomorphic Implications

LWD in the main channel will diversify the thalweg and initiate development of bedforms such as pools and gravel bars in the plane-bed channel. When the levees are removed, the

LWD will initiate split flows and development of a more complex channel network as the channel is able to migrate and overtop its banks into the low-lying floodplain. Creating a better surface water connection between the groundwater spring and the main channel is not expected to have significant geomorphic implications.

4.8.2.2 Biological Benefits

Relocation of rock and levee material to the toe of the existing lake berm will open up low wetland areas that are currently disconnected from the main channel. These areas will provide excellent off-channel habitat for juvenile fish. The channel will have a greater floodplain connectivity and ability to migrate, creating additional habitat areas over time via natural disturbance that creates habitat complexity. LWD in the main channel will provide adult holding, high-flow refuge, and cover for juveniles.

Connecting the channel to the groundwater spring will supply cool, flowing, and clean water through the channel and reconnected wetland area, providing temperature refuge and off-channel habitat that is preferred by juvenile fish. The wood debris and thick vegetation currently growing along the groundwater channel will provide good cover and complexity, as well as nutrients and protection from predators. Positioning the lake outfall through the floodplain will create additional off-channel habitat that will likely be highly utilized by juveniles if adequate cover and shading are provided along the channel.

4.8.2.3 Potential Challenges

Careful consideration must be given to the placement of materials along the Curl Lake berm to maximize the protection they may provide if the mainstem channel moves into this location in the future. Some trees and other existing vegetation (including wetland areas) will likely be disturbed in the process of proposed restoration actions, particularly levee removal and repositioning the lake outflow through the wetland/floodplain. Excavation required to connect the spring source to the main channel is expected to be minimal but will disturb some existing wetland area.

4.9 Project Area 9 (River Mile 44.4 to 44)

Project Area 9 (PA-9) is located within the active channel from just downstream of Curl Lake at RM 44.4 to RM 44.0.

Table 4-9
Restoration Recommendations for Project Area 9

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Maintain natural channel and floodplain processes throughout the project area.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove Big Four Lake and associated intake structure (approximately 2,560 linear feet) to re-establish floodplain connectivity downstream of the lake.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout approximately 0.6 river miles in the project area.

4.9.1 Site Description

4.9.1.1 Channel Characterization

Throughout PA-9, the river is characterized by multiple-channel pathways containing a variety of hydraulic conditions forced by the presence of LWD, including several pools and secondary flow paths (Photograph 4-9). Local channel expansion is occurring in the project area from just upstream of RM 44.4 to RM 44.25, as evidenced by bank erosion and multiple-flow path development, recently recruited trees in the channel and side channels, and high amounts of temporary sediment storage. A levee is located along the right bank from approximately RM 44.4 to RM 44.3 at the diversion structure to Big Four Lake. The structure is composed rock armoring and some rootwads along the toe. The channel adjacent to the levee is wide, shallow, and relatively well-armored due to locally high velocities. A straight, plane-bed stretch of channel adjacent to Big Four Lake near RM 44.1 had a well-armored bed lined with large cobbles. In general, the project area has good side channel

connectivity and contains a variety of side channel types from perennial to high-flow pathways.

Photograph 4-9
Deep pools and complex hydraulic conditions caused by LWD, near RM 44.4

The complex sections of channel within this project area provide a variety of hydraulic conditions, including a relatively high amount of off-channel habitat, that provide preferred habitat throughout different life stages over the water year. Instream habitat conditions in the main channel are generally good in these complex sections due to the presence of large LWD that retains additional mobile wood, forces deep pools, forms side channels, and provides cover and hydraulic refuge. These areas have several well-connected side channels and a wide active channel and floodplain, which allow the channel to migrate. However, the plane-bed sections of the project area lack a sufficient volume and size of LWD necessary for

instream complexity, which has led to wide, shallow conditions during low flows and high velocities during seasonal high flows. The LWD observed in these reaches did not appear substantial enough to persist and retain additional LWD over time.

4.9.1.2 Floodplain Characterization

This project area is characterized by a large active channel area but little floodplain connectivity. The floodplain surface is relatively high above the channel bed with a small amount of low floodplain area throughout the valley. The right bank levee at RM 44.35 likely prevents channel migration, but it does not cut the channel off from any significant low areas of the floodplain (within the 5-year water surface elevation). Big Four Lake is approximately two-thirds of the width of the valley, confining the potential width of the floodplain corridor. A large amount of low floodplain exists on the downstream side of the lake, which contained flowing water at the time of field observation that was likely sourced from lake seepage or tributary flow. The current position of the lake prevents an upstream surface water connection to this area.

The riparian zone is generally in moderate health, with some local areas that have been highly disturbed by fire. Riparian trees are predominantly mature Ponderosa pines and young dogwoods and alders. The understory is in moderate health dominated by emergent vegetation that provides little overhang. There are few mature trees and intermediate-sized plants and poor vegetation diversity in several areas. The upstream end of the severe burn zone from the 2005 School Fire begins at the downstream end of the project area (approximately RM 44.0). Many invasive plants were identified that were prominent in local areas, including reed canarygrass, evergreen blackberry, common teasel, Robert's geranium, sulfur cinquefoil, horsetail, and creeping buttercup.

4.9.2 Conceptual Project Actions

Restoration actions in PA-9 include removal of Big Four Lake and associated infrastructure, including the armored levee and intake structure at RM 44.35, and decommissioning the parking area near RM 44.2 (Figure B-9). Upon removal of the lake infrastructure, the plane-bed sections of the channel would be supplemented with LWD to provide instream complexity in these areas and to promote maintenance of the complex channel network that

is developing through the project area. LWD may include a range of treatments, from placing single logs in side channels and alcoves to larger ELJs.

4.9.2.1 Geomorphic Implications

In the short term, the addition of LWD to the main channel will force deep pools, sort sediment, and diversify the thalweg to create hydraulic diversity in plane-bed sections of the channel. Over time, the added LWD and the wood that is currently accumulating in the more complex sections of the project area will retain and distribute wood and sediment throughout the active channel, leading to increased channel complexity and floodplain connectivity. Removal of Big Four Lake will widen the low floodplain area and will allow better access for floodwaters to the floodplain on the downstream side of the lake.

4.9.2.2 Biological Benefits

Adding hydraulic complexity via LWD will form scour pools, increasing the available area for adult holding in the project area. The hydraulic diversity created by the structures will provide high-flow refuge and low-flow cover for juveniles where it is lacking in plane-bed sections. The structures also sort bedload sediment, promoting the development of spawning areas, and promote channel complexity. In the long term, these features will help maintain complex habitat in the project area to support the survival of juvenile salmonids and the productivity of adults.

4.9.2.3 Potential Challenges

Removing Big Four Lake may be undesirable for recreational managers as it will reduce public fishing options. However, Big Four Lake is currently threatened by potential flooding damage and is being considered for modification or removal (WDFW 2010). Removing the lake and regrading the area will require careful consideration of water source areas to the lake to maximize the future benefits from the lake area. In addition, the area should be carefully sloped so that floodwaters can recede without stranding juveniles.

5 REACH 9 CONCEPTUAL PROJECTS

Reach 9 is located from RM 44.0 near Big Four Lake to the hatchery dam at RM 40.0 (Figure 2). The reach spans the National Forest boundary at approximately RM 41.4. The reach is important for steelhead and spring Chinook, particularly for steelhead rearing and spring Chinook spawning and rearing.

The portion of the main channel riparian zone from approximately RM 40.4 to 42.8 was moderately to severely burned in the 2005 School Fire and all of the subbasins draining into Reach 9 were moderately to severely burned, including the Waterman Gulch and Big Four Canyon areas (USFS 2008). The portion of the valley that was not burned is primarily conifer forest with sparse undergrowth. No major hydrologic inputs are located in Reach 9 and a vast majority of the reach was identified as a losing reach (HDR 2006).

Approximately half of the length of the reach is unconfined by infrastructure and the other half is moderately confined. Although some portions of the reach are relatively dynamic in terms of channel planform and migration, many areas are incised and lack channel complexity and good floodplain connectivity. Channel confinement is also related to the road, to the berms around Watson and Beaver lakes, and to narrow portions of the valley created by alluvial fans and bedrock outcrops (e.g., RM 42.8).

Three conceptual project areas were identified in Reach 9. The primary restoration strategies focus on adding LWD, restoring riparian areas, and removing confining infrastructure. These actions are consistent with the limiting factors identified in the EDT analysis of key habitat quantity and increasing riparian function (Appendix J, CCD 2004). LWD will provide a greater quantity of holding areas by initiating pools and will contribute to reversing the incised condition of much of the channel that will eventually lead to better connectivity of riparian vegetation with water table and bank overtopping. Removal of confining infrastructure will reconnect low-lying areas of the floodplain, initiating recovery of riparian vegetation. Over time, these actions will allow the development of channel complexity and long-term creation and maintenance of habitat features such as pools and off-channel areas.

5.1 Project Area 10 (River Mile 44 to 42.4)

Project Area 10 (PA-10) is located within the active channel from just upstream of the North South Campground at RM 44 to one quarter-mile upstream of the Beaver/Watson lakes intake structure at RM 42.4.

Table 5-1
Restoration Recommendations for Project Area 10

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Maintain natural channel and floodplain processes in the recovering area between RM 43.85 and 43.65.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, other anthropogenic infrastructure impairing processes	Remove approximately 1,300 feet of levee infrastructure affecting channel and floodplain processes to re-establish floodplain connectivity to approximately 5.83 acres of low floodplain.
4. Restore riparian processes	Restore and re-vegetate riparian areas throughout the burn zone in the project area (approximately 40 acres).
5. Improve instream habitat conditions	Place LWD throughout 1.5 river miles.

5.1.1 Site Description

5.1.1.1 Channel Characterization

The channel through PA-10 is typically a single-thread, plane-bed channel. The channel contains very little hydraulic complexity and is highly incised throughout a majority of the project area. One section of the project area between approximately RM 43.85 and 43.65 is a highly dynamic, aggrading channel containing many flow paths forced by LWD that has been placed by the WDFW in previous years. The downstream sections of the project area are more characteristic of a single-thread channel with forced pools and riffles (Photograph 5-1). In addition to the placed LWD, rock/rootwad placements and other rock structures such as barbs were observed in a few locations. Multiple armored rock and "sugar dike"-style levees were observed throughout the project area from approximately RM 43.1 to 42.85. The left bank levee at RM 42.9 confines the channel against the valley wall at Waterman Creek, resulting in a deep, narrow, rapid section with high velocities. The upstream end of the

project area to approximately RM 43.1 contains a moderate amount of well-connected side channels, including a long, perched channel that appears to convey water from the downstream end of Big Four Lake and likely drains several tributaries. Downstream of RM 43.1, the project area contains few off-channel areas and little hydraulic complexity.

Photograph 5-1
A section of the main channel in PA-10 near RM 42.6

With the exception of the section of the channel between RM 43.85 and 43.6, the availability and quality of instream habitat in the project area is limited by lack of channel and hydraulic complexity, particularly downstream of RM 43.1 where the channel contains very little LWD. Although a few large downed logs were observed that provide some cover and holding habitat, these logs typically did not retain adequate wood or sediment to provide quality instream habitat. In addition, there are very few off-channel areas or secondary flow

paths available for juvenile fish to rear and seek refuge in the downstream end of the project area. The incised condition of the channel has resulted in limited floodplain connectivity. With little side channel habitat availability or floodplain connectivity, there is a lack of hydraulic refuge. The project area also lacks adequate shading along the river banks due to the severe burn of the riparian zone that occurred during the 2005 School Fire. In the long term, the lack of LWD recruitment from having no mature riparian trees limits the quality of habitat in this project area.

5.1.1.2 Floodplain Characterization

Floodplain connectivity is generally poor due to the incised condition of the channel. Although the project area contains a large amount of low-lying floodplain, bank overtopping is likely infrequent. The outlet of Waterman Creek, a tributary near RM 42.9, was perched 1 to 2 feet above the water surface elevation in the main channel at the time of field observation. The influence of most of the levee features around RM 43.1 to 42.85 to floodplain connectivity appeared relatively insignificant, although these features may impede channel migration and exacerbate the incised condition of the channel. The left bank levee at approximately RM 42.9 does appear to confine the channel against the valley wall and disconnect it from the low-lying area in the left floodplain.

One large, low-lying area is located along the base of the southeast valley slope between RM 42.75 and 42.4. Slow-moving water was observed in the channel that was assumed to be draining small tributaries from the valley slope. The channel had a good downstream surface water connection to the main river but appeared quite disconnected from the main channel at the upstream end, even during high seasonal and frequent flood events (e.g., 2-year recurrence interval).

The riparian zone is generally in poor health as it has been highly disturbed by fire and incision has limited the availability of hyporheic groundwater exchange with riparian vegetation. Riparian trees are predominantly mature Ponderosa pines that have been severely burnt; a majority of the trees have fallen over, lost most limbs and needles, or are standing dead or dying. Young dogwoods and alders have begun to populate the area since the fire occurred. The understory is in poor to moderate health dominated by emergent

vegetation and grasses that provide little overhang. There are few intermediate-sized plants and generally poor vegetation diversity. The project area contains invasive plants including St. John's wart, reed canarygrass, common teasel, and mullein. Most of the off-channel areas containing flowing water are heavily vegetated with reed canarygrass.

5.1.2 Conceptual Project Actions

Restoration actions involve placing LWD structures and removing infrastructure as access conditions allow (Figure B-10). LWD may include a range of treatments; however, larger structures such as ELJs are recommended in this project area to achieve a desired geomorphic and biologic response. Those levees affecting channel and floodplain processes should be removed. Intensive riparian treatment is also recommended in this project area to address the severe fire damage to the riparian zone during the 2005 School Fire.

5.1.2.1 Geomorphic Implications

Intensive LWD placement throughout this project area will force pools and hydraulic variability in this dominantly plane-bed, simplified channel in the short term. Over the long term, large LWD placements such as ELJs will promote side channel development, retention of additional LWD, and bedload, building up the bed elevation to reverse its incised condition and increase floodplain connectivity. Developing a healthy riparian zone additionally benefits natural processes in the long term. The vegetation creates roughness along the banks and floodplain that slow velocities during high flows and trap LWD and sediment. Mature riparian trees provide a sustainable source of LWD to the channel.

5.1.2.2 Biological Benefits

Immediate biological benefits of the project include high-flow refuge, low-flow cover, and pool development from LWD placement. Over time, the LWD will promote the formation of habitat elements (e.g., pools and side channels), leading to the development and maintenance of diverse habitats that will support salmonids throughout various life stages. ELJs will promote channel complexity by splitting flow and retaining wood and sediment. In the long term, reversing the incised condition of the channel will lead to better floodplain connectivity, in turn creating a healthier riparian zone and distribution of water and sediment across the floodplain that drives many ecosystem processes.

Riparian planting in this project area will have beneficial long-term effects on channel and floodplain habitat quality. A well-vegetated riparian zone will provide nutrients in the form of leaf-litter and terrestrial insect drop to the system and will support both fish and other animals that interact within the ecosystem. Riparian trees and diverse overhanging vegetation provide shade along the channel banks that greatly contributes to reduction of in-stream temperatures during adult migration and juvenile rearing. Healthy riparian trees provide LWD to the channel, providing a natural source and sustainable driver for habitat complexity.

5.1.2.3 Potential Challenges

The project area is approximately 1.5 river miles in length and multiple access point will be required to distribute LWD throughout. Some trees and other existing vegetation may be disturbed in the process of gaining access to and placing the LWD structures. Riparian revegetation will require several years of maintenance and monitoring. Establishing vegetation may be difficult where the incised condition of the river limits hyporheic exchange to the riparian zone.

5.2 Project Area 11 (River Mile 42.3 to 40.7)

Project Area 11 (PA-11) is located within the active channel and floodplain from one quarter-mile upstream of the Beaver/Watson lakes intake structure (RM 42.3) to RM 40.7.

Table 5-2
Restoration Recommendations for Project Area 11

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Maintain natural channel and floodplain processes where applicable in the project area.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove/modify approximately 1,100 linear feet of infrastructure associated with Beaver and Watson lakes, the access bridge, and parking area to re-establish floodplain connectivity to approximately 1.43 acres of low-lying floodplain. The reconfiguration of Watson Lake will require the removal of approximately 1,540 feet of road, and 650 feet of road realignment to maintain access for stocking fish to both lakes.
4. Restore riparian processes	Restore and revegetate riparian areas throughout the burn zone in the project area (approximately 40 acres).
5. Improve instream habitat conditions	Place LWD throughout 1.8 river miles.

5.2.1 Site Description

5.2.1.1 Channel Characterization

The channel through PA-11 between approximately RM 42.3 and RM 41.4 is characterized as a single-thread, plane-bed channel with few LWD-forced pools (Photograph 5-2). The channel is relatively straight and somewhat incised and was likely channelized historically. Downstream of RM 41.4, a large log jam has initiated an anabranching channel pattern and that extends to the downstream end of the project area. This portion of the channel contains more diverse channel types, although it is also somewhat incised and lacking instream complexity. Three weirs are located adjacent to Watson and Beaver lakes, along with some rock and LWD placements along the banks at the lake access footbridge. An armored levee associated with the bridge and parking lot is located along the left bank from approximately RM 42.1 to 42. The intake for Deer Lake, which includes an armored levee, is located at the downstream end of the eastern split flow channel near RM 40.9. Few side channels were observed upstream of RM 41.4. Several flow pathways are present between approximately RM 41.4 and 41.1.

Photograph 5-2
The main channel in PA-11 near RM 41.75, looking downstream

The availability and quality of instream habitat is limited by lack of channel and hydraulic complexity. Little LWD is present in the project area; deep pools with cover were typically observed only at LWD and rock restoration features near the access footbridge. Within the upstream end of the project area, there are very few off-channel areas or secondary flow paths available for juvenile fish to rear and seek refuge. The incised condition of the channel provides little opportunity to disperse velocities during high flows. Without side channels or sufficient LWD, there is very little hydraulic refuge in the project area. Shading along the river banks is highly limited due to the severe burn of the riparian zone that occurred during the 2005 School Fire. The channel is open and exposed, with little cover provided by instream LWD.

5.2.1.2 Floodplain Characterization

Floodplain connectivity is limited by the incised condition of the channel, although the amount of low-lying floodplain in the project area is relatively high. Few levees or other confining features are present, except the infrastructure associated with Watson and Beaver lakes and the parking area, which confine the channel and accessible floodplain to a narrow corridor. The rock levee located from approximately RM 42.1 to 42.0 disconnects low areas of the left floodplain, which were occupied by wet, swampy areas at the time of field reconnaissance. Low-lying elevations located on the opposite (west) side of Tucannon Road from approximately RM 41.8 to 41.4 were observed to be dry with no indication of river connectivity or groundwater availability.

Tributary flow was observed in several locations that drained small tributaries along the east side of the valley; much of the water flows through small culverts and drains to the high terrace flanking the right side of the channel from Beaver Lake to approximately RM 41.3. Downstream of Watson and Beaver lakes, at approximately RM 41.9, a large cattail pond is located in the floodplain that is perched above the water surface elevation in the river channel.

The riparian zone is generally in poor health, as it has been highly disturbed by fire, and incision has limited the availability of hyporheic groundwater exchange with riparian vegetation. Riparian trees are predominantly mature Ponderosa pines that have been severely burnt; a majority of the trees have fallen over, lost most limbs and needles, or are standing dead or dying. Young dogwoods and alders have begun to populate the area since the fire occurred. The understory is in poor to moderate health, dominated by emergent vegetation that provides little overhang. There are few intermediate-sized plants and generally poor vegetation diversity. The project area contains invasive plants, including St. John's wart, reed canary grass, common teasel, and mullein.

5.2.2 Conceptual Project Actions

Restoration actions would involve placing LWD structures throughout the project area, supplementing existing rock structures with wood for added complexity, and modifying the Watson Lake footprint to provide a wider floodplain corridor (Figure B-11). LWD may

include a range of treatments, from placing single logs in side channels to ELJs in plane-bed sections of the main channel to initiate split flow through the low-lying floodplain. Modifying Watson Lake and re-aligning a portion of the fish-stocking road to both Watson and Beaver lakes is recommended to aid in the recovery of this project area and provide a wider corridor for flooding and future channel migration. This will allow the fish-stocking road between RM 42.2 and 41.9 to be decommissioned. Removal of the parking lot and associated levees on the west side of the river will also add to a wider corridor and ease confinement. The lakes may be converted to a wade-in fly fishing use to minimize impacts to the channel, and the parking area could be moved to the upland campground (Beaver Watson Campground). At the downstream end of project area, reconfiguration of the Deer Lake intake structure is also recommended to allow long-term evolution of the river through the large floodplain area downstream of the intake. Intensive riparian treatment is recommended in this reach to address the severe fire damage done to the riparian zone during the 2005 School Fire.

5.2.2.1 Geomorphic Implications

Because the lakes are located on a high terrace that appears to be relatively resistant, widening the floodplain corridor by modifying Watson Lake will likely not have immediate geomorphic implications. However, this action in conjunction with removal of the parking area and levees will allow greater floodplain connectivity and hydraulic diversity, and allow a wider corridor for future channel migration with less risk to infrastructure. LWD placement in this and other areas of the project area will force pools and hydraulic variability in this dominantly plane-bed, simplified channel in the short term. In addition, placing ELJs in strategic locations to promote side channel development will develop complex channel patterns over time. Over the long term, large LWD placements will promote retention of additional LWD and bedload, building up the bed elevation to reverse its incised condition and to increase floodplain connectivity. Developing a healthy riparian zone additionally benefits natural processes in the long term. Vegetation creates roughness along the banks and floodplain that slow velocities during high flows. Mature riparian trees provide a sustainable source of LWD to the channel.

5.2.2.2 Biological Benefits

Immediate biological benefits of the project include high-flow refuge, low-flow cover, and pool development from LWD placement. Over time, the LWD will promote the formation of habitat elements (e.g., pools and side channels), leading to the development and maintenance of diverse habitats that will support the salmonids throughout various life stages. ELJs will promote channel complexity by splitting flow and allowing the project area to retain wood and sediment. In the long term, reversing the incised condition of the channel will lead to better floodplain connectivity, in turn creating a healthier riparian zone and distribution of water and sediment across the floodplain that drives many ecosystem processes. Removing the levees at the lake access parking lot will allow greater floodplain connectivity, decreasing velocities in the main channel.

Riparian planting in this project area will have beneficial long-term effects on channel and floodplain habitat quality. A well-vegetated riparian zone will provide nutrients in the form of leaf-litter and terrestrial insect drop to the system and will support both fish and other animals that interact within the ecosystem. Riparian trees and diverse overhanging vegetation provide shade along the channel banks that greatly contributes to reduction of instream temperatures during adult migration and juvenile rearing. Healthy riparian trees provide LWD to the channel, providing a natural source and sustainable driver for habitat complexity.

5.2.2.3 Potential Challenges

Modifying Watson Lake may be undesirable for recreational managers as it will reduce the size of the lake. Removing the parking lot and bridge would likely require the lakes to be converted to a different use because of the change in access conditions (e.g., fly-fishing). Riparian revegetation will require several years of maintenance and monitoring. Establishing vegetation may be difficult where the incised condition of the river limits hyporheic exchange to the riparian zone.

5.3 Project Area 12 (River Mile 40.7 to 40)

Project Area 12 (PA-12) is located within the active channel and floodplain from RM 40.7 to the hatchery dam (RM 40).

Table 5-3
Restoration Recommendations for Project Area 12

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Protect natural channel and floodplain processes throughout the main channel.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	No significant infrastructure was identified that impairs natural processes.
4. Restore riparian processes	Restore and revegetate riparian areas throughout the burn zone in the project area (approximately 18 acres).
5. Improve instream habitat conditions	Place LWD within the side channel along the left valley floor through approximately 0.4 RM.

5.3.1 Site Description

5.3.1.1 Channel Characterization

The channel through PA-12 is relatively complex with many flow pathways through a relatively wide corridor; natural processes are occurring that are aiding in recovery through this area. No major infrastructure was observed within the channel, although the Hatchery Dam at the downstream end of the project area is a significant grade control. Several side channels were observed, a majority of which are initiated by LWD. An anabranching channel pattern is located between RM 40.5 and 40.1, where a significant side channel has cut through the floodplain along the left valley floor (Photograph 5-3). This channel runs below a power line adjacent to the road through a grassy area. Another major side channel observed between approximately RM 40.2 and 40.0 conveyed at least a third of the total discharge at the time of observation.

Photograph 5-3
The side channel in the west floodplain near RM 40.4, looking upstream

Instream habitat in PA-12 is currently limited but recovering. The project area contains a moderate amount of LWD that provides some amount of cover and initiates channel and hydraulic complexity. The most significant limitation is the lack of adequate shading, nutrients, and other elements provided by a healthy riparian zone, due to the severe burn that occurred during the 2005 School Fire.

5.3.1.2 Floodplain Characterization

Floodplain connectivity in PA-12 is moderate and appears to be relatively unaffected by infrastructure. Deer Lake occupies a portion of the right floodplain around RM 40.4, but the floodplain is not significantly constricted by the presence of the lake or associated infrastructure. A perched wetland pond is present on the downstream side of the lake berm.

Additional remnant levees or spoil piles are located in a few places; however, the influence of these features to natural processes appears to be insignificant.

The riparian zone is generally in poor health due to fire disturbance. Riparian trees are predominantly mature Ponderosa pines that have been severely burnt; a majority of the trees have fallen over, lost most limbs and needles, or are standing dead or dying. Young dogwoods and alders have begun to populate the area since the fire occurred. The understory is in poor to moderate health, dominated by emergent vegetation that provides little overhang. There are few intermediate-sized plants and generally poor vegetation diversity. The project area contains invasive plants, including St. John's wart, reed canarygrass, common teasel, and mullein. The downstream end of the project area between RM 40.2 and 40 has healthier riparian zone along the outside margin of the severely burned area of the School Fire.

5.3.2 Conceptual Project Actions

LWD will be placed within the side channel along the left valley floor (Figure B-12). The mainstem channel should be protected as natural processes continue to recover and generate improved habitat conditions. Intensive riparian treatment is recommended in this reach to address the severe fire damage and address temperature concerns.

5.3.2.1 Geomorphic Implications

No immediate geomorphic implications are expected as a result of this project, although placement of LWD within the large side channel will provide roughness, likely retain mobile wood, and reduce the likelihood that the side channel will develop into the mainstem channel. Over time, continued LWD and sediment retention will continue to promote instream and channel complexity. Developing a healthy riparian zone is a long-term benefit to natural processes. The vegetation creates roughness along the banks and floodplain that slow velocities during high flows. Mature riparian trees provide a sustainable source of LWD to the channel.

5.3.2.2 Biological Benefits

LWD in the side channel will provide cover and complexity that is currently lacking. Riparian planting in the burn zones will have beneficial long-term effects on channel habitat quality. A well-vegetated riparian zone will provide shade and nutrients in the form of leaf-litter and terrestrial insect drop to the system and will support both fish and other animals that interact within the ecosystem. Shading will reduce instream temperatures during the summer months. A long-term source of wood to the channel will create pools and cover and distribute wood to downstream reaches.

5.3.2.3 Potential Challenges

Riparian revegetation will require several years of maintenance and monitoring. Establishing vegetation may be difficult where the incised condition of the river limits hyporheic exchange to the riparian zone.

6 REACH 8 CONCEPTUAL PROJECTS

Reach 8 is located from the hatchery dam just upstream of Rainbow Lake (RM 40.0) to RM 32.1 (Figure 2). The upstream end of the reach is at the boundary of the area that was severely burned by the School Fire; it also marks a significant change in general channel patterns and confinement. Reach 8 is used by steelhead and spring Chinook for spawning and rearing habitat. There is a high density of steelhead rearing and spring Chinook spawning and rearing in the reach, and the lower portion of the reach is particularly important for juvenile rearing of both species, as well as for steelhead spawning. The reach is likely only used by bull trout during migration periods.

The valley in Reach 8 is occupied with wooded wetland and forested floodplain, while some farmsteads and fields are present up to the mouth of Cummings Creek at (RM 37.8) where the W.T. Wooten Wildlife Area begins. The Tumalum Creek and Cummings Creek drainages were affected by the 2005 School Fire, with the greatest impacts in the Cummings Creek basin (USFS 2008). Tumalum and Cummings creeks are both major hydrologic inputs within Reach 8. The reach is primarily a losing reach except for the section of the valley between the two tributaries that was identified as gaining (HDR 2006).

Reach 8 is primarily a single-thread channel with moderate confinement due to the presence of infrastructure, which includes levees and bank armoring. Floodplain connectivity is typically highly impacted in areas of confinement. Some locations are locally incised, further limiting connectivity. The downstream end of the reach between RM 33.1 and 32.1 is relatively unconfined with good floodplain connectivity and dynamic conditions.

Six conceptual project areas were identified in Reach 8. The primary restoration strategies focus on establishing floodplain connectivity and promoting channel complexity via infrastructure removal and LWD placement. Two areas of protection are also recommended where the channel is naturally recovering. Allowing channel migration and floodplain connectivity where possible and adding LWD in areas lacking instream complexity will address the habitat-limiting factor of key habitat quantity identified in the EDT assessment (Appendix J, CCD 2004). Over time, a more complex channel network will allow the

development of channel complexity and long-term creation and maintenance of habitat features such as pools and off-channel areas.

6.1 Project Area 13 (River Mile 40 to 39.2)

Project Area 13 (PA-13) is located within the active channel and floodplain from the Hatchery Dam at RM 40.0 to the hatchery access road bridge at RM 39.2.

Table 6-1
Restoration Recommendations for Project Area 13

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Natural processes are impaired in this project area.
2. Reconnect isolated habitats	Levee removal will reconnect approximately 3.91 acres of wetland habitat near RM 39.3.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 3,190 linear feet of levees to re-establish floodplain connectivity of 3.91 acres of low-lying floodplain. Set back approximately 760 feet of levees to allow better floodplain connectivity.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout approximately 0.7 river miles in plane-bed reaches.

6.1.1 Site Description

6.1.1.1 Channel Characterization

The channel through PA-13 is characterized as a single-thread, plane-bed channel with forced pool-riffle and local rapid sections (Photograph 6-1). The channel is typically straight, wide, and contains little complexity in much of the project area. Large levees confine the channel along the right bank from approximately RM 39.95 to 39.8, at RM 39.6, and from RM 39.5 to 39.2. The levees are typically heavily armored with large angular boulders. The hatchery dam at the upstream end of the project area controls the channel grade. At the time of field observation, the dam had an approximately 3-foot drop in water surface elevation with a deep plunge pool on the downstream side. No significant side channels or off-channel areas were observed in the project area at the time of field reconnaissance.

Photograph 6-1
The main channel near RM 39.6 just upstream of the large levee on the right bank, looking downstream

The quality and availability of instream habitat is restricted by the lack of channel and hydraulic complexity. The straight and confined channel results in hydraulic conditions that create high velocities and high transport capacity. These conditions do not support the retention of LWD and bedload, and, therefore, lack hydraulic complexity. A few downed logs and one log jam provide pools and cover in the actively eroding area near RM 39.7, but overall very few adequate pools for adult holding are available. The lack of side channels (except some apparent high-flow channels) limits the quantity of habitat for rearing juveniles.

6.1.1.2 Floodplain Characterization

Floodplain connectivity in this project area is affected by the presence of infrastructure, and little low-lying floodplain is present, except the area near RM 39.8 and 39.3, which is disconnected by infrastructure. Although there is not a high quantity of disconnected floodplain, likely because of local channel incision, the levees prevent channel migration and the development of gravel bars and low-lying emergent floodplain, which exacerbates the limited floodplain connectivity. Rainbow Lake, the public camping areas, and the access road to these areas are located atop a terrace and not within the low-lying floodplain.

The riparian zone is generally in moderately good health, except for along the levees, which are typically populated with invasive understory species. The left side of the channel and forested areas in the right (east) floodplain contain riparian trees that are mostly deciduous, dominated by young to mature alders and cottonwood with some Ponderosa pine and older conifers. Understory vegetation is moderately diverse and includes groundcover, shrubs, and small trees that provide a moderate amount of overhanging vegetation. The levees are typically sparsely vegetated with shrubs and covered in thistle and other weedy plants that provide little overhang. The disconnected low-lying area in the east floodplain near RM 39.3 is a grassy field with some patches of sparse trees and shrubs.

6.1.2 Conceptual Project Actions

Restoration actions involve removing or setting back levees that restrict natural floodplain connectivity and channel migration, yet appear to be unnecessary to maintaining operations at the hatchery. Although some LWD is present, little is being recruited within the project area or being transported from upstream; therefore, LWD would be placed throughout the channel (Figure B-13).

6.1.2.1 Geomorphic Implications

Levee removal will allow the channel to adjust via bank erosion and channel migration, establishing a more natural configuration that allows for retention of LWD and sediment. These conditions will decrease channel velocities during high flows and allow pools and spawning gravels to develop. Reconnecting low-lying floodplain will allow dispersion of floodwaters, decreasing velocities in the main channel and allowing for dispersion of

overbank sediments and mobile debris. LWD placement in the project area will force pools and hydraulic variability in this dominantly plane-bed, simplified channel in the short term. Placing ELJs in strategic locations can promote side channel development through the low-lying areas in the left floodplain, increasing channel complexity.

6.1.2.2 Biological Benefits

Immediate biological benefits of the project include decreased instream velocities during high flows and additional instream complexity and pool development via LWD placement. In the long term, opening up the floodplain will increase complexity through the project area, providing diverse habitats for various life stages such as holding areas, side channels for rearing, and high-flow refuge.

6.1.2.3 Potential Challenges

Site access and project actions will likely involve disturbance and removal of existing vegetation. Any trees growing on levees to be removed could be incorporated into ELJs or other elements of the design. Levee removal will require a large amount of earthwork; the armor and other angular materials that compose the levee can be incorporated into ballast or set back to infrastructure in the floodplain, such as Rainbow Lake. An infiltration gallery used for hatchery operations is located in the low-lying floodplain upstream of the access bridge; potential impacts to this feature from the project actions would need to be assessed further.

6.2 Project Area 14 (River Mile 39.2 to 37.15)

Project Area 14 (PA-14) is located within the active channel and floodplain from the hatchery access road bridge (RM 39.2) to the downstream extent of public (WDFW) land at RM 37.15.

Table 6-2
Restoration Recommendations for Project Area 14

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Natural channel and floodplain processes are impaired in this project area.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 160 feet of spoils near RM 39.1 to increase floodplain connectivity and promote channel migration within the approximately 17.77-acres of low-lying floodplain west of the river.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout 1.95 river miles.

6.2.1 Site Description

6.2.1.1 Channel Characterization

The channel through PA-14 is primarily a single-thread, plane-bed channel with local forced pool-riffle and boulder rapids (Photograph 6-2a). Adjacent to the hatchery, the channel is relatively straight and simplified. Existing WDFW hatchery infrastructure, including the hatchery bridge and the levee adjacent to the hatchery ponds, confines the channel from approximately RM 39.2 to 39.0. From RM 39.0 to RM 38.5, the active channel widens slightly and a few side channels and split-flow paths are present.

Photograph 6-2a
The main channel and floodplain near RM 38.3, looking upstream

Between RM 38.2 and the mouth of Cummings Creek (RM 37.8), the channel is confined and somewhat entrenched into alluvial fan and hillslope deposits through a narrow section of the valley. The channel contains several large immobile boulders and rapids. Between RM 37.8 and 37.15, adjacent to the WFDW headquarters, the channel is single-thread and often plane-bed, but transitioning into a recovering state. Channel migration, LWD recruitment, and development of instream and channel complexity were all observed though this area (Photograph 6-2b). There was a higher amount of temporary sediment deposition and wider active channel in this portion of the project area. Only a few significant side channels were observed near RM 38.75, 38.6 and 37.3. The Spring Lake and Blue Lake outfalls both had downstream connections to the main channel.

Photograph 6-2b
Wood recruitment in the channel near RM 37.5

Upstream of Cummings Creek, instream habitat conditions in PA-14 are limited by a lack of hydraulic complexity. Very little substantial LWD was observed and the channel has little sediment sorting or pool development. The rapid sections contain high velocities throughout the year. The lack of side channels means there is little off-channel rearing area or high-flow refuge for juveniles. The remainder of the project area has a moderate amount of pools and cover, typically associated with migrating bends with overhanging banks and local wood recruitment. This section does not contain an adequate quantity of preferred juvenile rearing habitat; however, variable hydraulic conditions due to the presence of bedforms, LWD, and slow-moving margin area may provide useful rearing habitat.

6.2.1.2 Floodplain Characterization

Floodplain connectivity varies considerably throughout the project area. Between the hatchery bridge and RM 38.6, the low-lying floodplain is wide and comprises most of the valley bottom. A long, wide, and relatively low pathway is located through the floodplain between RM 39.1 and 38.6 that had no hyporheic connection with the river upon field observation. A short length of flowing water was observed at the downstream end of the channel that may have been from seepage out of Blue Lake. The floodplain from RM 38.6 to Cummings Creek has a poor connection to the channel. Remnant alluvial fan deposits create high cutbanks that are several feet higher than the channel in some places. Downstream of Cummings Creek, floodplain connectivity is moderate but still contains some locally incised areas with poor connectivity.

The riparian zone is generally in moderately good health, with some locally poor areas disturbed by fire or with poor connectivity to hyporheic exchange from the river. Riparian trees are mixed deciduous and conifers, dominated by alder, cottonwood, locust, and Ponderosa pine. Some areas contain several snags, dying trees, or burnt mature trees. The area between RM 37.7 and 37.3 is populated by several very large mature cottonwoods, some of which are being actively recruited to the channel. The understory is relatively dense with moderately diverse species in most areas. Some areas are dominated by invasive grasses or other weedy plants.

A large wetland area in the west floodplain near RM 38.8 is in good health, dominated by ferns, sedges, and dogwoods, but also contains some invasive species such as reed canarygrass and horsetail. There are many mature conifers in the floodplain, providing shade and a source of woody debris to the wetland.

6.2.2 Conceptual Project Actions

Restoration of this project area is focused on adding ELJs and other LWD to initiate side channel development through the low floodplain areas (Figure B-14). Removing or regrading the spoil piles in the left floodplain near RM 39.1 would allow future channel migration and better connectivity to the low floodplain. Long-term planning should consider replacement of the hatchery road access bridge at the upstream end of the project

area with a longer-spanning bridge that would allow for better connectivity and ability to migrate across the low floodplain. This may involve road relocation atop the hatchery levee or elsewhere. In addition, removing the footbridge near RM 37.75 will also improve hydraulic and geomorphic conditions, as it is markedly narrower than the highway bridge just upstream.

6.2.2.1 Geomorphic Implications

LWD placement throughout the project area upstream of RM 38.2 will force pools and hydraulic variability in this dominantly plane-bed, simplified channel in the short term. In addition, placing ELJs in strategic locations to promote side channel development will develop channel complexity. Downstream of RM 38.2, the ELJs may not have a significant effect on channel migration due to the relatively resistant materials that compose the banks; however, the ELJs will force pools to create more hydraulic variability. Throughout the LWD placement areas, the structures will promote retention of additional LWD and bedload. Between RM 38.2 and 37.8, and in the locally incised areas in the lower end of the project area, this effect may contribute to building up the bed elevation over time and increasing floodplain connectivity. Removing the spoil piles near RM 39.1 would likely result in better distribution of floodwaters across the floodplain as it exits the confined reach upstream of the bridge and drops in energy. In the future, the channel would have better ability to migrate and develop side channels through the floodplain.

6.2.2.2 Biological Benefits

Immediate biological benefits of the project include high-flow refuge, low-flow cover, and pool development from LWD placement. Over time, the LWD will promote the formation of habitat elements (e.g., pools and side channels), leading to the development and maintenance of diverse habitats that will increase the carrying capacity for juvenile salmonids. ELJs will promote channel complexity by splitting flow and promoting retention of wood and sediment, creating additional spawning areas, pools with cover, and refuge. In the long term, reversing the incised condition of the channel between RM 38.2 and Cummings Creek will lead to better floodplain connectivity, in turn creating a healthier riparian zone and distribution of water and sediment across the floodplain that drives many ecosystem processes. Removing the spoils near RM 39.1 will allow better access to the low

floodplain, decreasing velocities in the main channel and promoting channel migration and complexity that will lead to the generation of additional habitats.

6.2.2.3 Potential Challenges

Several access routes will be necessary to access all of the LWD placement sites. Some trees and other existing vegetation may be disturbed in the process of gaining access to and placing the LWD structures. Future channel migration and flooding in the low floodplain west of the hatchery must be considered in the design effort.

6.3 Project Area 15 (River Mile 37.15 to 36.35)

Project Area 15 (PA-15) is located within the active channel and floodplain from the downstream extent of public (WDFW) land at RM 37.15 to approximately RM 36.35.

Table 6-3
Restoration Recommendations for Project Area 15

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Protect the existing spring channel through the right floodplain.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 860 feet of levees to promote increased floodplain connectivity over time.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout 0.8 river miles. Modify log and rock structures so that they provide greater habitat benefits while allowing for natural processes, including channel migration and floodplain connectivity.

6.3.1 Site Description

6.3.1.1 Channel Characterization

The channel through PA-15 is characterized as a single-thread channel with forced pools and local rapid sections. Many of the bends in the channel are held by placed rock and wood structures (e.g., rock barb and LWD-rock revetments), which likely also influences the overall channel grade in the project area. Locally incised areas of the channel were consistent with the placement of many of the larger revetment structures, as evidenced by the high elevation of the rootwads relative to the channel bottom. In some cases, the rootwads were perched above or at the water surface (Photograph 6-3). The thalweg adjacent to the structures was deep, fast-moving, and turbulent. A few minor side channels were observed, one of which cut behind the head of the rock revetment at RM 37.7. A spring channel originating from the east floodplain at approximately RM 37.0 produces a significant quantity of flow that flows parallel to the main channel for approximately one-half mile and joins the main channel near RM 36.55. Many juvenile fish were observed in the channel throughout its length.

Photograph 6-3
Local incision and rapid velocities along the face of a rootwad and rock revetment

Instream habitat conditions in the main channel are affected by local high velocities, lack of complexity in plane-bed sections, and limited off-channel areas. Although a large quantity of LWD was observed between approximately RM 37.0 and 36.8, the remainder of the project area contained little LWD except for man-made structures, and the pools forced by these structures were typically fast-moving and turbulent. The spring channel provides excellent off-channel habitat but few other accessible side channels were observed.

6.3.1.2 Floodplain Characterization

Floodplain connectivity is primarily limited by the incised condition of the channel and also somewhat by levee and spoil features in the floodplain. A levee between RM 36.45 and 36.35 confines the channel to the toe of a tributary fan and cuts it off from the floodplain.

Several flood pathways are present through the floodplain that were accessed during the 1996 flood; these areas are lined with cobble and support little vegetation but do not appear to be inundated at more frequent flooding events.

The riparian zone adjacent to the channel is generally in a moderately healthy condition, with some local areas that have been degraded by development, historic flooding, or poor hyporheic connection with the channel. Riparian trees are predominantly cottonwoods and other deciduous species, with some Ponderosa pines. Understory vegetation is moderately diverse groundcover, shrubs, and small trees that provide overhanging vegetation adjacent to the channel. The areas of the floodplain inundated by the 1996 flood typically have little understory except for sparse grasses and weedy plants. Reed canarygrass is prominent along the banks and in the floodplain.

Wetlands observed in the floodplain near RM 36.9 and 36.8 contained juvenile salmonids but had a poor downstream surface water connection with the main channel. These areas contained sedges, rushes, and grasses that provide shade and terrestrial insect drop for the fish. Several stagnant and dried-up pools were observed in the floodplain.

6.3.2 Conceptual Project Actions

Protect the existing spring channel in the right floodplain. Install ELJs and other LWD to initiate side channel development through the left floodplain, which was recently converted to public land (Figure B-15). Remove levees and spoils and modify existing wood and rock structures to improve their habitat benefits and reduce impediments to natural processes.

6.3.2.1 Geomorphic Implications

LWD placement throughout the will force pools and hydraulic variability in the plane-bed channel sections, decrease instream velocities, and provide additional hydraulic complexity in the deep, incised sections. Placing ELJs in strategic locations along the left bank will promote side channel development through the former Russell property, developing a more complex channel network. Throughout the LWD placement areas, the structures will promote retention of additional LWD and bedload that will promote building up the bed elevation over time and increasing floodplain connectivity. Removing the levee at RM 36.4

will ease channel confinement and allow for better floodplain connectivity during high flows.

6.3.2.2 Biological Benefits

Adding complexity to the project area via LWD will address habitat limiting factors in the mainstem by diversifying the channel and initiating side channel development. In the short term, the pools that form at the structures will increase the available area for holding in the project area. The hydraulic diversity created by the structures will provide high-flow refuge and low-flow cover for juveniles. The structures also sort bedload sediment, leading to the formation of spawning areas. In the long term, ELJs will promote channel complexity by splitting flow and encouraging the natural processes that drive the formation of habitat elements such as pools and side channels. The availability of diverse habitats will increase the carrying capacity for juvenile salmonids and increase the number of pools for holding adults. Levee removal and modifying the existing revetment structures will increase floodplain connectivity and the ability for the channel to migrate throughout the valley. In the long term, increased floodplain connectivity will lead to better riparian conditions that drive many ecosystem processes that are beneficial to both aquatic and non-aquatic species.

6.3.2.3 Potential Challenges

Some trees and other existing vegetation may be disturbed in the process of gaining access to and placing the LWD structures and removing the levee. Project actions in the upstream end of the project area from RM 37.15 to 36.85 will involve cooperation of adjacent landowners. Because this project area is located just upstream of a residential area, LWD will likely require stabilization under extreme high-flow conditions to prevent it from mobilizing.

6.4 Project Area 16 (River Mile 36.35 to 34.9)

Project Area 16 (PA-16) is located within the active channel and floodplain from RM 36.35 to the intersection of McGovern Road and Tucannon Road (RM 34.9).

Table 6-4
Restoration Recommendations for Project Area 16

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Natural processes are impaired within this project area.
2. Reconnect isolated habitats	No significant isolated habitats will be reconnected by this project.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 520 feet of levee to reconnect approximately 4.59 acres of low-lying floodplain.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD in approximately 0.3 river miles within low-risk sections and in select locations to encourage side channel development away from infrastructure. Excavate floodplain areas to create side channels that will convey seasonal flows, approximately 1,120 feet.

6.4.1 Site Description

6.4.1.1 Channel Characterization

The channel through PA-16 is characterized as a single-thread, plane-bed channel with occasional pools forced by engineered structures and resistant banks. The channel is located through a highly developed residential area and is significantly affected by several levees, armored banks, and rock and LWD structures. These structures provide limited habitat benefits and prevent channel migration and floodplain connectivity. In addition, portions of the left bank are confined against resistant alluvial fan deposits. Some banks within the project area were actively eroding and migrating (Photograph 6-4). Remnant levee or spoil piles were observed on the right bank at approximately RM 35.9 and from about RM 35.7 to the mouth of Tumalum Creek. Large right bank levees with LWD and rock structures at the toe were observed from RM 35.45 to just downstream of RM 35.2. Large left bank levees were observed from approximately RM 35.2 to 35.1. Both banks from RM 35.1 to 34.9 were sporadically armored with large angular rock and riprap. Larger J-hook structures at the upstream end of the project area to approximately RM 36.2 likely have an influence on the channel grade. Very few off-channel areas were observed except the mouth of Tumalum

Creek and a short side channel at approximately RM 35.25 that appeared to be maintained for water diversion.

Photograph 6-4
Bank erosion adjacent to private infrastructure near RM 35.1, looking across at right bank

Instream habitat is limited by a lack of complexity and hydraulic conditions due to confinement. The confined condition of the channel likely results in high velocities during seasonal high flows and flooding that prevents the retention of sufficient volumes of LWD for cover and refuge, or sediment for spawning areas. Few pools were observed except at man-made structures, many of which were fast-moving along outer banks. Preferred juvenile rearing areas were very limited due to the absence of side channels. Much of the channel had little overhanging vegetation.

6.4.1.2 Floodplain Characterization

Floodplain connectivity in this project area is low. Levees, spoils, bank armoring, and other infrastructure observed throughout the project area disconnect several low-lying areas of the floodplain. Several low-lying cobble-bed channels were observed in the floodplain; all of them were dry. Many of these channels are disconnected from the main channel by infrastructure, and others are disconnected because the channel is low relative to the floodplain, such as in the left bank near RM 35.0. A wetted floodplain channel was observed in the right floodplain at approximately RM 35.9; however, no downstream connection to the main channel was observed. The mouth of Tumalum Creek is confined by levees along both banks that perch the water surface elevation of the creek above the low-lying floodplain areas that parallel the river (RM 35.65).

The riparian zone is generally in a moderately healthy condition where it has not been cleared or degraded by development, or is lacking a poor groundwater connection with the channel. Riparian trees are predominantly deciduous cottonwoods and locust trees; willows line the banks where bank armoring and restoration projects are present. Some Ponderosa pines have been planted along the right bank in a few areas. There are very few mature trees, except in the left floodplain at the upper end of the project area. Understory vegetation includes groundcover, shrubs, and small trees that provide minor amount of overhanging vegetation in most of the project area. There are several areas along the banks that are devoid of vegetation other than grasses and weeds; many of these areas are consistent with the presence of levees or irrigated fields. Many of the disconnected floodplain areas also have little vegetation other than weedy species such as chicory and cheat grass growing among cobble.

6.4.2 Conceptual Project Actions

Because this project area includes more private infrastructure than any of the other areas, restoration actions focus on achieving biological and geomorphic benefit while considering the highly restricted physical limitations. Proposed restoration actions include adding LWD in low-risk portions of the channel to initiate side channels through uninhabited portions of the low floodplain, such as river left near RM 35.55 (Figure B-16). Removal of the levee near RM 35.55 will reconnect the area of low-lying floodplain on the west side of the channel.

Off-channel habitat may be created by excavating one or more channels through the left floodplain between approximately RM 35.15 and 34.95 that would be active during seasonal high flows (i.e., spring runoff). The spoils from the excavation could be placed at the toe of McGovern Road.

6.4.2.1 Geomorphic Implications

The most significant geomorphic effect of this project will be decreased instream velocities. Placing LWD in the channel and promoting better side channel and floodplain connectivity where it is possible will collectively decrease overall velocities. The LWD placements will promote pools and deposition of sediment in the local areas around each structure.

6.4.2.2 Biological Benefits

In the short term, the pools that form at the LWD structures will increase the available area for holding, and the hydraulic diversity created by the structures will provide high-flow refuge and low-flow cover for juveniles. Establishing a channel through the floodplain at the downstream end of the project area will increase the available rearing area for juveniles and further diversify available habitat during seasonal high flows. In the long term, ELJs and removal of confining features will promote additional side channel development and floodplain access for high-flow refuge, and potentially for juvenile rearing year round. The availability of diverse habitats will increase the carrying capacity for juvenile salmonids and increase the number of pools for holding adults.

6.4.2.3 Potential Challenges

This project area contains the highest density of different landowners than any of the other areas within this study. Landowner coordination and involvement will be a high priority in order to implement projects. A detailed risk assessment will likely be necessary to implement some project elements.

6.5 Project Area 17 (River Mile 35.15 to 34.3)

Project Area 17 (PA-17) is located within the active channel and floodplain from one quarter-mile upstream of the intersection of McGovern Road and Tucannon Road (RM 35.15) to the upstream end of the WDFW property at RM 34.3.

Table 6-5
Restoration Recommendations for Project Area 17

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Natural processes are impaired in this project area.
2. Reconnect isolated habitats	No significant isolated habitats will be reconnected by this project.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 710 feet of levee to establish increased connectivity and allow channel migration within 2.25 acres of low-lying floodplain. Relocate approximately 720 feet of McGovern Road to increase the width of the floodplain corridor.
4. Restore riparian processes	Restore and revegetate riparian areas throughout approximately 17 acres of the project area.
5. Improve instream habitat conditions	Place LWD throughout approximately 0.6 river miles. Excavate an approximately 1,610 linear foot side channel that will be available during seasonal flows.

6.5.1 Site Description

6.5.1.1 Channel Characterization

The channel through PA-17 is characterized as a single-thread, plane-bed channel with local deep, rapid sections that contain little hydraulic complexity (Photograph 6-5). Resistant fine-grained material is located along much of the left bank. Bank armoring was observed in the upstream portion of the project area between RM 34.85 and 34.75 on both the left and right banks. From this section to approximately RM 34.7, the channel is incised and disconnected from the floodplain; riparian planting projects undertaken here have been largely unsuccessful, likely due to poor hyporheic exchange with the channel. Downstream of RM 34.7, the channel is wide and plane-bed with some deeper areas adjacent to the

resistant bank between RM 34.5 and 33.35. A few minor side channels were observed at approximately RM 34.5 and 34.35 that were wetted at the time of field observation.

Photograph 6-5
A plane-bed section of the channel that flows along the base of a high terrace (right bank) near RM 34.4

Instream habitat is limited by lack of complexity and high-velocity conditions through the incised portion of the project area. Very little LWD was observed. The straight, confined, and incised conditions found throughout much of the project area likely result in high velocities during seasonal high flows and floods, which prevent the retention of sufficient volumes of LWD that would provide cover, refuge, or sediment deposition for spawning areas. Few side channels are available to provide preferred rearing habitat for juveniles.