MIDDLE CALAPOOIA RIVER ASSESSMENT AND PROJECT IMPLEMENTATION PLAN

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EXECUTIVE SUMMARY

As a main tributary to the Willamette River in western Oregon, the Calapooia River drains the Cascade Mountain Range. Flowing in a westerly direction from its headwaters, the Calapooia River drains forested and agricultural land before joining the Willamette River at Albany. Chinook, steelhead, cutthroat, and Oregon chub are some of the native fish species that continue to inhabit the Calapooia River. Timber production, splash damming for log transport, irrigation systems, agriculture, and residential development have affected the Calapooia River and its fisheries. Limiting factors impacting the native fish community include fish passage barriers, simplified habitat, summertime water temperatures, and loss of riparian forests and associated large wood that once created dynamic habitat.

The Calapooia Watershed Council retained River Design Group, Inc. to complete an existing conditions assessment and restoration prioritization plain for the Middle Reach of the Calapooia River. This effort follows the Calapooia River Watershed Assessment (Calapooia Watershed Council 2004) which provided an evaluation of the drainage at the watershed scale. This document serves two purposes; one, as a reach assessment, it presents information on historical and existing conditions based on field data collection, remote sensing, and existing data review. Secondly, the document serves as a river corridor restoration plan that prioritizes aquatic habitat improvement projects in the Middle Reach of the Calapooia River. Restoration Actions were prioritized based on expected ecological benefits, costs, and risks. Conservation Actions were also presented as a means to preserve remaining floodplain and upland forests as well as to provide techniques for expanding such areas. The Restoration and Conservation actions are specified by reach to promote reach-level restoration and conservation.

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GLOSSARY

Active Floodplain: Lowlands bordering a river, which are subject to flooding on a periodic basis. Floodplains are composed of sediments carried by rivers (alluvium) and deposited on land during flooding. The active area is characterized by recently deposited river-borne debris, limited terrestrial vegetation, and recent scarring of trees by material transported by floodwaters.

Aggradation: The geologic process by which streambeds, floodplains and the bottoms of other water bodies are raised in elevation by the deposition of material eroded and transported from other areas. It is the opposite of degradation.

Alluvial: Deposited by running water.

Anadromous: Fish that breed in freshwater but live their adult life in the sea. On the Pacific coast, anadromous fish include all the Pacific salmon, steelhead trout, some cutthroat trout and Dolly Varden char, lampreys and eulachons.

Avulsion: An abrupt change in the course of a stream whereby the stream leaves its old channel for a new one.

Bankfull (Stage): Water surface elevation at which a stream first overflows its natural banks, spilling water onto the floodplain.

Base Flow: Streamflow coming from sustained subsurface sources, not directly from surface runoff.

Bedload: Sediment particles transported on or near the streambed by rolling and bouncing.

Beltwidth: The distance of a stream measured from outside of channel to outside of channel.

Bifurcate: The division of a stream channel into two branches or a fork in the stream channel.

Braided Stream: Stream that forms a network of branching and recombining channels separated by islands or channel bars.

Channelization: Straightening and (or) deepening a pre-existing channel, or constructing a new channel, for the purpose of runoff control or navigation.

Degradation: Removal of materials from one place to another via erosion, causing lowering of the elevation of streambeds and floodplains over time.

Floodplain: A level, low-lying area adjacent to streams that is periodically flooded by stream water. It includes lands at the same elevation as areas with evidence of moving water, such as active or inactive flood channels, recent fluvial soils, sediment on the ground surface or in tree bark, rafted debris, and tree scarring.

Groundwater: Subsurface water in the zone of saturation below the level of the water table, where the hydrostatic pressure is equal to or greater than the atmospheric pressure.

Hydric: Sites where water is removed so slowly that the water table is at or above the soil surface all year; gleyed mineral or organic soils are present.

Hyporheic Zone: Zone beneath and adjacent to streams where water and dissolved chemicals move easily between surface and groundwater.

Large Woody Debris: Coarse woody material (conventionally greater than 10 cm in diameter and 1 m long), such as twigs, branches, logs, trees, and roots, that falls into a stream.

Manning's n-value: Empirical coefficient for computing stream bottom roughness, or the irregularity of streambed materials as they contribute to resistance to flow, which is often used to determine water velocity in stream discharge calculations.

Meander: A sinuous channel form in flatter river grades formed by the erosion on one side of the channel (pools) and deposition on the other side (point bars).

Meander Length: Distance in the general course of the meanders between corresponding points of successive meanders of the same phase. Twice the distance between successive points of inflection of the meander wave.

Off Channel: Bodies of water adjacent to the main channel that have surface water connections to the main river channel at summer discharge levels.

Riffle: A shallow section of a stream or river characterized by rapid current and a surface broken by completely or partially submerged obstructions such as gravel or boulders.

Riparian (Area): An area of land adjacent to a stream, river, lake or wetland that contains vegetation that, due to the presence of water, is distinctly different from the vegetation of adjacent upland areas. The riparian area is influenced by and influences the adjacent body of water.

Riprap: A layer of large, durable material such as coarse rock used to protect exposed surfaces and slopes susceptible to erosion such as fills and streambanks

Salmonid: Refers to a member of the fish family *Salmonidae*, including the salmons, trouts, chars, whitefishes and grayling.

Shear Stress: Stress caused by forces operating parallel to one another but in opposite directions.

Sinuous: Characterized by a serpentine or winding form, typically referring to stream channels.

Substrate: The basic surface on which material adheres, typically mineral and (or) organic material that forms the bed of a stream.

Thalweg: Line of deepest water in a stream channel as seen from above. Normally associated with the zone of greatest velocity in the stream. If there is no stream, it is the line of lowest points of a valley.

Watershed: Also referred to as a drainage basin or catchment area. Watersheds are the natural landscape units from which hierarchical drainage networks are formed. Watershed boundaries typically are the height of land dividing two areas that are drained by different river systems.

1 INTRODUCTION

1.1. Purpose of Effort

The Calapooia Watershed Council (CWC) retained River Design Group, Inc. (RDG) to complete the *Middle Calapooia River Project Implementation Plan* (Plan). The Plan scope of work included reviewing existing information, completing a field assessment, and identifying potential restoration, conservation, and/or resource protection opportunities on the Middle Calapooia River between the former Brownsville Dam site and Sodom Dam, an approximately 8 mile reach.

The purpose of the Plan is to provide an overview of river corridor conditions and recommendations for restoring, conserving, and protecting resources in the study area. RDG and CWC developed the following project objectives for the Plan.

1) Evaluate existing river corridor conditions in the 8 mile project reach.
2) Address existing river corridor conditions that may affect migratory fish species.
3) Identify potential restoration sites and provide typical treatments for improving fish habitat.

   Treatments should:

   - Focus on water temperature reduction or at least not increase temperatures,
   - Increase channel complexity, and
   - Take into account multiple native fish species and their life histories, as well as other rare or critical species including the western pond turtle.
4) Provide treatment approaches for addressing severe bank erosion that is currently impacting landowners in the reach.

Field surveys and remote sensing were used to evaluate the river. Data collection and analyses were structured to achieve the assessment objectives.

2 METHODS

The following section outlines RDG's methods for evaluating the existing river corridor conditions and preparing the conceptual design plans.

RDG completed field data collection in October 2007 to characterize the stream corridor, channel habitats, sediment sources, and bank stabilization structures. Field data collection methods included a reconnaissance-level river walk-through, channel surveys, discharge measurements, and channel bed material characterization. The field surveys characterized typical channel conditions in each of the four reaches that were established. Project reaches were delineated according to river conditions typified by channel type, valley morphologies, and land development patterns. The following sections describe the methods used in our data collection.

2.1. River Reconnaissance

RDG completed a river reconnaissance on the Middle Calapooia River on October 22 and 23, 2007. The reconnaissance began at the former Brownsville Dam site and continued downstream approximately 8 miles to the channel bifurcation leading to Sodom Dam. Tasks completed during the reconnaissance included the following.

- Confirmation of the reach break delineation based on aerial photograph interpretation.
- Channel habitat unit classification and mapping.
- Bank stabilization structure and floodplain levee inventory and mapping.
- Bank erosion site mapping.
- Evaluation of existing impaired and reference reach conditions.
- Photographic documentation of river corridor conditions.

Data collection sheets were completed and transferred into Microsoft Excel for processing. Spatial data were plotted in ArcGIS on 2005 NAIP air photo imagery. Reach maps are included in Appendix A – Reach Maps. Reconnaissance information was also used for preparing conceptual restoration ideas, conservation, and stabilization plans.

2.1.1. Channel Habitat Unit Classification and Mapping

Channel habitat units were classified to evaluate habitat diversity in each of the four reaches. A laser rangefinder was used to measure habitat feature lengths. Habitat feature locations and extents were noted on air photo base maps. Habitat units were determined based on water velocity, turbulence, channel bed profile facet slopes, and water depth. The four primary features included riffles, runs, pools, and glides. Riffles were defined as higher gradient sections of channel exhibiting surface turbulence. Runs were defined as the transition from the riffle into the pool. Although determining the length of runs was difficult due to elevated flows at the time of the survey, run features were characterized as channel sections with higher water velocities transitioning into slower water velocities marked by the upstream end of the pool. Pools were the deepest habitat units and typically had the lowest water velocities. Glides were marked by an increasing channel bed elevation to the start of the subsequent riffle. Glides form the transition between the pool and riffle. Other sections of the river that lacked features associated with riffles and runs, were also noted as glides. Table 2-1 summarizes channel habitat unit features. A channel habitat unit map is presented in Appendix B – Habitat Unit Map.

Table 2-1. Characteristics of channel habitat features.

Habitat Unit	Surface Turbulence	Water Velocity	Water Depth	Bed Facet Slope	Fish Habitat Benefits
Riffle	High	Medium	Low	Negative	Food production
Run	Medium	High	Medium	Negative	Feeding areas
Pool	Low	Low	High	Negative	Resting and feeding areas
Glide	Low	Low	Medium	Positive	Resting and feeding areas

2.1.2. Bank Stabilization Structures and Floodplain Levee Mapping

Bank stabilization structures and floodplain levees were delineated on the air photo base maps. Data collected by RDG were combined with information provided by CWC to produce a bank stabilization GIS layer. Data were compiled by reach for comparisons. Stabilization information was reviewed as part of the reach review. Table 2-2 summarizes types of bank stabilization and flood levee treatments that were encountered during the field reconnaissance. A bank stabilization and floodplain levee map is included in Appendix C – Bank Stabilization and Erosion Site Map.

Table 2-2. Typical bank stabilization and floodplain levee treatments encountered on the Calapooia River.

Treatment	Location	Typical Materials	Typical Influence of River Corridor
Bank Riprap	Streambank	Angular rock	Limits channel migration, may promote channel bed scour
Large Wood Placement	Streambank	Angular rock, wood	Limits channel migration, may promote channel bed scour, fish habitat enhancement
Spurs	Streambank	Angular rock	Bank stabilization, may promote channel bed scour
Barbs	Streambank	Angular rock	Bank stabilization, may promote channel bed scour
Dike	Floodplain	Rock, gravel, soil	Limit floodwater extent, confine river flows

2.1.3. Bank Erosion Site Mapping

Prominent bank erosion sites were noted on the air photo base maps and photographed. Due to the widespread bank stabilization and historical channel manipulation in the study area, few bank erosion locations were identified. A bank erosion GIS layer was produced. Bank erosion sites are noted on the map located in Appendix C – Bank Stabilization and Erosion Site Map.

2.1.4. Impaired and Reference Conditions

Typical river corridor conditions were noted during the reconnaissance. Typical impaired condition sections of the river were noted by stabilized banks, low habitat diversity, infrequent large wood, and low floodplain habitat complexity. Reference sections of the river generally had dynamic channel conditions typified by abundant large wood, high habitat diversity characterized by a range of velocities and water depths, and well-developed floodplains with multi-story vegetation, floodplain channels and ponds, and large woody debris.

2.1.5. Channel Surveys

Channel surveys were completed with a total station and survey laser. Survey data collection followed U.S. Forest Service (USFS) procedures (Harrelson et al. 1994) and included channel cross-sections and profiles. Surveys were completed at both new sites and formerly established survey locations installed by the Natural Resources Conservation Service (NRCS). Channel survey data collected in 2007 were compared to earlier cross-section data collected by NRCS.

Survey data included cross-sections, longitudinal channel profiles, discharge measurements, pebble counts, and ground photos. Data were collected to characterize terrace, floodplain, bankfull, water surface, and thalweg features. Additional features were also collected if deemed important for characterizing the reach. Channel thalweg measurements were generally collected at changes in the channel bed elevation or habitat features. Water surface measurements were collected at changes in the water surface slope and corresponding habitat features. Total station survey data were processed using AutoCAD Land Development Desktop 2007/2008 (Autodesk 2007).

Pebble counts were collected to characterize the channel bed sediment (Wolman 1954). Pebble count data were imported into RiverMorph for storage, processing, and analysis. Multiple photographs were taken at each surveyed cross-section and within each reach. Ground photographs are stored on RDG's Corvallis office network and are provided on a DVD at the end of this report.

2.2. Hydraulic Modeling

Hydraulic modeling was completed to evaluate channel hydraulics in the four reaches. At-a-section modeling was completed using WinXSPro (Hardy et al. 2005). Data used in the models included the respective channel cross-sections, the low discharge and bankfull discharge water surface slopes, and the D84 particle size. Discharge measurements were completed to assist in model calibration.

2.3. Remote Sensing

ArcGIS programs were used to develop field base maps and visualization figures. Programs included ArcGIS Version 9.1 (ESRI 2005a) and ArcGIS extensions, Spatial Analyst (ESRI 2005b) and 3D Analyst (ESRI 2005c). Channel plan form measurements were based on air photo interpretation. Spatial data were acquired from multiple state and federal agency sources.

2.4. Stream Classification

The Rosgen stream classification system (Rosgen 1994) was used to characterize physical features of the Calapooia River. The classification system is useful as a communication tool to convey typical channel conditions exhibited by a river. Morphological features used to classify a river include the following variables.

- Entrenchment ratio (width of flood-prone area to top width of bankfull channel)
- Width-to-depth ratio (ratio of bankfull top width to mean bankfull depth)
- Dominant channel materials (D_{50} particle size)
- Slope
- Sinuosity (ratio of stream length to valley length)

The channel bankfull slope, width, mean depth, maximum depth, and floodprone width; and channel bed sediment were surveyed in the field. The channel sinuosity was measured using air photos. The Rosgen stream classification system uses these variables to delineate stream reaches into major stream types broken into alpha-numeric codes. Major stream types are given letters from A to G with each stream type defined by common physical characteristics. Numerals are added to the letter to denote the median particle (D_{50}) of a reach-averaged pebble count.

Stream types are typically used to label stream reaches that are either 20 bankfull widths or two meander sequences in length. Smaller subreaches may be labeled as stream type inclusions. The following section provides a general description of the characteristics of the major Rosgen stream types found within the Calapooia River study area.

Rosgen B Stream Type
Rosgen B stream types are moderately steep (between 2 and 4 percent), with rapids and riffles common and scour pools irregularly spaced. Pools are commonly pocket pools rather than more expansive pools typically associated with outside meanders. These stream types are moderately entrenched (narrow floodplain relative to the bankfull channel width – 1.4 to 2.2), with moderate width-to-depth ratios (>12) and sinuosity (>1.2). Vegetation has a moderate influence in determining channel stability in the Type B reaches. These B channel types are characterized by low to moderate sensitivity to disturbance and low streambank erosion. Fish habitat in B stream types is often associated with large woody debris that contributes to scour pool formation and cover (Rosgen 1996). Using the Montgomery and Buffington classification system (1997), B stream types are typically defined as plane bed morphology streams.

Portions of Reach 2 and Reach 4 in the Calapooia River study area are classified as Rosgen B stream types.

Rosgen C Stream Type
Rosgen C streams have a lower gradient, are slightly entrenched (>2.2), have moderate to high (>12) width-to-depth ratios, high sinuosity values (>1.4), and are characterized by riffle/pool sequences. These channels have characteristic point bars and broad, well-defined floodplains. Vegetation influences channel stability more so than in B stream types. When vegetation is disturbed and removed, C stream types are sensitive to both lateral (bank) and vertical (down-cutting) erosion. Natural sediment supply is moderate to high except in those areas where streambanks are well vegetated. These streams are highly sensitive to changes in sediment and stream flow (Rosgen 1996). Using the Montgomery and Buffington classification system (1997), C stream types are defined as riffle-pool morphology streams.

Rosgen C stream types are found in all four reaches.

Rosgen F Stream Type
The F stream type occurs sporadically throughout the study area in locations where the floodplain is restricted by topography, levees, or where the stream has a more unstable form as a result of disturbances. The F stream types are entrenched, with most flood flows confined to the channel. This stream type is typically creating a new floodplain at a lower elevation than the historical floodplain. This process leads to high levels of bank erosion, bar development, and sediment transport. Because of the entrenchment and high width-to-depth ratio, velocities can reach relatively high levels at flood flows because the floodplain is not developed enough to dissipate energies. Stream power is thus greater and may lead to increased damage to streambanks and the channel bed.

Rosgen Stream Type Numerical System
The median channel bed sediment particle size is used to allocate a numerical value to the stream type. The numbering system spans from 1 to 5, with increasing values representing a fining of the median particle size. A bedrock bed is defined as a 1, a silt bed is defined as a 6. Table 2-3 includes the numerical values and the associated particle size ranges.

Table 2-3. Rosgen stream classification system numerical values, common sediment class name, and associated particle size distribution.

Numerical Value	Sediment Class Name	Sediment Class Size Range (mm)
1	Bedrock	Bedrock
2	Boulder	256 – 2,048
3	Cobble	64 – 256
4	Gravel	2 – 64
5	Sand	0.062 – 2
6	Silt	< 0.062

The Calapooia River is a gravel bed river with minor inclusions of exposed bedrock in areas that have been scoured. Most of the reaches classify as Rosgen C4 or Rosgen B4 stream types.

3 CALAPOOIA RIVER WATERSHED OVERVIEW

The following sections are largely taken from the Calapooia River Watershed Assessment (Calapooia Watershed Council 2004). This information is provided as a summary of historical and existing conditions that are important to consider when evaluating both the current state of the river corridor, the restoration objectives, and the potential to re-establish ecological processes. The assessment excerpts are primarily about the Middle Calapooia River, the focus area of this assessment and restoration prioritization.

3.1. Historical Landscapes

The following section is largely taken from the Calapooia River Watershed Assessment (Calapooia Watershed Council 2004).

By the 1950s, the landscape features of the Calapooia River watershed had changed dramatically relative to pre-1850 conditions. Lands that were historically grass prairies, oak woodlands, wetlands, and riparian forests had been converted to farmlands, and, to a lesser extent, other land uses. The end of the Kalapuyan (indigenous tribe that inhabited the watershed prior to the arrival of Euro-American settlers) practice of using fire to control vegetation resulted in conversion of areas that were once grasslands and open oak woodlands to conifer forests. Stream habitat, especially along the Calapooia River, had been modified through a number of practices, including log drives down the river, removal of large wood from the channels, loss of riparian habitat, and bank stabilization. A number of dams within the Calapooia River presented obstacles to fish migration. Large scale bank stabilization projects took place following the 1962 floods to reduce property loss.

Land use activities including agriculture, logging, and residential development have led to the simplification of the once dynamic Calapooia River corridor.

3.2. Hydrology

Flows in the Calapooia River vary greatly throughout the year due to seasonal precipitation and summer use of water. The average monthly January flow in Albany is 55 times the average August monthly flow. Nearly 90% of the runoff occurs during the six wettest months (November through April). The magnitude of annual runoff also varies. Rain-on-snow flood events have been responsible for the largest floods of record. These events typically occur between December and February when warm storms rain on the snowpack. Table 3-1 includes the flood frequency for the Calapooia River. The flood frequency is based on data from the former Holley gaging station as well as regional relationships developed by Oregon Water Resources Department.

Table 3-1. The flood frequency for the Calapooia River based on a former gaging station in the watershed corrected for the watershed area in the study area (Gage Station Estimate), and regional relationships (Prediction).

	Gage Station Estimate			Prediction		
		95% Confidence			95% Confidence	
Return Period (years)	Peak Flow (dfs)	Lower (cfs)	Upper (cfs)	Peak Flow (dfs)	Lower (cfs)	Upper (cfs)
2	5,500	4,980	6,070	6,940	3,720	12,900
5	7,920	7,120	8,980	10,200	5,510	19,000
10	9,550	8,460	11,100	12,500	6,660	23,300
20	11,100	9,710	13,200	14,600	1,170	27,800
25	11,600	10,100	13,800	15,300	8,030	29,200
50	13,200	11,300	16,000	17,400	8,980	33,900
100	14,700	12,400	18,200	19,600	9,880	38,800
500	18,300	15,100	23,500	24,600	11,800	51,200

3.3. Vegetation

The following section is largely taken from the Calapooia River Watershed Assessment (Calapooia Watershed Council 2004).

The Calapooia River supports a varied riparian vegetation community. In more extensive floodplain areas, hardwood species consist of Oregon ash, black cottonwood, bigleaf maple, and red alder. These trees usually occur in combination. Younger hardwood stands are prevalent in the Middle Calapooia River, but are relatively scarce in other reaches of the Calapooia River. The Middle Calapooia River also has a high percentage of area in gravel bars. Younger hardwoods, usually found sandwiched between a gravel bar and the older hardwood stands, are probably a result of tree establishment in areas cleared of vegetation during a major flood.

Notes and maps from the original land surveys conducted in the 1850s indicate that the Calapooia River was bordered by a continuous corridor of trees. Because of repeated burning of the valley floor by Native Americans during the previous centuries, vegetation beyond this corridor of trees was mostly native prairie or oak savanna. An examination of natural and human features that currently occupy land within this historical corridor of trees indicates that the combined percentage of trees and water features is only about 50% of what it was in the 1850s.

About one-half of the land along the Calapooia River that supported trees in the 1850s has since been converted to grass seed fields and other development. Remaining patches of older trees are mostly in low-lying areas that are too wet for farming (Figure 3-1). Older stands of trees are most extensive downstream of Brownsville where the river meanders widely over a relatively flat floodplain. Here also, natural ponds are abundant, a result of the river abandoning its old channel and forming a new path. Most of the ponds are bordered by older hardwood stands and few have been altered by farming or development.

Figure 3-1. Examples of riparian conditions in the Middle Reach of the Calapooia River. Multiple age classes of willows populate depositional features, while mature floodplain forests characterize older floodplains (left). Varied riparian conditions exemplify much of the Middle Reach (right).

3.4. Fisheries and Habitat

The following sections are largely taken from the Calapooia River Watershed Assessment (Calapooia Watershed Council 2004).

3.4.1. Fish Community

The Calapooia River fish community includes both native and introduced fish species. Native salmonids include winter steelhead, spring Chinook salmon, and mountain whitefish. Non-salmonid fish present in the watershed include Pacific lamprey, a variety of minnow and sculpin species, the largescale sucker, and other fish. There is a greater abundance of non-salmonid fish in the lower watershed, but some species, such as shiners and sculpin species are found throughout the watershed. There is also a variety of non-native fish in the watershed. These fish have been "introduced" (either accidentally or intentionally) to the Willamette River and tributary streams. Most of the documented use by non-native fish is in the lower watershed where warmer water temperatures and altered habitat have provided ideal conditions for many of these fish. Fish species inhabiting the Calapooia River watershed are included in Table 3-2.

Table 3-2. Native salmonids, native non-salmonids, and introduced fish species in the Calapooia River.

Fish Species	Notes
Native Salmonid Species	
Winter steelhead, *Oncorhynchus mykiss* Spring Chinook salmon, *Oncorhynchus tshawytscha* Cutthroat trout, *Oncorhynchus clarki clark* Mountain whitefish, *Prosopium williamsoni*	Willamette spring chinook and winter steelhead (both anadromous species) were listed as threatened under the federal Endangered Species Act (ESA) in 1999. Factors contributing to their decline include habitat loss, fish passage barriers, altered flow regimes, water quality, and the negative impacts of hatchery fish.
Native Non-salmonid Species	
Lamprey Pacific lamprey, *Lampetra tridentata* Western brook lamprey, *Lampetra richardsoni* Other species	Pacific lamprey are anadromous (adults reside in the ocean and return to rivers and streams to spawn) and brook lamprey are resident species. Pacific lamprey was listed as an Oregon state sensitive species in 1993 due to a serious decline in abundance.
Minnows Speckled dace, *Rhinichthys osculus* Longnose dace, *Rhinichthys cataractae* Nothern pikeminnow, *Ptycheilus oregonensis* Redside shiner, *Richardsonius balteatus* Chiselmouth, *Acrocheilus alutaceus* Peamouth, *Mylocheilus caurinus* Oregon chub, *Oregonichys crameri*	Dace occur throughout the watershed, primarily in the Calapooia River and the lower portions of tributaries. *Oregon chub* is a small minnow native to the Willamette River basin. Oregon chub were listed as endangered under the Federal ESA. Chub prefer low gradient tributaries and off-channel habitats such as side-channels and sloughs. Their decline has been attributed to loss of habitats, altered flow regimes, and predation.
Suckers Largescale sucker, *Catostomus macrocheilus*	Most suckers occur in the lower watershed, primarily in the Calapooia River.
Sculpins Mottled sculpin, *Cottus baurdi* Paiute sculpin, *Cottus beldingi* Prickley sculpin, *Cottus asper* Shorthead sculpin, *Cottus confusus* Reticulate sculpin, *Cottus perplexus* Torrent sculpin, *Cottus rhotheus*	Sculpins occupy streams throughout the watershed, with the greatest abundance in the upper Calapooia River and tributaries.
Sticklebacks Three-spine stickleback, *Gastrosteus aculeatus*	
Troutperch Sand roller, *Percopsis transmontana*	
Non-Native Species (all non-salmonid)	
Largemouth bass, *Micropterus salmoides* Smallmouth bass, *Micropterus dolomieui* Yellow bullhead, *Ameiurus natalis* Bluegill, *Lepomis macrochirus* Pumpkinseed, *Lepomis gibbosus* Crappie (black), *Pomoxis nigromaculatus* Brown bullhead, *Ameiurus melas* Western mosquito fish, *Gambusia affinis* Goldfish, *Carassius auratus*	Most of these species occur in the lower watershed in the Calapooia River and permanent and seasonal tributary streams.

3.4.2. Species Habitat Needs

The following sections present the habitat needs for the three target salmonid species.

Winter steelhead

Migration and Spawning: Returning adults enter the Calapooia River between December and April, with peak spawning in May. Spawning occurs in low/moderate gradient streams (up to 8%). Most of the winter steelhead spawning takes place in the river channel and tributary streams above Holley.

Rearing: Juveniles rear in the upper river and smaller tributaries for as long as 4 years in fresh water; prefer pools with cover, large wood (Figure 3-2), and cool water temperatures (less than 64 °F), and high dissolved oxygen levels.

Figure 3-2. An example of a backwater habitat that provides juvenile rearing habitat connected to the river.

Cutthroat trout

Migration and Spawning: There are two life history forms of cutthroat residing in the watershed: 1) Resident cutthroats grow, mature, and spawn often very close to the location from which they hatched; and 2) cutthroat residing in the Calapooia River and larger streams that migrate to smaller streams for spawning. Both forms spawn in spring. Cutthroat spawning habitat requires connected streams (free from fish passage barriers).

Rearing and Adult: Juvenile and adult resident cutthroat reside in tributary streams, often in very small streams with gradients up to 12%. Cutthroat trout will move up and down the stream, particularly to escape warm water temperatures in the summer and into seasonal streams to escape high flows in the winter. Adult and juvenile cutthroat trout require cool water temperatures (less than 64 °F), and high dissolved oxygen levels.

Spring Chinook salmon

Migration and spawning: Spring Chinook enter the Calapooia River watershed in late April and May with the migration continuing into July. Spawning takes place between September and mid-November. Before spawning, adult spring Chinook hold in pools, preferring deep pools with cool water, abundant large wood, and undercut banks for cover. Most of the spring Chinook spawning takes place in the river channel and tributary streams above Holley. Spring Chinook salmon die after spawning, providing a marine-derived nutrient source to the Calapooia River.

Rearing: Juveniles can spend up to a year rearing in the Calapooia River. Like other salmonids, juvenile spring Chinook require cold water, and deep pools for feeding and cover from predators. Access to tributary streams to find refuge from high flows in the winter is also important. Juvenile spring Chinook salmon require cool water temperatures (less than 64 °F), and high dissolved oxygen levels.

Anadromous fish spend a portion of their lives residing in the ocean and return to the watershed for spawning and juvenile rearing. There is concern over decreased populations of resident and anadromous fish that currently or historically resided in the Calapooia River watershed. Three anadromous fish species that reside in the Calapooia River watershed are: spring Chinook salmon, winter steelhead, and Pacific lamprey. Because anadromous fish have very complex life cycles, including migrating through the river and stream network as adults on their way to spawning areas and as juveniles moving downstream to the ocean, they are very vulnerable to predation and human-related issues such as passage barriers, fishing pressures, and changes in habitat.

Upper Willamette River spring Chinook salmon and winter steelhead are listed as *threatened* under the Federal Endangered Species Act. Pacific lamprey is listed as an Oregon state sensitive species. In addition to these anadromous fish, there are reduced populations of Oregon chub, a resident fish native to the Willamette River basin. Historically, chub used side channels and other backwater areas in the lower Calapooia River watershed (Figure 3-3). There are no current reports of populations inhabiting the Calapooia River. Oregon chub are also listed as endangered under the Federal Endangered Species Act.

Figure 3-3. An example of a floodplain channel that is inundated over a range of mainstem stages. These habitats provide off-channel habitat for fish and amphibians.

All of the seasonal streams examined by Oregon State University (OSU) in the Calapooia River watershed had highly variable stream flows that fluctuate with rainstorms. There were general patterns of abundance of fish and amphibian species. Amphibians (primarily roughskin newts and long-toed salamanders) were much more abundant in areas where there were no fish present. At sites where fish were present, pacific tree frogs and red-legged frogs were the most abundant amphibians. The most abundant native fish species observed in the seasonal streams were threespine sticklebacks and redside shiners. Sticklebacks occupied the sites that were the longest distance from perennial streams – as much as seven miles. Other native species observed included northern pikeminnow, sculpins, dace, and suckers. Non-native fish and amphibians noted were bluegill, mosquitofish, goldfish, and bullfrogs.

In the OSU study, cutthroat trout were the most common salmonids observed in seasonal streams, with some observations listing rainbow trout (probably they were juvenile steelhead) and juvenile spring Chinook salmon. Young spring Chinook salmon were present at three sites in January and February. These small, seasonal streams provide favorable habitat during winter high flows. During this period juvenile spring Chinook and winter steelhead, and adult trout escape from high velocity flows in the river by moving into these seasonal streams where there is slow water. Fish passage is an important issue in streams that are used seasonally by fish. No fish were found at three of the seasonal stream sites where it appears that downstream fish passage barriers, such as road crossing culverts, were blocking fish access (Randy Colvin, OSU, personal communication, 2003).

The middle watershed has a greater abundance of salmonid species and very few non-native fish above Brownsville (this observation was likely related to the former operation of the dam, the dam has been removed). The river channel through this portion of the watershed continues to be an important migration corridor for adult and juvenile winter steelhead, spring Chinook salmon, and Pacific lamprey. Juvenile spring Chinook and winter steelhead, for example, use the river and probably use the lower portions of tributaries such as Brush Creek for rearing, particularly during high flow events in the winter and early spring (Gary Galovich, ODFW, personal communication, 2003). There have been no observations of winter steelhead spawning in the tributary streams in this portion of the watershed. Many of the streams in the middle Calapooia River watershed have suitable winter steelhead spawning and rearing habitat, so it is possible that there may be a small population of winter steelhead using some of the tributaries (Gary Galovich, ODFW, personal communication, 2003). Cutthroat trout also use the river and tributary streams. In addition to the cutthroat trout that reside year round in small streams (resident), there are cutthroat (a *fluvial* population) that reside in this portion of the river that move up the river and into tributary streams for spawning.

3.4.3. Fish Habitat

All other factors being equal, channels with high sinuosity often contain more features that are favorable for fish and wildlife than do channels with low sinuosity. A highly sinuous river creates a larger number of ponds, islands, alcoves, side channels, and gravel bars. These features provide special habitat niches for certain species during various life stages. Juvenile spring Chinook salmon and winter steelhead use these types of features during non-summer months.

The combination of channel gradient and channel sinuosity reflects where gravel deposition occurs along the Calapooia River. The greatest amount of gravel deposition occurs in the Middle Calapooia River. Through the reach, channel sinuosity increases and channel gradient decreases, thereby slowing the water velocity and causing much of the gravel load to settle out rather than move further downstream. Gravel bars were not observed along the three mapped tributaries in this study using aerial photographs, although gravel bars may be present if evaluated in the field. Areas with gravel bars benefit fish because the aggregate provides favorable habitat for aquatic insects and often creates areas of sorted gravels that are the right size for spawning. Zones of cooler water are often found immediately downstream of gravel bars. As a portion of the river flows subsurface through a gravel bar, the water loses heat to the gravel and exits at the downstream end at a cooler temperature. When the river becomes too warm, fish will often retreat to these cool zones for refuge.

The Middle Reach from the Sodom Ditch diversion upstream to the former Brownsville Dam site has the greatest amounts of gravel deposition in the Calapooia River. These areas of gravel deposition provide opportunities to improve fish habitat. Since this is a depositional area where gravel settles out, large trees and logs in the channel through these reaches would help create pools and hiding cover for fish.

The density of natural ponds (pond area per mile of channel) is greatest downstream of Brownsville. Because the ponds occur in low-lying areas that are too wet to farm, most of these ponds are still surrounded by mature, natural vegetation. Many of the natural ponds are connected to the main channel during high flows and then become isolated from the river during lower flows. Fish that retreat into the ponds during high water can become trapped within the ponds for the remainder of the year. The survival of native fish can be threatened if water temperatures become too warm during the summer and if largemouth bass inhabit the pond. Largemouth bass are an introduced species that thrive in warm water. This is a particular concern for the native, young spring Chinook salmon, which commonly seek out slow, backwater areas during high flows. A potential type of restoration project to benefit fish is to re-connect ponds to the main channel and allow fish to move out of the ponds during both high and low flows.

Alcoves, side channels, and natural ponds have a small overall area because they are usually narrow. Their influence on river the ecosystem is greater than what their area would suggest. Being narrow and long, these features have a sizable amount of edge habitat. The productivity of algae, aquatic plants, insects, and other animals is usually highest along the edges of a water body where the water is shallow enough for sunlight to reach the bottom surface of the water body.

Large wood historically played an important role in creating habitat diversity (Figure 3-4). However, log drives, riparian logging, and removal of large wood from the river and tributaries have reduced the prevalence of habitat-forming trees in the Middle Calapooia River. Similar to other areas in the Willamette Valley, logs on the floodplain are cut either for firewood or to reduce the chance of logs damaging property or infrastructure during floods (Figure 3-5). Large wood is important for fish in streams and rivers because it creates pools, hiding areas, bars of gravel that are sorted by size, and is a substrate for aquatic insects.

Figure 3-4. Large wood provides overhead cover for fish habitat and also influences channel morphology. Large wood is a vital component for maintaining fish habitat in the Calapooia River.

The major factors impacting fish habitat and populations in the Calapooia River watershed are fish passage barriers, limited large wood in the river and stream channels, and water quality issues. Major fish passage barriers in the Calapooia River watershed are being address. Adding large wood to the Middle Reach is proposed as part of the restoration prioritization plan.

There are two components constraining the passage of fish in the Calapooia River watershed: fish passage barriers at dams in the river channel, and fish passage issues at road crossing culverts. Dams are the most pressing fish passage issue. The Calapooia River, in comparison to tributary streams, provides most of the important fish habitat, particularly for spring Chinook salmon and winter steelhead trout. The river is the primary corridor for migrating fish and the river channel provides most of the important spawning and rearing habitat. The river's dams – within the

Thompson's Mill complex – delay fish moving upstream to spawning areas in the upper watershed and may prevent the movement of adult and juvenile fish during parts of the year. Delaying the migration of spring Chinook and winter steelhead stresses the fish, leading to reduced spawning success, and provides opportunities for poaching and harassment. Removal of the Brownsville Dam in 2007 is expected to improve fish passage through the Middle Reach to upper portion of the Calapooia River watershed.

Figure 3-5. An example of a large log on the Calapooia River floodplain upstream from Brownsville that was recently cut. The log will no longer function as a habitat forming element.

3.5. Land Use

The following section is largely taken from the Calapooia River Watershed Assessment (Calapooia Watershed Council 2004).

Agriculture and forestry are the dominant land uses within the Calapooia River Watershed. Forests and other natural vegetation (wetlands, riparian, and other areas) cover the largest proportion of the watershed (53%). Agricultural crops cover about 45% of the watershed's area. Grass seed crops dominate agricultural production, occupying more than 23% (including burned grass) of the watershed's area, primarily located in the lower watershed below Brownsville. Built areas (residential and commercial development) occupy the smallest proportion of the watershed (less than 2%).

3.6. Limiting Factors

The following section is largely taken from the Calapooia River Watershed Assessment (Calapooia Watershed Council 2004).

There are several conditions that are believed to limit fish populations in the Calapooia River. These limiting factors include historical logging practices, water quality, water temperatures, and habitat degradation.

Historically, there were frequent and large log drives down the lower and middle Calapooia River. These log drives and the associated removal of wood and log jams, probably continue to affect the river channel by limiting the current quantity of wood in the channel. The reduced number of logs and other wood in the river's channel limit the creation of pools and hiding habitat for fish. The loss of wood from the river channel is further exacerbated by current wood removal as logs continue to be removed from the Calapooia River and tributary streams (Figure 3-5). Logs are removed to prevent bank erosion, reduce damage to property and bridges, and, in some cases, to allow recreational boaters to pass down the channel (Robert Singleton, Corvallis Canoe and Kayak Club, personal communication, 2003). In addition, the lack of large trees growing along some sections of the river and streams contributes to the long-term shortage of wood in channels. The status of streamside forests and the wood removal actions have cumulatively impacted the river channel and fish habitat quality, reducing the formation of pools, limiting hiding cover, and slowing the trapping of spawning gravels. More wood throughout the river and stream system would be helpful. A targeted approach to in-channel wood restoration and riparian area enhancement would be to target the most responsive reaches of the river and the lower portions of tributary streams. The river reaches near Brownsville are areas of active gravel deposition that would be especially responsive to short-term actions to protect current wood in the channel and promote future activities that support enhanced riparian areas.

The quality of the water throughout the Calapooia River Watershed influences its use by fish, wildlife, and humans. Excessive values for water temperature, suspended sediment, nitrogen, phosphorus, and pesticides can make portions of the watershed unfavorable for some species fish and wildlife, especially during the summer when these species are most stressed and water levels are low. Excessive bacteria levels in the water can make the water more difficult to treat for drinking and increase the risk of infection for those who swim and angle in the river. The Calapooia River is included in the 303(d) list as water quality limited for temperature, as a result of the river exceeding the water quality standard of 64 °F in its lower reaches. The Calapooia River is on the 303(d) list for bacteria, as well as temperature. Consequently, it is subject to a TMDL process for bacteria.

Grass seed farming is an important agricultural occupation in the Calapooia River watershed (Figure 3-6). Improving agricultural practices would address nitrogen fertilizer runoff to the river. Compared to cultivated riparian zones, non-cultivated riparian zones are very effective at removing nitrogen from subsurface water draining into a stream. However, due to flow patterns and the speed of surface runoff, while retaining riparian vegetation is generally beneficial to streams, the benefits do not include mitigating nitrogen runoff. The most effective means to control nitrogen runoff from grass seed fields begin with applying only the minimum amount of fertilizer needed to grow a crop and that the timing of the fertilizer coincide with periods of drier weather.

Figure 3-6. A grass seed field paralleling the Calapooia River. The site is characterized by a minimal riparian buffer separating the river from agricultural production.

Water temperatures recently measured throughout the watershed are probably similar to natural patterns, except along some tributaries. The main channel of the river is wide throughout much of its length, and even if mature conifers and hardwoods again grew along the banks, the trees would still not provide much shade to the summer channel. Rapid regrowth of trees along those upper watershed forest streams that were once harvested of trees, combined with current regulations for retaining wide buffers of trees during timber harvest, means that shading levels are high on forest land. Shade is sparser along streams in agricultural and urban areas, and is most critical to providing cool water refuge for fish during the summer months. Brush Creek is an example of a year-round stream that is suitable, to some extent, for supporting winter steelhead and trout during the summer, but could be made cooler and more productive if streamside vegetation was restored along selected reaches that are currently grazed by cattle and horses.

Where rivers have been treated in such a way, conflicts among landowners and declines in fish habitat invariably occur (Figure 3-7). In addition, stopping the meandering on one segment of river usually causes an upstream or downstream increase in meandering and erosion, often creating problems for neighboring landowners. By decreasing the meandering of a river, water velocity increases, the river bottom downcuts, gravel bars become coarser, and zones of still water decrease; all of which are detrimental to fish. Treating a bank to control meandering can not be justified on the grounds of decreasing overall river sediment loads, since the amount of bank material is so small compared to the river's overall sediment load.

Figure 3-7. Working with landowners to address accelerated bank erosion (left) and providing alternatives to dumping fill along the channel (right), are two educational efforts that can be pursued to reduce sediment loading to the Calapooia River as well as slow property loss.

Pond turtle habitat and their populations have been especially altered by human changes in the watershed. Decades ago, largemouth bass and bullfrogs were introduced to the Willamette River and have since been a constant threat to the survival of young turtles. More importantly, pond turtles no longer have much habitat that allows for successful nesting. Now, blackberry and other introduced weeds quickly invade bare or natural grass areas and block the sunlight needed for warming the soil and fostering egg development. Farm fields can provide open space, but tilling can dice up the eggs or collapse the shallow burrows. An increase in turtle egg predators (opossums, coyotes, raccoons, and dogs) due to a lack of top predators, combined with the other above-mentioned factors, has lead to dismal turtle reproduction rates in the Willamette Valley.

3.7. Summary

In summary, the Calapooia River has been impacted by 150 years of development that has brought changes to the river corridor and greater watershed. Despite both historical and contemporary alterations to the river, the Middle Reach of the Calapooia River offers outstanding potential for restoring and conserving riverine and ecological processes necessary to improve conditions for Chinook salmon, steelhead, and cutthroat trout among other fish species. Proposed actions will address habitat conditions and water quality.

4 STREAM CORRIDOR CONDITIONS

The following sections present information from the river reconnaissance, river surveys, and remote sensing completed by RDG.

4.1. River Corridor Overview

The 8 mile study area was delineated into four reaches based on channel and valley morphologies (see Appendix A – Reach Maps). Reach 1 extends from the former Brownsville Dam site to the Town of Brownsville and a change in stream type. Reach 2 extends through the Town of Brownsville. Reach 3 begins downstream of Pioneer Park and continues to a change in stream type. Reach 4 extends downstream to the Sodom diversion dam bifurcation. Table 4-1 includes a reach summary.

Table 4-1. Reach dimensions and characteristics for the Calapooia River study area.

Reach	Dominant Stream Type	Channel Length (miles)	Valley Length (miles)	Channel Sinuosity	General Reach Characteristics
Reach 1	Rosgen C4	2.61	1.96	1.33	Sinuous channel, well-developed floodplain
Reach 2	Rosgen B4c	1.47	1.30	1.14	Narrow beltwidth and valley bottom
Reach 3	Rosgen C4	1.61	1.17	1.38	Dynamic channel, well-developed floodplain
Reach 4	Rosgen B4c	2.29	1.74	1.32	Confined channel, narrow floodplain
Total		8.0	6.17	1.30	

4.2. Reach 1 – Upper Meandering Reach

Reach 1 begins at the former Brownsville Dam site. The channel transitions from a Rosgen B4 stream type in the vicinity of the former dam, to a Rosgen C4 stream type 1,600 ft downstream from the former dam location. Reach 1 extends 2.61 miles to a change in the dominant stream type marking the start of Reach 2. The channel morphology is characterized by alternating riffle-pool sequences. Riffles are typically steep with short runs into deep pools. Glides tend to be relatively long and broad.

The floodplain morphology in the reach is influenced by the valley bottom width and river processes. At the beginning of the reach in the B stream type section, the valley bottom is narrow. The floodplain is defined by a narrow depositional feature on the north side of the river. Riparian vegetation is dominated by multiple age classes of willows. Mature cottonwoods and Oregon ash form the overstory on the outside of the meander. Bank erosion on the outside of the meander is recruiting mature large wood to the river.

The floodplain broadens with the expanding beltwidth marked by the retreating high terraces. Through this transition, the Calapooia River moves from a B stream type to a C stream type. Point bars become more expansive with a more diverse floodplain community. The floodplain exhibits greater development with overflow channels, downed large wood, and a wider range of vegetation age classes. Mature cottonwoods are common on older floodplain surfaces. Younger age classes populate more recent depositional surfaces with the youngest vegetation bordering the active channel. Striations in the point bar vegetation community suggest both preferential flow routes and lateral meander migration patterns.

Reach 1 had the largest number of habitat units (71) of the four reaches. Glide habitats were the most common and also accounted for the greatest channel length. Pool habitats were the least common and also comprised the shortest channel length. Habitat unit summary statistics are presented in Table 4-2. Appendix B presents the distribution of habitat units in all four reaches.

Table 4-2. The habitat unit summary for Reach 1.

Habitat Unit	Channel Length (ft)	Percent of Total Length	Number of Units	Percent of Total Units
Glide	4,826	34.5%	22	31.0%
Pool	1,336	9.5%	11	15.5%
Run	3,416	24.4%	17	23.9%
Riffle	4,429	31.6%	21	29.6%
Total	14,007	100.0%	71	100.0%

Channel habitat unit diversity in the reach reflects the range of fish habitat conditions found in Reach 1. Diverse habitats, frequent large wood, side channels, and extensive riparian vegetation contribute to fish habitat diversity in the reach. The channel habitat units provide the range of instream conditions to support food production, fish growth, and spawning. Instream large wood provides cover and varied flow paths beneficial for fish foraging and resting. Off-channel habitats provide juvenile rearing habitat during all flows, and are especially important resting areas during high water events. The multi-age riparian community provides wood and leaf litter to the stream creating habitat and the basic nutrients for the aquatic community.

4.2.1. Historical Planform Analysis

A time series air photo analysis was completed to evaluate the channel planform geometry over three periods; 1936, 1967, and 2005 (see Appendix F for historical channel alignment maps). This analysis provides insight into historical river changes, stability of the reach, river dynamics and potential for restoration. Planform metrics suggest the channel in 2005 is more similar to the 1936 condition relative to the 1967 condition (Table 4-3). The 1964 flood event may have affected the channel planform captured in the 1967 photograph. The average radius of curvature was lowest in 1937 and highest in 1967. Radius of curvature measurements were least variable in 2005 and most variable in 1967. The average meander length was greatest in 1967 and lowest in 1936. Meander lengths were most variable in 2005. The channel beltwidth was greatest in 2005 and lowest in 1967. Channel sinuosity was similar in 1936 and 2005; the 1967 channel had the lowest sinuosity.

Table 4-3. Channel planform metrics from the historical air photo analysis for Reach 1.

Year	Metric	Radius of Curvature (ft)	Meander Length (ft)	Beltwidth (ft)	Sinuosity
1936	Mean	264	1,555	665	1.26
	1 SD	144	279	136	
1967	Mean	370	1,685	620	1.15
	1 SD	190	304	267	
2005	Mean	344	1,620	760	1.28
	1 SD	102	344	244	

The channel metrics suggest the 1936 was characterized by a relatively tight planform with the shortest radius of curvature and meander length measurements, and a moderate beltwidth. The channel planform therefore reflected frequent, short pools. The 1967 metrics suggest the river planform was more elongated compared to the 1936 planform. The radius of curvature and meander lengths increased. The average beltwidth distance and lower sinuosity suggest a straighter active channel in 1967 relative to 1936. Lower radius of curvature and meander length values in 2005 suggest a trend back towards the 1936 conditions. However, the higher average channel beltwidth and sinuosity suggest the Calapooia River in Reach 1 expanded laterally from 1967 to 2005. The 2005 channel is eroding into lateral high terraces that bracket the active channel corridor, in five locations.

4.2.2. Bank Stabilization and Erosion Sites

Bank stabilization and erosion sites were mapped during the field reconnaissance. Data collected by Inter-fluve (2005) and the CWC were also integrated into the RDG map (see Appendix C for bank stabilization and erosion sites). Bank stabilization in Reach 1 included both traditional riprap and more recent rock barb and large wood projects. Bank stabilization metrics are included in Table 4-4.

Table 4-4. Bank stabilization structures in Reach 1.

Upstream Station	Downstream Station	Structure Length (ft)	Structure Type
13+50	14+50	100	Rock Riprap
20+00	20+50	50	Rock Barb
21+00	21+50	50	Rock Barb
34+00	36+50	250	Rock Riprap
66+00	66+50	50	Rock Barb
67+50	68+00	50	Rock Barb
79+00	79+50	50	Rock Barb
81+00	81+50	50	Rock Barb
82+00	82+50	50	Rock Barb
83+50	84+00	50	ELJ
91+00	91+50	50	Rock Barb
107+50	108+00	50	Rock Barb
108+50	109+00	50	Rock Barb

Table 4-4. Bank stabilization structures in Reach 1.

Upstream Station	Downstream Station	Structure Length (ft)	Structure Type
110+50	111+00	50	Rock Barb
111+00	111+50	50	Rock Barb
112+00	112+50	50	ELJ
Total		1,050	

Two riprap sites were located in the reach. The upstream riprap site stabilizes a bank adjacent to an agricultural field. The downstream site protects residential building located next to the river.

Bank stabilization projects, using rock barbs, are located at three sites. These projects consist of variations using rock barbs, bank re-shaping, vegetation, and/or large wood. For the most part, the barb projects have stabilized bank erosion as illustrated by the Carbajal site (station 104+00 to 111+00) in Figure 4-1. The landowner was losing over 10 ft of streambank every year with some localized erosion exceeding 25 ft per year due to lateral erosion prior to the project. Now, the bank has been stabilized and a riparian corridor has been established that consists of willows on the bank and trees and shrubs on the floodplain. At the Oakley site just upstream (station 68+00), the bank stabilization project was not revegetated as well and is showing signs of additional bank erosion.

Figure 4-1. Examples of eroding bank (left) at the Carbajal site pre-project and more recent (right) photo showing effects of bank stabilization using rock barbs and revegetation.

While these bank stabilization projects have been largely successful at halting lateral erosion, the project start and finish transition areas are exhibiting signs of additional erosion. It is recommended to provide additional stabilization at these points to preserve the investment that was previously made and increase habitat complexity. Treatments should address the entire bank profile, from the bank toe to the top of bank. Continued bank erosion is most likely related to the original treatments not being carried upstream and downstream a sufficient distance.

When evaluating bank stabilization it is important to consider the location on the landscape and the existing riparian conditions. The success or failure of bank stabilization often relates to the location in the context of the historical meander migration belt. Bank stabilization located near the outer limits of the migration corridor typically work better and still provide for river dynamics in the river corridor. The barb projects are all located near the outside edge of the meander migration corridor. In addition, augmenting and maintaining riparian vegetation at all bank stabilization sites is recommended to increase the riparian buffer and provide long-term bank resistance to scour.

There is considerable bank erosion in this dynamic reach of the Calapooia River. Erosion is predominantly associated with the outside of the lower third of meanders. This pattern is typical of meandering rivers as they migrate down-valley over time. The majority of the eroding banks are located on densely forested stream banks. Despite the dense vegetation, bank toe failure leads to block failure and extensive bank loss. Displacement of native riparian shrubs by Himalayan blackberry may have exacerbated streambank retreat in some areas. Given the dynamic nature of Reach 1, future channel alterations are likely. Locations of potential substantial channel adjustment include the channel meanders at the Oakley and Carbajal bank stabilization sites. The meanders through these two areas have the tightest radius of curvatures in the assessment reach. Over time, it is likely the river will avulse through the floodplain and ultimately disconnect these two meanders from the baseflow channel. Table 4-5 includes bank erosion metrics for Reach 1.

Table 4-5. Bank erosion sites in Reach 1.

Upstream Station	Downstream Station	Sediment Source Length (ft)
6+00	9+00	300
25+00	31+00	600
38+00	41+50	350
48+00	51+00	300
69+00	75+00	600
91+50	100+00	850
102+00	104+00	200
116+00	122+00	600
130+00	135+00	500
Total		4,300

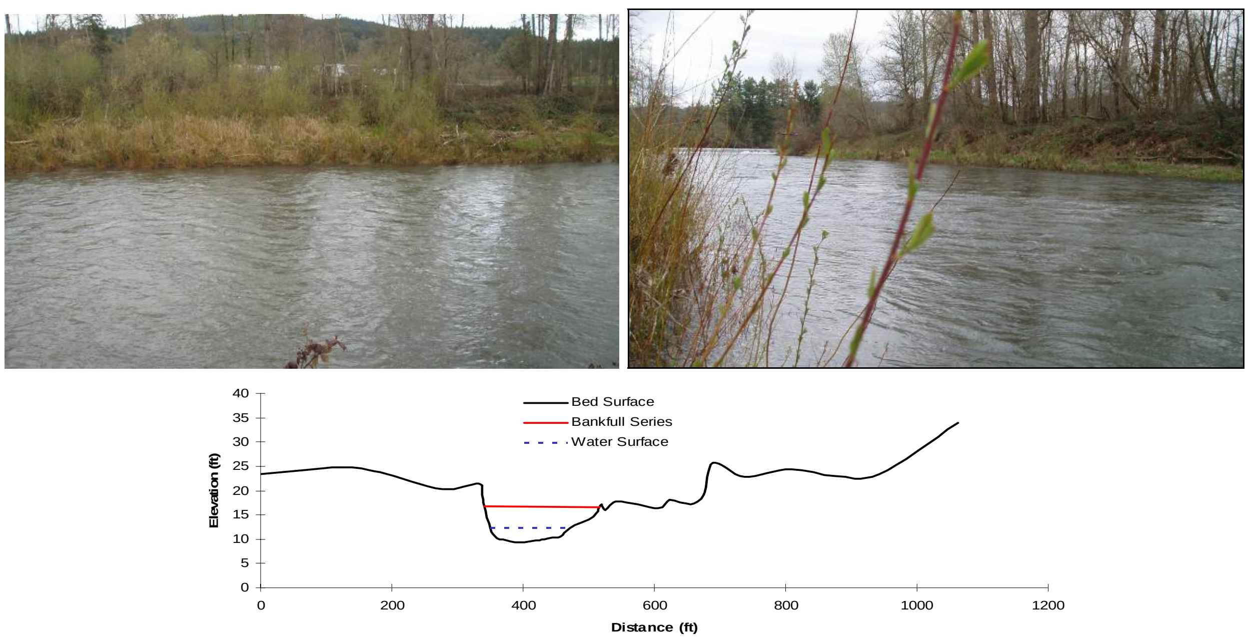
4.2.3. Channel Survey Results

Channel surveys were completed in Reach 1 in March 2007 as part of the Brownsville Dam removal project (see Appendix G for the site survey maps). Ten cross-sections were completed through the dam reach. Four cross-sections were surveyed upstream from the dam, six sections were completed downstream from the dam. Pebble counts and bar samples were also collected to evaluate the channel bed sediment. The cross-sections downstream from the dam site characterized both the Rosgen B stream type and Rosgen C stream type portions of Reach 1. A subset of the cross-sections from both the B and C stream types was analyzed for this report (Table 4-6).

Table 4-6. Bankfull channel cross-section summary for Reach 1. The bankfull channel was delineated based on topographic breaks, sediment deposition, and vegetation patterns.

Reach	Station	Stream Type	Feature	Width (ft)	Area (ft^2)	Mean Depth (ft)	Maximum Depth (ft)	Hydraulic Radius (ft)
Reach 1	6+00	B4c	Glide/Run	175.6	938.8	5.3	7.4	5.3
	10+00	B4c	Riffle/Run	211.9	777.0	3.7	6.5	3.6
	29+00	C4	Glide	126.7	577.9	4.6	6.6	4.5
	38+00	C4	Pool	169.5	715.9	4.2	6.7	4.2
	46+00	C4	Pool	375.9	1022.8	2.7	5.9	2.7

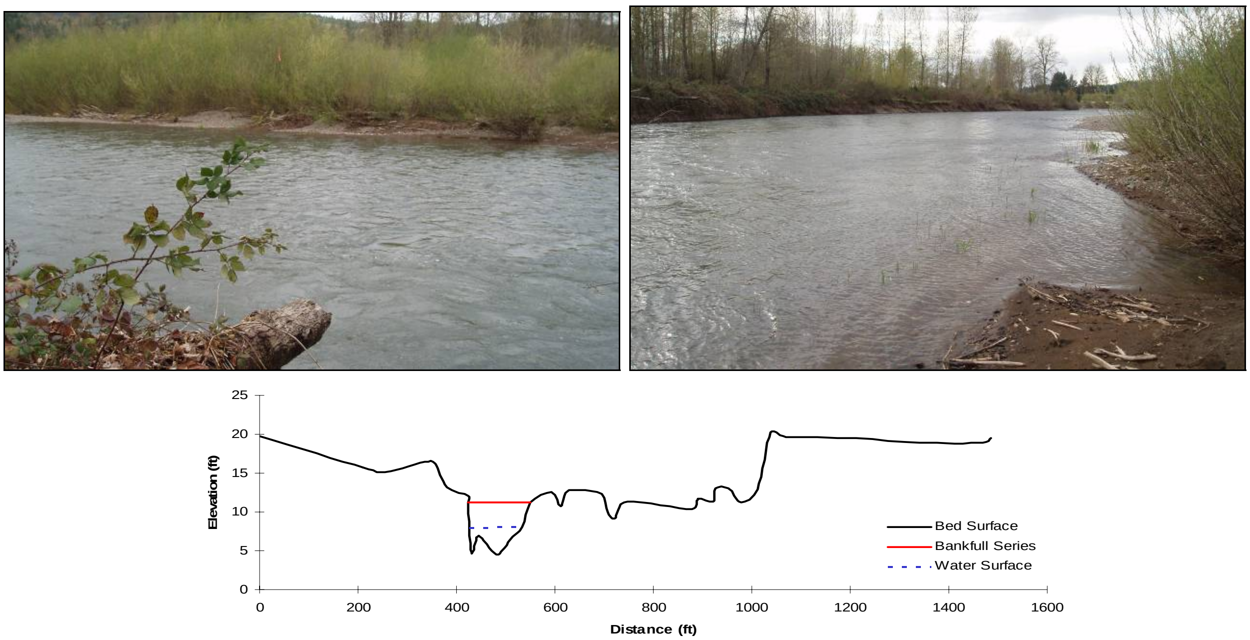
Figure 4-2 depicts the cross-section at Sta. 6+00. The photos capture the features surveyed in the cross-section. For example, the flat inset floodplain in the right portion of the channel cross-section immediately above the estimated bankfull elevation, is the willow surface in the upper left photograph. The low terrace shown forming the left bank in the cross-section figure is captured in the upper right photograph.



Feature	Width (ft)	Area (ft^2)	Mean Depth (ft)	Maximum Depth (ft)
Glide/Run	175.6	938.8	5.3	7.4

Figure 4-2. The cross-section at Sta. 6+00. The upper left photo shows the right floodplain noted by the flat section in the right portion of the cross-section diagram. The upper right photo is a view up river towards the left bank.

Figure 4-3 shows the cross-section at Sta. 29+00. The cross-section was located in the transition from the glide to a riffle. Similar to the cross-section at sta. 6+00, an inset floodplain is located adjacent to the baseflow channel. However, the distance between the terraces bracketing the channel beltwidth is over 1,000 ft. This distance compares to a width of only 560 ft at the cross-section at Sta. 6+00. Flatter channel slopes, lower water velocities and shear stress, and more diverse floodplain morphologies are typically associated with a broadening of the channel beltwidth. The undulations of the floodplain shown in Figure 4-3 show the multiple sidechannels and swales that are located on the floodplain north of the baseflow channel. Focusing restoration efforts on these areas of the stream corridor is suggested for enhancing juvenile fish rearing habitat and refugia.



Feature	Width (ft)	Area (ft^2)	Mean Depth (ft)	Maximum Depth (ft)
Glide	126.7	577.9	4.6	6.6

Figure 4-3. The cross-section at Sta. 29+00 in the Rosgen C4 stream type portion of Reach 1. The upper left photo shows the right floodplain noted by the flat in the right portion of the cross-section diagram. The upper right photo is a view down river towards the left bank. The beltwidth is almost twice as wide at Sta. 29+00 compared to Sta. 6+00, a Rosgen B4c stream type.

Pebble count data from four sampling sites are presented in Table 4-7. Pebble counts were completed downstream of the Brownsville Dam (Sta. 28+00 and 41+00) and at two locations in the same riffle at the Carbajal project location (Sta. 100+00). Channel bed sediment was relatively consistent through the reach.

Table 4-7. Pebble count results for Reach 1. Stationing refers to the base maps provided in Appendix A, Figure 1.

Particle Class	Sta. 28+00 (mm)	Sta. 41+00 (mm)	Sta. 100+00-1 (mm)	Sta. 100+00-2 (mm)
D16	24	23	19	21
D35	35	35	37	36
D50	48	41	51	50
D65	67	63	64	66
D84	85	93	90	90
D95	120	120	110	120

4.2.4. Hydraulic Modeling Results

Two at-a-section hydraulic models were completed in Reach 1 to evaluate channel hydraulics and connection to the floodplain. Pebble count and discharge data were used to calibrate the model. The first model was completed for the cross-section surveyed at Sta. 6+00 in the B stream type reach. The second model was completed for the cross-section surveyed at Station 29+00 in the C stream type reach.

B Stream Type Modeling Results

Three modeling runs were completed for Sta. 6+00 (Table 4-8). The Channel Capacity – Low Feature was the bankfull channel capacity with the bankfull elevation designated as the topographic break from the scoured channel to the vegetated floodplain. The Channel Capacity – High Feature was the bankfull channel capacity at a slightly higher topographic break from the scoured channel to the vegetated floodplain. The channel area increased 105 ft^2 from the Low Feature to the High Feature cross-sections. The third modeling run was completed for the floodway capacity that included the active channel to the top of the terrace. Once floodwater eclipsed this elevation, it would access the high floodplain (e.g., adjacent farmlands, roads). The modeling results are conceptual and would require additional detailed surveys to confirm hydraulic properties.

Table 4-8. The hydraulic modeling results for three stages on the Calapooia River at Sta. 6+00.

Feature	Max Depth (ft)	Area (ft^2)	Width (ft)	Hydraulic Radius (ft)	Slope	Mannings-n Value	Average Velocity (fps)	Discharge (cfs)	Shear Stress (lbs/ft^2)
Channel Capacity - Low feature	6.0	667	204	3.2	0.002	0.032	4.6	3,079	0.40
Channel Capacity - High feature	6.5	772	212	3.6	0.002	0.030	5.2	4,038	0.45
Floodway Capacity	15.4	5,253	1,073	4.9	0.002	0.028	9.9	51,917	0.61

The estimated bankfull discharge return interval for streams in western Oregon is 1.5-years (Castro 1997; Kuch 2000). The regional relation regression equation is Bankfull Discharge = 44.8*Drainage $Area^{0.918}$ (correlation coefficient $R^2 = 0.85$). Based on a drainage area of 152 square miles in the project area, the estimated bankfull discharge is 4,510 cfs. The Channel

Capacity – Low Feature and Channel Capacity – High Feature each conveyed less than the predicted 1.5-year event of 4,510 cfs. However, given the variability inherent in relational equations and hydraulic modeling, the modeling results suggest the scour channel conveys close to the bankfull discharge. The floodway capacity modeling run suggests the floodway conveys nearly 52,000 cfs before accessing terraces. This discharge is double the predicted 500-year event based on the discontinued stream gage station flood frequency analysis. Additional information that would be required to verify this result would include high stage water surface slopes and roughness estimates for the floodplain. In summary, the modeling results suggest the scoured channel conveys the approximate bankfull discharge and the floodway has the capacity to convey in excess of the 500-year event. Additional data and modeling would need to be completed to validate these results.

C Stream Type Modeling Results

Three modeling runs were completed for Sta. 29+00 (Table 4-9). The Channel Capacity – Low Feature was the bankfull channel capacity with the bankfull elevation designated as the topographic break from the scoured channel to the vegetated floodplain. The Channel Capacity – High Feature was the bankfull channel and the floodplain. The floodplain at Sta. 29+00 has patches of vegetation but mainly has expanses of gravel and sand suggesting it is frequently inundated. The channel area more than doubled from the Low Feature to the High Feature cross-sections. The third modeling run was completed for the floodway capacity that included the active channel to the top of the terrace. Once floodwater eclipsed this elevation, it would access the adjacent farmlands and roads. The modeling results are conceptual and would require additional detailed surveys to confirm hydraulic properties.

Table 4-9. The hydraulic modeling results for three stages on the Calapooia River at Sta. 29+00.

Feature	Max Depth (ft)	Area (ft^2)	Width (ft)	Hydraulic Radius (ft)	Slope	Mannings-n Value	Average Velocity (fps)	Discharge (cfs)	Shear Stress (lbs/ft^2)
Channel Capacity - Low feature	6.60	664	289	2.3	0.0020	0.025	4.7	3,112	0.28
Channel Capacity - High feature	8.30	1,392	581	2.4	0.0020	0.034	3.5	4,900	0.30
Floodway Capacity	15.30	7,236	1,457	4.9	0.0001	0.025	1.9	13,372	0.03

The Channel Capacity – Low Feature conveyed less than the predicted 1.5-year event of 4,510 cfs. The Channel Capacity – High Feature conveyed more than the estimated 1.5-year event but less than the 2-year event of 5,500 cfs. The Floodway Capacity run suggests the floodway contains up to the 50-year event before the lateral terraces are accessed. The floodway channel at Sta. 29+00 has substantially less capacity compared to the Sta. 6+00 cross-section due to the flatter floodplain slope in the C stream type reach. Similar to the Sta. 6+00 results, determining the appropriate flood stage water surface slope would improve the Floodway Capacity discharge estimate. In summary, the modeling results suggest the scoured channel and floodplain convey the approximate bankfull discharge and the floodway has the capacity to convey the 50-year event discharge. Additional data and modeling would need to be completed to validate these results.

4.2.5. Fish Habitat Conditions

In the study area, Reach 1 provides an intermediate level of fish habitat diversity. The sinuous C stream type provides juvenile rearing, adult resting, and spawning habitat. Juvenile rearing habitats include backwater channels, shallow channel margins in the lower third of meanders, and adjacent to point bars. Backwater channels typically connected with the mainstem channel in the lower third of meanders. Backwater channels were either connected with the baseflow channel or would be connected at elevated river stages. These areas provide ideal rearing habitat as well as resting habitat for all age classes when the river stage increases during high water. Shallow channel margins often supported sedges and rushes that provide additional cover for juvenile fish.

4.2.6. Summary

Bank stabilization sites are generally functioning as intended. More recent barb projects provide a range of microhabitats and have reduced bank erosion. The Carbajal site is characterized by a dense willow community that maintains bank stability. Bank erosion sites are typically located in the lower third of meanders and do not threaten infrastructure. Streambanks will continue to erode as the river evolves and migrates across the floodplain and down-valley over time.

4.3. Reach 2 – Brownsville Reach

Reach 2 begins at the start of the confined portion of the Calapooia River. Reach 2, also referred to as the Brownsville Reach, flows through the moderately urban portion of the watershed. Stream types in the reach include Rosgen C4, B4, and F4 stream types. Reach 2 extends 1.63 miles to a change in land use and the riparian community condition marking the start of Reach 3 downstream from Pioneer Park. The channel morphology in Reach 2 is dominated by riffle and glide habitats. Riprap bank stabilization throughout the reach as well as encroaching hillslopes in Brownsville limit lateral channel migration. Pool development is limited and the habitat is relatively homogenous.

The floodplain morphology in the reach is influenced by the valley bottom width and river processes. At the beginning of the reach in the C stream type section, the valley bottom width permits narrow floodplain development. The riparian community is dominated by a cottonwood overstory and willow shrub layer. Several large point bars between the start of Reach 3 and the Brownsville Bridge suggest a mobile streambed and localized sediment storage. A dispersed riparian canopy is located on the southern floodplain. Vegetation patterns reflect the agricultural practices that predominate on the south side of the Calapooia River upstream of the Brownsville Bridge. Figure 4-4 includes some typical photographs of the upstream half of Reach 2.

Figure 4-4. Typical vegetation conditions on the southern floodplain (left) and a point bar with backwater habitat (right).

Approaching the Brownsville Bridge, the channel planform is straight with minimal channel complexity. The channel morphology is dominated by riffle and glide habitats. A lack of point bars and minimal side bars suggest this section is a transport reach with limited sediment storage. The riparian community on the north side of the channel is more diverse than the community populating the southern floodplain although the understory vegetation appears to have been recently cleared from the northern floodplain 500 ft upstream of the bridge. Vegetation on the south side of the channel suggests a longer history of native riparian community manipulation. A bridge appears to have been located approximately 1,500 ft upstream of the Brownsville Bridge. Rock riprap and possible road approaches denote the site's likely history as a river crossing. At the time of the 2007 field survey, the City was installing a sewer pipe under the Calapooia River immediately upstream of the Brownsville Bridge.

Downstream of the Brownsville Bridge, the valley bottom widens as the Calapooia River borders Pioneer Park. An extensive riprap bank on the southwest bank limits channel migration. The channel morphology is dominated by glide habitat with a moderately sloped point bar defining the right bank. As the channel alignment straightens through the park section, the right bank experiences severe bank erosion. Previous attempts to stabilize the bank with concrete, asphalt, and car bodies have proven unsuccessful. Bank erosion now threatens park infrastructure as well as mature cottonwoods paralleling the channel. A narrow cottonwood forest is located on the west streambank. High streambanks through this area confine flood flows to the channel, exacerbating erosion concerns.

Reach 2 had the fewest number of habitat units (40) of the four reaches. Riffle and glide habitats were the most common and also accounted for the greatest channel length. Pool habitats were the second least common and comprised the shortest channel length. Habitat unit summary statistics are presented in Table 4-10. Appendix B presents the distribution of habitat units in all four reaches.

Table 4-10. The habitat unit summary for Reach 2.

Habitat Unit	Channel Length (ft)	Percent of Total Length	Number of Units	Percent of Total Units
Glide	2,022	25.3%	11	27.5%
Pool	708	8.9%	9	22.5%
Run	1,137	14.2%	6	15.0%
Riffle	4,113	51.5%	14	35.0%
Total	7,980	100.0%	40	100.0%

The low number of channel habitat units and the predominance of riffle and glide habitats in Reach 2 reflects the influence of both the natural and human-influenced channel morphology. Channel stabilization and the transport of large wood through the reach related to the more confined nature of the Calapooia River in the reach have resulted in a less dynamic channel. The active removal of wood from the channel also reduces habitat formation potential. Fish habitat through the reach is limited due to the homogenous channel conditions.

4.3.1. Historical Planform Analysis

A time series air photo analysis was completed to evaluate the channel planform geometry over three periods; 1936, 1967, and 2005 (Table 4-11). Planform metrics suggest the channel in 2005 is more similar to the 1967 condition relative to the 1936 condition (see Appendix F for historical channel alignment comparisons). The confined nature of the reach limits lateral channel adjustment. The average radius of curvature was lowest in 2005 and highest in 1936. Radius of curvature measurements were least variable in 2005 and most variable in 1936. The average meander length was greatest in 1967 and lowest in 1936. Meander lengths were most variable in 1936. The channel beltwidth was greatest in 1967 and lowest in 1936. Channel sinuosity was similar in 1967 and 2005; the 1936 channel had the lowest sinuosity.

Table 4-11. Channel planform metrics from the historical air photo analysis for Reach 2.

Year	Metric	Radius of Curvature (ft)	Meander Length (ft)	Beltwidth (ft)	Sinuosity
1936	Mean	900	1,580	275	1.01
	1 SD	707	427	77	
1967	Mean	779	1,940	455	1.07
	1 SD	686	239	180	
2005	Mean	713	1,795	450	1.09
	1 SD	612	355	164	

The channel metrics suggest the 1936 was characterized by a relatively straight and narrow channel planform with the shortest meander length, narrowest beltwidth and lowest sinuosity. Each of these metrics had high standard deviations suggesting variable conditions. The channel planform metrics suggest pools were more frequent and longer in 1936 relative to the two later periods. The 1967 metrics suggest a river planform that was intermediate to the 1936 and 2005 planforms. Metric values were generally in between the same metrics measured during the earlier and later periods. Values measured from the 2005 photos suggest the influence of bank stabilization projects that have limited lateral channel migration and meander extension.

4.3.2. Bank Stabilization and Erosion Sites

Bank stabilization and erosion sites were mapped during the field reconnaissance. Data collected by Inter-fluve (2005) and the CWC were also integrated into the RDG map (see Appendix C for bank stabilization and erosion sites). Rock riprap was the method of bank stabilization in Reach 2. Bank stabilization metrics are included in Table 4-12.

Table 4-12. Bank stabilization structures in Reach 2.

Upstream Station	Downstream Station	Structure Length (ft)	Structure Type
159+00	160+00	100	Rock Riprap
166+00	166+50	50	Rock Riprap
181+00	181+50	50	Concrete Slab
185+00	202+00	1700	Rock Riprap
207+00	209+00	200	Car Bodies
Total		2,100	

Two riprap sites were identified upstream of Brownsville Bridge. The upstream site protects a residence built adjacent to the river. The downstream site appears to be at a former river crossing location. The treated area is localized. Downstream of the Brownsville Bridge, the left bank is stabilized for approximately 2,000 ft. This project was likely implemented in the early 1960s when an extensive bank stabilization effort was undertaken. A concrete slab immediately downstream from the bridge may be an old crossing or the remnant of some other infrastructure. Figure 4-5 illustrates bank stabilization treatments in Reach 2.

Figure 4-5. Bank stabilization sites in Reach 2 include the house protection at Sta. 160+00 (left) and at Pioneer Park.

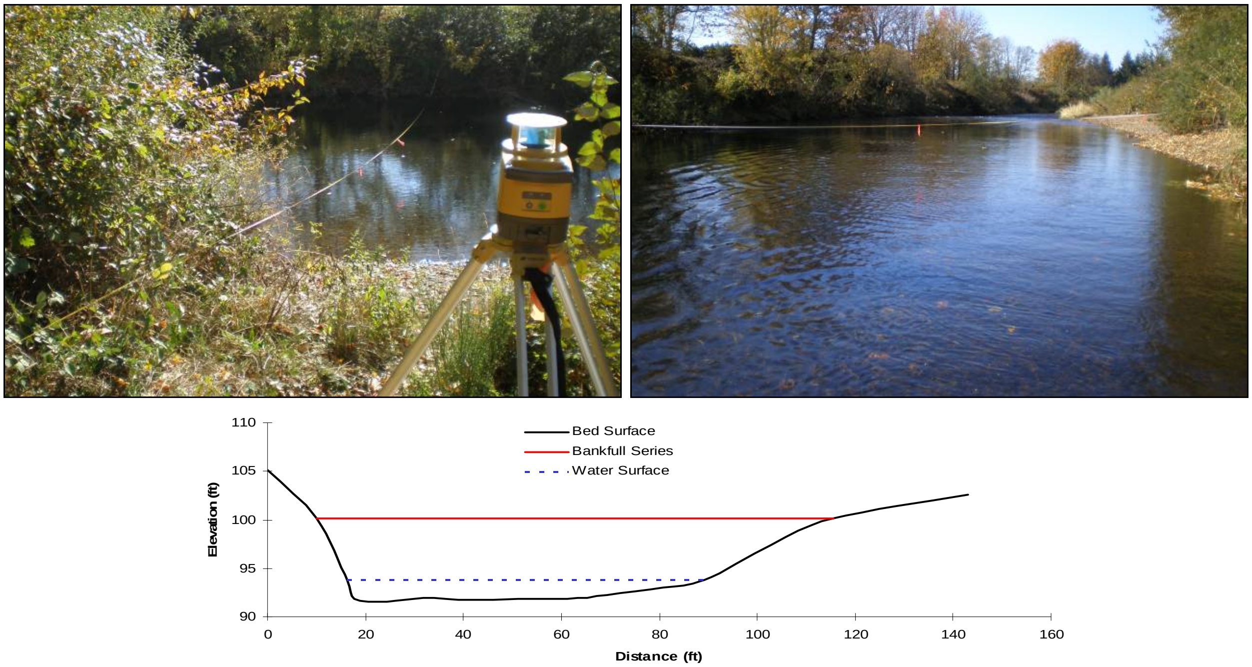
Bank erosion is less extensive in Reach 2 than in Reach 1. However, erosion in Reach 1 threatens infrastructure located on the Calapooia River floodplain and terraces. Erosion is likely related to vegetation conditions and bank stabilization efforts undertaken to improve agriculture. The narrow riparian zone through Reach 2 results in a narrower buffer between the active channel and adjacent upland properties. Displacement of the native shrub layer and the presence of grasses has reduced the floodplain's resistance to lateral erosion. The lengthy riprap bank across the river from the park may translate stream energy downstream to the severely eroded bank. Unfortunately, stabilizing this eroding streambank may further transfer the stream energy downstream. Table 4-13 includes bank erosion metrics for Reach 2.

Table 4-13. Bank erosion sites in Reach 2.

Upstream Station	Downstream Station	Sediment Source Length (ft)
144+00	155+00	1,100
161+50	162+25	75
172+00	177+00	500
182+00	188+00	600
204+00	214+00	1,000
214+25	215+50	125
Total		3,400

4.3.3. Channel Survey Results

A hydraulic channel cross-section was established in Reach 2 adjacent to Pioneer Park downstream from Brownsville Bridge. A channel survey was completed on October 25, 2007. The survey included a cross-section, channel profile, discharge measurement, and pebble count in the C stream type portion of Reach 2. Summary information from the survey is included in Figure 4-6. The photos capture typical river corridor conditions in the vicinity of Pioneer Park. The left bank is stabilized with riprap. The right bank is a point bar with medium density riparian vegetation at the topographic break. The right floodplain has been kept in a moderately natural state with a riparian canopy and grass floodplain surface. The shrub layer that would be expected in a more natural setting was removed in the past to create the park conditions. The cross-section also exhibits the sloped point bar and flat channel bottom that predominates through the park section of the Calapooia River.



Feature	Width (ft)	Area (ft^2)	Mean Depth (ft)	Maximum Depth (ft)
Riffle/Run	105.6	681.2	6.5	8.6

Figure 4-6. The cross-section at Sta. 188+50. The upper left photo shows the view across the river from the right bank. The upper right photo captures the river corridor downstream from XS-2.

Pebble count data from Reach 2 are presented in Table 4-14. The pebble count was completed to document channel bed materials and to determine a near baseflow roughness coefficient for the hydraulic modeling. Channel bed sediment was relatively consistent through the reach.

Table 4-14. Pebble count results for Reach 2. Stationing refers to the base maps provided in Appendix A, Figure 1.

Particle Class	Sta. 188+50 (mm)
D16	27
D35	40
D50	48
D65	55
D84	69
D95	87

4.3.4. Hydraulic Modeling Results

One at-a-section hydraulic model was completed in Reach 2 to evaluate channel hydraulics and connection to the floodplain. Pebble count and discharge data were used to calibrate the model. Modeling results are included in Table 4-15.

Table 4-15. The hydraulic modeling results for three stages on the Calapooia River at Sta. 188+50.

Feature	Max Depth (ft)	Area (ft^2)	Width (ft)	Hydraulic Radius (ft)	Slope	Mannings-n Value	Average Velocity (fps)	Discharge (cfs)	Shear Stress (lbs/ft^2)
Discharge Measurement	2.2	117	73	1.58	0.0009	0.049	1.2	140	0.08
Field Selected Bankfull Indicator	8.6	681	106	6.20	0.0009	0.038	3.8	2,658	0.27
Estimated 2-yr Event Hydraulics	11.3	1,039	157	5.53	0.0009	0.034	5.6	5,479	0.47

The field-delineated bankfull channel conveyed less than half the estimated bankfull discharge. Modeling results for the estimated 2-year discharge calculated in the flood frequency analysis suggests the 2-year flood event has a stage 2.7 ft higher than the field selected bankfull indicators. Modeling results at the Reach 2 cross-section suggest the Calapooia River is connected with the adjacent floodplain through the Pioneer Park section. However, upstream portions of Reach 2, particularly around the Brownsville Bridge, are laterally confined with no river communication with an adjacent floodplain.

4.3.5. Fish Habitat Conditions

Channel conditions in Reach 2 were relatively homogenous. Riffles were the predominant habitat feature by both percentage of habitats and total habitat unit length. Pools were limited through the reach and large wood was less frequent in Reach 2 than in Reach 1. The historical air photo analysis suggests the channel has been located in similar alignment since the 1930s. Hillslope encroachment on the channel and bank stabilization structures limit channel migration and the creation and destruction of habitats that would be driven by lateral channel migration. Large wood which would influence habitat formation and maintenance has been removed from or transported through the reach. Development of the adjacent floodplain has reduced the potential for large wood requirement to the channel. Finally, conversion of the native riparian community to a mature canopy and underlying grass/forb community has displaced the riparian community's shrub component. Shrubs typically provide overhead cover for fish along channel margins, contribute small wood and leaf detritus to the stream that serves as a forage base for macroinvertebrates, and maintain streambank stability. Fish habitat improvement recommendations for Reach 2 focus on large wood recruitment and recovery of the riparian zone.

4.3.6. Summary

The river corridor through Reach 2 is typified by a narrow riparian community, relatively stable channel, and homogenous habitat. The upper half of the reach has a low sinuosity. The lower half of the reach is constrained by a riprap bank but is actively eroding the downstream opposite streambank. Maintaining and enhancing the riparian community through the reach will improve the long-term stability of riverside properties and also benefit aquatic habitat. Stabilization of the park's eroding bank should include techniques and materials that provide habitat and promote vertical pool scour and energy dissipation.

4.4. Reach 3 – Lower Meandering Reach

Reach 3 begins in the riffle downstream from Pioneer Park. Similar to Reach 1, the Calapooia River in Reach 3 is characterized by a meandering riffle-pool channel morphology and relatively broad floodplain. The Calapooia River is classified as a Rosgen C4 stream type through Reach 3. Reach 3 extends 1.59 miles to a change in the channel and floodplain morphologies marking the start of Reach 4. Channel habitat units are well distributed by both percentage of total units and unit type lengths. Large wood is more influential in the reach than in Reach 2 and resembles the conditions in Reach 1. A cottonwood overstory riparian community dominates the floodplain in Reach 3. Floodplain sidechannel networks, relict channels, and floodplain ponds reveal the complex history of the Calapooia River through Reach 3. Remnant levees and extensive bank stabilization reflect twentieth century efforts to train the river and limit lateral channel migration.

A review of the historical channel alignments suggests the river pattern has varied over time, largely in response to large floods and human modification of the river corridor. Modifications have included extensive riprap bank stabilization of the southern stream bank. At least one floodplain levee was built to protect adjacent agricultural land from flooding. Vegetation has colonized most of the stabilized banks.

Floodplain expanses in Reach 3 provide a range of habitats beneficial for both fish and wildlife. Backwater habitats, groundwater-fed percolation channels, and floodplain ponds are inundated year round but may only be connected with the mainstem Calapooia River during elevated flows (Figure 4-7). Hyporheic (shallow subsurface flow) or groundwater upwelling in these floodplain features provide cool water refugia for fish during warmer summer months. Shallow channel margins also create cover for juvenile fish. Habitats containing large wood provide complex microhabitats for juvenile fish as well.

Figure 4-7. Backwater channels and large wood in Reach 3 provide a range of habitats that benefit juvenile and adult fish in the Calapooia River.

The history of channel locations throughout the Reach 3 floodplain has left a mosaic of relic channels that erupt on the floodplain creating diverse microhabitats. Accentuating these features and improving their connection with the mainstem are potential actions that could enhance habitats for juvenile fish rearing as well as provide areas for amphibians.

Reach 3 had the second fewest habitat units of the four study reaches, but had the highest percentage of pool length and highest percentage of pool habitats among the study reaches. Glide and riffle habitat units were the most common by both percent of the total units and the unit type channel length within Reach 3. Habitat unit summary statistics are presented in Table 4-16. Appendix B presents the distribution of habitat units in all four reaches.

Table 4-16. The habitat unit summary for Reach 3.

Habitat Unit	Channel Length (ft)	Percent of Total Length	Number of Units	Percent of Total Units
Glide	2,397	28.8%	16	26.7%
Pool	2,024	24.3%	14	23.3%
Run	1,677	20.2%	14	23.3%
Riffle	2,217	26.7%	16	26.7%
Total	8,315	100.0%	60	100.0%

The higher number of pool habitats in Reach 3 suggests the benefits of large wood and more sinuous channel planform than found in Reach 2. The pools also tended to be longer in Reach 3 than in Reach 2, potentially offering more adult fish habitat space in the downstream reach.

4.4.1. Historical Planform Analysis

A time series air photo analysis was completed to evaluate the channel planform geometry over three periods; 1936, 1967, and 2005 (Table 4-17). Planform metrics suggest the channel planform metrics have varied over time, probably an indication of the river response to channel and floodplain modifications in the reach. The average radius of curvature was lowest in 1936 and highest in 2005. Radius of curvature measurements were least variable in 1936 and most variable in 1967. The average meander length was greatest in 1967 and lowest in 1936. Meander lengths were most variable in 1967. The channel beltwidth was greatest in 1967 and lowest in 1936. Channel sinuosity was greatest in 1936 and has decreased over time.

Table 4-17. Channel planform metrics from the historical air photo analysis for Reach 3.

Year	Metric	Radius of Curvature (ft)	Meander Length (ft)	Beltwidth (ft)	Sinuosity
1936	Mean	165	973	270	2.03
	1 SD	51	229	269	
1967	Mean	383	1,860	760	1.5
	1 SD	339	531	294	
2005	Mean	554	1,435	385	1.29
	1 SD	173	174	195	

A review of historical and recent channel alignments illustrate the changes in the channel planform in Reach 3 over the past 70 years (Appendix F). The once multi-channel river has been simplified and straightened over time. The channel once traversed may of the today's forested floodplain areas.

4.4.2. Bank Stabilization and Erosion Sites

Bank stabilization and erosion sites were mapped during the field reconnaissance. Data collected by Inter-fluve (2005) and the CWC were also integrated into the RDG map (see Appendix C for bank stabilization and erosion sites). Bank stabilization in Reach 3 included riprap projects, a rock spur, and a large wood project. Bank stabilization metrics are included in Table 4-18.

Table 4-18. Bank stabilization structures in Reach 3.

Upstream Station	Downstream Station	Structure Length (ft)	Structure Type
231+00	232+00	100	Rock Riprap
232+00	236+00	400	4 Engineered Log Jams
241+00	241+50	50	Rock Spur
242+00	261+00	1,900	Rock Riprap
270+00	274+00	400	Rock Riprap
290+00	298+00	800	Rock Riprap
Total		3,650	

Five riprap sites and a rock spur were located in the reach. Riprap sites were generally extensive and protect adjacent agricultural land. The riprap was likely installed during the 1962 effort and is largely grown over with shrubs, blackberry, and overstory deciduous trees. The Ross bank stabilization site included bank re-grading, four engineered log jams, and riparian plantings. The downstream riprap sites stabilize streambanks adjacent to agricultural fields. Figure 4-8 depicts bank stabilization projects in Reach 3.

Figure 4-8. Examples of bank stabilization in Reach 3 include the Ross site (left) and an older riprap project spanning 2,000 ft from Sta. 242+00 to 262+00 (right).

The engineered log jams at the Ross site provide adequate bank protection. Willow cuttings planted on the re-graded bank have experienced low survival. To ensure the long-term stability of the site, more willows and other riparian vegetation should be replanted and maintained.

The extensive riprap bank stabilization in Reach 3 limits lateral channel migration and related streambank erosion. However, there are four primary bank erosion areas in the reach. The first site, located downstream from Pioneer Park is experiencing accelerated bank retreat caused by eddying. The bank failure is threatening one of the park buildings and continues to erode the adjacent neighbor's property (Figure 4-10). The river is also eroding the floodplain downstream from the Ross project. The streambank has experienced accelerated erosion since 2005 (Inter-fluve 2007). This trend is expected to continue as the river migrates down-valley over time. The Nealon property located in the next meander downstream from the Ross property is also experiencing accelerated streambank failure. The vertical bank has a poor riparian condition and no toe protection capable of withstanding flood hydraulics (see Figure 4-9). The final primary bank erosion site is located on an outside meander downstream from an extensive riprap bank. Located from Sta. 262+00 to 268+00, the Calapooia River is eroding a forested floodplain. Bank erosion will recruit mature trees to the river. Other sediment sources in the reach are relatively isolated and smaller scale. Table 4-19 includes sediment source metrics in Reach 3.

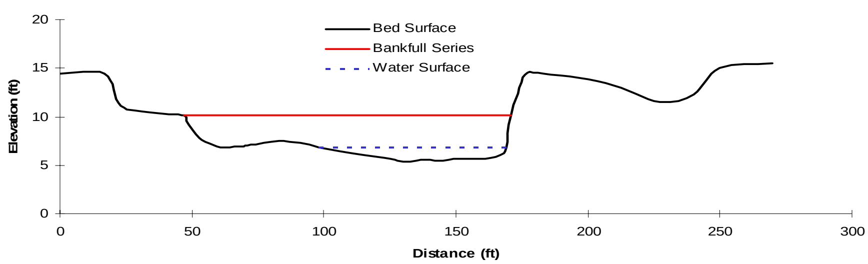
Figure 4-9. The bank erosion site downstream from Pioneer Park that continues onto the Gerber and Smith properties (left), and the vertical streambank on the Nealon property (right). The blackberry covered structure in the middle of the right photograph is a rock spur or levee.

Table 4-19. Bank erosion sites in Reach 3.

Upstream Station	Downstream Station	Sediment Source Length (ft)
221+50	226+50	500
235+00	239+00	400
238+50	243+00	450
262+00	268+00	600
288+00	290+00	200
Total		2,150

4.4.3. Channel Survey Results

A hydraulic channel cross-section was established in Reach 3 downstream from the Ross Property at the waste water discharge diffuser. A channel survey was completed on October 25, 2007. The survey included a cross-section, channel profile, discharge measurement, and pebble count. Summary information from the survey is included in Figure 4-10. The photos capture typical river corridor conditions in the vicinity of Pioneer Park. The left bank is stabilized with riprap. The right bank is point bar with moderately dense riparian vegetation at the topographic break. The right floodplain has been kept in a moderately natural state with a riparian canopy and grass floodplain surface. The shrub layer that would be expected in a more natural setting is mowed to maintain the park conditions. The cross-section also exhibits the moderately sloped point bar and flat channel bottom that predominates through the park section of the Calapooia River.



Feature	Width (ft)	Area (ft^2)	Mean Depth (ft)	Maximum Depth (ft)
Riffle/Run	124.0	444.0	3.6	4.7

Figure 4-10. The cross-section at Sta. 254+00. The upper left photo shows a view across the river from the left bank. The right photo captures the river corridor through the cross-section location.

Pebble count data from Reach 3 are presented in Table 4-20. Two pebble counts were completed in Reach 3. The first count was completed in 2006 by the NRCS as part of the Ross bank stabilization project. The second count was completed by RDG in 2007 at the hydraulic cross-section. The hydraulic cross-section pebble count was completed to document channel bed materials and to determine a near baseflow roughness coefficient for the hydraulic modeling. The particle size distribution was similar for the two sites although the 2007 pebble count documented coarser particles for the particle size classes less than the D95 class.

Table 4-20. Pebble count results for Reach 3. The pebble count at Sta. 254+00 was completed in October 2007, the pebble count at Sta. 235+00 was completed by the NRCS near the Ross bank stabilization project in 2006.

Particle Class	Sta. 254+00 (mm)	Sta. 235+00 (mm)
D16	35	26
D35	52	41
D50	64	52
D65	76	62
D84	96	83
D95	120	120

4.4.4. Hydraulic Modeling Results

One at-a-section hydraulic model was completed in Reach 3 to evaluate channel hydraulics and connection to the floodplain. Pebble count and discharge data were used to calibrate the model. Modeling results are included in Table 4-21.

Table 4-21. The hydraulic modeling results for three stages on the Calapooia River at Sta. 254+00.

Feature	Max Depth (ft)	Area (ft^2)	Width (ft)	Hydraulic Radius (ft)	Slope	Mannings-n Value	Average Velocity (fps)	Discharge (cfs)	Shear Stress (lbs/ft^2)
Discharge Measurement	1.4	68	71	0.97	0.0025	0.026	2.83	193	0.15
Field Selected Bankfull Indicator	4.7	445	125	3.50	0.0025	0.02	3.80	3,835	0.55
Estimated 2-yr Event Hydraulics	5.4	540	144	3.68	0.0025	0.019	10.2	5,502	0.57
Floodway Capacity	9.0	1,182	124	7.75	0.0025	0.013	19.5	23,119	0.80

The field-delineated bankfull channel conveyed less than the estimated 2-year discharge calculated in the flood frequency analysis. The flood frequency suggests the 2-year flood event is maintained within the existing channel. Stream flows up to approximately 22,000 cfs are maintained between the two lateral terraces at the site. This volume equates to approximately the 500 year event. Additional discharge measurements and hydraulic modeling would be necessary to verify these results. Nonetheless, flood flows are confined between the two terraces at the survey site. It is unclear how much floodplain and channel modification has taken place at the survey location. Based on the degree of channel entrenchment, it may be possible that the right bank was bermed to reduce flooding. Additionally, the left bank is stabilized and the historical floodplain may have been filled for agriculture.

4.4.5. Fish Habitat Conditions

Reach 3 maintains high quality in-stream and off-channel fish habitat. Sidechannels, floodplain ponds, and backwater habitats provide a range of depths and water velocities. Juvenile fish were found rearing in channel margins and alcoves with vegetated channel margins and stable large wood. Mature trees with attached rootwads appeared to provide the most diverse microhabitats for the juvenile fish inhabiting backwater habitats. Channel margins and off-channel habitats also provide resting habitat for both juvenile and adult fish during flood events when mainstem water velocities and turbulence reach maximum levels. Dense willow thickets lining the channel and riparian vegetation on floodplain surfaces would also provide velocity breaks during high water events. In summary, a diverse array of habitats accentuated by stable large wood and riparian vegetation, provided microhabitats for both juvenile and adult fish in Reach 3.

4.4.6. Summary

Reach 3 maintains high quality river and floodplain habitats. Although the river is less complex relative to historical conditions, frequent large wood and off-channel habitats present opportunities for enhancing fish habitat through the reach. Intact floodplain forests contribute large wood to the river, provide habitat diversity, and shade floodplain channels. Addressing bank erosion at the Nealon property would slow further land loss at the site.

4.5. Reach 4 – Quarry Reach

Reach 4 is influenced by a lateral hillslope that narrows the Calapooia River floodplain and straightens the channel alignment. Reach 4, also referred to as the Quarry Reach, as the river parallels the Knife River Quarry in the lower end of the reach. Stream types in the reach include both Rosgen C4 and F4 stream types. Reach 4 extends 2.31 miles to the channel bifurcation leading to Sodom Dam. The channel morphology in Reach 4 is dominated by glide habitat with a nearly equal distribution of riffle, run, and pool habitats. Bank stabilization is limited in the reach to four sites. A hillslope comprises the right streambank through most of the reach. Agricultural fields border the river corridor to the south.

The floodplain morphology in the reach is influenced by the valley bottom width and river processes. The floodplain is relatively narrow compared to Reach 3 and lacks the complexity found in the upstream reach. The northern hillslope supports oak and Douglas fir stands. Bedrock outcrops are apparent where the river interfaces with the toe of the hillslope.

Sediment and large wood are transported through the more confined portions of Reach 4. These materials are stored in two primary depositional sections of the reach (Sta. 342+00 and 380+00). A large backwater habitat adjacent to the upstream depositional reach has diverse aquatic habitat.

Reach 4 had the second highest number of habitat units (66) of the four reaches. Glide habitats were the most common and also accounted for the greatest channel length. Run habitats were the least common by total habitat unit length and pools were the most infrequent type of habitat unit. Habitat unit summary statistics are presented in Table 4-22. Appendix B presents the distribution of habitat units in all four reaches.

Table 4-22. The habitat unit summary for Reach 4.

Habitat Unit	Channel Length (ft)	Percent of Total Length	Number of Units	Percent of Total Units
Glide	5,889	50.3%	20	30.3%
Pool	1,911	16.3%	14	21.2%
Run	1,716	14.7%	16	24.2%
Riffle	2,190	18.7%	16	24.2%
Total	11,706	100.0%	66	100.0%

The extensive glide habitats in the reach are related to the straight sections of the channel that have homogenous habitat conditions. Several of the pools were also located through the reach. Large wood anchored in the river bed provided flow divergence and habitat diversity (Figure 4-11).

Figure 4-11. Example habitats in Reach 4 include glide-riffle transitions (left) and runs influenced by large wood (right).

4.5.1. Historical Planform Analysis

A time series air photo analysis was completed to evaluate the channel planform geometry over three periods; 1936, 1967, and 2005 (Table 4-23). Planform metrics suggest the channel in 2005 is more similar to the 1967 condition relative to the 1936 condition. The confined nature of the reach limits lateral channel adjustment. The average radius of curvature was lowest in 2005 and highest in 1936. Radius of curvature measurements were least variable in 2005 and most variable in 1936. The average meander length was greatest in 1967 and lowest in 1936. Meander lengths were most variable in 1936. The channel beltwidth was greatest in 1967 and lowest in 1936. Channel sinuosity was similar in 1967 and 2005; the 1936 channel had the lowest sinuosity. The historical channel alignments are included in Appendix F.

Table 4-23. Channel planform metrics from the historical air photo analysis for Reach 4.

Year	Metric	Radius of Curvature (ft)	Meander Length (ft)	Beltwidth (ft)	Sinuosity
1936	Mean	163	736	276	1.42
	1 SD	91	265	141	
1967	Mean	359	1,580	555	1.23
	1 SD	86	803	414	
2005	Mean	350	1,620	520	1.23
	1 SD	129	748	388	

The channel metrics suggest the 1936 alignment was more sinuous, had shorter radius of curvature, meander length, and beltwidth distances relative to the two later periods. The Calapooia River alignment in Reach 4 has remained stable since 1967.

4.5.2. Bank Stabilization and Erosion Sites

Bank stabilization and erosion sites were mapped during the field reconnaissance. Data collected by Inter-fluve (2005) and the CWC were also integrated into the RDG map (see Appendix C for bank stabilization and erosion sites). Bank stabilization in Reach 4 included four riprap projects. Bank stabilization projects protect agricultural land. Bank stabilization metrics are included in Table 4-24.

Table 4-24. Bank stabilization structures in Reach 4.

Upstream Station	Downstream Station	Structure Length (ft)	Structure Type
301+00	307+00	600	Rock Riprap
311+00	314+50	350	Rock Riprap
315+25	320+00	475	Rock Riprap
356+00	366+00	1,000	Rock Riprap
405+00	407+00	200	Rock Riprap
Total		2,625	

The riprap sites were generally short and were likely installed during the 1962 effort. Riprap is largely grown over with shrubs, blackberry, and overstory deciduous trees. Figure 4-12 depicts bank stabilization projects in Reach 4.

Figure 4-12. Examples of bank stabilization in Reach 4. The left bank is stabilized in upper Reach 4 (left). Blackberry bushes and deciduous trees have colonized the riprap. The right photograph shows a backwater habitat that has formed between a gravel bar and the adjacent riprap bank at station 309+00.

Bedrock and coarse bed material limit bank erosion in upstream half of Reach 4. However, streambank failures are prevalent in the downstream half of the Reach 4, primarily affecting the southern streambank. The bank erosion occurring at the Smith property exemplifies the mass wasting taking place in some portions of Reach 4 (Figure 4-13). Erosion at Sta. 354+00 and 366+00 is influenced by tight, low radius meanders. These two meanders may be influenced by the riprap bank that separates them. Sediment sources are delivery fine silts, clay, and sand material to the Calapooia River. These banks will continue to erode until an angle of repose is achieved. Based on the current vertical nature of these sites, they will continue to erode for the foreseeable future. Summary bank erosion metrics are included in table

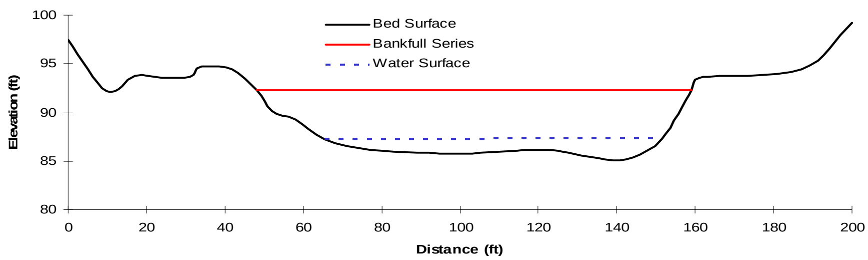
Figure 4-13. Example streambank failures in Reach 4 include the Smith property (left – photo courtesy of T. Putney) and the bank at Sta. 354+00 (right).

Table 4-25. Bank erosion sites in Reach 4.

Upstream Station	Downstream Station	Sediment Source Length (ft)
308+50	310+25	175
316+00	317+50	150
349+50	353+00	350
353+50	356+00	250
366+00	369+00	300
370+50	378+50	800
384+00	401+00	1,700
Total		3,725

4.5.3. Channel Survey Results

A hydraulic channel cross-section was established in Reach 4 adjacent to the Knife River gravel mining operation upstream from the Sodom Dam channel bifurcation. The cross-section was located immediately upstream of a backwater habitat unit. The channel survey was completed on October 30, 2007. The survey included a cross-section, channel profile, discharge measurement, and pebble count. Summary information from the survey is included in Figure 4-14. The photos show typical river corridor conditions in the downstream portion of Reach 4. The right bank separating the gravel extraction area is stabilized with riprap. The left streambank is not stabilized. A narrow riparian strip separates upland agricultural fields from the Calapooia River on the south bank.



Feature	Width (ft)	Area (ft²)	Mean Depth (ft)	Maximum Depth (ft)
Riffle/Run	111.0	613.5	5.5	7.1

Figure 4-14. The Reach 4 cross-section at Sta. 394+00. The upper left photo shows a view across the river to the left bank. The right photo captures the river corridor through the cross-section location looking upstream.

Pebble count data from Reach 4 are presented in Table 4-26. One pebble count was completed in Reach 4. The hydraulic cross-section pebble count was completed to document channel bed materials and to determine a near baseflow roughness coefficient for the hydraulic modeling.

Table 4-26. Pebble count results for Reach 4. Stationing refers to the base maps provided in Appendix A, Figure 1.

Particle Class	Sta. 394+00 (mm)
D16	12
D35	19
D50	25
D65	32
D84	43
D95	61

4.5.4. Hydraulic Modeling Results

One at-a-section hydraulic model was completed in Reach 4 to evaluate channel hydraulics and connection to the floodplain. Pebble count and discharge data were used to calibrate the model. Modeling results are included in Table 4-27.

Table 4-27. The hydraulic modeling results for three stages on the Calapooia River at Sta. 394+00.

Feature	Max Depth (ft)	Area (ft^2)	Width (ft)	Hydraulic Radius (ft)	Slope	Mannings-n Value	Average Velocity (fps)	Discharge (cfs)	Shear Stress (lbs/ft^2)
Discharge Measurement	2.1	109	86	1.27	0.0003	0.087	0.36	39	0.02
Field Selected Bankfull Indicator	7.2	619	112	5.39	0.0003	0.058	1.37	890	0.10
Floodway Elevation	12.4	1,464	192	7.35	0.0003	0.028	3.58	5,242	0.14

The field-delineated bankfull channel conveyed substantially less than the estimated 2-year discharge calculated in the flood frequency analysis. A slope break in Reach 4 marks the transition from the steeper valley and channel slope in Reach 3 to the low gradient valley and channel slope in Reach 4. The channel slope decreases from 0.0025 in Reach 3 to 0.0003 in Reach 4, an order of magnitude decrease. The flatter slope corresponds with a larger channel cross-section required for the river to convey the discharge and sediment load. The hydraulic modeling suggests the 2-year event fills the channel to nearly the terrace slope break. Although additional data collection and modeling would be necessary to validate this outcome, the preliminary model suggests that floods exceeding the 2-year event would access adjacent terraces.

Figure 4-15 shows the Reach 4 hydraulic cross-section location at the time of the survey and during elevated discharge during January 2008. A discharge measurement was not completed during the January site visit due to hazardous conditions.

Figure 4-15. A comparison of the Calapooia River at 40 cfs (left) and approximately 1,800 cfs (right) at the Reach 4 hydraulic cross-section. The backwater habitat in the left side of the baseflow photo was completely inundated during the 1,800 cfs event. The 1,800 cfs event was approximately one-third of the estimated 2-year discharge.

4.5.5. Fish Habitat Conditions

Fish habitat through Reach 4 varies between homogenous glide habitats in the straight sections of the channel, to diverse backwater habitats located in the depositional areas of the reach. Floodplain channels are limited in the reach due to the narrow river corridor. Large wood is prevalent in the depositional sections, creating both cover and varied hydraulics. Wood is generally lacking in the straight sections, offering an opportunity to enhance channel margin juvenile rearing habitat. Example Reach 4 habitats are shown in Figure 4-16.

Figure 4-16. The upstream half of Reach 4 is characterized by a plane bed channel with homogenous conditions (left). Large wood accumulations in the depositional areas of Reach 4 offer cover and lower water velocities that are beneficial for juvenile fish rearing.

4.5.6. Summary

Reach 4 is a laterally constrained section of the Middle Calapooia River that is influenced by hillslopes, bedrock, and a narrow riparian corridor. Large wood is a common feature in the depositional sections of the reach but mostly lacking from the straighter portions of the river. Agricultural feeds border the channel to the south. Several surface water pumps were seen in the reach. The Knife River gravel pit is another significant feature in the reach. Historical maps suggest the river has remained in a similar alignment since 1936. Four bank stabilization projects are relatively small and isolated. Bank erosion is common in the lower half of the reach, primarily eroding riparian forest. Opportunities for enhancing fish habitat include large wood placement and expanding the riparian corridor to buffer the river from upland land uses.

5 RESTORATION/CONSERVATION PRIORITIZATION PLAN

5.1. Introduction

In addition to the historical and existing conditions site assessment, RDG was tasked with developing a Restoration and Conservation Prioritization Plan for the Calapooia River between the former Brownsville Dam site and Sodom Dam. Restoration/Conservation (R/C) goals included the following items.

- Enhance river corridor habitat for multiple life stages and fish species inhabiting the Calapooia River.
- Address river corridor conditions that have been identified as limiting factors for the Middle Calapooia River, namely water temperature.
- Increase channel stability to reduce private property loss and decrease fine sediment loading to the channel.

R/C strategies were proposed to address the aforementioned goals. The following sections outline the types of habitats and treatments that are addressed by the R/C Prioritization Plan. Proposed treatments are also provided by reach. Appendix H locates the proposed R/C strategies. Additional assessment, design, and funding will be necessary to narrow the range of proposed actions as well as to implement the strategies.

5.2. Addressing Limiting Factors from Watershed Assessment

As part of the prioritization plan, RDG reviewed the 2004 Assessment to evaluate previous work and restoration priorities. The following information was adapted from the Assessment and pertains to the restoration and conservation treatments that RDG focused on during the prioritization.

There are opportunities within the Calapooia River watershed to restore and protect key wildlife habitats that have been lost throughout the Willamette Valley. Riparian forests, wetlands, oak woodlands and prairies are all important wildlife habitats. The watershed contains significant remnants of the Willamette Valley's historical floodplain riparian forests, particularly along the lower Calapooia River. In the Middle Reach there are opportunities to restore habitats for amphibians and pond turtles in areas where riparian vegetation and wetlands have been lost or modified for agriculture or flood protection.

The Middle Reach also marks a decrease in the channel gradient and increase in channel meandering. Gravel and large wood deposited in the reach provide adult holding, spawning, and juvenile rearing habitats. Hyporheic flow through the gravel bed cools the water and promotes the conditions that are hospitable to salmonid spawning. Off-channel habitats and vegetated channel margins offer the lower-velocity areas fish seek during high flows. Streamside areas consist of poor to well-drained, fertile alluvium that supports both hardwood and conifer trees. Log jams, structures that once created a more dynamic river environment, are less frequent than historically. Despite the lower distribution, large wood continues to be an important in-stream and off-channel feature in the Middle Reach.

There are several conditions that are believed to be negatively affecting the Calapooia River fish community. These limiting factors include the following issues.

- Fish passage and access to habitats necessary for completing fish life histories.
- Summer water temperatures.
- Channel complexity- loss of historical floodplain channels and ponds
- Historical and current large wood removal and resulting habitat simplification

Restoration and protection activities intended to address limiting factors were outlined in the 2004 Assessment (Calapooia Watershed Council 2004) including the following items directed towards improving the fish community and river corridor conditions.

1. Improve upstream passage of fish.

2. Improve some of the adult spring Chinook holding pools in the upper Calapooia River to discourage swimming and to provide areas for adult fish to hide from poachers.

3. Add large wood to selected tributaries in order to improve channel conditions for fish, especially in cool tributaries.

4. Increase shade along selected streams to expand cool water zones.

5. Protect intact riparian areas and restore other areas to increase the number of conifers along the Calapooia River to improve large wood for the channel and wildlife habitat.

6. Improve pond turtle reproduction and habitat in downstream portions of the watershed.

7. Explore options with landowners along selected tributaries for leasing their water rights to the state for purposes of having more water in the stream during the summer for fish.

8. Provide outreach and education on the importance of channel meandering for maintaining healthy habitat for fish. Work with landowners on alternatives to installing riprap along the banks of rivers and streams.

9. Restore wetlands by encouraging farmers and other landowners to restore nonfunctioning wetlands on marginally productive land through the use of wetland banks or other measures.

10. Conduct watershed education activities for landowners and in schools.

5.3. River Corridor Habitat Treatment Types

Recommended treatments in the Middle Reach are aimed at increasing habitat diversity for the Calapooia fish community, stabilizing eroding banks to preserve landowner properties, and enhancing the riparian community for stream shading, habitat, and reducing fine sediment loading. Treatments include sidechannel, backwater, and floodplain pond enhancement; streambank modifications for bank protection and land preservation; and riparian buffer establishment and revegetation. The following sections provide the scientific-basis for the recommended treatments.

5.3.1. Sidechannel, Backwater, and Floodplain Pond Overview

Sidechannels, backwater habitats, and floodplain ponds provide a range of habitats favorable for juvenile fish rearing and adult fish holding. These habitats also support a range of wildlife species including birds and amphibians. These unique features are influenced by river hydraulics, sediment transport, vegetation conditions, large wood, and ground water-surface water interactions. Enhancing existing features, creating new features, or re-establishing these habitats in historical channel locations, offer a range of opportunities for increasing the frequency and quality of these habitats.

A variety of factors have likely reduced the number and/or capacity of sidechannels in the assessment reach. Activities including land reclamation for agriculture, log transport and splash-damming, channel straightening and dredging, dike construction, removal of large woody debris jams, urbanization, and the Brownsville Dam, led to channel simplification and loss of unique habitats.

Sidechannels often derive a major portion of their flow from either groundwater or seepage from the adjacent stream/river. The role of surface water in sidechannel habitats varies depending on mainstem and groundwater hydrology, channel topography, and physical features. The following sections are adapted from Peterson and Reid (1984) and describe three types of sidechannel habitats within a river floodplain; overflow channels, percolation-fed channels, and wall-based channels as well as floodplain ponds.

> *Overflow channels* are flood swales, and often-relict mainstem channels, that are directly connected to the main river channel during high flows or at all times. They are often very dynamic as a result of the periodic influx of water, sediment, wood, nutrients, and organic material from the main channel. Fish habitat associated with overflow channels is often unstable and typically prone to flooding and channel shifting though possibly on an infrequent basis. Periodic floods through these channels can help maintain their productivity, cleaning and redistributing spawning material and creating new habitat as other habitat is destroyed. Restoration of overflow channels might include reconnection of the channel to the mainstem and placement of habitat features within the channel. The level of fish utilization of overflow channels may depend on the frequency of inundation by the mainstem. Entrapment of fish can occur if the surface water connection with the river attenuates abruptly.
>
> *Percolation channels* are relict river and/or flood channels and are primarily supplied by groundwater of the hyporheic zone. The hyporheic zone is the area beneath and next to a river channel that contains some proportion of water from the surface channel. Frequently, percolation channels are better protected from floods than overflow channels due to their more distant proximity to the mainstem channel. Groundwater inputs result in more stable stable flows. Groundwater channels provide winter and summer refuge for juvenile fish, larval and adult amphibians, and a suite of invertebrates; spawning habitat for adult fish, some amphibians, and some invertebrates; and foraging habitat for many

bird and mammal species. Groundwater discharge is typically cooler in the summer months and warmer in the winter relative to mainstem surface water temperatures.

Wall-based channels can be groundwater fed but are often fed from springs or surface water from an adjacent terrace. Wall-based channels are usually higher in elevation relative to percolation-fed channels. Habitat projects might include providing fish access to them and enhancing habitat within the channels. Wall-based channels were not identified during the field reconnaissance but likely exist were springs discharge to the river corridor or where tributaries or irrigation return channels flow to the river corridor.

F*loodplain ponds* are natural or constructed ponds in or above the floodplain such as abandoned gravel pits, mill ponds, ponds, and river oxbows. Floodplain ponds might be supplied by groundwater or surface water from streams or springs and have varying degrees of connectivity with the river. Habitat projects associated with floodplain ponds may include providing fish access to ponds from the river as well as enhancing habitat within the ponds. Fish stranding in floodplain ponds may also be problematic if fish remain in the pond following drawdown of the river stage. Depending on the pond's water source and other conditions, fish remaining in floodplain ponds may not survive through inter-flood periods.

Backwater habitats form another type of floodplain habitat. During the Calapooia River reconnaissance, backwater habitats were delineated as scoured areas connected to the mainstem river channel that remain inundated by the river over all stages of the hydrograph. Backwater areas with stable large wood and vegetated margins typically contained juvenile fish during the reconnaissance. These features tend to occur in the cross-over from one meander to the next and are located on in the lower third of the upstream point bar. Depending on hydraulics and sediment deposition and scour, these features may be shaped by the river on an annual basis. A backwater's persistence is dependent on alluvial processes. These habitat units provide important juvenile rearing habitats that typically also collect detritus, wood, and vegetation, the food items for aquatic macroinvertebrates and juvenile fish.

5.3.2. Sidechannel Ecological Benefits

Off-channel habitats, such as side channels and other permanently flooded areas, are important rearing areas for juvenile salmonids (Groot and Margolis 1991) and offer a wide variety of ecological benefits to other native fish species, amphibians, and wildlife.

Artificially constructed channels have been shown to support densities of juvenile salmonids equal to or greater than levels observed in natural sidechannels. Similarly, workers have also found that constructed sidechannels connected to shallow groundwater sources stayed cooler in the summer and warmer in the winter when compared to reference sidechannels and mainstem reaches. In the winter, even slightly lower water temperatures cause juvenile salmonids to become more sluggish and thus more vulnerable to predation (Sandercock 1991). During the summer, warmer temperatures result in higher fish metabolic rates and a corresponding increase in food requirements (Welsh et al. 2001). Sidechannels typically provide habitats influenced by both groundwater inputs and riparian vegetation. Unlike the Calapooia River mainstem which offers minimal shade (2004 Assessment), the proposed sidechannel locations are influenced by groundwater and also have moderate to dense multi-story riparian canopies. These two characteristics would be expected to result in warmer winter time water temperatures, and cooler summer water temperatures.

By locating sidechannels in areas of groundwater upwelling and providing appropriately sized gravels, constructed channels can also provide spawning habitat for *adult* salmonids (Cowan 1991). In addition, sidechannels are likely to offer adult fish with refugia from high flows. Off-channel refugia may be especially important for migratory species engaged in strenuous spawning migrations. Though coho have been the focus of many studies regarding the use of off-channel habitat, many other species of fish utilize sidechannels habitat at various lifestages (Lister and Finnigan 1997). Fish species inhabiting the Calapooia River that would be expected to benefit from sidechannel enhancement include the listed spring Chinook and winter steelhead, mountain whitefish, three-spined stickleback, Oregon chub, and cutthroat trout. Amphibians and pond turtles also stand to benefit from enhanced off-channel habitats.

5.3.3. Middle Calapooia River Sidechannel, Backwater, and Floodplain Pond Characteristics

Floodplain channel and pond features in the Middle Calapooia River include overflow channels, percolation channels, floodplain ponds, and backwater habitats. Several of these features are often associated with abandoned relict channels that continue to transmit hyporheic (shallow groundwater) flow. Hyporheic flow is typically associated with water temperatures and oxygen concentrations different than surface water. Some fish species, particularly salmonids, select spawning areas at least partially influenced by hyporheic discharge.

Reach 1 and Reach 3 in the assessment area had the greatest number and variety of sidechannel types. The broader valley and more dynamic channel history in these two reaches allow for greater floodplain development than the laterally constricted Reach 2 and Reach 4. In Reach 1 and 3, the river has developed a wider active meander migration corridor although training dikes, historical channel straightening, and bank stabilization structures now limit channel migration in some areas of the two reaches. Despite human-influenced river corridor modifications over the last one hundred years, the Calapooia River continues to create and destroy floodplain habitats. Flood channels, floodplain ponds, and a diverse riparian canopy in Reach 1 and Reach 3 offer the best opportunities for accentuating a range of habitats that support juvenile and adult life stages of the target species.

5.3.4. Sidechannel Prioritization Considerations

Potential projects are prioritized by reach (see 5.4 Project Prioritization Plan). A prioritization system was developed to rank sidechannels for enhancement. Variables used to prioritize sidechannels for enhancement included the following conditions.

- Sidechannel length and proximity to mainstem.
- Probability of intercepting groundwater (e.g. location of historical channel).
- Riparian canopy condition.
- Sidechannel proximity to a floodplain pond.
- Proximity of sidechannel treatment to other treatment locations.

Additional data will need to be collected and analyzed prior to implementing recommended projects. Example information that will be necessary for designing sidechannel enhancements includes the following items.

- Mainstem Calapooia River high and low flow water surface profiles to determine appropriate sidechannel design elevations. This information will require additional data collection and at-a-station hydraulic modeling.

- Existing ground surface profiles and cross-sections where the sidechannel enhancement will be completed to determine excavation volumes.

- Availability of large wood in the sidechannel area that can be relocated for habitat enhancement and grade control. If large wood is not available in the immediate area, wood will have to be imported to the project area.

- Modeled hydraulics of the sidechannel to size bed sediment materials for channel grade control. Grade control and ensuring adequate floodplain roughness is necessary to minimize the potential for channel avulsion through the sidechannel area.

Understanding what fish species are using sidechannel and floodplain ponds in the respective areas would also be useful for anticipating fish response. Ponds that are currently isolated from the baseflow channel should be sampled to determine introduced fish species presence. Removing these species prior to connecting ponds with the mainstem via sidechannel enhancement would be preferable.

The desired sidechannel and floodplain pond enhancement outcome is one that maximizes the recruitment of adult and juvenile fish while minimizing stranding potential. The enhanced sidechannels should also be self-sustaining. Fish that strategically use side channels may have an innate ability to sense groundwater sources. The point where the egress channel joins the stream is the most critical aspect of project design. Nickelson et al. (1992) stressed that sidechannels remain open at all flow levels and recommended locating alcoves at springs and tributary junctions to maximize the potential for fish use.

If flow from a channel exits into a low-velocity area or eddy with habitat cover, the water is not rapidly diluted and fish have a better opportunity to find the spring-fed sidechannel than if the cooler sidechannel water is rapidly dispersed and diluted in rapid turbulent flow. The majority of the Calapooia River sidechannels will join the mainstem in locations where alcoves and backwaters are already present. These sites are typically well-vegetated, are characterized by lower water velocities, and are somewhat depositional. Woody debris is often also located at these sites, providing diverse habitats.

5.3.5. Large Woody Debris Overview

Large woody debris (LWD) can be used to disperse flow energy (Buffington and Montgomery 1999), stabilize channel banks and bed forms (Bilby 1984), increase aquatic habitat (Bryant and Sedell 1995), narrow a stream and reduce the width to depth ratio (Sedell and Froggatt 1984), cause localized deposition (Keller et al. 1985), form pools (Bilby and Ward 1989), and route flood water (Ellis 1999). Installation of large woody debris (LWD) in the assessment reach is intended to serve multiple purposes. First, engineered log jams (ELJs) are recommended for protecting stream banks and promoting pool scour. ELJs are placed to intercept high water flow vectors. The ELJs deflect the flow away from the streambank but also promote vertical channel scour. Scour pools typically form in front of and to the streamside of ELJs. Scoured sediments are typically transported a short distance and deposited as a tailout feature of the scoured pool. Depending on the site hydraulics, the deposited gravels may be used by spawning fish. On the Calapooia River, ELJs are recommended for outside streambanks that are experiencing accelerated erosion, to augment existing bank stabilization projects that exhibit streambank erosion, or to diversify aquatic habitats in morphologically-homogenous sections of the river.

Placement of large wood is also recommended for enhancing off-channel habitats. Unlike ELJs which typically involved at least ten logs and considerable rock for structure ballast, large wood for habitat enhancement typically requires less anchoring material. Since the large wood will be placed in off-channel habitats (e.g. sidechannels, alcoves, and floodplain ponds), the wood will be subjected to lower water velocities. To maintain structure stability, logs can be partially buried, braced between standing mature trees, pinned together, or anchored with large rock placed below grade. Large wood with branches and rootwads provide the greatest range of microhabitats and also resist transport relative to limbed, cut logs.

5.3.6. Large Wood Ecological Benefits

Observations from intact low-gradient rivers suggest the on-going loss of wood substantially reduces biocomplexity (Gurnell et al. 2005) and alters key biophysical patterns in developed rivers. When present, logs enhance instream complexity and promote floodplain inundation (Kellerhals et al. 1976). Large logs are central to organic matter retention (Bilby 1981), to pool formation (Beechie and Sibley 1997), and to nutrient uptake (Valett et al. 2002). Remnant logs provide habitat for a variety of terrestrial organisms and facilitate conifer establishment. Most logs reside in floodplain river valleys for decades, though some fraction lasts for centuries or more (Montgomery and Abbe 2006). Those remaining stable over long periods may represent a sizeable carbon reservoir (Guyette et al. 2002) and aid in replenishing supplies of new large logs by protecting developing forests from erosion long enough for trees to grow large (Montgomery and Abbe 2006). In the absence of large wood, few structures in low-gradient rivers are suitable ecological surrogates for these functions.

Studies have documented the importance of large wood within the stream channel to slow bedload movement, deposit and sort gravel, scour pools, and increase nutrients through salmon carcass retention time (Ralph et al. 1994). Pools with large and complex accumulations of wood often show higher densities of rearing juvenile salmonids, particularly in winter, when storms routinely cause flooding. More recent studies have also shown the increase in percentage of surface area of pool habitat, pool depth, and an *increase in winter sidechannel habitat* following the placement of large wood in restoration activities (Johnson 2005). Results from Johnson (2005) indicate a higher smolt survival rate for coho, steelhead, and sea run cutthroat trout following large wood treatments in two streams.

5.4. Middle Calapooia River Large Wood Characteristics

Large wood was not formally documented during the Middle Calapooia River reconnaissance. However, the presence, location, and orientation of stable large wood were noted during the walk-through. In reaches with a valley bottom floodplain (Reach 1 and 3), large wood is recruited to the river during high water when standing trees fall or transient large wood on the floodplain is mobilized. Although individual trees exert a limited influence on the channel, aggregations of large trees influence channel and habitat forming processes. Large in-stream trees focus scour, creating deeper pool habitat. Tree aggregations may become stable enough that over time, riparian vegetation is able to colonize the fine sediment that accumulates around wood accumulations.

The Calapooia River maintains a diverse riparian zone characterized by a multi-age stand structure. Cottonwoods are the dominant overstory canopy species in the project reach. Cottonwoods, alder, and Oregon ash comprise most of the large wood found in the project reach. How large wood influences the river corridor depends on the wood properties, location in the river corridor, and vegetation conditions. Large trees with attached rootwads are more resistant to transport and may also collect mobile wood, forming large aggregations. Aggregations are resistant to transport and also provide interstitial space for fish and wildlife. Scour against stable aggregations creates pools and often develop habitats conducive to salmonid spawning.

How wood functions also depends on its location within the river corridor. Wood in the mainstem river is typically more mobile than floodplain wood as mainstem debris experiences higher velocities and shear stress. Floodplain wood experiences lower velocities and is less prone to mobilization. Vegetation can trap large wood and create rafts of debris. Vegetation may also colonize the fine sediments that typically deposit in the leeward direction of wood, and over time, vegetation anchors the wood. Figure 5-1 includes several examples of large wood in the Calapooia River. Photos illustrate the role of wood in forming channel morphology, providing fish habitat, and influencing channel hydraulics.

Figure 5-1. Examples of large wood in the Middle Calapooia River. Large wood influences sediment deposition patterns, focuses stream flow creating scour, provides cover for fish and wildlife, and captures additional debris.

5.4.1. Riparian Vegetation

Riparian vegetation provides numerous benefits for the river corridor. Plants maintain streambank integrity, filter runoff, maintain the water table, provide habitat and stream shading, and contribute organic debris to river systems. Each of these services is applicable to the Calapooia River.

Plant roots bind soil, increasing streambank integrity and resistance to scour. Deep penetrating roots associated with hydric grasses, sedges, rushes, and forbs provide structural support for streambanks. Plant stems and leafy canopies slow floodwater, increasing fine sediment deposition. During high flows, woody shrubs flex overlay the floodplain surface, slowing water velocities and protecting the floodplain surface. Water-tolerant or water-loving plants with deeper and stronger roots are more effective for holding streambanks in place than are plants from upland areas.

Plants decompact soils facilitating water capture and infiltration. Vegetation takes up nutrients transported into the riparian areas. Healthy riparian vegetation captures water and filters the water through the soil. Riparian areas with a diversity of plant species are most effective in slowing the flow of water and storing it for future use.

Different types of vegetation provides multiple services to hold streambank soils in place and protect them from erosion and undercutting by floodwaters, transported woody debris, or ice jams. The deep, penetrating roots of sedges, rushes, willow, grasses, and other herbaceous plants provide structural support for streambanks, while the thicker, harder roots of woody plants protect streambanks against bank scouring by floods and ice jams.

5.4.2. Vegetation Ecological Benefits

A healthy riparian zone provides habitat for terrestrial, aquatic, and amphibious wildlife. A diverse community supports more terrestrial species than a simplified forest with no understory complexity, or a diverse understory with no overstory canopy. From a fisheries perspective, grasses and shrubs maintain bank integrity, shrubs over-hang streams providing cover and contributing debris, and mature trees shade the stream corridor and contribute wood.

5.4.3. Middle Calapooia River Vegetation Characteristics

Vegetation conditions in the Middle Calapooia River vary according to site conditions, historical land uses and river processes, and contemporary land uses. In general, the Middle Reach is bracketed by a multi-structured riparian forest. However, historical log drives, land clearing, and the introduction of non-native plant species have modified native plant communities. Himalayan blackberry is an aggressive non-native species that is capable of out-competing native vegetation. Fast growing and hardy, blackberry is capable of crowding out native plant species. Wildlife such as pond turtles may not be capable of completing their life history with altered vegetation communities. Invasive plants have different properties that do not appropriately substitute the services provided by native species.

5.4.4. Off-Channel Habitats, Large Wood, and Vegetation for Habitat Enhancement

Restoration and conservation treatments seek to emulate existing functioning habitats to enhance the Calapooia River. Proposed activities will include augmenting existing backwater and off-channel habitats, importing and stabilizing large wood, planting riparian and upland vegetation and instituting riparian buffers. The remaining floodplain forests in the Middle Calapooia River should be protected. Recent development in Reach 3 (Sta. 225+00 to 230+00) replaced most of the riparian zone with a floodplain pond and in the future, a housing development. Displacement of the dwindling riparian forest will limit result in further simplification of the river corridor, result in more pressure to erect flood protection, and reduce large wood recruitment to the river. Maintaining and expanding riparian forests is encouraged to address the limiting factors that have been identified.

5.5. Reach Restoration Plans

The following sections outline the restoration and conservation prioritization plan for the Middle Reach of the Calapooia River.

5.5.1. Reach 1 Restoration Plan

Reach 1 offers numerous opportunities for enhancing fish and wildlife habitat on the Calapooia River. Although Reach 1 was modified in the past in an effort to reduce flooding and property loss, the river remains well connected to an expansive, dynamic floodplain. To achieve the biological goals presented by the project stakeholders, proposed restoration and Conservation Actions are aimed at enhancing existing moderate to high quality habitats, addressing landowner property loss, and expanding riparian buffers.

Restoration Actions

Twenty-two Restoration Action opportunities were identified in Reach 1. Each of the opportunities was prioritized for implementation. High priority projects are relatively low cost, augment existing moderate to high quality habitat, are lower risk, and are expected to yield biological benefits. Medium priority projects are more costly, typically requiring a more aggressive approach to stabilizing eroding streambanks and enhancing habitat. Low priority projects include habitat work similar to the medium priority projects. Low priority projects have a lower benefit-cost ratio or are sites that are not located near high priority sites.

The proposed projects primarily focus on enhancing fish habitat in the reach, with emphasis on addressing off-channel and floodplain habitats that provide juvenile rearing habitat and thermal refugia. Off-channel areas are also critical areas for fish during high water as these areas typically have lower velocities and require less energy expenditure for the fish to maintain their position. Adding large wood, extending backwater habitats, and accentuating floodplain channels are expected to provide resident and anadromous fish with a broader range of habitats. Table 5-1 includes the proposed Restoration Actions in Reach 1. A summary of each project is included following the table. Projects are presented from upstream to downstream.

Table 5-1. Proposed Restoration Actions for Reach 1. Benefits pertain to fish life stage and other attributes.

Site #	Landowner	Station	River Side (R/L)	Proposed Restoration Action	Benefits	Priority
R1-1	Barron	14+00	Right	Accentuate backwater at bottom of riffle, add large woody debris.	Juvenile rearing habitat, adult resting habitat	M
R1-2	Wheeler	19+00	Left	Potential backwater area on left bank floodplain, connect backwater with channel on downstream end, add large woody debris.	Juvenile rearing habitat, Adult resting habitat	H
R1-3	Wheeler	20+00	Left	Potential engineered log jam at existing barb to deflect flows towards point bar.	Adult resting habitat, pool scour, bank protection	L
R1-4	Wheeler	23+00	Left	Potential engineered log jam at existing barb to deflect flows towards point bar.	Adult resting habitat, pool scour, bank protection	L
R1-5	Wheeler	24+00 to 32+00	Right	Accentuate floodplain channel complex and connect with backwater at 33+00.	Juvenile rearing habitat, adult resting habitat, floodplain habitat	H
R1-6	Wheeler	28+00	Left	Construct engineered log jams to deflect flow from eroding bank and enhance habitat.	Adult resting habitat, pool scour, bank protection	M
R1-7	Curtis	30+00 to 46+00	Left	Historically complex sidechannel area. Excavate sidechannel at 1936 channel location. Topography to the south suggests possible groundwater source for	Juvenile rearing habitat, adult resting habitat, floodplain habitat, reduce stress on downstream left bank	H

Table 5-1. Proposed Restoration Actions for Reach 1. Benefits pertain to fish life stage and other attributes.

Site #	Landowner	Station	River Side (R/L)	Proposed Restoration Action	Benefits	Priority
				perc side channel. Natural pond mapped at 43+00.		
R1-8	Curtis	33+00	Right	Excavate deposits to accentuate backwater habitat and add large woody debris.	Juvenile rearing habitat, adult resting habitat, floodplain habitat	H
R1-9	Curtis	38+00 to 40+00	Right	Institute riparian buffer and install engineered log jams to provide bank protection at gravel extraction operation site.	Adult resting habitat, bank protection	M
R1-10	Curtis	42+00	Left	Add large woody debris to existing backwater.	Juvenile rearing habitat, adult resting habitat	H
R1-11	Curtis	48+00	Left	Excavate backwater/slough to existing floodplain pond, add large woody debris.	Juvenile rearing habitat, adult resting habitat, floodplain habitat	H
R1-12	Curtis	53+00	Right	Add large woody debris to floodplain, excavate floodplain swales. Discuss floodplain disturbance with landowner.	Floodplain habitat	M
R1-13	Weppler	62+00	Right	Excavate to accentuate backwater habitat and connect to floodplain pond, add large woody debris.	Juvenile rearing habitat, adult resting habitat, floodplain habitat	H
R1-14	Weppler	66+00	Right	Stabilize eroding terrace with engineered log jams, vegetated soil lifts, revegetation, riparian buffer.	Adult resting habitat, bank protection, pool scour	M
R1-15	Weppler	70+00	Right	Excavate head of floodplain side channel for habitat and to reduce downstream stress, add large woody debris.	Juvenile rearing habitat, downstream bank protection, floodplain habitat	M
R1-16	Oakley	78+00	Left	Excavate backwater slough to existing floodplain pond.	Juvenile rearing habitat, adult resting habitat, floodplain habitat	H
R1-17	Oakley	80+00	Left	Oakley Site - Re-grade bank upstream of barb project and stabilize with engineered log jam.	Adult resting habitat, bank protection	L
R1-18	Oakley	84+00 to 101+00	Left	Excavate head of floodplain sidechannel for habitat and to reduce downstream bank stress. Connect floodplain pond to mainstem.	Juvenile rearing habitat, adult resting habitat, floodplain habitat, bank protection	H
R1-19	Stevens	98+00	Right	Excavate head of floodplain sidechannel for habitat and to reduce downstream bank stress.	Juvenile rearing habitat, adult resting habitat, floodplain habitat, bank protection	H
R1-20	Eliason	104+00	Left	Add engineered log jam at start of project area for flow deflection, re-grade eroding bank and replant.	Adult resting habitat, streambank and ag land protection	M
R1-21	Dunn, Morse Bros Inc.	128+00 to 136+00	Right	Excavate head of relic channel at 128+00 to connect flows with backwater at 136+00.	Juvenile rearing habitat, adult resting habitat, floodplain habitat, bank protection	M
R1-22	Morse Bros Inc.	136+00	Right	Add large woody debris for habitat in backwater area.	Juvenile rearing habitat, adult resting habitat, floodplain habitat	M

R1-1: Add large wood aggregates and single pieces of large wood to an existing backwater habitat. The backwater habitat is inundated during low to moderate flows and also receives groundwater or hyporheic discharge. Adding large wood to the backwater will enhance the available habitat and increase the volume of juvenile rearing habitat. Large wood will also provide high water refugia for adult and juvenile fish.

R1-2: The proposed project would connect a backwater with the main channel. Large wood aggregates and single pieces would be added to the channel for habitat and channel stability. Fish are expected to benefit from rearing habitat enhancements, cool water refugia, and flood refugia.

R1-3: Add engineered log jam (ELJ) to existing rock barb to improve fish habitat and pool scour. Orient ELJ to deflect stream flow away from left bank.

R1-4: Add engineered log jam (ELJ) to existing rock barb to improve fish habitat and pool scour. Orient ELJ to deflect stream flow away from left bank.

R1-5: The proposed project would extend an existing backwater habitat further into the floodplain. Existing channels would be deepened to increase the period of inundation and connection with shallow groundwater. Large wood aggregates would be added to the backwater to increase the habitat volume. The backwater habitat (R1-8) is inundated over all flows and likely receives hyporheic discharge as well. Fish are expected to benefit from rearing habitat enhancements, cool water refugia, and flood refugia. Amphibians and other wildlife may also benefit.

R1-6: Install 3 ELJs to deflect flow from eroding forested floodplain. The structure would improve fish habitat and pool scour.

R1-7: Enhance an existing floodplain channel network and connect to the Calapooia River at the R1-10 backwater Large wood aggregates and single pieces would be added to the channel for habitat and channel stability. Fish are expected to benefit from rearing habitat enhancements, cool water refugia, and flood refugia.

R1-8: Excavate deposits in backwater to accentuate connectivity with proposed flood channel (R1-5). Large wood aggregates and single pieces would be added to the channel for habitat and channel stability. Fish are expected to benefit from rearing habitat enhancements, cool water refugia, and flood refugia.

R1-9: Work with landowner to improve land uses on north floodplain. Install ELJs to deflect flow from gravel operation. Establish riparian buffer.

R1-10: Add large wood aggregates and single pieces of large wood to an existing backwater habitat. The backwater habitat is inundated during low to moderate flows and also receives groundwater or hyporheic discharge. Adding large wood to the backwater will enhance the available habitat and increase the volume of juvenile rearing habitat. Large wood will also provide high water refugia for adult and juvenile fish.

R1-11: Enhance an existing floodplain pond and connect to the Calapooia River with an outlet channel. Large wood aggregates and single pieces would be added to the pond for habitat and to the channel for habitat and channel stability. Fish are expected to benefit from rearing habitat enhancements, cool water refugia, and flood refugia. Pond turtles and amphibians are also expected to benefit.

R1-12: Work with landowner to improve land uses on north floodplain. Connect floodplain swales and add large wood for habitat. Fish are expected to benefit from rearing habitat enhancements..

R1-13: Enhance an existing backwater and connect to floodplain pond. Large wood aggregates and single pieces would be added to the pond for habitat and to the channel for habitat and channel stability. Fish are expected to benefit from rearing habitat enhancements, cool water refugia, and flood refugia. Pond turtles and amphibians are also expected to benefit.

R1-14: Re-grade vertical eroding bank. Install 2 ELJs for habitat and flow deflection. Build vegetated soil lifts to provide bank stability and promote vegetation colonization. Revegetate and establish riparian buffer.

R1-15: Accentuate head of floodplain channel to reduce flood pressure on eroding bank. Place large wood for habitat and channel stability. Promote channel located through dense riparian vegetation for stability. Connect with Calapooia River at downstream end of meander at Sta. 89+00. Fish are expected to benefit from rearing habitat enhancements, cool water refugia, and flood refugia. There is the potential to reduce bank erosion through reach though flood channel modifications should be carefully considered to avoid avulsion channel promotion.

R1-16: Enhance an existing backwater and connect to floodplain pond. Large wood aggregates and single pieces would be added to the pond for habitat and to the channel for habitat and channel stability. Fish are expected to benefit from rearing habitat enhancements, cool water refugia, and flood refugia. Pond turtles and amphibians are also expected to benefit.

R1-17: Re-grade eroding streambank upstream of Oakley-NRCS bank stabilization project. Install ELJs, vegetated soil lifts, and revegtate. Maintain for at minimum of 2 years to ensure vegetation success. Establish riparian buffer for long-term riparian health.

R1-18: Accentuate head of floodplain channel to reduce flood pressure on eroding bank. Place large wood for habitat and channel stability. Promote channel located through dense riparian vegetation for stability. Connect with Calapooia River at the R1-20 backwater. Fish are expected to benefit from rearing habitat enhancements, cool water refugia, and flood refugia. There is the potential to reduce bank erosion through reach though flood channel modifications should be carefully considered to avoid avulsion channel promotion.

R1-19: Accentuate head of floodplain channel to reduce flood pressure on eroding bank. Place large wood for habitat and channel stability. Promote channel located through dense riparian vegetation for stability. Connect with Calapooia River at downstream end of meander at Sta. 116+00. Fish are expected to benefit from rearing habitat enhancements, cool water refugia, and flood refugia. There is the potential to reduce bank erosion through reach though flood channel modifications should be carefully considered to avoid avulsion channel promotion.

R1-20: Re-grade eroding streambank upstream of NRCS bank stabilization project. Install two or three ELJs, vegetated soil lifts, and revegtate. Maintain for at minimum of 2 years to ensure vegetation success. Establish riparian buffer for long-term riparian health.

R1-21: Accentuate head of floodplain channel to promote more flow through floodplain channel. Place large wood for habitat and channel stability. Fish are expected to benefit from rearing habitat enhancements and flood refugia. Connect channel with backwater at R1-22.

R1-22: Enhance an existing backwater with large wood aggregates and single pieces. Fish are expected to benefit from rearing habitat enhancements, cool water refugia, and flood refugia.

The proposed Restoration Actions focus on expanding off-channel and instream habitats. The actions call for augmenting existing habitats with large wood, creating more flood relief habitats, and providing fish access to cooler water habitats. Floodplain channel locations will benefit from both groundwater inputs and the overstory canopy that provides shade. Groundwater and overhead shade should result in lower water temperatures. Floodplain vegetation and the addition of large wood will increase complex microhabiat availability. More diverse microhabitats will increase the living space for both juvenile and adult fish. Exposed portions of large wood aggregations will also provide cover for other wildlife. Amphibians and pond turtles may benefit from floodplain ponds that will be temporally connected to the Calapooia River.

Conservation Actions

Several conservation opportunities were also identified for Reach 1. Conservation Actions are more passive approaches to preserving or enhancing desirable river corridor features. Example Conservation Actions include establishing conservation easements, livestock fencing to protect riparian buffers, and monitoring site conditions. Table 5-2 presents proposed Conservation Actions for Reach 1. Narrative descriptions of each action follow the table.

Table 5-2. Proposed Conservation Actions for Reach 1. Benefits pertain to water temperature, fish habitat, and river processes.

Site #	Landowner	Station	River Side (R/L)	Proposed Restoration Action	Benefits
C1-1	Holbrook; Wheeler	1+00 to 33+00	Right	Protect remaining floodplain vegetation.	Stream shading, habitat, large wood recruitment
C1-2	Barron	3+00 to 20+00	Left	Protect remaining floodplain vegetation.	Stream shading, habitat, large wood recruitment
C1-3	Wheeler	20+00 to 23+00	Left	Expand the riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment
C1-4	Curtis; Weppler; Oakley	23+00 to 78+00	Left	Protect remaining floodplain vegetation.	Stream shading, habitat, large wood recruitment
C1-5	Putnam; Sloan; Torroni; Curtis	34+00 to 40+00	Right	Expand the riparian buffer to 100 ft from the top of streambank. Address gravel mining operation.	Stream shading, habitat, large wood recruitment
C1-6	Curtis; Weppler	40+00 to 66+00	Right	Protect remaining floodplain vegetation.	Stream shading, habitat, large wood recruitment

Table 5-2. Proposed Conservation Actions for Reach 1. Benefits pertain to water temperature, fish habitat, and river processes.

Site #	Landowner	Station	River Side (R/L)	Proposed Restoration Action	Benefits
C1-7	Nether	66+00 to 68+50	Right	Expand the riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment
C1-8	Weppler; Oakley; Neher; Eliason; Morse Bros Inc.	68+50 to 136+00	Right	Protect remaining floodplain vegetation.	Stream shading, habitat, large wood recruitment
C1-9	Oakley	78+00 to 83+00	Left	Expand the riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment
C1-10	Oakley; Weppler; Stevens; Eliason	83+00 to 103+00	Left	Protect remaining floodplain vegetation.	Stream shading, habitat, large wood recruitment
C1-11	Eliason	104+00 to 112+00	Left	Expand the riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment
C1-12	Eliason; Dunn; Morse Bros Inc.	112+00 to 138+00	Left	Protect remaining floodplain vegetation.	Stream shading, habitat, large wood recruitment

C1-1: Preserve remaining floodplain forest for habitat, water quality, and upland protection. Pursue conservation easement or other approach to maintain or enhance current riparian conditions.

C1-2: Preserve remaining floodplain forest for habitat, water quality, and upland protection. Pursue conservation easement or other approach to maintain or enhance current riparian conditions.

C1-3: Expand the existing riparian buffer to 100 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

C1-4: Preserve remaining floodplain forest for habitat, water quality, and upland protection. Pursue conservation easement or other approach to maintain or enhance current riparian conditions.

C1-5: Expand the existing riparian buffer to 100 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years. Work with landowner to address gravel mining operation.

C1-6: Preserve remaining floodplain forest for habitat, water quality, and upland protection. Pursue conservation easement or other approach to maintain or enhance current riparian conditions.

C1-7: Expand the existing riparian buffer to 100 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

C1-8: Preserve remaining floodplain forest for habitat, water quality, and upland protection. Pursue conservation easement or other approach to maintain or enhance current riparian conditions.

C1-9: Expand the existing riparian buffer to 100 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

C1-10: Preserve remaining floodplain forest for habitat, water quality, and upland protection. Pursue conservation easement or other approach to maintain or enhance current riparian conditions.

C1-11: Expand the existing riparian buffer to 100 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

C1-12: Preserve remaining floodplain forest for habitat, water quality, and upland protection. Pursue conservation easement or other approach to maintain or enhance current riparian conditions.

The proposed Conservation Actions primarily focus on preserving existing high quality floodplain environments. Maintaining gallery forests provides fish and wildlife benefits as well as protecting upland properties from erosion. Vegetation patterns and large wood contributions to the river enhance habitat diversity. Canopy shading of backwater habitats and floodplain channels preserves cool water refugia for fish. Expanding riparian buffers is intended to reduce agricultural runoff to the river, increase bank stability, and result in a more diverse riparian community over the long-term.

Reach 1 Restoration Summary

Although riverine habitats in Reach 1 generally provide a diverse range of conditions, past and current land management has impacted river corridor complexity. Proposed Restoration Actions and Conservation Actions aim to enhance off-channel habitats by intercepting groundwater, adding large wood, and locating habitats within the riparian overstory to benefit from canopy shading. Juvenile and adult fish, amphibians, and other wildlife are expected to benefit from the proposed actions. Instream work including installation of ELJs and soil lifts is intended to improve habitat but also reduce bank erosion and sediment loading to the Calapooia River. Instream projects, though also beneficial, tend to be more costly and are at greater risk of failure. As such, the Restoration Actions emphasize off-channel habitat work with a limited number of instream projects.

Conservation Actions aim to preserve valuable riparian floodplains. Relative to historical conditions, the Calapooia River's riparian corridor is a remnant of its aboriginal extent. Similar to the Willamette River and other rivers in the drainage, most of the Calapooia River's floodplain has been converted for agriculture. Conserving remaining floodplain habitats is essential for maintaining a functioning river system buffered from human encroachment.

5.5.2. Reach 2 Restoration Plan

Due to the more confined valley bottom and the City of Brownsville, Reach 2 offers fewer opportunities for enhancing fish and wildlife habitat on the Calapooia River. Restoration Actions focus on adding large wood to the mainstem channel in the form of engineered log jams.

Conservation Actions focus on expanding riparian corridors to buffer developed areas from erosion as well as buffering the river from runoff.

Restoration Actions

Six Restoration Action opportunities were identified in Reach 2. Each of the opportunities was prioritized for implementation. For Reach 2, the highest priority projects include removing rubbish and stabilizing the streambank at Pioneer Park. Bank erosion is currently threatening the park and has also revealed car bodies and other debris hazardous to citizens and wildlife. Medium priority projects include the installation of stable ELJs to promote pool scour, to deflect flow away from the bank, and to provide diverse microhabitats. The proposed projects primarily focus on enhancing fish habitat in the mainstem river and halting bank erosion. The paucity of backwater habitats and floodplain channels in Reach 2 negates off-channel habitat enhancement. Table 5-3 includes the proposed Restoration Actions in Reach 1. A summary of each project is included following the table. Projects are presented from upstream to downstream.

Table 5-3. Proposed Restoration Actions for Reach 2. Benefits pertain to fish life stage and other attributes.

Site #	Landowner	Station	River Side (R/L)	Proposed Restoration Action	Benefits	Priority
R2-1	Baker	147+00	Left	Add engineered log jams for habitat and flow deflection, establish riparian buffer.	Bank protection, stream shading, floodplain and upland habitat	M
R2-2	Smiths Custom Construction, Inc	156+00	Left	Add engineered log jams for habitat and flow deflection, establish riparian buffer.	Adult resting habitat, bank protection, stream shading, floodplain habitat	M
R2-3	Swayze	175+00	Left	Install engineered log jams, establish riparian buffer.	Adult resting habitat, pool scour, bank protection, floodplain habitat	M
R2-4	Geil; Gradwohn	192+00 to 198+00	Left (riprap bank)	Install engineered log jams, plant riprap, establish riparian buffer.	Juvenile rearing habitat, adult resting habitat, pool scour	L
R2-5	Brownsville, City of	206+00 to 210+00	Right (Pioneer Park)	Rubbish removal, re-grade eroding bank, engineered log jams, vegetated soil lifts, revegetate.	Juvenile rearing habitat, adult resting habitat, pool scour, bank protection, riparian vegetation	H
R2-6	Gerber	211+00	Right	Re-grade eroding bank, engineered log jams, vegetated soil lifts, revegetate.	Juvenile rearing habitat, adult resting habitat, pool scour, bank protection, riparian vegetation	H

The proposed Restoration Actions focus on augmenting mainstem habitat with ELJs. The ELJs also provide bank protection. The proposed treatments are expected to provide holding habitat for adult fish migrating through the reach. Resident fish would also benefit from the added structural complexity.

Conservation Actions

Fourteen conservation opportunities were also identified for Reach 2. Conservation Actions are more passive approaches to preserving or enhancing desirable river corridor features. Example Conservation Actions include establishing conservation easements, livestock fencing to protect riparian buffers, expanding riparian buffers, and monitoring site conditions. Table 5-4 presents proposed Conservation Actions for Reach 2. Narrative descriptions of each action follow the table.

Table 5-4. Proposed Conservation Actions for Reach 2. Benefits pertain to water temperature, fish habitat, and river processes.

Site #	Landowner	Station	River Side (R/L)	Proposed Restoration Action	Benefits
C2-1	Morse Bros Inc.; Thibedeau; Baker; Smiths Custom Construction Inc.;	138+00 to 158+00	Right	Protect remaining floodplain vegetation.	Stream shading, habitat, large wood recruitment
C2-2	Thibedeau; Baker	138+00 to 146+00	Left	Protect remaining floodplain vegetation.	Stream shading, habitat, large wood recruitment
C2-3	Baker; Smiths Custom Construction, Inc.	146+00 to 150+00	Left	Expand the riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment
C2-4	Smiths Custom Construction, Inc.	150+00 to 156+00	Left	Protect remaining floodplain vegetation.	Stream shading, habitat, large wood recruitment
C2-5	Smiths Custom Construction, Inc.	156+00 to 157+00	Left	Expand the riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment
C2-6	Smiths Custom Construction, Inc.; Brownsville, City of	157+00 to 164+00	Left	Protect remaining floodplain vegetation.	Stream shading, habitat, large wood recruitment
C2-7	Smiths Custom Construction, Inc.; Dodge; Brownsville, City of	158+00 to 162+00	Right	Expand the riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment
C2-8	Dodge; Wright; Swayze; Howell	162+00 to 177+00	Right	Protect remaining floodplain vegetation.	Stream shading, habitat, large wood recruitment
C2-9	Wright	166+00 to 170+00	Left	Expand the riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment
C2-10	Swayze	170+00 to 177+00	Left	Expand the riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment
C2-11	Smith; Smith; Brownsville, City of; Geil; Gradwohl	178+00 to 202+00	Left	Expand the riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment
C2-12	Brownsville Christian Church; Brownville, City of	178+00 to 211+00	Right	Maintain existing vegetation through Pioneer Park.	Stream shading, habitat, large wood recruitment, reduce bank erosion and sediment delivery to the channel
C2-13	Lemhouse; Nealon	202+00 to 216+00	Left	Protect remaining floodplain vegetation.	Stream shading, habitat, large wood recruitment
C2-14	Gerber; Smith	211+00 to 216+00	Right	Expand the riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment

C2-1: Preserve remaining floodplain forest for habitat, water quality, and upland protection. Pursue conservation easement or other approach to maintain or enhance current riparian conditions.

C2-2: Preserve remaining floodplain forest for habitat, water quality, and upland protection. Pursue conservation easement or other approach to maintain or enhance current riparian conditions.

C2-3: Expand the existing riparian buffer to 100 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

C2-4: Preserve remaining floodplain forest for habitat, water quality, and upland protection. Pursue conservation easement or other approach to maintain or enhance current riparian conditions.

C2-5: Expand the existing riparian buffer to 100 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

C2-6: Preserve remaining floodplain forest for habitat, water quality, and upland protection. Pursue conservation easement or other approach to maintain or enhance current riparian conditions.

C2-7: Expand the existing riparian buffer to 100 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

C2-8: Preserve remaining floodplain forest for habitat, water quality, and upland protection. Pursue conservation easement or other approach to maintain or enhance current riparian conditions.

C2-9: Expand the existing riparian buffer to 100 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

C2-10: Expand the existing riparian buffer to 100 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

C2-11: Expand the existing riparian buffer to 100 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

C2-12: Preserve vegetation conditions in Pioneer Park.

C2-13: Preserve remaining floodplain forest for habitat, water quality, and upland protection. Pursue conservation easement or other approach to maintain or enhance current riparian conditions.

C2-14: Expand the existing riparian buffer to 100 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

The proposed Conservation Actions primarily focus on preserving existing high quality floodplain environments. Maintaining gallery forests provides fish and wildlife benefits as well as protecting upland properties from erosion. Vegetation patterns and large wood contributions to the river enhance habitat diversity. Canopy shading of backwater habitats and floodplain channels preserves cool water refugia for fish. Expanding riparian buffers is intended to reduce agricultural runoff to the river, increase bank stability, and result in a more diverse riparian community over the long-term.

Reach 2 Restoration Summary
Proposed Restoration Actions and Conservation Actions aim to enhance mainstem habitats by adding large wood. Juvenile and adult fish are expected to benefit from the proposed actions. Instream work including installation of ELJs is intended to improve habitat but also reduce bank erosion and sediment loading to the Calapooia River. Instream projects, though also beneficial, tend to be more costly and are at greater risk of failure.

Conservation Actions aim to preserve valuable riparian floodplains. Relative to historical conditions, the Calapooia River's riparian corridor is a remnant of its aboriginal extent. Similar to the Willamette River and other rivers in the drainage, most of the Calapooia River's floodplain has been converted for agriculture. Conserving remaining floodplain habitats is essential for maintaining a functioning river system buffered from human encroachment.

5.5.3. Reach 3 Restoration Plan

Reach 3 offers numerous opportunities for enhancing fish and wildlife habitat on the Calapooia River. Although Reach 3 has experienced substantial manipulation in the past in an effort to reduce flooding and property loss, the river remains well connected to an expansive, dynamic floodplain. To achieve the biological goals presented by the project stakeholders, proposed restoration and Conservation Actions are aimed towards both enhancing existing moderate to high quality habitats, and re-establishing floodplain features that have been affected by past land management activities.

Restoration Actions
Fourteen Restoration Action opportunities were identified in Reach 3. Each of the opportunities was prioritized for implementation. High priority projects are relatively low cost, augment existing moderate to high quality habitat, are low risk, and are expected to yield biological benefits. Medium priority projects are more costly, typically requiring a more aggressive approach to stabilizing eroding streambanks and enhancing habitat in areas of lower channel function. Low priority projects include either monitoring or habitat work similar to the medium priority projects. Low priority projects have a lower benefit-cost benefit. The proposed projects primarily focus on enhancing fish habitat in the reach, with emphasis on addressing off-channel and floodplain habitats that provide juvenile rearing habitat and thermal refugia. Off-channel areas are also critical areas for fish during high water as these areas typically have lower velocities and require less energy expenditure for the fish to maintain their position. Adding large wood, extending backwater habitats, and accentuating floodplain channels are expected

to provide resident and anadromous fish with a broader range of habitats. Table 5-5 includes the proposed Restoration Actions in Reach 3. A summary of each project is included following the table. Projects are presented from upstream to downstream.

Table 5-5. Proposed Restoration Actions for Reach 3. Benefits pertain to fish life stage and other attributes.

Site #	Landowner	Station	River Side (R/L)	Proposed Restoration Action	Benefits	Priority
R3-1	Smith Development	225+00 to 230+00	Right	Monitor area where riparian area cut and new development is planned.	Address potential problems pro-actively	L
R3-2	Ross	231+00	Right	Add engineeried log jam to start of NRCS bank stabilization project, revegetate, expand riparian buffer.	Juvenile and adult habitat, floodplain habitat, pool scour, bank protection, sediment loading reduction, vegetation improvement	M
R3-3	Nealon	238+00	Left	Add large woody debris for habitat in backwater area.	Juvenile and adult habitat, floodplain habitat	H
R3-4	Nealon	239+00 to 241+00	Left	Re-grade eroding terrace, install engineered log jams and vegetated soil lifts, revegetate, establish riparian buffer.	Juvenile and adult habitat, floodplain habitat, pool scour, bank protection, sediment loading reduction, vegetation improvement	M
R3-5	Nealon	241+00	Left	Remove rock spur projecting into channel.	Increase channel capacity, bank protection	M
R3-6	Ross	248+00 to 268+00	Right	Potential to activate historical active channel, convey flows through side channel.	Juvenile and adult habitat, floodplain habitat	L
R3-7	Ross	250+00	Right	Connect excavated floodplain pond to channel, add large woody debris, revegetate.	Juvenile and adult habitat, floodplain habitat, refugia	H
R3-8	M&B Lewis LLC	258+00	Left	Add large woody debris to backwater.	Juvenile and adult habitat, floodplain habitat	H
R3-9	M&B Lewis LLC	259+00 to 261+00	Left	Add 3 engineered log jams for habitat enhancement and establish riparian buffer.	Juvenile and adult habitat, pool scour	L
R3-10	Perry	269+00	Right	Excavate backwater channel, add large woody debris.	Juvenile and adult habitat, floodplain habitat	M
R3-11	Perry	278+00	Right	Excavate floodplain pond and connecting channel.	Juvenile and adult habitat, cool water refugia	H
R3-12	M&B Lewis LLC	280+00	Left	Connect off-channel groundwater fed spring ponds, add large woody debris.	Juvenile and adult habitat, cool water refugia	H
R3-13	M&B Lewis LLC	280+00 to 292+00	Left	Excavate floodplain channel and connect to backwater channel at R12.	Juvenile and adult habitat, floodplain habitat, cool water refugia	H
R3-14	Perry	289+00 to 297+00	Right	Excavate connecting floodplain channel, add large woody debris to backwater channel.	Juvenile and adult habitat, cool water refugia	H

R3-1: Monitor the river bank and floodplain area. A new development is planned for an area formerly riparian forest. The developer has excavated a floodplain pond and will be building residences north of the pond. Monitoring should include photo points and periodic site visits to investigate bank stability, riparian buffer maintenance, and development discharge to the river.

R3-2: The project site is a NRCS bank stabilization project at the Ross property. The project is functioning well. The recommended treatments include adding an engineered log jam (ELJ) at the upstream extent of the project to deflect flows towards the river at the start of the project. Replanting the stream bank through the project area is also recommended to improve the long-term stability of the site. A riparian buffer is also recommended to limit runoff to the river from the adjacent agriculture field, to provide habitat, and contribute wood to the river in the future.

R3-3: Add large wood aggregates and single pieces of large wood to an existing backwater habitat. The backwater habitat is inundated during low to moderate flows and also receives groundwater or hyporheic discharge. Adding large wood to the backwater will enhance the available habitat and increase the volume of juvenile rearing habitat. Large wood will also provide high water refugia for adult and juvenile fish.

R3-4: The site is characterized by a vertical eroding bank, poor vegetation conditions, and limited fish habitat. The proposed project will re-grade the eroding bank, install engineered log jams and vegetated soil lifts, plant vegetation, and institute a riparian buffer. The ELJs will deflect flow from the bank. The soil lifts will improve the streambank integrity and provide a growing medium for riparian vegetation. In the long-term, the riparian buffer should be colonized with shrubs and trees, providing stream shading and a source of organic material for the Calapooia River.

R3-5: A rock levee or spur dyke is located immediately downstream of R3-4. The structure constricts the channel and causes eddy erosion downstream of the structure. Although the structure has created a deep scour pool, it appears to also be impacting streambank stability on the opposite bank. The proposed action will remove the structure to the streambank face. ELJs may be installed to maintain bank stability until vegetation is able to recolonize the site.

R3-6: The proposed project would re-establish a flood channel on the right bank. The flood channel would traverse the floodplain to the west and would reduce the stress on the outside streambank by providing flood relief. The flood channel would either be routed through an existing floodplain pond, or connected with the Calapooia River downstream of the floodplain. Large wood aggregates and single pieces would be added to the channel for habitat and channel stability. Fish are expected to benefit from rearing habitat enhancements, cool water refugia, and flood refugia.

R3-7: Enhance an existing floodplain pond and connect to the Calapooia River with an outlet channel. Large wood aggregates and single pieces would be added to the pond for habitat and to the channel for habitat and channel stability. The pond appears to be located in an historical channel alignment and receives groundwater discharge. Existing blackberry thickets will be removed and replanted with native vegetation. Fish are expected to benefit from rearing habitat enhancements, cool water refugia, and flood refugia. Pond turtles and amphibians are also expected to benefit.

R3-8: Add large wood aggregates and single pieces of large wood to an existing backwater habitat. The backwater habitat is inundated during low to moderate flows and also receives groundwater or hyporheic discharge. Adding large wood to the backwater will enhance the available habitat and increase the volume of juvenile rearing habitat. Large wood will also provide high water refugia for adult and juvenile fish.

R3-9: Add three ELJs to a streambank to provide overhead cover, pool scour, and microhabitat complexity to benefit adult and juvenile fish. Fish habitat is currently limited through the reach. The riparian buffer would also be expanded.

R3-10: The proposed project would extend an existing backwater habitat further into the floodplain. Large wood aggregates would be added to the backwater to increase the habitat volume. The backwater habitat is undated over all flows and likely receives hyporheic discharge as well. Fish are expected to benefit from rearing habitat enhancements, cool water refugia, and flood refugia. Amphibians and other wildlife may also benefit.

R3-11: Excavate a floodplain pond in a portion of an historical channel alignment to access preferential flow paths. The pond will be connected to the Calapooia River with an outlet channel. Large wood aggregates and single pieces would be added to the pond for habitat and to the channel for habitat and channel stability. Fish are expected to benefit from rearing habitat enhancements, cool water refugia, and flood refugia. Pond turtles and amphibians are also expected to benefit.

R3-12: The proposed project would connect floodplain swales and small ponds that are inundated during baseflow. The features are currently isolated by human-placed fills and other deposition. Large wood aggregates would also be added to the channels for habitat enhancement. The proposed project area is located in the vicinity of a high functioning floodplain expanse. Juvenile salmonids were observed in off-channel habitats in the vicinity of the project area.

R3-13: Excavate a floodplain channel and tie-in to R3-12 project area. The proposed channel would be through an historical channel location. The proposed channel would capture upwelling groundwater and expand the habitat area for juvenile rearing. Large wood aggregates and single pieces would be added to the channel for habitat and channel stability. Fish are expected to benefit from rearing habitat enhancements, cool water refugia, and flood refugia.

R3-14: Excavate a floodplain channel and tie-in to the Calapooia River. Create an expanded backwater habitat at the floodplain channel tie-in and add large wood aggregates to the backwater. The proposed channel would be through an historical channel location. The proposed channel would capture upwelling groundwater and expand the habitat area for juvenile rearing. Large wood aggregates and single pieces would be added to the channel for habitat and channel stability. Fish are expected to benefit from rearing habitat enhancements, cool water refugia, and flood refugia.

The proposed Restoration Actions focus on expanding off-channel and instream habitats. The actions call for augmenting existing habitats with large wood, creating more flood relief habitats, and providing fish access to cooler water habitats. Floodplain channel locations will benefit from both groundwater inputs an the overstory canopy that provides shade. Groundwater and overhead shade should result in lower water temperature. Floodplain vegetation and the addition of large wood will increase complex microhabitat availability. More diverse microhabitats will increase the living space for both juvenile and adult fish. Exposed portions of large wood aggregations will also provide cover for other wildlife.

Conservation Actions

Several conservation opportunities were also identified for Reach 3. Conservation Actions are more passive approaches to preserving or enhancing desirable river corridor features. Example Conservation Actions include establishing conservation easements, livestock fencing to protect riparian buffers, and monitoring site conditions. Table 5-6 presents proposed Conservation Actions for Reach 3. Narrative descriptions of each action follow the table.

Table 5-6. Proposed Conservation Actions for Reach 3. Benefits pertain to water temperature, fish habitat, and river processes.

Site #	Landowner	Station	River Side (R/L)	Proposed Restoration Action	Benefits	Notes
C3-1	Smith	221+00 to 224+00	Right	Remove recent fill material and plant native riparian vegetation on streambank.	Reduced fine sediment loading, stream shading, improved bank stability, habitat	
C3-2	Smith Development	225+00 to 230+00	Right	Monitor streambank stability and floodplain. Maintain riparian buffer between development and river.	Reduced fine sediment loading, stream shading, improved bank stability, habitat	
C3-3	Ross	231+00 to 234+50	Right	Replant native riparian vegetation at the NRCS Ross project site. Maintain vegetation for 2 years.	Maintain existing project, stream shading, habitat	
C3-4	Ross	236+00 to 270+00	Right	Preserve floodplain vegetation.	Stream shading, habitat, large wood recruitment	Landowner Pursuing CREP
C3-5	Nealon; Ross	238+00 to 246+00	Left	Plant riparian vegetation in combination with bank stabilization. Implement a riparian buffer.	Reduced fine sediment loading, stream shading, improved bank stability, habitat	
C3-6	M&B Lewis LLC	258+00 to 262+00	Left	Expand riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment	
C3-7	M&B Lewis LLC; Cornucopia Family LTD PNTP	262+00 to 294+00	Left	Preserve floodplain vegetation.	Stream shading, habitat, large wood recruitment, flood attenuation	
C3-8	Perry	274+50 to 300+00	Right	Preserve floodplain vegetation.	Stream shading, habitat, large wood recruitment, flood attenuation	Landowner Pursuing CREP
C3-9	Cornucopia Family LTD PNTP	294+00 to 296+00	Left	Expand riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment	

C3-1: Remove recent fill material that was pushed over the streambank towards the river. The fill material includes soil and wood debris left over following a riparian harvest operation. The site should be planted with riparian vegetation following removal of the fill from the active channel.

C3-2: Action is similar to R3-1. An area of floodplain gallery forest was logged for a new development and floodplain pond. The development area should be monitored for discharge to the Calapooia River. Potential problems should be pro-actively addressed to avoid emergency bank stabilization projects in the future.

C3-3: Plant native riparian and upland vegetation at the NRCS-Ross project site. Existing vegetation conditions are inadequate due to low survival of willow cuttings. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

C3-4: A large floodplain expanse is located on the north side of the river downstream from the NRCS-Ross project site. Preserving the floodplain vegetation would benefit fish and wildlife, and reduce landowner flood risk. The landowner is currently pursuing a NRCS CREP easement.

C3-5: Plant native riparian and upland vegetation in conjunction with the proposed bank stabilization project (R3-4). Planted vegetation should be irrigated and maintained for a minimum of 2 years.

C3-6: Expand the existing riparian buffer to 100 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

C3-7: A large floodplain expanse is located on the south side of the river in the middle of Reach 3. Preserving the floodplain vegetation would benefit fish and wildlife, and reduce landowner flood risk. Opportunities for conservation easements might include NRCS and other state and federal programs.

C3-8: A large floodplain expanse is located on the north side of the river near the downstream extent of Reach 3. Preserving the floodplain vegetation would benefit fish and wildlife, and reduce landowner flood risk. The landowner is currently pursuing a NRCS CREP easement.

C3-9: Expand the existing riparian buffer to 100 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

The proposed Conservation Actions primarily focus on preserving existing high quality floodplain environments. Maintaining gallery forests provides fish and wildlife benefits as well as protecting upland properties from erosion. Vegetation patterns and large wood contributions to the river enhance habitat diversity. Expanding riparian buffers is intended to reduce agricultural runoff to the river, increase bank stability, and result in a more diverse riparian community over the long-term.

Reach 3 Restoration Summary

Although riverine habitats in Reach 3 generally provide a diverse range of conditions, past and current land management has impacted river corridor complexity. Proposed Restoration Actions and Conservation Actions aim to enhance off-channel habitats by intercepting ground water, adding large wood, and locating habitats within the riparian overstory to benefit from canopy shading. Juvenile and adult fish, amphibians, and other wildlife are expected to benefit from the proposed actions. Instream work including installation of ELJs and soil lifts is intended to improve habitat but also reduce bank erosion and sediment loading to the Calapooia River. Instream projects, though also beneficial, tend to be more costly and are at greater risk of failure. As such, the Restoration Actions emphasize off-channel habitat work with a limited number of instream projects.

Conservation Actions aim to preserve valuable riparian floodplains. Relative to historical conditions, the Calapooia River's riparian corridor is a remnant of its aboriginal extent. Similar to the Willamette River and other rivers in the drainage, most of the Calapooia River's floodplain has been converted for agriculture. Conserving remaining floodplain habitats is essential for maintaining a functioning river system buffered from human encroachment.

5.5.4. Reach 4 Restoration Plan

Due to the more confined valley bottom and low sinuosity channel, Reach 4 offers fewer opportunities for enhancing fish and wildlife habitat on the Calapooia River. Restoration Actions focus on adding large wood to the mainstem channel margins and to backwater habitats. Conservation Actions focus on expanding riparian corridors for habitat benefits and to buffer agricultural areas from erosion as well as buffering the river from runoff.

Restoration Actions
Five Restoration Action opportunities were identified in Reach 4. Each of the opportunities was prioritized for implementation. For Reach 4, the highest priority projects include adding wood to backwater habitats. Medium priority projects include the installation of stable ELJs to promote pool scour, to deflect flow away from the bank, and to provide diverse microhabitats. The proposed projects primarily focus on enhancing fish habitat in the mainstem river and backwaters, and halting bank erosion. Table 5-7 includes the proposed Restoration Actions in Reach 4. A summary of each project is included following the table. Projects are presented from upstream to downstream.

Table 5-7. Proposed Restoration Actions for Reach 4. Benefits pertain to fish life stage and other attributes.

Site #	Landowner	Station	River Side (R/L)	Proposed Restoration Action	Benefits	Priority
R4-1	Cornucopia Family LTD PNTP; Manning Land LLC	332+00 to 336+00	Left and Right	Engineered log jam to create pocket pool habitat and slow water velocities in straight channel section.	Juvenile rearing habitat, adult resting habitat, pool scour	M
R4-2	Cornucopia Family LTD PNTP	366+00	Left	Add large woody debris to alcove and excavate backwater channel, establish riparian buffer.	Juvenile rearing habitat, adult resting habitat, floodplain habitat	H
R4-3	Smith; Slate	375+00	Right	Re-grade eroding bank, construct engineered log jams and vegetated soil lifts, plant riparian vegetation, institute riparian buffer.	Juvenile rearing habitat, adult resting habitat, sediment loading reduction	M
R4-4	Slate	393+00	Right	Enhance backwater channel, add large woody debris.	Juvenile rearing habitat, adult resting habitat	H
R4-5	Jensen	398+00 to 400+00	Left	Repair and enhance barbs, institute riparian buffer.	Juvenile rearing habitat, adult resting habitat, pool scour, bank protection	L

R4-1: Add large wood to the channel margins to provide juvenile rearing habitat and to promote pool scour for adult fish holding habitat in the migration corridor. Diverse fish habitat is currently limited through the reach.

R4-2: Add large wood aggregates and single pieces of large wood to an existing backwater habitat. The backwater habitat is inundated during low to moderate flows and also receives groundwater or hyporheic discharge. Adding large wood to the backwater will enhance the available habitat and increase the volume of juvenile rearing habitat. Large wood will also provide high water refugia for adult and juvenile fish. Establish a riparian buffer.

R4-3: The site is characterized by a vertical eroding bank and poor vegetation conditions. The proposed project will re-grade the eroding bank, install engineered log jams and vegetated soil lifts, plant vegetation, and institute a riparian buffer. The ELJs will deflect flow from the bank. The soil lifts will improve the streambank integrity and provide a growing medium for riparian vegetation. In the long-term, the riparian buffer should be colonized with shrubs and trees, providing stream shading and a source of organic material for the Calapooia River.

R4-4: Add large wood aggregates and single pieces of large wood to an existing backwater habitat. The backwater habitat is inundated during low to moderate flows and also receives groundwater or hyporheic discharge. Adding large wood to the backwater will enhance the available habitat and increase the volume of juvenile rearing habitat. Large wood will also provide high water refugia for adult and juvenile fish.

R4-5: Repair the existing bank stabilization structures and augment with large wood. Institute a riparian buffer.

The proposed Restoration Actions focus on augmenting mainstem habitat with ELJs and augmenting backwater habitat with large wood. The proposed treatments are expected to provide holding habitat for adult fish migrating through the reach as well as juvenile rearing habitat.

Conservation Actions

Nine conservation opportunities were also identified for Reach 4. Conservation Actions are more passive approaches to preserving or enhancing desirable river corridor features. Example Conservation Actions include establishing conservation easements, expanding riparian buffers, and monitoring site conditions. Table 5-8 presents proposed Conservation Actions for Reach 4. Narrative descriptions of each action follow the table.

Table 5-8. Proposed Conservation Actions for Reach 4. Benefits pertain to water temperature, fish habitat, and river processes.

Site #	Landowner	Station	River Side (R/L)	Proposed Restoration Action	Benefits
C4-1	James	300+00 to 316+00	Right	Expand riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment
C4-2	Cornucopia Family LTD PNTP	300+00 to 356+00	Left	Expand riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment

Table 5-8. Proposed Conservation Actions for Reach 4. Benefits pertain to water temperature, fish habitat, and river processes.

Site #	Landowner	Station	River Side (R/L)	Proposed Restoration Action	Benefits
C4-3	James; Cornucopia Family LTD PNTP; Kemp; Ewers; Akin; Keyser; Smith; Abraham; Haworth; Williamson; Slate	316+00 to 392+00	Right	Preserve floodplain and hillslope vegetation. Recommendation covers 7,600 ft.	Stream shading, habitat, large wood recruitment
C4-4	Cornucopia Family LTD PNTP; Ewers; Jensen	356+00 to 366+00	Left	Preserve floodplain vegetation	Stream shading, habitat, large wood recruitment
C4-5	Jensen	366+00 to 369+00	Left	Expand riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment
C4-6	Jensen	369+00 to 398+00	Left	Expand riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment
C4-7	Jensen	372+00	Left	Discuss disturbance of gravel bar with land owner.	Floodplain habitat, improved vegetation condition
C4-8	Jensen	398+00 to 400+00	Left	Preserve floodplain vegetation	Stream shading, habitat, large wood recruitment
C4-9	Matlock	400+00 to 422+00	Left	Preserve floodplain vegetation and expand riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment

C4-1: Expand the existing riparian buffer to 100 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

C4-2: Expand the existing riparian buffer to 100 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

C4-3: Preserve remaining floodplain and upland forest for habitat, water quality, and upland protection. Pursue conservation easement or other approach to maintain or enhance current riparian conditions.

C4-4: Preserve remaining floodplain forest for habitat, water quality, and upland protection. Pursue conservation easement or other approach to maintain or enhance current riparian conditions.

C4-5: Expand the existing riparian buffer to 100 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

C4-6: Expand the existing riparian buffer to 100 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

C4-7: Discuss floodplain disturbance with the landowner.

C4-8: Preserve remaining floodplain and upland forest for habitat, water quality, and upland protection. Pursue conservation easement or other approach to maintain or enhance current riparian conditions.

C4-9: Preserve remaining floodplain and upland forest for habitat, water quality, and upland protection. Pursue conservation easement or other approach to maintain or enhance current riparian conditions. Expand the existing riparian buffer to 100 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

The proposed Conservation Actions primarily focus on preserving existing high quality floodplain environments. Maintaining gallery forests provides fish and wildlife benefits as well as protecting upland properties from erosion. Vegetation patterns and large wood contributions to the river enhance habitat diversity. Canopy shading of backwater habitats and floodplain channels preserves cool water refugia for fish. Expanding riparian buffers is intended to reduce agricultural runoff to the river, increase bank stability, and result in a more diverse riparian community over the long-term.

Reach 4 Restoration Summary

Proposed Restoration Actions and Conservation Actions aim to enhance mainstem and backwater habitats by adding large wood. Juvenile and adult fish are expected to benefit from the proposed actions. Instream work including installation of ELJs is intended to improve habitat but also reduce bank erosion and sediment loading to the Calapooia River. Instream projects, though also beneficial, tend to be more costly and are at greater risk of failure.

Conservation Actions aim to preserve valuable riparian floodplain and upland habitats. Conserving remaining floodplains is essential for maintaining a functioning river system buffered from human encroachment.

5.6 Restoration Plan Implementation

Restoration Actions and Conservation Actions were outlined for each of the four reaches in the Middle Reach of the Calapooia River. Actions were prioritized by reach rather than for the whole Middle Reach. Reach 1 and Reach 3 are the highest priority reaches as they have the most dynamic river-floodplain environments. Reach 2 and Reach 4 are more confined by hillslopes and influenced by bank stabilization structures. Because several landowners in Reach 3 are prepared to initiate project design, Reach 3 was given the highest priority for initiating restoration actions.

Restoration Actions were prioritized for each reach. Because actions were prioritized on a reach-specific basis, an action that ranked as a high priority in one reach may have only garnered a medium priority in another reach depending on how many and what types of actions were identified. Future funding applications will be prepared by reach to implement reach-level restoration planning rather than site-specific treatments which are usually less beneficial and more costly to implement.

Restoration Actions aim to enhance river and floodplain habitats, preserve landowner properties, and provide long-term river corridor improvements. The high priority Restoration Actions focus on enhancing floodplain habitats intended to benefit juvenile and adult fish. The proposed actions intend to re-establish or enhance habitats that have been affected by over 100 years of river corridor manipulations. Treatments include accentuating floodplain channels, connecting channels with floodplain ponds, creating floodplain ponds, and augmenting existing floodplain habitats with large wood. These actions are expected to benefit fish by providing more cool water refugia, flood refugia, and edge habitats for juvenile fish. Adult fish will also benefit from these habitats as well as deeper pools maintained by scour against large wood structures.

Medium priority projects generally include bank stabilization, engineered log jam installation, vegetated soil lift construction, and potentially less beneficial floodplain enhancements. The medium priority projects are expected to be more costly and be higher risk as the proposed treatments would be implemented in the mainstem Calapooia River. However, these treatments are intended to enhance mainstem habitats and also reduce bank erosion and property loss.

Low priority projects mainly include installing engineered log jams for bank stabilization and habitat. These projects are higher risk with lower biological benefits.

The following sections outline the implementation of the restoration activities.

5.6.1 Floodplain Channel and Pond Excavation

Floodplain and backwater enhancements would include expanding existing flood channels, enhancing backwaters, connecting floodplain ponds with the Calapooia River, creating floodplain ponds, and adding large wood to these environments. Work would be completed with heavy equipment including excavators, off-road dump trucks, and front-end loaders. Floodplain excavation would lower and/or expand existing habitats so that channels access groundwater or are hydraulically connected with the Calapooia River at baseflows or high frequency flood events. These actions would increase the juvenile rearing habitat and flood refugia. Channel and pond shaping would replicate naturally occurring habitats that provide the range of desired habitats.

Where possible, channel and pond work would be completed in forested areas of the floodplain. The floodplain forest would shade the channel, contribute organic material and woody debris, and provide stability through root structures. A range of elevations would also be created. Not all floodplain channels would be connected with the Calapooia River at baseflows. It would be beneficial for some species to only have channels and ponds connected with the Calapooia River during higher flood events. Creating a range of habitats would benefit a wider range of species and life histories.

Excavation would minimize disturbance to adjacent vegetation and floodplain surfaces. Excavated materials would either be shaped on the floodplain (creating topography) or hauled off-site for disposal. Construction would be completed in one pass (excavation and habitat materials placement) to speed construction and reduce the project footprint.

5.6.2 Large Wood Placement

Large wood has been removed from the Calapooia River over the last 100 years to improve navigation, saw log transport, and to protect infrastructure. The loss of large wood has led to habitat simplification, gravel mobilization, and a less dynamic river system. Incorporating large wood in floodplain habitat enhancement is proposed for creating and augmenting existing habitats. Fish use large wood for cover with juveniles inhabiting the interstitial spaces and adult fish using the scour pools commonly associated with stable wood aggregates. Large wood would be placed as both individual pieces and in aggregate. Aggregates would be more expensive to build as they require more material and time to complete, but provide more complex microhabitats than single pieces. Aggregates also tend to be more stable over time and typically collect other wood transported by the river.

Procuring large wood may be done by importing materials from outside the river corridor and using trees that are displaced during floodplain channel and pond work. Because large wood is a limited resource in the Calapooia River, importing large wood from outside of the project area is recommended. However, from a cost perspective, using displaced and downed trees to augment floodplain habitats is preferable.

Large wood will be used to ensure channel stability, provide habitat, and to trap sediment. Set large wood at grade in constructed channels will provide grade control. Orienting wood along the channel margin will deflect flows and provide bank stability. Placing trees in the channel alignment can promote several types of habitat. For example, large wood in a pool provides overhead cover and interstitial space. Wood in a run will promote vertical scour at the head of a pool.

Wood may be anchored by burying, with ballast rock, or pinned together. Wood should remain stable to provide the intended benefits as well as to limit downstream transport and the formation of unintended log jams. However, imported wood will be redistributed over time by large floods. Log relocation would be expected to benefit other areas of the Calapooia River than just where it is initially placed.

5.6.3 Engineered Log Jams

Engineered log jams (ELJs) are installed for bank stabilization, flow deflection, and mainstem river habitat. ELJs will be completed on the mainstem river and will provide complex cover for juvenile and adult fish. ELJs will be constructed with approximately 10 to 15 trees including rootwads, whole trees, and tree tops (Figure 5-2). To provide structure ballast, approximately 10 yd^3 of large rock will be placed within each structure. The ELJs are also backfilled with native alluvium to reduce the potential for intra-structure piping. Rootwad sizes will average 3 ft to 4 ft in fan diameters and have minimum stem lengths of 30 ft. ELJs span from the predicted scour depth to above the bankfull channel elevation to provide a range of fish habitat and structure stability.

Figure 5-2. An ELJ constructed on the Jocko River in western Montana following two run-off events.

5.6.4 Vegetated Soil Lifts

Vegetated soil lifts is a bioengineering technique that combines layers of dormant willow cuttings and/or containerized willows with fabric-wrapped soil to revegetate and stabilize stream banks and slopes (Figure 5-3). Vegetated soil lifts are proposed for stabilizing bank erosion sites where a new bank face will be constructed. To construct a vegetated soil lift, a coarse cobble toe is first established. The first soil lift incorporates a high density coir log backed with soil and wrapped within two layers of biodegradable coconut (coir) fiber fabric. Dormant willow cuttings or containerized plants and a native seed mix are placed on each lift. The cuttings or plants are placed horizontally to extend into the stream channel. Cuttings should be placed so that only ¼ of the cutting is exposed. A two to three-inch layer of top soil is placed between each lift to reduce air pockets and provide rooting medium for the willow cuttings. The coir fabric holds the soil in place while vegetation becomes established in the relatively high stress land/water interface. Vegetated soil lifts will provide near-term bank protection until planted vegetation becomes established.

Figure 5-3. A vegetated soil lift following spring runoff and at the start of the growing season on the Sprague River.

5.6.5 Large Wood Habitat

Large wood will be used to enhance floodplain channels and backwater habitats. Large wood will be installed both singularly and in aggregate. These structures will be smaller than ELJs and require less material (Figure 5-4). In general, each structure will include at two rootwads and several logs for ballast. Large wood structures may either be anchored in the ground, ballasted with large rock, pinned together, or longer tree pieces will be placed in the riparian zone angled towards the channel.

Figure 5-4. A large wood habitat composite with adjacent soil lift on Pilgrim Creek in western Montana.

5.6.6 Conservation Actions

Highlighted Conservation Actions are intended to preserve remaining floodplain and upland forests as well as expand these areas. Floodplain areas bordering the river have been impacted by agriculture and residential encroachment. The once expansive riparian forests have contracted in the Calapooia River drainage in a similar fashion to most of the Willamette Valley. Protect and expanding the remaining forests is advised to preserve riverine habitats, to maintain a naturally regenerating floodplain forest, and to protect upland property owners from erosion. Working with landowners to preserve these areas is critical. Various conservation programs are also available for landowners who are will to forego some land uses in exchange for compensation. Most programs require a time commitment from the landowner to take the land out of production. The Natural Resources Conservation Service and the Farm Service Agency offer qualifying programs. Landowners may work with the CWC and federal agencies to evaluate programs that would meet the landowners' needs and provide resource protection.

6 SUMMARY

The Middle Reach of the Calapooia River near Brownsville, Oregon, retains many of the characteristics that historically supported larger populations of Chinook salmon, steelhead, cutthroat trout, other native fish species and amphibians. Over 100 years of land uses favoring timber harvest and log transport, agricultural production, and residential development have altered the river corridor. An assessment of the Middle Reach from the former Brownsville Dam site downstream to the Calapooia River bifurcation leading to Sodom Dam was completed in 2007 to evaluate potential restoration, conservation, and stabilization opportunities. Proposed actions were developed and prioritized for four sections of the Middle Reach. Actions emphasize augmenting floodplain channels and backwater habitats to provide more habitat for juvenile and adult fish. Critical habitats include juvenile rearing habitat, adult holding habitat, cool water and flood refugia, as well as floodplain habitats that would support turtles and amphibians. Existing functional habitats that support juvenile and adult salmonids would be used as templates for creating and enhancing other such habitats.

Restoration Actions were prioritized based on their potential benefit, cost, and failure risk. Projects that would expand and enhance floodplain and backwater channels would be subjected to lower flood effects than mainstem projects, and were therefore given the highest priority. Mainstem projects including engineered log jams and soils lifts that would address sediment sources and land loss, where rated lower due to higher implementation costs and greater risk potential. Low priority projects included high risk projects or enhancing existing bank stabilization structures. Landowners may also collaborate with federal agencies to address bank stabilization as well as conservation opportunities for their properties. Conservation Actions include protecting remaining floodplain and upland forests and expanding riparian forest buffers that have been narrowed by development.

Implementing projects on a reach scale is preferable to maximize ecological benefits and lower implementation costs. The Calapooia Watershed Council is currently working with landowners to develop projects on a reach basis.

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APPENDIX A
REACH MAPS

APPENDIX B
CHANNEL HABITAT UNIT MAPS

APPENDIX C
BANK STABILIZATION AND BANK EROSION MAPS

APPENDIX D
EXISTING RIPARIAN CORRIDOR VEGETATION MAP

APPENDIX E
EXISTING WETLANDS MAP

APPENDIX F
HISTORICAL CHANNEL ANALYSIS MAPS

APPENDIX G
FIELD SURVEY SITES MAP

APPENDIX H
RESTORATION AND CONSERVATION SITES MAP

APPENDIX I
TYPICAL DRAWINGS