Klickitat Watershed Enhancement Project

Annual Report for January 1, 2009 – December 31, 2009

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Prepared By:

Will Conley
Watershed Restoration Specialist

David Lindley
Habitat Restoration Specialist

Yakima – Klickitat Fisheries Project
Yakama Nation Fisheries Resource Management Program
P.O. Box 151
Toppenish, WA 98948

Prepared For:

Mary Todd Haight, COTR
U.S. Department of Energy
Bonneville Power Administration
Fish and Wildlife Program

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SUMMARY

The Klickitat Watershed Enhancement Project (KWEP) works to restore, enhance, and protect watershed function within the Klickitat subbasin. Project work emphasizes restoration and protection in watersheds and reaches that support native salmonid stocks, particularly steelhead (*Oncorhynchus mykiss*; listed as "Threatened" within the Mid-Columbia ESU) and spring Chinook (*O. tshawytscha*) salmon. KWEP addresses goals and objectives of the Klickitat Subbasin Plan, Klickitat Lead Entity Strategic Plan, the Northwest Power & Conservation Council (NPCC) Fish and Wildlife Program and the NMFS Biological Opinion.

KWEP implements habitat and watershed project actions of the Yakima Klickitat Fisheries Project (YKFP) in the Klickitat Subbasin. Restoration activities are aimed at restoring stream processes by removing or mitigating watershed perturbances and improving habitat conditions and water quality. Watershed and habitat improvements also benefit bull trout (*Salvelinus confluentus*; ESA "Threatened"), fall Chinook (*O. tshawytscha*) and coho (*O. kisutch*) salmon, resident rainbow trout (*O. mykiss*), and cutthroat trout (*O. clarki*) and enhance habitat for many terrestrial and amphibian wildlife species. Protection activities complement restoration efforts within the subbasin by securing refugia and preventing degradation. Since 90% of the off-reservation project area is in private ownership, maximum effectiveness is accomplished via cooperation with other governmental, non-governmental, and/or private entities.

<u>Highlights of the January 1, 2009 – December 31, 2009 reporting period:</u>

- Completion of topographic surveys for 2 sites:
  - Haul Road Project
  - Tepee Creek Meadows Restoration – Phase 2

- Construction of Upper Klickitat In-Channel and Floodplain Enhancement Project (Phase 2)
  - Constructed 35 LWD jams
  - Reconnected ~2900’ of side-channel habitat
  - Enhanced habitat along ~1500’ of the mainstem Klickitat River
  - Stabilized ~1/3 mile of river bank

- Tepee Creek Meadows Restoration - Phase 2
  - Pre-project assessment – shallow groundwater monitoring wells, mapping of low-flow refugia, habitat survey/mapping, inventory of pre-project vegetation , abundance survey of *O. mykiss*, and sampling of macroinvertebrates

- Klickitat River Delta Pilot Assessment
  - Installation of sensors at the interface of the Klickitat and Columbia rivers.
  - Water depth and temperature measured and recorded at four stations and wind speed and direction at one station

- Initial construction of Haul Road project associated with abandoned railroad in Dead Canyon
  - Removal of a 570 lineal-foot cross-valley embankment
  - Removal of a 30’ span trestle, including 3 concrete abutments
  - Grading of approximately 120’ of Dead Canyon Creek to better match the channel profile and eliminate a pool that caused steelhead mortality.

- Acquisition of Light Detection and Ranging (LiDAR) data
  - Acquired LiDAR data and orthophotos for 42 miles of mainstem Klickitat River valley bottom, inclusive of eight tributary confluences

- Effectiveness monitoring of 4 Lower Klickitat River Revegetation Project sites
  - Follow-up survey to measure survival and growth of riparian plantings from 2008 on 4.0 acres of Klickitat River floodplain
  - Relocation of 707 plantings uniquely marked in 2008 to evaluate assortment of treatments (including planting depth and pruning)

INTRODUCTION

The Klickitat Watershed Enhancement Project (KWEP) enhances and restores watershed health in the Klickitat River subbasin. Project actions target stream reaches and watersheds that support steelhead (*Oncorhynchus mykiss*; ESA- listed as "Threatened") and/or spring Chinook (*O. tshawytscha*). Implemented by the Yakama Nation Fisheries Program (YNFP) and funded by Bonneville Power Administration, KWEP addresses habitat goals of the Yakima/Klickitat Fisheries Project (YKFP) as well as the Columbia Basin Fish & Wildlife Program of the Northwest Power and Conservation Council. KWEP is the principal project addressing salmonid habitat conservation and restoration in the Klickitat subbasin.

KWEP works to restore, enhance, and protect watershed function within the Klickitat subbasin. Project work emphasizes restoration and protection in watersheds and reaches that support native salmonid stocks, particularly steelhead (*Oncorhynchus mykiss*; listed as "Threatened" within the Mid-Columbia ESU), spring Chinook (*O. tshawytscha*) salmon, and bull trout (*Salvelinus confluentus*; ESA "Threatened"). Restoration activities are aimed at restoring stream processes by removing or mitigating watershed perturbances and improving habitat conditions and water quality. Watershed and habitat improvements also benefit fall Chinook (*O. tshawytscha*) and coho (*O. kisutch*) salmon, resident rainbow trout, and cutthroat trout (*O. clarki*) and enhance habitat for many terrestrial and amphibian wildlife species. Protection activities complement restoration efforts within the subbasin by securing refugia and preventing degradation. Since 90% of the off-reservation project area is in private ownership, maximum effectiveness is accomplished via cooperation with state, federal, tribal, and private entities. KWEP addresses goals and objectives presented in the Klickitat Subbasin Plan (NPPC 2004), Klickitat Lead Entity (KLE) Salmon Recovery Strategy (KLE 2009), and the recovery plan for mid-Columbia River steelhead (NMFS 2009).

Since 2000, KWEP has implemented over 18 projects encompassing over 60 sites resulting in:

- correction of fish barriers at 6 sites restoring access to over 14.8 miles of habitat
- enhancement of over 10,100' of stream including construction of 74 LWD jams
- installation of at least 9,000 plantings along 13,000' of stream
- fencing of over 10,000' of stream
- restoration of high-flow access to over 3150 lineal feet of side channels
- monitoring streamflow at 13 sites
- morphologic and habitat assessment of over 74 miles of stream
- assessment of over 145 miles of road and railroad
- treatment of 10.5 miles of road for drainage improvements

KWEP works interactively with other BPA-funded projects including YKFP-Klickitat Data Management (#1998-120-35) and YKFP-Klickitat Monitoring and Evaluation (#1995-063-35). KWEP has cooperated with numerous private and public entities, including:

- Mid-Columbia Regional Fisheries Enhancement Group
- Washington Department of Natural Resources
- Washington Department of Fish & Wildlife
- Washington State Parks & Recreation
- Central & Eastern Klickitat Conservation Districts
- Klickitat County
- Columbia Land Trust
- Yakama Nation Water Program
- Underwood Conservation District
- Yakama Forest Products
- BIA Forestry and BIA Range
- private individuals

These partnerships have involved an additional 11 projects resulting in:

- acquisition of over 1050 acres (through acquisition?) and 4 miles of fish-bearing streams and side channels
- correction of 4 fish passage barriers restoring access to 3.3 miles of habitat
- enhancement of over 4000' of stream and construction of 52 LWD jams
- installation of at least 19,400 plantings along 3,000' of stream
- design and development of relational databases to efficiently manage and analyze habitat, temperature, and sediment data
- implementation of no-till agricultural practices on local farmlands

Additionally, KWEP staff have provided technical support to private landowner and assisted various planning processes including:

- Subbasin Planning (Northwest Power Council)
- Salmon Recovery Planning (NOAA Fisheries)
- Strategic Planning (Washington Salmon Recovery Funding Board)
- Watershed Planning (Washington Department of Ecology)

PROJECT GOALS

The overall goal of KWEP is to restore watershed health to aid recovery of salmonid stocks in the Klickitat subbasin. This is accomplished via a three-pronged approach:

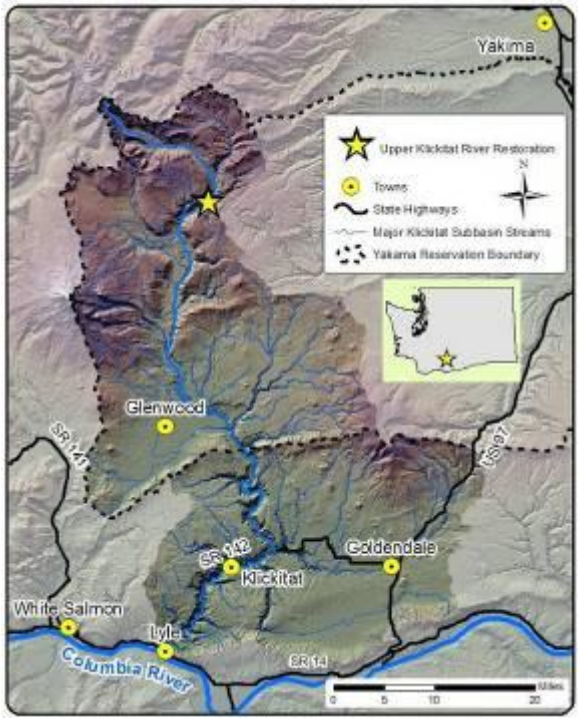
- *Assessment* of watershed and habitat conditions to prioritize sites for restoration activities. This involves data collection, compilation, and review of existing as well as historic habitat and watershed conditions. Identification and filling of data gaps is also a component of KWEP.

- *Protection*, *restoration*, and *enhancement* of priority watersheds and reaches to increase riparian, wetland, and stream habitat quality. In situ and watershed-scale restoration activities mitigate or resolve conflicting historic, present, and/or future land uses. Protect areas of existing high-quality habitat condition and prevent further deterioration of degraded habitats. Restore areas of degraded stream channel and/or habitat condition.

- *Monitoring watershed c*onditi*ons to asse*ss trends and effectiveness of restoration activities. Monitoring is a critical component in evaluating project success and guiding adaptive practices. Site-specific and basin-wide spatial scales are addressed. KWEP augments the Klickitat M&E and Klickitat Data Management projects by providing data QA/QC, database design, and oversight of physical habitat parameters including temperature, habitat, *a*nd channel substrate. KWEP is responsible for collection and analysis of geomorphic and hydrologic data.

FEATURED 2009 PROJECTS

Upper Klickitat River In-Channel and Floodplain Enhancement Project (Phase 2)



Introduction: The project addresses limiting features (channel confinement and habitat simplification) identified for this reach by the Klickitat Subbasin Plan and Klickitat Lead Entity Salmon Recovery Strategy (KLESRS). The core Ecosystem, Diagnosis & Treatment (EDT) reach that encompasses the project sites ranks third overall in the Klickitat subbasin in restoration potential for combined performance of steelhead and spring Chinook (NPCC, 2004). Project work addresses most of the top limiting factors identified for the reach between RM 70 and 74.5.

Site and Watershed Description: The project location is on the mainstem Klickitat River between river mile 70 and 75. This area provides critical spawning and rearing habitat for ESA-listed Middle Columbia River steelhead and spring Chinook. The project area consists of two reaches totaling 2.3 miles (cumulative). Both reaches are primarily forested and moderately incised, resulting primarily from encroachment by a floodplain road. The reaches are located between 2950-3240' above sea level. The contributing drainage area ranges from 130 mi^2 (Reach 1) to 89 mi^2 (Reach 2) and is predominantly forested by Douglas fir, grand fir, ponderosa pine, and lodgepole pine. Annual precipitation ranges from 60 to 65 inches and occurs primarily as snow. Streamflows are primarily snowmelt driven, though the highest peak events on record (e.g. 1996) were associated with large regional rain-on-snow events.

Fisheries Significance: Castile Falls is a series of 11 waterfalls located at RM 64 of the Klickitat River (roughly 5.0 – 10.0 miles downstream of the project site). Some steelhead and some spring Chinook passage was apparently possible prior to construction of a small headworks dam above Falls 11 in the 1960's to provide grade-control for the intake of a fishway constructed by the Washington Department of Fisheries. The fishway was constructed with the intent of improving spring Chinook salmon and steelhead passage and functioned properly for several years before becoming plugged with bedload at which point the fishway became a series of velocity barriers. The combined effect of the dam and fishway was obstruction of upstream passage under an estimated 99% of flows for which monitoring has occurred since 1996. There are no anecdotal accounts of adult steelhead or Chinook observations in intervening years. The Yakama Nation completed modifications to the upper fishway and the fishway at Falls 4/5 in 2003 and 2004, respectively.

In preparation for improved fish passage at Castile Falls surplus adult spring Chinook from the Klickitat Hatchery were trucked and released upstream of the falls in 2002 and 2003. In these years, the YNFP marked 146 and 82 spring Chinook redds, respectively, in the 8.0-mile long survey reach that includes both work areas. It is anticipated that natural straying of wild steelhead will recolonize upstream habitats including those in the vicinity of Upper Klickitat enhancement sites.

Pre-project Problem: The primary problem is channel simplification. The reach appears to have historically been a historic forced-pool and pool-riffle morphology had become a plane-bed. The channel had incised 1-2' and was largely armored with large cobble and small boulder material. Pools had become infrequent and where they did occur, residual depths were generally shallow (12-18"). The shift to a plane-bed is believed to have been triggered by realignment and filling of the channel and floodplain associated with a construction of the 255 Road in the mid-1970s and subsequently magnified by flooding. Prior to commencing project work there were six locations where the active channel contacted this arterial road and erodes the embankment.

In addition to the road's influence on morphology and habitat, it seems likely that stream cleaning occurred at some point. The Washington Department of Fisheries conducted a habitat survey between Castile Falls and McCormick Meadows in 1957 (LeMier, et al. 1957) and noted, "many log and debris jams caused by windfalls are present in the stream area covered ranging in size to 200 feet long, 50 feet wide, and 18 feet high." The report notes other conditions (depth and pool frequency) that were more favorable to salmonids than those observed pre-project. In particular, the reach within which the Upper Klickitat Phase 2 project occurs contained, "The largest and most serious log jams." The report went on to prescribe "…therefore, removal of these obstacles is mandatory if the [Castile] falls improvement work is undertaken." Stream cleaning was a common practice throughout the Pacific Northwest into the 1980s and the construction of the 255 Road would have made the reach much more accessible to the practice had it not occurred previously. Given the absence of jams or older relics of jams on floodplain, it seems highly likely that stream cleaning occurred in the project reach.

Project Goal: Increase physical habitat complexity and reduce river-road interaction. Enhance instream habitat and water quality to benefit mid-Columbia steelhead (ESA - Threatened) and spring Chinook (WDFW - Depressed) at three priority sites totaling 0.29 river miles (cumulative) along the Klickitat River between RM 70 and 74.5. Roughly 3750 lineal feet of side channel will be reconnected.

Design: The general premise of the project was to convert the plane-bed morphology to forced-pool morphology. There are currently a few isolated "islands" of recovering channel where large woody debris (LWD) recruited from bank mass-wasting has been deposited into jams and locally controls gradient and flow direction. These areas tend to have fair to good pool formation immediately upstream and downstream as well as accumulations of gravel.

The overall approach of the project is to mimic these areas and effectively fill the gaps in between them. YKFP staff developed the design in cooperation with Interfluve, Inc (Conley 2008). We developed a 30% paper design based on collection of topographic data and a 1-dimensional hydraulic model. Typical treatments were developed and continuous field supervision was provided to the construction contractor by YKFP and/or Interfluve staff. Constructed jams were not installed at scour depth, but were built to accommodate scour and settling. There were four main types of treatments:

- *Floodplain benches* were constructed in Reaches 3 and 4 where the active channel contacts the road to provide a buffer between the toe of the road fill and active channel. Excavation along the left (non-road) channel margin maintained channel capacity and provided a source for alluvial material to backfill the bench on the right-bank / road-side (Fig. 1). A base layer of boulders and LWD was be placed to create the core of the new floodplain surface then backfilled with native cobbles and gravels using a dig-and-pitch approach (Fig 2). This realigned the channel to be compatible with the bench treatment, yet maintain flow capacity. The finished grade of the new

floodplain was constructed to be inundated at approximately a 5-year recurrence (and greater) flood and provide a 10 to 25 horizontal foot buffer from road fill (Figures 3 and 4). The new surface was planted with dormant hardwood cuttings. Due to the greater hydraulic force in these areas, LWD was ballasted posts as well as with boulders using epoxy and cable. In some cases pools and runs were excavated adjacent to the benches and LWD treatments.

- *LWD jams* were constructed on the mainstem and side channel to encourage channel complexity and improve local hydraulic conditions to facilitate retention and sorting of sediments and pool formation/maintenance. In particular, jams were constructed at sites 2, 3, and 4. Jams consisted of 2-3 "key" pieces (>30" diameter) with additional members added as necessary. Stability of the jams was provided by site selection, partial burial/keying, orientation and sizing of key pieces, as well as placement of additional members as ballast. In some cases, cabling and ballasting with boulders, backfill, and/or posts was employed to increase stability.
- *Channel reconnection* occurred at site 4 where approximately 200' of channel was constructed to reconnect a roughly 4000' long side channel. Excavated materials were used for backfill of LWD structures as well as graded into a nearby talus slope.
- *Debris "barbs"* with adjacent pools were constructed at Site 2 instead of a continuous floodplain bench to conserve materials and budget (Fig. 5).

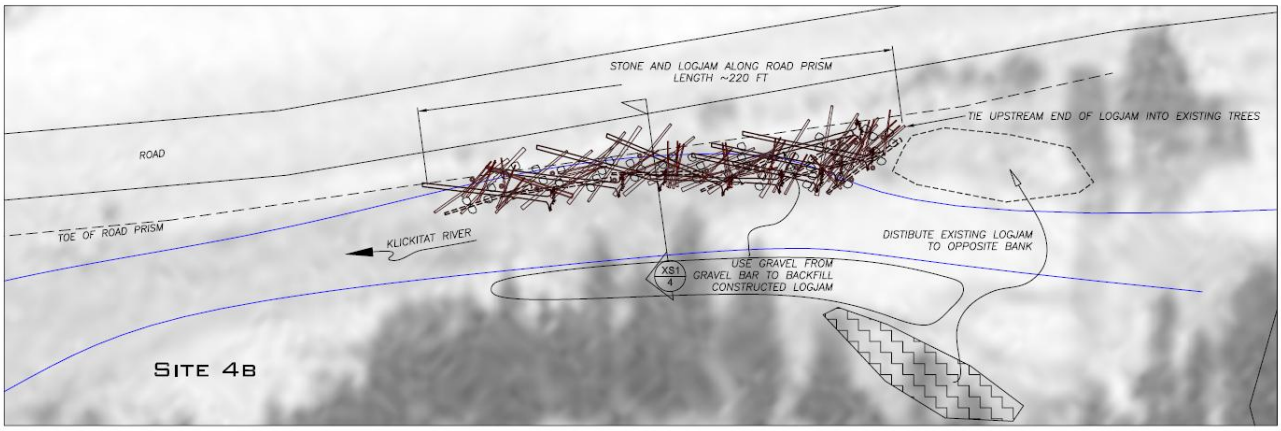


Figure 1. Plan view design of Site 4B of the Upper Klickitat River In-Channel and Floodplain Enhancement Project (Phase 2).

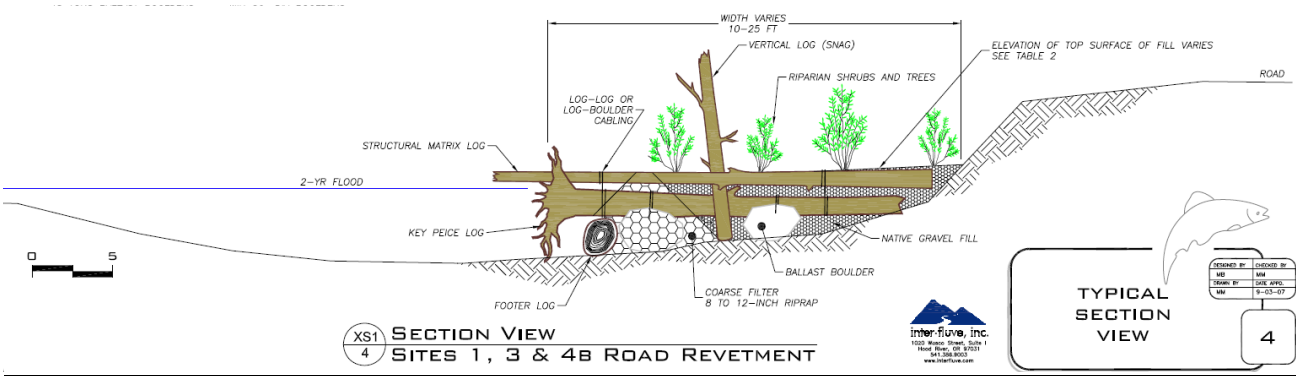


Figure 2. Typical design cross-section for construction of floodplain benches in the Upper Klickitat River In-Channel and Floodplain Enhancement Project (Phase 2).

Construction: Construction at sites 2, 3, and 4 occurred in the fall of 2009.

- Fall 2008 – logs of blowdown origin collected, transported and stockpiled at project sites
- Fall 2009 – logs of blowdown origin and boulders collected, transported and stockpiled at project sites; gravel fill produced; LWD jams completed; excavation of new channel and reconnection of historic side channel; temporary erosion control measures implemented

Follow-up work is prescribed for sites 3 and 4 in 2010. In particular, the side-channel will be activated, and several additional jams will be constructed on the mainstem in-between the road-side treatments implemented in 2009.

Construction was funded by YNFP sponsored grants from the Washington State Salmon Recovery Funding Board (SRFB) and the Pacific Coastal Salmon Recovery Fund (PCSRF). KWEP provided funding for design and construction oversight. KWEP also funded non-LWD materials and supplies. Significant components of the implementation (2009) include:

- 950 logs of blowdown origin and 690 boulders were collected and delivered to project sites
- Construction was completed at Sites 2, 3, and 4B totaling approximately 1500' of bank.
- Production and delivery of filter rock for reaches 1, 2, 3, and 4
- Collection and delivery of boulder ballast for reaches 1, 2, 3, 4, and 6
- Construction of approximately 2900' of side channel at reaches 4A & 4B, approximately 1300' of which is expected to be perennial
- Constructed 35 LWD jams
- Installed floodplain roughness at 5 locations
- Excavated 5 main-channel pools

Figure 3. Site 4 pre-treatment (June 13, 2005)

Figure 4. Site 4 post-enhancement (July 23, 2010).

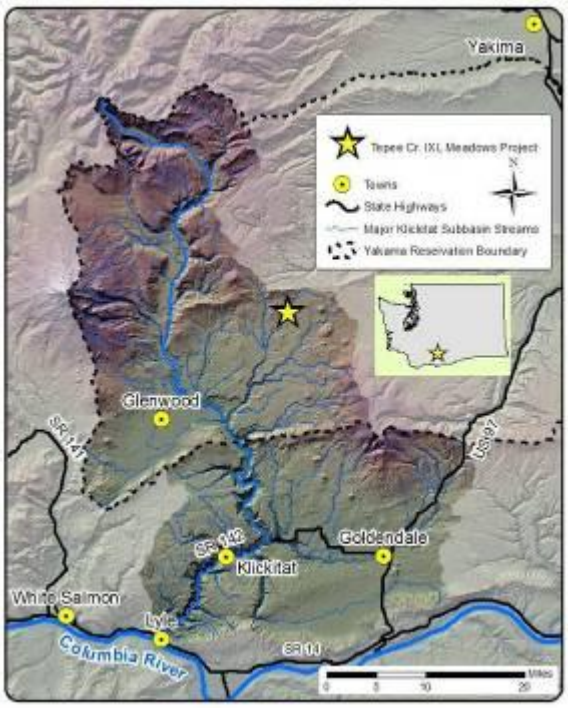
Figure 5. Site 2 at springtime flows pre- (left) and post-enhancement (right).

Tepee Creek Meadows Restoration - Phase 2

Introduction: The project addresses limiting habitat features (bed degradation and pool structure) identified by the Subbasin Plan (NPPC 2004) and KLESRS (2008) along 2000 feet of Tepee Creek. Tepee Creek is a tributary to White Creek and provides important spawning and rearing habitat for ESA-listed Middle Columbia River steelhead and is a top geographic priority. The White Creek watershed as a whole is likely the most important spawning and rearing tributary watershed within the Klickitat subbasin. In recent years (2002-2008), the White Creek watershed on average accounts for 26% (0-52%) of the observed steelhead spawning in the entire Klickitat subbasin. Tepee Creek has accounted for up to 20% of the observed spawning in the Klickitat subbasin in recent years (2002-2007), however on average it accounts for 5%. Extensive reaches of Tepee Creek have become incised and are now intermittent in many places that anecdotal information suggests were once perennial.

Site and Watershed Description: The project reach consists of approximately 1 mile of Tepee Creek in the vicinity of river-mile 5 (Fig. 6) and immediately downstream of the IXL Meadows Restoration Project (completed 2007; Conley 2008). The site is at 2900' elevation. The reach is a mix of meadow, ponderosa pine parkland and mixed conifer forest. The contributing drainage area is 8.4 square-miles

in size and occurs primarily between 3000' and 4000' feet in elevation. Basal geology is the Grand Ronde Basalt of the Columbia River Basalt Group which contributes both to low to moderate topographic relief and to resistant parent materials. Surficial parent material is likely originates as ash from Cascades, volcanic rocks and ash from the Simcoe Volcanic field. Faulting associated with the Yakima Fold Belt along the northern margin of the watershed has generated steeper slopes that increase weathering rates and help generate the meager gravel supply for the watershed. Soils and banks on-site are cohesive with a prevailing clay loam texture.



Fisheries Significance: Tepee Creek provides spawning and rearing habitat for ESA-listed ("threatened") Middle Columbia River steelhead. On average, Tepee Creek accounts for 6.3% of the total observed spawning in the Klickitat subbasin. The project area occurs within a reach that has been identified by the Klickitat Technical Advisory Group as one of the top priority areas for salmon recovery in the Klickitat Subbasin.

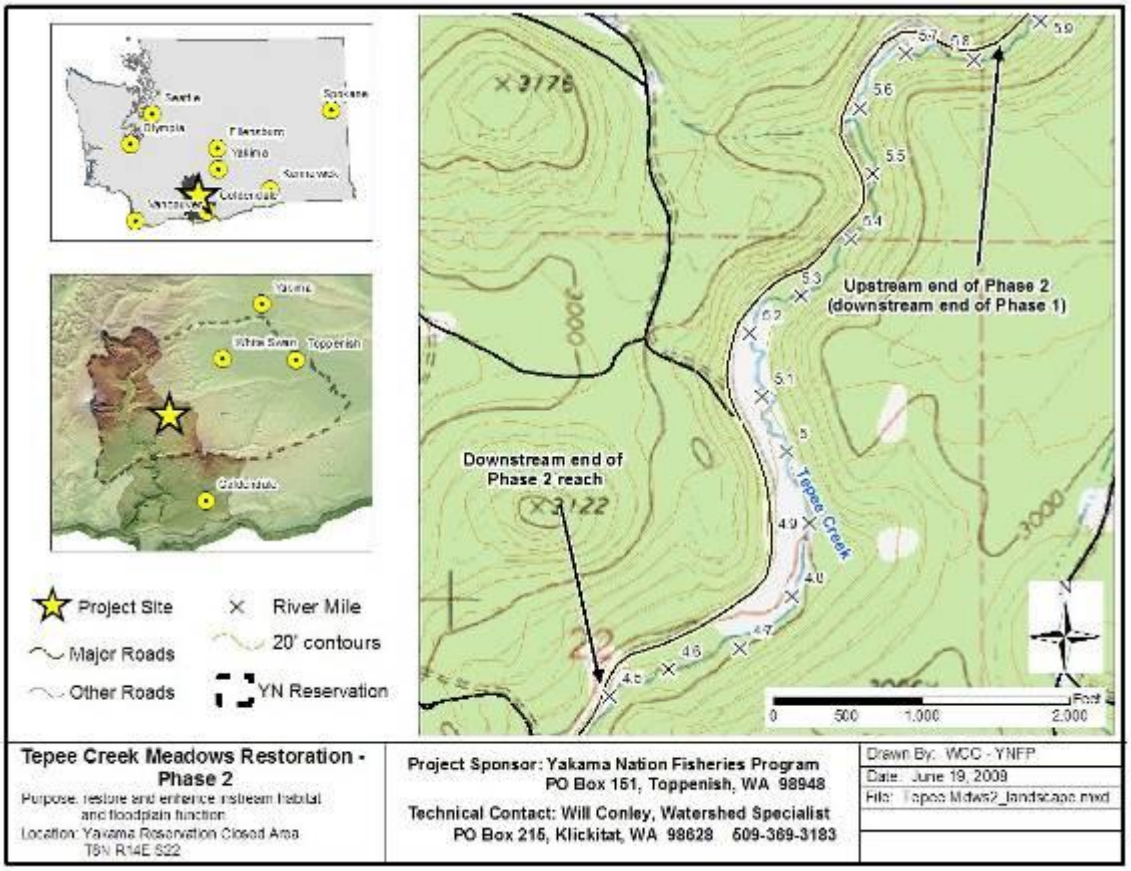


Figure 6. Map of Tepee Creek Meadows Restoration – Phase 2.

Problem: In general, summer rearing habitat in the White Creek watershed is highly limited. Summer refugia, in the form of perennially-flowing stream reaches or remnant pools in otherwise dry reaches, are highly limited in Tepee Creek and are necessary for successful rearing within this watershed. Stream channel incision throughout much of the watershed limits floodplain storage. Upstream, in the IXL Project reach, pre-project hydraulic modeling indicated that most cross-sections required at least a 10-year recurrence flood to generate overbank flow (Interfluve 2004). Where wetlands and floodplains are intact, such as in the headwaters of Tepee and in the East Fork Tepee Creek watershed perennial flows do exist. Where perennial pool habitat is present, survival appears to be good, particularly for 0+ and 1+ aged fish. Currently, downstream migrants resulting from summer freshets are often stranded in areas that dry up (Fig. 7). Additional refugia are critical for increased survival. Anecdotal evidence, along with watershed size, elevation, and precipitation, suggest that more reaches had perennial flow historically.

Figure 7. Deceased O. mykiss in dry streambed (left) and typical late-summer conditions (right).

Currently, most of the incised reaches in the White Creek watershed (including the project reach) dry up from July through October. Anecdotal accounts from the 1960s suggest that at least some of these reaches were historically perennial. Many of the same reaches showing signs of bed armoring are also characterized by a simplified morphology with low pool frequencies, rectangular, canal-like cross sections, and an absence of LWD.

The trigger for incision in the Phase 2 reach appears to be largely of local origin. There is a perched, abandoned channel (Figures 8 and 9) in the lower half of the reach possessing different channel geometry than the adjacent, active channel. The abandoned channel is much narrower and more sinuous and has remains of a bridge (Fig. 9) near its head at the diversion point with the active channel (Fig. 8). The deck appears to have been even with the elevation of the adjacent native ground which indicates that any structural members would have occupied a portion of the bankfull channel and, hence, obstructed streamflow with a relatively high frequency.

The most probable mechanism for the reach's current condition seems to be: 1) an undersized bridge was installed, 2) the road on either side was at-grade on native materials (i.e. no embankment), 3) the road on the east side ran parallel to the valley bottom, 4) a runoff event exceeded the channel capacity at the bridge section and was pushed out-of-bank, 5) ruts from vehicles and/or equipment channelized overbank flow along the down-valley road segment, 6) a head-cut was initiated where flow channelized by the road re-entered the stream channel at a steep, local gradient irregularity (e.g. where channel at re-entry point was over-fit for the discharge in question), 7) with substrate consisting only

of fines and lacking form-roughness, the road began incising and captured an increasing amount of flow, 8) incision progressed to the point where the base-elevation of the captured channel was lower than the historic channel, and 9) incision advanced headward / upstream of the diversion point.

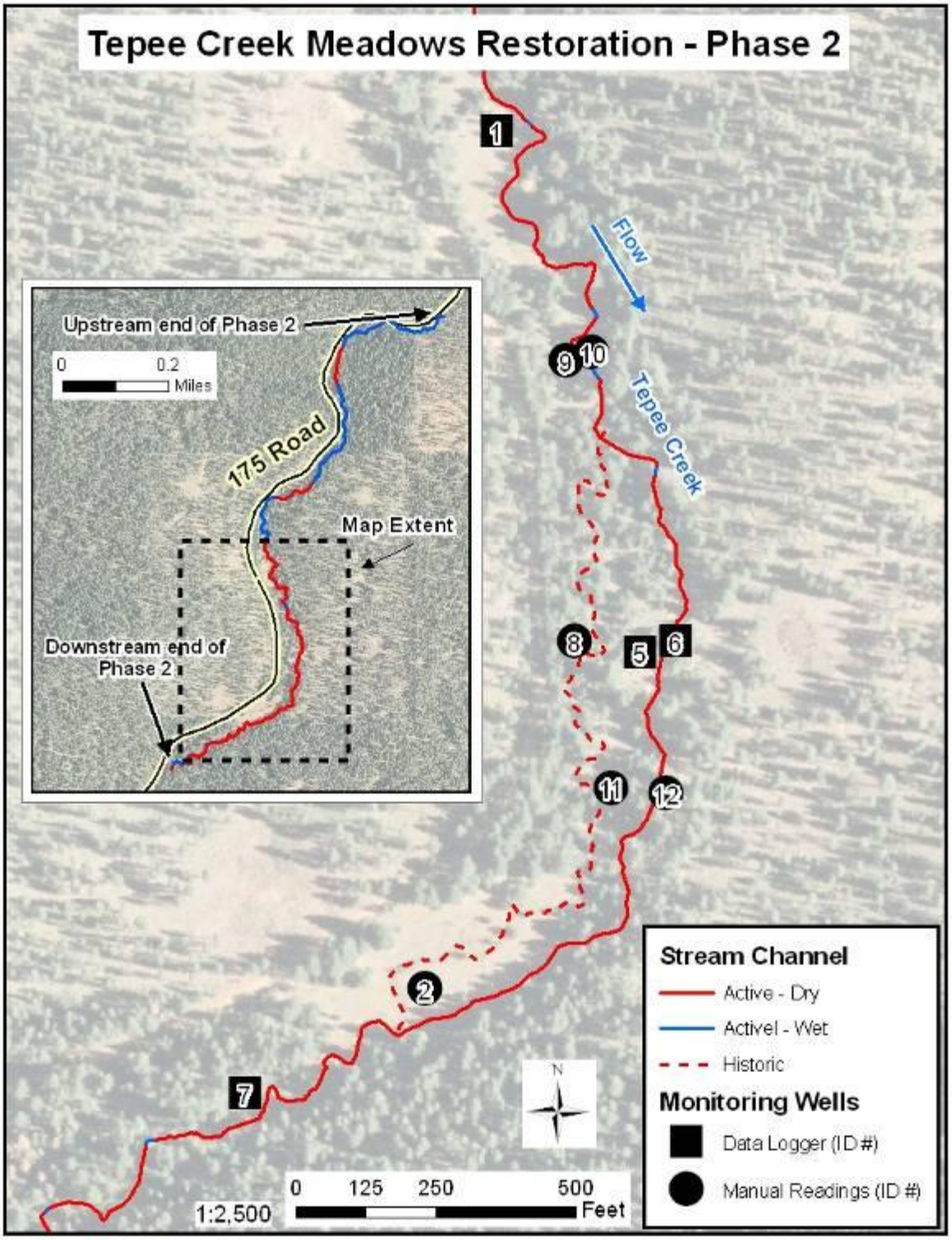


Figure 8. Distribution of monitoring wells and the portions of Tepee Creek with perennial water as observed on September 21, 2009.

Figure 9. Inlet to historic channel (left). Arrows indicate bridge deck remnants (right).

Livestock grazing (in the form of altered riparian vegetation, bank erosion, and channel incision) may have also pre-disposed the site to its response (Fig. 10 and 11). These site-based effects coupled with watershed scale management responses are the most probable causes of currently observed conditions. Hydrologic modeling (nhc 2003) indicated increased stormflow and volume in the upper White Creek and Tepee Creek watersheds due to density and drainage characteristics of forest roads.

Figure 10. The reach has been used as a livestock salting area (left). A slash pile (right) indicates local historic forest practices activity.

<u>Project Goals</u>:

1) Increase floodplain storage
2) Reduce severity of active channel hydraulic conditions during high flows
3) Enhance quantity and quality of steelhead spawning and rearing habitat
4) Potentially restore base flows to this and downstream reaches
5) Restore suitability of valley bottom for medicinal and traditional food plants

Figure 11. In-stream cattle trampling near the bottom (left) and top (right) of the reach.

Design: Conceptual design for enhancement of the Phase 2 reach is to raise the stream bed elevation and reconnect the historic channel and floodplain. This strategy provides a greater potential benefit than other alternatives (e.g. excavating new floodplain) as it maximizes potential to store water and increase hydroperiods over the valley width The primary design goal will be to configure the channel such that more frequent out-of-bank flooding will occur, which will improve conditions for fish while promoting better wetland habitats and water storage later in the year. In-channel treatment will involve importing gravel into the existing channel in combination with channel cross-sectional area adjustments and planform modifications.

Design templates will be configured such that the channel will convey the existing sediment supply, while mitigating the tendency to degrade. Planform modifications will be determined by design slope and hydraulic geometry. Hydraulic geometry, including bankfull width, will be refined by analysis of upstream analog cross-sections and slopes, regional hydraulic geometry relationships, and the creation of a hydraulic model for the project reach. A design hydrology that approximates actual and anticipates future conditions as much as possible will be selected to guide hydraulic geometry development. Once this is completed the proposed channel components will be designed to allow some threshold movement and deformation.

Methods/Elements:

- Constructed bedforms – This will be the primary treatment to raise the stream bed and involve importing gravel to construct riffles. Riffle crests will be constructed on an average reach gradient of 0.4%. Pools will be formed by default in locations where fill is not introduced. Because of the bedload-limited nature of the watershed, material will be sized to be immobile at the bankfull discharge (~$Q_{1.3}$). The size gradation will incorporate sufficient fines to control porosity keep lower discharges flowing over the riffle crests over as much of the flow-duration curve as possible without introducing so many fines as to destabilize imported material.

- Channel margins – Native bank materials are cohesive and moderately resistant to lateral erosion, particularly in the rooting zone. Large woody debris will be used on the outside of corners to encourage local scour that will help maintain pool depths and volumes, control lateral erosion, and provide primary habitat. Channel edges (banks) constructed with wood will be less expensive and more erosion resistant than if fabric were used. If cost efficiencies can be achieved elsewhere in the budget, soil protected by biodegradable erosion control fabric may

also be incorporated into the project. Use of fabric-encapsulated banks will facilitate bank deformability and result in greater habitat diversity through the reach.

- Vertical control - A roughened channel, on a steepened grade (approximately 5%) will be constructed at the downstream end of the reach to transition between restored bed elevations and the somewhat incised channel downstream. This feature will set the gradient for the upstream (constructed) reach and increase the stability of constructed riffles.

- Revegetation - Existing riparian vegetation will be salvaged where possible. Use of sod mats salvaged from the pre-project inset-floodplain of the IXL reach was very effective and dramatically reduced recovery time. Woody and herbaceous species native to the watershed will be used where salvaged materials are insufficient or inappropriate. Woody species will be propagated primarily from dormant cuttings of local origin. Seed for herbaceous revegetation will be sourced from a producer with source genetics suitable for the site.

- Floodplain roughness - Large woody debris will be strategically placed on the reactivated floodplain to prevent avulsions and flanking of constructed riffles.

<u>2009 Activity</u>: Administrative, assessment, and design project activities during the reporting period.

- *Administrative* - A grant application to fund Tepee Meadows 2 construction was submitted during the 2009 Washington State Salmon Recovery Funding Board (SRFB) grant cycle (10th round). On November 20, 2009 the SRFB awarded the funding request. The project timeline is for in-stream construction to be initiated in the late-summer/fall 2012 and completed in spring 2013.

- *Design* - Prior to the construction grant, a design-only SRFB grant was awarded in 2008. The topographic survey portion of the design process was conducted in mid-November 2009 and consisted of 5 days of field surveys. These surveys were led by a subcontractor (Interfluve, Inc.) and assisted by KWEP project staff. Data collected from these surveys will be compiled and analyzed during the winter of 2009-2010 and any supplemental survey data collection will take place in spring 2010. The end product will be a 30% design for restoration of floodplain connectivity for a 1.3 mile reach of Tepee Creek between river miles 4.5 to 5.85. The 30% design will guide a "fit in the field" implementation performed on numerous projects by KWEP staff.

- *Assessment* - intensive sampling program was initiated to document and assess pre-project baseline conditions. Elements include: groundwater, low-flow refugia mapping, habitat survey/mapping, vegetation inventory, juvenile *Onchorhynkus mykiss* (Steelhead/Rainbow trout) abundance estimation, and a food web study.

  - Groundwater: Twelve shallow (~6.5' deep) wells were installed to characterize existing groundwater conditions. They will be used for post-project effectiveness monitoring if future funding permits. Two wells are located outside of the project reach as controls (one upstream and one downstream). The remaining ten wells are dispersed strategically throughout the project reach to characterize local geohydrology (Fig. 8). Six wells (including both controls) have sensors that measure and record water level once every hour; data are downloaded several times per year using a field computer. KWEP staff take manual measurements of water level with an e-tape at the remaining six wells approximately once per month (on average). Preliminary data results from 3 wells are presented in Figure 12.

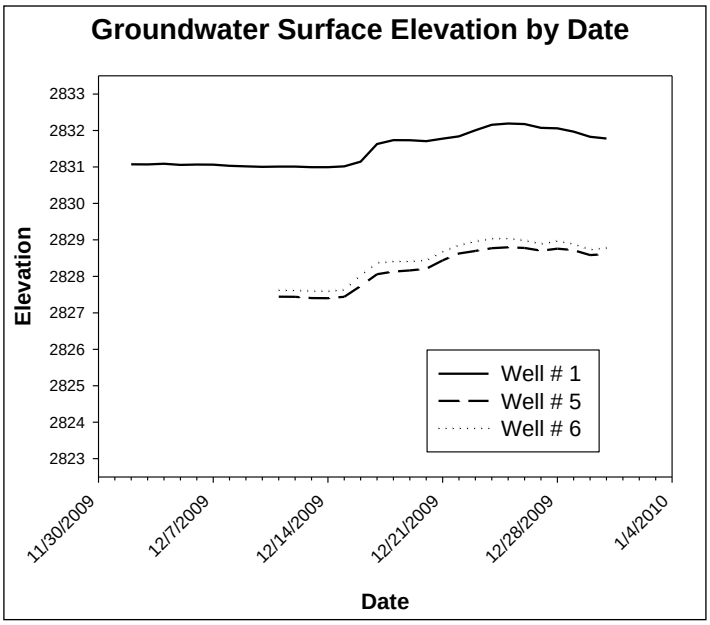


Figure 12. Groundwater surface elevations by date for wells 1, 5, and 6.

- Spatial distribution of streamflow: In September 2009, the 7851' project reach was mapped based on wetted or dry channel conditions observed using a Trimble GeoXT GPS unit and Hurricane external antennae. The timing of data collection corresponded to portion of the year when lowest streamflows typically occur. Field was quality controlled in the office to remove erroneous points due to poor GPS coverage or multipath. A polyline feature class was created in ArcGIS to document the spatial distribution of subreaches known to have gone dry. Given the timing of data collection, subreaches exhibiting flow are assumed to be indicative of perennial distribution. This survey depicting available perennial habitat at the limiting time of year will provide a baseline for post-project comparisons (Fig. 8).

- Vegetation: A baseline vegetation inventory was conducted by a subcontractor (SEE Botanical) in July. Survey design was developed jointly with the YN Wildlife Program's restoration ecologist. The survey involved sampling of 500 points located along point intercept transects. At each point, the sampling crew identified and recorded the plant species and canopy cover, and ground cover. Additionally, the same attributes were inventoried in radial clusters centered on each groundwater well (24 points per well).

- Stream habitat survey: In partnership with Klickitat Monitoring and Evaluation Project (M&E) staff, approximately 8500' of Tepee and White Creeks were surveyed using a modified version of Timber Fish and Wildlife (TFW) Monitoring Program method. The TFW protocol was modified to provide for a more rapid baseline monitoring sampling method. Parameters sampled include: classification of stream channel into pool, riffle, or glide (habitat unit), wetted channel width, bankfull channel width, habitat unit area, residual pool depth, location of LWD, LWD piece length and diameter, extent of bedrock intrusion into active channel, area and distribution of suitable spawning gravel. These measurements provide a baseline assessment of pre-project condition, specifically the location of residual pools and LWD.

- Fish abundance: In partnership with M&E staff, juvenile *O. mykiss* (Steelhead/Rainbow trout) abundance was estimated using a single-pass electroshocking technique. During this sampling

period, one pass was made through each of the four Tepee Creek treatment reaches. All juvenile steelhead and rainbow trout that were greater than or equal to 60 mm in length were tagged with a Passive Integrated Transmitter (PIT) tag. Length and weight measurements were also taken. A fixed PIT tagged detection station was installed by the M&E project at the mouth of White Creek. Subsequent survival and migration timing analysis can be performed on those fish tagged within the project reach.

- Food web: In partnership with M&E staff, a study was initiated in 2009 to examine if and how restoration project actions affect physical habitat as well as biological response by the invertebrate community and fish population (steelhead / rainbow trout). The study examines aquatic and terrestrially derived invertebrate prey sources and resident rainbow trout and juvenile steelhead diet and biometrics. Aside from project effectiveness, this comprehensive study explores a significant gap of current scientific understanding (Miller, et al. 2009). Specific objectives of the study will include the following:

  - Quantify riparian habitat conditions in treatment and control sub reach sample sections.
  - Compare invertebrate biomass and composition from benthic, drift, and allochthonous sources among treatment and control sub reach sample sections.
  - Compare fish diet (biomass and composition) among treatment and control sub reach sample sections.
  - Evaluate seasonal variation in prey availability and diet of juvenile steelhead trout in sub reach sample sections.

  Sampling occurred in four treatment sites in Tepee Creek and four control sites in White Creek:

  - 24 riparian habitat surveys were conducted, 12 on Tepee Creek (treatment) and 12 on White Creek (control).
  - 72 pan traps, 6 Surber, 8 Drift samples were collected. The samples were collected between October 6-21, 2009.
  - Stomach samples were collected from 48 resident rainbow trout and juvenile steelhead from October 12-14, 2009.
  - Identification of the invertebrates collected during the fall 2009 sampling period was completed in winter 2010.

Klickitat River Delta Pilot Assessment

Background: YKFP fisheries biologists have expressed concern about adult fish passage at the mouth of the Klickitat River. KWEP staff initiated sampling water surface data to provide data for evaluation of depth-frequency. Data will document inundation frequency of landforms in the vicinity of the delta and be used to evaluate potential factors limiting salmonid production. The initial phase of the project consists of: 1) collection of water level data at four locations in the vicinity of the delta fan and 2) compilation of historic information. Data are anticipated for use in subsequent assessments such as evaluation of water temperature, growth of aquatic vegetation, juvenile and/or adult fish passage, and/or predation. Funding for the pilot assessment is being cost-shared by a grant received from Columbia River Intertribal Fish Commission (CRITFC).

2009 Activity: Over the course of two days (8/24-8/25/2009), four sensors were installed around the delta to collect water depth and temperature data (Fig. 13). An anemometer was also installed at one

location to assess wind influence on the other parameters being sampled. The sensor network was designed to facilitate the transfer of data via radio frequency from three of the sensors to one central hub. The fourth sensor is built into the central hub, which receives and then transmits all of the data collected via a cell phone modem. From this ftp site KWEP staff has been monitoring collected data remotely to check for discrepancies/errors that may dictate site visits for troubleshooting purposes. Currently each sensor is on its own (relative) vertical datum. All gages will be surveyed to a common vertical datum in the future.

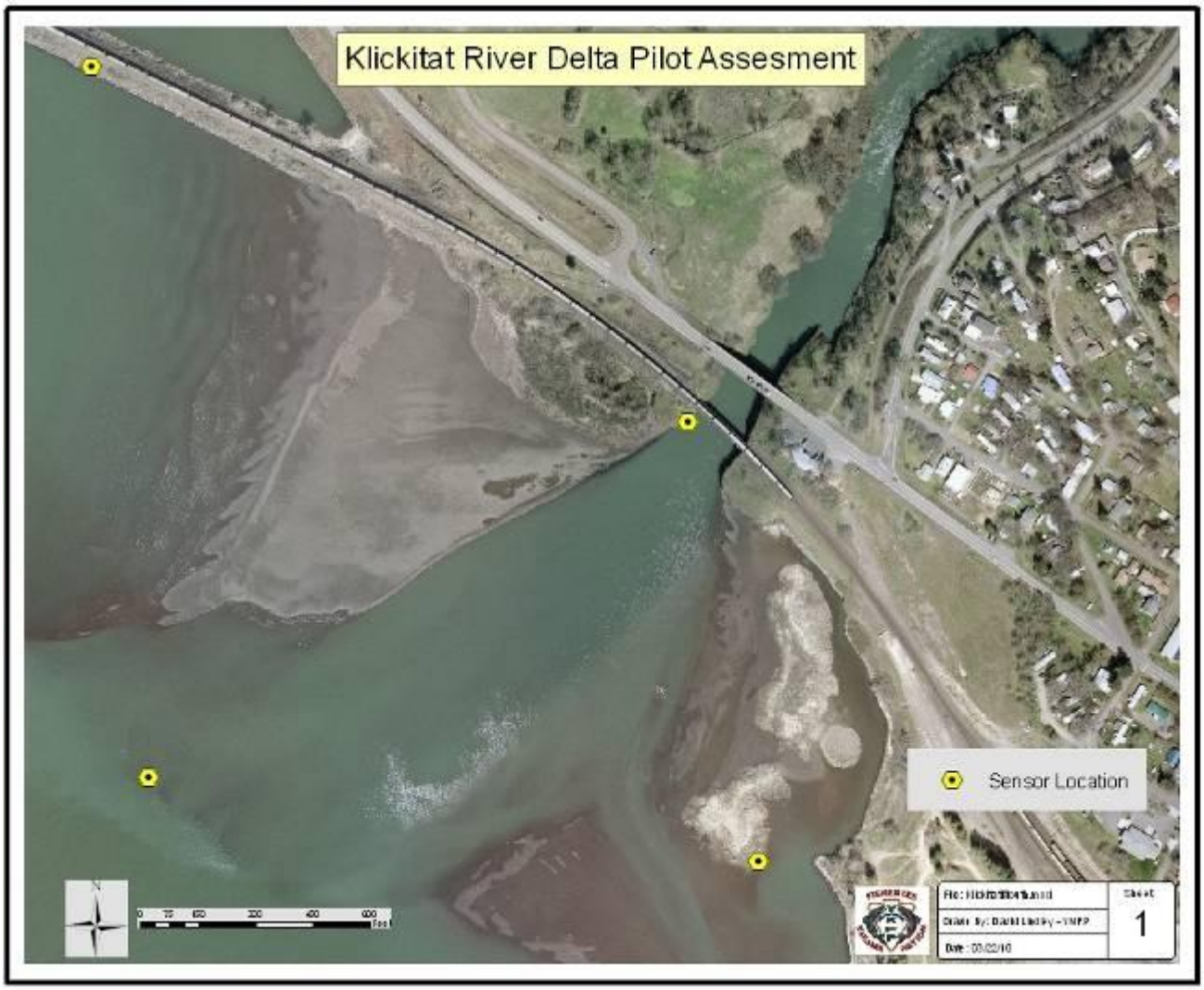


Figure 13. Sampling locations for the Klickitat River delta.

LiDAR Data Acquisition – Klickitat River Mile 0.0 – 42.0

In April 2009, the KWEP commissioned a flight to collect high resolution LiDAR and true-color orthophotography for the lower 42 miles of the Klickitat River and its valley bottom (Fig 14). The flight swath averaged approximately 2100 wide from the mouth to the salmon hatchery. Bare-earth topography (in DEM format), breaklines (in polyline format), and a summary report (Watershed Sciences 2009) were generated as deliverables and are on-file at the Klickitat Field Office of the Yakama Nation Fisheries Program. Draft data was delivered to KWEP staff in mid-May 2009. Three-

dimensional breaklines of streambanks, levees, and road embankments were refined through an iterative process between KWEP staff and the subcontractor (Watershed Sciences). Data have assisted planning and provide baseline monitoring data for the Klickitat Floodplain Conservation and Restoration Project (Haul Road) project as well as conduct reach-based geomorphic assessment.

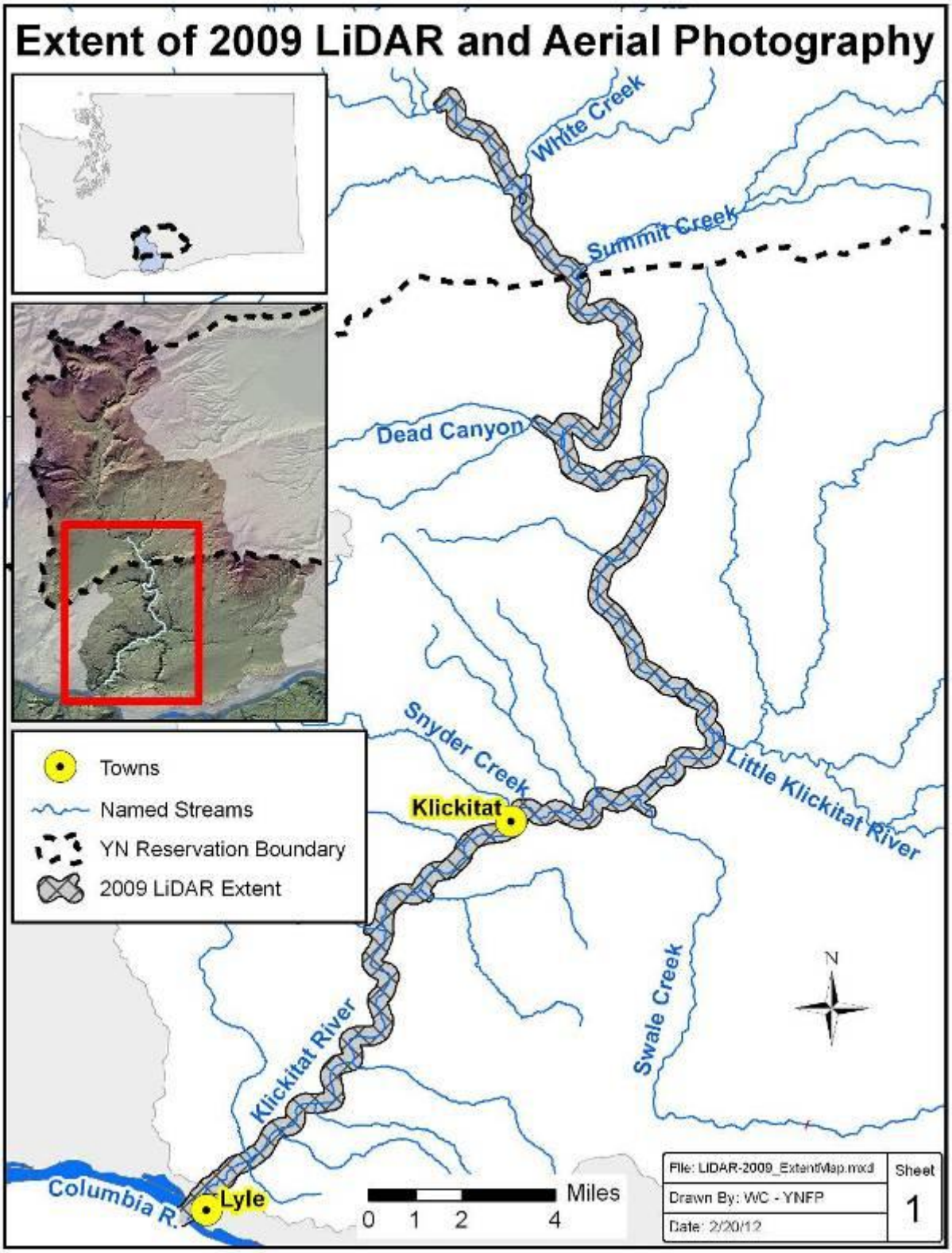
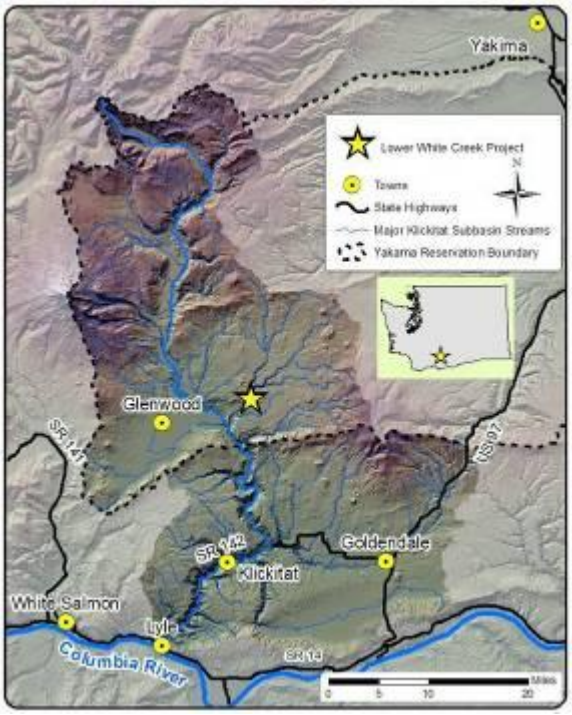


Figure 14. Spatial **e**xtent of 2009 LiDAR and high-resolution aerial photography.

Lower White Creek Large Woody Debris Project

Introduction: The White Creek watershed as a whole is likely the most important spawning and rearing tributary watershed within the Klickitat subbasin. In recent years (2002-2008), the White Creek watershed on average accounts for 26% (0-52%) of the observed steelhead spawning in the entire Klickitat subbasin.

Site and Watershed Description: The White Creek watershed is 138 square miles in area. Elevations range from 1140 to 5100 ft.; most of the watershed lies between 2500 and 3300 ft. in elevation. Average annual precipitation is between 20 and 29 inches, with roughly half falling as snow. Current stream habitat conditions in Tepee Creek and White Creek reflect past riparian timber harvest and road construction throughout the watershed; instream LWD levels are low in some reaches and base flows are very low to non-existent in many reaches. Changes in channel morphology are related to livestock grazing, road interactions, and in some locations, historic removal of LWD. The watershed lies within the Yakama Reservation Closed Area where commercial timber harvest has occurred since the 1950's. Current and future land uses include timber harvest and livestock grazing. The Yakama Nation/Bureau of Indian Affairs Forest Management Plan (2005) limits timber harvest somewhat in streamside areas.



Currently, most of the incised reaches in the White Creek watershed (upstream of the project reach) dry up from July through October. Anecdotal accounts from the 1960s suggest that at least some of these reaches were historically perennial. Many of the same reaches showing signs of bed armoring are also characterized by a simplified morphology with low pool frequencies, rectangular, canal-like cross sections, and an absence of large woody debris (LWD). Impacts from grazing (in the form of altered riparian vegetation, bank erosion, and channel incision) are also evident in several meadow reaches within the watershed. Anecdotal evidence, along with watershed size, elevation, and precipitation, suggest that more reaches had perennial flow historically.

The project reach encompasses the upper 3 miles of the perennial portion of lower White Creek. Dewatering of upstream reaches makes this are particularly important for juvenile rearing. However, poor habitat conditions limit capacity in this area.

One critical factor associated with the project is access difficulty. There is road access at RM 3.2 and 9.6. In between these access points, White Creek flows through a fairly rugged canyon bordered by steep slopes with walls as much as 700' high.

Fisheries Significance: During winter and spring, adult mid-Columbia River steelhead are regularly observed throughout the project reach. Juvenile *O. mykiss* are observed in the area year-round. Juvenile and adult steelhead and resident rainbow trout will be the primary beneficiaries of this project, as it will improve spawning and rearing habitat. There are no artificial or natural barriers to steelhead

downstream of the project reach, though shallow water depth has been observed to limit adult passage during drought years (e.g. WY 2005).

Problem: Much of the White Creek mainstem has a very simplified, plane-bed channel form and physical habitat conditions are correspondingly poor as evidenced by low pool and LWD frequency as well as low pool quality.

A 6.4 mile long reach (RM 9.6 to RM 3.2) that includes the project reach was assessed for summer refugia habitat in early September 2004 (Conley 2005). This reach was selected because it has clearly experienced simplification and it straddles the transitional zone of perennial water presence. Fish stranding in the summer is common upstream of the Brush Creek confluence (RM 5.0). Given the coarse nature of valley bottom sediments throughout the reach (i.e. low potential for long-term floodplain storage) and generally close proximity of bedrock, it seems most likely that baseflow hydrology is currently governed by groundwater inputs from aquifers affiliated with the Columbia River basalts that underlie the watershed. In the assessed reach pools only account for 14% (by length) of the channel. Pool quality is poor to marginal with residual depths averaging 1.7' (n = 55) and 67% of pools having less than the average depth. Bed armoring is particularly evident through the project reach where bed materials typically consist of an imbricated lag of cobbles and boulders. Active channel LWD frequency is also poor and averages 6.3 large logs (>50 cm diameter) and jams (cumulative) per mile.

The condition of the project reach is a function of both local and watershed-scale factors including:

- *Historic riparian harvest* - The presence of riparian stumps and yarding corridors throughout the reach suggest historic riparian clearcutting as a probable cause of low cover and in-channel LWD frequency (Conley 2005).
- *Increased peak flows associated with forest road drainage and density* - Increased peak flows associated with road development in the headwaters have likely had negative consequences on stream channel morphology and habitat. Hydrologic modeling (HEC-HMS) of upstream subwatersheds suggests road density has increased peak flows for a 2.5-year recurrence storm from 5.5 to 31.8% and 0.6 to 16.0% for a 100-year recurrence storm (nhc 2003). . The proposed project area is located roughly 10 miles downstream of the modeled subwatersheds, and the intermediate topography is of considerably lower relief than the modeled subwatersheds, thus, peaks would be expected to be attenuated somewhat before reaching the project reach. Treatments to reduce water and sediment delivery from the forest road network to streams in the White Creek headwaters were implemented on the top ten road segment priority groups in 2005.
- *Incision of upstream reaches* - Site indicators and aerial photo interpretation suggest that many upstream reaches have become incised. Hydraulic modeling has indicated some reaches currently contain a 10-year recurrence flood within banks. (Interfluve 2004). This loss of floodplain connectivity prevents energy dissipation and conveys more water to downstream reaches. Restoration of floodplain connectivity and habitat improvement within incised reaches is ongoing.
- *Historic debris torrent(s)* - Scour marks on trees and deposits in the upper mile of the reach suggest one or more debris torrents have occurred (Conley 2005). Torrents may have been associated with one or more historic road crossing failures as evidenced by chunks of concrete within the channel 3/4 mile downstream of the current 207 Road crossing. The 207 Road crossing appears to have been relocated (downstream) from its former alignment and is a well-sized bridge. Future failure risk of 207 crossing is considered very low.

Project Goal: The overall project goal is to improve habitat conditions by increasing LWD frequency and pool quality along 3 miles of White Creek. Treatments will specifically target juvenile rearing conditions, though increased sediment sorting is anticipated as a by-product which should improve spawning conditions as well. LWD treatments will increase active channel roughness and should increase overbank flow frequency.

2009 activity: Project planning and development involved selection and location of LWD harvest units, permitting, treatment site identification and sketches, and baseline stream habitat inventory were conducted during the reporting period.

- *LWD Harvest planning* - Due to the remoteness of the project sites and limited access points to the canyon portion of White Creek it was determined that using a helicopter for the placement of LWD would be the best approach. Given the need for rootwads to be connected to the bole, ground-based harvesting techniques are necessary. This limits harvest operations to lesser slopes. In order to facilitate helicopter placement, trees to be staged within close proximity (approx. 1000') to installation sites. To minimize cost, handling needs to be minimized. Hence harvest units need to within skidding distance of staging areas.

  Based upon review of aerial photos and topography, several suitable stands in vicinity of the eastern canyon rim appeared to be suitable given their location and apparent size distribution of trees. Ground verification was conducted by staff to evaluate road access and qualitatively assess stand conditions. This was followed by a simple timber survey of the most promising stand in T7N R 14E S30. This basic survey sampled 145 trees (Ponderosa Pine and Douglas Fir) for diameter at breast height and total tree height. The intent of this survey was to document whether the stand contained a suitable amount of trees that met diameter and height parameters needed for LWD treatment. Additional field visits were conducted throughout the summer of 2009 to inventory road accessibility, locate additional suitable stands, and locate potential landing areas for the stockpiling of LWD. In addition to these field surveys, maps of potential harvest areas were created to aide in both internal planning (YN) and environmental compliance documentation (Fig. 15).

- *Permitting* - Due to the two distinct components of the project, treatment and harvest areas, additional environmental compliance documentation was required by Bonneville Power Administration (BPA.) The harvest areas are located within the boundaries of previous timber sales administered by the Bureau of Indian Affairs (BIA). The relevant Environmental Assessment (EA) and Finding of NO Significant Impact (FONSI) documents were acquired from BIA personnel and provided to BPA staff for review. Upon review of all the environmental compliance documentation (Tribal Historic Preservation Office (THPO) concurrence letter, Endangered Species Act (ESA)/National Environmental Policy Act (NEPA) documents, and EA/FONSI from past timber sale) BPA staff granted environmental clearance for the project.

- *Site identification and sketches* -In addition to harvest area planning, 8 proposed treatment sites were assessed for the volume of LWD needed. Detailed sketches outlining the location of individual LWD pieces to be placed were completed for each.

- *Baseline inventory* - Habitat surveying and mapping was conducted on approximately 5 miles of White and Brush Creeks. The protocol for these habitat surveys was a modified version of Timber Fish and Wildlife (TFW) Monitoring Program method, designed jointly by the Northwest Indian Fisheries Commission and Washington State Department of Natural Resources. The TFW protocol

was modified to provide for a more rapid baseline monitoring sampling method. Parameters sampled include: classification of stream channel into pool, riffle, or glide (habitat unit), wetted channel width, bankfull channel width, habitat unit area, residual pool depth, location of LWD, LWD piece length and diameter, extent of bedrock intrusion into active channel, area and distribution of suitable spawning gravel. These measurements provide a baseline assessment of pre-project condition, specifically the location of residual pools and LWD.

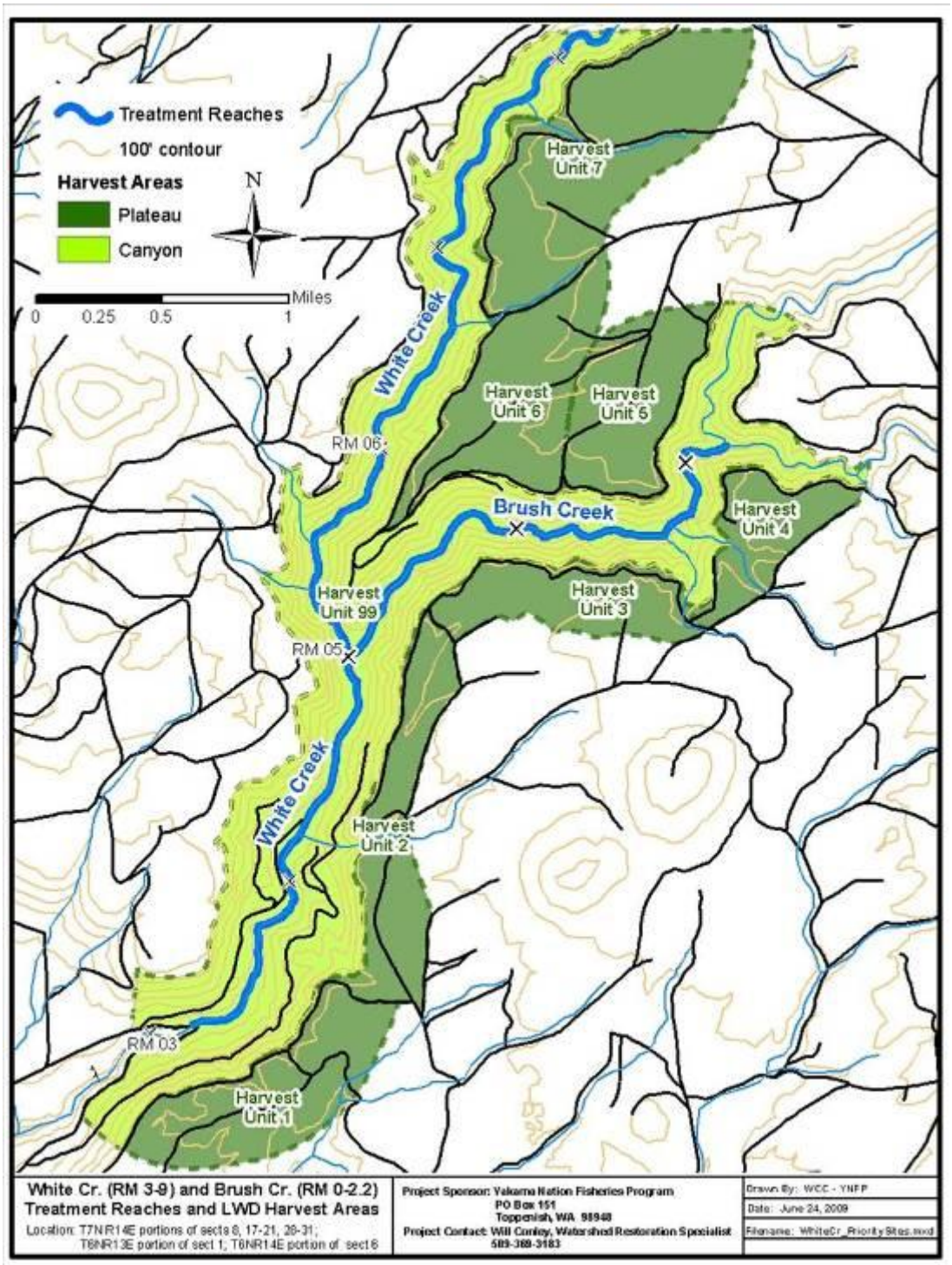
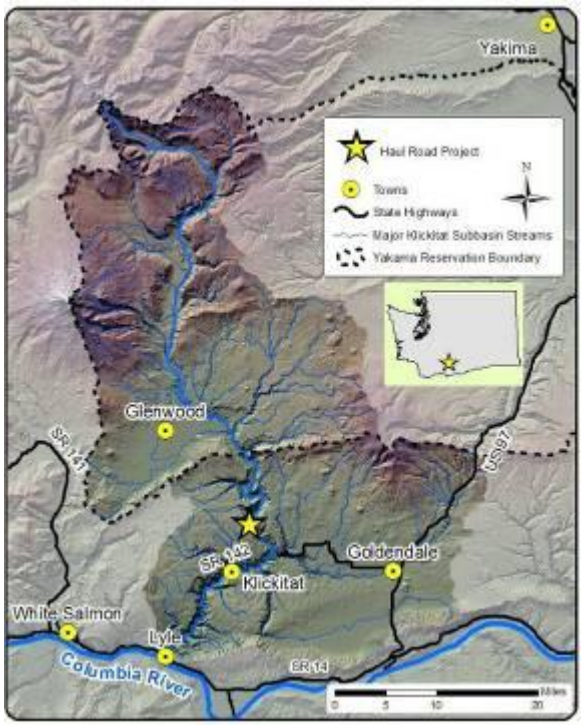


Figure 15. Proposed harvest areas and their proximity to treatment reaches.

Klickitat River (RM 18 to 32) Floodplain Conservation and Restoration (Haul Road) Project



Background: The project addresses limiting features (channel confinement) identified for the Klickitat River between river miles 18.3 and 32.2 by the Klickitat Subbasin Plan and Klickitat Lead Entity Salmon Recovery Strategy. This portion of the river has the greatest habitat complexity of any reach in the lower Klickitat River and provides critical spawning, migration and rearing habitat for winter and summer steelhead (ESA-"Threatened"), Chinook salmon (spring and fall runs), and coho salmon. This reach provides a high proportion of the basinwide spawning habitat for all three species, accounting for on average 18% (7-34%), 31% (10-58%), and 38% (5-37%) of the annually observed basinwide spawning for steelhead, fall Chinook, and coho, respectively (2002-2008). Riparian and floodplain conditions have been degraded by a combination of channel encroachment and floodplain isolation by road fill as well as 1996 flood deposits. The absence of other floodplain development coupled with somewhat less-confined valley conditions affords this reach greater resiliency than downstream reaches. The project is occurring in two stages: acquisition (Phase 1 funding) and restoration (all subsequent phases of funding). Columbia Land Trust (CLT) is the lead for acquisition and also sponsors the SRFB grant for the initial phase of restoration. KWEP is the technical lead for design and construction oversight of restoration actions as well as assisting planning activities.

Project Goal: The overall project goals are to prevent habitat fragmentation and restore floodplain connectivity and geomorphic processes to the valley bottom. CLT completed acquisition of the road and 480 acres of private riparian and upland in holdings within the Klickitat Wildlife Management Area in 2007 (Conley 2008). Phase 1 was completed in 2009 with removal of an old railroad embankment in Dead Canyon (tributary at upstream end of project reach). The Phase 2 grant addresses limiting features for a portion of this reach by restoring floodplain connectivity and pulling back and re-vegetating fill materials in other portions to enhance riparian vegetation. Phase 2 will enhance and restore riparian and floodplain habitat by modifying 2.1 miles (cumulative) of road to reduce channel confinement and restore floodplain access along 0.94 miles of the road. Roughly 7.5 acres of riparian and floodplain habitat will also be revegetated.

2009 activity: Project planning and development, permitting, and initial restoration treatments were conducted during the reporting period.

- *Planning* - KWEP and CLT staff conducted several field visits to refine treatments and geographic scope of Phase 2, as well as generate a timeline for implementation. KWEP staff determined stationing for road segments delineated during assessment (Conley and Lindley 2012) and marked on the road surface. Concurrently, the GIS database culvert layer was updated, improving the precision of location data and pipe type.

- *Permitting* – Design and permitting for removal of the abandoned railroad embankment across Dead Canyon Creek was conducted. Additionally, a public outreach meeting was held in the town of Klickitat on September 2, 2009. The meeting was facilitated by CLT staff. Thirteen local residents attended the meeting and were presented with the history of the Haul Road acquisition, funding sources, an outline of project goals, potential restoration treatments, prioritization of road segments, timeline, and expected outcomes. The floor was then opened for attendees to ask questions and make comments.

- *Restoration* – An abandoned cross-valley railroad embankment and trestle were removed from Dead Canyon Creek. The alignment was constructed in the 1930s when the original corridor was established as a railroad line to carry logs to the mill in Klickitat. When trucking superseded railroads in the 1950s or 1960s, the embankment was realigned to cross Dead Canyon closer to its confluence with the Klickitat River and the portion of the railroad embankment that crossed Dead Canyon was abandoned.

  The pre-project condition involved a cross-valley fill (570 lineal feet) and 30' wide trestle with a mid-span abutment. The lower reaches of Dead Canyon Creek (including the project site) are seasonal and general exhibit substantial braiding in coarse sediments. However, the railroad crossing created a pinch-point that concentrated flow and generated local scour that created an uncharacteristic pool for the reach (Fig. 16). The pool was an attractive nuisance for downstream migrants (*O. mykiss*), some of which would delay their transit, get trapped as flows receded, and eventually perish in the pool. In addition to being a contributor to fish mortality, the embankment was eroding (Fig. 16) and some parties had concern about water quality.

Figure 16. Tail-out of scour pool created by trestle (left) and embankment erosion (right).

Treatment occurred during the summer of 2009 and involved removal of trestle, abutments, and cross-valley embankment (Fig. 17). Embankment materials were graded into the adjacent borrow ditches with the surplus end-hauled and graded into cut-slopes along the valley wall. The channel was graded to better match the stream profile (Fig. 18) and eliminate false-attraction of the pool. Additionally, 2800 lineal feet of embankment along the south margin of Dead Canyon was re-sloped and rehabilitated back to where it meets the modern Haul Road alignment. CLT staff provided lead on planning, permitting, and funding administration while KWEP staff provided design and field construction oversight. Construction funding was provided by a Washington Salmon Recovery Funding Board grant.

Figure 17. Upstream view of railroad crossing before (left) and after (right) treatment.

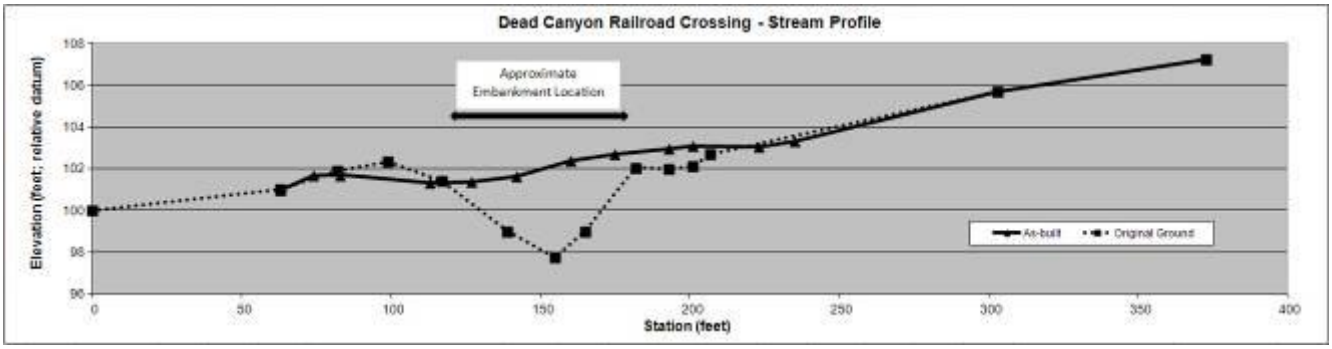
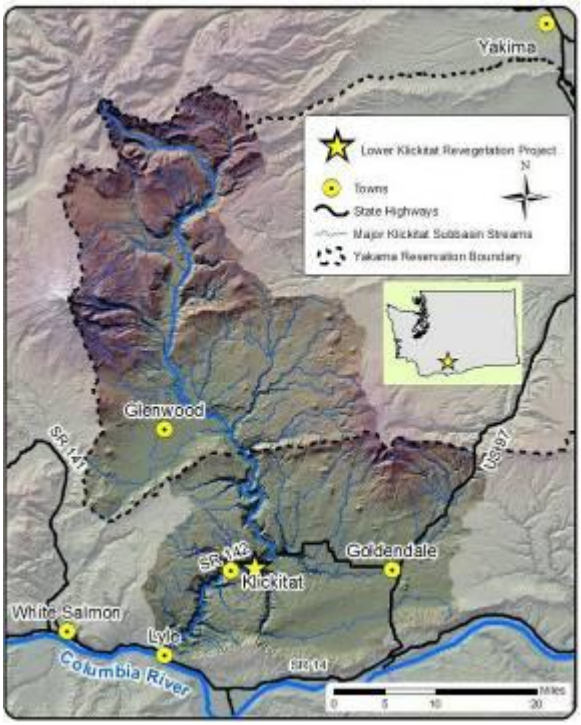


Figure 18. Profile of Dead Canyon Creek through railroad crossing before and after treatment.

ACTIVITIES INVOLVING PAST PROJECTS

Lower Klickitat River Riparian Re-vegetation Post-project Monitoring

Background: This project addresses limiting habitat features (poor riparian and floodplain vegetation) identified for this reach, a top geographic priority, as defined by the Subbasin Plan and Klickitat Lead Entity Salmon Recovery Strategy. This reach is a migration and rearing corridor for nearly 100% of migratory fish in the Klickitat watershed and has accounted, on average, for 10% of observed basinwide steelhead spawning. The project area occurs within a reach identified by the Klickitat Technical Advisory Group (KTAG) as fourth out of 21 priority areas within the Klickitat Lead Entity's scope. Riparian conditions in this reach are generally poor due to a combination of 1996 flood deposits and channel encroachment by highway and railroad fill. Many of the flood deposits are well above the 2-year flood surface and at a comparable elevation to surfaces that are well-vegetated and are generally stable. Vegetation has been very slow in colonizing these coarse, well-drained substrates. Similar deposits from flooding in 1974 along Swale Creek (a Klickitat River tributary) are still bare. A SRFB grant sponsored by the Mid-Columbia Regional Fisheries Enhancement Group (MCRFEG) funded the implementation of this project. KWEP provided design, construction oversight, and monitoring support for the project. KWEP and MCRFEG collaborated to revegetate 4 Lower Klickitat River sites with over 5,000 plantings in 2006 and 2008 (Conley and Lindley 2012).



Site and Watershed Description: The Klickitat River drains 1350 square-miles of south central Washington State. The landscape consists primarily of volcanic plateaus dissected by incised canyons carved by streams and rivers. The Klickitat River arises at about 5000 feet elevation in the vicinity of the Goat Rocks and flows just over 95 miles to enter the Columbia River at river-mile 180 near Lyle, Washington.

Channel complexity and riparian habitat in the lower 20 miles of the Klickitat River (inclusive of the project area) is generally lower quality than upstream reaches. Fill materials from railroad and highway embankments encroach on the active channel for at least (cumulatively) 9.8 miles of bank. This artificial confinement compounds the effects of increasing natural confinement as the river approaches Lyle Falls. Floodplain access is restricted by road and railroad embankments as well as localized levies. Some channel incision appears to have occurred but is currently unconfirmed by quantitative data. LWD is much less abundant than in upstream reaches, likely as a consequence of channelization, historic clearing, and reduced recruitment potential (Conley 2005). The most obvious effect of the embankments is their limitation on riparian cover and LWD recruitment.

Problem: The general problem is poor riparian and floodplain conditions within the project area. Encroachment by road fills and residual flood deposits have reduced riparian cover and LWD recruitment potential.

The 1996 flood event left extensive gravel and cobble deposits in many places along the lower 37 miles of river. The surfaces of many of these deposits are well above the 2-year inundation surface and vegetation has been very slow in re-colonizing these coarse, well-drained substrates. Successful plant establishment and growth has generally only occurred below the 2-year flood elevation where the perennial water table is more easily accessed. Similar deposits from flooding in 1974 along Swale Creek (a Klickitat River tributary) are still un-colonized suggesting that natural re-colonization could be a long time coming.

Project Goal: The goal of this project is to increase native riparian and floodplain vegetation, woody debris recruitment, and potential for trapping fine sediment between river miles 2.6 and 18.3 of the Klickitat River. The first round of planting was completed in 2006 on five sites totaling approximately 6.6 acres. Plantings consisted of willow, cottonwood, and dogwood livestakes.

2009 Activity: Following planting in 2008, YN and MCFEG staff randomly selected and uniquely marked 741 of the plantings at 4 sites to monitor survival and growth (Conley and Lindley 2012). KWEP staff performed the year-1 monitoring in May of 2009 and was able to relocate 707 plants uniquely marked plants. Originally, a GPS point was collected for each plant with a Trimble GeoXT and external hurricane antenna. Each plant was also originally marked with an aluminum tag inscribed with a unique ID number.

Depth was defined as the vertical distance from the bottom of the installed cutting or rootmass to the ground surface. The target depth for willows and cottonwoods was 3', but this was frequently not met due to the rock content of the substrate. Thus, plants were originally installed across a range of depths, but have been organized into bins of 1' depth increments for presentation purposes (Table 1). Species such as ponderosa pine and Oregon white oak are intolerant of burial of their root-crown and were planted at- or slightly below grade. Pines were grown in 0.8 cu-ft containers that were 14" deep and filled with planting media to within 1" of the container rim. Thus, upon planting, the deepest roots of the pines were 13-14" below ground surface. Oaks were grown in containers that were about 6" tall and filled within 1" of the rim. Roots of oaks would have been approximately 5-7" below grade upon installation.

Eight species were planted in 2008 (Tables 1 and 2), of which three involved both livestakes (a.k.a. dormant hardwood cuttings) and containerized stock. Caliper size on all livestakes was between ¼" and 3/4". There were three pruning treatments applied to the cottonwoods and three willow species: cut below ground surface (cut-), cut 4 bud scales above ground (cut+), and uncut (uncut). It was hypothesized that cutting hardwood stems below ground surface might aid survival in such highly exposed sites as ours as the method of planting (hydraulic stinger) leaves a conical depression. This effectively means that more stem is exposed to produce vegetative shoots that could desiccate livestakes in particular and reduce establishment.

Table 1. Plant survival (%) by depth class and pruning treatments for four non-crown sensitive species (sample size).

Species / Material Type (wetland indicator status)	Wetland Indicator Status	All Individuals (N = 631) (Independent of Depth)				Planted Depth Class (N = 545)							
						<3 ft				≥ 3 ft			
		Cut-	Cut+	Uncut	Overall	Cut-	Cut+	Uncut	Overall	Cut-	Cut+	Uncut	Overall
Coyote Willow *Salix exigua*	OBL												
Livestake		54.9 (51)	52.1 (48)	49.0 (51)	52.0 (150)	45.5 (22)	27.8 (18)	28.6 (21)	34.4 (61)	64.3 (28)	69.0 (29)	70.4 (27)	67.9 (84)
Containerized		47.1 (17)	60.0 (20)	78.9 (19)	62.5 (56)	55.6 (9)	60.0 (15)	66.7 (12)	61.1 (36)	66.7 (3)	50.0 (2)	100 (5)	80.0 (10)
Geyer's Willow *Salix geyeriana*	FAC W+												
Containerized		70.6 (17)	66.7 (18)	61.5 (13)	66.7 (48)	50.0 (2)	50.0 (4)	50.0 (4)	50.0 (10)	0.0 (3)	100 (3)	75.0 (4)	60.0 (10)
Black Cottonwood *Populus trichocarpa*	FAC												
Livestake		53.1 (32)	53.6 (28)	41.9 (31)	49.5 (91)	47.1 (17)	45.5 (11)	38.9 (18)	43.5 (46)	61.5 (13)	58.8 (17)	50.0 (12)	57.1 (42)
Containerized		33.3 (21)	55.6 (18)	76.5 (17)	53.6 (56)	9.1 (11)	54.5 (11)	55.6 (9)	38.7 (31)	75.0 (8)	80.0 (5)	100 (4)	82.4 (17)
Scouler's Willow *Salix scouleriana*	FAC												
Livestake		75.0 (52)	76.6 (47)	81.0 (42)	77.3 (141)	65.2 (23)	66.7 (21)	63.2 (19)	65.1 (63)	81.0 (26)	87.0 (23)	95.2 (21)	87.1 (70)
Containerized		67.6 (34)	76.7 (30)	80.0 (25)	74.2 (89)	62.5 (8)	76.9 (13)	72.7 (11)	71.9 (32)	65.0 (17)	80.0 (10)	100 (6)	75.8 (33)

Table 2. Survival for four plant species which lacked depth class as a variable.

Species	Planted Depth Not Specified			Species	Planted Depth Not Specified		
	Cut-	Cut+	Uncut		Cut-	Cut+	Uncut
Ponderosa Pine *Pinus ponderosa*				**Red-Osier Dogwood** *Cornus sericea*			
Containerized	-	-	97.3% (37)	Livestake	-	-	50.0% (2)
Red Alder *Alnus rubra*				**Oregon White Oak** *Quercus garryana*			
Containerized	-	57.1% (14)	46.2% (13)	Containerized	-	-	70.0% (10)

Overall plant survival averaged 64% through the first year. This was considered very good given the exposure of the sites to wind, flooding, and solar radiation combined with coarse, well-drained substrates that had largely precluded colonization by woody plants in the 12 years since the 1996 floods. The 97.3% survival exhibited by ponderosa pine (Table 2) was highest rate for all species and is consistent with a census of planted pines in March 2009 that relocated 762 of 858 ponderosa pines planted at sites 17.24, 22.06, and 22.68 and found 96.7% survival.

Independent of depth, containerized stock had better survival than livestakes for coyote willow. Overall, livestakes for the species toward the more hydric end of the continuum (coyote willow, Geyer's willow, and black cottonwood) also tended to survive better proportional with the amount of pruning. Conversely, survival of individuals of containerized origin for the same three species was inversely proportional to the amount of pruning received. Survival of Scouler's willow (the most drought tolerant of the riparian hardwood species planted) was basically the same between material types, both of which tended to survive better with no or less pruning.

Independent of pruning treatments, survival averaged 21% greater for all species and material types planted deeper than 3'. All types exhibited a ≥10% increase in survival with greater depth with the exception of containerized Scouler's willow (+3.9%). Containerized cottonwood (+43.7%) and coyote willow livestakes (+33.5%) had the most dramatic overall survival increases with depth.

For the site conditions and species in this study, it appeared to be important to install plant materials at least 3' below ground. However, professional judgment should be exercised when extrapolating or applying these results to other watersheds and depth thresholds can be expected to vary both regionally and locally. Regional differences are will relate to major changes in geology and climate. Local influences on subsurface hydraulic conditions will always require the greatest consideration, particularly with regard to: subsurface hydraulic control, seasonality and duration of alluvial aquifer stage, water-holding capacity of the substrate, and floodplain cross-sectional relief.

Additionally, desiccation will not always be the limiting condition on plant establishment as it was on these sites. For example, where plant establishment is limited by scour, high inundation frequency and/or duration, and/or sediment deposition the concept of a threshold depth for survival may be completely irrelevant.

Within depth classes, pruning treatment relationships generally mirrored overall relationships with less or no pruning being favorable to survival of individuals of containerized origin. Pruning of containerized cottonwoods appeared to greatly diminish survival. Scouler's livestakes planted less than 3' deep showed little response to pruning treatments, though individuals greater than 3' deep

showed increasing survival inverse to the amount of pruning. Cottonwood livestake survival increased with greater pruning in both depth classes.

The most interesting relationship appears to be a depth-dependent reversal in the response of coyote willow livestakes to pruning. Coyote willow livestakes planted <3' deep exhibited a jump in survival when pruned below mean ground level. Conversely, those planted ≥3' deep showed improved survival inverse to the amount of pruning. Coyote willow is the most hydric of the species planted and it appears that reducing the potential for initial vegetative production becomes important with installations at depths expected to have more marginal subsurface hydrology (i.e. greater depth to the water table).

Swale Creek River Mile 2 Enhancement Monitoring

In August and September 2008, KWEP partnered with MCFEG to construct 5 LWD jams and create adjacent pools along 600' of Swale Creek to reintroduce hydraulic and habitat complexity (Conley and Lindley 2012). Valley-bottom railroad construction (1902) and 90 years of subsequent operation simplified channel conditions resulting in:

- pool frequency of 7 pools per mile (4.2% of the habitat by channel length).
- an armored bed and has a simple, plane-bed morphology
- dis-climax conditions for riparian vegetation

The project occurred in the vicinity of river-mile 2.0 and involved:

- excavation of 5 pools
- construction of 5 LWD jams to promote pool persistence and enhance primary habitat for salmonids

All constructed elements performed well in the first year. No loss or shifting of log components of jams occurred (Figures 19 and 20). Pools were over-excavated at time of construction and were expected to fill initially, then stabilize in the 2.0' to 3.0' depth range, with the possible exception of Element 1 which is expected to stabilize between 1.5' and 2.0'. Initial monitoring of residual depths (Table 3) indicates that elements are performing as designed.

The project reach was subjected to several peak events in the initial winter (Fig. 21). While the period of record of the gage at the mouth of Swale Creek is not long enough to conduct a flow-frequency analysis, the largest peak on nearby gages on the Klickitat River and Little Klickitat River was approximately a 2 to 5-year event.

Table 3. Residual depths for 5 pools constructed in Swale Creek in the vicinity of RM 2.0.

Element	Residual Pool Depth (ft)			
	Pre-Construction	As-Built	March 2009	August 2009
1	0.2	No data	No data	2.0
2	Not constructed			
3	0.4	2.6	2.3	2.3
4	1.3	3.8	2.6	3.3
5	0.5	3.9	3.3	3.4
6	0.6	4.5	3.5	3.6

Figure 19. Element 4 during construction (inset) and post-flood.

Figure 20. Element 5 as-built (top, left), during flood (bottom), and post-flood (top, right).

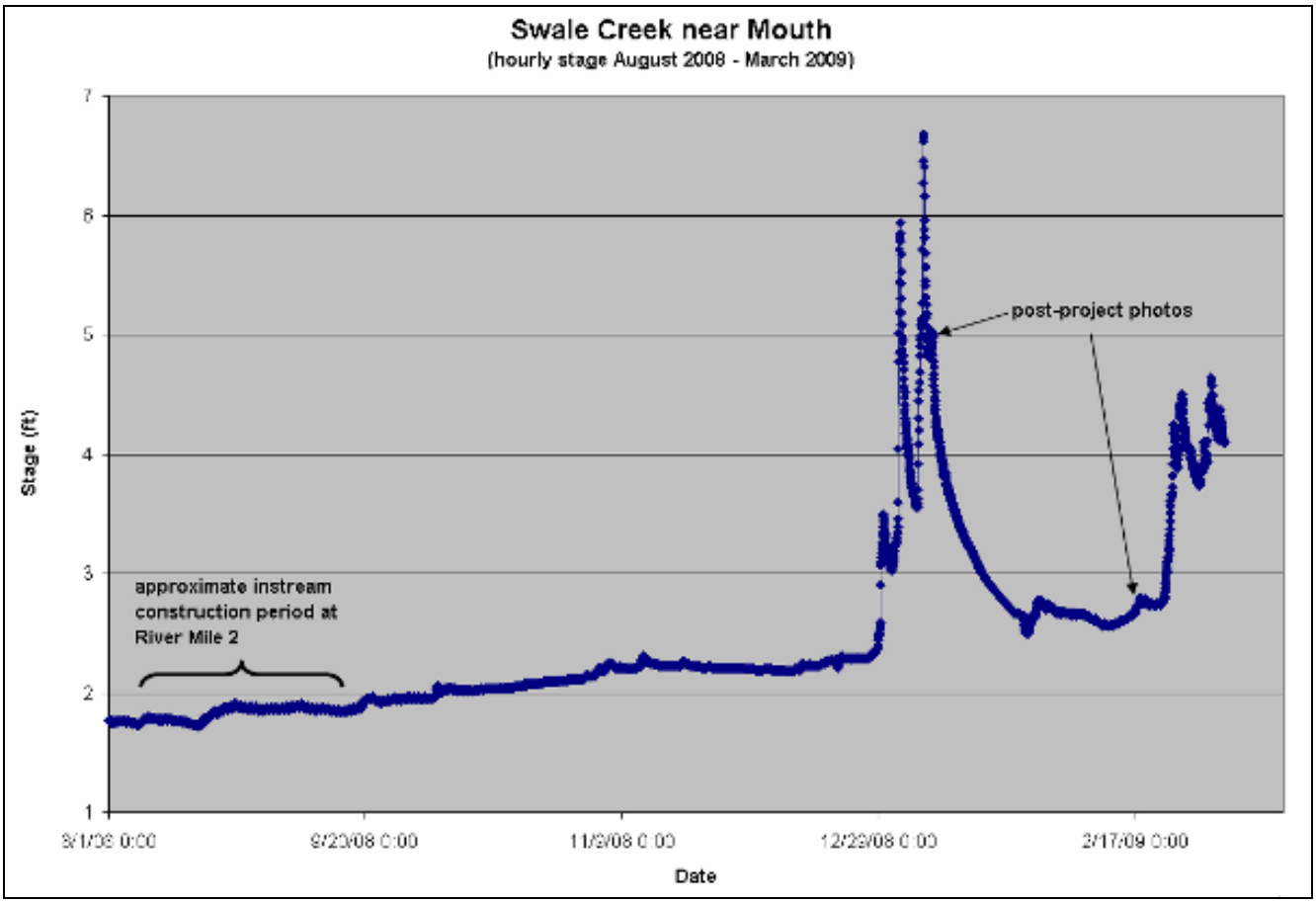


Figure 21. Hydrograph from the YNFP gage on Swale Creek near mouth.

Invasive Weed Control and Revegetation

Site visits were made to eight completed project sites (8.25 acres) to control the spread of weeds. Treatments involved manual pulling of target species, primarily knapweed and non-native thistles. Due to the extent of weed colonization found at Klickitat Meadows and Tepee Creek/IXL Meadow, efforts were focused on these two sites. After an initial pass through the sites was made, a second pass was made to remove newly emergent plants and those that had been missed previously.

In addition to weed removal, supplemental planting was conducted at 4 past project sites: E. Fork Tepee Ck/175 Road, Tepee Ck/175 Road, Tepee Ck/IXL Meadows, and White Creek/IXL. At these 4 sites approximately 300 spiraea (*Spiraea douglasii*) tubelings were planted with the aid of a hoedad. In addition, to *Spirea* plantings a seed mix was applied at the E. Fork Tepee Ck/175 fish passage restoration project site. Seed mixes vary but include some combination of: slender wheatgrass, Idaho fescue, bluebunch wheatgrass, hairgrass, sedges, rushes, timothy and mountain brome. These supplemental planting and seeding efforts are a result of project monitoring and an effort to establish native plant cover on areas disturbed during construction.

OTHER KWEP ACTIVITIES

Promote No-till Farming Practices

In late 2005, The Yakama Nation Fisheries Program purchased a small no-till (a.k.a. direct-seed) drill with a grant received from CRITFC. The goal is to increase awareness and implementation of no-till practices. These practices increase residual ground cover (stubble) in agricultural fields between crop cycles and reduce disturbance to the soil profile, producing greater infiltration of precipitation into the soil profile and less surface runoff and soil erosion. A Memorandum of Agreement was signed in 2006 with the Central and Eastern Klickitat County Conservation Districts (CEKCCD) to administer operation of the drill. This project targets smaller farmers (typically 80 ac or less) for whom it is not economical to purchase such equipment. CEKCCD provides necessary maintenance and rents the drill to small landowners for a small fee (sufficient to cover maintenance expenses). The landowners provide their own tractor, transportation of the drill, and are responsible for covering all of their own expenses. 2009 was the fourth year of drill operation and was rented to 14 landowners. Total acreage planted was 148 acres.

Streamflow Monitoring

KWEP cooperatively with the YN Water Program (YNWP) monitors stream flow throughout the Klickitat sub-basin. KWEP independently operated stream gages at six sites during the reporting period. Cooperative activity included thirty-eight instantaneous discharge measurements for use in rating curve development and maintenance. Activities also included installation (YNWP) of one staff gage (for manual observation of stage elevation) and three sensor / data-loggers (to record water surface elevation continuously) at two sites. Twenty-six visits were made to seven sites with data loggers to download data and check field calibration (KWEP). Maintenance was conducted at nine sites and repairs were necessary at one site (YNWP). Activities are summarized by site in Table 4. Figure 22 provides an example of continuous water surface elevation measurements. Stage and discharge observations are presented by site in Table 5.

Table 4. Services performed at 15 stream gaging sites in the Klickitat subbasin during 2009.

Site	Qmeas	Staff Read	Crest Read	Staff Install	Crest Install	Sensor Install	Down-load	Maint.	Repair	Survey	Total Visits
Clearwater Cr abv. Fish Lake Stream	1	1	1								1
Diamond Fk @ 255 Rd	3	3									2
East Fork Tepee Cr below 175 Rd	4	1	1	1							3
Fishlake Stream abv. Potato Hill Rd	1	1	1								1
Klickitat River @ Klickitat Hatchery						2	4				4
Klickitat River @ Cow Camp	2	2	2					1			2
Piscoe Creek nr mouth	2	2	1					1			2
Summit Creek nr mouth	3	9					6	2			9
Surveyor's Creek	6	7	7			1		2			7
Swale Creek nr mouth	2	4	1				4				8
Tepee Creek abv. 175 Rd	3	7					4	2			7
Tepee Creek abv. IXL Rd	4	7	2				3	2			7
White Creek @ 207 Rd	1	1	1					1			1
White Creek @ IXL Rd	3	3	3					2			3
White Creek nr mouth	3	5	2				5	2	2		12
Grand Total	38	53	22	1	0	3	26	15	2	0	69

Table 5. Stage and instantaneous discharge measurements from 14 sites for the period 1/1/09-12/31/09.

Site	Date	Stage	Discharge
Clearwater Stream abv Fish Lake Stream confl.	9/3/2009	0.80’	102.12 cfs
Diamond Fork at 255 Road	10/7/2009	5.65’	24.40 cfs
Diamond Fork at 255 Road	11/5/2009	5.79’	25.04 cfs
Diamond Fork at 255 Road	11/18/2009	5.88’	43.62 cfs
E.F. Tepee Creek blw 175 Road	4/23/2009	-0.43’ *	11.97 cfs
E.F. Tepee Creek blw 175 Road	5/6/2009	-0.44’ *	11.56 cfs
E.F. Tepee Creek blw 175 Road	6/2/2009	-0.71’ *	3.59 cfs
E.F. Tepee Creek blw 175 Road	11/10/2009	0.88’	0.40 cfs
Fish Lake Stream abv Potato Hill Road	9/3/2009	0.84’	93.33 cfs
Klickitat River @ Cow Camp	11/10/2009	2.78’	55.35 cfs
Klickitat River @ Cow Camp	11/19/2009	2.91’	124.54 cfs
Piscoe Creek nr mouth	9/2/2009	0.77’	1.95 cfs
Piscoe Creek nr mouth	11/10/2009	0.82’	3.58 cfs
Summit Creek nr mouth	4/21/2009	5.26’	88.61 cfs
Summit Creek nr mouth	11/3/2009	4.22’	13.70 cfs
Summit Creek nr mouth	11/18/2009	4.23’	12.49 cfs
Surveyor’s Creek	9/9/2009	1.84’	4.71 cfs
Surveyor’s Creek	10/6/2009	1.83’	5.11 cfs
Surveyor’s Creek	10/20/2009	1.92’	5.04 cfs
Surveyor’s Creek	11/4/2009	2.00’	5.07 cfs
Surveyor’s Creek	11/12/2009	2.07’	5.77 cfs
Surveyor’s Creek	11/18/2009	2.17’	6.96 cfs
Swale Creek nr mouth	1/8/2009	4.82’	657.0 cfs
Swale Creek nr mouth	11/24/2009	2.33’	0.84 cfs
Tepee Creek abv. 175 Road	6/2/2009	0.89’	3.53 cfs
Tepee Creek abv. 175 Road	11/6/2009	1.33’	14.17 cfs
Tepee Creek abv. 175 Road	11/10/2009	0.65’	0.41 cfs
Tepee Creek abv. IXL Road	4/23/2009	4.36’	20.39 cfs
Tepee Creek abv. IXL Road	5/6/2009	4.27’	12.02 cfs
Tepee Creek abv. IXL Road	6/2/2009	4.05’	3.27 cfs
Tepee Creek abv. IXL Road	11/10/2009	3.96’	0.46 cfs
White Creek nr mouth	5/21/2009	2.22’	53.66 cfs
White Creek nr mouth	11/3/2009	0.97’	0.85 cfs
White Creek nr mouth	11/18/2009	1.07’	1.97 cfs
White Creek abv. 207 Road	11/18/2009	4.46’	1.63 cfs
White Creek abv. IXL Road	5/6/2009	7.18’	14.70 cfs
White Creek abv. IXL Road	5/21/2009	6.99’	5.26 cfs
White Creek abv. IXL Road	11/10/2009	6.72	0.21 cfs

*Negative stage values are a result of the staff gage being out of the water. The value is obtained by differential leveling to the water surface.

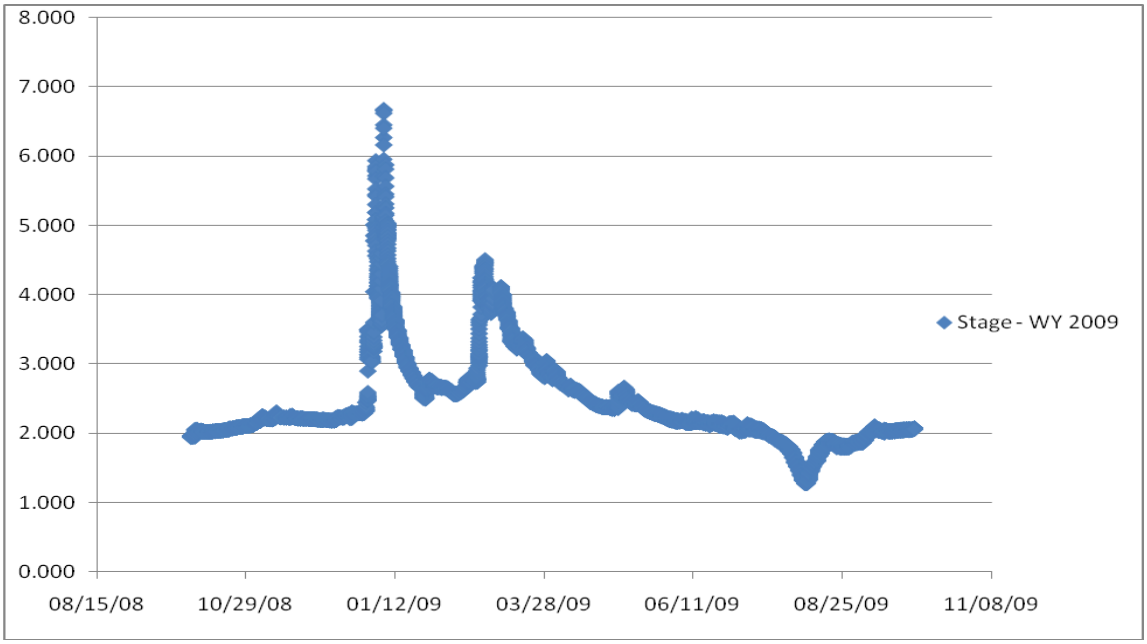


Figure 22. Stage at the Swale Creek Mouth site for Water Year 2009 (10/1/2008 – 9/31/2009).

Stream Temperature Monitoring

During 2009 KWEP personnel were involved in transferring the maintenance, exchange and downloading of temperature sensors for the Klickitat M&E project. KWEP personnel continue to assist YKFP Data Management staff with maintenance and continued development of the relational database that houses and manages all of the temperature data for the Klickitat subbasin. Data summaries are published in the Klickitat M&E Project's annual report. Monthly temperature reports are also available via an interactive map on the YKFP website:

http://www.ykfp.org/klickitat/Data_thermo.htm

Habitat Monitoring

The YKFP-Klickitat uses the Timber, Fish, and Wildlife (TFW) methodology for status and trend monitoring. Field data is collected primarily by Klickitat M&E project personnel. KWEP personnel designed and developed a relational database to enter, house, and analyze the data in cooperation with Klickitat Data Management project personnel. KWEP personnel provide QA/QC, data entry and error-checking, report design, and analysis as well as assistance to Data Management project personnel with maintenance and continued development of the database.

During 2009, KWEP staff focused on locating and scanning print photos depicting the upstream and downstream endpoints of TFW Habitat Survey segments. Once scanned, these photos were linked to the database record that corresponds to the TFW Habitat segments. When data have been finalized, reports for Reference Point, LWD, and Habitat will be available for each segment via an interactive map on the YKFP-Klickitat website: (http://www.ykfp.org/klickitat/Data_TFW.htm).

Education and Outreach

Though education and outreach constitutes a minor portion of overall KWEP staff time allocation, it is a critical component of the project. KWEP staff engaged in three types of education and outreach during 2009. These activities are oriented toward helping the public understand what we do, why we do it and what we've learned and/or professional development.

- *Elementary school outreach*: KWEP staff assisted the Salmon in the Classroom program (taught in conjunction with USFWS) where staff visited six local elementary, middle and high schools: Dallesport, Glenwood, Klickitat, Lyle, Mill A, and Wishram Schools. Staffs describe our program and explain the cultural significance salmon have to native people, including demonstrations of traditional fishing methods. The presentations at the six schools involved roughly 107 students and 12 teachers.

- *Public presentations*: KWEP staff presented at three professional meetings in 2009, including:

  - 2009 Klickitat and White Salmon Rivers Fisheries and Watershed Science Conference: KWEP staff were invited to give an oral presentation on the background, goals, and priorities of KWEP demonstrated through project examples undertaken during 2008 (Conley 2009a). The presentation may be viewed on the YKFP website.

  - River Restoration Northwest's 8th Annual Northwest Stream Restoration Design Symposium: KWEP staff presented a poster providing an overview of KWEP activities, highlighting: background, goals, priorities, and completed projects. The poster session was a designated hour and a half segment of the Symposium that facilitated the one-on-one interaction of participants with KWEP staff.

  - 2009 Salmon Habitat Conference: KWEP staff were invited to give two oral presentations to the biennial conference affiliated with the Washington Salmon Recovery Funding Board (SRFB):

    - "Turning Cobble into Functioning Floodplain along the Lower Klickitat River" (Conley 2009b) focused on the Lower Klickitat River Riparian Revegetation Project. It highlighted the partnership between the Yakama Nation and Mid-Columbia Fisheries Enhancement Group and presented design and implementation techniques as well as effectiveness monitoring results.
    - "Reversing Channel Incision and Enhancing Steelhead Habitat in Tepee Creek" (Conley 2009c) focused on the Tepee Creek IXL Meadows restoration project. It highlighted design and implementation that involved reconstructing an incised, largely plane-bed stream to an unentrenched, pool-riffle channel. Effectiveness monitoring data was also presented.

- *Professional Development*: The KWEP hydrologist was the planning lead for and coordinated a five-day hydraulic modeling short course for River Restoration Northwest. The class, "HEC_RAS Open Channel Flow Modeling and Sediment Transport Analysis" was attended by 28 professionals from around the Pacific Northwest. The KWEP staff involved received free registration, lodging, and per diem for the course, a $1,780 savings.

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