Klickitat Watershed Enhancement Project (KWEP)

Yakima/Klickitat Fisheries Project (YKFP)

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I. Executive Summary

This report describes restoration and enhancement activities as well as on-going watershed monitoring in the Klickitat River subbasin implemented by the Klickitat Watershed Enhancement Project (KWEP). The activities described in this report are funded in part by the Bonneville Power Administration (BPA) through the 3Yakima-Klickitat Fisheries Project (YKFP). Funds provided by BPA are matched with in-kind contributions from the Yakama Nation in the form of materials and supplies, and cash donations awarded through the solicitation of competitive grants such as the Salmon Recovery Funding Board (SRFB) administered by the Washington State Recreation and Conservation Office. Project work emphasizes restoration and protection in watersheds and stream reaches that support restoration of native salmonid stocks, particularly steelhead/rainbow trout (*Oncorhynchus mykiss*), spring Chinook salmon (*O. tshawytscha*), and bull trout (*Salvelinus confluentus*).

Major restoration activities this period focused on restoring floodplain connectivity, creation of diverse active channel hydraulic conditions (varying depths and velocities), enhancement of the quality and quantity of salmonid rearing habitat, and the restoration of deformable stream banks and geomorphic processes to the valley bottom of the mainstem Klickitat River.

A restoration focus during this reporting period included construction of Phase 5 of the Haul Road Project along the mainstem Klickitat River. The project removed 1.75 miles of asphalt and graded the embankment to enhance riverine and floodplain function. Additionally, the project installed nearly 750 feet of high-flow channel, two logjams, and exposed 600 feet of bedrock to channel forming processes during an abbreviated season.

Monitoring and assessment activities during this period focused on characterizing the hydrologic and geomorphic conditions in the mainstem Klickitat and its tributaries. Activities included monitoring a network of stream gages, a subset of which have more focused objectives (Klickitat Delta Pilot Study and Big Muddy Creek) and Rapid Aquatic Habitat Assessment Protocol (RAHAP) surveys. The purpose of these data collection efforts was to understand baseline or current conditions, develop insights related to land use planning, assist in developing new restoration projects that can improve watershed health and fisheries restoration effectiveness. Post-project monitoring occurs on select sites to allow for adaptive management and to refine future projects by documenting whether or not intended physical and biological responses occurred. Completed projects are presented as case studies at professional meetings to facilitate discussion and advance the knowledge and effectiveness of restoration science.

II. Introduction

The Klickitat Watershed Enhancement Project (KWEP) works to restore, enhance, and protect watershed function within the Klickitat [River] subbasin. Project work emphasizes restoration and protection in watersheds and reaches that support native salmonid stocks, particularly steelhead (*Oncorhynchus mykiss*; listed under the Endangered Species Act as "Threatened" within the Mid-Columbia Evolutionarily Significant Unit), spring Chinook salmon (*O. tshawytscha*), and Bull Trout (*Salvelinus confluentus*; "Threatened"). Restoration activities focus on restoring stream processes by removing or mitigating disturbances to watershed function, improving habitat conditions, and improving and protecting water quality. Watershed and habitat improvements also benefit fall Chinook (*O. tshawytscha*), Coho salmon (*O. kisutch*), Rainbow Trout, 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 by reducing habitat degradation. Since 90% of the off-reservation, project area is in private ownership, cooperation and collaboration with state, federal, tribal, and private entities increases project effectiveness. KWEP's project selection and implementation strategy is designed to address goals and objectives presented in the 2004 Klickitat Subbasin Plan and the Klickitat Lead Entity Salmon Recovery Strategy.

Project Goals

The overall goal of KWEP is to restore watershed processes to aid recovery of salmonid stocks in the Klickitat subbasin. KWEP employs three main approaches to achieve this goal:

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

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

• **Monitor** watershed conditions to assess trends and effectiveness of restoration activities. Monitoring is a critical component for evaluating project success and guiding adaptive practices; both site-specific and basin-wide spatial scales are addressed. KWEP complements the Klickitat Monitoring & Evaluation Project (BPA project #1995-06-335) by assisting data collection, providing Quality Assurance /Quality Control (QA/QC) and analysis of channel morphology, streamflow, temperature, aquatic habitat, and channel substrate data.

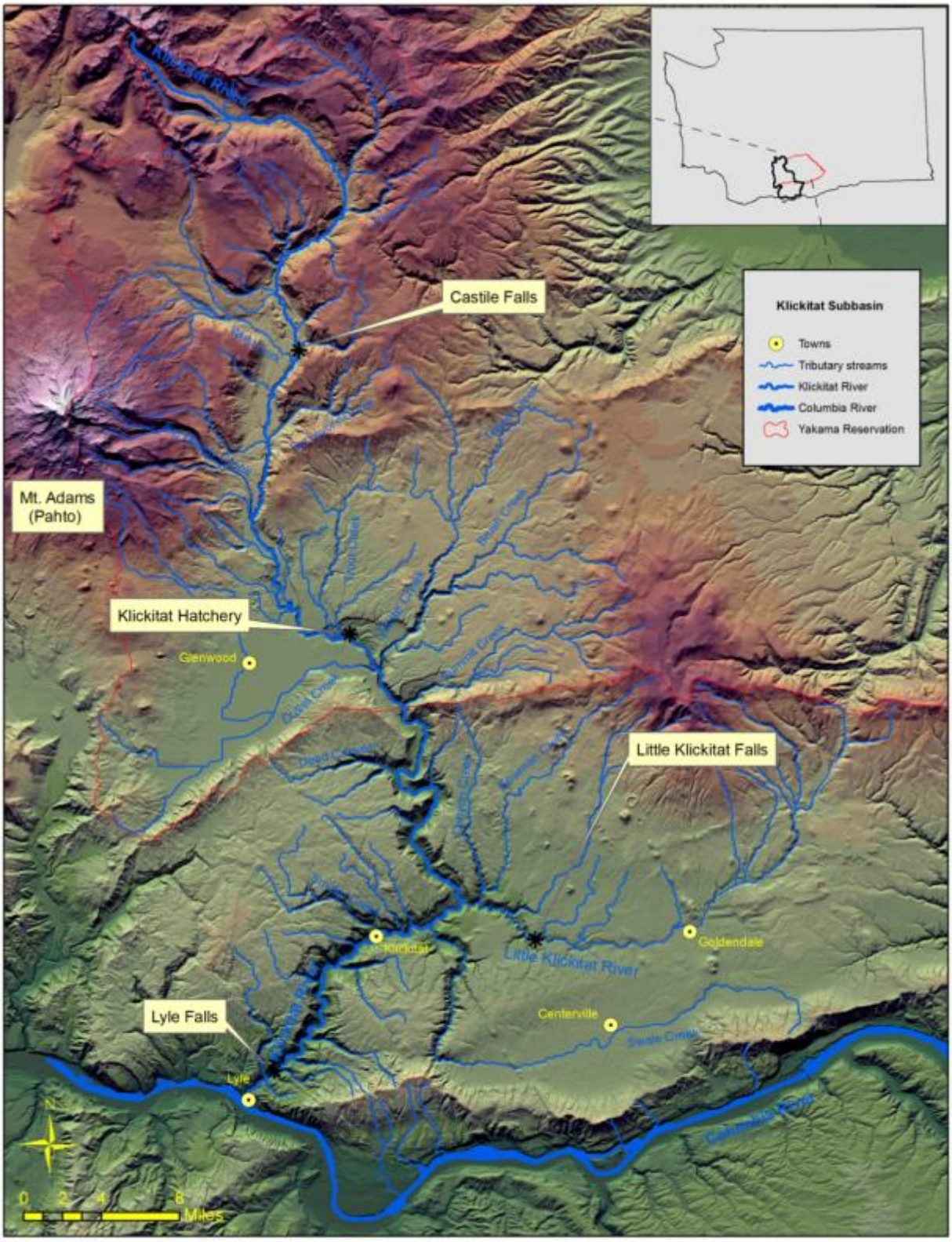

Figure 1. Klickitat River Subbasin

III. Work Elements/ Deliverables

Tributary Habitat Restoration and Protection

Klickitat River Floodplain Conservation and Restoration (Haul Road) Project – Phase 5

Background: The Haul Road project addresses a limiting feature (channel confinement) identified for the Klickitat River between river miles 18.3 and 32.2 (Fig. 3) by the Klickitat Subbasin Plan and Klickitat Lead Entity Salmon Recovery Strategy (KLESRS, 2013). 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 threatened winter and summer steelhead, 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 19% (2-40%), 42% (24-65%), and 15% (0-37%) of the annually observed basinwide spawning for steelhead, fall chinook, and coho, respectively (2002-2014). A combination of channel encroachment, floodplain isolation by road fill and 1996 flood deposits have degraded riparian and floodplain conditions within the project area. The absence of other floodplain development coupled with less-confined valley conditions affords this reach greater resiliency than downstream reaches. The project is occurring in two stages: 1) acquisition (Phase 1 funding) and 2) restoration (all subsequent phases of funding). Columbia Land Trust (CLT) is the primary sponsor for the SRFB grant that funded the acquisition and subsequent restoration. KWEP is the technical lead for design and construction oversight of restoration activities, and assists with planning activities, which include Road Maintenance and Abandonment Plan (RMAP) revisions.

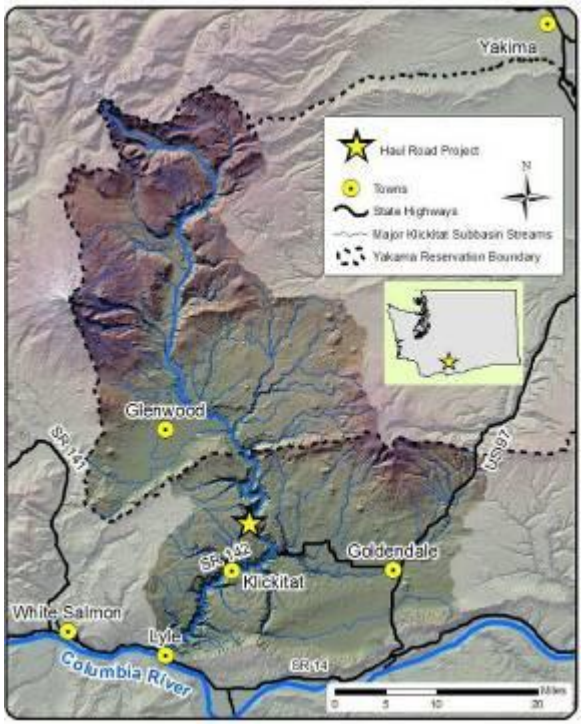

Figure 2. Klickitat River Restoration site location (star) within Klickitat watershed.

Project Goal: The overall project goals are to prevent habitat fragmentation and restore floodplain connectivity and geomorphic processes that support listed species to the valley bottom. CLT completed acquisition of the road and 480 acres of private riparian and upland in-holdings which are within the Washington Department of Fish and Wildlife, Klickitat Wildlife Management Area in 2007 (Conley 2008). Phase 1 was completed in 2009 with the removal of a cross-valley railroad embankment in Dead Canyon (tributary at upstream end of project reach). Phase 2 of the project addressed limiting features for a portion of this reach by restoring floodplain connectivity by pulling back and re-vegetating fill materials in other portions to enhance riparian vegetation. Activities completed during Phase 2 included

enhancement and restoration of riparian and floodplain habitat by modifying 2.1 miles (cumulative) of road to reduce channel reduced confinement and restoration of floodplain access. The nature of valley type along the road removal locations resulted in 0.94 miles of restored floodplain access. Once road removal, grading, and habitat enhancement features were completed, approximately 7.5 acres of riparian and floodplain habitats were revegetated. Phases 3 and 4 cumulatively removed 3.25 miles of asphalt, restored access to 9.75 acres of floodplain, removed 14 culverts (including one on a seasonal fish-bearing tributary), placed 45+ pieces of wood to improve floodplain roughness and habitat heterogeneity, and restored the river's access to adjacent hillslopes.

2015-2016 activity: Project planning, administration, and construction activities were conducted during the reporting period related to Phases 5 and 6 of the Haul Road Project.

Planning - KWEP and CLT staff conducted several field visits to refine treatments and geographic scope of Phase 5 (Figure 3). KWEP staff determined stationing for road segments delineated during the geomorphic assessment (Conley and Lindley 2012) and performed layout prior to soliciting bids for Phase 5. Phase 6 of the Haul Road received funding during the 2014 SRFB grant round. During 2015, preliminary planning of Phase 6 activities began and exploratory excavation work was completed in early 2016 to refine quantity estimates for earthwork (cut and fill for roadbed excavation).

Administration – During the construction process, KWEP project staff supported CLT with permitting, RMAP revisions, and contract administration. The contract was awarded to Crestline Construction LLC (The Dalles, OR) for Phase 5 in 2014 and was extended to 2015 in order to complete the specified scope of work. Additionally, the YN hydrologist provided field oversight of construction activities and directed fit-in-the-field implementation.

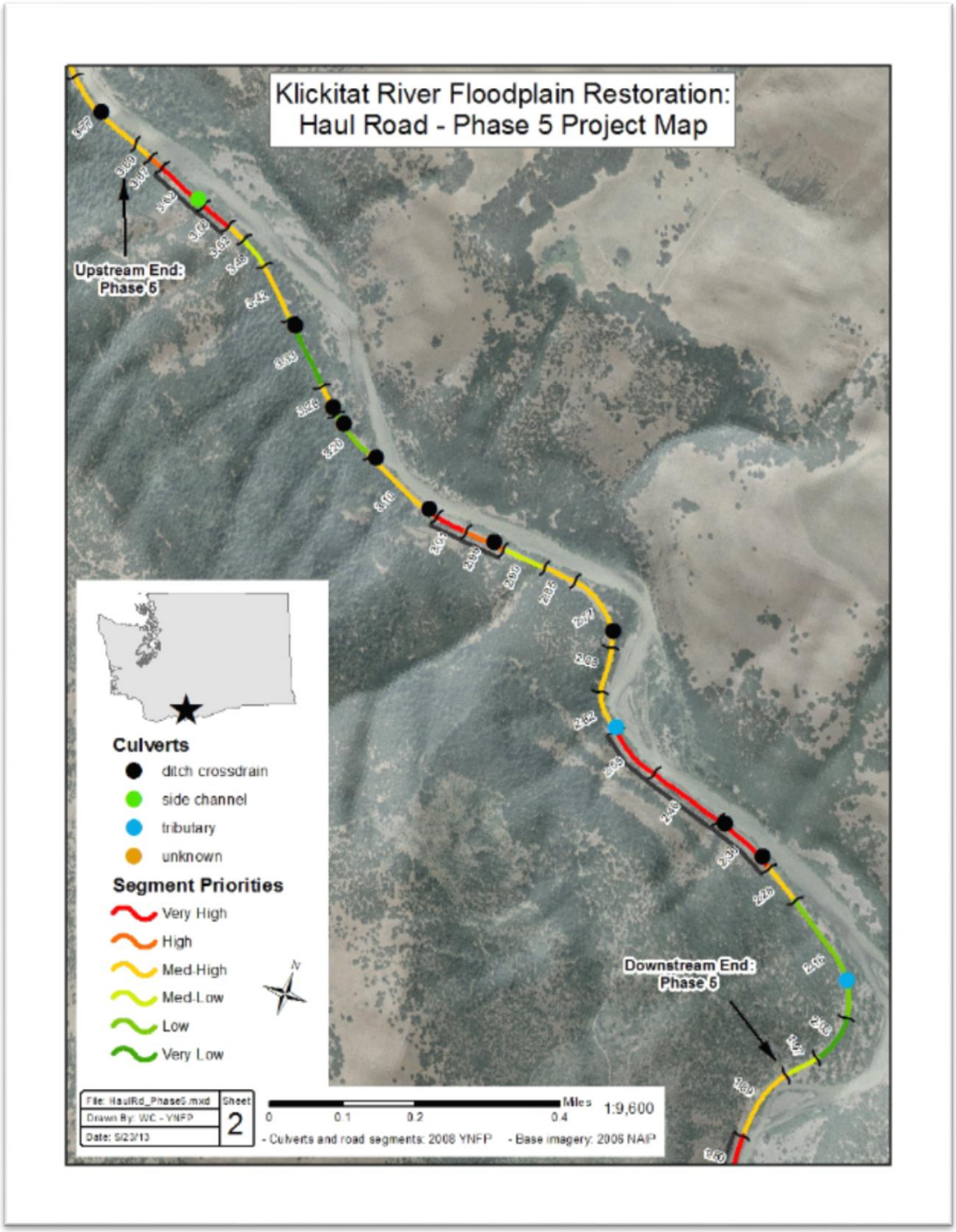

Figure 3. Klickitat River Floodplain Conservation and Restoration (Haul Road) - Phase 5 Project Map

Construction – Construction activities took place June-July 2014. The project was suspended in October 2014 in order to ease concerns from local river users regarding short-term turbidity spikes resulting from construction activities. Phase 5 was approximately 60% complete when the project was curtailed and heavy equipment demobilized for the year. Construction activities resumed in 2015 following coordination (YN, CLT, DNR and WDFW) and discussion on timing of a suitable "fish window".

Construction activities completed in 2015 (Figures 4 and 5):

- Total Stream Length Treated: **0.77 miles** (Phase 5 total = 1.9 miles)
- Total Road Length Treated: **0.66 miles** (Phase 5 total = 1.7 miles)
- Implementation/Construction Oversight Visits: **28** (Phase 5 total = 67)
- Primary Instream Pools Constructed: **1 pool** (Phase 5 total = 2)
- Total Riparian Area Treated: **7.2 ac** (Phase 5 total = 18.1 ac)
- Total Primary Channel Instream Habitat Created: **1.2 ac** (Phase 5 total = 2.5 ac)
- Floodplain Habitat Created: **0.4 ac** (Phase 5 total = 2.3 ac)

Figure 4. Haul Road segment 3.56 before (5/9/2012) and after (5/12/2016) treatment.

Figure 5. Haul Road segment 2.46 after (5/12/2016) treatment.

Haul Road Phase 6 Design: Bedrock outcroppings are a primary landform feature that contributes to aquatic habitat formation in the Klickitat River subbasin. The Haul Road alignment cuts off potential bedrock contacts from the river in several places, preventing pool formation, energy dissipation, as well as sediment sorting and deposition. In order to reestablish these contact points, contractors excavated fill materials until native alluvial materials or bedrock were uncovered. Due to the embankment fill and naturalized vegetation of the Haul Road, the depth to reach bedrock was generally unknown prior to beginning excavation at each location. In previous phases (2-5), the depth and alignment of bedrock was assumed to be at the road center (on average). This was a compromise, assuming in some instances bedrock would project beyond road center and some instances it would be located farther inland. Compensation to contractors for the fill removal aspects of the project was billed on an hourly basis due to this uncertainty.

In March of 2016, multiple test pits were excavated within fill removal segments in order to determine the depth and alignment of bedrock (Fig. 6). The information collected from these exploratory digs will reduce uncertainty and the amount of fill to be removed will be calculated and ultimately costs will be reduced. Over the course of 12 days, 42 trenches and 15 potholes were excavated. Field notes, GPS location information, and measurements on depth and width were collected for each dig.

Figure 6. Example of test trench (left) and profile (right) displaying mixed alluvium fill and native soils.

Revegetation: In both spring 2015 and 2016 KWEP, contracted with the Washington Department of Ecology's Conservation Corps to conduct revegetation at the Haul Road Phase 5 project site. The intent was to install native vegetation in areas disturbed during recent construction and in adjacent undisturbed areas, to enhance existing conditions on both the floodplain and associated uplands in proximity to the Klickitat River. Within these areas, crews planted suitable native species along a tolerance gradient ranging from the slope toe at the river's edge, upslope to drier upland habitats. *Populus trichocarpa* (Black Cottonwood) and *Salix spp*. (Willows) were planted along the toe of the slope, *Pinus ponderosa* (Ponderosa Pine) and *Quercus garryana* (Oregon White Oak) within the upland,

and *Philadelphus lewisii* (Mock Orange) and *Amelanchier alnifolia* (Serviceberry) span both zones. The planting material was a mix of cuttings and bareroot stock. Revegetation activities included collection of planting materials on-site (cuttings), transport of planting material to the site, and physical installation of plants at appropriate densities and locations (based on tolerance of individual species).

The contract crew used a planting prescription that divided the larger reach into small planting units (Fig. 7). For each planting unit, a priority was assigned with species and quantities specified. Over the two-year period, approximately 9,500 plants were installed (4,000 in 2015 and 5,400 in 2016).

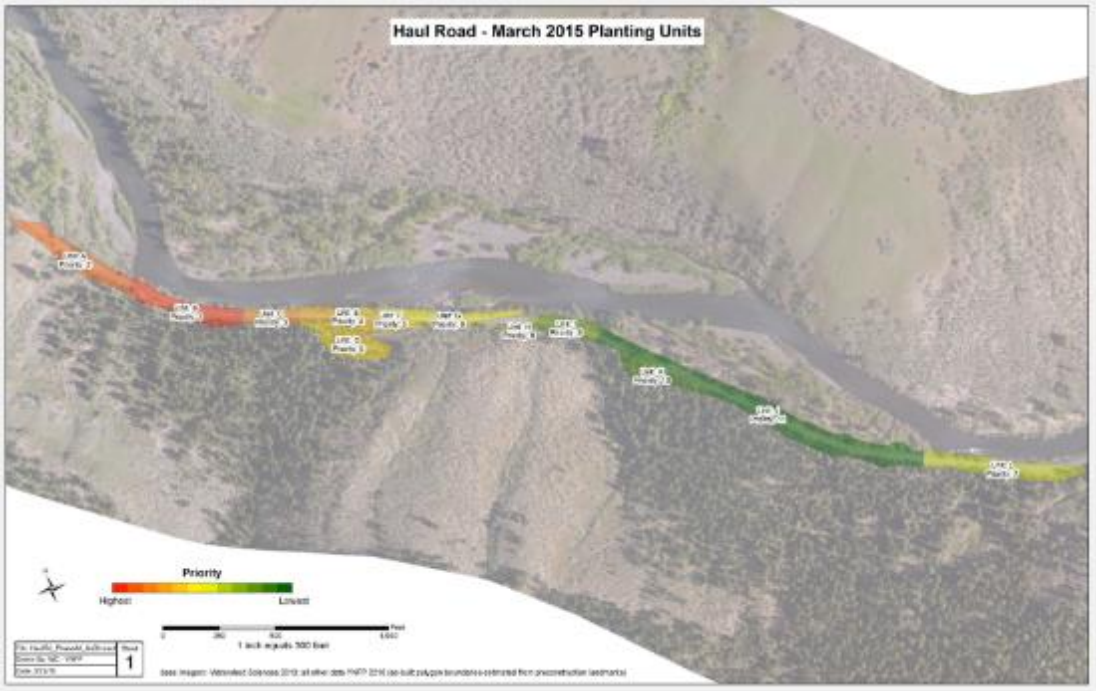

Figure 7. Haul Road Phase 5 Planting Units.

Manage Native Plant Nursery

KWEP personnel constructed a small nursery at the Klickitat Field Office (KFO) in Wahkiacus, WA in 2006 to reduce the costs associated with revegetation efforts. Maintaining a supply of locally adapted and locally sourced plants that can generate a source of in-kind match for grant-based funds remains an important component of KWEP's work. The nursery consists of constructed wooden frames sized appropriately to hold treepot style containers (Stuewe & Sons, Corvallis, OR). KWEP staff harvest live cuttings from native hardwoods each spring prior to leaf-out, cut material to size, and root it in a planting medium in containers. KWEP staff irrigate three times weekly throughout the growing season and generally out-plant stock at restoration sites the same year. The nursery has the capacity to grow 3,600 containerized plants within treepots with additional irrigated space to house purchased plants or holdovers from a previous growing season (Fig. 8).

In 2015, approximately 2,500 plants were grown at the KFO nursery. Containerized plants consisted of a mix of pine (*Pinus ponderosa*), Coyote willow (Salix exigua), Scouler's willow (*Salix scouleriana*), and black cottonwood (*Populus trichocarpa*). All plants grown at KFO in 2015 were planted at the Haul Road Phase 5 project site in the spring of 2016.

In 2016, approximately 3,400 plants were grown at the KFO nursery. Containerized plants consisted of a mix of species harvested from cuttings Coyote willow (Salix exigua), Scouler's willow (*Salix scouleriana*) and black cottonwood (*Populus trichocarpa*) and bare-root plants purchased from the Washington Association of Conservation Districts Plant Material Center. Bare-roots plants purchased and then potted included bigleaf maple (Acer macrophyllum), black hawthorn (Crataegus douglasii), douglas fir (Pseudotsuga menziesii), mock orange (Philadelphus lewisii), Nootka rose (Rosa nutkana), pine (*Pinus ponderosa*), redosier dogwood (Cornus sericea), and western spirea (Spiraea douglassi). All plants grown at KFO in 2016 will be planted at the Haul Road Phase 6 project site in the fall of 2017.

Figure 8. Nursery at Klickitat Field Office.

Invasive Plant Control

Typically, sites selected for restoration or enhancement projects have a history of disturbance or perturbation. As a result, non-native vegetation is typically present to a degree and poses a potential threat to be "released" once soils are disturbed during construction activities. In order to prevent spread and assist with native plant establishment, KWEP personnel make annual visits to project sites both pre- and post-treatment to monitor and control invasive plants.

KWEP staff made site visits to fourteen completed project sites (totaling 63.75 acres) in 2015 and 2016 in order to evaluate the establishment of native plants and managing invasive species. Treatment of invasives involved manual pulling of target species, primarily knapweed and non-native thistles. An initial pass was made through each site to remove large or obvious invasives, followed later by a second

pass to focus removal on newly emergent plants and those that had been missed previously. On-Reservation, the Yakama Nation currently has a no-spray policy, thus hand removal is conducted. Off-Reservation, KWEP consults with Klickitat County Noxious Weed Board (KCNWB) staff in order to develop the most effective strategy for a given site. KCNWB treated sections of the Haul Road Project seasonally (fall and spring) in 2015 and 2016. The treatments primarily focused on houndstongue, sulfur cinquefoil, knapweed, and non-native thistles.

Tributary Habitat RM&E

Habitat Enhancement Project Monitoring

KWEP staff annually visit past project sites to photo-monitor performance of treatments implemented since 2002. Staff take photos at specific photo monitoring locations within project areas that are typically linear in planform. Either prominent landmarks (trees, rocks, stumps) or stations along the stream continuum are used to reorient/relocate photo points. A consistent annual photo record facilitates comparisons between and among years to determine changes occurring over time, and facilitates adaptive management, if needed. Photos utilized throughout this document are a result of photo documentation at project sites.

All photos taken as part of photo-monitoring are saved digitally, filed electronically in subdirectories by their respective project name and stored on the KWEP server. Examples of photographic comparison pre- and post-project are presented in first section of this report entitled the “Tributary Habitat Restoration and Protection”.

Streamflow Monitoring

KWEP staff, cooperatively with Klickitat M&E and the YN Water Program (YNWP), monitor stream flow throughout the Klickitat sub-basin. Cooperative activities during 2015 and 2016 included twenty four instantaneous discharge measurements for use developing rating curves (Table 1 and 2). Fewer instantaneous discharge measurements were taken during 2015 due to closure of YN forestlands for wildfire precaution in August and September.

KWEP staff operated stream gages with continuous dataloggers at thirteen sites during the reporting period. Staff made 89 visits to thirteen sites with data loggers for maintenance, data downloads, and field calibration of loggers. Activities conducted at all thirteen sites are summarized in Table 1. Graphs of 15 minute increment stage data for Water Year (WY) 2015 and 2016 at stream gaging sites on White and Tepee Creeks are presented in Figures 11 and 12.

In 2015, KWEP incorporated current and historic stream gaging data into the AQUARIUS Server software platform. The Aquarius Server combines the data correction, quality control, rating curve development, and reporting tools of AQUARIUS software with a data management solution that optimizes data storage, processing, and workflows using a web-based interface. Implementation of this software tool will assist the KWEP hydrologist and biologist by streamlining and documenting the processes involved from data collection through analysis. An example of the toolset in AQUARIUS Server KWEP uses

includes the “Location Manager” framework to organize stream gage sites (**Error! Reference source not ound.** and 11).

Table 1. Services performed by KWEP and YNWP at 13 stream gaging sites in the Klickitat subbasin in 2015 & 2016

Site	Q	Staff Read	Crest Read	Staff Install	Sensor Install	Download	Maint	Survey	Total Visits
Big Muddy Creek @ 255 x-ing	-	1	-	-	-	-	3	-	3
Dillacort Creek	-	4	-	-	-	3	-	-	4
Klickitat River @ Klickitat Hatchery	-	2	-	-	-	2	-	-	2
Klickitat River blw Summit Ck	-	9	-	-	-	5	3	-	9
Klickitat River @ Wahkiacus	2	10	-	-	-	9	1	-	12
Logging Camp Creek	-	3	-	-	-	3	1	-	3
Snyder Creek	-	4	-	-	-	3	-	-	4
Summit Creek nr mouth	6	14	1	-	-	3	2	2	15
Swale Creek nr mouth	5	10	-	-	-	5	2	-	10
Tepee Creek abv. 175 Rd	1	7	-	-	-	6	-	-	10
Tepee Creek abv. IXL Rd	5	12	-	-	-	6	-	-	12
Wheeler Creek	1	3	-	-	-	4	-	-	4
White Creek nr mouth	4	10	1	-	-	3	3	1	14
Grand Total	**24**	**89**	**2**	**0**	**0**	**52**	**15**	**3**	**102**

Table 2. Data collected by YNWP personnel at sites which KWEP operates continuous dataloggers.

Site	Date	Stage	Discharge
Summit Creek nr mouth	3/26/2015	5.62’	52.4 cfs
Summit Creek nr mouth	4/20/2015	5.62’	26.5 cfs
Summit Creek nr mouth	8/20/2015	4.88’	10.8 cfs
Summit Creek nr mouth	2/9/2016	5.75’	59.4 cfs
Summit Creek nr mouth	4/22/2016	5.78’	63.3 cfs
Summit Creek nr mouth	6/13/2016	5.21’	21.3 cfs
Swale Creek nr mouth	2/5/2015	3.90’	116.8 cfs
Swale Creek nr mouth	2/10/2016	3.36’	58.8 cfs
Swale Creek nr mouth	3/1/2016	4.48’	72.5 cfs
Swale Creek nr mouth	3/11/2016	4.26’	218.0 cfs
Swale Creek nr mouth	4/12/2016	2.51’	6.0 cfs
Tepee Creek abv. IXL Road	2/10/2015	1.69’	22.2 cfs
Tepee Creek abv. IXL Road	3/9/2016	4.50’	29.0 cfs
Tepee Creek abv. IXL Road	3/17/2016	4.44’	19.9 cfs
Tepee Creek abv. IXL Road	4/7/2016	4.42’	16.7 cfs
Tepee Creek abv. IXL Road	6/2/2016	4.09’	1.7 cfs
White Creek nr mouth	2/25/2015	2.72’	70.7 cfs
White Creek nr mouth	2/9/2016	2.31’	61.75 cfs
White Creek nr mouth	4/22/2016	2.24’	56.25 cfs
White Creek nr mouth	6/22/2016	1.21’	3.8 cfs

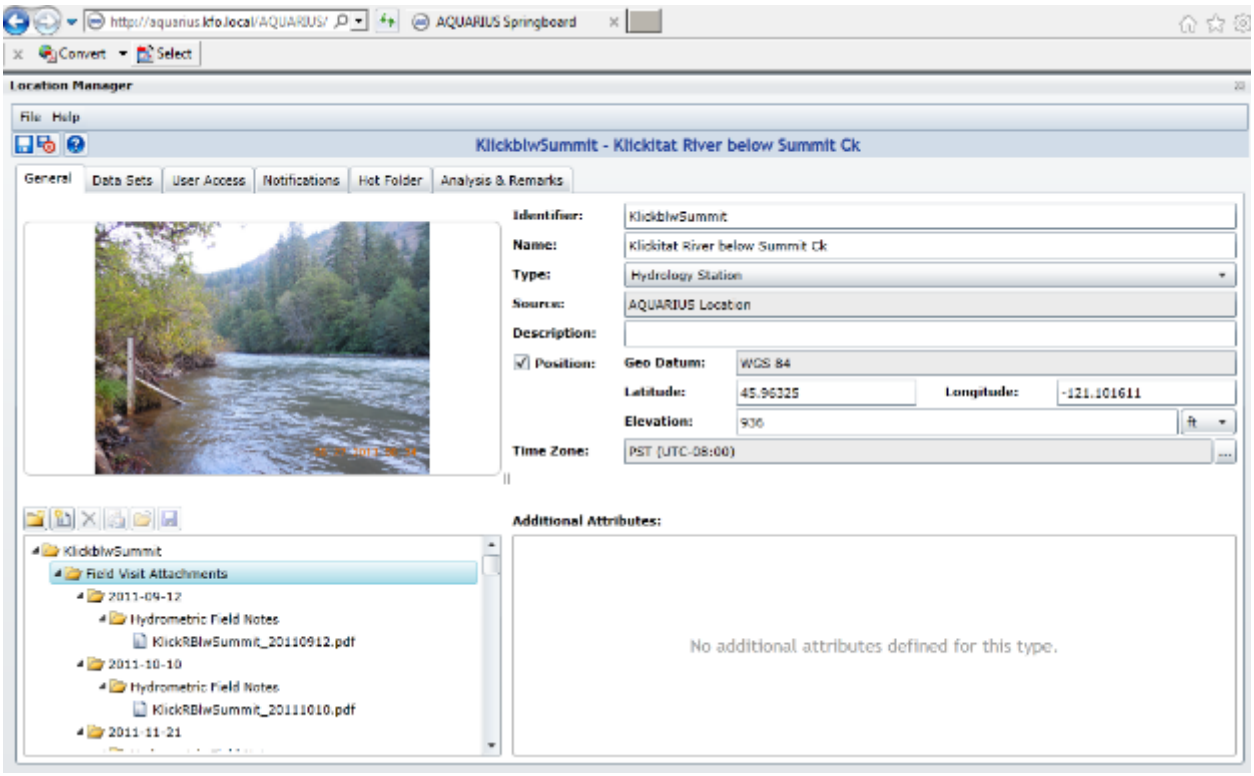

Figure 9. Screenshot of Aquarius SERVER stream gage “Location Manager” tool.

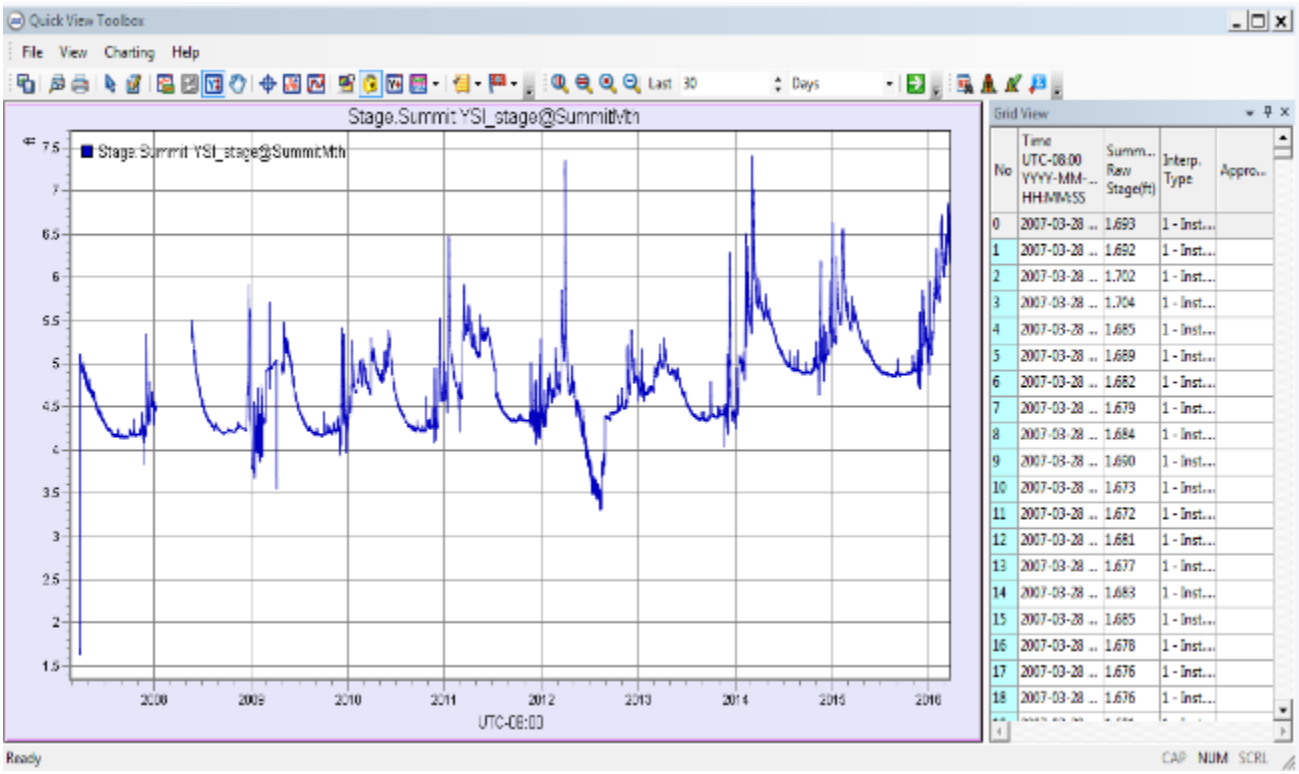

Figure 10. Screenshot of Aquarius SERVER "quick view" tool for visualizing time series data.

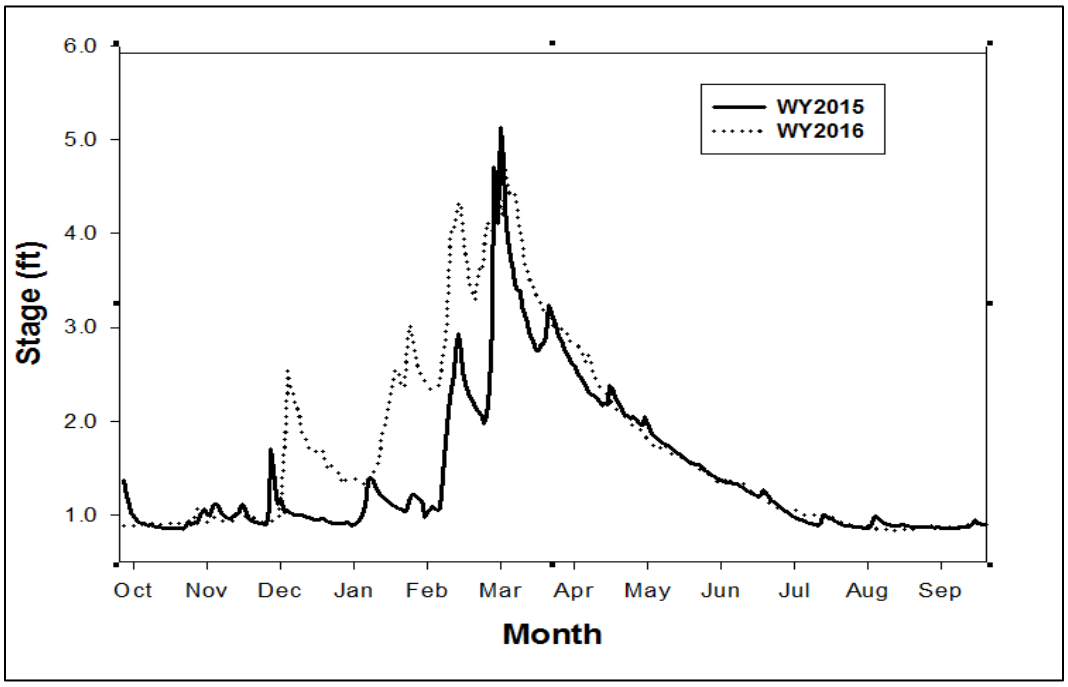

Figure 11. White Creek stage at the gaging site near the confluence with the Klickitat River for Water Years 2015 and 2016.

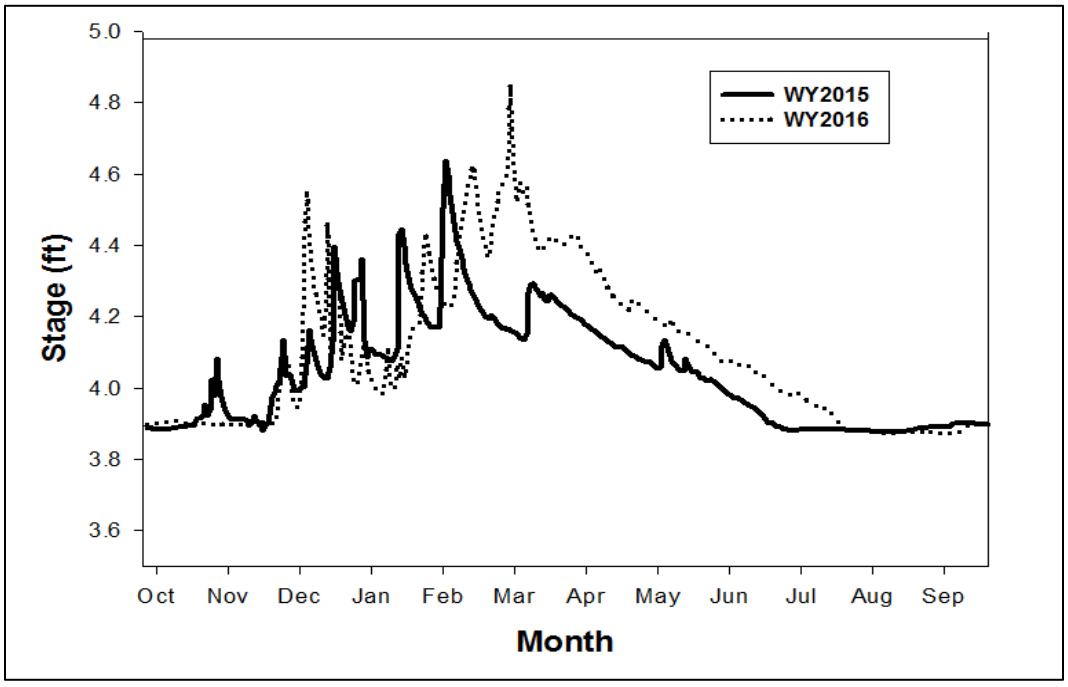

Figure 12. Tepee Creek stage at the gaging site near the intersection of the IXL and 175 roads for Water Years 2015 and 2016.

Conduct Food Web Study on Tepee and White Creeks (Effectiveness Monitoring)

The objective of the study is to examine how instream restoration efforts along a 0.7-mile section of Tepee Creek affect aquatic and terrestrially derived invertebrate prey sources and the diet of residualized *Oncorhynchus mykiss* and juvenile steelhead. Klickitat Monitoring and Evaluation Project (#1995-06-335) will complete additional reporting and the final comprehensive study report. Sampling has occurred and will continue on Tepee and White Creeks. Specific objectives of the study include the following:

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

Methods

Study Area

Tepee Creek, a tributary to White Creek, is one of the major tributaries supporting natural production of steelhead in the Klickitat subbasin. The White Creek watershed is 138 square miles in area. Elevations range from 1140 to 5100 ft. though most of the watershed lies between 2500 and 3300 ft. in elevation. Average annual precipitation is between 20 and 29 in., with roughly half falling as snow. Current habitat conditions in Tepee Creek and White Creek reflect past riparian timber harvest and road construction throughout the drainage. Instream large woody debris (LWD) levels are low in some reaches, and base flows are very low to non-existent in many reaches. Changes in channel morphology are attributable to numerous landscape-level activities such as livestock grazing, road interactions, up-slope timber harvest, and in some locations, historic removal of instream LWD.

Study reaches are located on Tepee Creek (treatment) and White Creek (control). There are four sample sections within each reach. The control and treatment study reaches have similar drainage areas and channel morphology. Sample section lengths range from 61-101 m in Tepee Creek and 80-107 m in White Creek. Bankfull widths ranged from 10.7-26.1 m and 16.3-28.8 m in Tepee Creek and White Creek, respectively. Pool-riffle sequences characterize sample sections.

During 2015, all of the components of the Food Web Study were sampled. In 2015, post-treatment samples were collected in spring, summer, and fall (Table 3). Drought conditions resulted in long sections of dry or standing water in summer and fall 2015. Consequently, collection of benthic, drift, and stomach samples fell significantly short of sample size projections. Samples were sent to a specialized laboratory for enumeration and identification in the laboratory.

KWEP staff monitored groundwater elevations throughout 2015 via physical measurements and continuously deployed dataloggers (Figs. 13 and 14).

Table 3. Summary of post-treatment food web samples collected spring 2015 – fall 2016. Seasons with sample types without numeric values were not collected due to insufficient flows.

Stream	Sample Type	Year	Season	# Benthic Samples	# Drift Samples	# Pan Trap Samples	# Stomach Samples
Tepee Ck	Treatment	2015	Spring	15	-	-	-
		2015	Summer	3	-	43	40
		2015	Fall	12	-	43	-
		2016	Spring	15	-	-	-
		2016	Summer	15	20	44	21
		2016	Fall				
		2015-2016	**Total**	**30**	**0**	**86**	**40**
White Ck	Control	2015	Spring	12	-	-	-
		2015	Summer	3	4	36	56
		2015	Fall	12	-	34	6
		2016	Spring	12	-	-	-
		2016	Summer	12	16	33	3
		2016	Fall				
		2015-2016	**Total**	**27**	**4**	**70**	**62**

Invertebrate prey availability

To compare invertebrate prey availability between pre-and-post treatment conditions, estimates of invertebrate abundance, biomass, and composition from benthic, drift, and allochthonous sources were obtained seasonally during the study in treatment and control sub reaches. Benthic invertebrates are collected with a 500-µm net Surber sampler (0.09 m^2 area) at 3 random locations in riffle habitat in each sub reach sample section. Invertebrate drift are estimated by placing a 500-µm drift net (0.45 m x 0.20 m) in the thalweg of riffle habitat at the upstream and downstream end of each sub reach sample section. Drift nets will be set for 20 minute intervals at dawn and afternoon. Staff positioned drift nets to intercept the total water column to ensure capture of invertebrates floating on the surface. Surber and drift samples are sieved (500-µm), large organic material removed, and organisms preserved in a 95% ethanol alcohol solution prior to processing.

During each sampling event, allochthonous invertebrate inputs were estimated from samples collected in pan traps (0.071 m^2) for 7 days. Nine pan traps were suspended 1 m above the water surface from rebar in each sub sample reach section. Pan traps were filled with approximately 3 cm of water with 2-3 drops of soap surfactant to help retain captured invertebrates. The wetted width of the stream reaches

were divided longitudinally into three subsections (left, center, and right) and three pan traps are randomly placed in each subsection. During each sampling event, the random placement of pan traps were repeated in each sub reach sample section. Pan traps are sieved (500-µm) at the end of each 7-day sample period and preserved in a 95% ethanol alcohol solution prior to processing.

Resident rainbow trout and juvenile steelhead diet

During each sampling period, resident rainbow trout and juvenile steelhead were collected in each sub reach section to sample for stomach contents. Fish are collected 24 h after instream invertebrate sampling to allow fish to return to natural foraging behavior. A variable waveform backpack electroshocker (Smith Root Inc., Vancouver, Washington) was used to collect fish. Electroshocking was conducted from the downstream end of each sub reach sample section to the upstream. Every effort was made to collect a minimum of 20 fish (≥ 70 mm fork length). Captured fish are placed in 5 gallon buckets with aerators. Sampling occurs between 10:00 and 16:00 to include stomach contents of prey from aquatic and terrestrial derived sources.

Captured fish were anesthetized in a solution of water and MS-222. Stomach contents were removed by a flushing procedure using a narrow pipetted bottle, strained into coffee filters, and placed into small plastic bags with 95% ethanol alcohol (Meehan and Miller 1978). For each fish, time and date of capture, length (nearest mm FL), and weight (to the nearest 0.1 g) are recorded. Each sampled fish receives a 12 mm Passive Interrogator Tag (Destron Fearing, South St. Paul, Minnesota). All fish were returned to their original location after fully recovering from anesthesia.

Invertebrate Identification

Invertebrates collected from the benthos, drift, pan traps, and fish stomachs were sorted under a dissecting microscope, taxonomically identified (primarily to the family level), enumerated, and measured to the nearest 0.5 mm using an eyepiece micrometer. Organisms were categorized as either aquatically or terrestrially derived based on the larval residence time (Wipfli 1997). Macroinvertebrate biomass (dry mass $mg \bullet m^{-2}$) is estimated using published taxon-specific length-mass regression equations. Lengths of partially digested organisms were estimated from intact individuals of the same taxon that appear to be of similar size (Wipfli 1997).

The sampling of additional physical and biological attributes at the sampling sites were initiated in 2009 to document and assess pre-project baseline conditions. Elements included groundwater, low-flow refugia mapping, habitat survey/mapping, vegetation inventory, juvenile *Onchorhynkus mykiss* (Steelhead/Rainbow trout) abundance estimation, and a food web study.

Fish abundance

In partnership with M&E staff, juvenile *O. mykiss* (Steelhead/Rainbow trout) populations were estimated using a multiple-pass electroshocking technique. In each sampling event, a multiple-pass electrofishing survey was conducted in each of the four Tepee (treatment) and White Creek (control) reaches. All juvenile steelhead and rainbow trout greater than or equal to 65 mm in length are tagged with a Passive

Integrated Transponder (PIT) tag and staff measure length and weight. A fixed PIT-tag detection array installed by the M&E project at the mouth of White Creek will facilitate survival and migration timing analysis on those fish tagged within the project reach.

Groundwater

Twelve shallow (~6.5'-deep) wells were installed to characterize existing groundwater conditions. They will be used for post-project effectiveness monitoring of meadow groundwater levels 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. 13). Six wells (including both controls) have sensors that measure and record water level once every hour. KWEP staff have downloaded data several times per year using a field computer. Staff take manual measurements of water level with an e-tape at the remaining six wells approximately once per month (on average). Data from four wells with continuous sampling were presented in Figure 14. In-stream construction of riffles and wood placement was initiated in October 2012 and completed in November 2013. Continuous groundwater elevation data from 2015 in Wells 1, and 6 reveal a prolonged period of raised ground water elevations (approx. 8 months), compared to before the project followed by a recession in October to base level elevations. Similar time periods in 2010-2012 show brief periods of elevated groundwater followed shortly by a receding limb of the hydrograph. The data suggest that water is being stored within the project reach as groundwater, but does not persist year-round, and may not necessarily be expressed within the reach as surface flow in Tepee Creek.

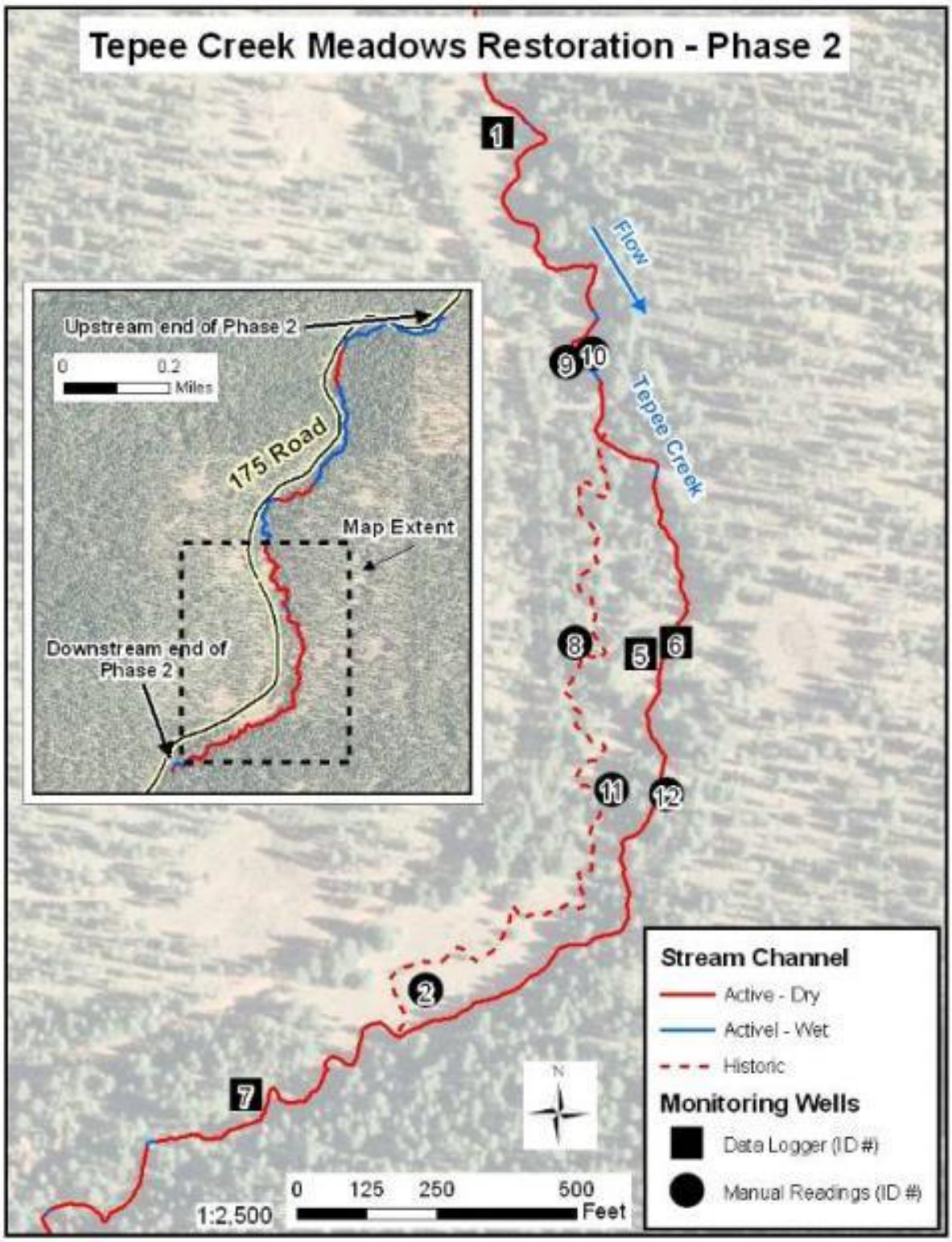

Figure 13. Distribution of monitoring wells and the portions of Tepee Creek with perennial water as observed on September 21, 2009.

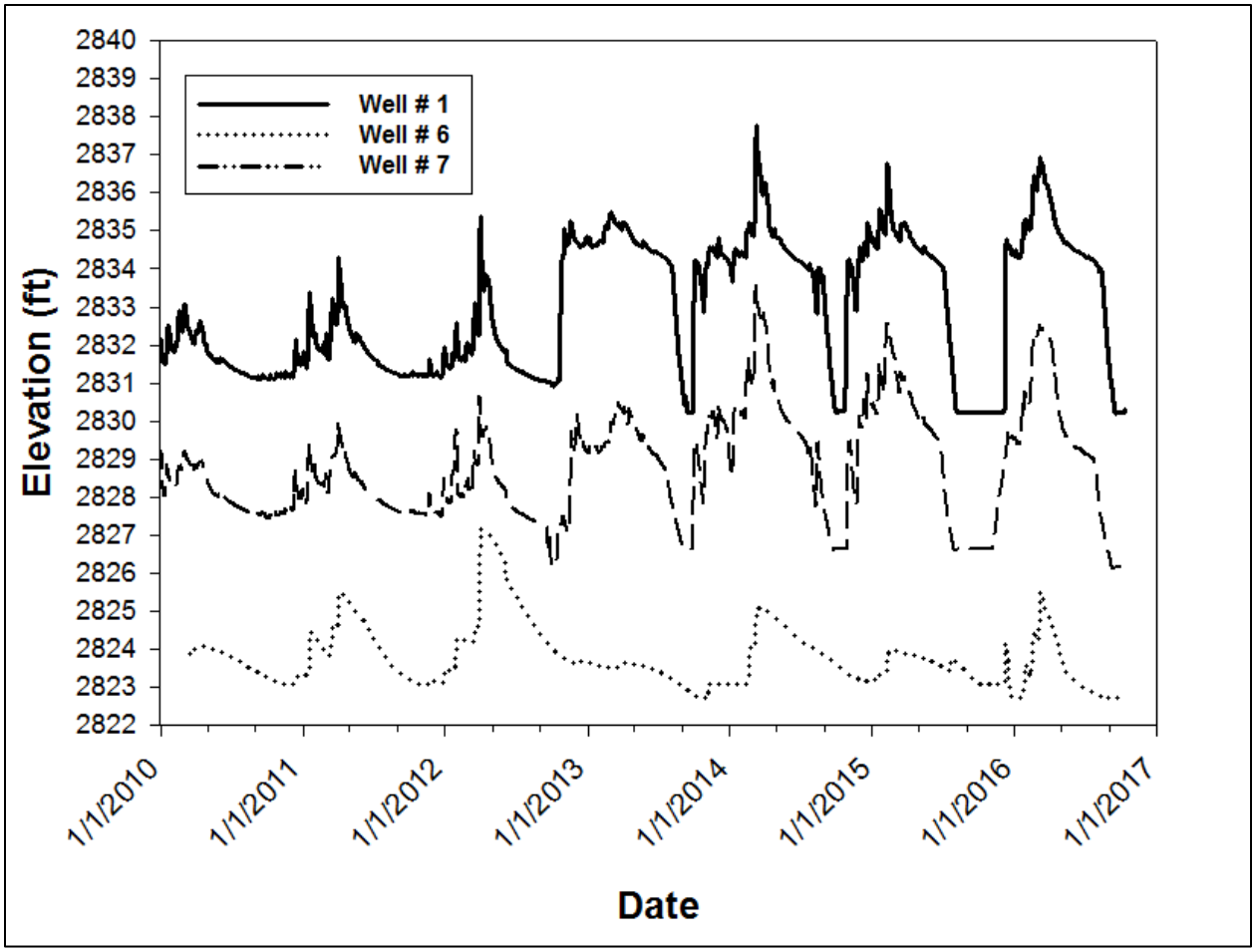

Figure 14. Groundwater surface elevations by date for wells 1, 6, (treatment) and 7 (control) for 2010-2015.

Habitat Assessment

In late 2009, KWEP and M&E staff began a review of the aquatic habitat protocol (TFW) utilized by M&E in the Klickitat subbasin to determine if it met current and future management needs. Established aquatic habitat assessment needs are:

- Determine the effectiveness of habitat enhancement projects by quantifying differences between pre- and post-project aquatic habitat conditions.
- Expand the spatial extent of known baseline conditions within the anadromous-bearing portion of the Klickitat subbasin.
- Identify stream sections that warrant further investigation as sites with potential for enhancement via intervention or restoration efforts.

The objectives for the stream habitat assessment protocol are to provide a single approach for effectiveness monitoring, status and trends monitoring, and to inform project development by identifying need, location, type, and project scope.

A variety of existing stream habitat protocols were reviewed and compared to determine if they fulfilled the defined management objectives. While there are numerous stream habitat assessments currently used in the Pacific Northwest, they vary in their performance, compatibility, and repeatability (Roper et. al. 2010). Based on this review, a new protocol was subsequently developed that combined two widely used Pacific Northwest stream classification systems, TFW (Pleus et al. 1999, and Schuett-Hames et al. 1999) and the Aquatic Inventory Project (Moore et al. 2010). Data collected in the future to characterize large woody debris will be backward-compatible with the historic TFW data. The new protocol is the Rapid Aquatic Habitat Assessment Protocol (RAHAP) (Romero and Lindley 2012). The RAHAP approach is: 1) spatially continuous, 2) relatively fast (per unit of collection), and 3) collects paired physical and fisheries data.

RAHAP utilizes field crews comprised of two people to delineate reaches, habitat units, spawning patches, wood pieces, and wood jams. Surveys are conducted in the upstream direction by defining and sequentially numbering each geomorphic habitat unit. YKFP staff collect the following metrics for each habitat unit: habitat type (pool, riffle, or glide), wetted width, maximum and residual pool depth, percent undercut banks, and bankfull width. Delineated habitat units are geo-referenced and photo-documented. Surveys to quantify LWD (jams and individual pieces) are conducted concurrently with the habitat surveys and spatially linked to the defined habitat units. Following the completion of the habitat inventories, fish abundance surveys are conducted. Single-pass fish surveys (by electrofishing or snorkeling) are conducted to spatially quantify fish distribution, composition, and relative abundance.

In fall 2015, the lower portion of the mainstem Klickitat River was surveyed from the confluence of the Little Klickitat River to a screw trap located at river kilometer 4.3. Approximately 28 kilometers of the mainstem Klickitat River were surveyed (Fig. 19) between September 12 and October 20, 2015. The lower section of the Klickitat River was selected in an effort to quantify baseline habitat conditions from the Little Klickitat River (RKM 28) to the Klickitat River delta (RKM 0).

The sampled section of the Klickitat River has a low pool frequency (1/km), minimal pieces of large woody debris (4/km), and 5 total LWD jams. Riparian vegetation is characterized by a thin band of Alder along the bank (Figs. 15 and 67). Bedrock is an important pool-forming and channel-influencing feature in the Klickitat subbasin. Bedrock was present along 3,117 meters of stream length or 11.1% of the overall length (Fig. 17).

Figure 15. Alder lined Klickitat River side-channel.

Figure 16. Typical open canopy Klickitat River side-channel.

Figure 17. Left-bank bedrock influenced scour pool, Klickitat River mainstem.

Perennial Water Mapping

In 2015, KWEP staff conducted perennial water mapping as a component of RAHAP habitat surveys. During these surveys, streams or reaches were walked and continuously evaluated for whether there was surface flow (flowing, standing or damp) or not (dry). Survey data assists in the identification of high priority reaches that provide perennial refugia and may inform potential projects aimed at enhancing these locations or utilizing them as design analogs. Swale Creek, Dillacort, Wheeler, Logging Camp, Snyder White and Tepee Creeks were surveyed as part of this effort. In subsequent annual reports, maps and summary data will be presented.

Table 4. Summary of aquatic habitat inventory data collected September-October 2015. Parentheses denote values from side channels.

Purpose	Survey Date	Stream	Total Survey Length (m)	Total Survey Area (m^2)	Avg. Bankfull Width (m)	Avg. Habitat Unit Width (m)	Pool Frequency (pools/km)	Avg. Residual Pool Depth (m)
Mainstem Habitat Survey	**9/12-10/20/2015**	**Klickitat R.**	**27,999 (6,041)**	**1,054,883 (103,594)**	**43.5**	**36.2 (12.1)**	**1.0 (2.5)**	**3.3 (1.2)**

Table 5. Summary of Large Woody Debris (LWD) and LWD Jam inventory data collected September-October 2015. Parentheses denote values from side channels.

Purpose	Survey Date	Stream	Total Survey Length (m)	Total Survey Area (m^2)	# LWD Pieces (pieces/km)	# LWD Jams (jams/km)
Mainstem Habitat Survey	**9/12-10/20/2015**	**Klickitat R.**	**27,999 (6,041)**	**1,054,883 (103,594)**	**4.2 (14.2)**	**0.18 (1.2)**

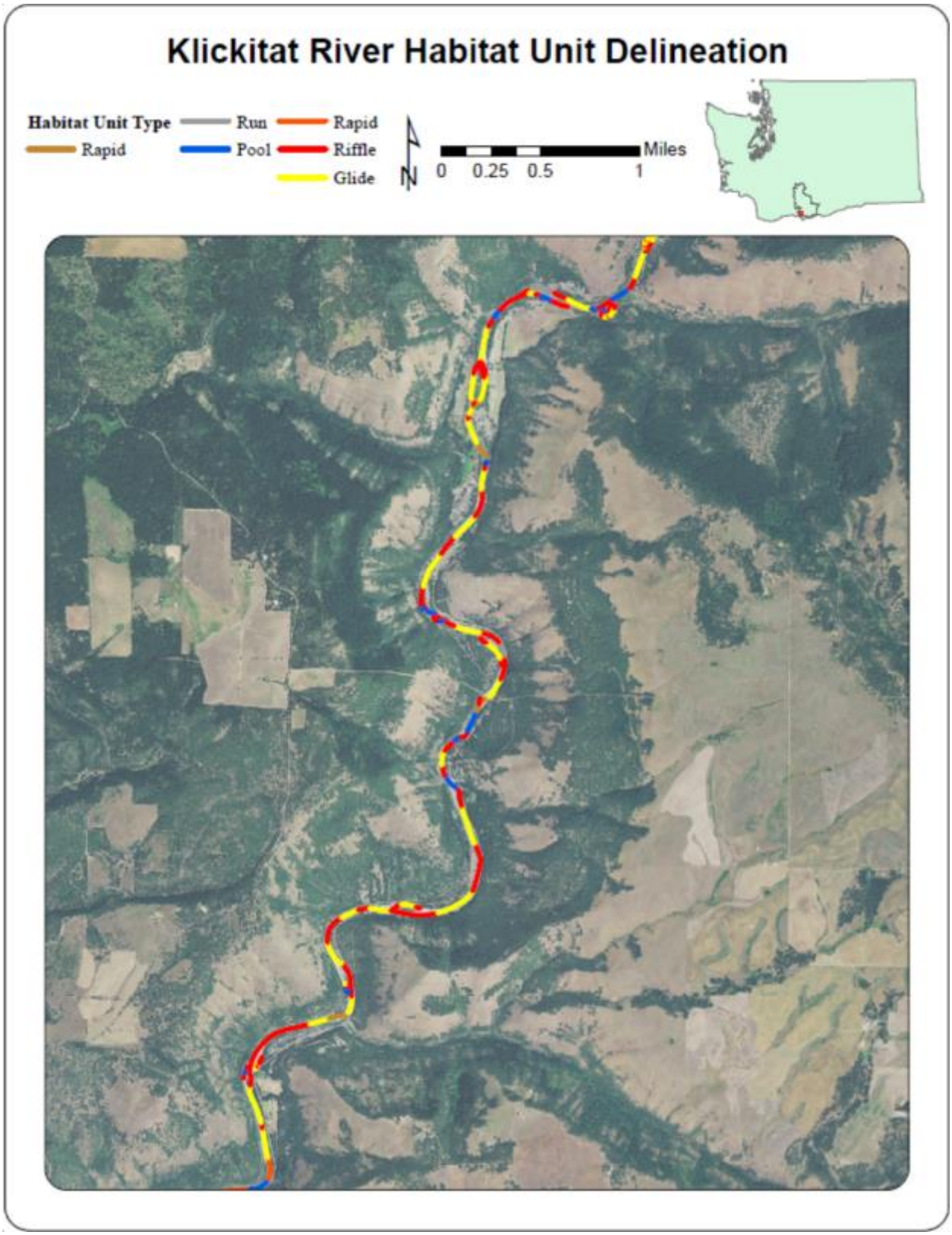

Figure 18. Habitat Units as defined during RAHAP surveys conducted fall 2015.

Collect water surface elevation data - Klickitat/Columbia River Confluence (Klickitat Delta Assessment)

YKFP fisheries biologists have expressed concern about adult upstream fish passage and juvenile migration conditions at the mouth of the Klickitat River where it meets the impounded waters of the Bonneville Pool. KWEP staff initiated sampling water surface data (August 2009) 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. KWEP staff are collecting data 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 was cost-shared by a grant received from Columbia River Inter-Tribal Fish Commission (CRITFC).

During the reporting period, the sensor array installed in August of 2009 was operated continuously (Fig. 19). Data collection was primarily monitored via a File Transfer Protocol (FTP) site KWEP staff can access from the Klickitat Field Office. KWEP staff from time to time observed discrepancies, errors, data gaps, or non-reporting that dictated site visits for troubleshooting purposes. Additional site visits were conducted to collect staff gage observations during a range of stages (Figures 20 and 21) to establish stage reference points. These reference points are used to quality-control data collected by deployed sensors.

Figure 19. Locations for sensors sampling water temperature, water surface elevation, wind direction, and wind speed for the Klickitat River delta.

KWEP staff conducted several site visits = to the East Delta site during 2015 to change out the 12-volt marine battery. The configuration of two solar panels was unable to maintain a voltage in excess of 11 volts. Encroaching vegetation and low light exacerbated this situation.

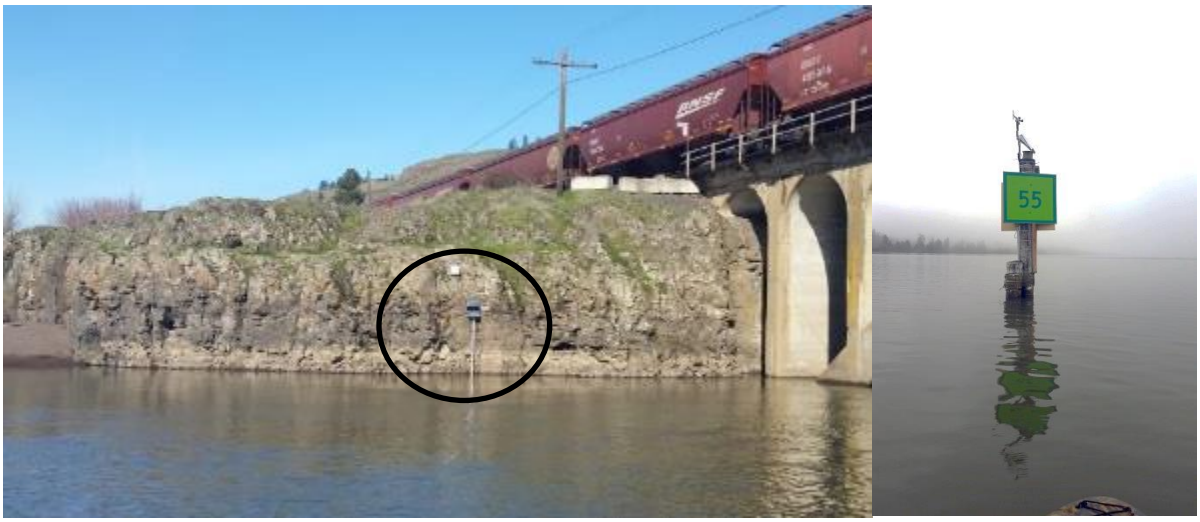

Figure 20. Basalt Cliff site under low-flow conditions (left) and February conditions at the Daybeacon.

Figure 21. Klickitat River Delta under low Bonneville Pool conditions as observed on February 15, 2015.

Measure turbidity timing and duration associated with Big Muddy Creek

Big Muddy Creek is a Klickitat River tributary that originates on the south-eastern flank of Mt. Adams and is a known source of debris flows. In the past, debris flows have contributed to salmonid mortality observed in the mainstem Klickitat River. In 2011, a data collection effort was initiated to document patterns associated with runoff production and sediment generation. KWEP Staff will use data to inform decision-making regarding location and type of enhancement projects to be implemented. Dependent upon the duration of the data collection effort, longer-term trends regarding the timing, duration and frequency of turbidity events may be characterized. In the future, as time and budget permits, suspended sediment may be measured to develop a rating curve between observed turbidity and suspended sediment loads.

In 2013, KWEP staff installed telemetry equipment at two existing sites to facilitate remote data transmission (Big Muddy Ck @ 255 rd crossing and Klickitat River downstream of Summit Ck). Due to the remoteness of the sites and critical nature of having functioning equipment during episodes of increased turbidity, remote monitoring is made possible via the GOES satellite network. Data are accessed via the Web multiple times a week to ensure the station is functioning properly. Construction and project managers utilized the turbidity-monitoring network to monitor turbidity from construction activities at the Haul Road Phase 5 during late summer and fall 2015. The long-term status-and-trend turbidity dataset that this network provides allows managers to compare the short-term, lower magnitude

turbidity events resulting from Haul Road deconstruction to naturally occurring, longer-duration, higher-magnitude turbidity events (Figure 22). In 2015-2016, the mainstem Klickitat River station downstream of Summit Creek functioned well, without interruption of data collection or transmission. The Big Muddy Creek station was vandalized in the fall of 2015 and continues to present operational challenges given the location is in a dynamic environment subject to depositional events. Operation of the Big Muddy Creek turbidity gage was temporarily halted in 2015 until a more suitable site can be identified.

Figure 22. Naturally occurring winter turbidity event on the Klickitat River, February 16, 2015, as observed from Horseshoe Bend Rd Bridge, Wahkiacus, WA.

Education and Project 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 made two presentations at conferences in 2015 and 2016 and conducted multiple field tours for various audiences. These activities are oriented toward helping the public understand our mission and objectives and communicate lessons learned to improve the field of watershed and stream restoration science.

During 2016, an Em2 Stream Demonstration Table was purchased from Little River Research and Design. The stream table demonstrates basic principles of river behavior, channel morphology, and sediment transport processes. The stream table was set up at Camp Cowabunga (Whitson Elementary School), Water Jam (White Salmon School District), and the Columbia Gorge Fisheries and Watershed Science Conference. These outreach events facilitated interactions with hundreds of students and provided a means for discussing watershed processes and concepts.

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