Tucannon River Restoration Effectiveness Monitoring:

2015 Results

Prepared for

Snake River Salmon Recovery Board

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EXECUTIVE SUMMARY

Introduction

The Snake River Salmon Recovery Board (SRSRB) is coordinating the development of restoration designs and implementation of restoration actions in the Tucannon River primarily focused on ESA listed spring Chinook. A Geomorphic Assessment and Habitat Restoration study of the Tucannon mainstem has been completed to assess historic and current conditions, and to assess and prioritize restoration actions best suited to address ecological concerns identified in the Snake River Salmon Recovery Plan (AQEA 2011, SRSRB 2011). Priority restoration actions identified during the Tucannon Assessment began in 2011. The main restoration actions proposed are levee removal/setbacks, side-channel reconnection, and the addition of large woody debris (LWD).

A set of restoration priorities with specific targets have been developed for the Tucannon River and are outlined in the recovery plan. Target recovery goals have been developed for a single metric related to each of the following restoration priorities: channel confinement, large woody debris, riparian condition, substrate conditions, and water temperature. These targets are designed to achieve a 17% improvement in overall habitat conditions. This monitoring report will assess progress towards these targets. Further, Eco Logical Research Inc. (ELR) is working with the SRSRB to establish a larger set of additional metrics based on broad ecological concerns related to the restoration priorities to further assess status, trends, and effectiveness of the ongoing restoration. Targets for these extra metrics have not been established at this time.

The monitoring plan consists of three main components: Columbia Habitat Monitoring Program (CHaMP) surveys, rapid habitat surveys, and remote sensing assessments (LiDAR, aerial photography, and other readily available GIS data). CHaMP and rapid habitat data is collected and analyzed annually but LiDAR and aerial photography will only be reviewed periodically. The Tucannon River was selected as a CHaMP watershed in 2011 and ELR helped to develop sampling strata and implement a generalized random tessellation stratification (GRTS) sampling design that distributed monitoring sites within restoration (treatment) and non-restoration (control) reaches along the mainstem Tucannon River, and in the lower reaches of major tributaries. The reaches are collectively referred to as the domain of inference. The domain of inference was selected as the presumed historical extent of spring Chinook. The sample design incorporates annual and panel year sites based on a three year rotating panel design.

This report presents the results of CHaMP surveys from 2011-2015 as well as the results from rapid habitat surveys, and a preliminary assessment of confinement and riparian condition. LiDAR and aerial photography were collected in 2010 along the mainstem of Tucannon River and will be recollected in 2017 or later, at which time a more continuous assessment of the habitat changes will be conducted.

Restoration Completed

Five levee removal projects and 11 LWD treatment projects have been completed during the assessment period (2011-2015). Ten projects have occurred in the upper Tucannon River (river mile 12.3-50.2) and one project in the lower Tucannon River (river mile 0-12.3). Since 2011, 3468 key pieces of LWD have been added to the channel, 7.5 km of levee has either been removed or set back, and 6 km of side channel habitat has been created or reconnected.

Effectiveness by Assessment Unit

We have sampled a complete panel rotation (three years) plus an additional two years of CHAMP sites: 49 total sites with 134 unique visits. The sampling so far has confirmed previous assessments that the mainstem is relatively confined and has low instream channel complexity. Based on a GRTS rollup of all CHaMP data collected between 2011-2015 by location, the status of the lower Tucannon River generally is less confined and has more pools and large woody debris than the upper Tucannon River. However, both the Lower and Upper Assessment units have < 1 key pieces of LWD (> 6m long and >0.3 m diameter) per bankfull width and relatively low habitat diversity. The frequency of deep pools (≥ 1 m deep) is 1.27 in the lower and 0.5/100 m in the upper Tucannon River. There is not enough data to reliably detect trends in most of the CHaMP data when summarized across the assessment units at this time.

Effectiveness by Project

Comparison of CHaMP data from treatment in project areas to control sites nearby within the same River Style are showing positive changes in channel complexity and channel form. For example, on average there has been an increase in treatment sites (levee removal and/or LWD additions) compared to control sites of LWD frequency by 530%, channel unit frequency by 20%, and pools by 43%. Other channel characteristics are not showing consistent changes such as average thawleg and width to depth ratio and we are seeing limited geomorphic change when comparing erosion and deposition rates using topographic data.

Watershed Assessment Tools

This report also provides new data analyses on the condition of valley bottom confinement and riparian conditions derived from GIS data. These analyses suggest that large portions of the valley bottom are still disconnected and the current extent of riparian habitat is a small fraction of the historic extent.

Conclusion

We have presented several monitoring methods (CHaMP, rapid, and watershed scale assessments) that can provide insight into the effectiveness of the restoration actions in the Tucannon. We will work with the TCC to refine these approaches and finalize the DRAFT monitoring plan so that it will be clear moving forward what data is needed to fully understand the effectiveness of the ongoing restoration actions.

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LIST OF ABBREVIATIONS AND AGENCIES

AQEA	- Anchor QEA
CCD	- Columbia Conservation District
CHaMP	- Columbia Habitat Monitoring Program
CTUIR	- Confederated Tribes of the Umatilla Reservation
DEM	- Digital elevation model
ELJs	- Engineered Log Jams
ELR	- Eco Logical Research Inc.
GCD	- Geomorphic Change Detection using the difference between two DEMs
GRTS	- Generalized random tessellation stratification
LWD	- Large woody debris
NOAA	- National Oceanic and Atmospheric Administration's
RTT	- Regional Technical Committee
SRSRB	- Snake River Salmon Recovery Board
TCC	- Tucannon River Coordinating Committee (includes members of AQEA, CCD, CTUIR, NOAA, USFS, WDFW)
USFS	- United States Forest Service
WDFW	- Washington Department of Fish and Wildlife

1 INTRODUCTION

1.1 BACKGROUND

The Snake River Salmon Recovery Board (SRSRB) are proposing a series of large-scale restoration actions in the Tucannon River in southeast Washington as part of the Biological Opinion (BiOP) requirements to recover Endangered Species Act (ESA) threatened spring Chinook salmon (*Oncorhynchus tshawytscha*). It is expected that other ESA listed salmonids will also benefit from the restoration actions including fall Chinook salmon, steelhead (*O. mykiss*), and bull trout (*Salvelinus confluentus*). The primary goals of the restoration actions are to restore physical and biological processes to address the ecological concerns for spring Chinook salmon and other salmonids in the Tucannon River. Ecological concerns were specifically identified for spring Chinook during the sub-basin planning process and have been updated during the recent revision of the Snake River Sub-basin Plan (SRSRB 2011). The specific objectives of the restoration actions are to provide a 17% overall improvement in habitat conditions across all restoration priorities by 2018, or soon thereafter, to meet objectives outlined in the Tributary Actions Analyses (NOAA 2008). The restoration priorities are: channel confinement, large woody debris, riparian condition, substrate embeddedness, and water temperature.

A Geomorphic Assessment and Habitat Restoration study of the Tucannon watershed has been completed to assess the historic and current conditions of the Tucannon watershed and to assess and prioritize restoration options best suited to address the ecological concerns (AQEA 2011). The extent of the assessment was from the mouth (RM 0) to RM 50.2 at the confluence of the mainstem Tucannon River and Panjab Creek (RM 50.2; Figure 1). Following the geomorphic assessment, conceptual restoration plans were developed based on a prioritization of the potential restoration benefits. The assessment area in the Tucannon River is divided into the Lower and Upper Assessment units (Figure 1). Pataha Creek is not included in the assessment. The majority of the restoration is focused on improving conditions for spring Chinook in the Upper Assessment Unit (upstream of RM 20). The main restoration actions proposed are levee removal/setbacks, side channel reconnection/creation, and the addition of large woody debris (LWD).

Eco Logical Research Inc. (ELR) was tasked with developing a monitoring plan to determine the effectiveness of the proposed restoration activities on fish habitat (Bennett and Hill 2013). The monitoring plan consists of three main components: Columbia Habitat Monitoring Program (CHaMP 2014) surveys, rapid habitat surveys, and watershed scale assessments using LiDAR/aerial photography and other readily available spatial data such as vegetation cover (Rollins 2009, WSI 2010). The Tucannon River was selected as a CHaMP watershed in 2011 and ELR helped to develop a sampling design that allocated CHaMP sites within restoration (treatment) and non-restoration (control) areas throughout the domain of inference which was selected as the presumed historical extent of spring Chinook (Figure 1). The sample design incorporates 12 treatment and 28 CHaMP control sites throughout the mainstem, and 9 tributary sites. These sites will be used to collect detailed habitat and topographic data as described in the CHaMP protocol (CHaMP 2014).

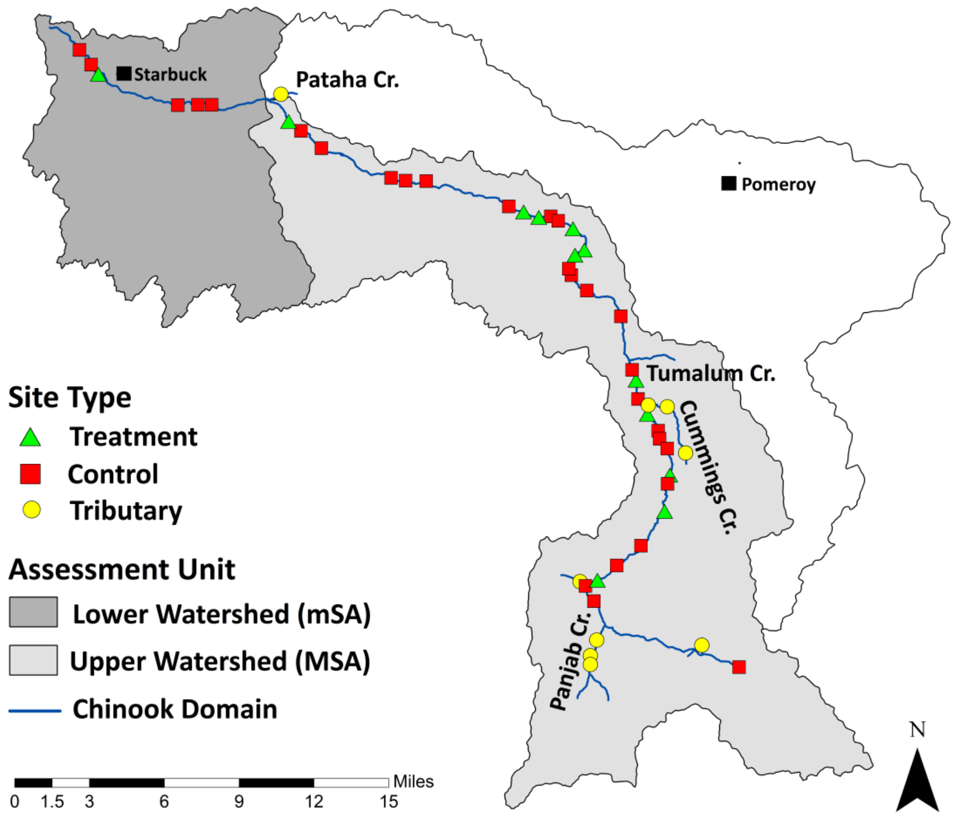

Figure 1. Tucannon River watershed, Lower and Upper Assessment units, Chinook domain (i.e., historic extent of Chinook use), and CHaMP treatment and control site locations.

1.2 REPORT GOALS AND OBJECTIVES

The goals of this report are to present preliminary findings of the CHaMP monitoring program for the period 2011-2015, and describe ongoing efforts to monitor and assess restoration priorities and goals. This period represents the first full cycle of the CHaMP three-year rotating panel study design plus an additional two years. The specific objectives of the report are to i) described the restoration to the end of 2015, ii) present results from ongoing status and trend surveys of habitat conditions at the assessment unit scale and the project scale, iii) provide a provisional assessment of the effectiveness of restoration actions, iv) and outline further monitoring actions through 2018.

1.2.1 ECOLOGICAL CONCERNS, METRICS, AND TARGETS

The Snake River Salmon Recovery Board (SRSRB) identified five ecological concerns in the Tucannon River that affect the spring Chinook population (ADEQ 2011). The Lower and Upper Assessment units have similar restoration targets except that the Upper Assessment unit does not have a target for embeddedness (Figure 1 and Table 1). The Lower Assessment unit is described as a minor spawning area (mSA) located from river mile (RM) 0.0 – 12.3 and the Upper Assessment unit is a major spawning area

(MSA) located from RM 12.3 – 60.0 (SRSRB 2011). The BiOP requires a 17% overall improvement in ecological concerns by 2018 or soon thereafter.

Along with the 17% improvement in ecological concerns, we have expanded the set of metrics to be monitored with respect to five broad ecological concerns and set preliminary restoration targets of 50% improvement for 75% of the CHaMP treatment sites by 2018 (Appendix I). We have expanded the set of metrics based in part on recommendations in Kershner and Roper (2010) and Bisson et al. (2009) that suggest using a range of metrics to assess restoration "success" for each specific ecological concern. Many of the metrics we are proposing to use come from the existing CHaMP dataset and require no further data collection or analysis to obtain (e.g., total LWD frequency, percent pools, width to depth ratio, thalweg depth coefficient of variation, etc.). However, some metrics will require analysis of post-treatment LiDAR or other data sources (see Section 2.3.4). All metric definitions and calculations presented in this report are provided in Appendix I.

Table 1. Ecological concerns by assessment unit and restoration targets proposed to determine the effectiveness of restoration in the Tucannon River. Ecological concerns are listed in order of priority for restoration (SRSRB 2011). BFW = Bankfull Width.

Lower Assessment Unit mSA (from Pataha Creek downstream to the Tucannon mouth)		
Ecological Concern	**Target**	**Metric Description**
Water Temperature	< 4 days > 72 F	summer water temperature
Substrate Conditions	< 20%	embeddedness
Large Woody Debris	> 1 key piece/BFW	≥ 0.3 m diameter and ≥ 6 m long
Riparian Condition	> 40 to 75% of max	riparian cover
Channel Confinement	<25 to 50%	confinement of stream bank length
Upper Assessment unit MSA (from Pataha Creek upstream to Tucannon headwaters)		
Ecological Concern	**Target**	**Metric Description**
Riparian Condition	> 40 to 75% of max	riparian cover
Large Woody Debris	> 1 key piece/BFW	≥ 0.3 m diameter and ≥ 6 m long
Channel Confinement	<25 to 50%	confinement of stream bank length
Water Temperature	< 4 days > 72 F	summer temperature

2 METHODS

We outlined two basic monitoring approaches in the monitoring plan: Implementation Monitoring and Effectiveness Monitoring (Bennett and Hill 2013). In order to track the effectiveness of restoration actions at improving instream habitat complexity and floodplain connectivity it will first be necessary to determine the extent of restoration actions. Implementation monitoring has been suggested as the first step assessing restoration effectiveness (Bernhardt et al. 2005, Katz et al. 2007). The goal of implementation monitoring is to determine whether the restoration was implemented as designed (Kershner 1997). We will conduct implementation monitoring in partnership with the TCC and SRSRB each year after restoration activities have been completed. We outline the methods and data we will collect in Section 2.2.

Effectiveness monitoring is used to evaluate whether the specified activities had the desired effect (Kershner et al. 2004). To conduct effectiveness in the Tucannon River we are using a variety of monitoring protocols and comparisons. Where appropriate, we integrate data from multiple sources available across the watershed to maximize our ability to detect changes in the availability and quality of freshwater habitat. To do this we are coordinating data collection between the various groups working within the Tucannon watershed and promote the collection of standardized attributes and calculation of metrics. The major data sources that we are aware of include the CHaMP (CHaMP 2014), Confederated Tribes of the Umatilla Reservation (CTUIR) habitat monitoring using ODFW's habitat monitoring protocol (Moore et al. 2008), WDFW assessments of restoration structures (protocol to be defined), USFS temperature and habitat monitoring, LiDAR and aerial photography collected in 2010, and the original Tucannon geomorphic assessment (ADEQ 2011a). We outline the methods and data we will collect for effectiveness monitoring in Section 2.3.

2.1 DESIGN HYPOTHESES AND EXPECTED RESPONSES

We developed a set of draft design hypotheses which directly or indirectly stem from the conceptual model of the current conditions derived from reviewing past assessments and consultation with project managers, and participating technical staff (Appendix II; Bennett and Hill 2013). From this understanding of the current stream conditions we generated an envisioned condition post restoration that we then used to form specific, testable hypotheses, and a monitoring plan to test those hypotheses. We will seek input from the Tucannon River Coordinating Committee (TCC) to review and revise the restoration hypotheses and present monitoring data to test these hypotheses in futures reports for both short-term responses (immediately after construction) and long-term responses (after the first high flow event). We expect some reconnections will not be immediately connected to the main flow due the dynamic nature of alluvial channels. Reconnections and levee setbacks may remain relatively unchanged for several years once they are given an "opportunity" to become active by infrastructure removal or direct excavation. In the same way, some LWD may be washed away or be relatively inactive once placed in a project area. The monitoring infrastructure is set up to learn from these situations as much as from immediate and dynamic responses.

2.2 IMPLEMENTATION MONITORING

The proposed implementation monitoring methods are as follows:

SRSRB will be performing as-built surveys for each of the projects. Other project sponsors have not decided on the level of detail for implementation monitoring. We propose that the following implementation monitoring be completed for all projects:

Project Type – clear description of the restoration action using a consistent terminology (* we recommend the terms already defined by AQEA (2011a,b,c).

Project location – mapping and/or surveying of all levee setbacks or removals, GPS locations of all LWD structures using the control network established for the monitoring plan (see below).

Timing – description of the time projects were started and completed.

Magnitude – detailed description of the project extent (i.e., amount of levee removal in linear feet and volume, or number and size of LWD additions).

Methods – description of how treatment areas were restored (e.g., construction methods and materials).

Project details – were the structures secured on site and if so, how; was riparian vegetation from the levee added to mainstem or side-channels to enhance habitat complexity; were structures labeled, if so, what markings were used and where were they placed.

Photo documentation – all restoration sites should be photographed pre and immediately post restoration to act as a permanent record of site conditions. Standard photo points should be collected (i.e., photo upstream, downstream, river left and river right) at each restoration structure or site.

2.3 EFFECTIVENESS MONITORING BY ASSESSMENT UNIT

In this section we describe the methods we are employing to implement effectiveness monitoring. First we are using a modification of a reach classification exercise known as the River Styles framework (Brierley and Fryirs 2005). The modified River Styles framework we are using is a combination of a hydrologic and geomorphic classification system which provides tools for interpreting river character (form), behavior (e.g. processes that create or maintain river form), and assessment of geomorphic condition. Two other steps in the framework are determining the recovery potential of stream segments and prioritizing areas for restoration; however, these steps are not part of the effectiveness monitoring plan. Within this river classification framework, we are collecting data at the site, project, and watershed scale using a variety of methods. At the site scale (100-400 m) we are using the Columbia Habitat Monitoring Protocol (CHaMP) to collect channel and riparian data. At the project scale (500-3000 m) we are using CHaMP data and a Rapid Habitat data protocol that is designed to generate a small number of key metrics to assess project effectiveness. At the watershed scale (expert panel Assessment Areas; 10-75 km), we are using readily available spatial data and custom GIS Network Tools to assess the effectiveness of multiple projects (i.e., overall change in habitat metrics) within River Styles and Assessment Units. The River Styles framework and individual monitoring approaches are described in more detail below.

2.3.1 RIVER STYLES

The River Styles framework provides a method for understanding why rivers look and behave the way they do given the imposed sediment and water flux and how they might look in the future, given specific management actions. The nested hierarchical classification system embraces the relationship between large-scale processes of sediment and water flow that directly influence smaller scales. As such, the large-scale features within the watershed are characterized with the delineation of dominant landscape units. Stage 1 and 2 of the River Styles framework have been implemented as part of the monitoring plan and are in draft form (Portugal et al. 2015). We will revise stage 1 and 2 in 2017 as part of the monitoring plan implementation based on feedback from the TCC.

Stage 1 classification – the perennial network of the Tucannon River has been classified into geomorphically distinct stream reaches by conducting a baseline survey of stream form and behavior within the target watersheds. Stage 1 was completed with readily available geospatial data (LiDAR, aerial photography, soils, geology, LANDFIRE, etc.), an aerial survey, and limited field surveys of the Tucannon watershed (Portugal et al. 2015).

Stage 2 condition - will estimate the evolution and geomorphic condition of all reaches within the target watersheds using historic assessments (USFS 2002, CCD 2004, Bilhimer et al. 2010, AQEA 2011) and ongoing surveys (CHaMP 2014). Stage 2 will allow us to determine which reaches are the most degraded and which fluvial geomorphic processes are not properly functioning (i.e., departure from a reference condition that will be identified for each river type). Reference conditions are identified so that only departures from relevant abiotic and biotic indicators are used to assess a reach's condition. We will bolster the condition assessment with spatially explicit network based models of floodplain (e.g., confinement), LWD input, and riparian condition. These models are described in Section 2.3.42.3.4.

2.3.2 COLUMBIA HABITAT MONITORING PROTOCOL (CHAMP)

We are using the Columbia Habitat Monitoring Program (CHaMP) protocol to collect habitat data (CHaMP 2014). The Tucannon was selected as a CHaMP watershed in 2011 and a survey design was established using control and treatment areas as strata for distributing site locations. The Tucannon CHaMP study design uses the generalized random tessellation stratified survey (GRTS; Stevens and Olsen 2004) to distribute sampling effort across the Chinook domain in the treatment and control strata identified at the beginning of the project (Figure 1). After five years, all annual sites and panel sites plus an additional two years of panel sites have been sampled. Each year the sites that are surveyed are assigned a GRTS weight based on the stratum extent (km) / number of sites within stratum. This weighting is done using SPSurvey in R (http://cran.r-project.org/web/packages/spsurvey/index.html).

The status and trends of a variety of metrics that characterize channel form, instream complexity, floodplain, riparian, and substrate conditions are then calculated by using the weighted mean of each metric based on GRTS. We present the five-year status and trends for the Lower and Upper Assessment units, and all tributaries combined as well as 95% confidence intervals for all years combined (2011-2015). In future reports we can present a rollup of the CHaMP data by different subgroups (e.g., River Styles, Treatment and Control) based on feedback from the TCC.

Project effectiveness evaluations are provided by assessing the pre and post restoration conditions at CHaMP sites within individual project areas as data becomes available. For these analyses, we compare changes in average metric values between pre and post restoration time periods for the treatment site and control sites within the same River Style.

There are three data sets collected during a CHaMP survey: auxiliary, topographic, and temperature data. See www.champmonitoring.org and CHaMP (2014) for details on the specific protocols for each type of data collected.

2.3.2.1 AUXILLIARY DATA

The CHaMP auxiliary data is collected at the habitat unit scale (e.g., slow water, fast water turbulent, and fast water non-turbulent) using counts, measurements, and/or visual estimates of key attributes thought to be related to fish habitat quality (e.g., LWD, sediment, fish cover, riparian cove, solar input, etc.). Data are summarized across habitat types and the site length to calculate the frequency of key attributes (e.g., LWD/100 m).

2.3.2.2 TOPOGRAPHIC DATA

The bankfull channel and banks are mapped using standard survey methods with a total station and rod. Topographic data (X, Y, Z points) is used to generate relatively high resolution (10 cm accuracy) digital elevation models (DEM) of the site. These DEMs can then be compared from year to year and changes in elevation (erosion and deposition) can be calculated in GIS using custom software. Hydraulic models can also be run using the digital elevation models and used to predict habitat suitability along with auxiliary data on channel roughness.

2.3.2.3 TEMPERATURE MONITORING

Temperature probes are maintained at each CHaMP site, downloaded annually, and uploaded to the CHaMP website (champmonitoring.org). The temperature data is summarized based on daily mean, maximum, minimum, and 7-day average maximum values. We also summarize the number of days the temperature exceeds 72° F at each site as part of the ecological concerns effectiveness monitoring.

These data are compared to annual discharge estimates collected from the Department of Ecology gauge at Marengo #35B150.

2.3.3 RAPID HABITAT ASSESSMENTS

In addition to monitoring with the CHaMP protocol, we initiated a rapid habitat survey along with SRSRB staff to expand the spatial coverage of habitat surveys. Rapid habitat surveys are a cost efficient method that measures key attributes (LWD, pools, side channels) continuously along the river corridor. We have developed a GIS Pro™ application for use on an iPad to collect these data within GIS while in the field so that each attribute has a spatially explicit location. Data collected from these surveys are used to summarize key metrics at larger spatial scales (i.e., project area) compared to CHaMP surveys and provides a means to monitor the implementation of restoration projects by SRSRB staff (Hill and Bennett 2014). Rapid habitat data are analyzed in a similar way to project effectiveness by comparing the changes between pre and post treatment metrics in treatment and control project areas.

2.3.4 WATERSHED LEVEL CONDITION ASSESSMENTS WITH NETWORK TOOLS

We are working with CHaMP and ISEMP to apply GIS tools to conduct condition assessments on ecological concerns that cannot be easily assessed with CHaMP or rapid survey data (e.g., riparian and floodplain conditions, and LWD recruitment potential). These assessments are part of a larger effort to develop and validate tools that use readily available GIS data to assess the condition of floodplain and riparian habitats in a consistent manner across watersheds in the Columbia River Basin. Below we briefly describe the tools. Two key tools are used: the valley bottom extraction tool (V-BET; Gilbert et al. 2016) and the riparian condition assessment tool (R-CAT; Macfarlane et al. 2016).

2.3.4.1 VALLEY BOTTOM CONFINEMENT

To determine the current extent of valley bottom confinement and reductions in confinement due to restoration we are using GIS tools combined with ground truthing. We define the valley bottom as a low lying area of a valley comprised of both the stream channel and contemporary floodplain. This area also represents the maximum possible extent of riparian areas of the streams associated with the valley bottom. We are using the valley bottom extraction tool (V-BET) in GIS to delineate the valley bottom consistently across assessment units (Gilbert et al. 2016). V-BET uses a minimum of two input datasets, a Digital Elevation Model (DEM) and a stream network to create a polygon representing the valley bottom. We are comparing two sources of DEM - the nationally available 10 m dataset and a 1 m dataset collected for the Tucannon and Cummings Creek mainstems (WSI 2010) to determine the how well each data set can assess confinement. The valley bottom polygons are also used as an extent for the riparian condition assessment.

2.3.4.2 RIPARIAN CONDITION ASSESSMENT

The riparian condition assessment tool (R-CAT) is a lotic riparian area (valley bottom) mapping, condition assessment, and recovery potential tool intended to help researchers and managers assess riparian condition and recovery potential over large regions and watersheds (Macfarlane et al. 2016). The R-CAT model can be run with nationally available existing GIS datasets or high resolution landcover and DEM datasets. The models are designed to delineate valley bottoms, assess riparian vegetation, evaluate floodplain condition, and estimate recovery potential of riparian areas. The stream network model consist of the following: the valley bottom extraction tool (V-BET), riparian vegetation departure (RVD) from historic condition tool, riparian condition assessment (RCA) tool and riparian recovery potential (RRP) tool. These network models were first developed and implemented across the Colorado Plateau Ecoregion and the state of Utah. The models are now being run for the Interior Columbia River Basin. We are currently using LANDFIRE data (2012) as the vegetation input. By assessing the riparian condition, we can also develop a model to predict the potential input of LWD to the stream channel which can be used to assess the sustainability of LWD inputs.

2.4 EFFECTIVENESS MONITORING BY PROJECT

To determine the effectiveness of restoration actions within each individual project area, we compare pre and post treatment CHaMP results for sites within treated project areas to the pre and post treatment average of control sites within the same River Style and assessment unit. We compare treatment sites to control sites within the same River Style and assessment unit because sites within a similar River Style (or geomorphic setting) are expected to behave similarly which allows us to more adequately compare the effectiveness of restoration at treatment sites. From 2011-2015, five CHaMP sites were sampled that represent post treatment results. These sites reflect post treatment conditions in Project Areas: 3, 10, 14, 15, and 26. All treatment and control sites are located within the Partly Confined, Low to Moderate Sinuosity Wandering Gravel/Cobble Bed River Style in the Upper Assessment unit.

3 RESULTS

Results are presented by quantifying the restoration implementation (Section 3.1 and 3.2) and assessing the effectiveness of restoration at the assessment unit (Section 3.3), project area scale (Section 3.4), and the watershed condition (Section 3.5).

3.1 RESTORATION IMPLEMENTATION BY ASSESSMENT UNIT

Restoration is planned for over 24 km of the mainstem Tucannon River. This includes approximately 23 km in the Upper Assessment unit and 1 kilometer in the Lower Assessment unit (Figure 2; Table 2). Since 2011, approximately 77% of the planned restoration actions in the Upper Assessment unit (based on river length) have been completed and 100% of planned restoration actions in the Lower Assessment unit have been completed. Implementation of restoration actions in 2015 occurred after CHaMP sampling in Project Areas 11, 23, and 24. Therefore, results from 2011-2015 do not represent post treatment conditions within these Project Areas. Post treatment results are available at five Project Areas: 3, 10, 14, 15, and 26. These post treatment results represent approximately 43 percent of the total restoration planned in the Upper Assessment unit.

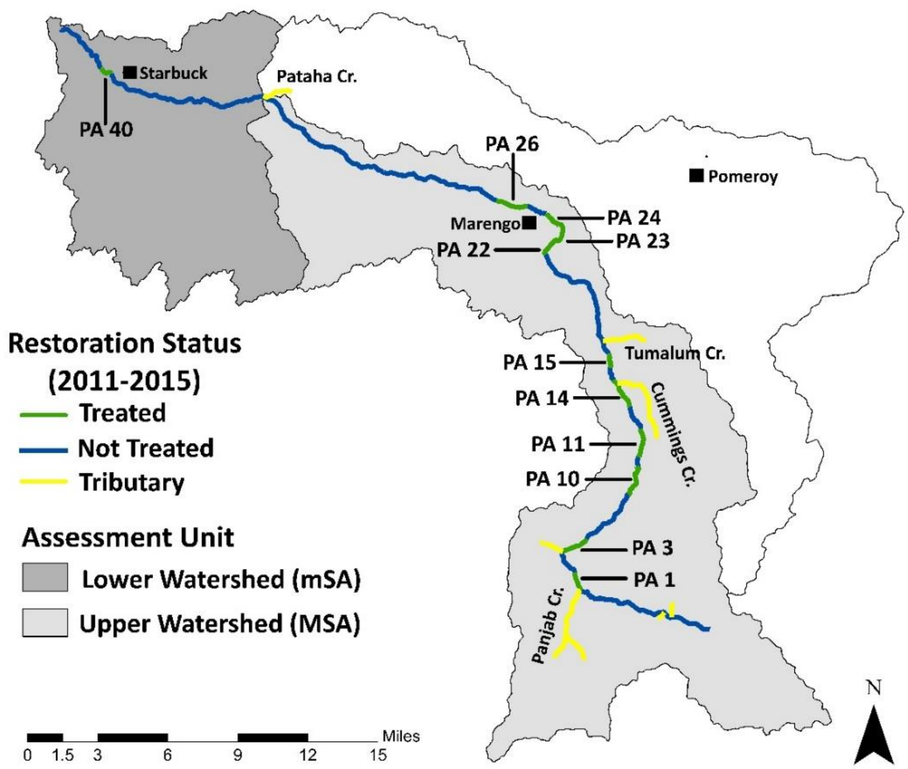

Figure 2. Tucannon River Chinook domain delineated by Project Areas (PA) treated from 2011-2015, areas not treated (as of early summer 2015), and tributaries within the Lower and Upper Assessment units. No restoration actions are planned in tributaries at this time.

Table 2. River lengths within the Tucannon River Chinook domain, the total percent of river designated as treatment and control segments within the Lower and Upper Assessment units, and the total percent of restoration completed from 2011-2015.

	Lower Assessment unit (Mainstem)	Upper Assessment unit (Mainstem)	Tributary
Total River Length (km)	17.31	67.79	21.98
Planned Treatment Length (km)	0.95	22.69	NA
Control Length (km)	16.36	45.10	NA
2011-2015 Treatments Completed (% of Total Planned Treatment Length)	100	76.95	NA
2011-2015 CHaMP Post Treatment Results (Sites Representing % of Total Planned Treatment Length)	100	43.68	NA

3.2 RESTORATION IMPLEMENTATION BY PROJECT AREA

Restoration was completed in 11 project areas between 2011 and 2015 (AQEA 2011, Table 3). This includes the implementation of one project in 2011, 2012, and 2013, 6 projects in 2014, and 1 project in 2015. Thus far, 7.5 km of levee has been removed or setback, 6 km of side-channel has been created or reconnected, and over 3400 key pieces (>.3m diameter, >6m long) of LWD have been added.

Table 3. Location, restoration action, and year of implementation by project area within the Tucannon River from 2011-2014. Table adapted from Tucannon River Programmatic 2014 Annual Progress Report. Note that table does not include data for Project Area 40 (Buelow and Martin 2014).

Project Area	Year	River Mile		Total Length (km)	# Key LWD Pieces Added	Levees (km)		Side Channels (km)		CHaMP Post Treatment Sample
		From	To			Remove	Set Back	New	Reconnect	
1	2014	49.5	50.1	1.0	231	-	-	0.6	-	N
3	2014	46.8	48.1	2.1	324	-	-	-	-	Y
10	2012	42.4	44	2.6	300	0.4	-	1.2	0.8	Y
11	2015	40.7	42.3	2.6	582	-	-	0.1	0.4	N
14	2014	37.2	39.2	3.2	712	-	-	2.0	0.3	Y
15	2014	36.4	37.2	1.3	597	0.1	-	0.5	-	Y
22	2014	29.3	30.3	.6	36	-	-	-	-	N
23	2015	28.3	29.3	.6	51	0.2	-	-	-	N
24	2015	27.5	28.3	1.3	498	0.1	-	0.3	0.2	N

26	2011, 2013	23.7	26.9	5.1	78	2.5	3.7	-	-	Y
40	2014	1.8	4.5	4.3	59	.4		0.4	0.7	Y
TOTAL	-	-	-	24.7	3,468	3.7	3.7	5.1	2.4	-

3.2.1 PROJECT AREA 1

Restoration in Project Area 1 (RM 49.5-50.1) downstream from Panjab Creek was sponsored by the Confederated Tribes of the Umatilla Indian Reservation and implemented in 2014. The objectives of this project were to increase channel complexity and side channel habitat. Approximately 231 key pieces of LWD were added and over 550 m of side channels were reconnected or created (Figure 3). More information about this project can be found at: Project Area 1.

Figure 3. Restoration implemented in Project Area 1 included the creation of side channels and addition of LWD structures. No CHaMP site is present in this Project Area. Photos courtesy of the SRSRB.

3.2.2 PROJECT AREA 3

Restoration in Project Area 3 (RM 46.8-48.1) between Camp Wooten and the Little Tucannon River was implemented in 2014. The primary objective of this project was to increase channel complexity by adding LWD to the stream channel. Approximately 324 key pieces of LWD were added to the project area (Figure 4). This project was sponsored by the Confederated Tribes of the Umatilla Indian Reservation. More information about this project can be found at: Project Area 3.

Figure 4. Restoration in Project Area 3 included the addition of LWD by helicopter. Photos show LWD structure located in CHaMP site 519039. Aerial photo courtesy of the Pomeroy Conservation District.

3.2.3 PROJECT AREA 10

Restoration in Project Area 10 (RM 42.4-44.0) between Beaver/Watson Lake and Big 4 Lake was sponsored by the WDFW and implemented in 2012. The objectives were to reduce channel confinement and incision as well as increase channel complexity. Over 350 key pieces of LWD were added during restoration (Figure 5). More information about this project can be found at: Project Area 10.

Figure 5. Restoration implemented in Project Area 10 included the addition of LWD.

3.2.4 PROJECT AREA 11

Restoration in Project Area 11 (RM 40.5-41.8) between Deer and Watson Lakes was implemented in 2015. The objectives of this project were to improve and maintain floodplain connectivity and increase in-stream complexity. Within the Project Area, approximately 657 key LWD pieces were used to construct 94 LWD and ELJ structures (Figure 6). This project was sponsored by the Washington Department of Fish and Wildlife. More information on this project can be found at: Project Area 11.

Figure 6. Project Area 11 pre and post-treatment conditions (from Rapid Habitat Surveys) for key LWD pieces and side channels. CHaMP post-treatment sample not available for this report.

3.2.5 PROJECT AREA 14

Restoration in Project Area 14 (RM 37.2-39.2) between Cummings Creek and the Tucannon Fish Hatchery was implemented in 2014 and included addition of over 700 key pieces of LWD and the creation/reconnection of over 2200 m of side channel (Figure 7). The objectives were to improve floodplain connectivity and instream channel complexity. This project was sponsored by the Washington Department of Fish and Wildlife. More information on this project can be found at: Project Area 14.

Figure 7. Restoration implemented in Project Area 14 included the creation and reconnection of side-channels (left photo) and installation of LWD structures (right photo). Photos courtesy of the SRSRB.

3.2.6 PROJECT AREA 15

Restoration began in Project Area 15 (RM 36.4-37.2) downstream from the Wooten Wildlife Area headquarters in 2014 and was completed in 2015. The objectives include increasing channel complexity and side channels (Figure 8). Approximately 600 key pieces of LWD were added and 500 m of new side channels were created. More information on this project can be found at: Project Area 15.

Figure 8. Restoration implemented in Project Area 15 included the installation of LWD structures (left photo) and the creation of new side channels (right photo). Photos courtesy of the SRSRB.

3.2.7 PROJECT AREA 22

Restoration in Project Area 22 (RM 29.3-30.3) upstream of Marengo was implemented in 2014. Eight LWD structures consisting of 36 key pieces of LWD were placed in order to increase channel complexity and pool habitat (Figure 9). This project was sponsored by the Columbia Conservation District. More information on this project can be found at: Project Area 22.

Figure 9. Photos showing two of eight LWD structures placed in Project Area 22. CHaMP post-treatment sample not available for this report.

3.2.8 PROJECT AREA 23

Restoration in Project Area 23 (RM 28.3-29.3) upstream of Marengo was sponsored by the Columbia Conservation Districts and completed in 2015. The objectives were to increase floodplain connectivity and in-stream complexity. Almost 160 m of levee were removed and 12 LWD structures, consisting of 51 key pieces were constructed (Figure 10). More information can be found at: Project Area 23.

Figure 10. Restoration actions implemented in Project Area 23 included levee removal (left photo) and installation of LWD structures (right photo). Photos courtesy of the SRSRB. **CHaMP post-treatment sample not available for this report.**

3.2.9 PROJECT AREA 24

Restoration in Project Area 24 (RM 27.5-28.25) upstream of Marengo was implemented in 2015. The objective was to increase floodplain connectivity, in-stream channel complexity, and side channel habitat. Almost 115 m of levee was removed and 61 LWD structures were built consisting of 498 key pieces (Figure 11). CCD was the sponsor and information can be found at: Project Area 24.

Figure 11. Photos showing two of 61 LWD structures constructed in Project Area 24. **CHaMP post-treatment sample not available for this report.**

3.2.10 PROJECT AREA 26

Restoration in Project Area 26 (RM 23.7-26.9) downstream of Marengo was first implemented in 2011. The objective was to reconnect the disconnected floodplain and riparian habitat by removing and setting back over 2500 and 3700 m of levee, respectively (Figure 12). In addition to the 2011 levee removal/setback, in 2013, 17 structures comprised of 78 key pieces of LWD were constructed. The objective of this additional restoration action was to provide habitat complexity and encourage channel migration. This project was sponsored by the Columbia Conservation District. More information on this project can be found at: Project Area 26.

Figure 12. Restoration actions implemented in Project Area 26 included levee removal (left photo) in 2011 and LWD placement (right photo) in 2012. Photos courtesy of the SRSRB.

3.2.11 PROJECT AREA 40

Restoration in Project Area 40 (RM 1.8-4.5) downstream of Starbuck was sponsored by the Columbia Conservation District and implemented in 2014. The primary objective was to improve winter rearing habitat in the Lower Assessment unit by creating side-channel and off-channel habitat. Implementation included removal and set back of levees to reconnect floodplain and existing side channels, the creation of new side channels, and the placement of small LWD structures within the side channels. More information on this project can be found at: Project Area 40.

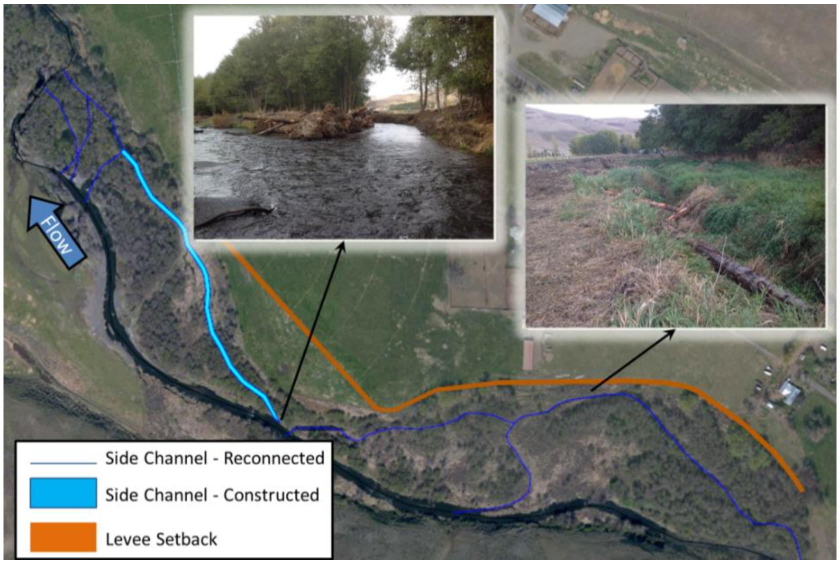

Figure 13. Map and photos of restoration implemented in Project Area 40 which included levee setback, LWD additions, and the reconnection and creation of side channels.

3.3 RESTORATION EFFECTIVENESS BY ASSESSMENT UNIT

3.3.1 RIVER STYLES

There are only four River Styles represented in the mainstem Tucannon based on the draft River Styles analyses (Table 4). The majority of the River Styles in the mainstem are partly confined with low to moderate sinuosity. The Bed rock controlled discontinuous floodplain River Style is “artificially” created by levees and is only found in the Lower Assessment unit and lower portions of the Upper Assessment unit (Table 4; Portugal et al. 2015). The Bed rock controlled discontinuous floodplain River Style has a relatively low capacity for adjustment in channel attributes, channel planform, or bed character. The Low-Moderate Sinuosity Wandering Gravel/Cobble Bed River Style is the most common in the Upper Assessment unit and has a high capacity for adjustment so expect restoration actions in this River Style to lead to changes in channel attributes, channel planform, or bed character. We do not present any habitat results summarized River Styles in this report, but may provide analyses by River Style in the future based on feedback by the TCC.

Table 4. Number of CHaMP sites in each River Style within the lower and upper Tucannon River Assessment units and tributaries.

		Length (km)		
River Styles	Valley Setting	Lower Mainstem	Upper Mainstem	Tributary
Confined Occasional Floodplain Pockets	Confined			4.0
Bedrock Controlled Discontinuous FP	Partly Confined	8.5	17.0	
Low Sinuosity PC Anabranching	Partly Confined		10.8	
Low-Mod Sinuosity PC Discontinuous FP	Partly Confined			15.7
PC Low-Mod Sinuosity Wandering Gravel/Cobble Bed	Partly Confined	3.5	38.6	
Alluvial Fan	Unconfined			0.2
Entrenched Low-Mod Sinuosity Gravel/Sand Bed	Unconfined			2.1
Low-Moderate Sinuosity Wandering Gravel Bed	Unconfined	7.9	6.0	
Total		19.8	72.4	22.0

3.3.2 COLUMBIA HABITAT MONITORING PROTOCOL RESULTS BY ASSESSMENT UNIT

The CHaMP data from the first five years of sampling generally confirm previous assessments of the status of anadromous fish habitat in the Tucannon River (USFS 2002, AQEA 2011). The mainstem Tucannon River is relatively straight, confined, with limited floodplain connection, and lacks deep pools and instream habitat complexity (Table 5). Appendix III presents a list of all CHaMP sites and visits between 2011 and 2015 and metrics representing each ecological concern category.

3.3.2.1 CHANNEL FORM

As expected the Lower Assessment unit is deeper, wider, and more sinuous than the Upper Assessment unit or tributaries (Table 5, Appendix II). The Lower Assessment unit is approximately 4 m wider on average (18.5 m bankfull width) than the Upper Assessment unit (14.1 m). The average thalweg depth in the Lower Assessment unit is 0.58 m compared to the Upper Assessment unit which averages 0.48 m deep. The Lower Assessment planform is also significantly more sinuous (1.5) than the Upper Assessment unit (1.1).

3.3.2.2 COMPLEXITY OF INSTREAM HABITAT

Instream habitat complexity was generally low throughout with the tributaries having more complexity per unit length than the mainstem (Table 5, Appendix III). The Lower Assessment unit had slightly higher mean instream complexity than the Upper Assessment unit with more pools, deep pools, channel units, and LWD. The average pieces of key LWD were $\leq$ 0.35/bankfull width for the Lower, Upper and Tributary Assessment units which is below the 1 piece/ bankfull width that is the target for restoration in both the lower and Upper Assessment unit. Pools $\geq$ 1.0 m in depth (deep pools) are also infrequent ($\leq$ 1.3 pools/100 m).

3.3.2.3 FLOODPLAIN CONDITION

We are still assessing some CHaMP metrics to determine if they can provide information on status and trend of floodplain condition. See Section 3.5.1 for an assessment of floodplain (valley bottom) condition using GIS derived data.

3.3.2.4 RIPARIAN

Riparian metrics indicate relatively similar conditions among the lower and upper mainstem, and tributaries. The Lower Assessment unit generally has a greater amount of Solar Access (78%) compared to the Upper Assessment unit (66%, Table 5). This may partially be due to fewer big trees (>0.3m DBH, >5.0m tall) at sites in the Lower Assessment unit compared to Upper Assessment unit or it may be due to the orientation of the valley and wider floodplain in the Lower Assessment unit that naturally allow more solar inputs. A more detailed assessment of riparian condition is presented in Section 3.5.2 using GIS derived data.

3.3.2.5 SUBSTRATE

Substrate is less coarse and made up of more fines in the Lower Assessment unit as expected based on lower gradient, higher sinuosity, and the introduction of fine sediment from Pataha Creek (AQEA 2011). Cobble embeddedness is relatively low at all sites with the Lower Assessment unit generally having higher values compared to the Upper Assessment unit and tributaries (Table 5, Appendix III).

The majority of all the metrics we have assessed have undetermined trends (Table 6). This is likely due to the limited number of years of data (five), the variability of these metrics, the low flow conditions, and the relatively small amount of restoration captured by CHaMP surveys from 2011-2015. Large restoration projects implemented in 2016 and 2017 will increase the likelihood that trends will be detected in future assessments.

Table 5. Watershed status by ecological concern and metric based on CHaMP data collected from 2011-2015. Data are summarized by the Lower Assessment unit (RM 0 – 12.3), Upper Assessment unit (RM 12.3 – 60), and all Tributaries combined. See Appendix I for definitions of all metrics, and see Appendix III for list of CHaMP sites, RM locations and tributaries sampled. All sites are within the Chinook domain (Figure 1). Means and 95% confidence intervals are based on weighted average of CHaMP sites within survey strata using SPSurvey package for R (http://cran.r-project.org/web/packages/spsurvey/index.html).

			Lower Tucanon		Upper Tucannon		Tributary	
Ecological Subgroup	**Metric Name**	**Units**	**Mean**	**95% CI ±**	**Mean**	**95% CI ±**	**Mean**	**95% CI ±**
Channel Form and Function	Bankfull depth average	m	0.51	0.03	0.47	0.02	0.33	0.07
	Bankfull width	m	18.49	5.08	14.12	0.42	5.49	0.68
	Bankfull width to depth ratio	ratio	38.03	11.94	29.99	1.42	18.73	2.12
	Gradient	%	0.52	0.09	1.02	0.09	3.10	1.01
	Sinuosity	ratio	1.45	0.32	1.14	0.02	1.15	0.07
	Thalweg depth ave	m	0.58	0.05	0.46	0.02	0.25	0.06
	Thalweg depth CV	ratio	0.45	0.02	0.37	0.02	0.37	0.05
Channel Structure/ Instream Complexity	Channel unit frequency	#/100 m	5.05	1.19	4.46	0.58	10.28	1.43
	Deep pool (≥ 1 m) frequency	#/100 m	1.27	0.53	0.50	0.15	0.12	0.20
	LWD key pieces/20 bankfull widths	#/20 BFW	0.28	0.26	0.35	0.11	0.16	0.12
	LWD/20 bankfull widths	#/BFW	5.24	3.25	3.59	0.66	2.97	1.57
	LWD/bankfull	#/BFW	29.75	18.77	25.69	5.68	44.88	25.50
	Residual pool depth	%	0.73	0.05	0.48	0.05	0.27	0.12
	Pool frequency	#/100 m	2.75	1.05	1.95	0.36	3.72	0.69
	% Undercut	%	2.78	1.53	2.40	1.13	4.09	5.56
Peripheral/ Floodplain Condition	Side-channel wet area	m^2	337.53	180.58	180.13	72.63	-	-
	Confinement (area wet/area bfw)	ratio	0.78	0.09	0.80	0.02	0.77	0.04
Riparian Conditon	Riparian cover big tree	%	6.82	3.68	8.75	1.38	6.09	3.23
	Solar input	%	78.38	6.09	64.17	3.57	52.84	5.60
Substrate Conditions	D50	mm	34.34	6.97	57.85	3.48	50.59	7.94
	Embeddedness	%	13.02	8.10	2.45	0.69	4.93	1.67
	Embeddedness SD	%	13.51	7.72	4.96	1.01	7.99	2.69
	Fines > 2 mm	%	9.07	4.86	3.25	1.08	11.96	6.04
	Fines > 6 mm	%	11.78	6.28	5.14	1.20	16.02	6.40

Table 6. Watershed trends by ecological concern and metric based on CHaMP data collected from 2011-2015. Mean is the predicted change per year in the units of the metric (e.g., -11.78 LWD = a loss of 11.78 LWD/year from the Lower Assessment unit). We consider a trend positive (+), negative (-), or no trend (0) unless the 95% CI values are > mean in which case the trend is undetermined (Und). NA = unavailable. Data are summarized by the Lower Tucannon River (RM 0 – 12.3), Upper Tucannon River (RM 12.3 – 60), and all Tributaries combined. See Appendix I for definitions of all metrics, and see Appendix III for list of CHaMP sites, RM locations and tributaries sampled. All sites are within the Chinook domain. Means and 95% confidence intervals are based on weighted average of CHaMP sites within survey strata using SPSurvey package for R (http://cran.r-project.org/web/packages/spsurvey/index.html).

			Lower Tucannon			Upper Tucannon			Tributary		
Ecological Subgroup	**Metric Name**	**Units**	**Mean**	**95% CI ±**	**Trend**	**Mean**	**95% CI ±**	**Trend**	**Mean**	**95% CI ±**	**Trend**
Channel Form and Function	Bankfull depth average	m	-0.01	0.03	Und	0.01	0.01	Und	-0.01	0.01	Und
	Bankfull width	m	-0.36	1.44	Und	0.20	0.36	Und	-0.17	0.20	Und
	Bankfull width to depth ratio	ratio	-4.62	2.85	-	-0.06	0.64	Und	0.11	0.83	+
	Gradient	%	-0.01	0.01	Und	0.00	0.01	Und	0.01	0.02	Und
	Sinuosity	ratio	0.00	0.03	Und	0.00	0.01	Und	0.00	0.01	Und
	Thalweg depth ave	m	0.00	0.01	Und	-0.01	0.01	Und	0.00	0.02	Und
	Thalweg depth CV	ratio	0.03	0.02	+	0.01	0.01	Und	0.01	0.02	Und
Channel Structure/ Instream Complexity	Channel unit frequency	#/100 m	0.50	0.31	+	0.03	0.25	Und	0.42	0.45	Und
	Deep pool (≥ 1 m) frequecy	#/100 m	0.08	0.10	Und	0.06	0.09	Und	0.07	0.11	Und
	LWD key pieces/20 bankfull widths	#/20 BFW	-0.02	0.04	Und	0.05	0.05	Und	0.01	0.06	Und
	LWD/20 bankfull widths	#/20 BFW	-1.06	0.42	Und	0.01	0.32	Und	0.07	0.12	Und
	LWD/bankfull	#/BFW	-6.92	2.71	-	0.32	2.10	Und	0.99	1.92	Und
	Pool frequency	#/100 m	0.32	0.132	+	0.098	0.195	Und	0.523	0.672	Und
	Residual pool depth	m	0.00	0.05	Und	-0.02	0.02	Und	0.01	0.03	Und
	% Undercut	%	1.36	0.89	Und	0.20	0.88	Und	1.42	3.47	Und
Peripheral/ Floodplain Condition	Side-channel wet area	m^2	-	0.00	NA	188.20	336.63	Und	-	-	-
	Confinement (area wet/area bfw)	ratio	0.03	0.01	+	-0.02	0.01	-	0.04	0.02	+
Riparian Conditon	Riparian cover big tree	%	-1.95	1.13	-	-0.77	1.35	Und	-0.65	0.78	Und
	Solar input	%	0.15	0.17	Und	2.38	2.47	+	2.23	5.64	Und
Substrate Conditions	D50	mm	2.67	0.73	+	-1.70	1.82	Und	1.28	2.19	Und
	Embeddedness	%	-0.59	0.33	-	-1.54	2.28	Und	1.00	3.70	Und
	Embeddedness SD	%	-1.09	0.10	-	-1.95	3.19	Und	1.00	4.84	Und
	Fines > 2 mm	%	-3.89	2.72	-	0.39	0.65	Und	-0.87	2.43	Und
	Fines > 6 mm	%	-3.65	2.46	-	0.82	0.90	Und	-0.56	2.23	Und

3.3.3 PROJECT EFFECTIVENESS

The following results represent metrics summarized by ecological concerns comparing pre and post treatment conditions in Project Areas: 3, 10, 14, 15, and 26. Treatment and control sites are within the same River Style.

3.3.4 INSTREAM HABITAT COMPLEXITY

Indicators of instream structural complexity include the number of key pieces of large wood (> 0.3m diameter, > 6.0m length) per bankfull width, channel unit frequency (number of channel units per 100 m of stream length, percent pools, and variation (CV) in thalweg depth; Appendix I).

3.3.4.1 KEY LARGE WOOD PIECES

Prior to restoration, treatment sites averaged 0.27 key large wood pieces (>0.3m diameter, >6.0m length) per bankfull width compared to 0.30 pieces at control sites within the same River Style in the Upper Assessment unit (Table 7). Post restoration, the average number of key pieces increased to 1.83 (+583%) at treatment sites and 0.46 pieces (+54%) at control sites. The number of post treatment key LWD pieces at treatment sites ranged from 0.8 to 3.25. The range in post treatment LWD reflects differences in restoration designs. In general, key LWD pieces also increased at control sites between pre and post treatment years but at a much smaller magnitude (average net change = 530%). The increase of key LWD pieces is a direct result of the restoration action within each project area while increases at control sites reflect natural recruitment of LWD.

Table 7. Average pre and post treatment changes in key LWD pieces (> 0.3m diameter, > 6.0m length) per bankfull width at treatment and control sites within the same River Style. All treatment and control sites are located within the Partly Confined, Low to Moderate Sinuosity Wandering Gravel/Cobble Bed River Style in the Upper Assessment unit.

Project Area(s)	Site Type (number of sites)	Pre-Treatment Year(s)	Post Treatment Year(s)	Key LWD Pieces/Bankfull Width			
				Pre-Treatment	Post Treatment	Change (%)	Trend
3	Treatment (1)	2012-2014	2015	0.32	0.8	150	+
3, 14	Control (2)	2012-2014	2015	0.43	0.63	47	+
10	Treatment (1)	2011-2012	2013-2014	0.23	1.00	335	+
3, 12	Control (2)	2011-2012	2013-2014	0.16	0.39	144	+
14	Treatment (1)	2012-2014	2015	0.37	3.25	778	+
3, 14	Control (2)	2012-2014	2015	0.43	0.63	47	+
15	Treatment (1)	2011-2014	2015	0.19	3.15	1558	+
3	Control (1)	2011-2014	2015	0.24	0.35	67	+
26	Treatment (1)	2011-2013	2014-2015	0.23	0.95	313	+
3	Control (1)	2011-2013	2014-2015	0.22	0.28	25	+
	Treatment	Average		0.27	1.83	583	+
	Control	Average		0.30	0.46	54	+

3.3.4.2 CHANNEL UNIT FREQUENCY

Prior to restoration, treatment sites averaged 4.4 channel units per 100m compared to 4.2 units at control sites within the same River Style in the Upper Assessment unit (Table 8). Post restoration, the average frequency of channel units increased to 5.3 (+20%) at treatment sites and remained the same (4.2; 0% change) at control sites. The overall average increase in channel unit frequency at treatment sites can mostly be attributed to sites within Project Areas 10 and 15, which saw an increase of 53 and 54 percent, respectively between pre and post-treatment averages. Treatment sites within Project Areas 3, 14, and 26 exhibited little to no change (<10%) in channel unit frequency. The increase in channel unit frequency at the Project Area 15 site can be directly attributed to the restoration action which included creation of a new side channel which increased the total number of channel units within the site. While the increase in frequency at Project Area 10 may be indirectly related to changes in channel morphology due to the restoration action, there is uncertainty about whether these changes are a direct result of the restoration action due to a similar increase in frequency at control sites within the same years.

Table 8. Average pre and post treatment changes in channel unit frequency (units/100m) at treatment and control sites within the same River Style. All treatment and control sites are located within the Partly Confined, Low to Moderate Sinuosity Wandering Gravel/Cobble Bed River Style in the Upper Assessment unit.

Project Area(s)	Site Type (number of sites)	Pre-Treatment Year(s)	Post Treatment Year(s)	Channel Unit Frequency (Count/100m)			
				Pre-Treatment	Post Treatment	Change (%)	Trend
3	Treatment (1)	2012-2014	2015	4.4	4.0	-8	Und
3, 14	Control (2)	2012-2014	2015	4.9	3.0	-38	-
10	Treatment (1)	2011-2012	2013-2014	3.5	5.4	53	+
3, 12	Control (2)	2011-2012	2013-2014	4.0	6.8	70	+
14	Treatment (1)	2012-2014	2015	5.1	5.3	3	Und
3, 14	Control (2)	2012-2014	2015	4.9	3.0	-38	-
15	Treatment (1)	2011-2014	2015	4.4	6.8	54	+
3	Control (1)	2011-2014	2015	3.9	3.5	-12	-
26	Treatment (1)	2011-2013	2014-2015	4.4	4.7	7	Und
3	Control (1)	2011-2013	2014-2015	3.3	4.6	41	+
	Treatment	Average		4.4	5.3	20	+
	Control	Average		4.2	4.2	0	Und

3.3.4.3 PERCENT POOLS

Prior to restoration, the percent of the wetted area classified as pools at treatment sites averaged 18.8 compared to 23.0 at control sites within the same River Style in the Upper Assessment unit (Table 9). Post restoration, the average percentage of pools increased to 26.9 (+43%) at treatment sites compared to 22.9 (0% change) at control sites. Percent pools increased (>10%) at four of the six treatment sites between pre and post treatment periods compared with only two control sites during the same time periods. This indicates that the increase in pools at Project Areas 10 and 14 may be attributed to the restoration action whereas post-treatment increases at Project Areas 15 and 26 likely reflect natural changes to morphology throughout the upper mainstem Tucannon, evidenced by the increase in percent pools at control sites during the same time period.

Table 9. Average pre and post treatment changes in percent pools at treatment and control sites within the same River Style. All treatment and control sites are located within the Partly Confined, Low to Moderate Sinuosity Wandering Gravel/Cobble Bed River Style in the Upper Assessment unit.

Project Area(s)	Site Type (number of sites)	Pre-Treatment Year(s)	Post Treatment Year(s)	Percent Pools			
				Pre-Treatment	Post Treatment	Change (%)	Trend
3	Treatment (1)	2012-2014	2015	12.7	12.3	-3	Und
3, 14	Control (2)	2012-2014	2015	28.4	18.3	-36	-
10	Treatment (1)	2011-2012	2013-2014	13.4	28.9	116	+
3, 12	Control (2)	2011-2012	2013-2014	23.0	22.1	-4	-
14	Treatment (1)	2012-2014	2015	24.4	31.4	28	Und
3, 14	Control (2)	2012-2014	2015	28.4	18.3	-36	-
15	Treatment (1)	2011-2014	2015	24.1	31.2	29	Und
3	Control (1)	2011-2014	2015	19.8	26.0	30	+
26	Treatment (1)	2011-2013	2014-2015	19.2	30.7	60	+
3	Control (1)	2011-2013	2014-2015	15.4	29.6	93	+
	Treatment	Average		18.8	26.9	43	+
	Control	Average		23.0	22.9	0	Und

3.3.4.4 THALWEG DEPTH VARIATION

Prior to restoration, the coefficient of variation (CV) in thalweg depth at treatment sites averaged 0.35 compared to 0.31 at control sites within the same River Style in the Upper Assessment unit (Table 10). Post restoration, the average thalweg CV remained the same at both treatment sites and control sites. The only treatment site that showed a change in thalweg depth variation (>10%) was the treatment site in Project Area 3 which decreased approximately 13% despite minimal detectable geomorphic change (see Section 3.4.7). This decrease in thalweg depth variation is likely due to sample timing in 2015 which represented a low flow year in comparison with previous years. The average discharge at the time of pre-treatment (2012-2014) sampling was 1.9 m^3/s compared to 1.1 m^3/s for the post treatment (2015) sample in Project Area 3.

Table 10. Average pre and post treatment changes in thalweg depth variation (coefficient of variation) at treatment and control sites within the same River Style. All treatment and control sites are located within the Partly Confined, Low to Moderate Sinuosity Wandering Gravel/Cobble Bed River Style in the Upper Assessment unit.

Project Area(s)	Site Type (number of sites)	Pre-Treatment Year(s)	Post Treatment Year(s)	Thalweg Depth CV			
				Pre-Treatment	Post Treatment	Change (%)	Trend
3	Treatment (1)	2012-2014	2015	0.36	0.31	-13	-
3, 14	Control (2)	2012-2014	2015	0.33	0.36	9	Und
10	Treatment (1)	2011-2012	2013-2014	0.31	0.31	0	Und
3, 12	Control (2)	2011-2012	2013-2014	0.3	0.28	-6	Und
14	Treatment (1)	2012-2014	2015	0.37	0.39	5	Und
3, 14	Control (2)	2012-2014	2015	0.33	0.36	9	Und
15	Treatment (1)	2011-2014	2015	0.34	0.36	6	Und
3	Control (1)	2011-2014	2015	0.3	0.28	-6	Und
26	Treatment (1)	2011-2013	2014-2015	0.37	0.39	5	Und
3	Control (1)	2011-2013	2014-2015	0.31	0.29	-6	Und
	Treatment	Average		0.35	0.35	0	Und
	Control	Average		0.31	0.31	0	Und

3.3.5 FLOODPLAIN CONDITION

An indicator of floodplain condition derived from the CHaMP topographic surveys is the confinement ratio (ratio of the site wetted area to bankfull area) where values closer to one represent more confined channel conditions. Prior to restoration, the confinement ratio at treatment sites averaged 0.75 compared to 0.72 at control sites within the same River Style in the Upper Assessment unit (Table 11). Post restoration, the average confinement ratio decreased to 0.69 (-8%) at treatment sites compared to 0.69 (-4%) at control sites. The confinement ratio decreased >10% at two of the treatment sites (Project Areas 14 and 26) between pre and post treatment sampling periods. The decrease in the confinement ratio in Project Area 14 is likely due to sample timing in 2015 which represented a low flow year in comparison with previous years. The average discharge at the time of pre-treatment (2012-2015) sampling was 2.2 m^3/s compared to 1.4 m^3/s for the post treatment (2015) sample. Differences in sample timing and flows also accounts for the decrease in confinement ratio at treatment sites in Project Area 26, 10, and at control sites within the same sample periods.

Table 11. Average pre and post treatment changes in confinement ratio at treatment and control sites within the same River Style. All treatment and control sites are located within the Partly Confined, Low to Moderate Sinuosity Wandering Gravel/Cobble Bed River Style in the Upper Assessment unit.

Project Area(s)	Site Type (number of sites)	Pre-Treatment Year(s)	Post Treatment Year(s)	Confinement Ratio			
				Pre-Treatment	Post Treatment	Change (%)	Trend
3	Treatment (1)	2012-2014	2015	0.79	0.78	-1	Und
3, 14	Control (2)	2012-2014	2015	0.70	0.73	4	Und
10	Treatment (1)	2011-2012	2013-2014	0.76	0.71	-7	Und
3, 12	Control (2)	2011-2012	2013-2014	0.79	0.68	-14	-
14	Treatment (1)	2012-2014	2015	0.74	0.6	-19	-
3, 14	Control (2)	2012-2014	2015	0.70	0.73	4	Und
15	Treatment (1)	2011-2014	2015	0.68	0.71	4	Und
3	Control (1)	2011-2014	2015	0.70	0.66	-6	Und
26	Treatment (1)	2011-2013	2014-2015	0.78	0.63	-19	-
3	Control (1)	2011-2013	2014-2015	0.72	0.65	-10	-
	Treatment	Average		0.75	0.69	-8	Und
	Control	Average		0.72	0.69	-4	Und

3.3.6 CHANNEL FORM

An indicator of channel form is the bankfull width to depth ratio where higher values indicate wider, more shallow channels. Prior to restoration, the width to depth ratio at treatment sites averaged 32.2 compared to 29.9 at control sites within the same River Style in the Upper Assessment unit (Table 12). Post restoration, the average width to depth ratio decreased to 30.3 (-6%) at treatment sites compared to 28.5 (-3%) at control sites. Width to depth ratio decreased >10% at two of the treatment sites (Project Areas 15 and 26) and increased at one site between pre and post treatment. The decrease in the width to depth ratio in Project Area 26 may partly be due to increased scour as a result of LWD structures placed at the time of restoration (See Section 3.2.10). The post treatment decrease in width to depth ratio in Project Area 15 is likely in part due to the excavation of the new, deep side channel near the top of site and pool near the constructed LWD structure at the bottom of site. Not all changes at this site can be attributed to the restoration action since control sites within the same time period also decreased, yet at a smaller magnitude (9% less). The increase in width to depth ratio may be partly attributed to equipment rearranging substrate and banks during restoration implementation.

Table 12. Average pre and post treatment changes in confinement ratio at treatment and control sites within the same River Style. All treatment and control sites are located within the Partly Confined, Low to Moderate Sinuosity Wandering Gravel/Cobble Bed River Style in the Upper Assessment unit.

Project Area(s)	Site Type	Pre-Treatment Year(s)	Post Treatment Year(s)	Bankfull Width to Depth Ratio			
				Pre-Treatment	Post Treatment	Change (%)	Trend
3	Treatment (1)	2012-2014	2015	35.5	35.1	-1	Und
3, 14	Control (2)	2012-2014	2015	30.9	27.6	-11	-
10	Treatment (1)	2011-2012	2013-2014	23.3	22.1	-5	Und
3, 12	Control (2)	2011-2012	2013-2014	25.8	29.9	16	+
14	Treatment (1)	2012-2014	2015	31.2	34.3	10	+
3, 14	Control (2)	2012-2014	2015	30.9	27.6	-11	-
15	Treatment (1)	2011-2014	2015	31.9	25.9	-19	-
3	Control (1)	2011-2014	2015	30.4	27.4	-10	-
26	Treatment (1)	2011-2013	2014-2015	39.2	34.0	-13	-
3	Control (1)	2011-2013	2014-2015	29.5	30.2	2	Und
	Treatment	Average		32.2	30.3	-6	Und
	Control	Average		29.5	28.5	-3	Und

3.3.7 GEOMORPHIC CHANGE

Areas of geomorphic change are identified by differencing elevations between topographic surveys conducted at two different time periods to identify and quantify areas of erosion and deposition. Identifying how much and where changes have occurred contextualizes and aids in the interpretation of changes in habitat and provides information about whether restoration actions are elucidating expected geomorphic changes.

3.3.7.1 PROJECT AREA 3

Very little geomorphic change has been detected between pre (2014) and post treatment (2015) surveys in Project Area 3 (Figure 14). While there is little evidence that any major changes have occurred, there is evidence of scour near the banks where LWD was placed during restoration (Figure 14, label A). This lack of detectable change is primarily due to a lack of any high flow events during the winter and spring of 2015. Further geomorphic change is expected as high flows interact with the placed LWD to create scour near the LWD structures and deposition downstream.

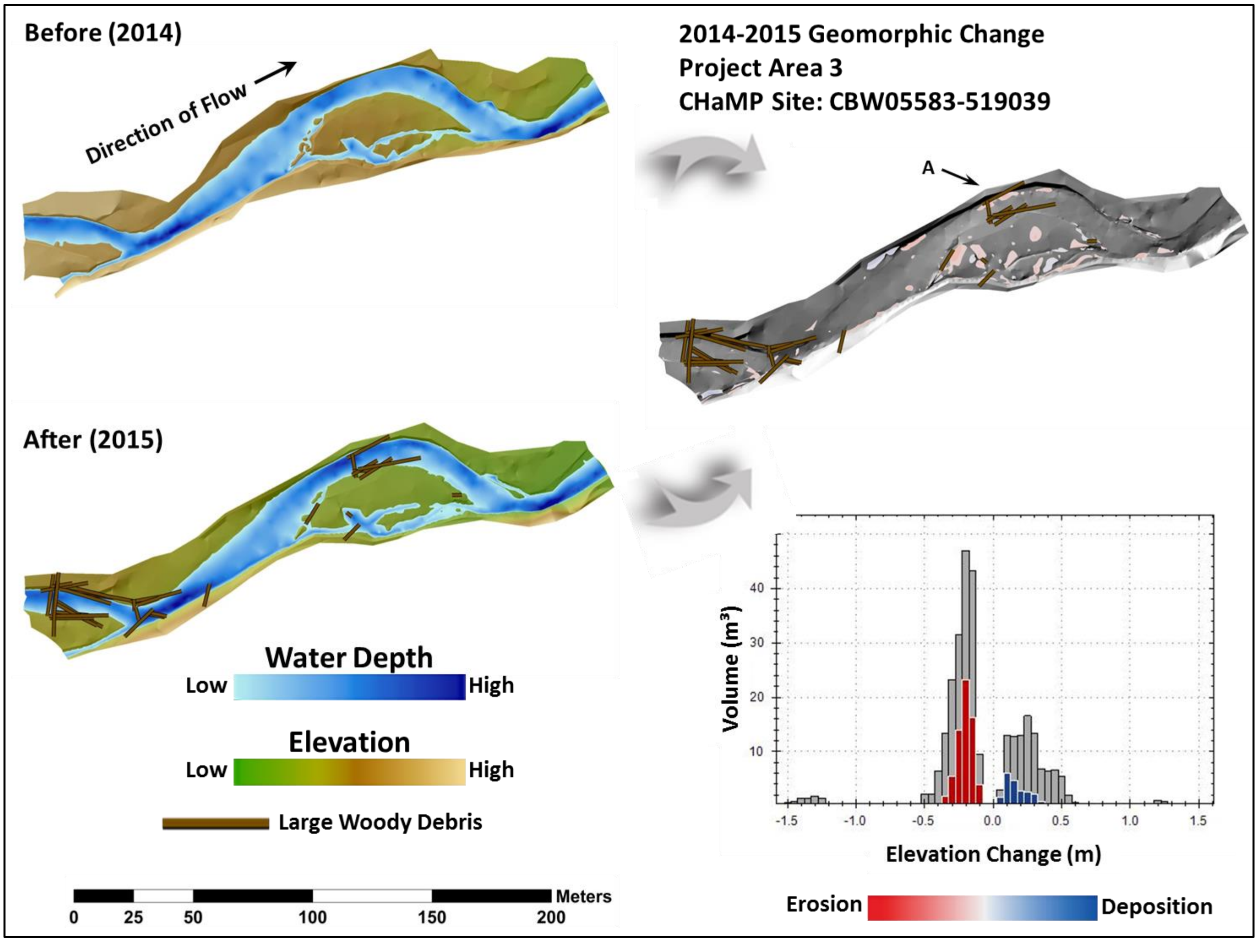

Figure 14. Geomorphic change detection for CHaMP site 519039 (Project Area 3) from 2014 (pre-treatment) to 2015 (post treatment). Approximate large wood piece locations derived from Google Earth.

3.3.7.2 PROJECT AREA 10

Geomorphic change detection results between pre (2012) and two years post treatment (2014) surveys in Project Area 10 indicate geomorphic change in some areas of the stream channel (Figure 15). This includes erosion of the bank near where LWD was placed and where natural recruitment has occurred (Figure 15, label A). A small cutoff of an existing bar has also been created along with deposition at the downstream end of this cutoff (Figure 15, label B). Some of the deposition at this specific location is due to campers building rock dams. Overall, most of the geomorphic change has occurred in the downstream portion of the site where LWD was placed during restoration. Additional natural recruitment of LWD at this location has also been observed. Very little geomorphic change has been detected in the upper 2/3 of the site.

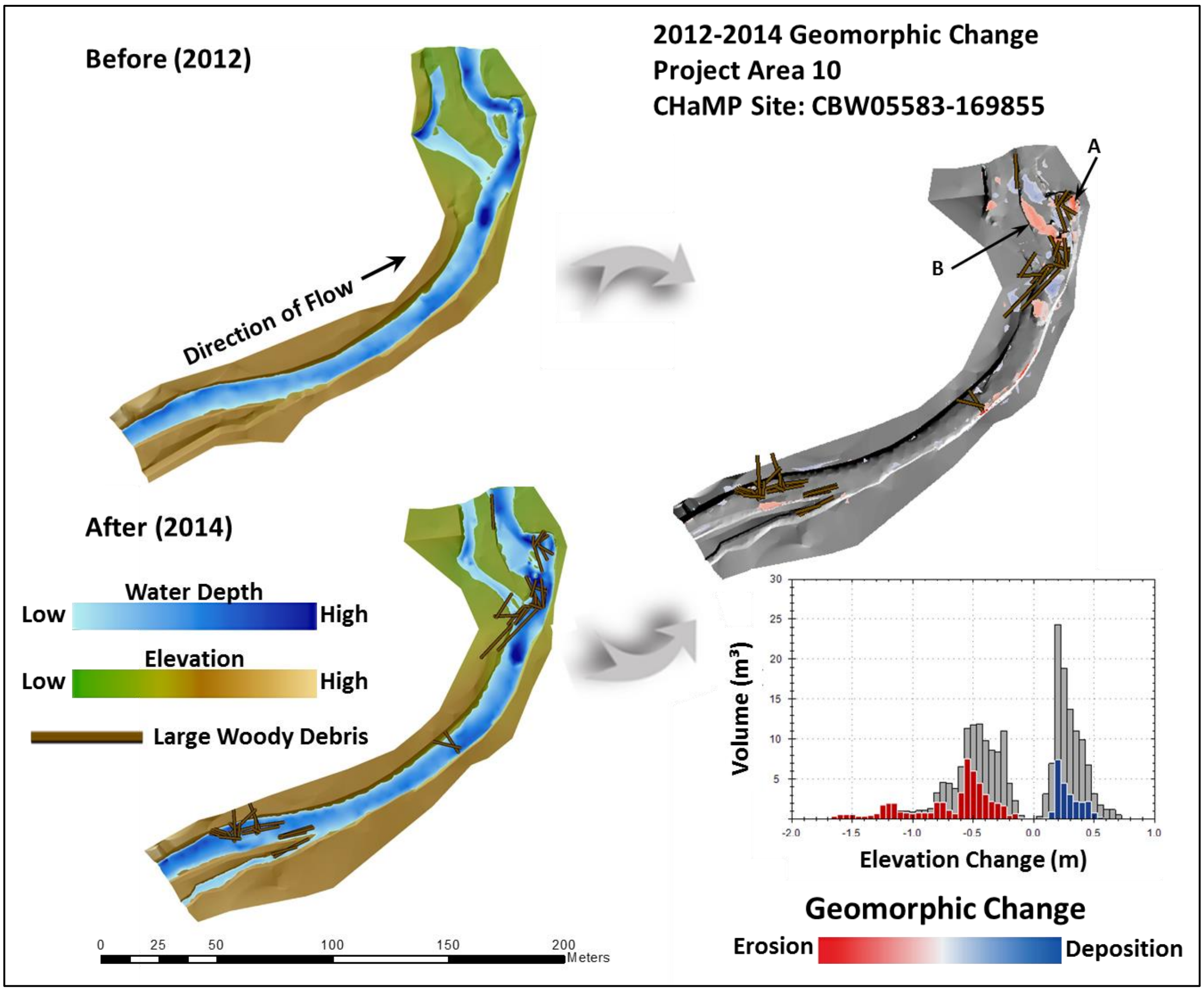

Figure 15. Geomorphic change detection for CHaMP site 169855 (Project Area 10) from 2012 to 2014. Approximate large wood piece locations derived from Google Earth.

3.3.7.3 PROJECT AREA 14

Results between pre (2014) and post treatment (2015) surveys in Project area 14 indicate geomorphic change in some areas of the stream channel (Figure 16). These changes include bed erosion and associated downstream deposition near the river left bank where a large natural LWD spanner with rootwad and placed LWD pieces are located (Figure 16, label A), bed scour near placed LWD (Figure 16Figure 16, label B), “deposition” near placed LWD structures likely due to equipment during restoration (Figure 16, label C), and a strong signal of “deposition” which is the direct result of constructing a large mid-channel LWD structure (Figure 16Figure 16, label D; Figure 7 right photo). Overall the site shows geomorphic change that is an indirect result of natural and placed LWD in the stream channel while other indications of “erosion” and “deposition” are a direct result of equipment rearranging substrate (Figure 16, C and D).

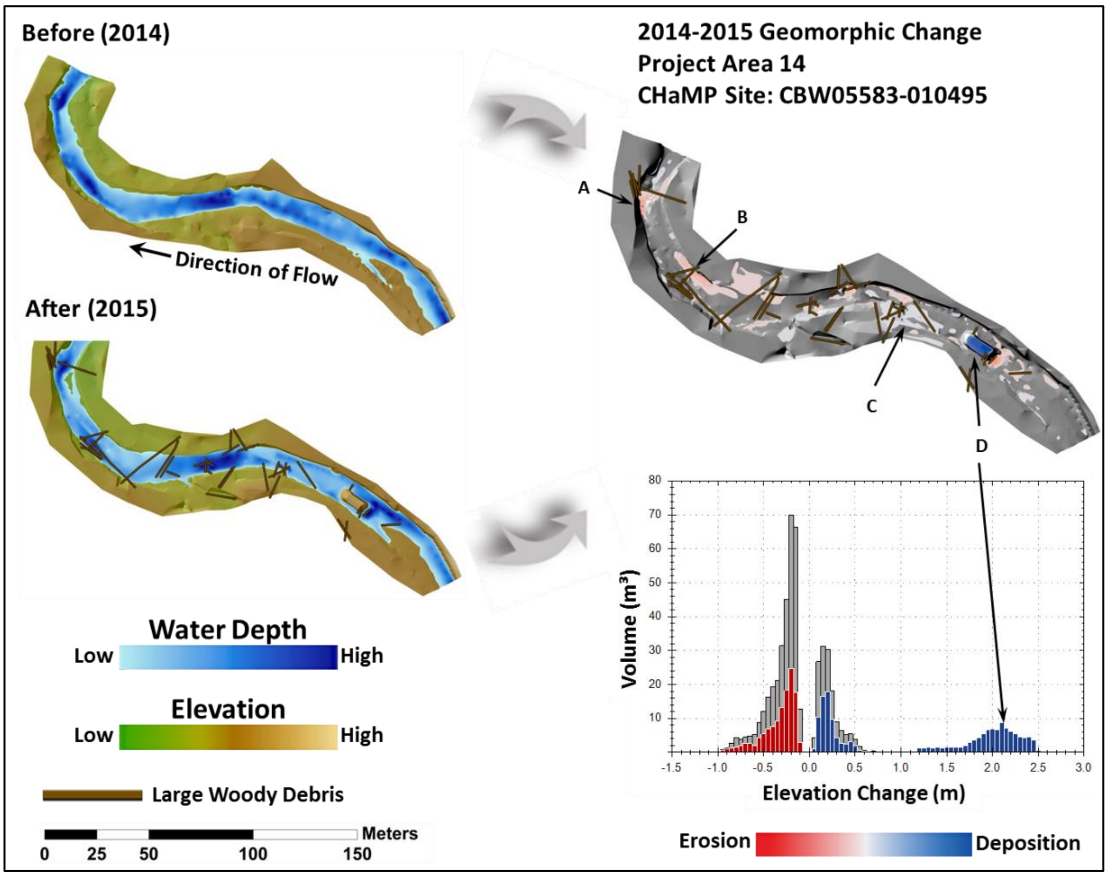

Figure 16. Geomorphic change detection for CHaMP site 010495 (Project Area 14) from 2014 to 2015. Approximate large wood piece locations derived from Google Earth.

3.3.7.4 PROJECT AREA 15

Results between pre (2014) and post treatment (2015) surveys indicate geomorphic change in Project Area 15, primarily at the lower end of the site where a large mid-channel structure was built (indicated as deposition) and an upstream pool was excavated (Figure 17, label A), and the upper end of the site where a large side channel was excavated (Figure 17, label B). The newly excavated channel is now the main channel while the old main channel contains very little flow. Additional changes in bedform throughout the site are likely due to both the interaction of placed LWD with flows and the movement of substrate with equipment during restoration.

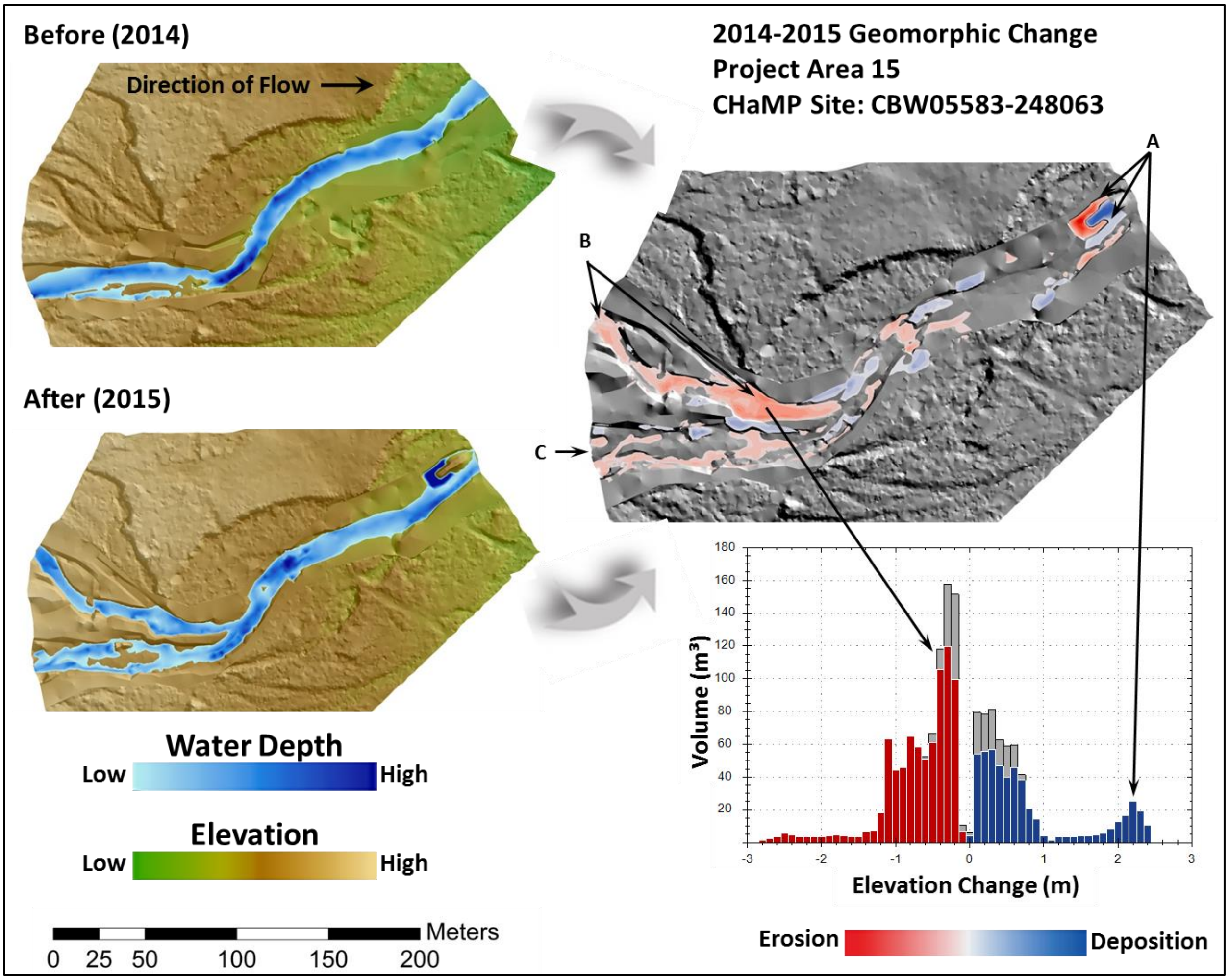

Figure 17. Geomorphic change detection for CHaMP site 248063 (Project Area 15) from 2014 to 2015.

3.3.7.5 PROJECT AREA 26

The most evident change in Project Area 26 between 2011 (pre levee removal) and 2015 (post levee removal and LWD placement) is the removal of the levee and levee setback (Figure 18). Due to the levee removal, the river now has access to the floodplain. After installing LWD structures in 2013, a comparison of pre-treatment (2013) and post treatment (2015) surveys shows areas of pool forming erosion near LWD structures in association with downstream bar formation. Some of this scour near structures can be attributed to an increase in the percentage of pools at the site from 22% in 2013 to 33% in 2015.

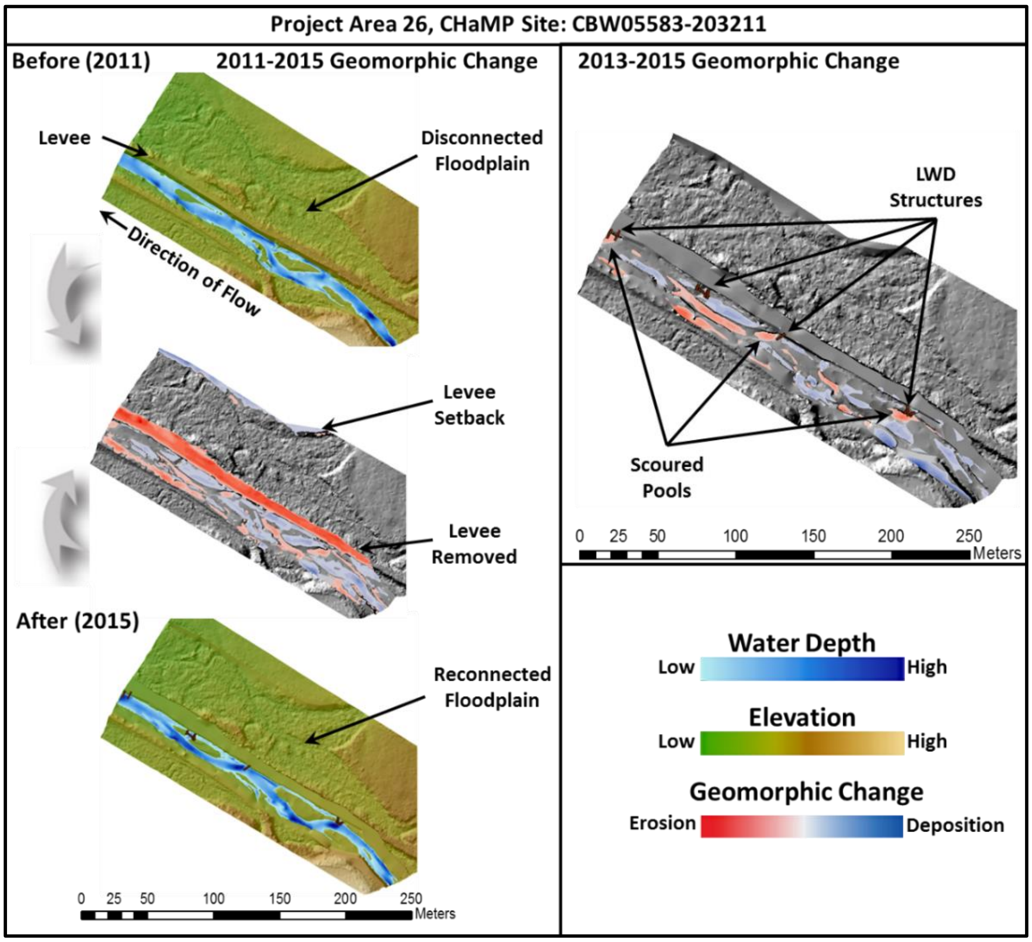

Figure 18. Geomorphic change detection for CHaMP site 203211 (Project Area 26) from 2011 to 2015 and from 2013 to 2015. A levee was removed at this site in 2011 and LWD structures were added in 2013.

3.4 WATERSHED LEVEL CONDITION ASSESSMENTS

We have run the valley bottom extraction tool (V-BET) and riparian condition assessment tool (R-CAT) for the Tucannon River watershed. We identified 5,349.8 acres (2,64.9 ha) of valley bottom habitat along the Tucannon mainstem. This was approximately 20% less (1,397 acres) than identified in the ADEQ geomorphic assessment due to the different methods used. These results can be broken out by the perennial stream network, the chinook domain, or the Lower and Upper Assessments units as required. These tools are constantly being revised and validated so these results should be considered preliminary. LWD input potential tools have been

3.4.1 CONFINEMENT

As expected a significant amount of the historic floodplain is disconnected by infrastructure such as roads and levees. We compared confinement based on both 10 m and 1 m DEMs and found that using the 1 m DEM we were able to identify over twice as much disconnected valley bottom (27.9%) compared to using 10 m DEM (13.4%). There was more disconnected valley bottom in the Lower Assessment unit compared to the Upper Assessment unit regardless of DEM data used (Figure 19). Based on 1 m DEM, it appears that 345.4 acres in Lower Assessment unit and 1111.9 acres in Upper Assessment unit (total = 1457.3 acres) may be disconnected from historic floodplain habitat by existing infrastructure. These estimates were compiled from output from V-BET using 1 m DEM data, existing ADEQ GIS layers that identified levees, and additional visual inspection of the 1 m DEM and delineation of potential levees. A representative set of sites visits should be conducted to validate these estimates.

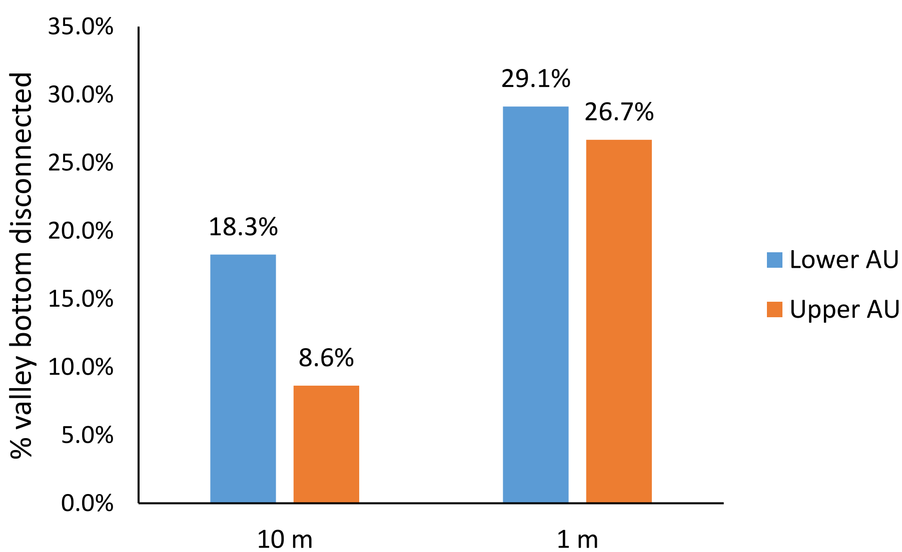

Figure 19. Proportion of historic valley bottom disconnected in the Lower and Upper Assessment units of the Tucannon River mainstem based on analysis using 10 m and 1 m digital elevation data.

3.4.2 RIPARIAN CONDITION

We ran the R-CAT tool to document the determine the condition of riparian habitat and determined that the majority of both the Chinook and steelhead extents are in poor-moderate condition (Figure 20).

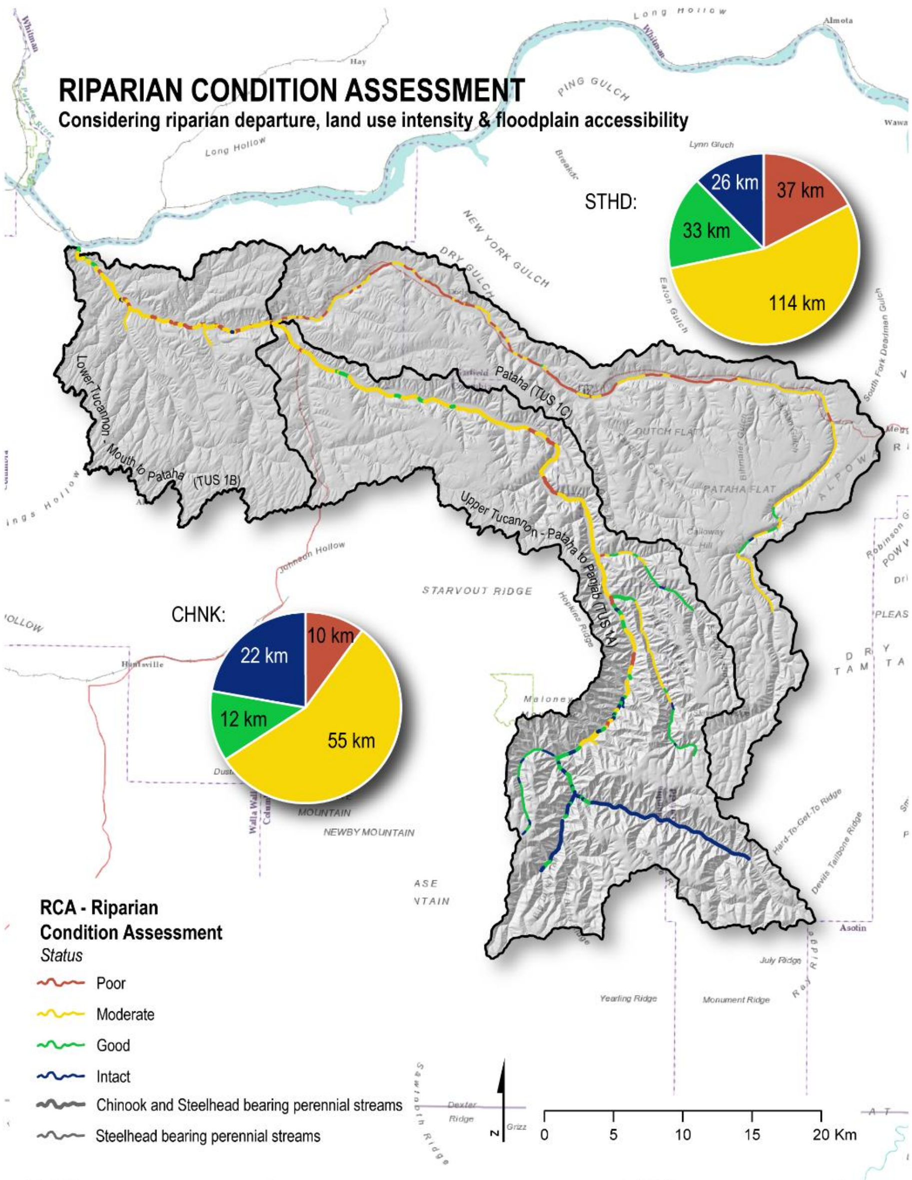

Figure 20. Riparian condition assessment for the Chinook and steelhead extents in the Tucannon River.

We also compared the extent of historic riparian habitat to the full extent of valley bottom (no disconnected valley bottom) and determined that approximately 55-60% of the valley bottom was occupied by riparian habitat historically and that has been reduced to 5-28% due to infrastructure (roads and levees) and development (Table 13). We then compared the historic extent of riparian habitat to the current extent and found that between 10-47% remains. These estimate that disconnected areas can no longer support riparian habitat.

Table 13. Comparison of the historic amount of riparian habitat within the valley bottom to the current amount of riparian habitat within the disconnected valley bottom for the Lower and Upper Assessment units.

Riparian habitat	**Riparian Area (acres)**		**VB Area (acres)**		**% of VB with riparian**		**% of Historic riparian**	
	Lower	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**
Historic	659.4	2513.8	1185.4	4164.3	55.6	60.4	-	-
Current (2012)	68.1	1188.5	1185.4	4164.3	5.7	28.5	10.3	47.3

3.4.3 RAPID HABITAT SURVEYS

Rapid habitat surveys have been conducted since 2014 and covered approximately 17 miles of the upper Tucannon River assessment unit (Figure 21). This includes both pre and post treatment surveys in Project Areas 1, 3, 11, 14, 15, and 22-24, post treatment surveys in Project Areas 10 and 26, and surveys in non-treated (control) Project Areas 2-7, 27, as well as above the confluence with Panjab Creek.

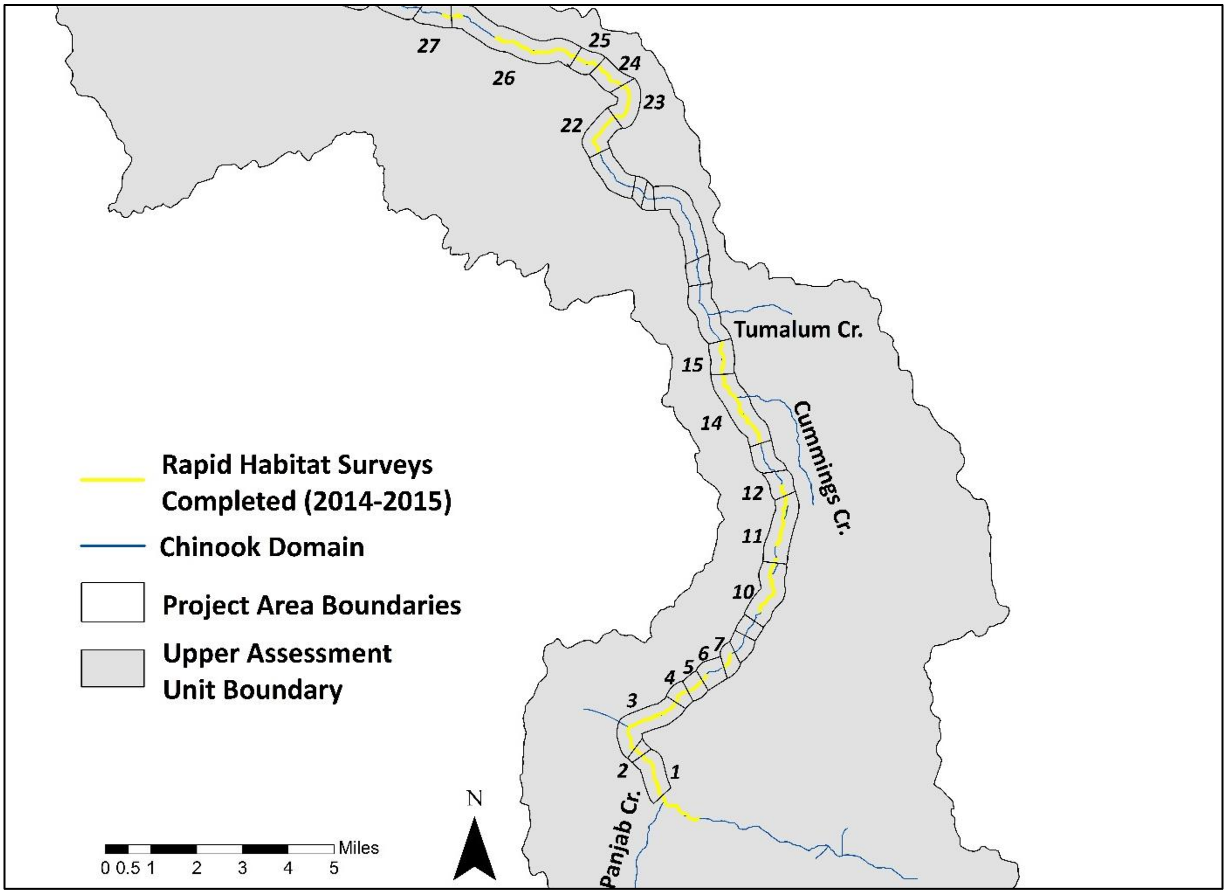

Figure 21. Map of rapid habitat surveys completed from 2014-2015 within the Upper Assessment unit. Numbers indicate project area locations where surveys have been conducted.

The results of the rapid surveys allow spatially explicit mapping of habitat elements such as LWD, pools and side channels, and the ability to compare pre and post treatment conditions (Figure 22). In 2016 and 2017, we will continue to fill in gaps where rapid surveys have not taken place, focusing on the upper Assessment unit.

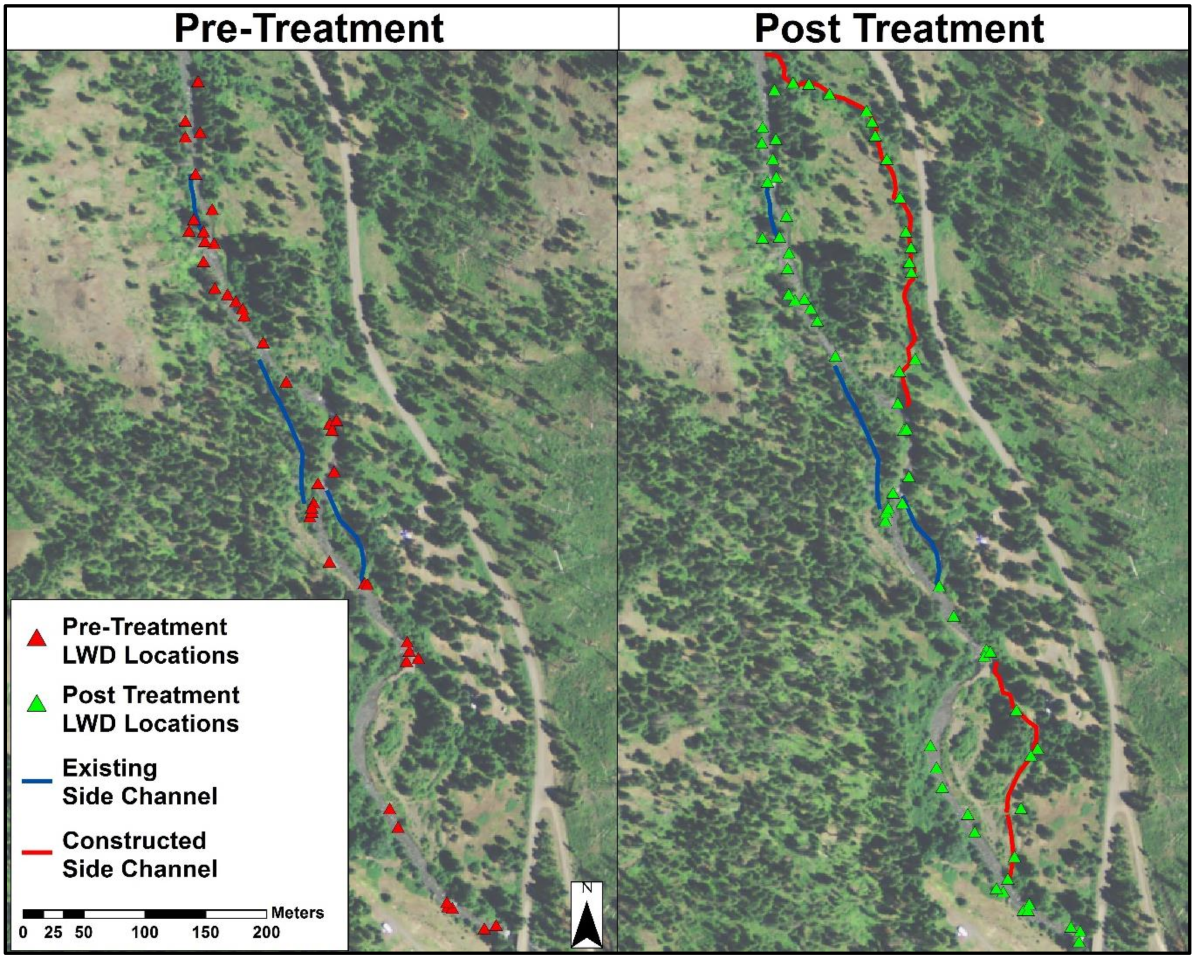

Figure 22. Pre and post treatment rapid habitat data for Project Area 1. LWD represent key LWD pieces.

3.4.4 TEMPERATURE

The restoration target for water temperatures in both the lower and Upper Assessment unit is less than four days greater than 72° F (SRSRB 2011). Results derived from the Washington State Department of Ecology stream gauge at Marengo between 2003 and 2015 indicate a general decrease in the number of days exceeding 72° F until 2015, with no days exceeding 72° F from 2008-2012 (Figure 23). While temperature responses may be due to previous restoration actions aimed at improving upstream riparian conditions, the decrease in exceedance days also corresponds to a general increase in mean annual flows over the time period. Stream gauge information can be found at https://fortress.wa.gov/ecy/eap/flows/station.asp?sta=35B150#block0.

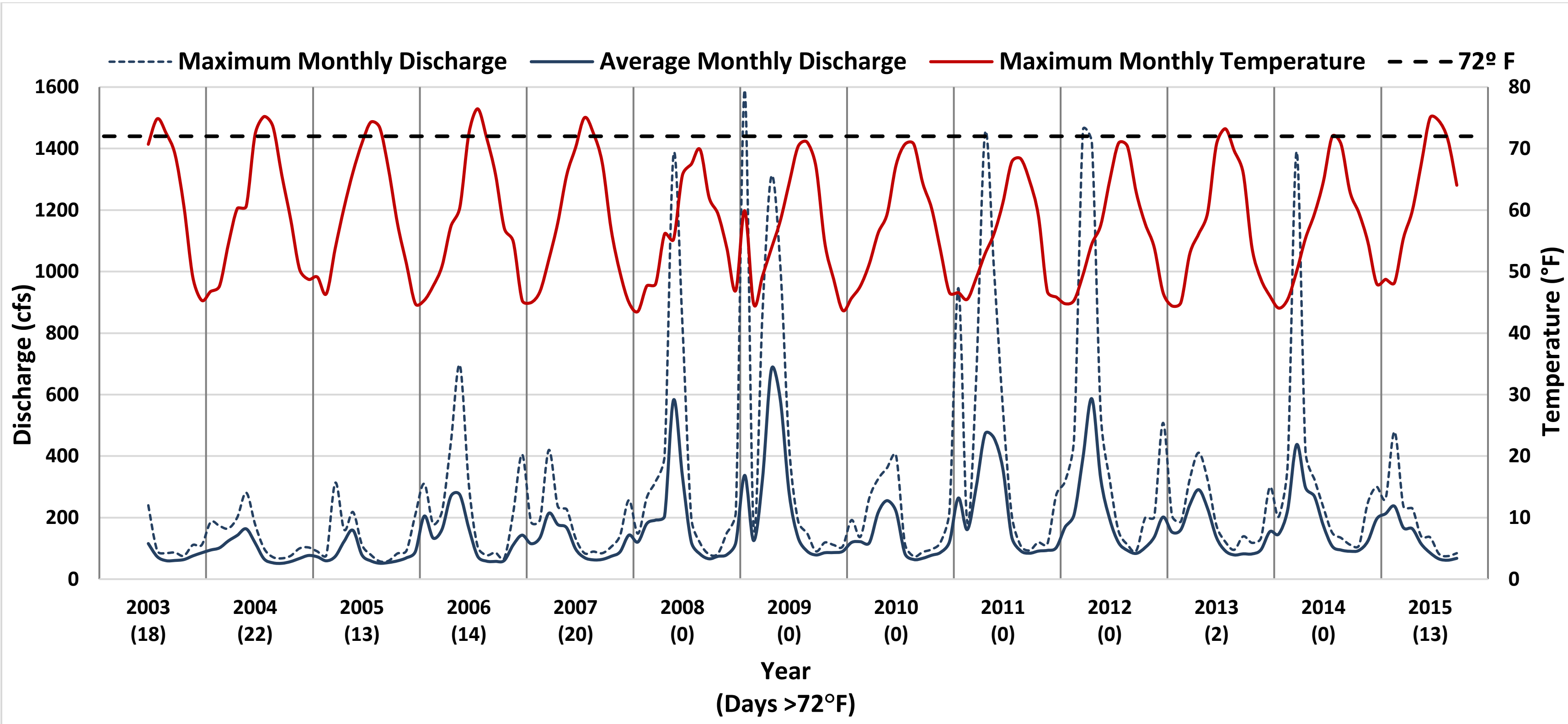

Figure 23. Monthly maximum (blue dashed line) and average discharge (solid blue line), maximum water temperature (red), and number of days water temperature exceeded 72° at Marengo from 2003-2015. Restoration target is < 4 days > 72° F. Note that temperature and flow records for 2003 only include data after the June 1 installation date and 2015 records only include data up to October 1 (end of Water Year).

Water temperature data at CHaMP sites from 2012-2015 indicate that at least 1 site in 2012, 3 sites in 2013, 1 site in 2014, and 3 sites in 2015 exceeded the restoration target of less than 4 days greater than 72° F (Figure 24). This data represents sites where full temperature records existed throughout the summer (July 15-August 31) time period. All of the sites sampled in the Lower Assessment unit exceeded the 72° F threshold for each year where data was available. Sites exceeding more than 4 days in the Upper Assessment unit were all located below river mile 20.

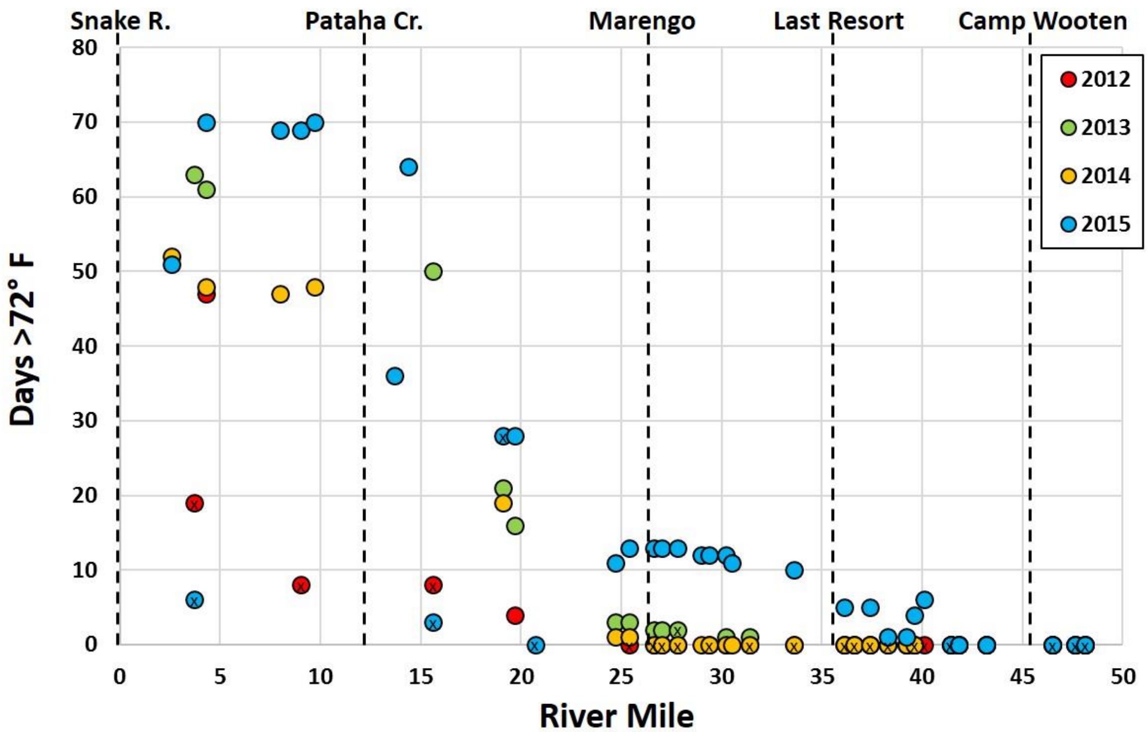

Figure 24. Number of days water temperature exceeded 72° F at CHaMP sites from 2012-2015 by river mile.

4 CONCLUSION

The results from data collected between 2011-2015 generally are unchanged from 2014. Summaries of CHaMP data at the watershed and assessment unit scale are not showing significant changes in key metrics suggesting that ecological concerns have not improved. However, project level effectiveness is generally showing improvements in several key metrics including LWD frequency, channel unit frequency, and deep pools. This summary report only includes data covering 43% of the planned actions and it is expected that the 2016 report, which will cover 77% of the planned restoration actions may start to detect more changes in channel attributes.

This report also provides new data analyses on the condition of valley bottom confinement and riparian conditions derived from GIS data. These analyses suggest that large portions of the valley bottom are still disconnected and the extent of riparian habitat is a small fraction of the historic extent. We will work with the TCC to refine these approaches and finalize the DRAFT monitoring plan so that it will be clear moving forward what data is needed to fully understand the effectiveness of the ongoing restoration actions.

5 FUTURE WORK

We recommend meeting with the RTT and Tucannon working groups to decide the direction of monitoring in the Tucannon River. The following is a list of suggested task to be completed in 2017:

- update the Monitoring Plan
- review rollup of CHaMP data (i.e., what scale and time periods will be used to assess effectiveness)
- develop baseline conditions for assessing restoration effectiveness (i.e., what data set is going to be considered “pre” data for determining changes in ecological concerns)
- review, refine, and continue rapid habitat surveys pre and post restoration
- refine metrics to consider for assessing ecological concerns
- refine draft River Styles to aid in assessing effectiveness and informing future restoration

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APPENDIX I. METRICS AND DEFINITIONS TO BE USED FOR ASSESSING CHANGES IN FIVE BRAOD CLASSES OF ECOLOGICAL CONCERN (FLOODPLAIN, INSTREAM COMPLEXITY, CHANNEL FORM, SUBSTRATE, RIPARIAN CONDITIONS). SEE CHAMPMONITORING.ORG FOR PROTOCOLS AND SPECIFCS ON HOW METRICS ARE CALCULATED.

Ecological Concern/ Sub-Category	Attribute Type	Metric	Calculation
Peripheral and Transitional Habitats/Floodplain Condition	off-channel	Off-channel area/ site area	Area of Tier 1/2 Slow-Water/Pool/Off-Channel units divided by the wetted area
	off-channel	Off-channel units/100m	Number of Tier 1/2 Slow-Water/Pool/Off-Channel Units divided by the site length and standardized to number per 100m.
	side-channel	Side-channel area/site area	Wetted side channel area at a site divided by total wetted site area.
	side-channel	Length of side-channels/ site length	Centerline length of side channels divided by total length of all channels (side and main).
	side-channel	Active side-channels/ site length	Calculation not available.
	valley	% floodplain accessible	Calculation not available.
	valley	% Confinement	Calculation not available.
	valley	Confinement Ratio	Bankfull wetted area divided by the low-flow site wetted area.
Channel Structure/Instream Structural Complexity	channel units	Channel Units/100 m	Number of channel units divided by the site length and standardized to number per 100m.
	channel units	Channel Unit Diversity Index	Calculation not available.
	pool	Pools/ 100 m	Number of Tier 1 Slow--Water/Pool designated channel units divided by the site length and standardized to number per 100m.
	pool	% Pool volume/ site volume	Volume of Tier 1 Slow-Water/Pool designated channel units divided by the wetted site volume.
	pool	% Pool area/ site area	Area of Tier 1 Slow-Pool designated channel units divided by the wetted site area.
Ecological Concern/ Sub-Category	**Attribute Type**	**Metric**	**Calculation**

Channel Structure/Instream Structural Complexity (cont.)	pool	Residual pool depth	The average difference of the maximum depth and downstream end depth of all Slow-Water/Pool channel units for a site. The downstream depth is extracted from the raster cell where the thalweg and downstream edge of the channel unit meet.
	pool	Deep pools/ 100 m (> 1 m)	Number of Tier 1 Slow--Water/Pools with max depths >1m divided by the site length and standardized to number per 100m.
	undercut	% Undercut/ site area	Sum of all undercut areas divided by the area of the wetted stream plus undercuts.
	undercut	% Undercut/ site length	Sum of all undercut lengths divided by the wetted stream length (length is multiplied by 2 to account for the total length of the right and left banks).
	wood	Key pieces/ 100 m	Number of key pieces (≥ 0.3 m diameter and ≥ 6 m long) divided by site length and standardized to number per 100m.
	wood	LWD (all pieces)/ 100 m	Count of qualifying large wood pieces within the bankfull channel divided by the site length and standardized to number per 100m. Qualifying pieces are > 0.10 m diameter and > 1.0 m length.
	wood	Key pieces/ BFW	Number of key pieces (≥ 0.3 m diameter and ≥ 6 m long) divided by the number of bankfull widths along the sites length.
	wood	LWD (all pieces)/ BFW	Count of qualifying large wood pieces within the bankfull channel divided by the number of bankfull widths along the sites length. Qualifying pieces are > 0.10 m diameter and > 1.0 m length.
	wood	LWD volume/ BFW	Total volume of all qualifying large wood pieces within the bankfull channel divided by the number of bankfull widths along the sites length. Qualifying pieces are > 0.10 m diameter and > 1.0 m length. Volume is estimated using diameter and length, then calculating the volume of a cylinder.

Ecological Concern/ Sub-Category	Attribute Type	Metric	Calculation
Channel Form & Function/ Bed & Channel Form	depth	Thalweg depth mean	Mean depth of the thalweg taken at even measurements (every 0.5 m) along the length.
	depth	Thalweg depth CV	Coefficient of Variation of thalweg depths. Taken at even measurements (every 0.5 m) along the length of the thalweg.
	depth	Water depth stdev	Standard deviation of all water depths derived from the DEM.
	form	Sinuosity	Ratio of the thalweg length to the straight line distance between the start and end points of the thalweg.
	width	Bankfull width CV	Cross-sections are distributed perpendicular to the bankfull centerline at intervals of 0.5m. The width of each cross-section is measured at each interval down the centerline of the bankfull channel and the coefficient of variation is calculated from all cross-sections.
	width	Wetted width CV	Cross-sections are distributed perpendicular to the wetted centerline at intervals of 0.5m. The width of each cross-section is measured at each interval down the centerline of the wetted channel and the coefficient of variation is calculated from all cross-sections.
	width	WD ratio	Bankfull width to average depth ratio derived from cross-sections. Cross-sections are laid out at 0.5m intervals perpendicular to the bankfull centerline extending across the bankfull polygon. Calculated by dividing the average depth by the width at each cross-section. All cross-sections are averaged at a site.
Riparian Condition/Structure and Composition	age	Age structure	Calculation not available.
	extent	Big tree cover	Estimate of the aerial coverage from big trees (>0.3 m DBH) in the canopy layer (trees >5 m tall). Calculated across the site from visual estimates of big tree coverage in each of ten plots (left and right bank of transects 1, 6, 11, 16, and 21).

Ecological Concern/ Sub-Category	Attribute Type	Metric	Calculation
Riparian Condition/Structure and Composition (cont.)	extent	Average Summer Solar Access	A measure of the solar radiation availability at a site. Insolation data is summed across all days in a month to provide monthly solar insolation values. Monthly readings from July-Sept are averaged for a site.
	extent	% Cover trees > 5'	Calculation not available.
	extent	% Green, Wetness, NDVI	Calculation not available.
	species	Species composition	Calculation not available.
Water Quality/Temperature, Flow, and Turbidity	temperature	Day > 16 C (PFC) or 22.2 C (RTT)	Count of calendar days exceeding temperature threshold.
	temperature	7 day moving ave max July/Aug	Calculation not available.
	flow	7 day moving ave min flow July/Aug/Sept	Calculation not available.
	turbidity	ISCO NTU	Calculation not available.
Sediment Conditions/Fines and Substrate	substrate	D50	Diameter of the 50th percentile particle calculated from substrate measurements in fast-water turbulent and non-turbulent channel units. Bedrock measurements are excluded and bank particles are not measured.
	fines	% fines < 6 mm	Average percentage of pool tail substrates comprised of fine sediment <6 mm. A fines grid with 50 intersections is placed at three locations at the tail of Slow Water/Pool and Non-Turbulent channel units. For each grid, the number of intersections <2 mm and 2-6 mm is recorded for each grid. The percent of fines <6 mm for each grid is calculated by adding together the number of <2 mm and 2-6 mm intersections and dividing by 50 (intersections) minus the number of nonmeasureable intersections. Averaged across a site.
	fines	% fines < 2 mm	Same method as “fines < 6 mm” but only particles <2mm are counted.

Ecological Concern/ Sub-Category	Attribute Type	Metric	Calculation
Sediment Conditions/Fines and Substrate	substrate	% embeddedness	Embeddedness is estimated as the product of the percentage of the cobble's surface that is buried below the surface of the streambed and the percentage of fine sediment < 2 mm in the substrate immediately surrounding the cobble. The average embeddedness is calculated across all 65-200 mm particles at the site.

APPENDIX II. PRELIMINARY DESIGN HYPOTHESES BY EACH RESTORATION ACTION.

The following draft design hypotheses all directly or indirectly stem from the conceptual model of the current conditions derived from reviewing past assessments and consultation with project managers, and participating technical staff. From this understanding of the current stream conditions we generated an envisioned condition post restoration that we then used to form specific, testable hypotheses, and a monitoring plan to test those hypotheses. In the following sections we outline the design hypotheses and expected responses of the main restoration actions for both short-term responses (immediately after construction) and long-term responses (after the first high flow event). As noted in the Restoration Philosophy section above, we expect some reconnections will not be immediately connected to the main flow due the dynamic nature of alluvial channels. Reconnections and levee setbacks may remain relatively unchanged for several years once they are given an "opportunity" to become active by infrastructure removal or direct excavation. In the same way, some LWD may be washed away or be relatively inactive once placed in a project area. The monitoring infrastructure is set up to learn from these situations as much as from immediate and dynamic responses.

FLOODPLAIN RECONNECTION

River channels are directly influenced and shaped by inputs of water, sediment, and wood within the unique biophysical context of a watershed (Montgomery and Buffington 1997). These inputs are all partially influenced by the floodplain habitat, usually defined as periodically inundated areas adjacent to the channel (Ward et al. 2002). Common features of a properly functioning floodplain include main channels, side-channels, beaver ponds, oxbows, natural levees, alluvial deposits, mid-channel islands (vegetated and non-vegetated), wetlands, and woody debris (Pess et al. 2005). Constructed levees and confinement of the channel to protect infrastructure and increase flow capacity reduce or eliminate many of these features leading to an overall decrease in habitat complexity, fish habitat, organic inputs, channel migration, wood recruitment, floodplain inundation, and exchange with hyporheic zone (reviewed in Pess et al. 2005).

We recognize two important plausible "responses" of the floodplain reconnection: i) some levee setbacks will 'fail' (i.e., not lead to a change in channel form), and/or ii) will lead to a change in channel form that is not desired (i.e., extensive braiding or unstable channels that are shallow and have limited diversity of habitats). Rivers are dynamic and we fully expect both desired and undesired outcomes to occur within the project areas. However, the design of infrastructure removal and setbacks and side-channel reconnections are designed to promote natural processes wherever possible. The monitoring program is also designed to learn what characteristics of the channel and removal process create positive responses.

SHORT-TERM RESPONSE OF INFRASTRUCUTRE REMOVAL OR SETBACK

The following list of hypotheses are a DRAFT and will require input from the TCC to fully develop.

List of short-term hypotheses (i.e., before the first flood)

1) Levee removal/setback
   I. Channel migration - limited
   II. Inundation – limited prior to high flows
   III. Channel width – the channel (as defined by bankfull height) will be wider after levee removal although water may not access the wider channel right away
   IV. Water depth – little change in depth expected; there may be a decrease in the depth of flow if the water spreads across new channel
   V. We do not expect any significant geomorphic adjustment in response to these hydraulic changes at base-flows

2) Side-channel or floodplain reconnection
   VI. Flow – if the reconnection is done below the current water level will expect a proportion of flow from the mainstem to enter the existing channel
   VII. Inundation - limited prior to high flows depending on degree of reconnection via earth moving
   VIII. We do not expect any significant geomorphic adjustment in response to these hydraulic changes at base-flows

After the first high flow event we expect the following responses:

1. Levee removal/setback
   IX. Channel migration – increased braiding in unconfined reaches and increased meandering in more confined reaches
   X. Inundation – newly exposed floodplain will be inundated which may enhance channel migration
   XI. Channel width – the variability in the channel width will increase; variability will be greater in unconfined reaches
   XII. Water depth - the variability in the water depth will increase; variability will be greater in unconfined reaches
   XIII. Deposition/Scour – increased deposition and sediment sorting will be evident in form of newly created gravel bars varying in substrate size based on forcing mechanism. Deposition will be higher in unconfined and partly confined reaches compared to confined reaches. Expect the opposite results for scour.

2. Side-channel reconnection/enhancement
   XIV. Flow – should increase proportional to the size of the side-channel
   XV. Inundation – should be based on elevation and connection of floodplain
   XVI. Side-channel behavior – should see similar behavior as in the mainstem; channel migration, increased depth and width variability, and deposition and/or scour depending on confinement.

LONG-TERM AND SITE SCALE RESPONSE OF INFRASTRUCUTRE REMOVAL OR SETBACK

These hypotheses have not been fully articulated. Depending on the envisioned condition, we could expect a semi-braided or anastomosing channel to more of a single-thread, meandering channel. In all likelihood the restoration will promote all these reach types depending on the landownership, valley confinement, and gradient. On public land there are probably more opportunities to allow the channel more room to migrate and create more of an anastomosing channel type.

DEVELOPMENT OF INSTREAM HABITAT COMPLEXITY

We recognize two important plausible "responses" of the LWD additions: i) some structures will 'fail' (i.e., be swept downstream, or the channel will move around the structure, possibly leaving them outside the active channel), and/or ii) some structures will have limited immediate effect (i.e., create a limited number of all the possible responses). Rivers are dynamic and we fully expect both outcomes to occur at some structures.

SHORT-TERM RESPONSE AT INDIVIDUAL LWD STRUCTURES AND ELJS

The individual LWD structures are designed to produce an immediate hydraulic response by constricting the flow width and/or directing flow into side-channels or onto the floodplain. Immediately following placement of the structure we hypothesize the following physical responses (assuming a deflecting type structure):

A. Shift from uniform flow pattern to convergent flow pattern
B. An eddy will form in the wake of the LWD and extend downstream
C. Flow paths will strongly diverge downstream of the main zone of convergence
D. Limited geomorphic adjustment in response to these hydraulic changes at base-flows

In response to high flows, we hypothesize the following potential responses:

E. Drifting woody debris will accumulate on structures.
F. Scour and formation or enhancement of forced pools
G. Eddy formation behind the structure
H. Bank erosion and/or an undercut bank to develop opposite the structure
I. Gravel bar may form where the flow path becomes highly divergent downstream
J. Gravel bars initiate convergent flow and cause creation of a bar-forced pool

We hypothesize that the high-flows will result in the following geomorphic changes:

K. Greater variability in channel & flow width.
L. Increased variability in water depth
M. Increased diversity in the type of geomorphic units and a larger number of geomorphic units.
N. An increase in both the amount of erosion and deposition

O. An increase in the presence of structural cover for fish
P. An increase in the number, size and proximity of shear zones

If the LWD are washed downstream, we expect the channel to either:

Q. Quickly revert back to the pre LWD condition; or if the wood accumulates on a downstream feature,
R. Follow a similar progression to hypotheses A-J, resulting in K-P

LONG-TERM AND SITE SCALE RESPONSE TO INDIVIDUAL LWD STRUCTURES AND ELJS

Over time the continued we expect the eventual 'failure', shift, or evolution of the LWD. We expect the LWD to be ephemeral on the time frame of 3-5 years but at sites with initial high densities of LWD treatments:

S. Material (both wood and sediment stored in associated active bars) will re-deposit or accumulate at downstream LWD or LWD jam.

On the scale of these treatments, we hypothesize that over our 5-10 year monitoring window:

T. LWD used in the initial placement of the LWD will break down, but may be self-sustaining if natural LWD recruitment roughly matches the rate of breakdown.
U. Residence time of gravels to increase, as indicated by a general increase in the number of active bar deposits, which regularly turn over and are replaced.

In summary, the desired habitat conditions to increase the growth and survival of juvenile chinook are largely reflected and predicted in hypotheses K-P. ***In the long term we expect the woody structures to become a part of the study creeks that is more dynamic, resilient, and regularly adjusts to switch between alternative stable states, which maintain a diversity of habitat types, and support increased Chinook production.***

APPENDIX III. SUMMARY OF COLUMBIA HABITAT MONITORING PROTOCOL DATA BY SITE AND YEAR: 2011-2015.

										Channel Form & Function						Channel Structure and Complexity					Floodplain & Riparian			Substrate			
Stream	RM	Site_ID	SampleDate	Visit Year	Site Type	Location	Project Area	Restoration Type	Restored	Sinuosity	Gradient	Thalweg depth (m)	Thalweg CV	WD	BFW	Channel Units/ 100 m	LWD/ 100 m	Key LWD/ BFW	Residual pool depth (m)	Deep pools/ 100 m	Confinement ratio	Tree cover	Solar Access	% Embed	D50	Fines < 2 mm	Fines < 6 mm
Tucannon River	2.6	CBW05583-353323	9/29/2013	2013	Control	Lower	42		No	1.45	0.49	0.71	0.43	25.14	14.80	3.90	14.28	0.05	0.62	2.51	0.82	14.00	61.50	25.92	24.00	25.27	26.87
Tucannon River	3.7	CBW05583-222251	8/25/2011	2011	Control	Lower	41		No	1.21	0.78	0.52	0.37	74.17	30.52	5.67	54.38	0.65	0.75	1.67	0.51	27.00	37.22	-	28.00	21.50	25.67
Tucannon River	3.7	CBW05583-222251	10/13/2014	2014	Control	Lower	41		No	1.04	0.66	0.59	0.42	39.79	19.15	5.92	43.53	0.25	0.56	1.32	0.67	12.00	-	1.90	34.00	19.82	23.29
Tucannon River	4.3	CBW05583-386091	10/1/2013	2013	Treatment	Lower	40	LWD, Levee	Yes	1.07	0.47	0.59	0.54	20.94	13.02	3.33	10.56	0.00	0.89	0.91	0.83	2.50	90.44	6.59	35.00	5.51	9.11
Tucannon River	4.3	CBW05583-386091	9/28/2012	2012	Treatment	Lower	40	LWD, Levee	Yes	1.06	0.48	0.58	0.54	21.73	12.66	3.34	17.90	0.05	0.87	0.91	0.86	5.00	85.54	3.11	28.00	0.34	1.26
Tucannon River	4.3	CBW05583-386091	8/24/2011	2011	Treatment	Lower	40	LWD, Levee	Yes	1.07	0.38	0.55	0.40	18.07	13.01	2.13	18.52	0.10	0.90	0.61	0.84	0.00	87.60	-	32.00	2.44	6.00
Tucannon River	4.3	CBW05583-386091	8/28/2015	2015	Treatment	Lower	40	LWD, Levee	Yes	1.08	0.47	0.46	0.49	27.40	11.86	2.71	9.02	0.20	0.72	0.60	0.91	0.50	87.29	1.89	33.00	2.89	5.33
Tucannon River	4.3	CBW05583-386091	7/11/2014	2014	Treatment	Lower	40	LWD, Levee	Yes	1.07	0.47	0.56	0.40	21.44	12.87	3.05	7.60	0.20	0.51	0.91	0.86	0.00	85.91	1.05	40.00	0.44	3.78
Tucannon River	8	CBW05583-420019	9/26/2013	2013	Control	Lower	37		No	1.02	0.37	0.49	0.48	21.41	13.44	3.19	4.15	0.00	0.67	0.32	0.91	0.00	85.33	22.05	47.00	14.56	20.00
Tucannon River	9	CBW05583-481459	9/24/2013	2013	Control	Lower	37		No	1.31	0.59	0.52	0.42	54.44	22.33	7.65	41.93	0.05	0.82	1.47	0.79	4.50	83.70	6.00	28.00	3.22	5.11
Tucannon River	9	CBW05583-481459	8/26/2015	2015	Control	Lower	37		No	1.51	0.58	0.55	0.52	-	-	7.00	51.13	1.35	0.73	1.62	0.76	4.50	82.25	1.42	30.00	2.22	5.26
Tucannon River	9	CBW05583-481459	8/29/2012	2012	Control	Lower	37		No	1.49	0.56	0.56	0.46	58.66	27.47	7.75	51.02	0.15	0.48	1.66	0.72	15.00	84.31	1.43	27.00	1.20	3.87
Tucannon River	9	CBW05583-481459	8/27/2011	2011	Control	Lower	37		No	1.44	0.64	0.60	0.36	-	-	3.53	89.98	1.50	0.79	1.47	0.55	7.50	80.53	-	18.00	29.25	31.17
Tucannon River	9	CBW05583-481459	10/20/2014	2014	Control	Lower	37		No	1.46	0.65	0.66	0.52	49.55	27.86	7.13	47.27	0.30	0.80	2.57	0.57	4.00	-	1.31	33.00	4.06	8.02
Tucannon River	9.7	CBW05583-415923	10/1/2013	2013	Control	Lower	36		No	1.94	0.54	0.63	0.45	36.86	15.68	5.49	25.91	0.15	0.81	1.31	0.81	8.50	79.74	18.38	35.00	1.21	1.81
Pataha Creek	12.3	CBW05583-109611	10/11/2012	2012	Tributary	Tributary	-		No	1.08	0.33	0.49	0.50	7.20	4.59	6.74	4.17	0.00	0.63	0.84	0.70	6.60	64.96	7.12	27.00	39.50	41.17
Pataha Creek	12.3	CBW05583-109611	9/29/2011	2011	Tributary	Tributary	-		No	1.09	0.36	0.44	0.53	8.20	4.40	6.70	4.96	0.00	0.60	0.84	0.68	5.50	48.91	-	38.00	39.60	40.77
Pataha Creek	12.3	CBW05583-109611	10/16/2013	2013	Tributary	Tributary	-		No	1.09	0.43	0.58	0.47	7.61	3.54	6.60	4.11	0.05	0.76	1.65	0.90	5.50	70.25	17.16	41.00	27.37	28.98
Tucannon River	13.7	CBW05583-057139	9/28/2011	2011	Control	Upper	33	-	No	1.14	0.52	0.44	0.34	32.45	13.45	4.35	14.68	0.25	0.44	0.31	0.90	11.00	60.04	-	46.00	0.32	0.63
Tucannon River	13.7	CBW05583-057139	9/29/2014	2014	Control	Upper	33	-	No	1.14	0.58	0.49	0.52	24.56	15.13	4.05	30.95	0.30	0.55	1.25	0.78	2.00	-	1.68	36.00	8.67	9.67
Tucannon River	14.4	CBW05583-384819	8/6/2014	2014	Control	Upper	33		No	1.12	0.46	0.49	0.57	26.03	13.13	3.75	11.21	0.00	0.63	0.34	0.82	14.00	88.96	1.90	38.00	3.62	9.90
Tucannon River	14.4	CBW05583-384819	10/13/2013	2013	Control	Upper	33		No	1.12	0.56	0.48	0.44	28.27	13.12	4.76	5.37	0.00	0.58	0.68	0.86	2.50	80.00	17.52	35.00	0.97	2.55
Tucannon River	14.4	CBW05583-384819	8/12/2015	2015	Control	Upper	33		No	1.10	0.49	0.50	0.53	27.46	13.31	3.76	8.14	0.05	0.56	0.68	0.81	-	-	-	-	-	-
Tucannon River	15.6	CBW05583-212787	9/5/2011	2011	Control	Upper	32		No	1.17	0.58	0.58	0.40	29.18	14.47	5.24	17.80	0.15	0.51	1.21	0.73	8.00	67.19	-	41.00	1.33	4.50
Tucannon River	15.6	CBW05583-212787	9/25/2012	2012	Control	Upper	32		No	1.22	0.64	0.52	0.50	29.10	13.48	5.36	26.39	0.15	0.73	1.53	0.88	9.50	84.31	8.73	32.00	0.86	1.05
Tucannon River	15.6	CBW05583-212787	10/14/2013	2013	Control	Upper	32		No	1.20	0.63	0.48	0.47	28.91	14.10	6.54	17.10	0.15	0.45	2.31	0.82	1.50	82.65	5.87	51.00	0.78	2.56
Tucannon River	15.6	CBW05583-212787	9/13/2014	2014	Control	Upper	32		No	1.31	0.57	0.61	0.50	37.32	22.01	9.30	16.61	0.20	0.72	3.10	0.61	8.50	77.69	0.44	36.00	1.52	4.73
Tucannon River	19.1	CBW05583-196787	9/28/2012	2012	Control	Upper	29		No	1.10	0.60	0.55	0.38	27.14	14.56	3.21	24.40	0.55	0.58	0.49	0.79	5.00	91.36	0.77	45.00	2.09	3.18
Tucannon River	19.1	CBW05583-196787	8/16/2015	2015	Control	Upper	29		No	1.11	0.60	0.51	0.39	28.46	12.88	3.99	10.46	0.25	0.33	0.50	0.79	1.50	86.27	4.43	43.00	0.89	1.72
Tucannon River	19.7	CBW05583-327859	9/30/2012	2012	Control	Upper	29		No	1.16	0.96	0.49	0.33	31.12	14.47	2.58	14.06	0.00	0.41	0.00	0.89	10.50	72.64	0.95	50.00	0.17	1.49
Tucannon River	19.7	CBW05583-327859	9/17/2013	2013	Control	Upper	29		No	1.19	0.99	0.49	0.32	31.73	14.69	5.59	10.99	0.00	0.25	0.00	0.87	6.50	58.27	4.73	36.00	0.00	0.53
Tucannon River	19.7	CBW05583-327859	9/15/2014	2014	Control	Upper	29		No	1.16	0.99	0.47	0.34	27.91	18.50	4.05	6.67	0.05	0.34	0.34	0.71	9.50	72.29	2.25	41.00	1.34	3.24
Tucannon River	19.7	CBW05583-327859	9/16/2011	2011	Control	Upper	29		No	1.19	0.99	0.49	0.30	28.30	15.51	2.35	7.95	0.10	0.30	0.00	0.80	17.00	46.57	-	30.00	0.44	0.89
Tucannon River	20.7	CBW05583-051659	8/12/2015	2015	Control	Upper	28		No	1.13	0.66	0.41	0.42	39.56	12.79	4.25	20.73	0.00	0.55	0.61	0.87	23.00	74.26	0.29	44.00	2.93	5.94
Tucannon River	20.7	CBW05583-051659	9/16/2012	2012	Control	Upper	28		No	1.18	0.62	0.49	0.31	40.75	18.48	6.05	46.72	0.25	0.44	0.91	0.81	24.50	59.08	0.83	49.00	2.14	3.52
Tucannon River	24.7	CBW05583-141771	10/9/2012	2012	Control	Upper	26		No	1.07	0.67	0.44	0.43	36.32	17.53	2.70	37.49	0.05	0.74	0.60	0.78	13.20	84.89	1.53	49.00	1.07	3.34
Tucannon River	24.7	CBW05583-141771	8/12/2015	2015	Control	Upper	26		No	1.05	0.61	0.52	0.29	42.30	17.27	3.57	62.08	0.30	0.37	0.00	0.74	4.00	64.86	1.51	33.00	14.40	15.93
Tucannon River	25.4	CBW05583-203211	9/14/2011	2011	Treatment	Upper	26	Levee, LWD	Yes	1.06	0.76	0.43	0.42	40.90	17.67	4.85	16.98	0.00	0.53	0.61	0.75	3.50	41.04	-	52.00	1.33	2.93
Tucannon River	25.4	CBW05583-203211	10/12/2012	2012	Treatment	Upper	26	Levee, LWD	Yes	1.07	0.86	0.45	0.32	36.06	15.81	4.25	67.35	0.55	0.59	0.30	0.80	11.60	56.01	2.75	45.00	8.60	10.80
Tucannon River	25.4	CBW05583-203211	8/14/2014	2014	Treatment	Upper	26	Levee, LWD	Yes	1.07	0.88	0.58	0.36	33.72	18.04	5.67	25.32	0.85	0.57	2.09	0.62	4.50	76.66	0.56	48.00	9.93	10.40
Tucannon River	25.4	CBW05583-203211	8/14/2015	2015	Treatment	Upper	26	Levee, LWD	Yes	1.09	0.83	0.49	0.42	34.28	16.51	3.82	46.01	0.95	0.55	1.17	0.63	3.00	28.82	7.08	46.00	2.67	3.50
Tucannon River	25.4	CBW05583-203211	7/21/2013	2013	Treatment	Upper	26	Levee, LWD	Yes	1.08	0.81	0.48	0.36	40.53	18.02	4.23	28.77	0.15	0.68	0.60	0.80	1.00	44.68	1.29	40.00	2.42	3.58
Tucannon River	26.1	CBW05583-465355	8/17/2013	2013	Treatment	Upper	26	Levee, LWD	Yes	1.07	0.68	0.50	0.38	33.08	15.29	4.44	17.48	0.00	0.50	0.63	0.86	6.50	68.14	1.35	65.00	0.17	0.52
Tucannon River	26.6	CBW05583-072139	7/20/2013	2013	Control	Upper	26		No	1.20	1.01	0.47	0.34	40.35	16.09	2.39	11.65	0.05	0.54	0.48	0.80	5.50	59.58	3.71	53.00	0.83	3.55
Tucannon River	26.6	CBW05583-072139	8/16/2014	2014	Control	Upper	26		No	1.18	1.03	0.44	0.35	36.17	17.06	3.02	14.60	0.10	0.48	0.50	0.84	9.50	64.87	0.54	68.00	3.92	5.25
Tucannon River	26.6	CBW05583-072139	9/2/2011	2011	Control	Upper	26		No	1.19	1.06	0.42	0.39	29.66	15.27	2.43	9.40	0.40	0.56	0.49	0.87	22.00	44.34	-	45.00	0.00	1.00
Tucannon River	27	CBW05583-432587	10/13/2012	2012	Control	Upper	25		No	1.07	0.98	0.45	0.32	28.77	14.70	2.27	26.59	0.00	0.73	0.32	0.81	10.20	80.11	0.37	65.00	1.01	3.41
Tucannon River	27	CBW05583-432587	9/18/2011	2011	Control	Upper	25		No	1.09	0.94	0.39	0.40	29.75	14.13	3.88	8.12	0.00	0.26	0.32	0.89	31.00	29.65	-	47.00	58.33	60.33
Tucannon River	27	CBW05583-432587	9/27/2014	2014	Control	Upper	25		No	1.07	0.95	0.45	0.30	26.58	15.11	3.96	15.45	0.00	0.29	0.00	0.76	9.50	-	0.88	63.00	1.41	2.52
Tucannon River	27	CBW05583-432587	6/19/2013	2013	Control	Upper	25		No	1.06	0.99	0.41	0.40	38.06	14.40	4.95	14.80	0.00	0.36	0.33	0.87	7.50	49.71	6.50	45.00	1.39	3.70
Tucannon River	27	CBW05583-432587	8/16/2015	2015	Control	Upper	25		No	1.07	0.93	0.42	0.33	26.63	15.24	3.87	19.36	0.05	0.32	0.00	0.73	22.00	30.47	6.33	47.00	8.39	11.35
Tucannon River	27.8	CBW05583-170443	6/21/2015	2015	Treatment	Upper	24	LWD, Levee	Yes	1.24	1.10	0.54	0.43	30.35	15.29	5.11	80.99	0.60	0.47	0.79	0.67	4.50	39.82	1.94	55.00	11.52	12.48
Tucannon River	27.8	CBW05583-170443	10/23/2012	2012	Treatment	Upper	24	LWD, Levee	Yes	-	-	-	-	-	-	-	-	0.15	-	-	-	9.00	66.57	2.74	45.00	6.68	8.50
Tucannon River	27.8	CBW05583-170443	8/18/2014	2014	Treatment	Upper	24	LWD, Levee	Yes	1.23	1.13	0.52	0.44	31.69	12.92	8.56	80.99	0.30	0.53	1.17	0.76	13.00	67.54	0.43	52.00	10.39	11.75
Tucannon River	29	CBW05583-214475	6/22/2015	2015	Treatment	Upper	23	LWD, Levee	Yes	1.11	0.79	0.36	0.37	33.81	14.34	3.46	23.47	0.05	0.47	0.31	0.80	16.50	50.71	5.27	51.00	5.43	6.48
Tucannon River	29	CBW05583-214475	9/14/2013	2013	Treatment	Upper	23	LWD, Levee	Yes	1.13	0.79	0.48	0.44	31.21	15.63	4.73	18.36	0.05	0.49	0.95	0.79	17.00	53.16	1.61	77.00	0.67	1.63
Tucannon River	29.4	CBW05583-208767	7/8/2014	2014	Treatment	Upper	22	LWD	No	1.02	0.89	0.41	0.40	39.09	16.47	3.49	11.93	0.05	0.47	0.00	0.84	6.50	64.39	8.05	65.00	3.87	5.46
Tucannon River	29.4	CBW05583-208767	8/28/2011	2011	Treatment	Upper	22	LWD	No	1.05	0.89	0.45	0.30	41.48	16.88	1.76	19.71	0.20	0.42	0.00	0.82	16.50	51.50	-	45.00	0.67	1.33
Tucannon River	30.2	CBW05583-339839	8/31/2014	2014	Control	Upper	22		No	1.04	0.81	0.44	0.31	22.02	13.82	1.82	4.70	0.00	0.44	0.00	0.80	16.00	69.85	1.13	59.00	1.78	5.78
Tucannon River	30.2	CBW05583-339839	10/26/2012	2012	Control	Upper	22		No	1.05	0.80	0.47	0.30	20.47	13.04	1.08	1.81	0.10	0.65	0.00	0.81	10.60	74.59	2.84	58.00	2.00	2.67
Tucannon River	30.2	CBW05583-339839	10/15/2013	2013	Control	Upper	22		No	1.05	0.80	0.51	0.36	23.44	12.09	1.45	6.90	0.10	0.59	0.36	0.90	5.00	64.34	4.49	65.00	0.33	3.33
Tucannon River	30.2	CBW05583-339839	6/19/2015	2015	Control	Upper	22		No	1.05	0.84	0.37	0.30	28.68	12.10	1.81	3.97	0.10	0.34	0.00	0.87	13.00	65.15	3.57	49.00	2.22	7.33
Tucannon River	30.2	CBW05583-339839	8/28/2011	2011	Control	Upper	22		No	1.05	0.82	0.47	0.29	27.44	13.23	1.09	8.30	0.20	0.61	0.00	0.88	9.50	49.22	-	55.00	1.33	2.67
Tucannon River	30.5	CBW05583-274303	10/15/2013	2013	Control	Upper	21		No	1.04	1.11	0.44	0.39	33.59	15.47	2.49	5.83	0.00	0.64	0.42	0.90	9.00	66.92	2.09	55.00	3.56	4.89
Tucannon River	31.4	CBW05583-178047	9/25/2014	2014	Control	Upper	21		No	1.11	1.30	0.46	0.28	23.92	13.89	5.51	26.23	0.00	0.54	0.69	0.70	6.00	71.42	0.89	66.00	6.44	7.04
Tucannon River	31.4	CBW05583-178047	8/30/2011	2011	Control	Upper	21		No	1.12	1.33	0.46	0.25	-	-	6.37	75.17	0.55	0.36	0.00	0.81	21.50	43.10	-	62.00	16.00	18.83
Tucannon River	33.6	CBW05583-079743	9/12/2013	2013	Treatment	Upper	18	LWD, Levee	No	1.19	1.16	0.47	0.36	32.93	15.02	7.52	25.98	0.00	0.42	0.63	0.86	14.50	54.51	1.80	80.00	1.03	2.18
Tucannon River	36.1	CBW05583-522111	9/3/2012	2012	Control	Upper	16		No	1.14	1.02	0.46	0.22	24.91	15.42	1.58	9.12	0.00	0.26	0.00	0.73	17.60	72.23	0.20	83.00	0.33	1.34
Tucannon River	36.1	CBW05583-522111	7/31/2015	2015	Control	Upper	16		No	1.16	1.00	0.42	0.28	33.84	13.31	2.52	11.34	0.15	0.35	0.00	0.90	8.50	40.57	0.68	61.00	1.50	2.17
Tucannon River	36.6	CBW05583-248063	9/2/2011	2011	Treatment	Upper	15	LWD, SC	Yes	1.12	1.15	0.48	0.36	27.86	16.47	3.52	14.92	0.00	0.50	0.35	0.70	8.50	59.55	-	81.00	50.00	50.67
Tucannon River	36.6	CBW05583-248063	9/3/2013	2013	Treatment	Upper	15	LWD, SC	Yes	1.10	1.19	0.48	0.32	33.78	14.08	5.40	16.10	0.10	0.39	0.36	0.77	6.50	66.96	6.73	53.00	0.27	0.93
Tucannon River	36.6	CBW05583-248063	7/22/2014	2014	Treatment	Upper	15	LWD, SC	Yes	1.09	1.25	0.49	0.34	34.83	19.23	5.72	14.11	0.25	0.30	0.36	0.57	9.00	74.51	0.68	82.00	3.31	4.69
Tucannon River	36.6	CBW05583-248063	8/26/2015	2015	Treatment	Upper	15	LWD, SC	Yes	1.21	1.28	0.45	0.36	25.87	12.95	6.83	62.41	3.15	0.34	1.02	0.71	8.50	58.26	1.88	58.00	11.92	13.76
Tucannon River	36.6	CBW05583-248063	9/15/2012	2012	Treatment	Upper	15	LWD, SC	Yes	1.12	1.15	0.48	0.32	30.92	14.91	3.11	34.76	0.40	0.39	0.35	0.67	5.00	69.30	2.22	54.00	0.80	0.93
Tucannon River	37.4	CBW05583-276351	8/15/2013	2013	Control	Upper	14		No	1.40	0.97	0.58	0.34	30.13	13.45	5.86	38.20	0.50	0.59	0.78	0.77	1.00	68.54	6.62	35.00	1.71	2.86

										Channel Form & Function						Channel Structure and Complexity					Floodplain & Riparian			Substrate			
Stream	RM	Site_ID	SampleDate	Visit Year	Site Type	Location	Project Area	Restoration Type	Restored	Sinuosity	Gradient	Thalweg depth (m)	Thalweg CV	WD	BFW	Channel Units/ 100 m	LWD/ 100 m	Key LWD/ BFW	Residual pool depth (m)	Deep pools/ 100 m	Confinement ratio	Tree cover	Solar Access	% Embed	D50	Fines < 2 mm	Fines < 6 mm
Tucannon River	37.4	CBW05583-276351	7/31/2015	2015	Control	Upper	14		No	1.47	0.96	0.41	0.43	27.78	11.47	2.57	32.10	0.90	0.86	0.73	0.80	1.50	67.11	5.89	39.00	12.00	17.17
Tucannon River	37.4	CBW05583-276351	8/21/2012	2012	Control	Upper	14		No	1.38	0.98	0.58	0.36	32.75	16.48	5.85	54.82	0.95	0.56	1.17	0.71	2.00	75.46	1.67	50.00	4.00	5.41
Tucannon River	37.4	CBW05583-276351	7/18/2014	2014	Control	Upper	14		No	1.41	1.00	0.51	0.39	30.28	13.07	4.96	22.14	0.45	0.55	0.76	0.74	0.50	68.02	4.08	58.00	0.27	0.80
Cummings Creek	37.9	CBW05583-141567	8/27/2013	2013	Tributary	Tributary	14		No	1.20	2.63	0.21	0.27	18.54	4.55	10.23	12.48	0.00	0.11	0.00	0.81	0.00	66.00	7.69	71.00	3.12	4.67
Cummings Creek	37.9	CBW05583-182527	9/28/2011	2011	Tributary	Tributary	-		No	1.39	3.30	0.20	0.42	15.82	4.73	9.83	134.50	0.60	0.43	0.00	0.72	5.50	39.21	-	15.00	21.33	30.33
Cummings Creek	37.9	CBW05583-329599	8/14/2015	2015	Tributary	Tributary	-		No	1.11	3.24	0.16	0.43	17.28	4.88	10.44	71.36	0.75	0.11	0.00	0.78	1.00	46.77	2.24	46.00	19.43	25.63
Cummings Creek	37.9	CBW05583-182527	9/17/2012	2012	Tributary	Tributary	-		No	1.45	3.25	0.26	0.47	16.07	6.35	18.12	203.98	0.25	0.35	0.00	0.54	1.50	67.29	8.40	28.00	28.44	31.05
Cummings Creek	37.9	CBW05583-182527	9/23/2013	2013	Tributary	Tributary	-		No	1.48	3.21	0.24	0.41	20.38	5.78	17.88	94.16	0.25	0.27	0.00	0.69	1.00	65.77	11.09	43.00	29.08	32.17
Cummings Creek	37.9	CBW05583-182527	8/14/2015	2015	Tributary	Tributary	-		No	1.43	3.25	0.21	0.36	21.30	5.42	17.31	146.12	0.30	0.21	0.00	0.73	1.00	40.90	2.28	35.00	8.44	17.51
Cummings Creek	37.9	CBW05583-329599	7/22/2012	2012	Tributary	Tributary	-		No	1.10	3.26	0.20	0.31	17.72	4.62	11.11	60.79	0.35	0.12	0.00	0.71	2.30	69.66	4.08	39.00	6.56	16.11
Tucannon River	38.3	CBW05583-010495	8/31/2012	2012	Treatment	Upper	14	LWD, SC	No	1.25	1.13	0.52	0.39	32.62	17.08	5.42	19.62	0.50	0.66	1.25	0.59	0.00	75.54	1.00	74.00	1.90	3.24
Tucannon River	38.3	CBW05583-010495	7/6/2014	2014	Treatment	Upper	14	LWD, SC	No	1.22	1.15	0.53	0.31	30.96	12.58	4.52	14.28	0.25	0.27	0.00	0.79	0.50	81.35	3.06	71.00	2.41	3.85
Tucannon River	38.3	CBW05583-010495	7/31/2015	2015	Treatment	Upper	14	LWD, SC	No	1.25	1.13	0.55	0.39	34.29	15.69	5.28	54.53	3.25	0.74	1.22	0.60	1.00	82.75	0.86	57.00	3.83	10.08
Tucannon River	38.3	CBW05583-010495	8/4/2013	2013	Treatment	Upper	14	LWD, SC	No	1.25	1.13	0.54	0.40	29.95	11.83	5.45	16.66	0.35	0.51	1.26	0.83	1.30	69.33	2.50	70.00	0.67	1.04
Tucannon River	39.2	CBW05583-460671	8/28/2013	2013	Control	Upper	13		No	1.08	1.24	0.40	0.26	36.32	15.28	2.80	7.33	0.15	0.16	0.00	0.89	6.50	59.84	5.58	53.00	5.83	8.83
Tucannon River	39.2	CBW05583-460671	8/8/2011	2011	Control	Upper	13		No	1.07	1.28	0.47	0.64	38.83	15.11	2.50	6.21	0.25	0.00	0.00	0.91	10.00	51.14	-	40.00	-	-
Tucannon River	39.2	CBW05583-460671	8/15/2012	2012	Control	Upper	13		No	1.07	1.26	0.39	0.25	31.73	16.10	2.52	11.64	0.30	0.17	0.00	0.84	20.10	69.20	1.09	60.00	3.20	6.00
Tucannon River	39.6	CBW05583-100223	8/1/2015	2015	Control	Upper	13		No	1.33	1.18	0.38	0.51	33.88	14.80	3.26	12.72	0.15	0.72	0.65	0.92	9.50	64.61	0.29	66.00	0.53	6.93
Tucannon River	39.6	CBW05583-100223	8/19/2012	2012	Control	Upper	13		No	1.27	1.25	0.43	0.37	32.52	14.78	3.58	17.92	0.20	0.41	0.98	0.90	9.50	71.53	1.49	67.00	2.93	8.27
Tucannon River	40.1	CBW05583-427903	8/30/2014	2014	Control	Upper	12		No	1.17	1.23	0.36	0.27	26.88	11.86	12.42	44.11	0.75	0.30	0.00	0.66	2.00	68.10	1.61	62.00	2.94	5.81
Tucannon River	40.1	CBW05583-427903	8/31/2011	2011	Control	Upper	12		No	1.11	1.24	0.45	0.30	21.78	8.43	4.31	8.18	0.10	0.46	0.48	0.88	1.00	62.02	-	71.00	0.50	0.50
Tucannon River	40.1	CBW05583-427903	8/3/2012	2012	Control	Upper	12		No	1.10	1.06	0.44	0.29	25.47	9.17	5.54	16.19	0.20	0.28	0.00	0.79	4.00	76.86	0.97	58.00	3.43	6.34
Tucannon River	40.1	CBW05583-427903	9/1/2013	2013	Control	Upper	12		No	1.10	1.05	0.38	0.24	27.27	10.89	5.24	21.52	0.30	0.37	0.00	0.73	4.50	57.12	5.84	45.00	0.13	0.40
Tucannon River	41.4	CBW05583-018303	8/1/2012	2012	Treatment	Upper	11	LWD	Yes	1.09	1.13	0.46	0.37	34.40	11.82	3.44	32.43	1.25	0.48	0.31	0.90	0.70	85.17	1.21	90.00	1.33	3.62
Tucannon River	41.4	CBW05583-018303	6/18/2015	2015	Treatment	Upper	11	LWD	Yes	1.09	1.12	0.45	0.43	30.89	11.53	4.29	17.13	0.45	0.82	0.31	0.85	0.00	76.36	1.27	79.00	1.19	2.96
Tucannon River	41.8	CBW05583-038783	8/4/2014	2014	Control	Upper	11		No	1.40	1.43	0.51	0.39	28.99	13.20	5.29	15.18	0.55	0.44	0.71	0.69	0.00	76.40	0.87	71.00	1.54	2.67
Tucannon River	41.8	CBW05583-038783	10/1/2011	2011	Control	Upper	11		No	1.44	1.32	0.52	0.56	29.51	14.91	6.48	23.69	0.35	0.59	1.44	0.81	0.10	81.48	-	72.00	0.56	1.33
Tucannon River	43.2	CBW05583-169855	8/30/2013	2013	Treatment	Upper	10	LWD	Yes	1.28	1.08	0.52	0.30	23.45	11.60	5.58	40.68	0.65	0.42	0.40	0.66	10.00	64.44	2.04	86.00	1.20	2.67
Tucannon River	43.2	CBW05583-169855	8/28/2014	2014	Treatment	Upper	10	LWD	Yes	1.27	1.10	0.50	0.32	20.66	11.69	5.16	44.73	1.35	0.44	1.19	0.76	6.50	78.58	0.14	71.00	1.55	3.55
Tucannon River	43.2	CBW05583-169855	8/17/2012	2012	Treatment	Upper	10	LWD	Yes	1.31	1.02	0.53	0.30	25.67	11.58	3.44	13.19	0.15	0.42	0.38	0.77	4.80	70.77	0.49	78.00	0.54	2.42
Tucannon River	43.2	CBW05583-169855	8/7/2011	2011	Treatment	Upper	10	LWD	Yes	1.31	1.04	0.52	0.32	20.94	11.02	3.58	10.05	0.30	0.19	0.00	0.75	9.00	68.05	-	73.00	0.00	2.00
Tucannon River	45	CBW05583-345983	9/12/2012	2012	Control	Upper	7		No	1.03	1.28	0.45	0.23	23.13	12.36	3.16	37.07	1.10	0.35	0.00	0.90	2.60	67.19	1.72	75.00	1.50	3.17
Tucannon River	45	CBW05583-345983	8/12/2015	2015	Control	Upper	7		No	1.04	1.29	0.37	0.26	17.04	13.28	2.51	46.60	1.55	0.27	0.00	0.80	0.50	48.65	2.14	50.00	0.83	4.17
Tucannon River	46.5	CBW05583-214911	7/29/2015	2015	Control	Upper	4		No	1.09	1.34	0.33	0.29	-	-	1.95	11.97	0.20	0.10	0.00	0.85	1.50	48.67	1.47	69.00	10.87	21.05
Tucannon River	46.5	CBW05583-214911	8/5/2012	2012	Control	Upper	4		No	1.12	1.29	0.46	0.29	31.05	13.79	6.34	18.48	0.20	0.39	0.28	0.84	11.20	56.81	1.75	72.00	4.31	8.23
Tucannon River	47.6	CBW05583-519039	7/29/2015	2015	Treatment	Upper	3	LWD	Yes	1.16	1.21	0.46	0.31	35.08	12.27	4.01	33.12	0.80	0.41	0.36	0.89	2.00	68.13	1.61	98.00	0.67	6.75
Tucannon River	47.6	CBW05583-519039	7/31/2013	2013	Treatment	Upper	3	LWD	Yes	1.16	1.20	0.50	0.32	34.64	12.94	4.40	11.22	0.10	0.50	0.00	0.79	4.60	67.42	1.92	87.00	0.13	0.67
Tucannon River	47.6	CBW05583-519039	9/1/2012	2012	Treatment	Upper	3	LWD	Yes	1.16	0.92	0.50	0.38	39.19	16.20	5.47	21.40	0.40	0.51	0.36	0.82	19.10	71.41	1.66	52.00	3.00	4.67
Tucannon River	47.6	CBW05583-519039	6/23/2014	2014	Treatment	Upper	3	LWD	Yes	1.15	1.20	0.52	0.37	32.72	13.71	3.28	24.74	0.45	0.48	0.73	0.77	9.50	71.28	0.60	62.00	0.00	0.00
Tucannon River	48.1	CBW05583-007039	9/13/2012	2012	Control	Upper	3		No	1.14	1.44	0.46	0.30	26.99	14.08	3.04	25.96	0.15	0.52	0.34	0.65	5.00	66.73	0.47	82.00	0.28	1.37
Tucannon River	48.1	CBW05583-007039	9/26/2011	2011	Control	Upper	3		No	1.14	1.48	0.43	0.32	29.13	11.73	3.10	11.33	0.20	0.48	0.34	0.83	6.50	65.50	-	66.00	0.89	1.33
Tucannon River	48.1	CBW05583-007039	7/31/2014	2014	Control	Upper	3		No	1.13	1.41	0.46	0.29	33.00	13.14	5.83	7.15	0.20	0.27	0.34	0.65	8.00	68.41	0.42	82.00	0.53	0.67
Tucannon River	48.1	CBW05583-007039	8/2/2013	2013	Control	Upper	3		No	1.15	1.42	0.47	0.32	32.28	13.89	3.73	11.94	0.30	0.54	0.34	0.68	3.00	67.73	3.41	69.00	4.67	9.50
Tucannon River	48.1	CBW05583-007039	7/29/2015	2015	Control	Upper	3		No	1.12	1.42	0.43	0.30	27.40	12.88	3.46	11.33	0.35	0.39	0.35	0.66	8.50	66.41	0.74	67.00	0.00	0.53
Little Tucannon River	48.2	CBW05583-256895	8/3/2011	2011	Tributary	Tributary	-		No	1.05	3.28	0.16	0.31	19.76	3.58	8.69	4.72	0.00	0.05	0.00	0.81	22.50	22.95	-	51.00	6.01	9.69
Little Tucannon River	48.2	CBW05583-256895	7/21/2014	2014	Tributary	Tributary	-		No	1.04	3.38	0.16	0.29	16.35	3.77	11.06	12.68	0.00	0.13	0.00	0.94	14.50	50.65	1.82	55.00	6.78	10.86
Tucannon River	49	CBW05583-413951	9/1/2011	2011	Control	Upper	1		No	1.07	1.32	0.45	0.41	27.85	11.51	2.82	5.04	0.15	1.20	0.31	0.90	12.50	51.27	-	95.00	0.00	2.67
Tucannon River	49	CBW05583-413951	8/2/2014	2014	Control	Upper	1		No	1.06	1.33	0.44	0.49	24.93	12.91	2.22	3.78	0.20	0.66	0.32	0.79	11.00	71.50	0.71	74.00	0.00	1.33
Panjab Creek	50.7	CBW05583-310143	8/7/2012	2012	Tributary	Tributary	-		No	1.12	2.38	0.25	0.26	22.45	5.84	6.29	28.89	0.00	0.18	0.00	0.80	5.40	61.11	3.24	63.00	2.42	7.02
Panjab Creek	50.7	CBW05583-310143	8/5/2011	2011	Tributary	Tributary	-		No	1.13	2.32	0.29	0.21	24.14	7.12	8.66	31.33	0.05	0.03	0.00	0.58	3.70	44.88	-	48.00	3.33	6.67
Panjab Creek	50.7	CBW05583-310143	6/21/2013	2013	Tributary	Tributary	-		No	1.18	2.31	0.25	0.27	22.24	5.85	11.98	54.26	0.05	0.16	0.00	0.72	4.50	53.09	4.84	39.00	2.30	4.44
Panjab Creek	50.7	CBW05583-310143	9/2/2014	2014	Tributary	Tributary	-		No	1.15	2.26	0.24	0.27	21.69	6.31	7.37	27.27	0.25	0.12	0.00	0.68	5.00	71.93	0.46	65.00	4.40	6.53
Panjab Creek	51.2	CBW05583-047999	10/9/2013	2013	Tributary	Tributary	-		No	1.08	2.33	0.26	0.33	23.34	7.59	10.70	42.41	0.00	0.18	0.00	0.71	11.00	50.89	1.28	70.00	0.12	0.24
Panjab Creek	52	CBW05583-473983	7/19/2012	2012	Tributary	Tributary	-		No	1.08	2.92	0.33	0.30	20.59	8.21	9.18	31.74	0.50	0.30	0.00	0.77	3.50	63.74	4.18	53.00	5.46	10.46
Panjab Creek	52	CBW05583-473983	8/13/2015	2015	Tributary	Tributary	-		No	1.06	3.01	0.19	0.45	25.09	6.48	10.39	40.76	0.15	0.25	0.00	0.81	3.00	48.67	2.22	38.00	4.74	18.19
Sheep Creek	54.5	CBW05583-428287	9/20/2011	2011	Tributary	Tributary	-		No	1.15	7.50	0.22	0.48	19.64	5.47	10.09	53.44	0.15	0.55	0.00	0.84	7.60	35.06	-	54.00	19.44	22.92
Tucannon River	57.7	CBW05583-168191	9/12/2014	2014	Control	Upper	0		No	1.18	2.19	0.29	0.38	31.71	11.04	7.73	72.52	1.05	0.39	0.00	0.65	7.50	64.94	0.00	43.00	6.13	9.47
Tucannon River	57.7	CBW05583-168191	9/21/2011	2011	Control	Upper	0		No	-	-	-	-	-	-	-	-	1.20	-	-	-	10.00	14.60	-	44.00	6.40	9.87