Tucannon River Restoration Effectiveness Monitoring:

2014 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 two main components: Columbia Habitat Monitoring Program (CHaMP) surveys and remote sensing (LiDAR and aerial photography) assessments. CHaMP 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 habitat surveys from 2011-2014 as well as the results from rapid habitat surveys, and a preliminary River Styles assessment. LiDAR and aerial photography were collected in 2010 along the mainstem of Tucannon River and will be recollected in 2016 or later, at which time a more continuous assessment of the habitat changes will be conducted.

Restoration Completed

Two levee setback projects and six LWD treatment projects have been completed during the assessment period (2011-2014). Five 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, over 1900 key pieces of LWD have been added to the channel, 4.7 linear miles (7.5 km) of levee has either been removed or set back, and 2.5 miles (2.7 km) of side channel habitat has been created or reconnected.

CHaMP Site Assessment

We have sampled a complete panel rotation (three years) plus an additional year of CHAMP sites: 49 total sites with 108 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 2011-2014 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 river 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 ($\geq$ 1 m deep) is 1.25 in the lower and 0.75/100 m in the upper Tucannon River. No deep pools were observed in the lower reaches of tributaries within the CHaMP sample frame. There is not enough data to reliably detect trends in most of the CHaMP data at this time but we have seen in general that the lower Tucannon River appears to have more positive trends in ecological concerns than the upper Tucannon River. Sites across the entire Chinook domain (lower, upper, tributaries) all appear to have a decreasing trend in the overall LWD frequency ($\geq$ 0.1 m diameter, 1 m long).

Although there has been a significant amount of LWD and levee restoration, we have only surveyed CHaMP sites in two projects areas (1 site with 2 visits post restoration in Project Area 10 and 1 site with 2 visits post restoration in Project Area 26). We have not detected significant changes in any of the ecological concerns except key pieces of LWD and this likely reflects the relatively low spring flows that have taken place during the first four years of monitoring.

We have completed a classification of the River Styles and an initial geomorphic condition assessment of the Tucannon River watershed and will be using this framework to further interpret the status, trend, and effectiveness of habitat, riparian, and floodplain conditions. We are working with CHaMP and the Integrated Status and Effectiveness Monitoring Protocol (ISMEP) to develop assessments of riparian and floodplain conditions that will support the expert panel process and will present drafts of these assessments in the 2015 effectiveness report.

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LIST OF ABBREVIATIONS AND AGENCIES

CCD	- Columbia Conservation District
CHaMP	- Columbia Habitat Monitoring Program
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, PUD, 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. Seven 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 by 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 spring Chinook priority area of the Tucannon River (upstream of RM 20) has been prioritized for restoration actions based on current use and anticipated benefits to ESA listed species; however, actions are planned for the lower river as well. 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 two main components: Columbia Habitat Monitoring Program (CHaMP 2014) surveys and LiDAR/aerial photography assessments (WSI 2010). The Tucannon River was selected as a CHaMP watershed in 2011 and ELR helped to develop a sampling design that would maximize the number of 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.

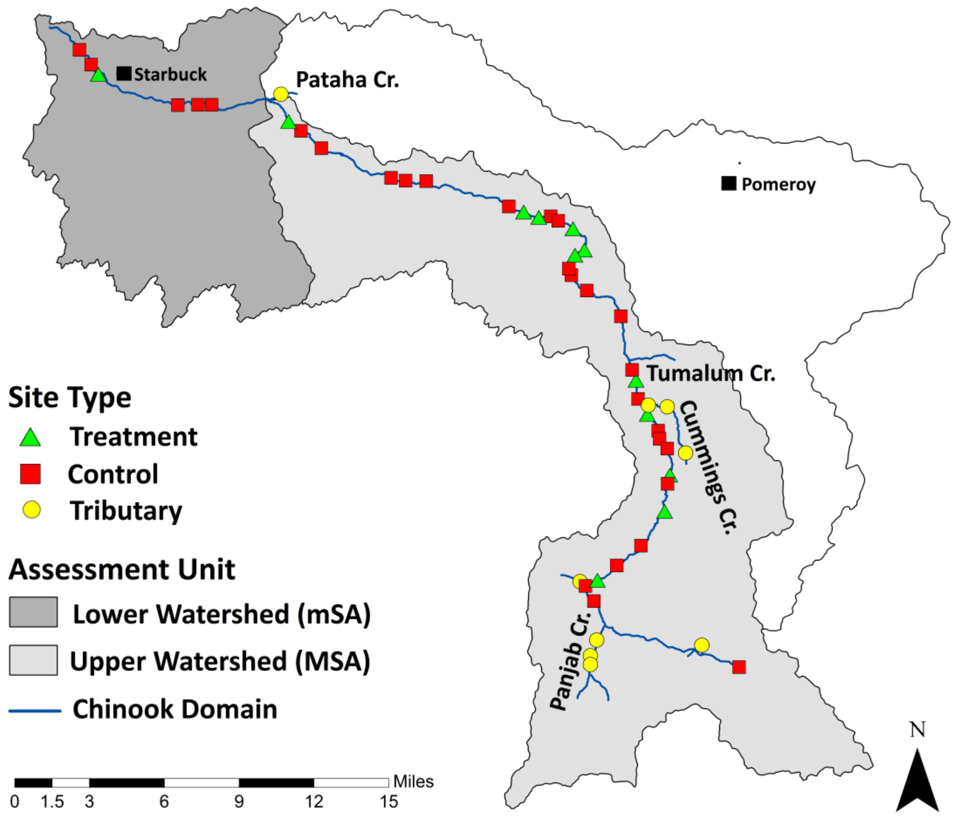

Figure 1. Tucannon River watershed, lower and upper watershed assessment units, Chinook domain (i.e., historic extent of Chinook use), and CHaMP treatment and control site locations.

1.2 REPORT GOALS AND OBJECTIVES

The goals of this report are to present preliminary findings of the CHaMP monitoring program for the period 2011-2014. This period represents the first full cycle of the CHaMP study design plus an additional year where all sites have been visited at least once. The specific objectives of the report are to i) described the restoration to the end of 2014, ii) present results from ongoing status and trend surveys of habitat conditions, iii) provide a provisional assessment of the effectiveness of restoration actions, iv) and results of a River Styles assessment of the Tucannon River.

1.2.1 ECOLOGICAL CONCERNS, METRICS, AND TARGETS

The Snake River Salmon Recovery Board (SRSRB) identified five restoration targets for the Tucannon River spring Chinook population and the current restoration actions are designed to improve these ecological concerns (ADEQ 2011). The mainstem Tucannon River is divided into the lower and upper watershed and the priority order of restoration targets are the same except that the upper river does not have a target for embeddedness (Figure 1 and Table 1). The lower river is described as a minor spawning area (mSA) located from river mile (RM) 0.0 – 12.3 and the upper river is a major spawning area (MSA) located from RM 12.3 – 60.0 (SRSRB 2011). The BiOP requires a 17% overall improvement in restoration priorities by 2018 or soon thereafter.

Along with the 17% improvement in restoration priorities, ELR has expanded the set of metrics to be monitored with respect to six broad ecological concerns and set preliminary 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 Methods Section "Conditions Assessments for the Expert Panel" below) that has yet to be conducted. All metric definitions and calculations presented in this report are provided in Appendix I.

Table 1. 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 Tucannon River mSA (from Pataha Creek downstream to the Tucannon mouth)		
Restoration Priority	**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 Tucannon River MSA (from Pataha Creek upstream to Tucannon headwaters)		
Restoration Priority	**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 TUCANNON RIVER RESTORATION

2.1 RESTORATION BY LOWER AND UPPER MAINSTEM AND TRIBUTARY

Over 20 kilometers is planned for restoration within the mainstem Tucannon River. This includes approximately 19 kilometers in the upper watershed and 1 kilometer in the lower watershed (Figure 2 and Table 2). Since 2011, approximately 66 percent of the planned restoration actions in the upper watershed (based on river length) have been completed and 100 percent of planned restoration actions in the lower watershed have been completed. All of the restoration actions completed in 2014 occurred after CHaMP sampling occurred. Therefore, results from 2011-2014 only represent post treatment sampling at two CHaMP sites, one in Project Area 10 and one in Project Area 26. Post treatment sampling in these project areas represent approximately 25 percent of the total restoration planned in the upper watershed.

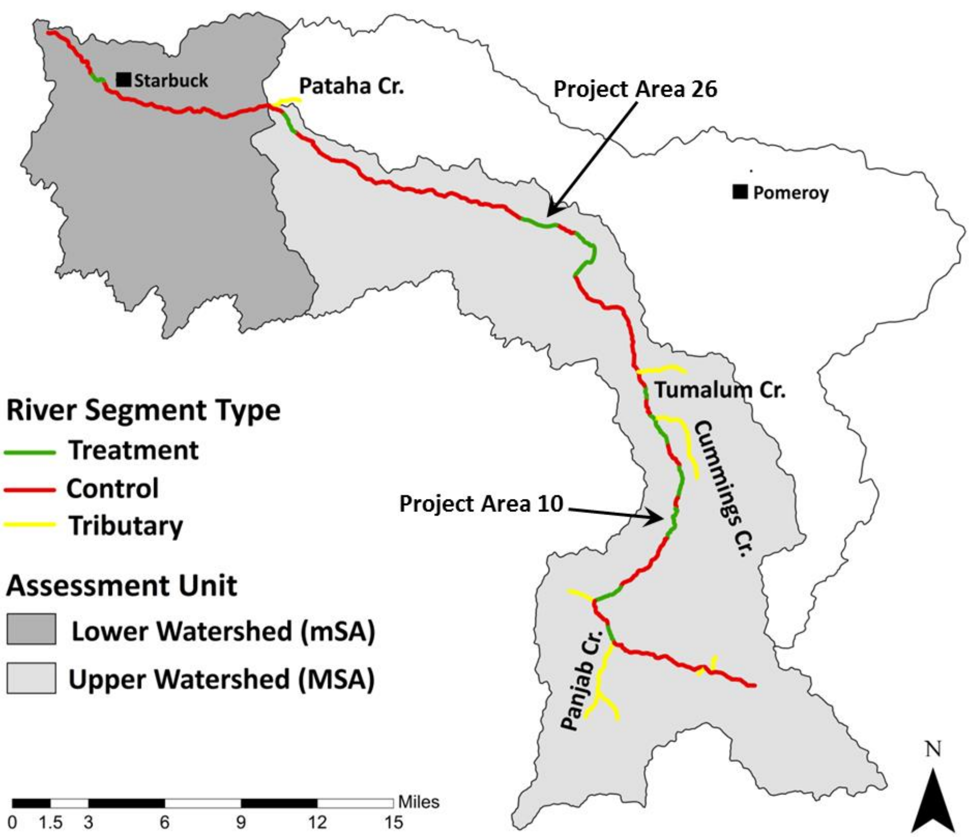

Figure 2. Tucannon River Chinook domain delineated by planned treatment and control segments for the upper and lower mainstem. No restoration actions are planned in tributaries.

Table 2. River lengths within the Tucannon River Chinook domain, the total percent of river designated as treatment and control segments within the upper and lower mainstem, and the total percent of restoration completed from 2011-2014.

	Lower Watershed (Mainstem)	Upper Watershed (Mainstem)	Tributary
Total River Length (km)	17.31	67.79	21.98
Planned Treatment Length (km)	0.95	18.89	NA
Control Length (km)	16.36	48.90	NA
2011-2014 Treatments Completed (% of Total Planned Treatment Length)	100	66.33	NA
2011-2014 CHaMP Post Treatment Results (% of Total Planned Treatment Length)	0.00	24.72	NA

2.2 RESTORATION BY PROJECT AREA

Restoration was completed in 8 project areas between 2011 and 2014 (AQEA 2011, Table 3). This includes the implementation of one project in 2011, 2012, and 2013, and 6 projects in 2014. Thus far, 4.7 linear miles (7.5 km) of levee has been removed or setback, 2.5 miles (2.7 km) of side-channel has been created or reconnected, and over 1900 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 watershed 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 Implemented	River Mile		# Key LWD Pieces Added	Levees (feet)		Side Channels (miles)		CHaMP Post Treatment Sample
		From	To		Remove	Set Back	New	Reconnect	
1	2014	49.5	50.1	231	0	0	0.36	0	N
3	2014	46.8	48.1	324	0	-	-	-	N
10	2012	42.4	44	365	1305	0	0.46	0.47	Y
14	2014	37.2	39.2	712	0	0	1.22	0.17	N
15	2014	36.4	37.2	210	0	-	0.26	0	N
22	2014	29.3	30.3	36			-	-	N
26	2011, 2013	23.7	26.9	78	8305	12218	-	-	Y

2.2.1 PROJECT AREA 1

Restoration in Project Area 1 (RM 49.5-50.1) downstream from Panjab Creek was 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 meters 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 installation of LWD structures. Photos courtesy of the SRSRB.

2.2.2 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). 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 within CHaMP site 519039. Aerial photo courtesy of the Pomeroy Conservation District.

2.2.3 PROJECT AREA 10

Restoration in Project Area 10 (RM 42.4-44.0) between Beaver/Watson Lake and Big 4 Lake was implemented in 2012. The objectives of this project 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.

2.2.4 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 the addition of over 700 key pieces of LWD and the creation or reconnection of over 2200 meters of side channel habitat (Figure 6). The objectives of this project were to improve floodplain connectivity and instream channel complexity. More information on this project can be found at: Project Area 14.

Figure 6. 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.

Restoration began in Project Area 15 (RM 36.4-37.2) downstream from the Wooten Wildlife Area headquarters in 2014 and will continue in 2015. The objectives of this project include increasing channel complexity and side channel development (Figure 7). In 2014, approximately 210 key pieces of LWD were added and 400 meters of new side channels were created. More information on this project can be found at: Project Area 15.

Figure 7. 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.

2.2.5 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 8). More information on this project can be found at: Project Area 22.

Figure 8. Photos showing two of eight LWD structures placed in Project Area 22.

2.2.6 PROJECT AREA 26

Restoration in Project Area 26 (RM 23.7-26.9) downstream of Marengo was first implemented in 2011. The objective of this project was to reconnect the disconnected floodplain and riparian habitat by removing and setting back over 2500 and 3700 meters of levee, respectively (

Figure 9). 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. More information on this project can be found at: Project Area 26.

Figure 9. 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.

2.2.7 PROJECT AREA 40

Restoration in Project Area 40 (RM 1.8-4.5) downstream of Starbuck was implemented in 2014. The primary objective was to improve winter rearing habitat in the lower river 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.

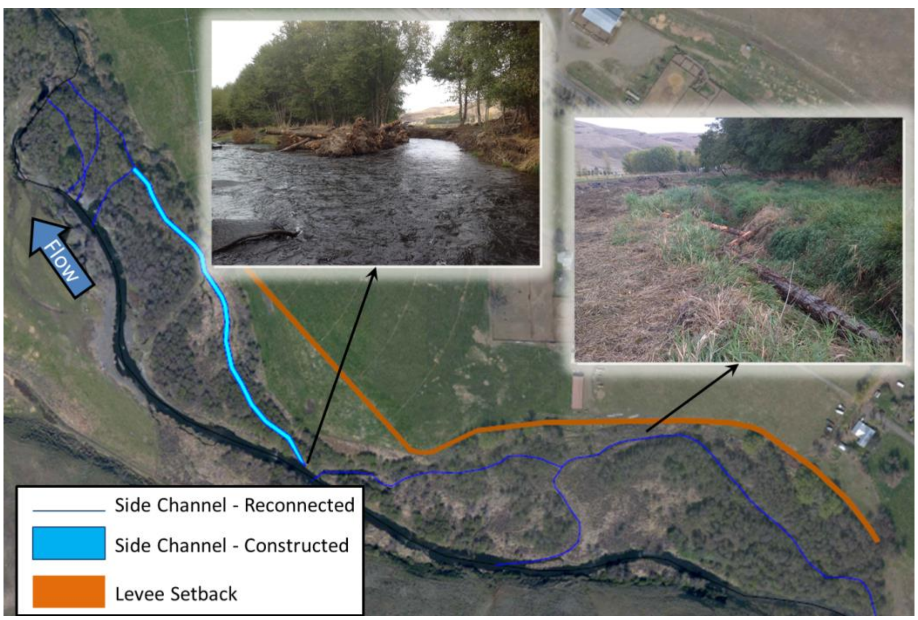

Figure 10. Map and photos of restoration implemented in Project Area 40 which included levee setback, LWD additions, and the reconnection and creation of side channels.

3 METHODS

3.1 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 four years, all annual sites and panel sites plus an additional year 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, instream complexity, floodplain, riparian, and substrate conditions are then calculated by using the weighted mean of each metric based on GRTS. We present the four year status and trends for the lower Tucannon River, upper Tucannon River, and all tributaries combined as well as 95% confidence intervals for all years combined (2011-2014). Future analyses may provide rollups by other subgroups such as River Styles or treatment type.

We also provide project effectiveness evaluations 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.

The CHaMP field data collection methods fall into two major groups: collection of topographic data (X, Y, Z points) and collection of non-topographic habitat attributes (e.g., LWD, sediment, fish cover, etc.). A crew of three people collects CHaMP data. Two crew members use a total station to collect topography of the stream bed and banks while a third crew member collects instream habitat data. The topographic data is used to generate relatively high resolution (10 cm) 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. See www.champmonitoring.org and CHaMP (2014) for details on the protocol.

3.1.1 RAPID HABITAT ASSESSMENTS

In addition to monitoring with the CHaMP protocol, we initiated a rapid habitat survey along with the SRSRB 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. Rapid habitat data is analyzed in a similar way to project effectiveness by comparing the changes between pre and post treatment metrics in treatment and control project areas. These analyses look at a smaller set of metrics but are gathered over the entire project area (1-4 km) instead of at a CHaMP site (< 0.4 km).

3.2 CONDITION ASSESSMENT FOR THE EXPERT PANEL

We are working with CHaMP and ISEMP to develop tools to conduct condition assessments on ecological concerns that cannot be easily assessed with CHaMP data (e.g., riparian and floodplain conditions, and LWD recruitment potential). These assessments are part of a larger effort to assist the expert panel in determining how ecological concerns are being addressed by restoration. A first step that we have proposed is to conduct a River Styles geomorphic assessment of the watershed which can act as the network model for mapping condition assessments. In the next annual report of effectiveness monitoring we will include some of these condition assessment results. In this report, we present the first two stages of River Styles, a classification of the River Styles (geomorphic reach types) and a condition assessment of the River Styles.

3.2.1 RIVER STYLES

We are progressing through a geomorphic assessment of the Tucannon watershed using a modified version of the River Styles framework. The River Styles framework is a hydrologic and geomorphic classification system which provides tools for interpreting river character, behavior, geomorphic condition, and recovery potential (Brierley and Fryirs 2005). It consists of a series of four stages that includes 1) an identification of the unique suite of River Styles (i.e., reach types) within the watershed, 2) an assessment of the current condition of the watershed, given the historical context, 3) predictions about the recovery potential and finally 4) implications for watershed management and restoration planning. This framework is widely used by watershed managers in Australia and New Zealand and is gaining traction in the Columbia River Basin. Our geomorphic assessment of the Tucannon River Watershed does not strictly adhere to the River Styles framework in that we do not explicitly incorporate all elements of Stages 2 – 4 (e.g., measured cross sections) and we bolster the condition assessment with spatially explicit network based models of riparian and floodplain condition.

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 and explained. We present a summary of stages 1-2 in this report and begin to use stage 1 as a means of comparing CHaMP treatment and control sites (i.e., comparing conditions and change due to restoration using sites within the same River Style). A preliminary River Styles report covering stage 1 and 2 is presented in a separate report (Portugal et al. 2015). We also include preliminary methods and results of network models (riparian and floodplain condition, LWD input models) that we are using to inform River Styles and provide an assessment of ecological concerns as identified by the expert panel that relate to riparian and floodplain conditions that are not adequately measured by CHaMP data alone.

4 MONITORING RESULTS

4.1 LOWER AND UPPER MAINSTEM, AND TRIBUTARY STATUS

The CHaMP data from the first four 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 4). Appendix II presents either the average or maximum value for each metric plotted by river mile (RM) for all CHaMP sites and all years. Appendix III presents a list of all CHaMP sites and visits between 2011 and 2014 and metrics representing each ecological concern category.

4.1.1 CHANNEL FORM

As expected the lower river is deeper, wider, and more sinuous than the upper river or tributaries (Table 4, Appendix II). The lower river is approximately 5 m wider on average (19.6 m bankfull width) than the upper river (14.6 m). The average thalweg depth in the lower river is 0.1 m deeper than the upper river and 0.3 m deeper than the tributaries. The lower rivers planform is also significantly more sinuous (1.4) than the upper river (1.1).

4.1.2 COMPLEXITY OF INSTREAM HABITAT

Instream habitat complexity was generally low throughout with the tributaries having more complexity per unit length than the mainstem (Table 4, Appendix II). The lower river had slightly higher mean instream complexity than the upper river with more pools, deep pools, channel units, and LWD. The average pieces of key LWD were $\leq$ 0.23/bankfull width for the lower, upper and tributary sections which is below the 1 piece/ bankfull width that is the target for restoration in both the lower and upper river. Pools $\geq$ 1.0 m in depth (deep pools) are also infrequent and average $\leq$ 1.3 pools/100 m across the mainstem with no deep pools observed in the tributaries.

4.1.3 FLOODPLAIN CONDITION

An assessment of floodplain confinement was conducted by AQEA (2011) using LiDAR, aerial photography, and field assessments. The ADEQ assessment found that much of the river is confined primarily below RM 30. We will be repeating these analyses when new LiDAR and aerial photography is available once much of the planned restoration is completed. We have also begun an assessment of floodplain condition using existing GIS data including LANDFIRE data. We will provide some of these results in the 2015 Monitoring report but see Appendix II for description of methods.

CHaMP metrics that provide some insight into floodplain and channel confinement are the relationship between the wetted area and the bankfull area (confinement ratio) and the amount of off-channel habitat (Table 4, Appendix II). Both the confinement ratio and the side channel metrics indicated that the lower river is generally less confined than the upper river and there was greater variability in these metrics at CHaMP sites in the lower compared to the upper river (Table 4, Appendix II).

4.1.4 RIPARIAN

Riparian metrics indicate relatively similar conditions among the lower and upper mainstem, and tributaries. The lower river generally has a greater amount of Solar Access (78%) compared to the upper river (66%, Table 4, Appendix II). This may partially be due to fewer big trees (>0.3m DBH, >5.0m tall) at sites in the lower river compared to upper river or it may be due to the orientation of the valley and wider floodplain in the lower river that naturally allow more solar inputs. A more detailed assessment of riparian condition will be presented in the next report but see Portugal et al. (2015) for methods.

4.1.5 SUBSTRATE

Substrate is less coarse and made up of more fines in the lower river as expected based on lower gradient, higher sinuosity, and the introduction of fine sediment from Pataha Cr. (AQEA 2011). Cobble embeddedness is relatively low at all sites with the lower river generally having higher values compared to the upper river and tributaries (Table 4, Appendix II). Fine sediment follows a similar pattern where there are higher amounts of fine sediment found in the lower river compared to the upper river with the exception of tributaries, which have higher values. Overall, embeddedness and fine sediment is relatively low throughout the watershed.

4.2 LOWER AND UPPER MAINSTEM, AND TRIBUTARY TRENDS

The majority of all the metrics we have assessed have undetermined trends (Table 5). This is likely due to the limited number of years of data (four), the variability of these metrics, the low flow conditions, and the relatively small amount of restoration captured by CHaMP surveys from 2011-2014. Large restoration projects implemented in 2014 and 2015 will increase the likelihood that trends will be detected in future assessments.

Table 4. Watershed status by ecological concern and metric based on CHaMP data collected from 2011-2014. 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 (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 Tucannon		Upper Tucannon		Tributary	
Ecological Subgroup	**Metric**	**Units**	**Mean**	**95% CI ±**	**Mean**	**95% CI ±**	**Mean**	**95% CI ±**
	Bankfull Width	m	19.62	6.65	14.57	0.49	5.98	0.77
	Bankfull Width CV	ratio	0.01	0.00	0.01	0.00	0.02	0.00
	Bankfull Width/Depth	ratio	32.18	6.96	28.75	1.09	17.70	2.09
Channel Form and Function	Sinuosity	ratio	1.44	0.32	1.14	0.02	1.15	0.07
	Thalweg Depth	m	0.57	0.05	0.46	0.02	0.26	0.06
	Thalweg Depth CV	ratio	0.02	0.00	0.01	0.00	0.02	0.00
	Bankfull Depth	m	0.51	0.03	0.48	0.02	0.33	0.07
	Channel Units/100 m	#/100 m	4.91	0.97	4.70	0.70	10.62	1.40
	Large Wood Debris/100 m	#/100 m	30.22	19.48	25.72	5.92	43.63	25.33
Channel Structure/Instream Complexity	Key Pieces LWD/BFW	#/BFW	0.23	0.19	0.31	0.10	0.16	0.12
	Residual Pool Depth	m	0.73	0.05	0.48	0.05	0.26	0.11
	Slow Water Channel Units/100 m	#/100 m	2.74	1.02	1.96	0.40	3.80	0.68
	Deep Pools (≥ 1 m)/100 m	#/100 m	1.25	0.57	0.73	0.17		0.00
Peripheral & Transitional Habitats/ Floodplain Condition	Channel Confinement	ratio	0.77	0.10	0.79	0.02	0.73	0.05
	Wetted Side Channel Percent By Area	%	10.14	4.30	8.48	2.74	8.23	11.61
	Wetted Small Side Channel Area	m^2	316.12	205.75	105.46	41.62		0.00
Riparian Condition/ Structure & Composition	Big Tree Riparian Cover	%	7.03	3.73	9.33	1.37	6.23	3.18
	Summer Solar Access	%	78.42	6.10	65.96	3.99	55.41	6.56
	Fines < 2mm	%	9.48	5.01	2.80	1.04	11.78	6.55
Sediment Conditions/ Fines and Substrate	Fines < 6mm	%	12.17	6.40	4.52	1.14	15.44	6.59
	D50	mm	34.15	7.20	59.90	4.06	50.86	7.90
	Embeddedness	%	13.15	7.94	2.22	0.72	5.47	1.72

Table 5. Watershed trends by ecological concern and metric based on CHaMP data collected from 2011-2014. 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 Tucannon). 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**	**Units**	**Mean**	**95% CI ±**	**Trend**	**Mean**	**95% CI ±**	**Trend**	**Mean**	**95% CI ±**	**Trend**
Channel Form and Function	Bankfull Width	m	-3.57	1.49	-	0.32	0.64	Und	0.12	0.34	Und
	Bankfull Width CV	ratio	0.00	0.00	Und	0.00	0.00	Und	0.00	0.00	Und
	Bankfull Width/Depth	ratio	-1.04	1.72	Und	-0.43	0.86	Und	0.11	1.01	Und
	Sinuosity	ratio	-0.02	0.02	0	0.00	0.01	Und	0.01	0.02	Und
	Thalweg Depth	m	0.01	0.00	+	0.00	0.01	Und	0.02	0.03	Und
	Thalweg Depth CV	ratio	0.00	0.00	0	0.00	0.00	Und	0.00	0.00	Und
	Bankfull Depth	m	-0.01	0.03	Und	0.02	0.01	+	0.00	0.01	Und
Channel Structure/Instream	Channel Units/100 m	#/100 m	0.81	0.48	+	0.24	0.38	Und	1.27	1.64	Und
	Large Wood Debris/100 m	#/100 m	-11.78	5.50	-	-1.24	3.44	Und	-4.00	9.02	Und
	Key Pieces LWD/BFW	#/BFW	-0.29	0.18	-	0.01	0.05	Und	-0.02	0.09	Und
	Residual Pool Depth	m	0.00	0.09	Und	0.01	0.04	Und	0.01	0.06	Und
	Slow Water Channel Units/100 m	#/100 m	0.44	0.23	+	0.28	0.39	Und	1.56	1.26	+
	Deep Pools (≥ 1 m)/100 m	#/100 m	0.23	0.19	+	0.12	0.30	Und	NA	NA	Und
Peripheral & Transitional Habitats/ Floodplain Condition	Channel Confinement	ratio	0.04	0.02	+	-0.03	0.01	-	0.05	0.04	+
	Wetted Side Channel Percent By Area	%	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Wetted Small Side Channel Area	m^2	NA	NA	NA	NA	NA	NA	NA	NA	NA
Riparian Condition/ Structure & Composition	Big Tree Riparian Cover	%	-2.23	1.06	-	-0.54	2.07	Und	-1.15	1.28	Und
	Summer Solar Access	%	1.18	1.19	Und	6.72	2.00	+	10.12	2.05	+
Sediment Conditions/ Fines and Substrate	Fines < 2mm	%	-5.58	3.90	-	0.03	0.88	Und	-0.42	3.43	Und
	Fines < 6mm	%	-5.19	3.60	-	0.41	1.25	Und	-1.22	2.57	Und
	D50	mm	4.08	1.16	+	0.27	1.48	Und	4.88	5.10	Und
	Embeddedness	%	-0.31	0.72	Und	-4.03	4.53	Und	3.78	6.55	Und

4.3 PROJECT EFFECTIVENESS

To determine the effectiveness of restoration actions within each individual project area, we compare pre and post treatment results for sites within project areas that have been treated to the pre and post treatment average of control sites within the same River Style and assessment unit (upper/lower watershed). 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. In 2014, we sampled two CHaMP sites that had post treatment results. One site in Project Area 10 and one site in Project Area 26.

4.3.1 PROJECT AREA 10

Project Area 10 is located within the Partly Confined (PC), Low to Moderate Sinuosity Wandering Gravel/Cobble Bed River Style. There is one CHaMP site located in Project Area 10 (Site 169855). This site has been sampled each year from 2011 to 2014. Data presented for this site includes two years of pre-treatment data (2011-2012) and two years of post-treatment data (2013-2014). Large Wood treatment at this site was applied in 2012 after CHaMP sampling occurred.

The following results represent a comparison between average pre-treatment (2011-2012) and post treatment (2013-2014) values at Site 169855 (treatment site) and control sites within the PC Low to Moderate Sinuosity Wandering Gravel/Cobble Bed River Style in the upper watershed.

4.3.1.1 COMPLEXITY OF INSTREAM HABITAT

Two indicators of instream structural complexity include the number of key pieces of large wood (> 0.3m diameter, > 6.0m length) per bankfull width and thechannel unit frequency (number of channel units per 100 meters of stream length; Appendix I). Prior to the large wood placement (2011-2012), the treatment site averaged 0.23 key pieces of wood per bankfull width compared to an average of 0.25 at control sites within the same River Style in the upper watershed (Table 6). After restoration (2013-2014), the average number of key pieces of wood increased to 1.0 pieces/bankfull width whereas the number of key pieces remained relatively the same at control sites (0.28). Due to the restoration action, the number of key pieces at the treatment site increased substantially (Figure 11). This increase in key pieces is primarily due to the restoration action but evidence of post-treatment wood recruitment into the stream channel has also been observed since 2013.

The increase in large wood at the treatment site may also have contributed to an increase in channel unit frequency which went from an average of 3.75 units/100m prior to the restoration to 5.63 units post restoration (Table 6). On average, channel unit frequency increased at control sites as well (4.60 (pre), 6.26 (post)) potentially indicating an overall trend at sites within the PC Low to Moderate Sinuousity Wandering Gravel/Cobble Bed River Style in the upper watershed.

The post-treatment responses in key pieces of wood and channel units are expected. Further increases in both of these indicators are also expected as the large wood interacts with the stream bed and banks at high flows leading to the formation of new channel units and the potential for additional wood recruitment from the adjacent floodplain.

Table 6. Average pre and post treatment metric values for each ecological concern at Site 169855 compared to the average at control sites within the PC Low-Mod Sinuosity Wandering Gravel/Cobble Bed River Style in the upper watershed (pre-treatment *n*=10, post treatment *n*=9).

Ecological Concern	Metric	Units	Site Type	Pre-Treatment (2011-2012)	Post Treatment (2013-2014)	Change (%)	Trend
Complexity	Key LWD Pieces per Bankfull Width	#/BFW	Treatment Site	0.23	1.00	77.50	+
			Control Sites	0.25	0.28	11.11	+
Complexity	Channel Unit Frequency	#/100m	Treatment Site	3.75	5.63	33.39	+
			Control Site	4.60	6.26	26.50	+
Floodplain	Confinement Ratio	Ratio	Treatment Site	0.76	0.71	-6.73	Und
			Control Sites	0.79	0.74	-6.78	Und
Channel Form and Function	Width to Depth Ratio	Ratio	Treatment Site	22.37	21.85	-2.35	Und
			Control Sites	27.77	28.47	2.45	Und

4.3.1.2 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. Between pre and post restoration samples, the confinement ratio decreased slightly at the treatment site (0.76 (pre), 0.71 (post)) as well as at control sites in the same River Style within the upper watershed (0.79 (pre), 0.74 (post); Table 6). The lack of change in confinement ratio at the treatment site is expected over a short time interval and with low peak flows during both the winter/spring of 2013 and 2014. Changes to confinement over longer time periods are expected as the channel starts to aggrade due to the increase in large wood at the site and high flows begin to access the floodplain.

Figure 11. Images showing differences in large wood between pre-treatment and post treatment samples at Site 169855.

4.3.1.3 CHANNEL FORM

An indicator of channel form derived from the CHaMP topographic data is the width to depth ratio. Prior to restoration (2011-2012), the average width to depth ratio at the treatment site was 22.37 compared to an average of 27.78 at control sites within the same River Style in the upper watershed (Table 6). After restoration (2013-2014), the average width to depth ratio at both the treatment site and control sites remained relatively the same. In the future, we expect that width to depth ratio should decrease further as the channel starts to narrow and scour due to large wood placement.

4.3.1.4 GEOMORPHIC CHANGE

The implementation of restoration actions in Project Area 10 are directly evidenced by the number of new large pieces of wood now occupying the stream channel (Figure 11). Preliminary data suggests that the addition of wood into the channel may have attributed to an increase in the number of channel units at the site through the interaction of high flows with the wood to scour new pools and sort sediment, although the direct link between wood and channel units is uncertain. Geomorphic change detection results indicate some changes in bed scour near the bottom of the site but relatively minor changes in the stream channel in the upper 2/3 of the site (Figure 12).

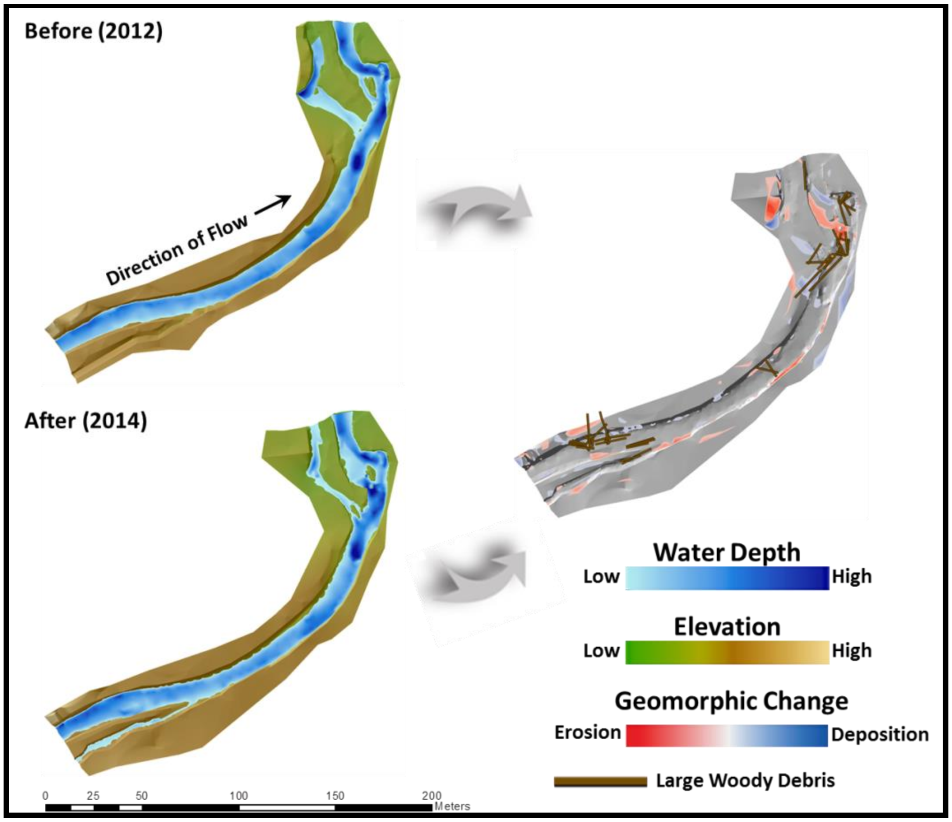

Figure 12. Geomorphic change detection for CHaMP site 169855 (Project Area 10) from 2011 to 2014. Approximate large wood piece locations derived from Google Earth.

Project Area 26 is primarily located within the Partly Confined (PC), Low to Moderate Sinuosity Wandering Gravel/Cobble Bed River Style. There is one CHaMP site currently surveyed in Project Area 26 (Site 203211). This site has been sampled each year from 2011 to 2014. Data from this site includes one year of pre-treatment data (2011) and three years of post-treatment data (2012-2014). In 2011, a levee removal treatment was applied and LWD structures were placed in 2013, both after CHaMP sampling occurred in those years.

The following results represent comparisons between pre levee treatment (2011) and the average of post levee and LWD treatment (2012-2014) values at Site 203211 (treatment site) and control sites within the PC Low to Moderate Sinuosity Wandering Gravel/Cobble Bed River Style in the upper watershed.

4.3.1.1 COMPLEXITY OF INSTREAM HABITAT

Two indicators of instream structural complexity include the number of key pieces of large wood (> 0.3m diameter, > 6m long) per bankfull width and channel unit frequency (number of channel units per 100 meters of stream length). At the treatment site, the number of key pieces increased from 0 key pieces prior to the levee removal treatment (2011) to an average of 0.52 pieces after levee removal, which includes the LWD treatment in 2013 (Table 7). At control sites within the same River Style in the upper watershed, the number of key pieces between pre and post treatment periods remained relatively the same (0.25 (pre), 0.27 (post)). The number of key pieces per bankfull width increased from 0.15 in 2013 to 0.85 pieces in 2014 as a direct result of the LWD treatment.

Channel unit frequency decreased slightly at the treatment site between the pre levee removal sample (4.44) and the average of post levee removal samples (4.35) while the average at control sites within the same River Style in the upper watershed increase from 4.81 to 5.61 (Table 7). Channel unit frequency did increase at the treatment site between the pre LWD treatment in 2013 and the post LWD treatment in 2014 from 3.89 channel units/100m to 5.28 channel units/100m. In comparison, the average channel unit frequency at control sites within the same River Style in the upper watershed for that time period also increased from 5.64 to 6.79.

There are limited responses in key pieces of LWD and channel unit frequency that can be directly attributed to the levee removal restoration action though the increase in key pieces of LWD can be attributed to the LWD treatment in 2013. The increase in key pieces at the treatment site is not only a direct result of the LWD treatment but other sources of this increase could be due to natural recruitment. It is uncertain what lead to the small decrease in channel units at the treatment site post levee removal compared to the general increase at control sites. Increases in both of these indicators at the treatment site are expected as the river has the opportunity to access the floodplain and interacts with the placed LWD at high flows creating new channels and recruiting new wood to the channel.

Table 7. Average pre and post treatment metric values for each ecological concern at Site 203211 compared to the average at control sites within the PC Low-Mod Sinuosity Wandering Gravel/Cobble Bed River Style in the upper watershed (pre-treatment *n*=6, post treatment *n*=12).

Ecological Concern	Metric	Units	Site Type	Pre-Treatment (2011-2012)	Post Treatment (2013-2014)	Change (%)	Trend
Complexity	Key LWD Pieces per Bankfull Width	#/BFW	Treatment Site	0	0.52	99.81	+
			Control Sites	0.25	0.27	5.66	Und
Complexity	Channel Unit Frequency	#/100m	Treatment Site	4.44	4.35	-2.13	Und
			Control Site	4.81	5.61	14.36	+
Floodplain	Confinement Ratio	Ratio	Treatment Site	0.75	0.74	-1.40	Und
			Control Sites	0.81	0.75	-8.17	Und
Channel Form	Width to Depth Ratio	Ratio	Treatment Site	36.14	34.50	-4.74	Und
			Control Sites	26.82	28.51	5.93	Und

4.3.1.2 FLOODPLAIN CONDITION

An indicator of floodplain condition derived from the CHaMP topographic surveys is the confinement ratio (ratio of bankfull wetted area to site wetted area). At the treatment site, the confinement ratio remained relatively unchanged between pre levee removal values (0.75) and the average of post levee removal values (0.74). The average confinement ratio decreased slightly at control sites within the same River Style in the upper watershed for the same time periods (0.81 (pre), 0.75 (post); Table 7).

The lack of change in confinement ratio post treatment may indicate that the river has yet to fully access the newly accessible floodplain opened up by the levee removal. In the future, we expect that the confinement ratio will significantly decrease at the site as the river overtops its banks and spreads out into the floodplain that was previously unaccessible prior to the levee removal.

4.3.1.3 CHANNEL FORM

An indicator of bed and channel form derived from the CHaMP topographic data is the width to depth ratio. The width to depth ratio at the treatment site decreased slightly from 36.14 prior to the levee removal treatment (2011) to an average of 34.50 after the treatment (2012-2014; Table 7). At control sites within the same River Style in the upper watershed, the width to depth ratio increased slightly on average from 26.82 to 28.51 during the same time period. From 2013 to 2014 (pre and post LWD treatment), the width to depth ratio decreased from 36.01 to 32.03. In the immediate future, we expect the width to depth ratio to increase as the channel starts access the reconnected floodplain and the ratio over longer time periods to decrease as the main channel and subsequent side channels become more stable and more bed scour occurs with aid from the placed LWD.

4.3.1.4 GEOMORPHIC CHANGE

Site 203211 showed changes in both the stream channel and the floodplain from 2011 to 2014 that is not directly evidenced by the above metrics but can be seen using geomorphic change detection (GCD; Figure 13). The “erosion” in the floodplain was primarily due to the removal of the levee in 2011. Due to the levee removal, the river now has access to the floodplain and we expect to see additional erosion and deposition in the floodplain as new side channels form in the future during high flows. Within the stream channel we see a change in channel form. Some of this change can be attributed to the placement of the LWD structures. One of the more significant changes observed through GCD and site visits is the increase in scouring and pool habitat in the immediate vicinity of the LWD structures. From 2013 to 2014 (pre and post LWD treatment), pool frequency (pools/100m) increased at the site from 2.10 to 3.27 and percent pools also increased from 22.5 to 40.3 percent during the same time period.

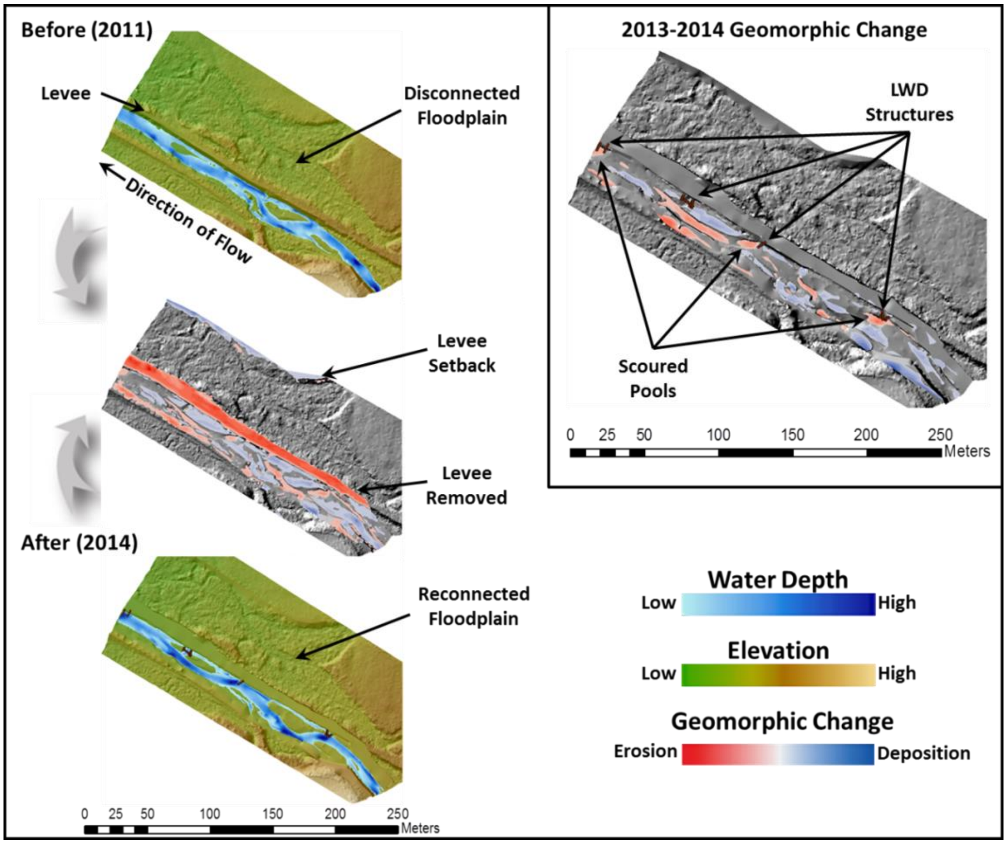

Figure 13. Geomorphic change detection for CHaMP site 203211 from 2011 to 2014 and from 2013 to 2014. A levee was removed at this site in 2011 and LWD structures were added in 2013.

4.4 TEMPERATURE

The restoration target for water temperatures in both the lower and upper watershed is less than four days greater than 72 degrees Fahrenheit (SRSRB 2011). Results derived from the Washington State Department of Ecology Stream Gauge at Marengo between 2003 and 2014 indicate a general degrease in the number of days exceeding 72 degrees with no days exceeding 72 degrees from 2008-2012 (Figure 14 and 15). 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 guage information can be found at https://fortress.wa.gov/ecy/eap/flows/station.asp?sta=35B150#block0.

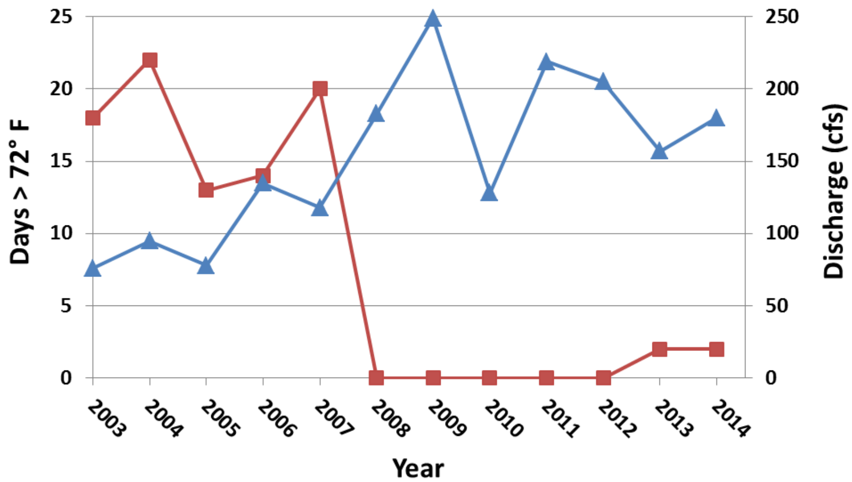

Figure 14. Number of days water temperature exceeded 72° F and mean annual flow (cfs) at Marengo. Restoration Target is < 4 days > 72° F. Note that temperature and flow records for 2003 only include data after the June 1 installation date and 2014 records only include data up to October 1 (end of Water Year).

Water temperature data at CHaMP sites from 2012-2014 indicate that 4 sites in 2012, 5 sites in 2013, and 3 sites in 2014 exceeded the restoration target of less than 4 days greater than 72 degrees (

Figure 15). All of the sites sampled in the lower watershed exceeded the 72 degree threshold for each year where data was available. Sites exceeding more than 4 days in the upper watershed were all located below King Grade.

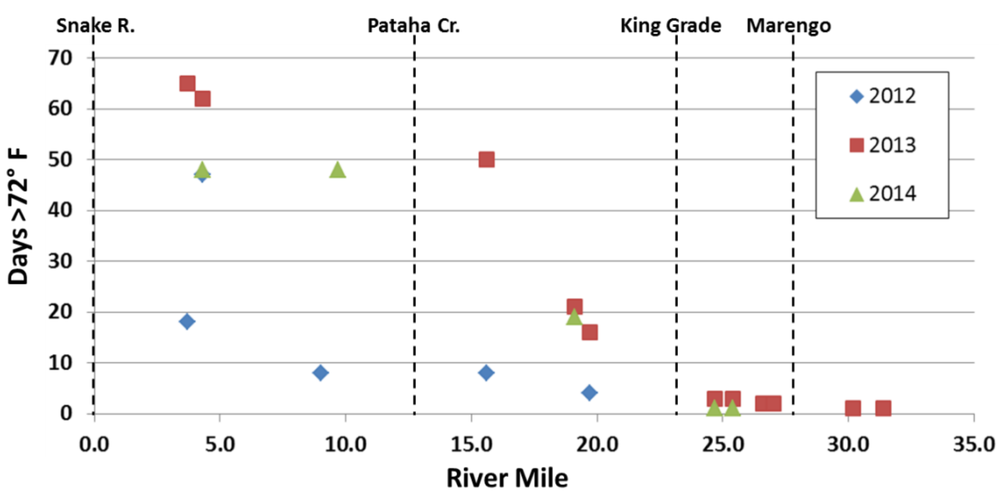

Figure 15. Number of days water temperature exceeded 72° F at CHaMP sites from 2012-2014 by river mile.

4.5 RAPID HABITAT SURVEYS

In 2014, rapid habitat surveys were conducted over approximately 9 miles of the Tucannon River and included Project Areas 0, 1, 3-9, 14, 15, 22, and 40. In Project Areas 1, 3, 14, 15, 22, and 40, both pre and post-treatment surveys were conducted. Based on the results of these surveys, we compare the number of pre-treatment key pieces of LWD and pool frequency to post treatment results in project areas that have been treated and those not treated (control). Project Area 0 represents the river upstream from Panjab Bridge.

Results from the rapid habitat survey of key pieces/bankfull width indicate that four out of the five project areas that were treated in 2014 exceeded the restoration goal of one key piece of LWD per bankfull width (Figure 16). Key pieces in Project Area 22 did increase due to restoration but this project was on a much smaller scale than other projects implemented in 2014. The average number of key pieces/bankfull width at post treatment project areas was 2.22 pieces compared to an average of 0.48 pieces in control project areas. The overall average of key pieces for all project areas (treatment + control) surveyed was 1.28 key pieces/bankfull width.

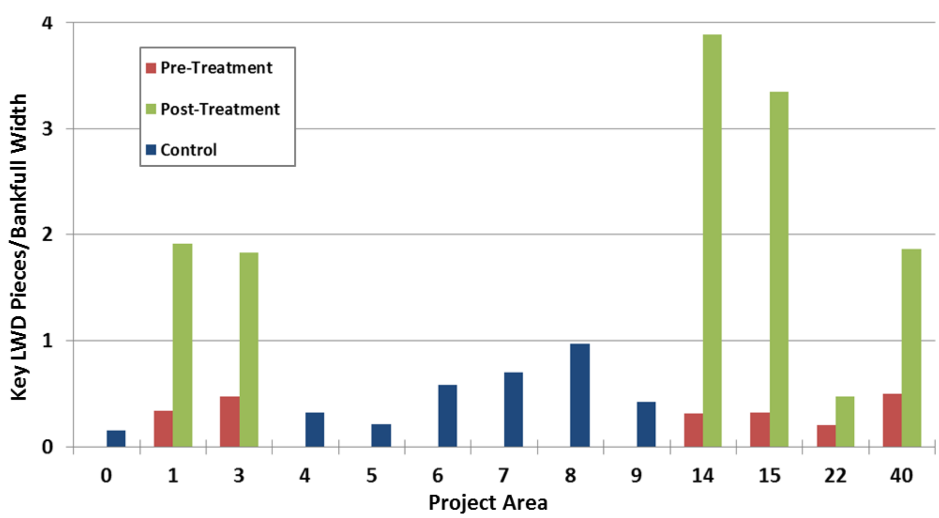

Figure 16. Rapid habitat survey results showing the number of key LWD pieces in each project area surveyed in 2014. The overall restoration goal is 1 key piece per bankfull width. Data collected by SRSRB and Eco Logical staff.

Rapid habitat survey results summarizing pool frequency within each project area indicate a greater number of pools on average within control project areas (2.22 pools/100m) compared to post treatment results in restoration project areas (1.24 pools/100m; Figure 17). In general the number of pools within treated project areas did increase post treatment from 1.02 to 1.24 pools/100m, likely as a result of excavation or damming of the river from LWD placement. In the future, we expect pool frequency to further increase as LWD has the chance to interact with high flows to scour out more pool habitat. We will continue to conduct rapid habitat surveys in 2015 to fill in project areas not accounted for in 2014.

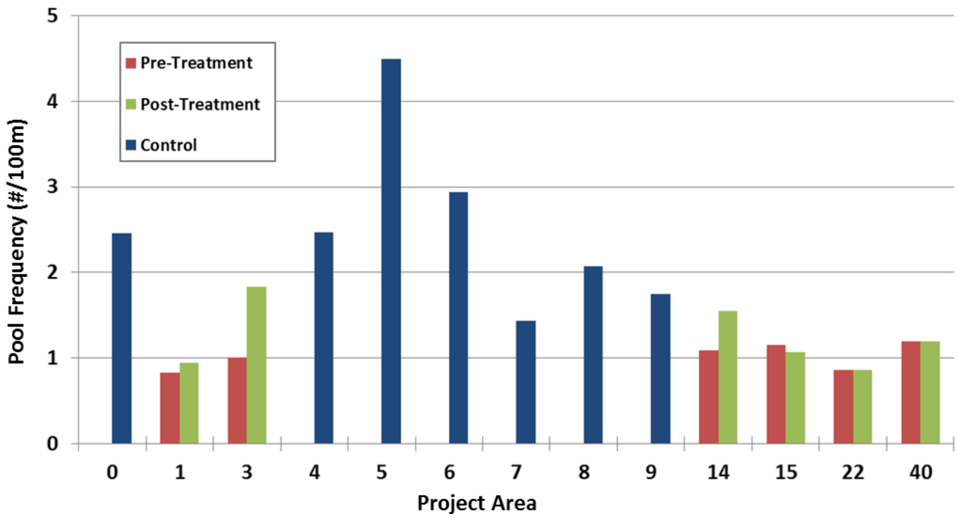

Figure 17. Rapid habitat survey results showing pool frequency in each project area surveyed in 2014. Data collected by SRSRB and Eco Logical staff.

4.6 RIVER STYLES

We have completed preliminary assessments of the River Styles present in the Tucannon River (Stage 1 - Figure 18 and Table 8) and the condition of the River Styles (Stage 2 -Figure 19). For the purposes of the expert panel process, we reduced the stream network to the fish-bearing portion as identified by the StreamNet database. The geomorphic and riparian assessment is based on, 1) the baseline survey of river character and behavior accomplished in Stage One of the River Styles assessment and, 2) continuous metrics of riparian and floodplain condition derived from three spatially explicit, network based models (see full report Portugal et al. 2015). Geomorphic condition refers to the deviation from an expected form and function of the river given the specific valley setting, boundary conditions of sediment and water flux, and biotic resistance elements. The deviation from reference conditions is driven by historic and current land-use and development. Essentially, good or pristine condition reference reaches are identified for each River Style and each reach-scale occurrence of that RS (hereafter referred to as 'variants') are compared against the reference conditions for that specific RS to assess geomorphic condition. Inherent to the geomorphic condition assessment is the concept of a River Styles natural 'capacity for adjustment' (Brierley and Fryirs 2005). This is the ability of a given RS to adjust it channel shape and planform, bed material characteristics and instream and floodplain geomorphic units in response to local and system-wide disturbances but do not 'record a wholesale change is River Style'. These disturbances can be driven by natural (e.g., wildfire, changing climate, mass-wasting, etc.) and anthropogenic (e.g., logging, agriculture, grazing, mining, development, etc.) perturbations. From this first assessment of condition it appears the lower river has a larger proportion of poor and moderate habitat than the upper river and essentially all of Pataha Creek is in poor or moderate condition. We will be refining the Stage 1 and 2 of River Styles in future reports and using the outputs to better interpret the effectiveness of restoration actions within the Tucannon River.

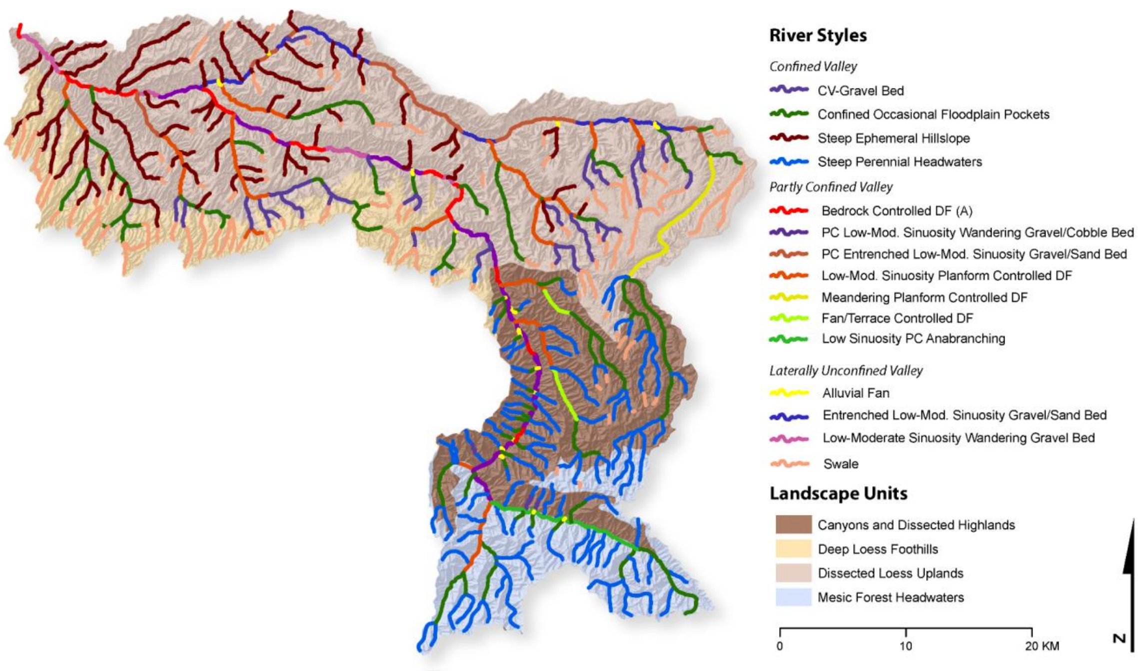

Figure 18. Stage 1 of River Styles assessment: Tucannon River Styles and valley confinement.

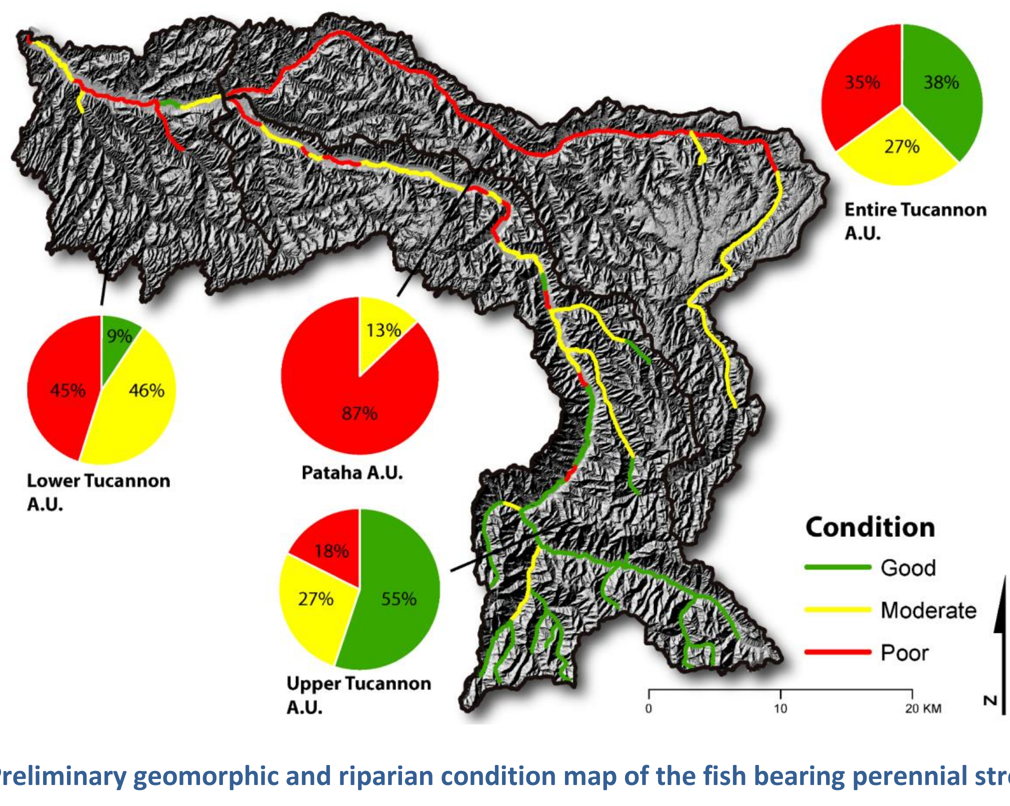

Figure 19. Preliminary geomorphic and riparian condition map of the fish bearing perennial stream network for the Tucannon watershed

Table 8. Number of CHaMP sites in each River Style within the lower and upper Tucannon River and tributaries.

River Style	Lower Watershed		Upper Watershed		Tributary	Watershed Total
	Treatment	Control	Treatment	Control		
Bedrock Controlled Discontinuous Floodplain (A)	1	2	4	9	NA	16
Confined Occasional Floodplain Pockets	NA	NA	NA	NA	1	1
Entrenched Low-Mod Sinuosity Gravel/Sand Bed	NA	NA	NA	NA	1	1
Low Sinuosity PC Anabranching	NA	NA	NA	1	NA	1
Low-Mod Sinuosity Planform Controlled Disconnected FP	NA	NA	NA	NA	6	6
Low-Mod Sinuosity Wandering Gravel Bed	NA	3	1	1	NA	5
PC Low-Mod Sinuosity Wandering Gravel/Cobble Bed	NA	NA	6	13	NA	19
Total	1	5	11	24	8	49

5 CONCLUSION

Data presented in this report primarily represent baseline conditions from which the “success” of restoration actions will be compared to in future years. From 2011-2014, a complete panel rotation (three years) and one additional year of CHaMP panel sites has been sampled. The sampling so far has confirmed previous assessments that the mainstem is relatively confined and has low instream channel complexity. The lower river generally is less confined and has more pools and large woody debris. However, both the lower and upper river have few key pieces of LWD (>0.3 m diameter and > 6m long) per bankfull width.

In locations where restoration actions have occurred (Project Areas 10 and 26), post-treatment data indicates that these actions are providing immediate improvements to habitat conditions (increase in LWD) compared to control sites and that continuing improvements to habitat conditions (increase in channel units, side channels, and pools) would be expected over time. While we do see immediate improvements to habitat at the project level scale, the evidence of these actions within the watershed as a whole is not evident. This reflects the relatively small amount of restoration that has taken place and captured at CHaMP sites to date as the status is based on a weighted average of all sites across the lower and upper river. As more restoration actions are implemented in the watershed, we not only expect to see immediate (increases in LWD) and gradual (increase in channel units and side channels) improvements to habitat at the project level but also a more noticeable response across the entire watershed. These current and future actions should also be evident in the trend data which is inconclusive due to having only four years of trend data available so far.

The results do indicate that substrate conditions meet restoration targets in both the lower and upper river. The average weighted cobble embeddedness for the lower and upper river is 13.2% and 2.2%, respectively (Table 4). The restoration target for lower river is < 20% embeddedness (Table 1). This relatively low measure of embeddedness is likely due to previous restoration activities in the watershed aimed at reducing sediment inputs.

Monitoring results from 2011 to 2014 have been presented here that report the status, trends, and effectiveness of stream restoration within the Tucannon River watershed as well as a description of methods used to describe conditions of each ecological concern. In future reports, we will present data on the condition of floodplain and riparian areas using existing GIS data, River Styles assessments and potential for LWD recruitment see for more details on these methods Portugal et al. (2015).

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APPENDIX I. METRICS AND DEFINITIONS TO BE USED FOR ASSESSING CHANGES IN SIX 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.

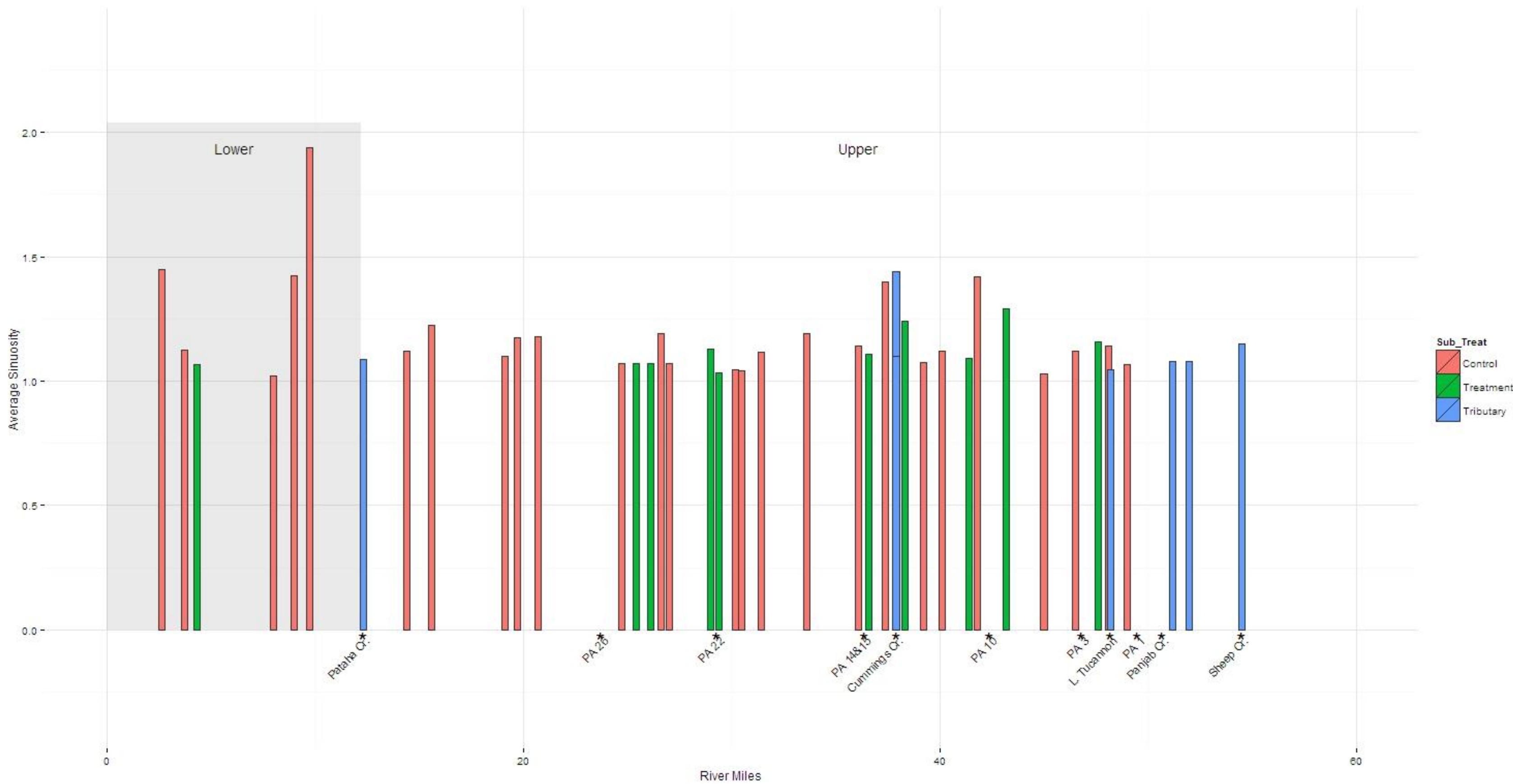
Ecological Concern/ Sub-Category	**Attribute Type**	**Metric**	**Calculation**
Channel Structure/Instream Structural Complexity (cont.)	pool	Residual pool depth	The average difference of the maximum depth and downstream end depth of all Slow-Water/Pool channel units for a site. The downstream depth is 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.

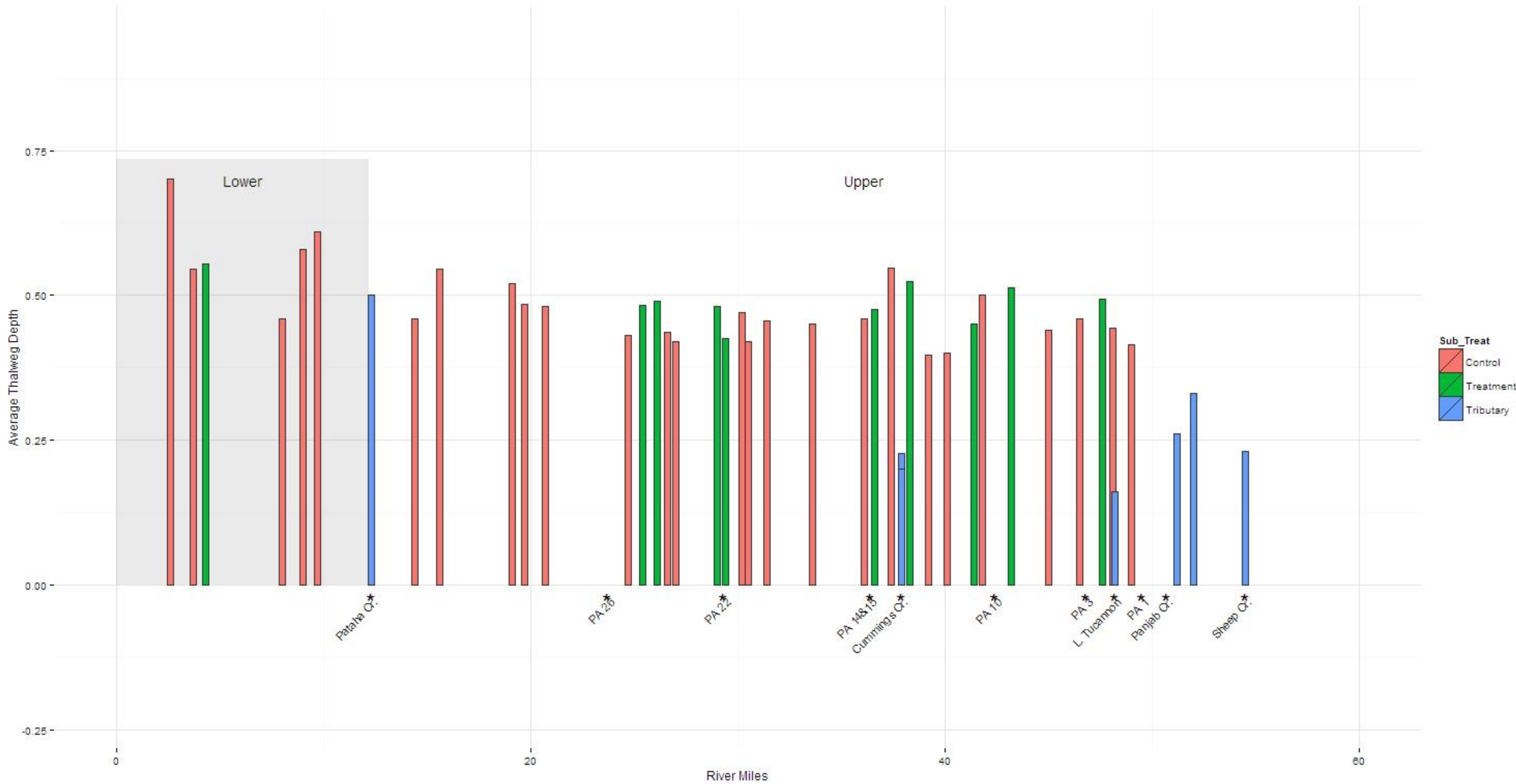
Ecological Concern/ Sub-Category	Attribute Type	Metric	Calculation
Channel Form & Function/ Bed & Channel Form	depth	Thalweg depth mean	Mean depth of the thalweg taken at even measurements (every 0.5 m) along the length.
	depth	Thalweg depth CV	Coefficient of Variation of thalweg depths. Taken at even 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).

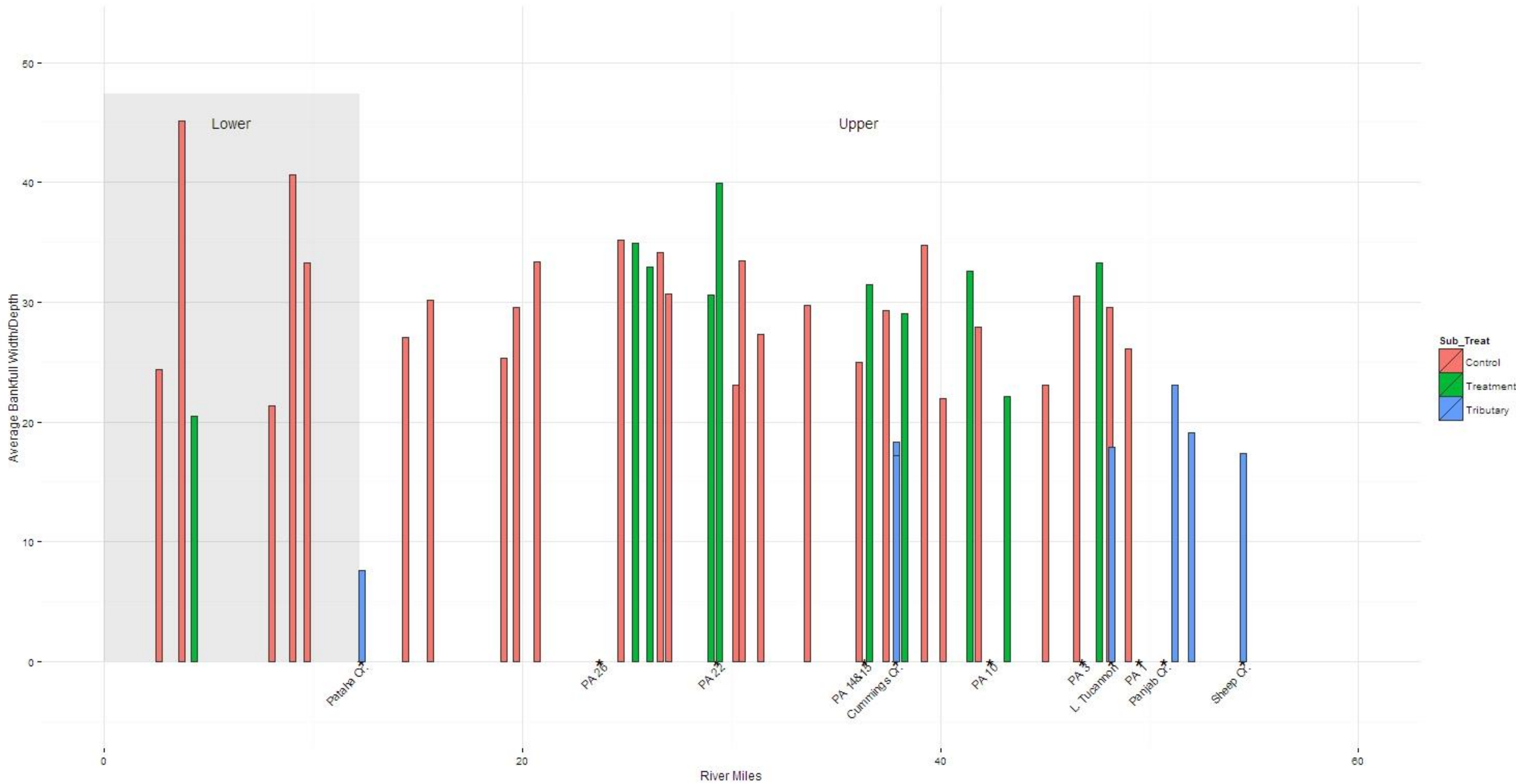
Ecological Concern/ Sub-Category	Attribute Type	Metric	Calculation
Riparian Condition/Structure and Composition (cont.)	extent	Average Summer Solar Access	A measure of the solar radiation availability at a site. Insolation data is summed across all days in a month to provide monthly solar insolation 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.

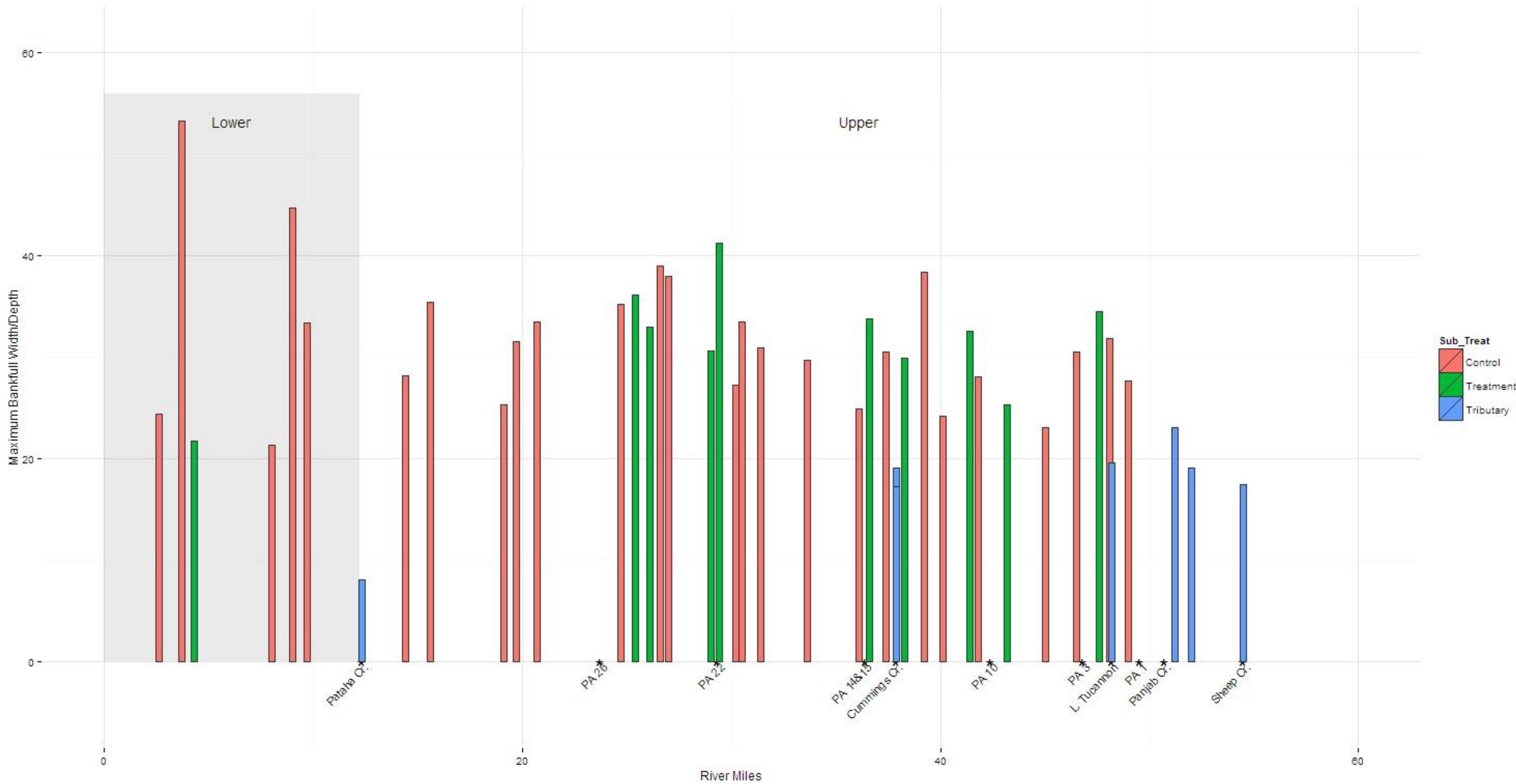
Ecological Concern/ Sub-Category	Attribute Type	Metric	Calculation
Sediment Conditions/Fines and Substrate	substrate	% embeddedness	Embeddedness is estimated as the product of the percentage of the cobble’s surface that is buried below the surface of the streambed and the percentage of fine sediment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

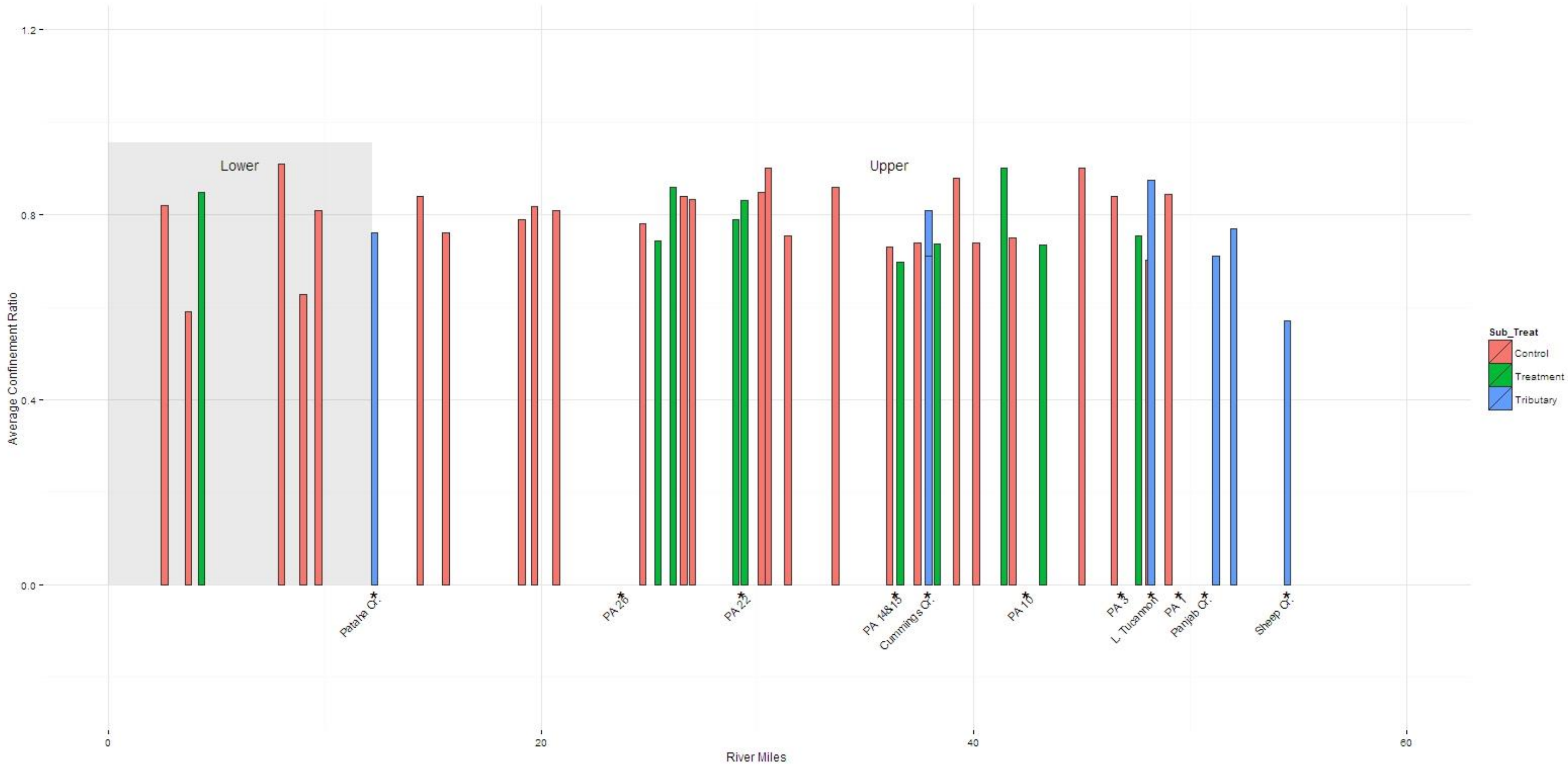
APPENDIX II. BAR PLOTS OF ALL CHAMP SITES PLOTTED BY RIVER MILE (RM) FOR EACH METRIC. BARS REPRESENT MAXIMUM VALUES IF THE METRIC WAS EXPECTED TO CHANGE OVER THE THREE YEARS OF SMAPLING (2011-2014) OR AVERAGE VALUES IF METRIC WAS EXPECTED TO NOT CHANGE SIGNIFICANTLY. COLOR OF EACH BAR REPORESNETS WHETHER THE CHAMP SITE IS A CONTROL OR TREATMENT SITE. GREY SHADE REPRESENTS THE LOWER RIVER. TRIBUTARIES ARE PLOTTED AT THE APPROXIMATE RM WHERE THE ENTER THE MAINSTEM TUCANNON RIVER. SEE APPENDIX I FOR METRIC DEFINITIONS.

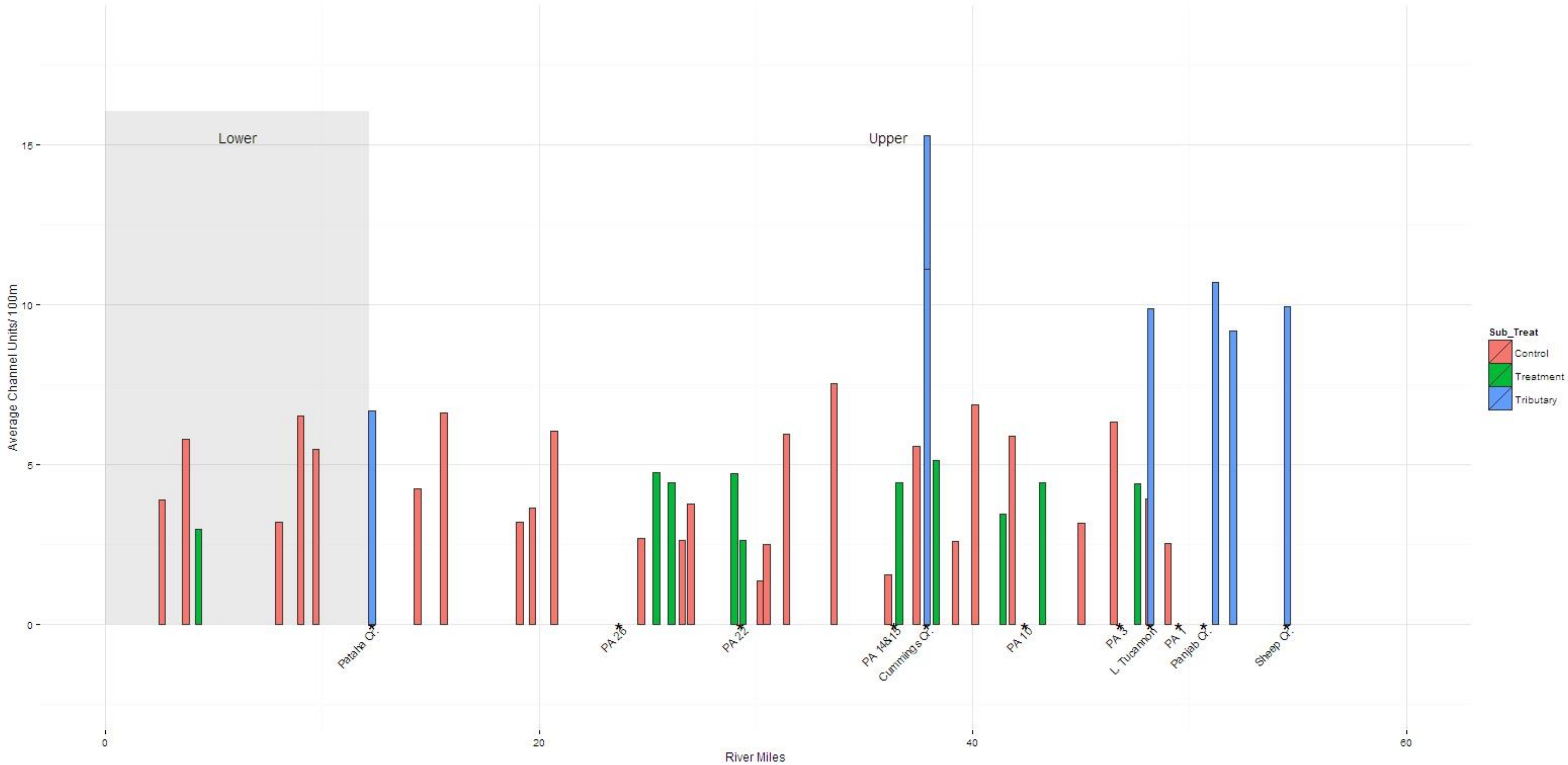


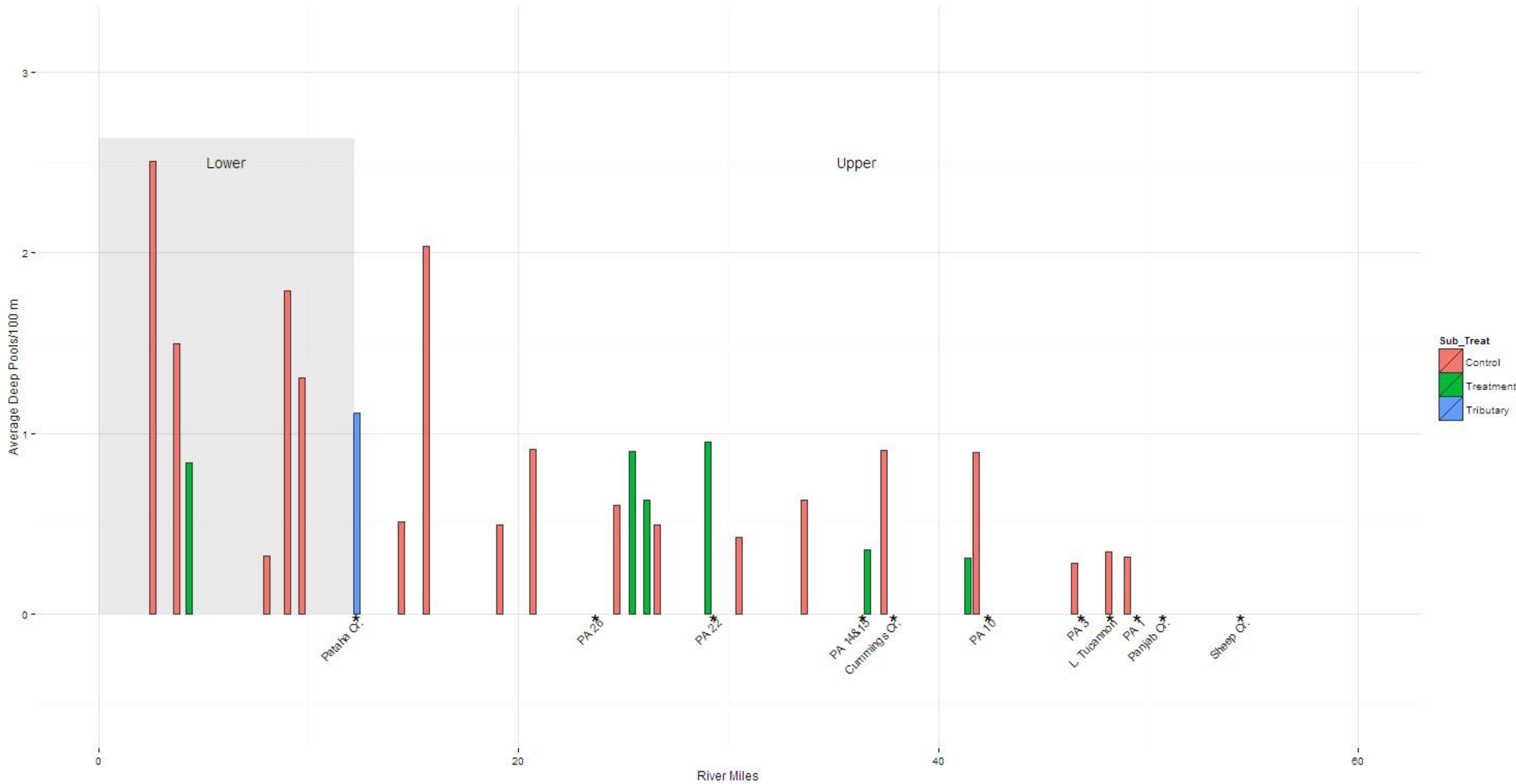

Lower
Upper
Average Thalweg Depth
0.75
0.50
0.25
0.00
-0.25
River Miles
0
20
40
60
Pataha Cr.
PA 26
PA 22
PA 14&15
Cummings Cr.
PA 10
PA 3
L. Tucannon
PA 1
Panjab Cr.
Sheep Cr.
Sub_Treat
Control
Treatment
Tributary

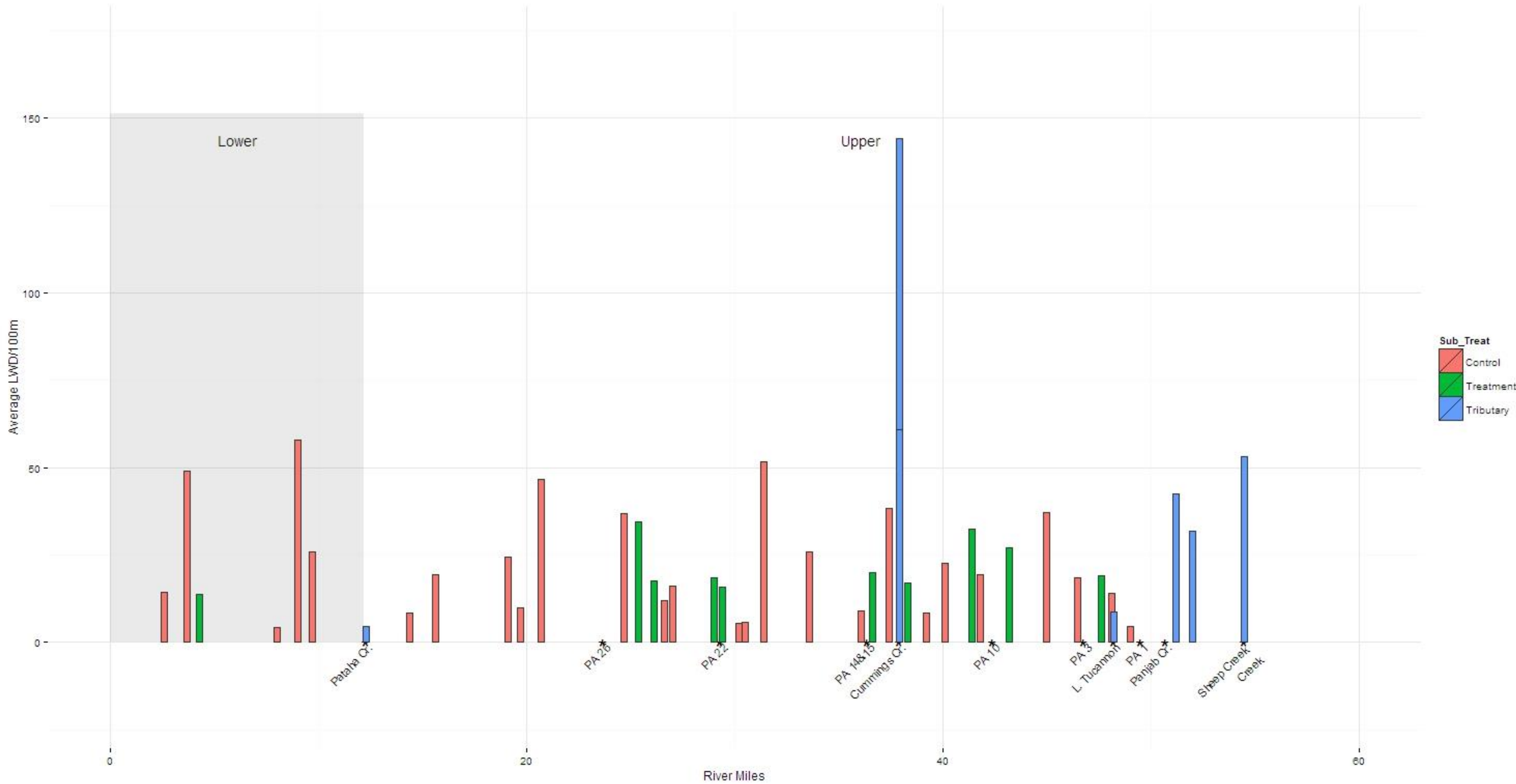

Lower
Upper
Average Bankfull Width/Depth
50
40
30
20
10
0
Pataha Cr.
PA 26
PA 22
PA 14&15
Cummings Cr.
PA 10
PA 3
L. Tucannon
PA 1
Panjab Cr.
Sheep Cr.
0
20
40
60
River Miles
Sub_Treat
Control
Treatment
Tributary

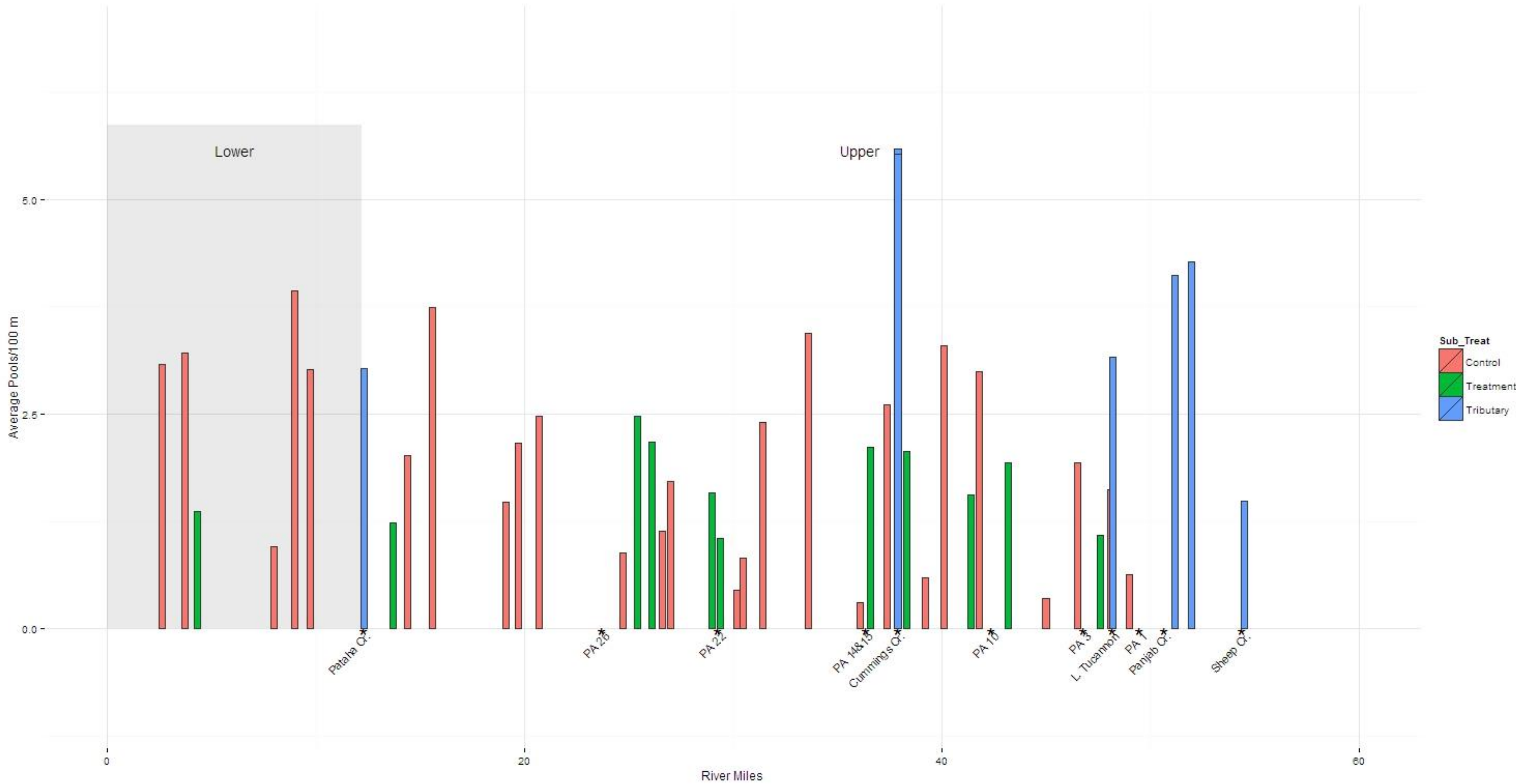

Lower
Upper
Maximum Bankfull Width/Depth
River Miles
Sub_Treat
Control
Treatment
Tributary
Pataha Cr.
PA 26
PA 22
PA 14&15
Cummings Cr.
PA 10
PA 3
L. Tucannon
PA 1
Panjab Cr.
Sheep Cr.

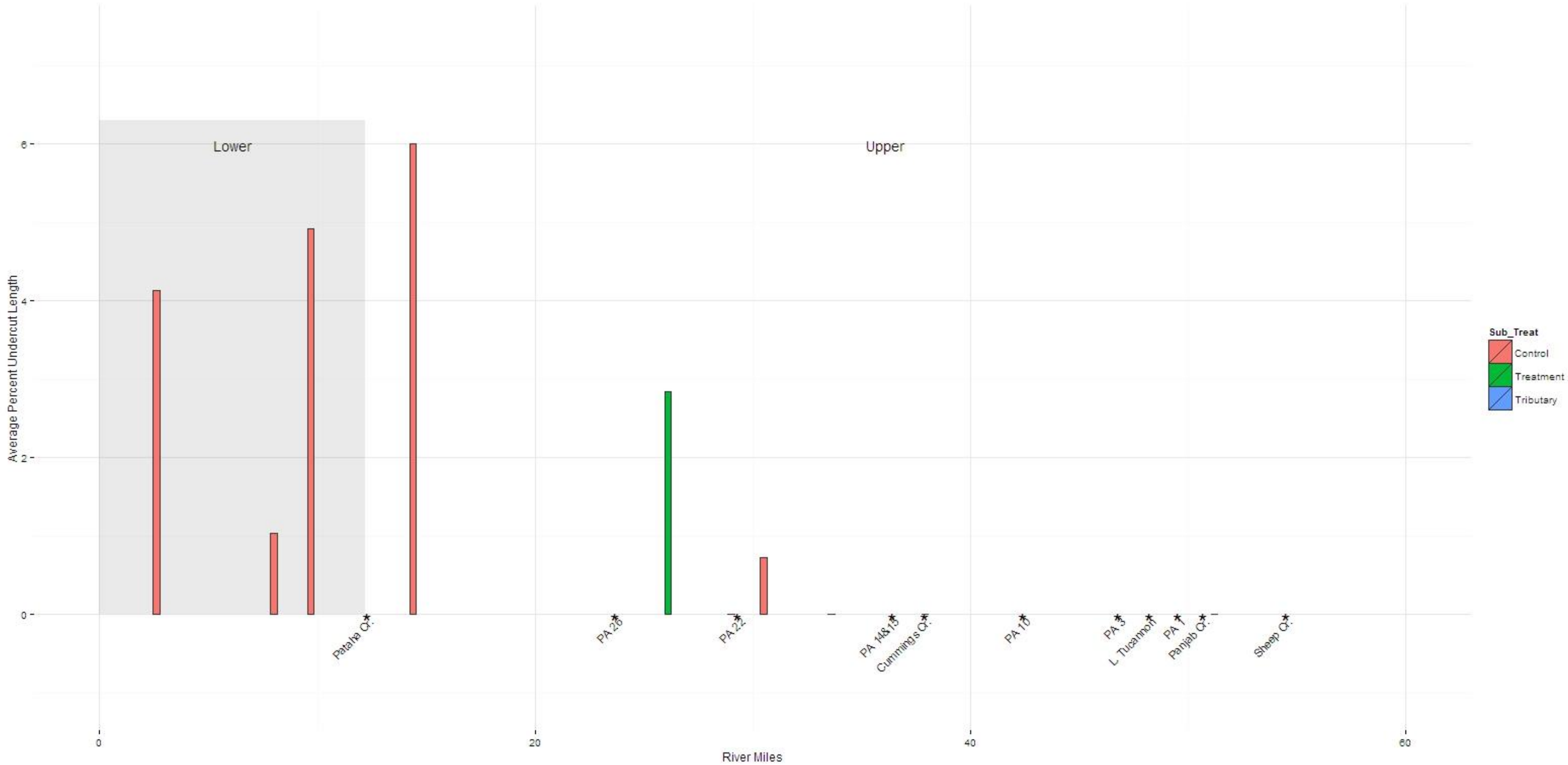

Lower
Upper
Average Confinement Ratio
River Miles
Sub_Treat
Control
Treatment
Tributary
Pataha Cr.
PA 26
PA 22
PA 14&15
Cummings Cr.
PA 10
PA 3
L. Tucannon
PA 1
Panjab Cr.
Sheep Cr.
1.2
0.8
0.4
0.0
0
20
40
60


Lower
Upper
Average Channel Units/ 100m
River Miles
0
5
10
15
0
20
40
60
Pataha Cr.
PA 26
PA 22
PA 14&15
Cummings Cr.
PA 10
PA 3
L. Tucannon
PA 1
Panjab Cr.
Sheep Cr.
Sub_Treat
Control
Treatment
Tributary


Lower
Upper
Average Deep Pools/100 m
River Miles
Sub_Treat
Control
Treatment
Tributary
Pataha Cr.
PA 26
PA 22
PA 14&15
Cummings Cr.
PA 10
PA 3
L. Tucannon
PA 1
Panjab Cr.
Sheep Cr.


Lower
Upper
150
100
50
0
Average LWD/100m
0
20
40
60
River Miles
Sub_Treat
Control
Treatment
Tributary
Pataha Cr.
PA 26
PA 22
PA 14&15
Cummings Cr.
PA 10
PA 3
L. Tucannon
PA 1
Panjab Cr.
Sheep Creek
Creek


Lower
Upper
5.0
2.5
0.0
Average Pools/100 m
Pataha Cr.
PA 26
PA 22
PA 14&15
Cummings Cr.
PA 10
PA 3
L. Tucannon
PA 1
Panjab Cr.
Sheep Cr.
0
20
40
60
River Miles
Sub_Treat
Control
Treatment
Tributary


Lower
Upper
Average Percent Undercut Length
River Miles
Sub_Treat
Control
Treatment
Tributary
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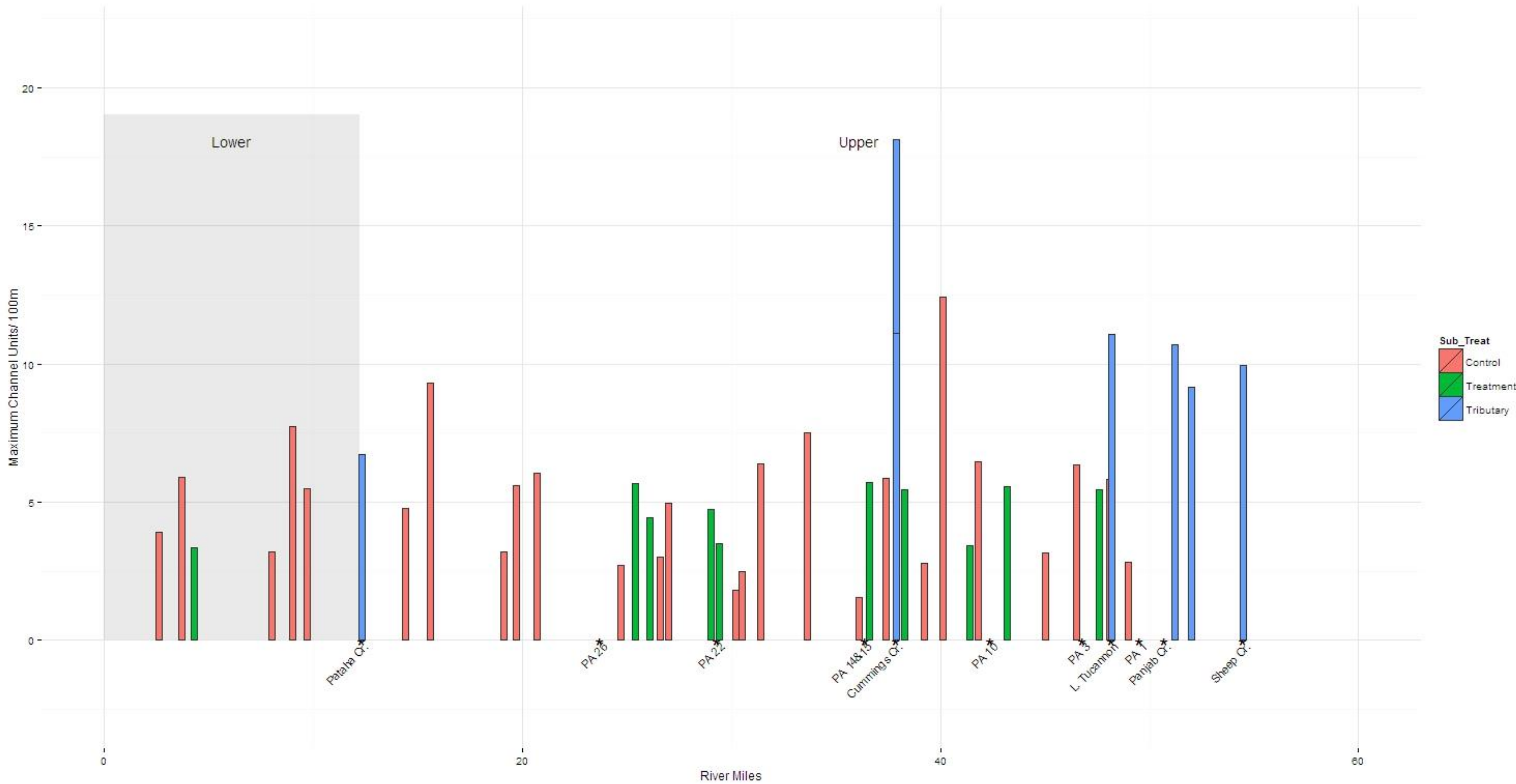
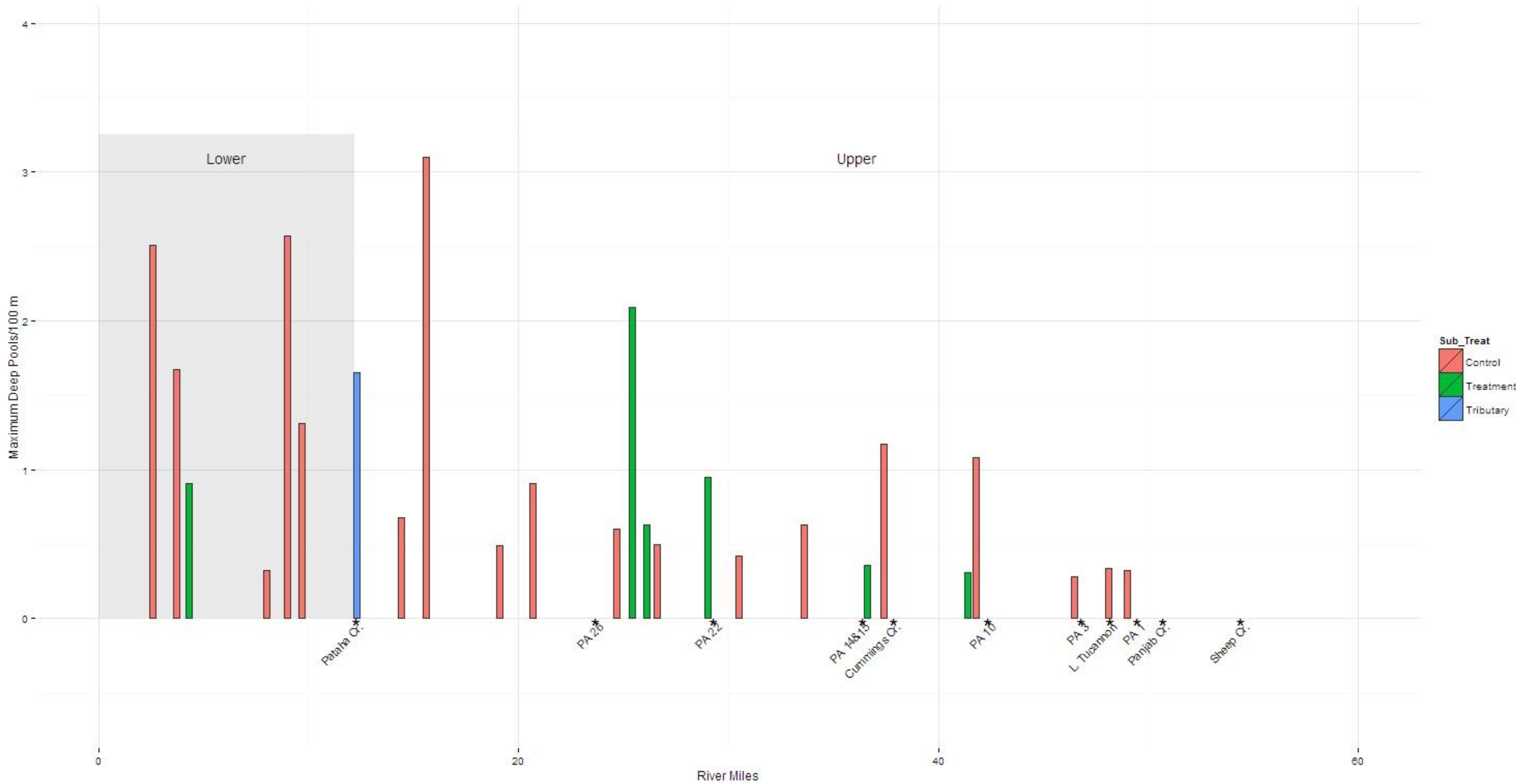
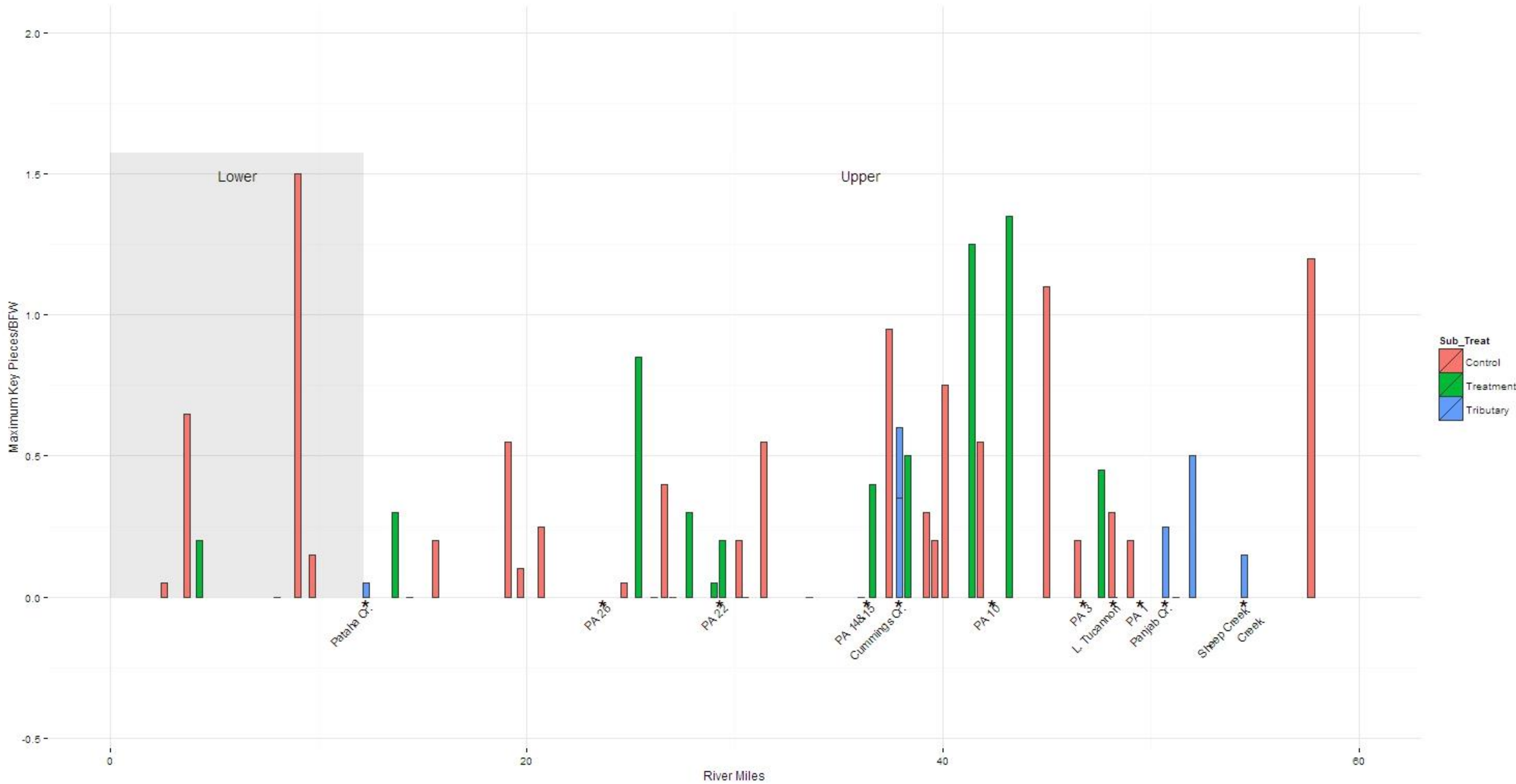
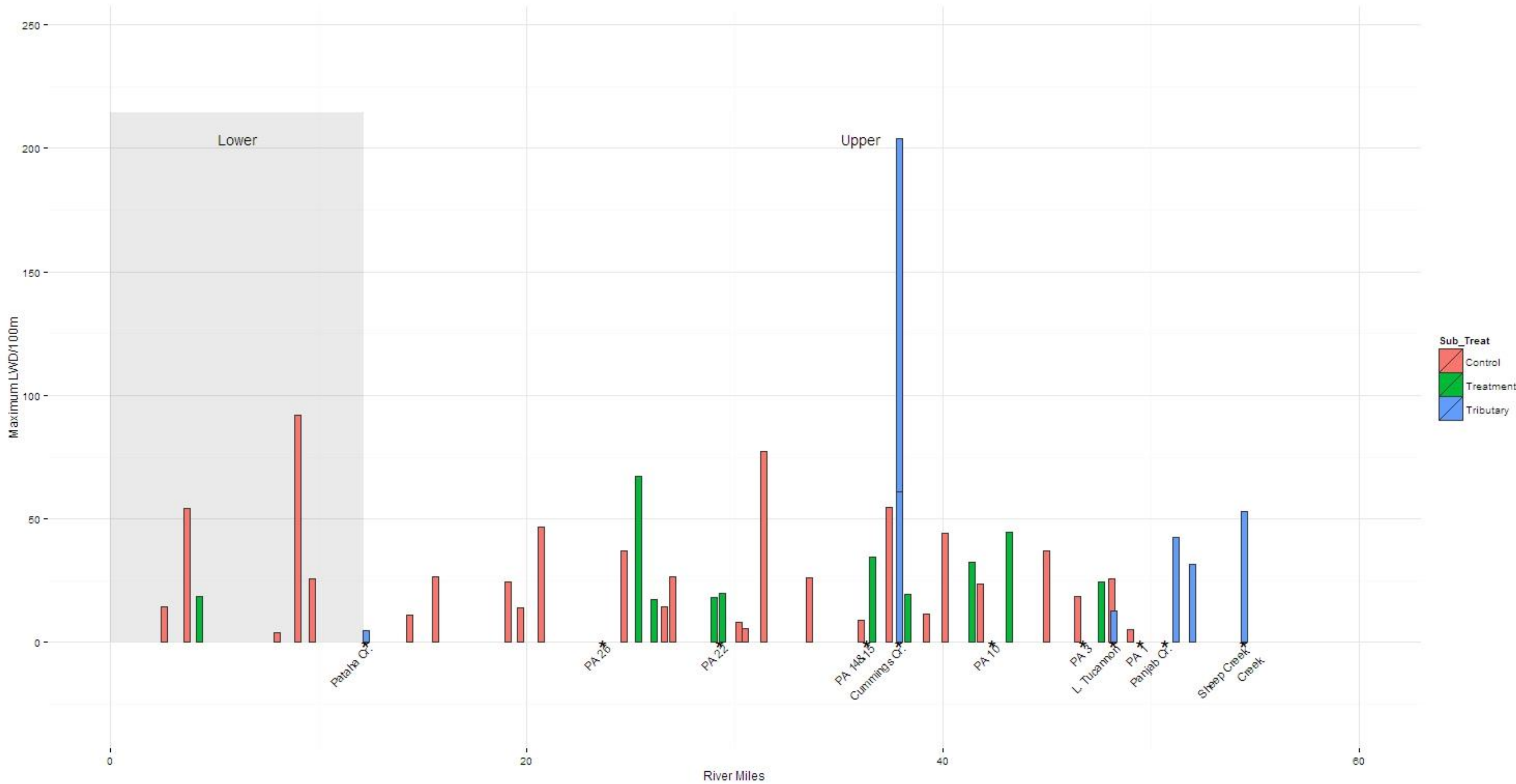
PA 26
PA 22
PA 14&15
Cummings Cr.
PA 10
PA 3
L. Tucannon
PA 1
Panjab Cr.
Sheep Cr.



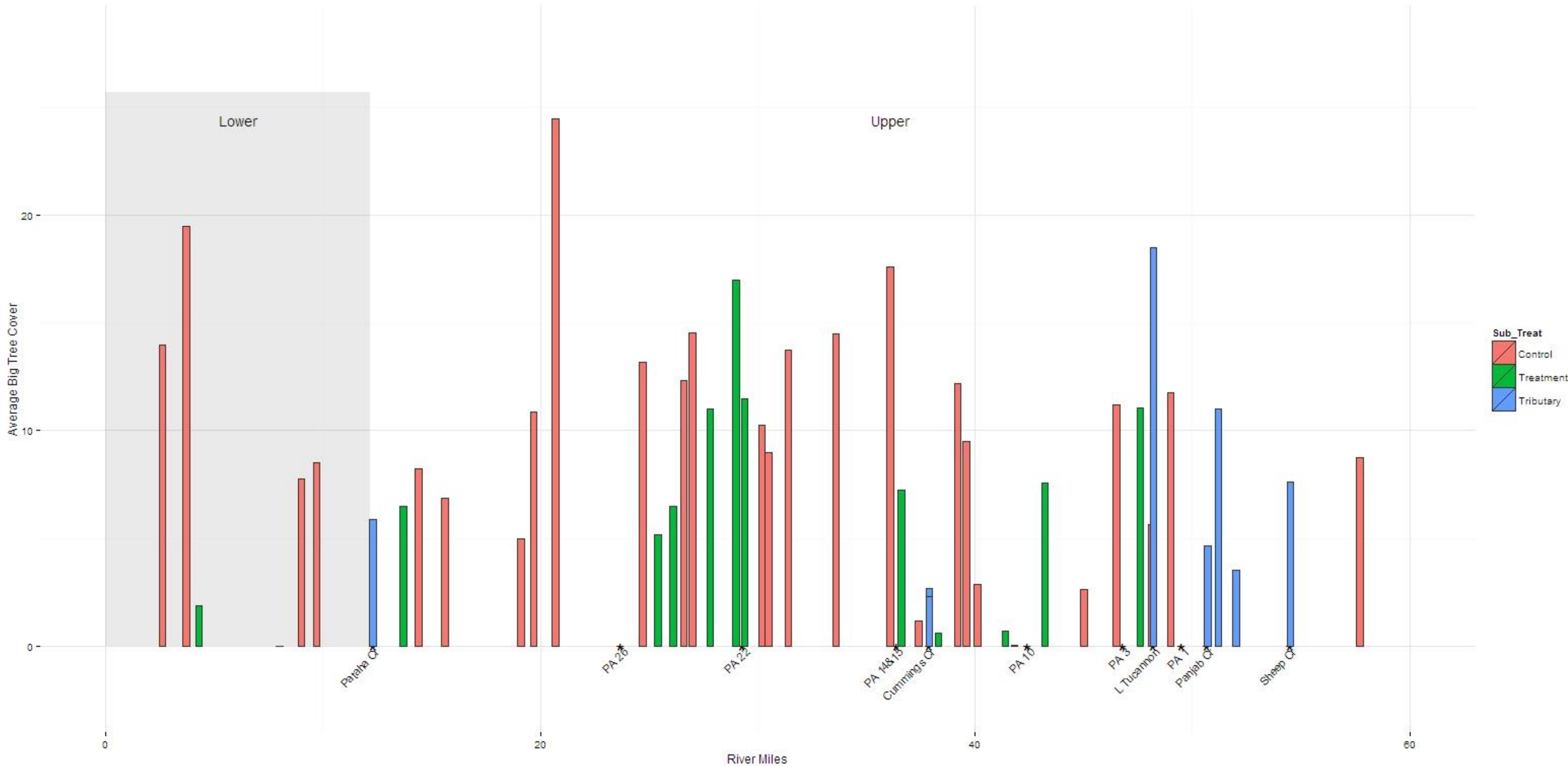
Lower
Upper
Maximum Channel Units/ 100m
River Miles
Pataha Cr.
PA 26
PA 22
PA 14&15
Cummings Cr.
PA 10
PA 3
L. Tucannon
PA 1
Panjab Cr.
Sheep Cr.
Sub_Treat
Control
Treatment
Tributary


Lower
Upper
Maximum Deep Pools/100 m
River Miles
0
1
2
3
4
0
20
40
60
Pataha Cr.
PA 25
PA 22
PA 14&15
Cummings Cr.
PA 10
PA 3
L. Tucannon
PA 1
Panjab Cr.
Sheep Cr.
Sub_Treat
Control
Treatment
Tributary

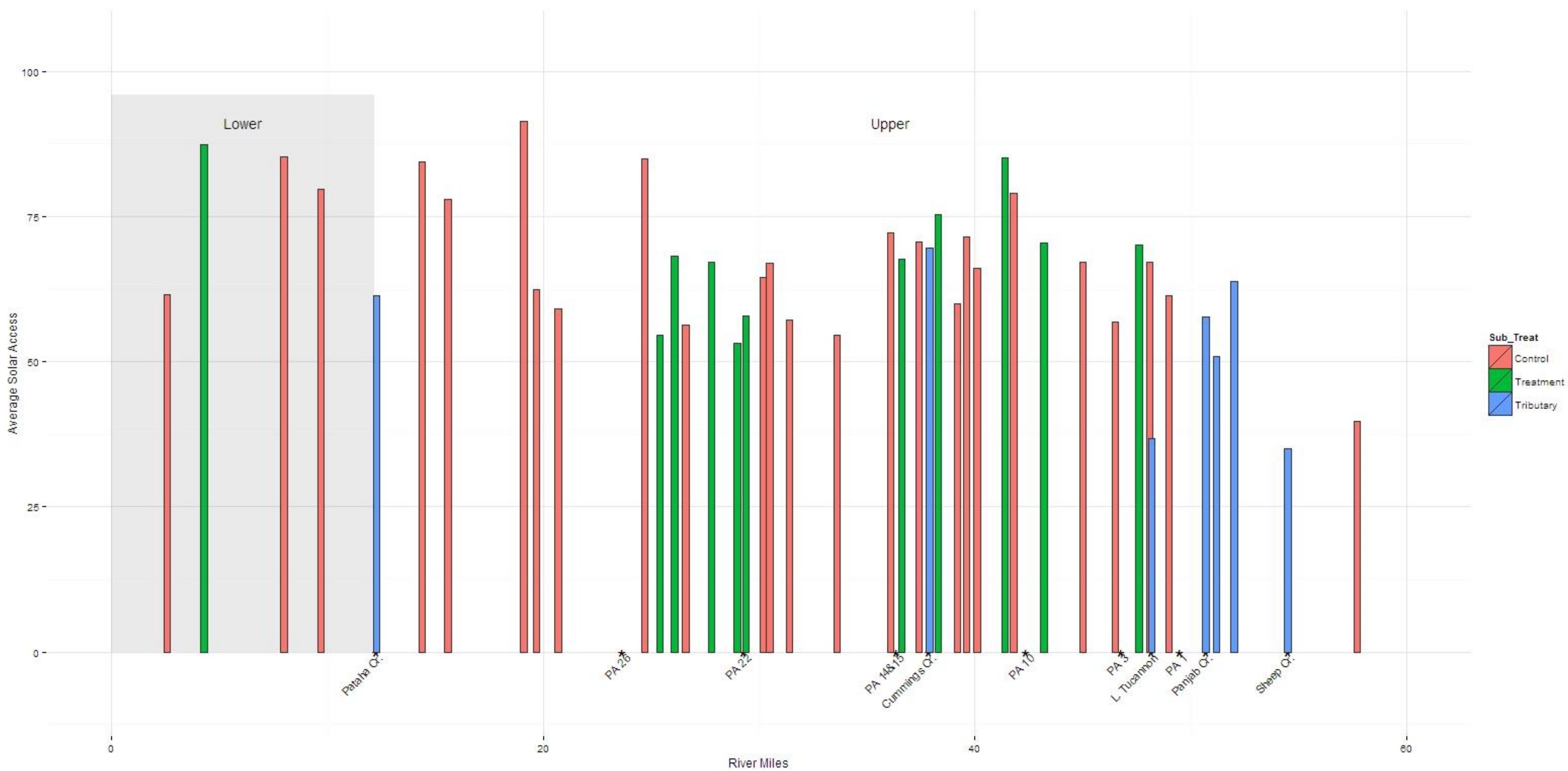

Sub_Treat
Control
Treatment
Tributary
Lower
Upper
Maximum Key Pieces/BFW
River Miles
Pataha Cr.
PA 26
PA 22
PA 14&15
Cummings Cr.
PA 10
PA 3
L. Tucannon
PA 1
Panjab Cr.
Sheep Creek
Creek

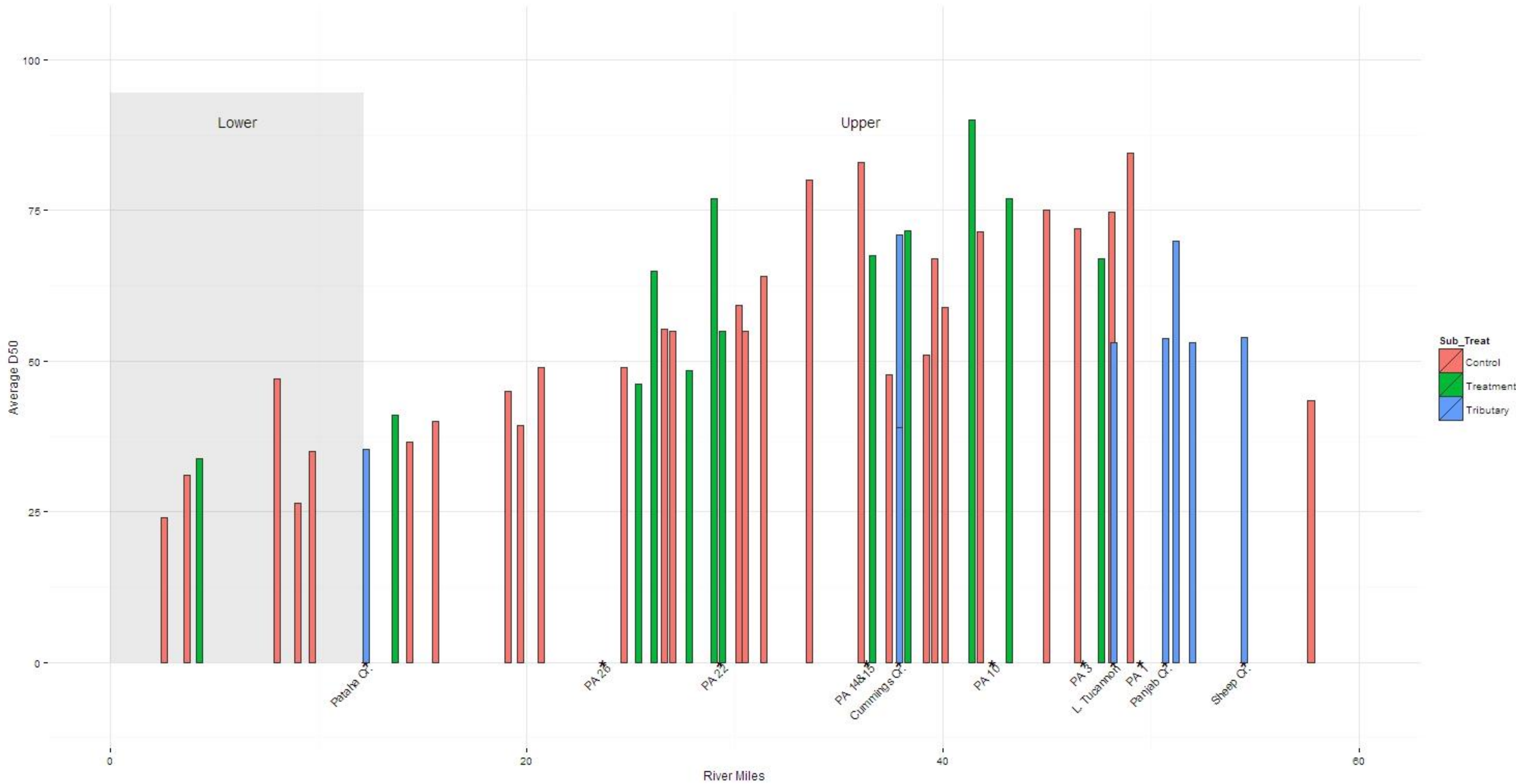


Lower
Upper
Maximum LWD/100m
250
200
150
100
50
0
Pataha Cr.
PA 26
PA 22
PA 14&15
Cummings Cr.
PA 10
PA 3
L. Tucannon
PA 1
Panjab Cr.
Sheep Creek
Creek
0
20
40
60
River Miles
Sub_Treat
Control
Treatment
Tributary

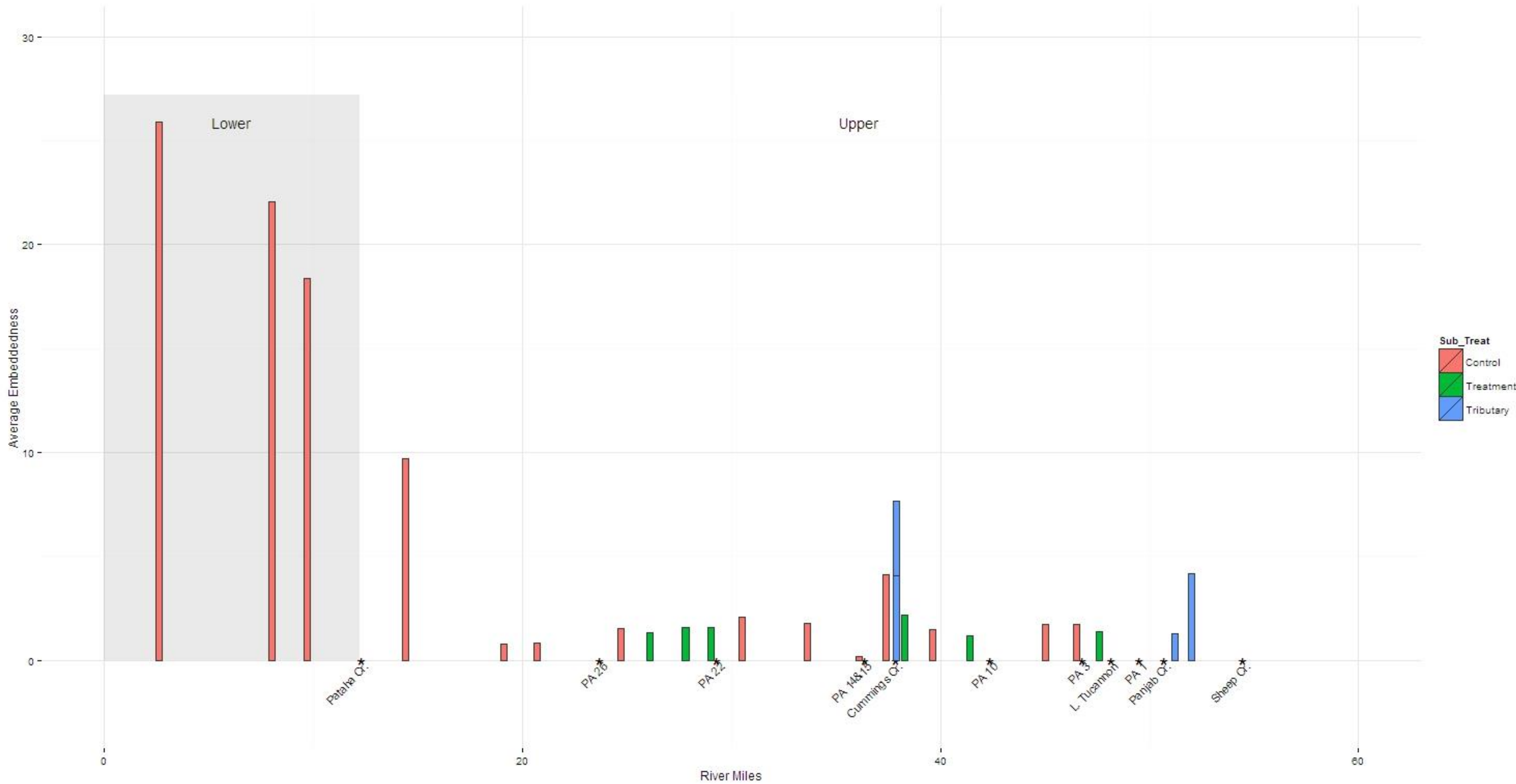


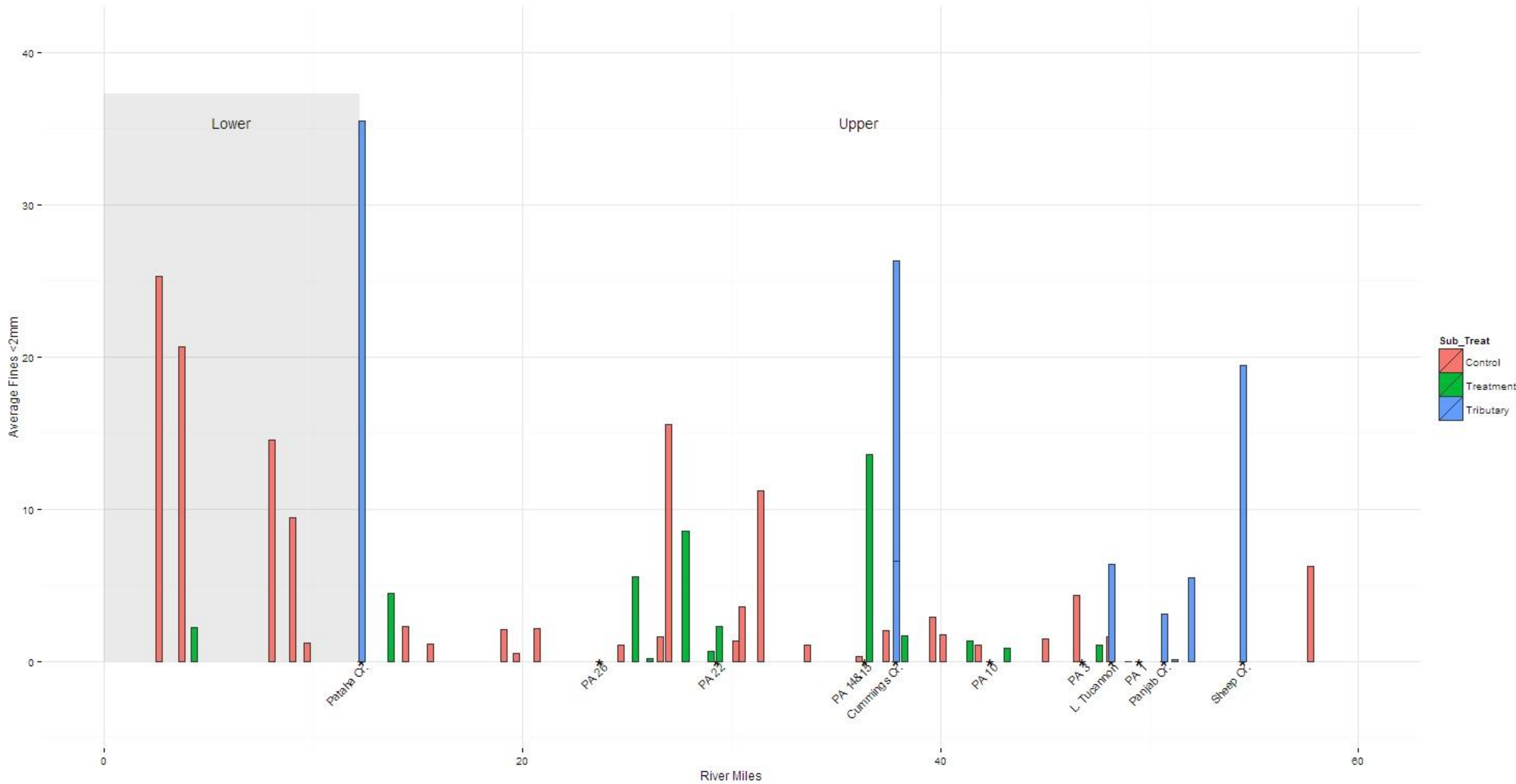
Lower
Upper
Average Big Tree Cover
20
10
0
Pataha Cr
PA 26
PA 22
PA 14&15
Cummings Cr
PA 10
PA 3
L Tucannon
PA 1
Panjab Cr
Sheep Cr
0
20
40
60
River Miles
Sub_Treat
Control
Treatment
Tributary

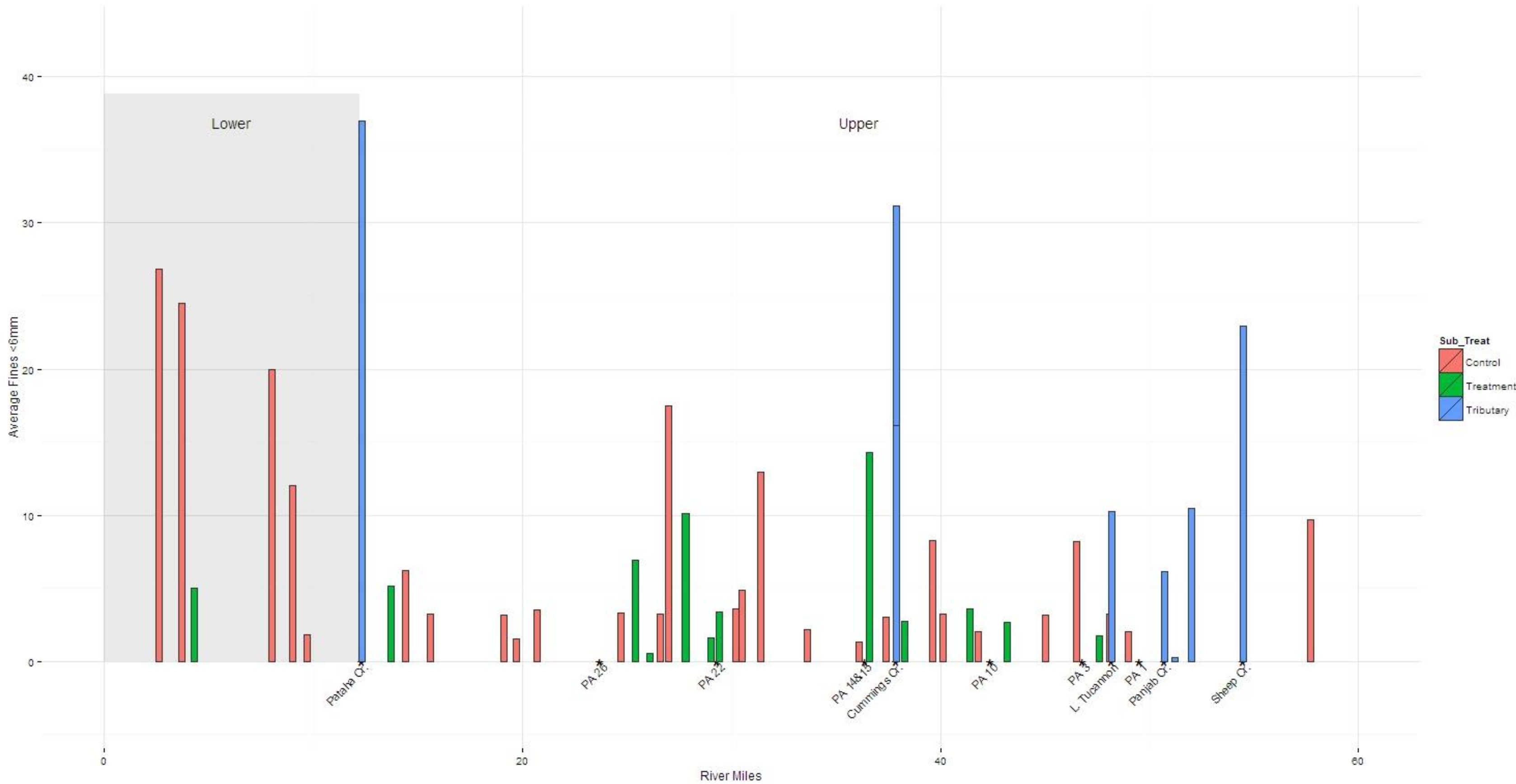

Lower
Upper
Average Solar Access
River Miles
Sub_Treat
Control
Treatment
Tributary
Pataha Cr.
PA 26
PA 22
PA 14&15
Cummings Cr.
PA 10
PA 3
L. Tucannon
PA 1
Panjab Cr.
Sheep Cr.



100
75
50
25
0
Average D50
Lower
Upper
Pataha Cr.
PA 26
PA 22
PA 14&15
Cummings Cr.
PA 10
PA 3
L. Tucannon
PA 1
Panjab Cr.
Sheep Cr.
0
20
40
60
River Miles
Sub_Treat
Control
Treatment
Tributary


Lower
Upper
Average Embeddedness
River Miles
Sub_Treat
Control
Treatment
Tributary
Pataha Cr.
PA 26
PA 22
PA 14&15
Cummings Cr.
PA 10
PA 3
L. Tucannon
PA 1
Panjab Cr.
Sheep Cr.


Lower
Upper
Average Fines <2mm
River Miles
Sub_Treat
Control
Treatment
Tributary
Pataha Cr.
PA 26
PA 22
PA 14&15
Cummings Cr.
PA 10
PA 3
L. Tucannon
PA 1
Panjab Cr.
Sheep Cr.


40
30
20
10
0
Lower
Upper
Average Fines <6mm
Pataha Cr.
PA 26
PA 22
PA 14&15
Cummings Cr.
PA 10
PA 3
L. Tucannon
PA 1
Panjab Cr.
Sheep Cr.
0
20
40
60
River Miles
Sub_Treat
Control
Treatment
Tributary

APPENDIX III. SUMMARY OF ALL CHAMP SITES VISITS FROM 2011-2014. SEE APPENDIX I FOR METRIC DEFINITIONS.

									Channel Form & Function					Channel Structure/ Instream Complexity					Floodplain	Riparian		Substrate			
Stream	RM	CHaMP Site ID	Sample Date	Visit Year	Type	Location	Project Area	Restored	Sinuosity	Gradient	Thalweg Depth (m)	WD	BFW	Channel Units/ 100m	LWD/ 100m	Key LWD/ BFW	Pool/ 100 m	Deep Pools/ 100 m	Confinement Ratio	Big Tree Cover	Solar Access	Embed	D50	Fines < 2mm	Fines < 6 mm
Tucannon	2.6	CBW05583-353323	9/29/2013	2013	Control	Lower	42	No	1.45	0.49	0.70	24.41	14.80	3.90	14.28	0.05	3.08	2.51	0.82	14.00	61.50	25.92	24.00	25.27	26.87
Tucannon	3.7	CBW05583-222251	8/25/2011	2011	Control	Lower	41	No	1.21	0.79	0.51	53.26	31.97	5.67	54.38	0.65	2.40	1.67	0.51	27.00	37.22		28.00	21.50	25.67
Tucannon	3.7	CBW05583-222251	10/13/2014	2014	Control	Lower	41	No	1.04	0.66	0.58	37.02	19.90	5.92	43.53	0.25	4.02	1.32	0.67	12.00		1.90	34.00	19.82	23.29
Tucannon	4.3	CBW05583-386091	8/24/2011	2011	Treatment	Lower	40	No	1.07	0.38	0.53	18.01	13.01	2.13	18.52	0.10	0.91	0.61	0.84	0.00	87.60		32.00	2.44	6.00
Tucannon	4.3	CBW05583-386091	9/28/2012	2012	Treatment	Lower	40	No	1.06	0.48	0.55	21.69	12.66	3.34	17.90	0.05	1.52	0.91	0.86	5.00	85.54	3.11	28.00	0.34	1.26
Tucannon	4.3	CBW05583-386091	10/1/2013	2013	Treatment	Lower	40	No	1.07	0.47	0.58	20.87	13.02	3.33	10.56	0.00	1.81	0.91	0.83	2.50	90.44	6.59	35.00	5.51	9.11
Tucannon	4.3	CBW05583-386091	7/11/2014	2014	Treatment	Lower	40	No	1.07	0.47	0.56	21.34	12.87	3.05	7.60	0.20	1.22	0.91	0.86	0.00	85.91	1.05	40.00	0.44	3.78
Tucannon	8	CBW05583-420019	9/26/2013	2013	Control	Lower	37	No	1.02	0.37	0.46	21.33	13.44	3.19	4.15	0.00	0.96	0.32	0.91	0.00	85.33	22.05	47.00	14.56	20.00
Tucannon	9	CBW05583-481459	8/27/2011	2011	Control	Lower	37	No	1.44	0.64	0.60	44.65	40.07	3.50	91.84	1.50	2.32	1.46	0.43	7.50	80.53		18.00	29.25	31.17
Tucannon	9	CBW05583-481459	8/29/2012	2012	Control	Lower	37	No	1.49	0.56	0.55	38.44	27.47	7.75	51.02	0.15	4.96	1.66	0.72	15.00	84.31	1.43	27.00	1.20	3.87
Tucannon	9	CBW05583-481459	9/24/2013	2013	Control	Lower	37	No	1.31	0.59	0.52	35.32	22.33	7.65	41.93	0.05	4.13	1.47	0.79	4.50	83.70	6.00	28.00	3.22	5.11
Tucannon	9	CBW05583-481459	10/20/2014	2014	Control	Lower	37	No	1.46	0.65	0.65	44.21	28.09	7.13	47.27	0.30	4.32	2.57	0.57	4.00		1.31	33.00	4.06	8.02
Tucannon	9.7	CBW05583-415923	10/1/2013	2013	Control	Lower	36	No	1.94	0.54	0.61	33.30	15.68	5.49	25.91	0.15	3.02	1.31	0.81	8.50	79.74	18.38	35.00	1.21	1.81
Pataha	12.3	CBW05583-109611	9/29/2011	2011	Tributary	Tributary	NA	No	1.09	0.36	0.44	8.12	4.40	6.70	4.96	0.00	3.31	0.84	0.68	5.50	48.91		38.00	39.60	40.77
Pataha	12.3	CBW05583-109611	10/11/2012	2012	Tributary	Tributary	NA	No	1.08	0.33	0.49	7.13	4.59	6.74	4.17	0.00	2.50	0.84	0.70	6.60	64.96	7.12	27.00	39.50	41.17
Pataha	12.3	CBW05583-109611	10/16/2013	2013	Tributary	Tributary	NA	No	1.09	0.43	0.57	7.55	3.54	6.60	4.11	0.05	3.29	1.65	0.90	5.50	70.25	17.16	41.00	27.37	28.98
Tucannon	13.7	CBW05583-057139	9/28/2011	2011	Treatment	Upper	33	No								0.25	0.00			11.00	60.04		46.00	0.32	0.63
Tucannon	13.7	CBW05583-057139	9/29/2014	2014	Treatment	Upper	33	No	1.14	0.58	0.47	24.49	15.13	4.05	30.95	0.30	2.48	1.25	0.78	2.00		1.68	36.00	8.67	9.67
Tucannon	14.4	CBW05583-384819	10/13/2013	2013	Control	Upper	33	No	1.12	0.56	0.46	28.18	13.12	4.76	5.37	0.00	2.68	0.68	0.86	2.50	80.00	17.52	35.00	0.97	2.55
Tucannon	14.4	CBW05583-384819	8/6/2014	2014	Control	Upper	33	No	1.12	0.46	0.46	25.94	13.13	3.75	11.21	0.00	1.36	0.34	0.82	14.00	88.96	1.90	38.00	3.62	9.90
Tucannon	15.6	CBW05583-212787	9/5/2011	2011	Control	Upper	32	No	1.17	0.59	0.58	28.50	14.47	5.24	17.80	0.15	2.43	1.21	0.73	8.00	67.19		41.00	1.33	4.50
Tucannon	15.6	CBW05583-212787	9/25/2012	2012	Control	Upper	32	No	1.22	0.64	0.51	28.74	13.48	5.36	26.39	0.15	3.06	1.53	0.88	9.50	84.31	8.73	32.00	0.86	1.05
Tucannon	15.6	CBW05583-212787	10/14/2013	2013	Control	Upper	32	No	1.20	0.63	0.48	28.19	14.10	6.54	17.10	0.15	4.18	2.31	0.82	1.50	82.65	5.87	51.00	0.78	2.56
Tucannon	15.6	CBW05583-212787	9/13/2014	2014	Control	Upper	32	No	1.31	0.57	0.61	35.36	23.24	9.30	16.61	0.20	5.30	3.10	0.61	8.50	77.69	0.44	36.00	1.52	4.73
Tucannon	19.1	CBW05583-196787	9/28/2012	2012	Control	Upper	29	No	1.10	0.60	0.52	25.34	14.56	3.21	24.40	0.55	1.48	0.49	0.79	5.00	91.36	0.77	45.00	2.09	3.18
Tucannon	19.7	CBW05583-327859	9/16/2011	2011	Control	Upper	29	No	1.19	0.99	0.49	28.11	15.51	2.35	7.95	0.10	0.99		0.80	17.00	46.57		30.00	0.44	0.89
Tucannon	19.7	CBW05583-327859	9/30/2012	2012	Control	Upper	29	No	1.16	0.96	0.49	30.94	14.47	2.58	14.06	0.00	1.34		0.89	10.50	72.64	0.95	50.00	0.17	1.49
Tucannon	19.7	CBW05583-327859	9/17/2013	2013	Control	Upper	29	No	1.19	0.99	0.49	31.55	14.69	5.59	10.99	0.00	3.66		0.87	6.50	58.27	4.73	36.00	0.00	0.53
Tucannon	19.7	CBW05583-327859	9/15/2014	2014	Control	Upper	29	No	1.16	0.99	0.47	27.82	18.50	4.05	6.67	0.05	2.67	0.34	0.71	9.50	72.29	2.25	41.00	1.34	3.24
Tucannon	20.7	CBW05583-051659	9/16/2012	2012	Control	Upper	28	No	1.18	0.62	0.48	33.40	18.47	6.05	46.72	0.25	2.48	0.91	0.81	24.50	59.08	0.83	49.00	2.14	3.52
Tucannon	24.7	CBW05583-141771	10/9/2012	2012	Control	Upper	26	No	1.07	0.67	0.43	35.18	18.93	2.70	36.94	0.05	0.89	0.60	0.78	13.20	84.89	1.53	49.00	1.07	3.34
Tucannon	25.4	CBW05583-203211	9/14/2011	2011	Treatment	Upper	26	Yes	1.06	0.76	0.42	36.14	17.67	4.85	16.98	0.00	1.82	0.61	0.75	3.50	41.04		52.00	1.33	2.93
Tucannon	25.4	CBW05583-203211	10/12/2012	2012	Treatment	Upper	26	Yes	1.07	0.86	0.45	35.47	15.89	4.25	67.35	0.55	2.72	0.30	0.80	11.60	56.01	2.75	45.00	8.60	10.80
Tucannon	25.4	CBW05583-203211	7/21/2013	2013	Treatment	Upper	26	Yes	1.08	0.81	0.48	36.01	18.02	4.23	28.77	0.15	2.10	0.60	0.80	1.00	44.68	1.29	40.00	2.42	3.58
Tucannon	25.4	CBW05583-203211	8/14/2014	2014	Treatment	Upper	26	Yes	1.07	0.88	0.58	32.03	18.06	5.67	25.32	0.85	3.28	2.09	0.62	4.50	76.66	0.56	48.00	9.93	10.40
Tucannon	26.1	CBW05583-465355	8/17/2013	2013	Treatment	Upper	26	Yes	1.07	0.68	0.49	32.92	15.29	4.44	17.48	0.00	2.18	0.63	0.86	6.50	68.14	1.35	65.00	0.17	0.52
Tucannon	26.6	CBW05583-072139	9/2/2011	2011	Control	Upper	26	No	1.19	1.06	0.41	28.48	15.19	2.43	9.40	0.40	0.96	0.49	0.88	22.00	44.34		45.00	0.00	1.00
Tucannon	26.6	CBW05583-072139	7/20/2013	2013	Control	Upper	26	No	1.20	1.01	0.47	38.93	16.20	2.39	11.65	0.05	0.71	0.48	0.80	5.50	59.58	3.71	53.00	0.83	3.55
Tucannon	26.6	CBW05583-072139	8/16/2014	2014	Control	Upper	26	No	1.18	1.03	0.43	35.05	17.08	3.02	14.60	0.10	1.76	0.50	0.84	9.50	64.87	0.54	68.00	3.92	5.25
Tucannon	27	CBW05583-432587	9/18/2011	2011	Control	Upper	25	No	1.09	0.94	0.38	29.59	14.13	3.88	8.12	0.00	1.30	0.32	0.89	31.00	29.65		47.00	58.33	60.33
Tucannon	27	CBW05583-432587	10/13/2012	2012	Control	Upper	25	No	1.07	0.98	0.44	28.68	14.72	2.27	26.59	0.00	0.66	0.32	0.81	10.20	80.11	0.37	65.00	1.01	3.41
Tucannon	27	CBW05583-432587	6/19/2013	2013	Control	Upper	25	No	1.06	0.99	0.41	37.91	14.40	4.95	14.80	0.00	2.63	0.33	0.87	7.50	49.71	6.50	45.00	1.39	3.70
Tucannon	27	CBW05583-432587	9/27/2014	2014	Control	Upper	25	No	1.07	0.95	0.45	26.46	15.11	3.96	15.45	0.00	2.30		0.76	9.50		0.88	63.00	1.41	2.52
Tucannon	27.8	CBW05583-170443	10/23/2012	2012	Treatment	Upper	24	No								0.15				9.00	66.57	2.74	45.00	6.68	8.50
Tucannon	27.8	CBW05583-170443	8/18/2014	2014	Treatment	Upper	24	No	1.23	1.13	0.52	29.84	13.03	8.56	80.99	0.30	5.42	1.17	0.76	13.00	67.54	0.43	52.00	10.39	11.75
Tucannon	29	CBW05583-214475	9/14/2013	2013	Treatment	Upper	23	No	1.13	0.79	0.48	30.64	15.63	4.73	18.36	0.05	1.58	0.95	0.79	17.00	53.16	1.61	77.00	0.67	1.63
Tucannon	29.4	CBW05583-208767	8/28/2011	2011	Treatment	Upper	22	No	1.05	0.89	0.45	41.15	16.88	1.76	19.71	0.20	0.70		0.82	16.50	51.50		45.00	0.67	1.33
Tucannon	29.4	CBW05583-208767	7/8/2014	2014	Treatment	Upper	22	No	1.02	0.89	0.40	38.70	16.47	3.49	11.93	0.05	1.40		0.84	6.50	64.39	8.05	65.00	3.87	5.46
Tucannon	30.2	CBW05583-339839	8/28/2011	2011	Control	Upper	22	No	1.05	0.82	0.47	27.26	13.23	1.09	8.30	0.20	0.36		0.88	9.50	49.22		55.00	1.33	2.67
Tucannon	30.2	CBW05583-339839	10/26/2012	2012	Control	Upper	22	No	1.05	0.80	0.46	20.31	13.04	1.08	1.81	0.10	0.36		0.81	10.60	74.59	2.84	58.00	2.00	2.67
Tucannon	30.2	CBW05583-339839	10/15/2013	2013	Control	Upper	22	No	1.05	0.80	0.51	23.39	12.09	1.45	6.90	0.10	0.36	0.36	0.90	5.00	64.34	4.49	65.00	0.33	3.33
Tucannon	30.2	CBW05583-339839	8/31/2014	2014	Control	Upper	22	No	1.04	0.81	0.44	21.47	14.21	1.82	4.70	0.00	0.72		0.80	16.00	69.85	1.13	59.00	1.78	5.78
Tucannon	30.5	CBW05583-274303	10/15/2013	2013	Control	Upper	21	No	1.04	1.11	0.42	33.42	15.47	2.49	5.83	0.00	0.83	0.42	0.90	9.00	66.92	2.09	55.00	3.56	4.89
Tucannon	31.4	CBW05583-178047	8/30/2011	2011	Control	Upper	21	No	1.12	1.33	0.46	30.95	19.59	6.39	77.31	0.55	2.77		0.81	21.50	43.10		62.00	16.00	18.83
Tucannon	31.4	CBW05583-178047	9/25/2014	2014	Control	Upper	21	No	1.11	1.30	0.45	23.63	14.02	5.51	26.23	0.00	2.04	0.69	0.70	6.00	71.42	0.89	66.00	6.44	7.04
Tucannon	33.6	CBW05583-079743	9/12/2013	2013	Control	Upper	18	No	1.19	1.16	0.45	29.73	15.02	7.52	25.98	0.00	3.44	0.63	0.86	14.50	54.51	1.80	80.00	1.03	2.18
Tucannon	36.1	CBW05583-522111	9/3/2012	2012	Control	Upper	16	No	1.14	1.02	0.46	24.94	15.45	1.56	9.06	0.00	0.31		0.73	17.60	72.23	0.20	83.00	0.33	1.34
Tucannon	36.6	CBW05583-248063	9/2/2011	2011	Treatment	Upper	15	No	1.12	1.15	0.47	27.76	15.50	3.49	14.70	0.00	0.68	0.35	0.78	8.50	59.55		81.00	50.00	50.67
Tucannon	36.6	CBW05583-248063	9/15/2012	2012	Treatment	Upper	15	No	1.12	1.15	0.48	30.66	14.91	3.11	34.76	0.40	1.74	0.35	0.67	5.00	69.30	2.22	54.00	0.80	0.93
Tucannon	36.6	CBW05583-248063	9/3/2013	2013	Treatment	Upper	15	No	1.10	1.19	0.48	33.56	14.08	5.40	16.10	0.10	3.22	0.36	0.77	6.50	66.96	6.73	53.00	0.27	0.93

									Channel Form & Function					Channel Structure/ Instream Complexity					Floodplain	Riparian		Substrate			
Stream	RM	CHaMP Site ID	Sample Date	Visit Year	Type	Location	Project Area	Restored	Sinuosity	Gradient	Thalweg Depth (m)	WD	BFW	Channel Units/ 100m	LWD/ 100m	Key LWD/ BFW	Pool/ 100 m	Deep Pools/ 100 m	Confinement Ratio	Big Tree Cover	Solar Access	Embed	D50	Fines < 2mm	Fines < 6 mm
Tucannon	36.6	CBW05583-248063	7/22/2014	2014	Treatment	Upper	15	No	1.09	1.25	0.47	33.76	19.26	5.72	14.11	0.25	2.82	0.36	0.57	9.00	74.51	0.68	82.00	3.31	4.69
Tucannon	37.4	CBW05583-276351	8/21/2012	2012	Control	Upper	14	No	1.38	0.98	0.57	29.92	16.47	5.85	54.82	0.95	2.59	1.17	0.71	2.00	75.46	1.67	50.00	4.00	5.41
Tucannon	37.4	CBW05583-276351	8/15/2013	2013	Control	Upper	14	No	1.40	0.97	0.57	27.48	13.45	5.86	38.20	0.50	2.23	0.78	0.77	1.00	68.54	6.62	35.00	1.71	2.86
Tucannon	37.4	CBW05583-276351	7/18/2014	2014	Control	Upper	14	No	1.41	1.00	0.50	30.49	13.33	4.96	22.14	0.45	3.00	0.76	0.74	0.50	68.02	4.08	58.00	0.27	0.80
Cummings	37.9	CBW05583-182527	9/28/2011	2011	Tributary	Tributary	NA	No	1.39	3.30	0.20	15.58	4.73	9.83	134.50	0.60	1.63		0.72	5.50	39.21		15.00	21.33	30.33
Cummings	37.9	CBW05583-182527	9/17/2012	2012	Tributary	Tributary	NA	No	1.45	3.25	0.25	15.80	6.34	18.12	203.98	0.25	6.35		0.54	1.50	67.29	8.40	28.00	28.44	31.05
Cummings	37.9	CBW05583-329599	7/22/2012	2012	Tributary	Tributary	NA	No	1.10	3.26	0.20	17.24	4.62	11.11	60.79	0.35	5.53		0.71	2.30	69.66	4.08	39.00	6.56	16.11
Cummings	37.9	CBW05583-182527	9/23/2013	2013	Tributary	Tributary	NA	No	1.48	3.21	0.23	19.12	5.78	17.88	94.16	0.25	8.78		0.69	1.00	65.77	11.09	43.00	29.08	32.17
Cummings	37.9	CBW05583-141567	8/27/2013	2013	Tributary	Tributary	NA	No	1.20	2.63	0.20	18.32	4.55	10.22	12.47	0.00	3.90		0.81	0.00	66.00	7.69	71.00	3.12	4.67
Tucannon	38.3	CBW05583-010495	8/31/2012	2012	Treatment	Upper	14	No	1.25	1.13	0.51	28.51	17.09	5.42	19.62	0.50	1.64	1.25	0.59	0.00	75.54	1.00	74.00	1.90	3.24
Tucannon	38.3	CBW05583-010495	8/4/2013	2013	Treatment	Upper	14	No	1.25	1.13	0.54	28.67	11.83	5.45	16.66	0.35	2.92	1.26	0.83	1.30	69.33	2.50	70.00	0.67	1.04
Tucannon	38.3	CBW05583-010495	7/6/2014	2014	Treatment	Upper	14	No	1.22	1.15	0.52	29.91	12.79	4.52	14.28	0.25	1.63		0.79	0.50	81.35	3.06	71.00	2.41	3.85
Tucannon	39.2	CBW05583-460671	8/8/2011	2011	Control	Upper	13	No	1.07	1.28	0.40	38.37	15.11	2.49	6.24	0.25	0.00		0.91	10.00	51.14		40.00		
Tucannon	39.2	CBW05583-460671	8/15/2012	2012	Control	Upper	13	No	1.07	1.26	0.39	31.20	16.18	2.52	11.64	0.30	0.51		0.84	20.10	69.20	1.09	60.00	3.20	6.00
Tucannon	39.2	CBW05583-460671	8/28/2013	2013	Control	Upper	13	No	1.08	1.24	0.40	34.61	15.28	2.80	7.33	0.15	1.26		0.89	6.50	59.84	5.58	53.00	5.83	8.83
Tucannon	39.6	CBW05583-100223	8/19/2012	2012	Control	Upper	13	No								0.20				9.50	71.53	1.49	67.00	2.93	8.27
Tucannon	40.1	CBW05583-427903	8/31/2011	2011	Control	Upper	12	No	1.11	1.24	0.44	17.22	9.16	4.30	8.18	0.10	1.92	0.48	0.78	1.00	62.02		71.00	0.50	0.50
Tucannon	40.1	CBW05583-427903	8/3/2012	2012	Control	Upper	12	No	1.10	1.06	0.43	24.21	9.19	5.54	16.19	0.20	3.24		0.79	4.00	76.86	0.97	58.00	3.43	6.34
Tucannon	40.1	CBW05583-427903	9/1/2013	2013	Control	Upper	12	No	1.10	1.05	0.38	23.26	10.89	5.24	21.52	0.30	1.87		0.73	4.50	57.12	5.84	45.00	0.13	0.40
Tucannon	40.1	CBW05583-427903	8/30/2014	2014	Control	Upper	12	No	1.17	1.23	0.35	23.30	13.20	12.42	44.11	0.75	6.17		0.66	2.00	68.10	1.61	62.00	2.94	5.81
Tucannon	41.4	CBW05583-018303	8/1/2012	2012	Treatment	Upper	11	No	1.09	1.13	0.45	32.55	11.82	3.44	32.43	1.25	1.56	0.31	0.90	0.70	85.17	1.21	90.00	1.33	3.62
Tucannon	41.8	CBW05583-038783	10/1/2011	2011	Control	Upper	11	No	1.44	1.32	0.49	28.00	14.91	6.48	23.69	0.35	2.55	1.08	0.81	0.10	81.48		72.00	0.56	1.33
Tucannon	41.8	CBW05583-038783	8/4/2014	2014	Control	Upper	11	No	1.40	1.43	0.51	27.77	14.10	5.29	15.18	0.55	3.45	0.71	0.69	0.00	76.40	0.87	71.00	1.54	2.67
Tucannon	43.2	CBW05583-169855	8/7/2011	2011	Treatment	Upper	10	Yes	1.31	1.04	0.52	19.47	11.02	3.58	10.05	0.30	0.80		0.75	9.00	68.05		73.00	0.00	2.00
Tucannon	43.2	CBW05583-169855	8/17/2012	2012	Treatment	Upper	10	Yes	1.31	1.02	0.52	25.26	11.58	3.44	13.19	0.15	1.88	0.38	0.77	4.80	70.77	0.49	78.00	0.54	2.42
Tucannon	43.2	CBW05583-169855	8/30/2013	2013	Treatment	Upper	10	Yes	1.28	1.08	0.52	23.18	11.60	5.58	40.68	0.65	2.71	0.40	0.66	10.00	64.44	2.04	86.00	1.20	2.67
Tucannon	43.2	CBW05583-169855	8/28/2014	2014	Treatment	Upper	10	Yes	1.27	1.10	0.49	20.52	11.69	5.16	44.73	1.35	2.33	1.19	0.76	6.50	78.58	0.14	71.00	1.55	3.55
Tucannon	45	CBW05583-345983	9/12/2012	2012	Control	Upper	7	No	1.03	1.28	0.44	23.09	12.36	3.16	37.07	1.10	0.35		0.90	2.60	67.19	1.72	75.00	1.50	3.17
Tucannon	46.5	CBW05583-214911	8/5/2012	2012	Control	Upper	4	No	1.12	1.29	0.46	30.53	13.79	6.34	18.48	0.20	1.93	0.28	0.84	11.20	56.81	1.75	72.00	4.31	8.23
Tucannon	47.6	CBW05583-519039	9/1/2012	2012	Treatment	Upper	3	No	1.16	0.92	0.48	34.43	16.20	5.47	21.40	0.40	1.45	0.36	0.82	19.10	71.41	1.66	52.00	3.00	4.67
Tucannon	47.6	CBW05583-519039	7/31/2013	2013	Treatment	Upper	3	No	1.16	1.20	0.50	33.85	12.86	4.40	11.22	0.10	1.09		0.76	4.60	67.42	1.92	87.00	0.13	0.67
Tucannon	47.6	CBW05583-519039	6/23/2014	2014	Treatment	Upper	3	No	1.15	1.20	0.50	31.48	15.04	3.29	24.71	0.45	0.73	0.73	0.68	9.50	71.28	0.60	62.00	0.00	0.00
Tucannon	48.1	CBW05583-007039	9/26/2011	2011	Control	Upper	3	No	1.14	1.48	0.41	28.65	11.73	3.10	11.33	0.20	1.03	0.34	0.83	6.50	65.50		66.00	0.89	1.33
Tucannon	48.1	CBW05583-007039	9/13/2012	2012	Control	Upper	3	No	1.14	1.44	0.45	26.61	14.08	3.04	25.96	0.15	0.67	0.34	0.65	5.00	66.73	0.47	82.00	0.28	1.37
Tucannon	48.1	CBW05583-007039	8/2/2013	2013	Control	Upper	3	No	1.15	1.42	0.46	31.06	13.89	3.73	11.94	0.30	1.36	0.34	0.68	3.00	67.73	3.41	69.00	4.67	9.50
Tucannon	48.1	CBW05583-007039	7/31/2014	2014	Control	Upper	3	No	1.13	1.41	0.45	31.87	13.14	5.83	7.15	0.20	3.41	0.34	0.65	8.00	68.41	0.42	82.00	0.53	0.67
Little Tucannon	48.2	CBW05583-256895	8/3/2011	2011	Tributary	Tributary	NA	No	1.05	3.28	0.16	19.54	3.58	8.69	4.72	0.00	1.57		0.81	22.50	22.95		51.00	6.01	9.69
Little Tucannon	48.2	CBW05583-256895	7/21/2014	2014	Tributary	Tributary	NA	No	1.04	3.38	0.16	16.22	3.77	11.06	12.68	0.00	4.76		0.94	14.50	50.65	1.82	55.00	6.78	10.86
Tucannon	49	CBW05583-413951	9/1/2011	2011	Control	Upper	1	No	1.07	1.32	0.42	27.60	11.51	2.82	5.04	0.15	0.32	0.31	0.90	12.50	51.27		95.00	0.00	2.67
Tucannon	49	CBW05583-413951	8/2/2014	2014	Control	Upper	1	No	1.06	1.33	0.41	24.53	13.08	2.22	3.78	0.20	0.95	0.32	0.79	11.00	71.50	0.71	74.00	0.00	1.33
Panjab	50.7	CBW05583-310143	8/5/2011	2011	Tributary	Tributary	NA	No	1.13	2.32	0.29	21.70	7.13	8.66	29.24	0.05	0.68		0.58	3.70	44.88		48.00	3.33	6.67
Panjab	50.7	CBW05583-310143	8/7/2012	2012	Tributary	Tributary	NA	No	1.12	2.38	0.25	22.05	5.84	6.29	28.89	0.00	0.78		0.80	5.40	61.11	3.24	63.00	2.42	7.02
Panjab	50.7	CBW05583-310143	6/21/2013	2013	Tributary	Tributary	NA	No	1.18	2.30	0.25	21.84	5.85	11.98	54.26	0.05	7.08		0.72	4.50	53.09	4.84	39.00	2.30	4.44
Panjab	50.7	CBW05583-310143	9/2/2014	2014	Tributary	Tributary	NA	No								0.25				5.00	71.93	0.46	65.00	4.40	6.53
Panjab	51.2	CBW05583-047999	10/9/2013	2013	Tributary	Tributary	NA	No	1.08	2.33	0.26	23.04	7.59	10.70	42.41	0.00	4.12		0.71	11.00	50.89	1.28	70.00	0.12	0.24
Panjab	52	CBW05583-473983	7/19/2012	2012	Tributary	Tributary	NA	No	1.08	2.92	0.33	19.08	8.21	9.18	31.74	0.50	4.27		0.77	3.50	63.74	4.18	53.00	5.46	10.46
Sheep	54.5	CBW05583-428287	9/20/2011	2011	Tributary	Tributary	NA	No	1.15	7.53	0.23	17.40	8.61	9.95	53.02	0.15	1.49		0.57	7.60	35.06		54.00	19.44	22.92
Tucannon	57.7	CBW05583-168191	9/21/2011	2011	Control	Upper	NA	No								1.20				10.00	14.60		44.00	6.40	9.87
Tucannon	57.7	CBW05583-168191	9/12/2014	2014	Control	Upper	NA	No	1.18	2.19	0.29	28.84	11.26	7.73	72.52	1.05	3.85		0.65	7.50	64.94	0.00	43.00	6.13	9.47