INTEGRATED SPECIES RESTORATION PRIORITIZATION
TUCANNON RIVER

Prepared for

Columbia Conservation District

Snake River Salmon Recovery Board

Prepared by

Anchor QEA, LLC

1605 Cornwall Avenue

Bellingham, Washington 98225

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LIST OF ACRONYMS AND ABBREVIATIONS

Anchor QEA	Anchor QEA, LLC
CRB	Columbia River Basalt
EDT	Ecosystem Diagnosis and Treatment
ESA	Endangered Species Act
ESU	evolutionarily significant unit
ICTRT	Interior Columbia Technical Recovery Team
ISRP	Independent Scientific Review Panel
LiDAR	Light Detection and Ranging
LWD	Large woody debris
mi^2	square miles
MSA	major spawning area
MiSA	minor spawning area
NMFS	National Marine Fisheries Service
PA	Project area
RM	River mile
R/S	Return to smolt
SRSRB	Snake River Salmon Recovery Board
SRSRP	*Snake River Salmon Recovery Plan*
TSP	*Tucannon Subbasin Plan*
USFWS	U.S. Fish and Wildlife Service
VSP	Viable Salmonid Population
WDFW	Washington Department of Fish and Wildlife

1 INTRODUCTION

The Tucannon River is a tributary to the Snake River in southeast Washington (Figure 1). The river supports Endangered Species Act (ESA)-listed summer steelhead, spring Chinook salmon, fall Chinook salmon, and bull trout, which have all been identified as aquatic focal species of concern in the *Tucannon Subbasin Plan* (TSP) (CCD 2004). These species collectively utilize the entire length of the river at some stage of their lifecycles; at least one species is present throughout the Tucannon River channel throughout the year.

This report builds on previous studies and the integration framework encompasses the four aquatic focal species of concern into the prioritization framework. Previous prioritization efforts were focused exclusively on spring Chinook, and this effort prioritizes projects based on likely broader benefits to the four ESA species. The following summarizes the previous assessments leading up to this report.

Anchor QEA, LLC (Anchor QEA), has been retained by the Columbia Conservation District and the Snake River Salmon Recovery Board (SRSRB) to evaluate physical and biological conditions in the river and floodplain and to develop conceptual restoration plans throughout the Tucannon River. The previous studies included a basin-scale geomorphic study resulting in the delineation of 10 discrete reaches throughout 50 miles of the river (Anchor QEA 2011a; Figure 2). The geomorphic assessment was prepared to strengthen the technical understanding of existing physical conditions and geomorphic processes in the basin to identify and prioritize habitat restoration opportunities. The assessment included:

- Identification of the source, magnitude, and distribution of hydrologic and sediment inputs through the basin
- Analysis of floodplain connectivity
- Identification of passage barriers or infrastructure constraints
- Identification of stressors and features leading to habitat degradation
- Qualitative evaluation of restoration opportunities

Within each reach, potential restoration opportunities and concepts were identified and discussed. The results of that study were used to identify the first of three study areas to follow. The first study area was completed in 2011 for river miles (RM) 20 to 50, which further refined conceptual projects within the upper basin in Reaches 6 through 10 (Anchor

QEA 2011b). A second study identifies conceptual projects within the lower basin in Reach 5 (Anchor QEA 2012a), and a third study will identify concept-level projects in Reaches 3 and 4 (Anchor QEA 2012b). A memorandum completed in December 2011 addressed conceptual-level projects in Reach 2 (Anchor QEA 2011c).

Preliminary restoration opportunities identified in the geomorphic assessment were developed based on habitat-limiting factors identified in the TSP (CCD 2004) and *Snake River Salmon Recovery Plan* (SRSRP) (CCD 2004 and SRSRB 2006); salmonid life history and distribution through the river system; and site-specific physical, hydrologic, and geomorphic conditions. The restoration framework was loosely categorized based on the actions described in Figure 2 from Roni et al. (2002). Table 1-1 lists the initial restoration actions in the geomorphic assessment that correspond to the framework proposed by Roni.

Table 1-1
Restoration Framework

	Roni et al. (2002)	Tucannon Basin
1.	Protect and maintain natural processes	Promote natural hydrologic and sediment routing throughout the system; allow natural migration and wood recruitment.
2.	Connect isolated habitats	Reconnect floodplains, groundwater channels, wetlands, and former mainstem and side channels.
3.	Address roads, levees, and other human infrastructure-impairing processes	Remove or modify levees, dredge spoils, rock embankments, and grade control structures.
4.	Restore riparian processes	Protect healthy riparian areas. Eradicate invasive species and plant native communities to rehabilitate degraded riparian forests.
5.	Improve instream habitat conditions	Install large individual trees and large woody debris structures in the channel.

1.1 Purpose

The purpose of this document is to provide an overall basin prioritization for all of the project areas identified in Reaches 2 through 10, based on restoration potential and known adult and juvenile use in the basin. Conceptual projects were not identified for Reach 1 because it is the backwater area from the reservoir and local experts do not consider restoration actions in this reach to be fruitful. Conceptual project areas were delineated and evaluated based in part on:

- Findings in the Geomorphic Assessment (Anchor QEA 2011a)
- Field reconnaissance during the summer of 2011 and 2012 that characterized channel, floodplain, and riparian conditions
- Existing spawning and juvenile rearing data
- Input from the Tucannon Coordinating Committee (a committee comprised of technical representatives from local, state, federal, and tribal government agencies)

Based on the results of our evaluation, project areas were delineated into Tiers 1, 2, and 3, with Tier 1 projects being the highest priority for implementation. As a result of this prioritization, 30 percent designs will be developed for selected Tier 1 projects. During the current scope of work, the 2011 conceptual projects in Reaches 6 through 10 were evaluated in an effort to tier those projects relative to all projects within the basin. This approach will allow all projects to be grouped in a coordinated manner.

2 BASIN OVERVIEW

2.1 Basin Description

The Tucannon River basin is located in Columbia and Garfield counties in the southeast corner of Washington State (Figure 1). The main channel is approximately 58 miles long and drains approximately 503 square miles (mi^2) from its headwaters in the Blue Mountains and Umatilla National Forest to the mouth at the Snake River approximately 3 miles upstream of the Lower Monumental Dam (CCD 2004). Several major tributaries drain into the main channel; the largest (by basin area) is Pataha Creek, which enters the main channel at RM 12.3. Pataha Creek is approximately 52 miles long with a long, narrow watershed draining 185 mi^2. The second and third largest tributaries (by basin area) are Kellogg Creek (35 mi^2) and Willow Creek (30 mi^2).

A majority of the watershed downstream of Tumalum Creek (RM 35.5) is cultivated, primarily with grain crops. The valley floor is occupied primarily by livestock pastures and some cultivated crops downstream of the National Forest boundary at RM 41, except for a vegetated riparian buffer along the margins of the channel. The watershed upstream of Tumalum Creek is typically covered in evergreen forest, with scrub/shrub on the steeper, southwest-facing slopes. The valley floor is forested, with sparse undergrowth in the floodplain until upstream of Panjab Creek (RM 50.2), where tree and undergrowth density increases significantly. The riparian corridor typically contains interspersed evergreen and deciduous trees with dense undergrowth. Large forest fires in 2005 (School Fire), 2006 (Columbia Complex Fire), and 2009 (Hubbard Fire) impacted the upper basin, including portions of the floodplain and riparian corridor.

2.2 Geomorphic Context

2.2.1 Regional Geology

The Tucannon River watershed consists primarily of Miocene-aged Columbia River basalt (CRB) flows of the Grande Ronde, Wanapum, and Frenchman Springs members with recent Quaternary river alluvium along the valley floor. Basalt is exposed at the surface upstream of Tumalum Creek (RM 35.5) and along the valley walls and gullies down from Tumalum Creek to RM 18. Downstream of RM 18, including within the Pataha and Willow Creek subbasins, the basalt is overlain by loess deposits (fine sand and silt) of the Palouse Formation. In these areas, bedrock is typically exposed in gullies and along valley slopes. Bedrock sills are also occasionally present in the valley and river bottom of the lower basin downstream of approximately RM 28. The valley walls in much of the lower basin downstream of RM 18 are comprised of Quaternary flood outburst deposits consisting of stratified sand, gravel, and cobble; alluvial fan deposits; and bedrock. Alluvial fans line the valley floor at the mouths of tributaries throughout the study area; the fans tend to be large and wide in locations where tributaries drain loess-dominated subbasins (i.e., lower basin), and small and narrow in basins where mainly bedrock is exposed (upper basin). Significant ancient alluvial fan and hillslope deposits are present in many locations that constrict the overall valley and floodplain width.

2.2.2 Channel Patterns and Floodplain

Review of the historic aerial photographic record and traces of active channel positions through time revealed notable trends in channel form and behavior (Anchor QEA 2011a). Channel types include single-thread sections; braided, gravel bar-dominated sections; multi-threaded anastomosing sections, and anabranching sections, which have two or more diverging channels separated by significant lengths of vegetated floodplain. The character of channel movement, or migration, was identified as both relatively steady channel migration of a river bend through a gravel bar or floodplain, and channel avulsion where the river suddenly changes course, often through historic channels previously abandoned through a similar process.

2.2.3 Channel Confinement and Floodplain Connectivity

Confining features along the banks of the Tucannon River and within the floodplain influence hydraulic conditions during large floods, affecting local and reach-scale geomorphic processes, such as sediment mobility and channel migration. Confining features may be both natural and influenced by anthropogenic activities. However, the presence of anthropogenic features related to land use appears to be the primary factor related to adverse conditions created by channel confinement in the study area, particularly downstream of RM 47. Upstream of this point, natural features such as alluvial fans and overall valley width are more prominent and have a greater effect on channel confinement. Channel migration within the historic record also appears to be limited in portions of the channel in the lower basin that contain bedrock outcrops.

2.2.4 Large Woody Debris

Channel clearing and riparian timber harvesting in the Tucannon River basin have removed large woody debris (LWD) from the system and greatly reduced recruitment of additional LWD, especially large-diameter mature trees that form the core of stable log jams. Previously logged and cleared riparian areas have been regenerating for approximately the past 20 to 50 years in publicly owned and protected riparian forests. While these trees are fairly mature, many (particularly conifers in the upper watershed) may not be large enough to remain stable within the mainstem channel.

2.2.5 Future Channel Evolution

The Tucannon River is currently in the process of recovering from anthropogenic disturbance and re-establishing more natural conditions. The river has been slowly recovering from clearing and straightening of the channel, although many simplified portions of the channel remain because of confinement by infrastructure. In unconfined areas, the channel is attempting to recover via channel migration, recruitment of LWD, and deposition of LWD and sediment. Through time, additional channel migration will further extend the length of the channel network, increase floodplain connectivity, and reduce in-channel velocities. Introduction of maturing riparian trees and LWD material will lead to the formation of log jams, which promote sediment deposition in the lee of the structures. Log jams also promote split flow and side channel development, leading to hydraulic conditions that often provide preferred habitat for juvenile salmonids, and distribute sediment load and organic debris across the floodplain. In addition, split flows and side channels reduce the hydraulic energy of the mainstem, increasing the ability for the channel to retain LWD and sediment.

In this manner, the recovery of the system is a feedback loop where channel migration leads to LWD deposition on bars and shallow areas, which leads to log jams and split flow conditions, which reduces hydraulic energy in the channel, leading to additional deposition of LWD and sediment, and the feedback loop continues. The result of this process is an overall widening of the active channel and better hydraulic connectivity between the river, side channels, and floodplain. The projects identified in this plan are developed to help achieve these desired conditions over time as natural processes are restored in selected areas.

Protection is identified in areas with recovering natural processes that are currently creating or leading to desirable habitat conditions.

2.3 Fish Timing and Distribution

The Tucannon River supports four ESA-listed Snake River Basin salmonid populations throughout all or a portion of their life stages. Summer steelhead, spring Chinook salmon, fall Chinook salmon, and bull trout were identified in the TSP as aquatic focal species (CCD 2004). Collectively, these species use the main channel from the mouth to the headwaters as well as major tributaries, including Pataha Creek. The following information is summarized from the TSP (CCD 2004) and the SRSRP (SRSRB 2006) and was revised to include new information from recent data being collected by the Washington State Department of Fish and Wildlife (WDFW) and others in the basin (SRSRB 2011a; Gallinat and Ross 2010).

Table 2-1 shows the spatial distribution of steelhead and Chinook salmon in the mainstem of the Tucannon River, with darker shades of gray indicating higher densities of fish present during their respective life stages. Information on bull trout was not sufficient to provide detailed distribution data as reported for the other focal species.

2.3.1 Steelhead Trout

Steelhead trout in the Tucannon River are part of the Snake River Basin steelhead evolutionarily significant unit (ESU) that was listed as threatened in 1997. Summer steelhead trout enter the Tucannon River in September and begin spawning in late February/early March until mid-May. Spawning occurs in the mainstem from Kellogg Creek (RM 4.8) upstream to the Tucannon River headwaters and within Cummings Creek and the lower portions Panjab and Sheep creeks. The greatest concentration of steelhead spawning is typically found in the mainstem between Tucannon Falls (RM 15.3) and Beaver Lake at approximately RM 42. Juveniles also rear throughout the mainstem but are typically found in the greatest numbers between approximately RM 18 and School Canyon (approximately RM 45).

Table 2-1
Distribution of Steelhead, Chinook Salmon, and Bull Trout in the Mainstem Tucannon River

			Summer Steelhead			Spring Chinook			Fall Chinook			Bull Trout		
Geographic Area	**From (RM)**	**To (RM)**	**Spawning**	**Juvenile Rearing**	**Adult Holding**	**Spawning**	**Juvenile Rearing**	**Adult Holding**	**Spawning**	**Juvenile Rearing**	**Adult Holding**	**Spawning**	**Juvenile Rearing**	**Adult Holding**
Mouth	0	0.7												
Lower Tucannon	0.7	4.8												
	4.8	5.5												
	5.5	8.7												
	8.7	12.3												
Pataha-Marengo	12.3	16.5												
	16.5	18.6												
	18.6	22.8												
	22.8	26.6												
Marengo-Tumalum	26.6	35.6												
Tumalum-Hatchery	35.6	37.8												
	37.8	41.9												
Hatchery-Little Tucannon	41.9	44.6												
	44.6	45.6												
	45.6	48.1												
Mountain	48.1	50.2												
	50.2	55												

Notes:
1. Distribution data are summarized from CCD (2004) and updated based on recent data collected in the basin by WDFW, SRSRB, and others (SRSRB 2011b, email communication). Geographic areas and river mile sections correspond to Ecosystem Diagnosis and Treatment (EDT) analysis reaches used during subbasin planning.
2. Darker shades of gray indicate higher densities of fish present during their respective life stages.
3. Juvenile data presented represent summer rearing distribution.

2.3.2 Spring Chinook Salmon

Spring Chinook salmon in the Tucannon River are of the Snake River spring/summer Chinook salmon ESU that was listed as threatened by the ESA in 1992. Spring Chinook salmon enter the Tucannon River as early as late April and as late as mid-September; spawning occurs from mid-August to the end of September. Spawning occurs almost exclusively in the main channel from approximately King Grade (RM 22.9) to the mouth of Sheep Creek near RM 55 (Gallinat and Ross 2012); the greatest densities are between Marengo and the Little Tucannon River (approximately RM 48.1). Juveniles rear from approximately Tucannon Falls (RM 15.3) to the headwaters, with the highest densities located between Marengo and School Canyon (approximately RM 45).

2.3.3 Fall Chinook Salmon

Fall Chinook salmon are part of the Snake River fall Chinook salmon ESU that was listed as threatened in 1992. Fall Chinook salmon enter the lower Tucannon River beginning in early October and have a brief holding period until spawning begins in mid-October. Fall Chinook salmon use the main channel of the river from the mouth to upstream of Pataha Creek (RM 12.3), with the highest concentration of spawning occurring from the mouth to around the Starbuck Dam near RM 5.5. Juvenile fall Chinook salmon do not overwinter in the Tucannon River and out-migrate shortly after emergence during the late winter to early summer.

2.3.4 Bull Trout

Bull trout in the Columbia Basin were listed as threatened by the ESA in 1998. The Tucannon River bull trout population is part of the Lower Snake River Critical Habitat Unit (USFWS 2010). Bull trout life histories present in the Tucannon River include resident, fluvial, and adfluvial forms. Migratory bull trout move upstream from the Snake River into the upper Tucannon River in the spring and early summer. Critical habitat in the Tucannon Critical Habitat Subunit, as designated by the U.S. Fish and Wildlife Service (USFWS), includes the mainstem Tucannon River, Cummings Creek, Hixon Creek, the Little Tucannon River, Panjab Creek, Cold Creek, Sheep Creek, and Bear Creek (USFWS 2010). Juvenile rearing occurs upstream of Tumalum Creek to the headwaters. The lower Tucannon River is an important migratory corridor to spawning and rearing areas upstream in the watershed, including headwaters and tributary streams.

Historically, the bull trout population in the Tucannon River has been considered healthy; however, recent data suggest some population declines (USFWS 2010). As cited by USFWS, WDFW surveys indicate that the number of redds in the upper Tucannon River have dropped from more than 100 in 2002 and 2003 to less than 20 in 2007. This decrease correlates with a decline in the number of adult migratory bull trout captured at the Tucannon Hatchery Trap as they were moving upstream.

3 HABITAT RESTORATION GOALS AND OBJECTIVES

The restoration objective for the Tucannon River is to improve habitat conditions for ESA-listed species for all life history stages within the river. Improving habitat conditions will lead to an increase in the abundance of listed species returning to the river. Increasing abundance will lead to delisting of the species, which is the overall recovery goal for the system.

Throughout this section, spring Chinook are used as an example species to help clarify the discussion and to provide examples for the types of data collected and evaluated in the basin. These data are also being evaluated for the other ESA species included in the prioritization framework.

3.1 Limiting Factors

An Ecosystem Diagnosis and Treatment (EDT) analysis was performed that assessed habitat conditions in the Tucannon River for aquatic focal species (Appendix B in CDD 2004). This analysis allowed watershed planners and stakeholders to identify the primary limiting factors to aquatic focal species in discrete reaches throughout the river. These results are summarized in the SRSRP for summer steelhead and spring Chinook salmon (Tables 3-1 and 3-2); the SRSRP also provides priority habitat objectives for the Upper Tucannon River major spawning area (MSA). The Lower Tucannon River is a minor spawning area (MiSA) and was not considered for active restoration in the 2006 SRSRP; however, the lower Tucannon River is now considered a priority for restoration actions and the status was changed to a priority restoration reach beginning in 2010 (SRSRB 2011a).

Table 3-1

Factors Limiting the Viability of the Tucannon River Steelhead Population

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Tucannon R, Pataha Cr to Marengo	Medium	High	Low		Low		Low		Low		Low		Low		Low	Medium		Medium
Tucannon R, Tumalum Cr to Panjab Cr	High	High	Low		Low		Low		Low	Low	Low		Low			Low		High
Pataha Cr, mouth to Pomeroy		Medium	Medium				Medium	Low	Medium		High				High	Low		Medium
Tucannon R, Marengo to Tumalum	Medium	Medium	Low		Low		Low		Low				Low		Low	Medium		Medium
Cummings Cr	Low	Low			Low		Low		Low									Medium
Tucannon R, mouth to end of backwater		Low	Low		Low		Low		Low				Medium	Medium	High	Medium		Medium
Panjab Cr	Low	Low	Low				Low		Low									Medium
Pataha Cr, Pomeroy to headwaters		Low	Low		Low		Medium		Medium		High				High			Medium
Tucannon R, Panjab Cr to headwaters	Medium	Low	Low						Low									Low
Tucannon R, end of backwater to Pataha Cr		Low	Low		Low		Low		Low				Low	Low	Medium	Low		Medium
Tumalum drainage		Low	Medium		Low		Low		Low					Low	Low			Medium
Bihmaier Gulch Cr			Low						Low		High				Low			High
Dry Pataha Cr			Medium				Medium		Medium		High				Medium			Medium
Hixon Cr			Low		Low		Low			Low					Low			Medium
Iron Springs Cr			Medium				Low		Medium						Medium			Medium
Kellog Cr			Medium		Low		Medium		Medium				Low	Low	High	Medium		Medium
Little Tucannon River drainage			Medium		Low		Low		Medium									Medium
Pataha above Dry Pataha			Medium				Medium		Medium	Low	Medium				High			Medium
Smith Hollow Cr			Medium		Medium		Medium	Low	Medium				Low	Low	High	Medium		Medium

Key to strategic priority (corresponding Benefit Category letter also shown)

A	B	C	D & E
High	Medium	Low	Indirect or General

Note:
Table taken from SRSRB 2006

Table 3-2
Factors Limiting the Viability of Tucannon River Spring Chinook

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Tucannon R, Pataha Cr to Marengo	High	High	Low				Low	Low	Medium						Low	Medium		Medium
Tucannon R, mouth to Starbucks Dam		Medium	Low				Low	Low	Low	Low			Low	Low	High	High		Medium
Pataha above Pomeroy		Medium	Low				Medium	Low	High	Low	Medium				High			Medium
Pataha below Pomeroy		Medium	Low				Medium	Low	High	Low	Medium				High	Medium		Medium
Tucannon R, Starbucks Dam to Pataha Cr		Medium	Low				Low	Low	Medium						Medium	High		Medium
Tucannon R, Marengo to Tumalum	Low	Medium	Low		Low		Low	Low	Medium	Low			Low		Low	Medium		Medium
Tucannon R, Tumalum Cr to Panjab Cr	Medium	Medium	Low				Low	Low	Medium	Low						Low		High
Pataha above Dry Pataha		Low	Low				Medium	Low	High	Low	Medium			Low	High			Medium
Tucannon above Panjab		Low							Medium	Low								Medium
Panjab drainage			Low		Low		Low		Medium	Low					Low			Medium

Key to strategic priority (corresponding Benefit Category letter also shown)

A High; B Medium; C Low; D & E Indirect or General

Note:
Table taken from SRSRB 2006

3.2 Viable Salmonid Population

To inform habitat restoration actions, spring Chinook in Reach 5 were identified as a species to focus on with the expectation that restoration actions targeted at improving habitat conditions for spring Chinook life stages will also improve conditions for steelhead and other species important to the Tucannon River. Another approach to evaluate the health of Tucannon River spring Chinook is to consider how the population is performing compared to the National Marine Fisheries Service (NMFS) standard of a Viable Salmon Population (VSP), a population biology concept. According to the NMFS, a viable salmonid population is an "independent population of any Pacific salmonid (genus *Oncorhynchus*) that has a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year time frame" (McElhany et al. 2000). McElhany et al. (2000) identified four key population characteristic or parameters for evaluating population viability status:

- Abundance
- Population growth rate or entire lifecycle productivity

- Population spatial structure
- Diversity

The following sections present a brief introduction to each of the VSP parameters and how these apply to the Tucannon River habitat conditions and future restoration planning.

It must be emphasized that any change in risk associated with these population parameters is affected by a myriad of factors (including in-basin factors, conditions in the Snake and Columbia rivers, and ocean conditions), and consequently is a long-term proposition. Many of these factors (e.g., ocean conditions and marine survival rates) are largely outside of human control. Moreover, changes expected from the types of actions considered in this report are most likely to occur on a generational scale; the likelihood is low that there would be detectable changes in the near future. Also, there is uncertainty associated with the Tucannon River supplemental hatchery program that may affect the spring Chinook salmon population in ways that may not be well understood.

3.2.1 Abundance

Population size is perhaps the most straightforward measure of the VSP parameters and is an important consideration in estimating extinction risk. All other factors being equal, a population at low abundance is intrinsically at greater risk of extinction than is a larger one. The primary drivers of this increased risk are the many processes that regulate population dynamics, particularly those that operate differently on a relatively small population, such as Tucannon River spring Chinook. Examples include environmental variation and catastrophes, demographic stochasticity (intrinsic random variability in population size), selected genetic processes (e.g., inbreeding depression), and deterministic density effects. Although the negative interaction between abundance and productivity may protect some small populations, there is obviously a point below which a population is unlikely to persist (McElhany et al. 2000).

Tucannon River spring Chinook populations spawn almost exclusively in the mainstem Tucannon River with spawning occurring from just above the mouth of Sheep Creek (RM 52) downstream to King Grade (RM 21). Average annual spawning for the past decade (2000 to 2010) is 200 redds, with 53 percent of these being natural spawners and 47 percent hatchery-origin fish (Appendix B in SRSRB).

Between 1986 and 2010, the annual returns of natural-origin spring Chinook to the Tucannon River ranged from 0 to 1,500 adults; the high of approximately 1,500 returning adults occurred in 2010 and the low of 0 returning natural-origin spawners occurred in 1995 and 1999 (Chart 1: Gallinat and Ross 2011). The 10-year geometric mean abundance has varied between approximately 100 and 400 returning adults. The Interior Columbia Technical Recovery Team (ICTRT) estimated that the minimum abundance threshold of returning adults is 750 and the current average is 371 (SRSRB 2011c).

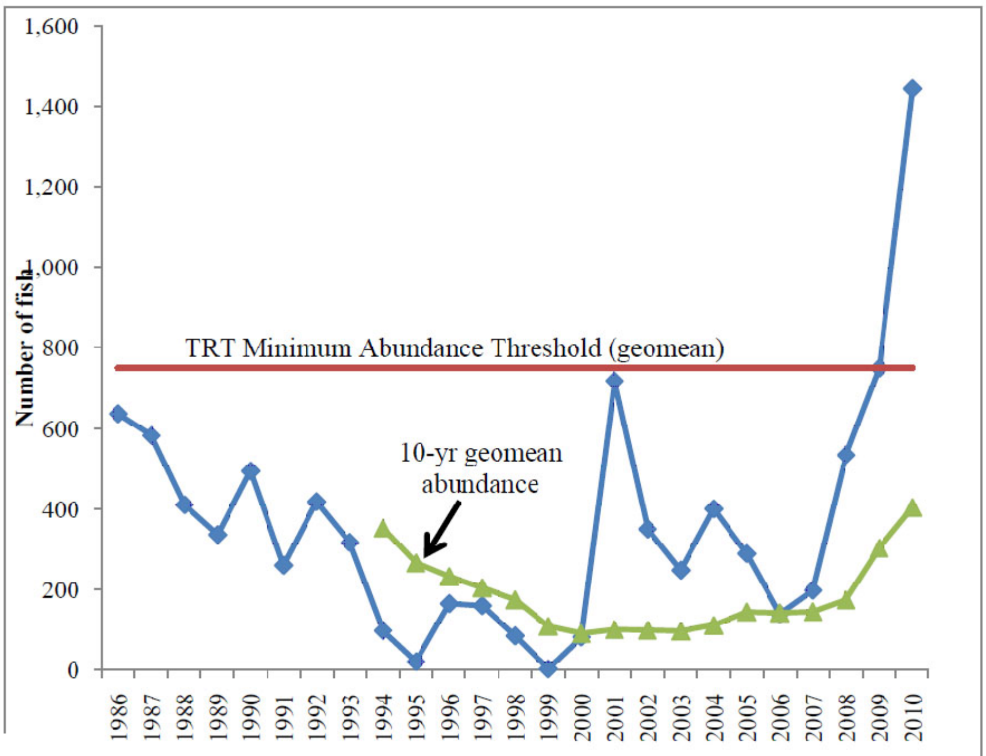


Chart 1

Estimated Abundance of Tucannon River Natural-origin Spring/Summer Chinook Salmon Adults and 10-year Geomean between 1986 and 2010 (Gallinat and Ross 2011)

3.2.2 Lifecycle Productivity

Population growth rate (λ) or productivity over the entire lifecycle is a key measure of population performance in a species' habitat. In simple terms, it describes the degree to which a population is replacing itself. A population growth rate of 1 ($\lambda = 1.0$) means that a population is exactly replacing itself (one spawner produces one spawner in the next generation), whereas a $\lambda = 0.71$ (the λ value determined in the Tucannon River for spring Chinook) means that the population is declining at a rate of 29 percent annually—a trend that is obviously not sustainable in the long term (Chart 2). This return to smolt (R/S) value does not account for the nearly 25 percent of returning adults that bypass the Tucannon River upon return, based on PIT-tag detections, and ascend the Snake River without returning back to the Tucannon River. Nevertheless, recruits per spawner are often less than 1 and documented R/S is nearly always less than 1 for spring Chinook (SRSRB 2011c). The Technical Review Team estimated that an R/S of 1.8 is needed for an extinction risk of less than 5 percent and an R/S of 2.1 is needed for an extinction risk of less than 1 percent (highly viable criteria) (SRSRB 2011c).

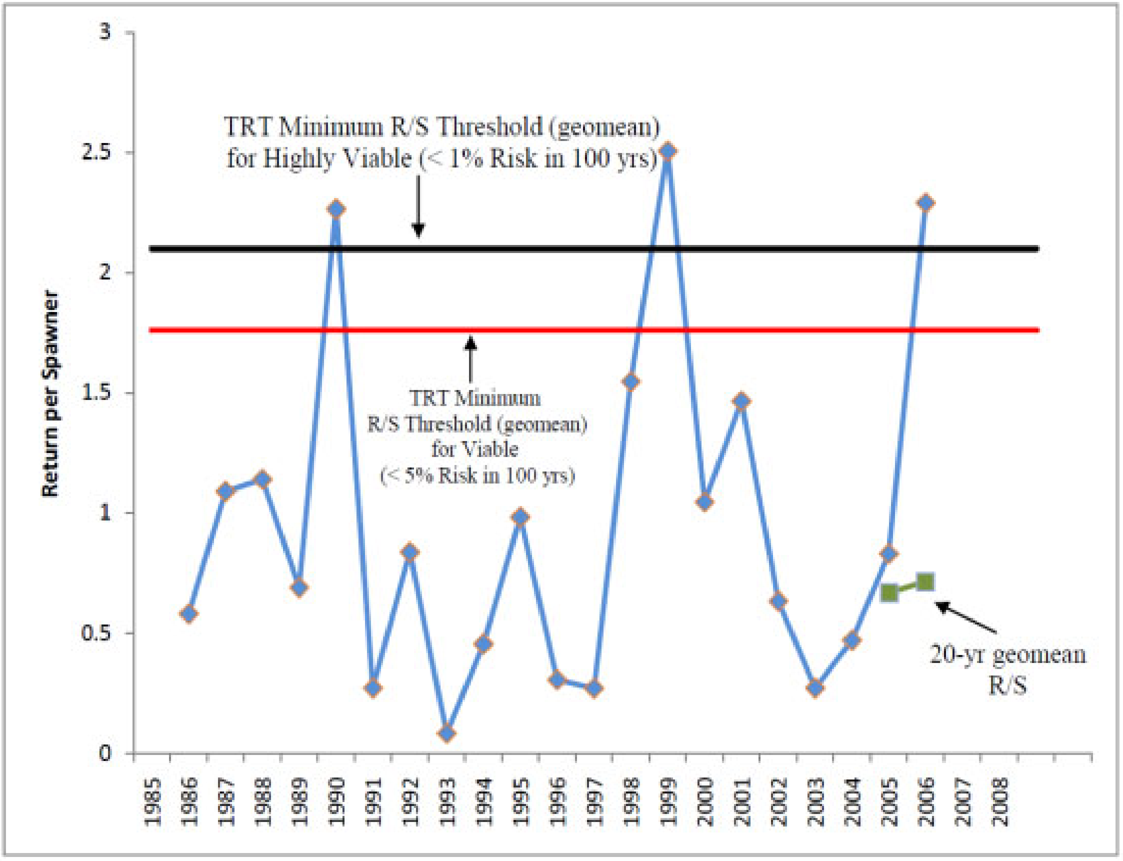


Chart 2

Estimated Productivity of Natural-origin Spring/Summer Chinook Salmon Adults and 20-year Geomean from the Tucannon River

Notes:
1986 to 2003 data from NOAA salmon population summary SPS database:
https://www.webapps.nwfsc.noaa.gov/apex/f?p=238:home:0
2003 to 2005 data from Gallinat and Ross (2010)

The causes for the low R/S are not precisely known and likely include multiple factors that are difficult to quantify, such as potential effects from habitat conditions and habitat capacity (WDFW 2011). Hatchery supplementation, the Columbia and Snake rivers, and ocean conditions are also factors of the R/S value.

3.2.3 Spatial Structure

Spatial structure, as the term suggests, refers to the geographic distribution of individuals in a population unit and the processes that generate that distribution. Distributed populations that interact genetically are often referred to as a metapopulation. Although the spatial distribution of a population, and thus its metapopulation structure, is influenced by many factors, none are perhaps as important as the quantity, quality, and distribution of habitat. One way to think about the importance or value of a broad geospatial distribution is to consider that in the presence of such a distribution, a population is less likely to go extinct from a localized catastrophic event or localized environmental perturbations (McElhany et al. 2000).

Spatial distribution (of spawning and summer rearing) of spring Chinook in the Tucannon River is primarily restricted to the area upstream of Marengo (RM 25) to the headwaters, yet historically it is presumed that spring Chinook spawned and reared at least down to Pataha Creek, near RM 12.5 (Gallinat and Ross 2011). The spring Chinook salmon spawning and rearing distribution is reported in the SRSRP, which is currently being updated.

Table 3-3
Spring/Summer Chinook Redd Distribution in the Tucannon River

Section	River km (Rkm)	River mile (RM)	Percent of Total Redds	Average Redds	Redds per Rkm	Redds per RM
Mouth to Marengo (Lower)	0-20.1	0-13.6	0	0	0.0	0.0
Marengo	20.1-39.9	13.6-26.9	1	2.1	0.1	0.2
Hartsock	39.9-55.5	26.9-37.5	20	33.0	1.7	2.5
HMA	55.5-74.5	37.5-50.3	66	108.3	5.7	8.5
Wilderness	74.5-86.3	50.3-58.3	13	20.7	1.8	2.6

Note:
1985 to 2011 data from Gallinat and Ross (2012). Rkm and RM differ slightly; RM shown were developed for the current scope of work and have been compared to Rkm primarily based on landmarks (bridges, property boundaries) for consistency.

Per Table 3-3, it is noteworthy that approximately 88 percent of the spring Chinook spawning documented over the past 24 years occurs between RM 22.8 (King Grade) and

RM 48.1 (near Cow Camp Bridge), recognizing that spawning near the headwaters may have occurred historically at a higher density than is currently occurring (WDFW 2011).

3.2.4 Life History Diversity

Biological diversity within and among populations of salmon is generally considered important for three reasons (McElhany et al. 2000):

- Diversity of life histories patterns is associated with a use of a wider array of habitats
- Diversity protects a species against short-term spatial and temporal changes in the environment
- Genetic diversity is the so-called raw material for adapting to long-term environmental change

The latter two reasons are often described as nature's way of hedging its bets—a mechanism for dealing with the inevitable fluctuations in environmental conditions—in the long and short terms. With respect to diversity, more is better to minimize the risk of extinction.

Current life-history diversity of Tucannon River spring Chinook is presumed to reflect historic life-history diversity, with the majority of juveniles emerging from the gravel in spring, rearing for one summer and one winter, and then out-migrating as 1-year-old smolts in the spring. Of interest is the apparent lack of winter rearing habitat and channel complexity (e.g., side channels, back water, and pools) that support juvenile fish. Existing data demonstrate that the largest mortality occurs between egg and smolt, with the majority of the mortality occurring between egg and parr; it is alarming that, from brood year 1983 to brood year 2003, on average less than 6 percent of spring Chinook survived from egg to smolt (Gallinat and Ross 2010).

3.3 Restoration Expectations Related to Viable Salmonid Population Goals

3.3.1 Abundance

Population abundance is a key parameter used to assess the status of a stock and evaluate trends in stock improvement or decline. Abundance is also useful in identifying critical population dynamics that can be used to identify success in restoring a stock or levels at which extinction risk is high and the level of attention given to restoration be increased.

Collectively proposed restoration actions in the Tucannon River are intended to improve abundance holistically; hence, no restoration action proposed in this report is targeting abundance specifically.

3.3.2 Lifecycle Productivity

As presented and referenced in this document, previous studies have identified degraded habitat conditions and juvenile carrying capacity as primary causes for the low R/S ratio currently observed in the Tucannon River. Therefore, proposed restoration actions are highly focused on addressing limitations to productivity. The largest mortality occurs between egg and smolt, with the majority of the mortality occurring between egg and parr (SRSRB 2006). In addition, WDFW data indicate that smolt production generally increases with an increase in adult returns in the basin, although a carrying capacity issue may exist above approximately 200 female spawners (Gallinat and Ross 2010). Spawning and incubation for spring Chinook begins in August and continues through March, with fry developing to parr through June. This timeline represents a large range in hydrologic conditions and habitats used by Chinook; prioritizing specific time periods and associated habitats is necessary to target critical lifecycle periods affecting productivity (ISRP 2011a).

The life stage between egg and parr coincides with late summer low flow, winter storm flows, and the spring runoff period. Summer low flows are unpredictable, and other efforts in the basin are focused on improving water quality and quantity. Winter storm events are stochastic and vary greatly in the effect that they may have on growth and productivity. For example, several consecutive years of minor peak flows, where impacts to fish are also minor, may occur between larger, less frequent flood events that have the ability to scour redds, resulting in significant losses to the run. Spring runoff flows occur each year and are relatively predictable in their magnitude and their effect on the habitat types required by juvenile salmonids; these habitats are currently lacking in the system. Data from smolt trapping in the lower river indicate that parr are arriving in the lower basin throughout the spring runoff period, long before their genetic signal should be initiating movement downstream (WDFW 2011). It is speculated that this may be occurring either because they are being flushed downstream and are not able to find suitable refuge habitat or because juvenile fish are actively seeking out habitats in the lower river because of the lack of refuge areas (carrying capacity) in the preferred rearing areas upstream.

Based on high egg-to-parr mortality and uncertainty related to much of the hydrologic cycle during the egg-to-parr timeline, improving habitat conditions for juveniles during the spring runoff period was determined to be of high priority and to provide the greatest certainty of success with respect to improving growth and productivity for the ESA species collectively. Therefore, restoration actions that will provide hydraulic complexity; will improve or create side channels, alcoves, or hydraulic refuge and cover; or will improve low-lying floodplain connectivity will be considered to have high biological benefit when developing conceptual projects.

Installing necessary instream structure to provide adequate cover and complexity, while designing within the basin and reach-scale geomorphic context, will be critical to achieving both an immediate biological benefit and long-term restoration success. Hydraulic complexity and off-channel habitat projects will provide hydraulic refuge and rearing habitat for juvenile salmonids during moderate to high flows and will also provide more desirable habitat during lower flow conditions. LWD placements will provide refuge and cover and will be used to initiate a geomorphic response in many locations where natural channel development and floodplain connectivity can be achieved. Levee and riprap removal will remove stressors in the system, allowing for more natural geomorphic processes and promoting habitat recovery. See Appendix A for more details on specific restoration actions proposed for the Tucannon River.

Collectively, these improvements can re-establish natural "processes of material and energy transfer across the watershed that enables the formation and maintenance of productive habitat," identified by the Independent Scientific Review Panel (ISRP) for the Tucannon River (ISRP 2011b). It is expected that these improvements will promote the re-establishment of natural processes, which will increase habitat diversity and total rearing area available for juveniles and will improve their survival and productivity. The habitat improvements should also increase spawning and emergence conditions over time through improved energy dissipation from increases in channel complexity, improved temperature conditions, and improved distribution of nutrients and fine sediment across the floodplain.

3.3.3 Spatial Structure

Improving the population spatial structure relates to improving habitat conditions throughout the river corridor such that habitat needs are met across the various life stages and hydrologic regimes, and the health of the population is not jeopardized by local environmental effects. The restoration approach for the Tucannon River does not focus exclusively on one reach or segment of the study area, but values both areas of the river currently experiencing high fish use, as well as areas with high restoration potential should a "full build out" of restoration opportunity be realized. This approach is further described below and in Section 4 of this report.

In general terms, the restoration strategy for the Tucannon River is a holistic basin-scale approach that values both immediate and long-term biological benefits. Implementation of restoration projects will likely occur in high-use areas early to maximize growth and productivity in areas of current use. In addition, projects with high benefit and low cost will be highly recommended regardless of location to maximize the growth and productivity of the segment of the population currently using those areas. Projects implemented on the fringes of the current high-use areas will expand the linear extent of high-quality habitat throughout the river corridor, increasing the distribution and carrying capacity for fish using those areas. Projects removing stressors on habitat will allow for natural recovery of the system and better habitat continuity through the river in the long term.

This restoration strategy will improve the spatial distribution of the stock by improving existing high-use areas, implementing high-benefit/low-cost projects in non-high-use areas, expanding the size of high-use areas by implementing projects on the fringes of those areas, and removing stressors affecting natural processes for long-term improvement of quality habitat throughout the river corridor production; and improve the spatial distribution of the stock.

3.3.4 Life History Diversity

None of the proposed restoration actions will specifically target improving life history diversity within the target species.

4 REACH PRIORITIZATION

4.1.1 Reach Priority

Reaches were prioritized using a variety of biologic and physical data. High priority was given to reaches where existing fish use is high and the restoration potential has also been determined to be high. Physical characteristics included the area of low-lying floodplain, the amount of disconnected low-lying floodplain, and the percent of the reach that is a gaining reach versus a losing reach. Biological data included redd surveys (Gallinat and Ross 2012) and juvenile distribution (SRSRB 2006) that provide a relative density of spawning and juvenile presence in each reach.

Table 4-1
Summary of Physical Reach Characteristics, Reaches 2 to 10

Reach	Length (miles)	Low-lying Floodplain Area (acres)	Low-Lying Floodplain per River Mile (acres/mile)	Degree of Confinement (%)			Disconnected Low-Lying Floodplain (acres/RM)	Groundwater Input (%)	
				Confined	Moderate	Unconfined		Gaining	Losing
2	2.7	210	78	14%	44%	41%	13.4	0%	100%
3	4.4	89	20	96%	4%	0%	15.8	96%	4%
5	6.6	325	48	58%	27%	15%	18.0	25%	75%
6	7.5	454	61	5%	68%	28%	15.5	36%	64%
7	4.6	130	28	52%	48%	0%	12.2	0%	100%
8	7.9	247	31	11%	82%	8%	10.5	22%	78%
9	4	128	32	0%	51%	50%	1.3	8%	92%
10	6.2	135	22	24%	76%	0%	4.2	79%	21%

The following four reach characteristics were chosen to collectively represent the relative restoration potential of the reaches and achieve watershed-scale restoration objectives:

- **Available low-lying floodplain:** The total amount of low-lying floodplain within the reach represents the maximum habitat that could be available if a "full build-out" condition with respect to restoration actions were realized. Hence, those reaches with naturally wider low-lying floodplain areas were scored higher than reaches with floodplains that are higher and naturally confined. Low-lying floodplain was calculated by determining an average height of the 5-year flood elevation within each reach using the basin-scale hydraulic model (Anchor QEA 2011a). This elevation value was projected out across the Light Detection and Ranging (LiDAR) existing grade surface. Areas of the existing grade surface below the modeled 5-year flood elevation were classified as low-lying floodplain, and these areas were then summed up for each reach and compared to the length of the reach in RM. The low-lying floodplain area was refined and updated from the values presented in the Geomorphic Assessment (Anchor QEA 2011a).

- **Disconnected low-lying floodplain:** The potential for additional floodplain connection is represented by the relative amount of disconnected low-lying floodplain in a reach. The channel alignment was broken out into sections that are disconnected from the low-lying floodplain by infrastructure and sections that are not influenced by infrastructure. A percent length within each category was calculated and compared to acres of available low-lying floodplain per RM as described above. These values were refined and updated from the values presented in the Geomorphic Assessment (Anchor QEA 2011a); revisions were based on field observations and refined spatial analysis.
- **Distribution of known spawning areas:** Redd distribution for spring Chinook, fall Chinook, steelhead, and bull trout as presented in Gallinat and Ross (2012), was compared to the Tucannon River geomorphic reaches. A relative weight was assigned to each reach to represent the density of existing spawning.
- **Distribution of ESA species juveniles:** Estimates of juvenile distribution for spring Chinook, fall Chinook, summer steelhead, and bull trout as presented in the Snake River Salmon Recovery Plan (2006), was compared to the Tucannon River geomorphic reaches. A relative weight was assigned to each reach to represent the density of existing juvenile use.

Table 4-2 presents a numeric representation of the fish use distribution information (spawning and rearing) presented in Table 2-1. Numeric values were assigned to provide a loose quantitative measure for fish use that can be used to prioritize reaches. A numeric 0 is assigned to reaches that have no species and represents the low score, and a numeric 5 represents the highest density.

Table 4-2

Distribution of Steelhead, Chinook Salmon, and Bull Trout in the Mainstem Tucannon River

Geographic Area	From (RM)	To (RM)	Reach	Summer Steelhead		Spring Chinook		Fall Chinook		Bull Trout	
				Spawning	Juvenile Rearing	Spawning	Juvenile Rearing	Spawning	Juvenile Rearing	Spawning	Juvenile Rearing
Mouth	0	0.7	1	0	0	0	0	0	1	0	0
Lower Tucannon	0.7	4.8	2	0	1	0	0	5	5	0	0
	4.8	5.5	3	1	1	0	0	5	5	0	0
	5.5	8.7	3	1	1	0	0	3	3	0	0
	8.7	12.3	4	1	1	0	0	3	1	0	0
Pataha-Marengo	12.3	16.5	4 and 5	3	1	0	1	1	1	0	0
	16.5	18.6	5	5	3	0	1	0	0	0	0
	18.6	22.8	5 and 6	5	5	1	1	0	0	0	0
	22.8	26.6	6	5	5	1	3	0	0	0	0
Marengo-Tumalum	26.6	35.6	6, 7, 8	5	5	1	5	0	0	0	0
Tumalum-Hatchery	35.6	37.8	8	5	5	3	5	0	0	0	1
	37.8	41.9	8 and 9	5	5	5	5	0	0	0	1
Hatchery-Little Tucannon	41.9	44.6	9	3	5	5	5	0	0	0	1
	44.6	45.6	10	1	5	5	3	0	0	0	1
	45.6	48.1	10	1	3	5	1	0	0	0	3
Mountain	48.1	50.2	10	1	3	3	1	0	0	1	3
	50.2	55	Upstream of Project Scope								

Note:
The numbers in this table reflect the shading found in Table 2.1 of the Draft Integrated Species Restoration Prioritization report.
= 5 = 3 = 1

Table 4-3 represents a qualitative reach scale numeric ranking for each of the four species of concern. The Anchor QEA (2011a) reach extents that intersect the river segments identified by Gallinat and Ross (2012) were weight-averaged using percentage of length in each reach; this resulted in a biological ranking factor not always represented as a whole number.

Table 4-3
Biological Factors Ranking for Reaches 2 to 10

Reach	Summer Steelhead		Spring Chinook		Fall Chinook		Bull Trout	
	Adult	Juvenile	Adult	Juvenile	Adult	Juvenile	Adult	Juvenile
2	0	1	0	0	5	5	0	0
3	1	1	0	0	3.4	3.4	0	0
4	1.5	1	0	.2	2.5	1	0	0
5	4.1	2.5	.2	1	.5	.5	0	0
6	5	5	1	2.5	0	0	0	0
7	5	5	1	5	0	0	0	0
8	5	5	2.7	5	0	0	0	.6
9	3.8	5	5	5	0	0	0	1
10	1	3.4	4.3	1.4	0	0	.4	2.6

The upper reaches (5 through 10) rank the highest for adult and juvenile summer steelhead and spring Chinook. Adult and juvenile fall Chinook ranked highest in the lower reaches (2 through 4). While it is known that adult bull trout use the entire river, bull trout ranked lowest of all the species evaluated in the portion of the Tucannon River because priority areas of use are still mostly unknown.

Building upon the values in Table 4-3, the priority ranking for Reaches 2 to 10 were determined separately for physical (Table 4-4) and biological parameters (Table 4-5).

Table 4-4
Physical Criteria Ranking for Reaches 2 to 10

Reach	Low-lying Floodplain (acres/RM)	Disconnected Low-lying Floodplain (acres/RM)	Instream complexity	Sum Physical Criteria	Relative Percent
2	4	5	2.5	11.5	96
3	1	2	2	5	42
4	3	3	4	10	83
5	3	3	5	11	92
6	5	5	2	12	100
7	2	4	4	10	83
8	3	3	3	9	75
9	3	1	5	9	75
10	1	1	4	6	50

Potential floodplain connectivity, disconnected floodplain, and existing instream complexity were used to evaluate restoration potential based on physical criteria and expected physical response to restoration treatments. These criteria were summed and compared relative to the highest ranking reach; Reach 6.

Biological criteria were evaluated separately. Adult and juvenile scores from Table 4-3 were summed for each species for each reach, and the scores for all four species were also summed. The total scores for each reach were weighted against each other, with Reach 9 having the highest total score of 19.8 (representing 100 as the relative percent scale).

Table 4-5
Physical Criteria Ranking for Reaches 2 to 10

Reach	Summer Steelhead	Spring Chinook	Fall Chinook	Bull Trout	Total	Relative Percent
2	1.0	0.0	10.0	0.0	**11.0**	55
3	2.0	0.0	6.7	0.0	**8.7**	44
4	2.5	0.2	3.5	0.0	**6.2**	31
5	6.5	1.2	0.9	0.0	**8.7**	44
6	10.0	3.5	0.0	0.0	**13.5**	68
7	10.0	6.0	0.0	0.0	**16.0**	81

Reach	Summer Steelhead	Spring Chinook	Fall Chinook	Bull Trout	Total	Relative Percent
8	10.0	7.7	0.0	0.6	**18.2**	92
9	8.8	10.0	0.0	1.0	**19.8**	100
10	4.4	5.6	0.0	3.0	**13.0**	65

The results presented in Tables 4-4 and 4-5 were averaged to create a combined ranking of reaches and an overall reach prioritization (Table 4-6). This process values physical and biological criteria equally.

Table 4-6
Combined Ranking and Reach Prioritization

Physical Relative Percent	Biological Relative Percent	Combined Relative Percent	Reach Priority
96	55	86	2
42	44	49	3
83	31	66	3
92	44	77	2
100	68	96	1
83	81	94	1
75	92	95	1
75	100	100	1
50	65	66	3

Using this weighted method, each reach was assigned a reach priority of 1, 2, or 3. A reach priority of P1 represents a high priority reach, and a reach priority of P3 represents a low priority reach.

Four P1 reaches were identified using this methodology (Reaches 6 to 9). Projects in P1 reaches would have higher priority than those projects identified in the lower ranking priority reaches, P2 and P3 (see Section 5 for projects identified by reach).

5 PROJECT EVALUATION CRITERIA

Projects were evaluated and placed into implementation tiers based on four criteria: expected biological response, consistency with natural processes, benefit-to-cost ratio, and reach priority. Biologic and geomorphic criteria were assigned qualitative values of high, moderate, or low value and benefit-to-cost was given a qualitative ratio using high, moderate, or low values. Reaches were prioritized into three levels of relative importance. The following sections of this report describe the prioritization criteria and process. As projects are implemented, it may be appropriate to revisit projects and re-evaluate tier levels. This evaluation does not consider feasibility in terms of landowner willingness to participate. The information presented in this report is intended to provide an objective look at the conceptual projects that would most benefit target species based on biological benefit and physical effects.

5.1 Evaluation Criteria

5.1.1 Expected Biologic Response

The expected biological benefit was scored based on the expected magnitude of benefits and the likelihood that project objectives would be met. Those projects that most directly address limiting factors and critical life stages, while creating the greatest volume of quantifiable habitat, received the highest scoring. The diversity of existing habitat and the functionality of the existing and proposed habitat during target life stages were included in the evaluation. The juvenile life history stage (egg-to-parr) was identified as critical to improving spring Chinook populations in the Tucannon River. In particular, the persistent lack of adequate juvenile rearing habitat during winter and spring runoff (post-emergence to parr), bed scour during stochastic winter/spring flows, and summer water temperature have been identified as limiting to juvenile populations. Therefore, projects that improve the quality and quantity of juvenile habitat during these periods or create rearing habitat in areas where it does not currently exist received a higher rating.

The expected biologic response of each project was evaluated within the following categories:

- Provides immediate habitat benefits for critical life history stages

- Reconnects isolated habitats or improves existing habitats and promotes floodplain connectivity
- Provides diversity throughout the active channel and low-lying floodplain for all life history stages

5.1.2 Consistency with Natural Geomorphic Process

Natural geomorphic processes are the primary factor in creating and maintaining high-quality habitat in properly functioning rivers and streams. Designing for geomorphic process or removing inhibitors to geomorphic processes are important considerations in project prioritization. The sustainability and functionality of the project is highly dependent on consistency with geomorphic processes, and it is the restoration of these processes that will create and maintain habitat features in the long term. The projects that are expected to most effectively address the rehabilitation of natural processes will receive the highest qualitative rating.

For each project, consistency with natural geomorphic processes was evaluated within the following categories:

- Removes stressors that promote habitat degradation or inhibit natural channel and floodplain processes
- Promotes reach-scale geomorphic response consistent with natural processes
- Promotes the retention of LWD and sediment and forces pool-riffle morphology and complex channel plan form

5.1.3 Benefit-to-cost Ratio

A qualitative evaluation of the magnitude of biological and physical benefits of the project was determined, as was a rough opinion of the probable implementation cost. The result of this estimate is a qualitative ranking of the benefit-to-cost ratio. Those projects that achieve the greatest benefit for the least amount of money received the highest ratings. This criterion also considers whether the benefit is achieved on a short-term or long-term timeline.

5.2 Project Prioritization Summary

Table 5-1 summarizes the ratings assigned to each project within the four evaluation criteria categories: Expected Biologic Response, Consistency with Natural Geomorphic Processes, and Benefit-to-cost Ratio. High, medium, and low rankings were assigned to all projects for each of the evaluation criteria, with the exception of reach priority. The reach priority ranking (P1, P2, and P3) is based on overall geomorphic factors and existing and potential habitat use. P1 is the highest priority ranking and is assigned to reaches that are considered to provide long-term potential value for restoration in the area. P2 is the second highest, and P3 are reaches with lowest priority based on long-term restoration value. Table 5-2 provides the relevant quantities of reconnected floodplain area, levee removals, and other project actions that were considered in developing the qualitative ranking for each project.

Table 5-1
Project Prioritization

Project	Reach	Expected Biologic Response			Consistency with Natural Geomorphic Processes			Benefit-to-cost Ratio	
		Provides immediate benefit for critical life history stages	Reconnects or enhances off-channel habitat; promotes floodplain connectivity	Promotes diversity throughout the active channel and low-lying floodplain	Removes stressors that promote degradation or inhibit natural channel processes	Promotes reach-scale geomorphic response consistent with natural process	Promotes retention of LWD and sediment; forces pool-riffle morphology and complex planform	Magnitude of benefit vs. cost of implementation	Timeline for achieving benefit
1	10	H	M	M	L	H	H	M/M	H
2	10	H	H	M	L	L	L	H/L	H
3	10	H	L	M	L	H	H	M/M	H
4	10	M	M	M	H	M	L	M/M	H
5	10	L	H	H	M	M	L	M/H	M
6	10	L	M	M	M	M	L	M/H	M
7	10	H	L	M	M	M	H	M/H	M
8	10	M	M	M	M	M	M	M/L	H
9	10	M	L	M	L	L	H	M/M	M
10	9	H	M	H	L	H	H	M/M	M
11	9	H	M	M	L	M	H	M/M	H
12	9	H	L	L	L	L	L	L/L	H
13	8	H	M	H	H	H	H	H/M	H
14	8	H	M	M	L	M	H	M/M	M
15	8	H	M	M	M	M	H	M/L	H
16	8	L	M	M	L	L	L	L/L	H
17	8	H	M	M	H	M	H	M/H	H
18	8	M	M	M	L	L	M	M/L	M
19	7	M	M	M	M	M	M	M/H	H
20	7	L	L	M	L	L	L	L/L	L
21	7	H	L	M	L	M	M	M/M	M
22	7	H	M	M	M	M	M	M/M	H
23	7	H	M	M	M	M	M	M/M	H
24	7	H	M	M	H	H	H	M/M	H

Project	Reach	Expected Biologic Response			Consistency with Natural Geomorphic Processes			Benefit-to-cost Ratio	
		Provides immediate benefit for critical life history stages	Reconnects or enhances off-channel habitat; promotes floodplain connectivity	Promotes diversity throughout the active channel and low-lying floodplain	Removes stressors that promote degradation or inhibit natural channel processes	Promotes reach-scale geomorphic response consistent with natural process	Promotes retention of LWD and sediment; forces pool-riffle morphology and complex planform	Magnitude of benefit vs. cost of implementation	Timeline for achieving benefit
25	6	L	L	M	L	L	M	L/L	H
26	6	H	H	H	H	H	H	H/H	H
27	6	M	M	M	L	M	M	M/L	H
28	6	L	M	L	M	M	L	M/L	H
29	5	M	L	M	M	M	M	M/M	H
30	5	L	M	M	M	L	L	M/M	M
31	5	M	M	M	M	M	H	M/M	H
32	5	M	M	M	M	M	M	M/H	M
33	5	M	M	M	H	M	M	M/M	H
34	4	M	M	M	H	H	M	M/H	H
35	4	M	L	M	L	M	M	M/M	H
36	4	L	L	H	L	H	H	H/L	M
37	3	M	M	M	M	M	M	M/M	H
38	3	M	M	M	M	M	M	M/H	H
39	3	M	M	M	H	H	M	M/H	M
40	2	M	H	H	H	H	H	H/M	H
41	2	L	M	M	L	L	M	M/L	M
42	2	M	M	M	M	M	M	M/M	M
43	2	M	H	H	M	H	M	H/M	M
44	2	L	M	M	M	M	M	M/M	M
45	2	L	M	M	M	L	M	M/H	M

Notes:
LWD = large woody debris
L = Low
M = Medium
H = High

Table 5-2
Approximate Physical and Habitat Quantities for Conceptual Projects

Reach	Project Area	RM		LWD Addition	Project Actions (in feet)							Reconnected Low Floodplain (in acres)	Riparian Enhancement (in acres)	Protection Area (RM)
					Levees/Riprap		Side Channels			Roads				
		From	To		Remove	Set Back	Enhance	New	Reconnect	Remove	Realign			
10	1	50.00	48.9	6713.6	-	-	-	-	-	-	-	-	-	-
	2	49.1	48.65	1097.3	-	-	1412.1	202.8	-	-	-	-	-	-
	3	48.65	46.8	6908.0	377.1	-	-	-	-	-	-	0.6	-	-
	4	46.8	46.4	2385.6	1190.7	1028.5[a]	1968.9	256.4	821.9	-	-	1.6	-	-
	5	46.4	45.95	2459.7	988.0	95.1	-	-	-	2326.9	-	10.7	-	-
	6	45.95	45.3	1134.1	144.9	-	-	-	-	-	-	-	-	RM 45.3-45.7
	7	45.3	44.85	2443.2	337.3	-	-	-	-	2706.5	2467.6	-	-	-
	8	44.85	44.4	1504.2	684.1	329.1	445.3	-	545.7	-	-	1.0	-	-
	9	44.4	44	2969.6	2563.5	-	-	-	-	-	-	-	-	-
9	10	44	42.4	8173.6	1304.9	-	-	-	-	-	-	5.8	39.37	-
	11	42.3	40.7	9716.3	1108.1	-	-	-	-	1539.6	652.1	1.4	39.79	-
	12	40.7	40	1965.1	-	-	-	-	-	-	-	-	17.81	RM 40.0-40.7
8	13	40	39.2	3555.7	3191.7	759.0	-	-	-	-	-	3.9	-	-
	14	39.2	37.15	10309.3	162.3	-	-	-	-	-	-	17.8	-	-
	15	37.15	36.35	4027.3	864.8	-	-	-	-	-	-	-	-	-
	16	36.35	34.9	1708.1	524.0	-	-	1118.2	-	-	-	4.6	-	-
	17	34.9	34.3	2935.7	706.2	-	1614.1	-	-	663.9	724.2	2.3	17.26	-
	18	34.3	32.1	3558.4	-	-	-	-	-	-	-	-	-	RM 33.65-34.3, 32.1-33.1
7	19	32.1	31.8	1432.5	639.3	-	-	-	-	-	-	-	-	-
	20	31.8	31.5	-	-	-	-	-	-	-	-	-	-	RM 31.5-31.8
	21	31.5	30.3	5976.7	1742.7	2551.1	-	-	-	-	-	0.6	-	-
	22	30.3	29.3	5338.4	2945.2	193.1	-	-	-	-	-	2.5	-	-
	23	29.3	28.25	5059.0	2159.5	888.7	-	-	-	-	-	9.5	-	-
	24	28.25	27.5	3972.3	2532.4	2924.3	-	-	-	-	-	1.3	-	-
6	25	27.5	26.9	1177.1	-	-	-	-	-	-	-	-	-	RM 27.15-27.5
	26	26.9	23.65	9578.4	8304.9	12217.7	-	-	-	-	-	29.3	-	-
	27	23.65	22.85	1256.8	265.9	2819.5	-	-	-	-	-	-	-	-
	28	22.85	20	1037.0	657.0	-	-	-	-	-	-	22.1	-	RM 20.5-21.7, 22.1-22.8
5	29	20	18.6	7433.5	847.9	411.5	-	-	730.4	-	-	-	-	-
	30	18.6	17.6		1053.7	1075.9			-	-	-	4.6	-	-
	31	17.6	16.1	4248.1	634.5	-	-	-	1346.5	31.7	-		-	-
	32	16.1	14.65	2882.3	1574.0	6137.8				-	-	2.1	-	16.1-15.6
	33	14.65	13.4	6703.4	2285.7		-	-	-		-	0.7	-	-
4	34	13.4	11.45	6887.1	3268.0	4542.4	-	-		-	-	2.4	-	12.1 to 11.45

Reach	Project Area	RM		Project Actions (in feet)								Reconnected Low Floodplain (in acres)	Riparian Enhancement (in acres)	Protection Area (RM)
					Levees/Riprap		Side Channels			Roads				
		From	To	LWD Addition	Remove	Set Back	Enhance	New	Reconnect	Remove	Realign			
	35	11.45	10.85	3373.9	-	-			-	-	-	-	-	-
	36	10.85	9			-	-	-		-	-		-	10.85 to 9.0
3	37	9.0	7.9	5823.2	1041.0	1400.0	-	-	-	-	-	1.2		-
	38[1]	7.9	4.95	15610.3	10685.7	12329.4	-	-	-			7.8		-
	39.1	4.95	4.5	2390.1	1850.6	2493.2						2.0		
	39.2	4.95	4.85	2390.1	1850.6	1902.2	-	-	-	-	-	2.0		
2	40	4.5	3.95	3500	2450	3422	2739	1032	-			10.1		
	41	3.95	3.55	2200	-	-	-	-	1815			0.0		
	42	3.55	3.2	1670	225	-	-	-	1137			1.0		
	43	3.2	2.7	2530	300	1056	-	1602	1975			0.0		
	44	2.7	2.45	1850	225	-	-	-	2303			0.0		
	45	2.45	1.95	2750	3090	140	-	-	2462			10.6		

Table 5-3 presents the results of the prioritization evaluation where qualitative physical, biological, and cost values were assigned numeric values and evaluated relative to one another. The following bullets explain the values provided in Table 5-3.

- Summary Value of Qualitative Physical and Biological Criteria is the summary of the qualitative values in Table 5-1 where each "H" is scored a numeric value of 5, "M" is scored a numeric value of 3, and "L" is scored a numeric value of 1.
- Summary Value of Benefit/Cost Ratio is the assigned numeric value for benefit/cost using the H=5, M=3, L=1 scoring criteria.
- Reach Potential Factor is the numeric value assigned to the reach prioritization results from Table 4-3, where P1=5, P2=3, and P3=1
- Summary Value are the summation of the three previously described values
- Relative Percent is the relative valuation of projects when compared to the highest valued project (project area [PA] 26).
- Project Tier Level is the resultant tier level for each project where are projects with relative percent values greater than 70 where determined to be Tier 1 projects and projects with relative percent values less than 61 where determined to be Tier 3 projects.

Table 5-3
Integrated Prioritization Analysis Summary

Project	Reach	Summary Value of Qualitative Physical and Biological Criteria	Summary Value of Benefit/Cost Ratio	Reach Potential Factor (Long-term potential value for restoration in the reach)	Summary Value	Relative Percent	Project Tier Level
1	10	22	1	1	24	67	**2**
2	10	16	5	1	22	61	**2**
3	10	20	1	1	22	61	**2**
4	10	18	1	1	20	56	**3**
5	10	18	0.6	1	19.6	54	**3**
6	10	14	0.6	1	15.6	43	**3**
7	10	20	0.6	1	21.6	60	**3**
8	10	18	3	1	22	61	**2**
9	10	14	1	1	16	44	**3**
10	9	24	1	5	30	83	**1**
11	9	20	1	5	26	72	**1**
12	9	10	1	5	16	44	**3**
13	8	28	1.7	5	34.7	96	**1**
14	8	20	1	5	26	72	**1**
15	8	22	3	5	30	83	**1**
16	8	10	1	5	16	44	**3**
17	8	24	0.6	5	29.6	82	**1**
18	8	14	3	5	22	61	**2**
19	7	18	0.6	5	23.6	66	**2**
20	7	8	1	5	14	39	**3**
21	7	16	1	5	22	61	**2**
22	7	20	1	5	26	72	**1**

Project	Reach	Summary Value of Qualitative Physical and Biological Criteria	Summary Value of Benefit/Cost Ratio	Reach Potential Factor (Long-term potential value for restoration in the reach)	Summary Value	Relative Percent	Project Tier Level
23	7	20	1	5	26	72	**1**
24	7	26	1	5	32	89	**1**
25	6	10	1	5	16	44	**3**
26	6	30	1	5	36	100	**1**
27	6	16	3	5	24	67	**2**
28	6	12	3	5	20	56	**3**
29	5	16	1	3	20	56	**3**
30	5	12	1	3	16	44	**3**
31	5	20	1	3	24	67	**2**
32	5	18	0.6	3	21.6	60	**3**
33	4	20	1	1	22	61	**2**
34	4	22	0.6	1	23.6	66	**2**
35	4	14	1	1	16	44	**3**
36	4	18	5	1	24	67	**2**
37	3	18	1	1	20	56	**3**
38	3	18	0.6	1	19.6	54	**3**
39	3	22	0.6	1	23.6	66	**2**
40	2	28	1.7	3	32.7	91	**1**
41	2	12	3	3	18	50	**3**
42	2	18	1	3	22	61	**2**
43	2	24	1.7	3	28.7	80	**1**
44	2	16	1	3	20	56	**3**
45	2	14	0.6	3	17.6	49	**3**

6 RESULTS

Based on the results presented in Table 5-3, each individual project was assigned a tier ranking. For implementation prioritization, all of the restoration projects are categorized into three tiers: Tier 1, Tier 2, and Tier 3. The tier rankings for all of the projects are listed below in Tables 6-1 (Tier 1), 6-2 (Tier 2), and 6-3 (Tier 3). Tier 1 projects are the highest ranking; implementation of these projects in the near term is highest priority for habitat restoration. Tier 2 projects represent the next highest priority, and Tier 3 projects have the lowest priority for implementation.

6.1.1 Tier 1 Projects

Tier 1 projects are those projects that would be considered for early implementation within basin restoration planning. In general, the actions recommended in these projects are expected to provide an immediate biological response for the identified critical life history stages within a relatively large area of impact (Table 6-1). The Tier 1 projects are concentrated in the upper basin above RM 20 where the potential for developing and sustaining key habitats is higher, with the exception of two Reach 2 projects that were valued as Tier 1 projects. No Tier 1 projects were identified in Reaches 3 and 4 (Table 6-6) due to the low use of this area for spawning and summer rearing; however, improving conditions for juveniles during the spring runoff period was determined to be of high priority and to provide the greatest certainty of success with respect to improving growth and productivity. Therefore, while no projects in these reaches were identified as Tier 1, three were identified as Tier 2 for the intended purpose of improving conditions during spring runoff. Further, while there is no data demonstrating that juvenile salmon over-winter in these reaches, it is strongly suspected that they do. Over winter utilization and survival in these reaches is a key data gap.

Table 6-1
Tier 1 Projects

Project	Reach	River Miles	Description
10	9	44.0 to 42.4	Adding LWD through the incised and simplified channel in this project area results in a high benefit to both instream habitat and physical processes long term.

Project	Reach	River Miles	Description
11	9	42.3 to 40.7	This project removes important stressors and adds LWD to a confined portion of the channel that lacks complexity and cover, resulting in a high expected benefit within one of the high-priority reaches.
13	8	40.0 to 39.2	This project is expected to provide a high biological benefit for a moderate cost in a section of a P1 reach where the river is tightly confined and simplified by infrastructure and channel modification.
14	8	39.2 to 37.15	This project adds LWD and increases floodplain connectivity for a moderate cost.
15	8	37.15 to 36.35	The cost of implementing this project is relatively low and would increase channel complexity and floodplain connectivity within a high-priority reach.
17	8	34.9 to 34.3	Although the cost of this project is relatively high, biological and physical benefits are expected in a degraded section of the river within a high-priority reach.
22	7	30.3 to 29.3	This project will reduce channel confinement and promote channel complexity and wood retention in a second priority reach.
23	7	29.3 to 28.75	This project will promote natural processes by significantly increasing floodplain connectivity, and will create immediate instream habitat by adding LWD to the channel.
24	7	28.25 to 27.5	This project will significantly increase the width of the floodplain corridor and promote increased channel complexity for a moderate implementation cost.
26	6	26.9 to 23.65	Removing the levees that confine much of this project area is expected to have a high biological and physical benefit.
40	2	4.5 to 3.95	This project significantly widens the floodplain corridor and promotes recovery of natural processes by removing key stressors. It also provides instream habitat in the mainstem and promotes side channel development through the floodplain.
43	2	3.2 to 2.7	This project is expected to have a high benefit for a moderate cost. The proposed actions will significantly widen the floodplain corridor and create over 3,500 feet of new side channel area. Strategic LWD placements will promote increased activation of existing flow paths over time.

Note:
LWD = large woody debris

6.1.2 Tier 2 Projects

Tier 2 projects are moderate- to high-priority projects that should be considered for strategic implementation as funding and other opportunities arise. These projects are expected to achieve moderate biologic and physical benefits for target life stages; however, it may take time for the benefits to be fully realized or achieving the results may be contingent upon other actions or have potential challenges that have been identified by local stakeholders. Tier 2 projects were identified in all the project reaches

Table 6-2
Tier 2 Projects

Project	Reach	River Miles	Description
1	10	50.0 to 48.9	This project will add LWD throughout an area that lacks cover and hydraulic complexity.
2	10	49.1 to 48.65	The minor amount of earthwork required to achieve enhanced flow to a significant length of off-channel habitat results in a substantial benefit-to-cost ratio.
3	10	48.65 to 46.8	This project will add LWD and remove unnecessary bank armoring through this project area, creating instream complexity and promoting natural processes.
7	10	45.3 to 44.85	Adding LWD to the channel will provide immediate benefits to critical life stages and, with road relocation, would promote natural processes to reverse the incised channel conditions over time. However, the cost of implementation would be high.
8	10	44.4 to 44.0	The cost of this project is relatively low and will approximately double the floodplain width and create instream complexity.
18	8	34.3 to 32.1	This relatively small project is expected to have moderate biological benefits for a low cost of implementation and is located in a priority reach.
19	7	32.1 to 31.8	This project is expected to have moderate benefit in a second priority reach. However, replacing the bridge will likely involve a long-term effort.
21	7	31.5 to 30.3	This project will add LWD and remove stressors within this incised and plane-bed section of the channel that lacks cover and complexity.
27	6	23.65 to 22.85	Existing habitat conditions are moderate or actively recovering throughout much of the project area. The small amount of proposed restoration actions is expected to have a moderate benefit and low cost.

Project	Reach	River Miles	Description
31	5	17.6 to 16.1	Improve connection to right bank side channel at RM 17.2. Remove right bank rock levee (17.6 to 17.5). Remove sugar dike (RM 15.5 (right bank)). Remove access road and culvert (RM 17.05). Add LWD in main channel between RM 17.6 and 17.2.
32	5	16.1 to 14.65	Construct right bank setback levee from RM 15.8 to RM 14.8. Setback levee at RM 16.1 excavate channel at RM 16.0 to ease confinement. Setback levees at RM 15.1 (right bank) and RM 14.8 (left bank). Add LWD to main channel between RM 15.65 and 15.1. Protection area designation between RM 16.1 and 15.6.
33	5	14.65 to 13.4	Remove right bank levees between approximately RM 14.4 and 15.6. Remove levee at RM 14.3 (right bank). Remove levee between RM 13.65 and 13.5 (right bank). Strategically place LWD to add channel complexity between RM 14.65 and RM 13.4.
34	4	13.4 to 11.45	Right bank levee setback between RM 13.4 and RM 12.5. Protect on-going processes in RM 12.1 and 11.45.Remove small section of levee at RM 11.45.
36	4	10.85 to 9.0	Protect natural channel and floodplain processes within the entire project area (RM 9.0 to 10.85).
39	3	4.95 to 4.5	Setback levee along the right bank through the town of Starbuck. Two potential options are proposed: (1) set levee back along entire project area (RM 4.95 to 4.5), or (2) set levee back downstream of the Kellogg Road bridge (RM 4.8). Replace the bridge at Kellogg Road to limit the influence of the artificial constriction. LWD would be placed throughout to improve habitat and hydraulic complexity.
42	2	3.55 to 3.2	This project is expected to achieve a moderate benefit for a moderate cost by widening the floodplain corridor, promoting more frequent floodplain connectivity, and initiating side channel development.

Note:
RM = river miles

6.1.3 Tier 3 Projects

The Tier 3 group represents those projects that are appropriate for long-term strategic implementation. The biological and physical response may have less impact or be less certain, or the expected benefit of the project is low compared to the relative cost. Achieving the full benefits of a Tier 3 project may depend on implementing other actions, or it may take place on a relatively long time scale. Tier 3 projects are expected to have a low to moderate biological benefit and would require a low to moderate implementation cost. Alternately, PA 36, where protection (no action), is proposed received lower ranking than active restoration projects and was ranked as a Tier 3 project. This naturally recovering area currently provides good biological and physical benefits, but this was not necessary reflected in the prioritization process. Table 6-3 presents the Tier 3 projects that were identified throughout the study area.

Table 6-3
Tier 3 Projects

Project	Reach	River Miles	Description
4	10	46.8 to 46.4	This project will significantly reduce channel confinement for a moderate cost of implementation.
5	10	46.4 to 45.95	Removing the road through the floodplain will approximately double the width of the floodplain corridor for a relatively high cost.
6	10	45.95 to 45.3	Although removing the campground is expected to have an overall moderate benefit, the implementation cost may be high and immediate biological benefit is low.
9	10	44.4 to 44.0	Existing habitat and physical conditions in this section of the river are moderate. Lake removal is not expected to have significant impact to existing floodplain processes or critical life stages.
12	9	40.7 to 40.0	This project involves a small amount of active restoration (LWD placement) and is not expected to result in significant benefits or geomorphic response.
16	8	36.35 to 34.9	The high concentration of private homes through this project area greatly limits the possibilities for restoration without incurring risk. The proposed restoration actions are not extensive enough to have significant impacts to natural processes, but they would provide some amount of biologic benefit.
20	7	31.8 to 31.5	This project involves passive restoration efforts and did not rank high in the prioritization process. However, some biological benefit to water quality and the riparian vegetation can be

Project	Reach	River Miles	Description
			achieved with little effort and low cost.
25	6	27.5 to 26.9	This project involves a small amount of active restoration (LWD placement) and is not expected to result in significant benefits or geomorphic response.
28	6	22.85 to 20.0	The recommendation for a majority of this project area is protection of recovering sections of the channel. The small amount of active restoration will have a moderate biological response for a relatively low cost of implementation.
29	5	20.0 to 18.6	Remove 922 feet of bank armoring and place LWD throughout the entire project area (RM 20.0 to 18.6). Reconnect an off-channel wetland near RM 18.7.
30	5	18.6 to 17.6	Setback right bank revetment at RM 17.9 to 17.8 to reconnect the main channel to an old channel area. Limit cattle grazing access (via fencing) to the river to improve channel habitat conditions between RM 17.8 to 18.0.
35	4	11.45 to 10.85	Place LWD in the channel throughout the project area (RM 11.45 to RM 10.85). Supplement existing weirs with LWD to improve habitat benefit.
37	3	9.0 to 7.9	Setback right bank levee at RM 9.0 (RV Park). Place LWD in the main channel between RM 8.7 and 7.9 to improve sediment retention and bar development.
38	4	7.9 to 4.95	Setback the right bank levee throughout the entire project area (RM 7.9 to RM 4.95) to allow for channel migration and recovery of natural channel processes. Place LWD in the channel throughout the entire project area.
41	2	3.95 to 3.55	Although this project promotes floodplain connectivity, the area already contains a moderate amount of quality instream habitat and the overall geomorphic response is low.
44	2	2.7 to 2.45	The proposed actions would promote better floodplain connectivity and side channel development; however, the existing conditions in this project area provide moderately good habitat; therefore, the priority of this project is relatively low.
45	2	2.45 to 1.95	Removal of the railway and road grade materials will result in a relatively high cost for a moderate expected benefit.

7 REFERENCES

Anchor QEA, 2011a. *Tucannon River Geomorphic Assessment and Habitat Restoration Study*. Prepared for Columbia Conservation District. April 2011.

Anchor QEA, 2011b. *Conceptual Restoration Plan, Reaches 6 to 10. Tucannon River Phase II*. Prepared for Columbia Conservation District. October 2011.

Anchor QEA, 2011c. *Design Restoration Feature Prioritization, Tucannon River Reach 2*. Memorandum prepared for the Columbia Conservation District. November 16, 2011.

Anchor QEA, 2012a. *Draft Conceptual Restoration Plan, Reach 5 Tucannon River RM 4.5to RM 13.4*. October 2012.

Anchor QEA, 2012b. *Draft Conceptual Restoration Plan, Reaches 3 and 4 Tucannon River RM 4.5to RM 13.4*. October 2012.

CCD (Columbia Conservation District), 2004. *Tucannon Subbasin Plan*. Prepared for Northwest Power and Conservation Council. May 2004.

Gallinat, M.P. and L.A. Ross, 2010. *Tucannon River Spring Chinook Salmon Hatchery Evaluation Program 2009 Annual Report*. Washington Department of Fish and Wildlife. August 2010.

Gallinat, M.P. and L.A. Ross, 2011. *Tucannon River Spring Chinook Salmon Hatchery Evaluation Program 2010 Annual Report*. Washington Department of Fish and Wildlife. August 2011.

Gallinat, M.P. and L.A. Ross, 2012. *Tucannon River Spring Chinook Salmon Hatchery Evaluation Program 20011 Annual Report*. Washington Department of Fish and Wildlife. August 2011.

ISRP (Independent Scientific Review Panel), 2011a. Memorandum to: Erik Merrill, ISRP/ISAB Coordinator, Northwest Power and Conservation Council. Regarding: Response to ISRP comments on the BiOp proposal, Tucannon River Programmatic Habitat Project (#2010-077-00) dated March 10, 2011. July 5, 2011.

ISRP, 2011b. Memorandum to: Bruce Measure, Northwest Power and Conservation Council. Regarding: Final Review of the BiOp Proposal, Tucannon River Programmatic Habitat Project. March 10, 2011.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt, 2000. *Viable salmonid populations and the recovery of evolutionarily significant units*. U.S. Department of Commerce, NOAA Technical Memorandum. June 2000.

Roni, P., T. Beechie, R.E. Bilby, F.E. Leonetti, M.M. Pollock, and G.R. Pess, 2002. A Review of Stream Restoration Techniques and a Hierarchical Strategy for Prioritizing Restoration in Pacific Northwest Watersheds. American Fisheries Society. *North American Journal of Fisheries Management* 22:1-20.

SRSRB (Snake River Salmon Recovery Board), 2006. *Snake River Recovery Plan for SE Washington*. Prepared for Washington Governor's Salmon Recovery Office. December 2006.

SRSRB, 2011a. Email communication with Kris Buelow regarding updated data on fish species distribution and life history in the Tucannon River basin. March 28, 2011.

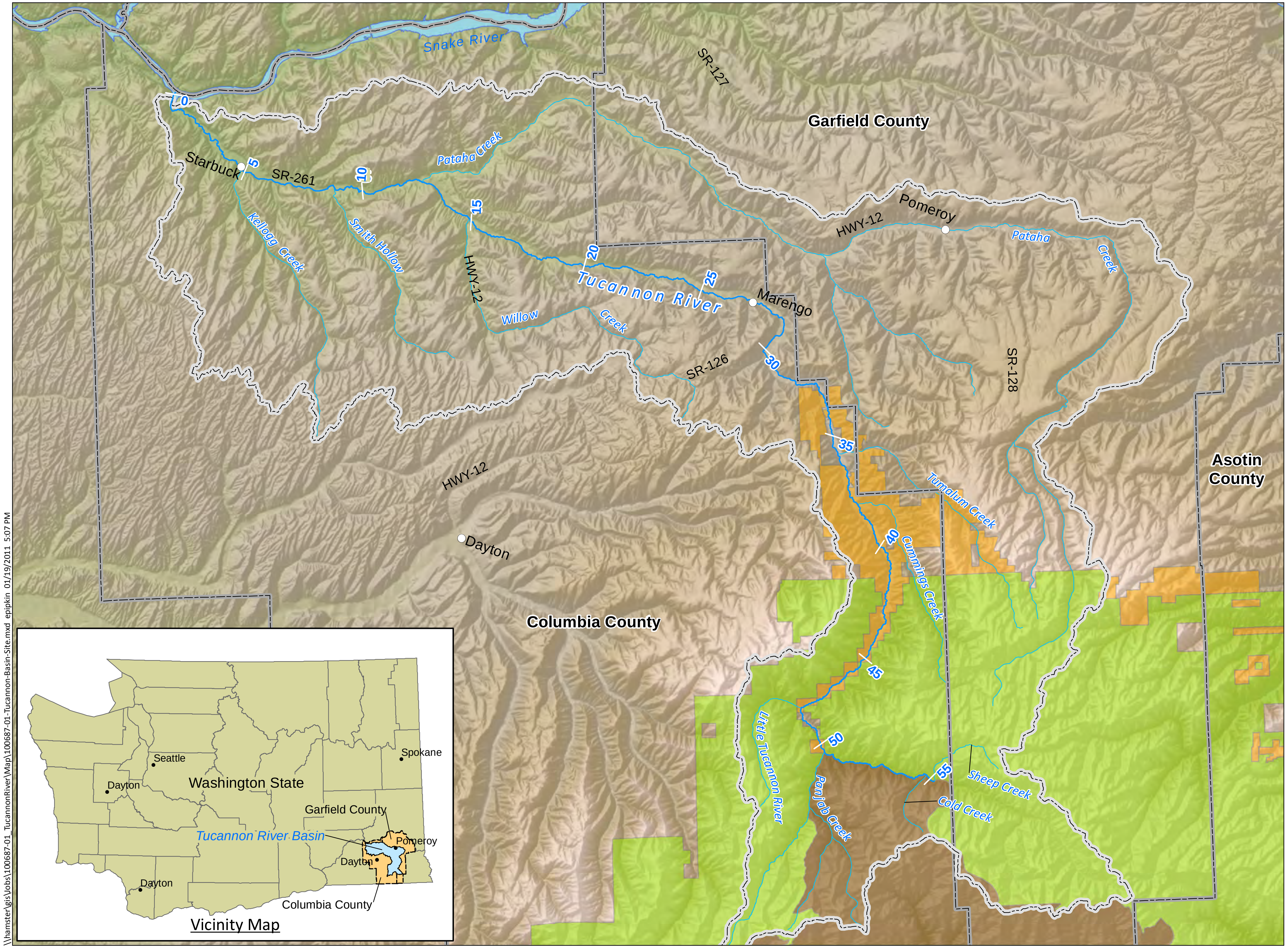
SRSRB, 2011b. Response from Steve Martin, Executive Director of the SRSRB, to ISRP comments on the BiOp proposal, Tucannon River Programmatic Habitat Project. January 2011.

SRSRB, 2011c. *Snake River Salmon Recovery Plan, Draft. Appendix B. Current Status Assessment of Southeast Washington Management Unit Populations*. April 2011.

USFWS (U.S. Fish and Wildlife Service), 2010. Bull Trout Final Critical Habitat Justification: Rationale for Why Habitat is Essential, and Documentation of Occupancy. Chapter 15. Mid-Columbia Recovery Unit-Lower Snake River Critical Habitat Unit. pp. 428-431. September 2010.

WDFW, 2011. Personal communication from Glen Mendel. September 2011.

FIGURES



LEGEND

- Tucannon River Assessment Reaches (Ticks Indicate River Mile)
- Tributary to Tucannon River
- Tucannon River Basin
- County Boundary

Public Land Areas

- Washington State - WDFW Wildlife Area
- U.S. Forest Service - Wenaha Tucannon Wilderness
- U.S. Forest Service - Umatilla National Forest

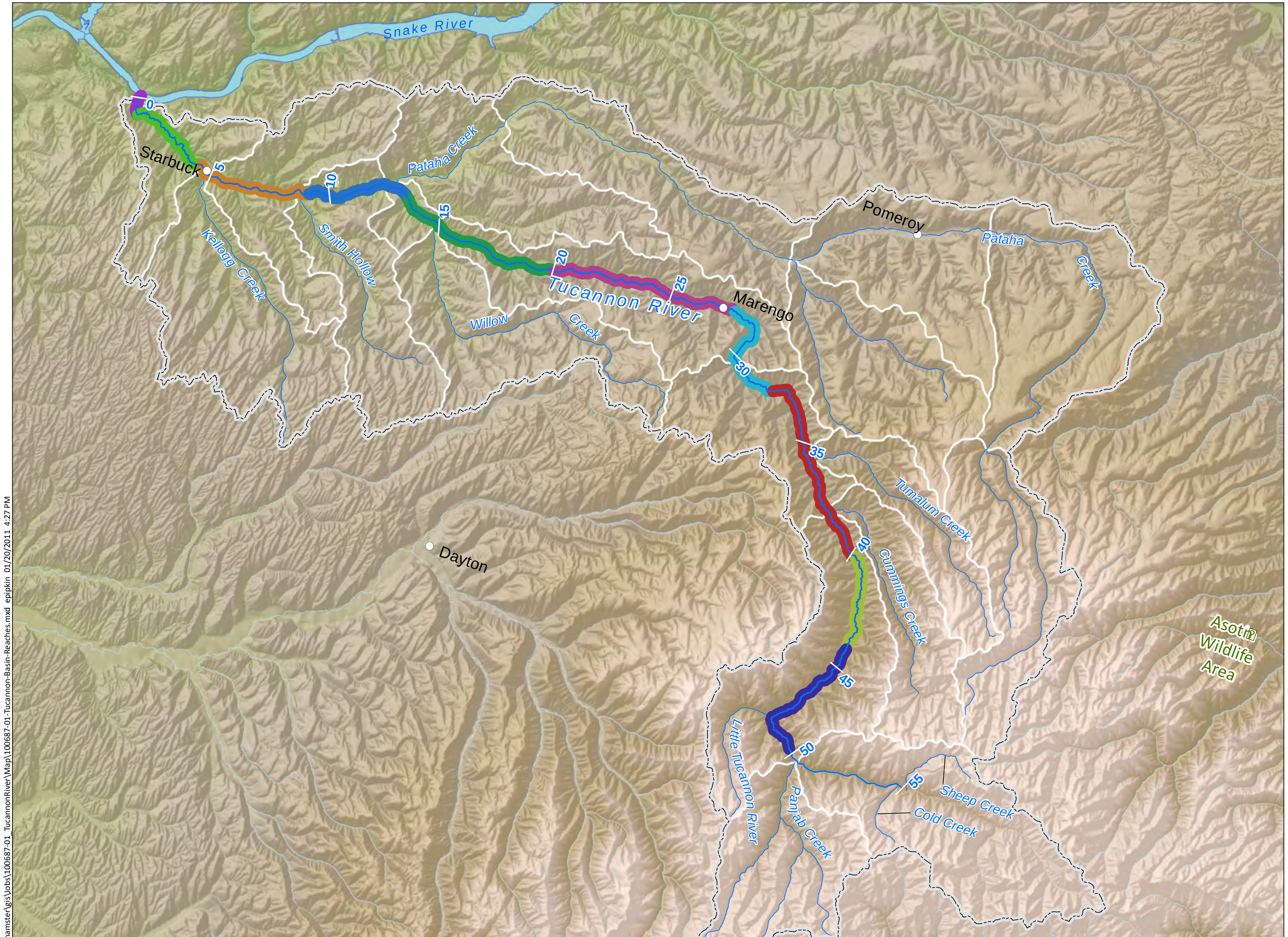
0 2.5 5 Miles

NOTES:

1. Horizontal Datum: WA State Plane South Zone, NAD 83, Feet.
2. Public lands data provided by Washington State Dept. of Natural Resources.

ANCHOR QEA

Figure 1
Basin Site and Vicinity Map
Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
Columbia Conservation District



LEGEND

- Tucannon River Assessment Reaches (Ticks Indicate River Mile)
- Tributary to Tucannon River
- Tucannon River Basin
- Tucannon River Sub-Basins

Geomorphic Reaches

- Reach 10 (R.M. 50.0 - R.M. 44.0)
- Reach 9 (R.M. 44.0 - R.M. 40.0)
- Reach 8 (R.M. 40.0 - R.M. 32.1)
- Reach 7 (R.M. 32.1 - R.M. 27.5)
- Reach 6 (R.M. 27.5 - R.M. 20.0)
- Reach 5 (R.M. 20.0 - R.M. 13.4)
- Reach 4 (R.M. 13.4 - R.M. 9.0)
- Reach 3 (R.M. 9.0 - R.M. 4.5)
- Reach 2 (R.M. 4.5 - R.M. 0.7)
- Reach 1 (R.M. 0.7 - R.M. 0.0)

0 2.5 5
Miles

NOTES:
1. Horizontal Datum: WA State Plane South Zone, NAD 83, Feet.
2. Sub-basins are based on USGS HUC areas.
3. R.M. stands for River Mile.

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Figure 2
Assessment Reaches
Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
Columbia Conservation District