July 5, 2011

To: Erik Merrill, ISRP/ISAB Coordinator, Northwest Power and Conservation Council

From: Steve Martin, Executive Director, Snake River Salmon Recovery Board

Subject: Response to ISRP comments on the BiOp proposal, Tucannon River Programmatic Habitat Project (#2010-077-00) dated March 10, 2011

The Independent Scientific Review Panel (ISRP) reviewed the initial proposal submitted by the Snake River Salmon Recovery Board (SRSRB) for the Tucannon River Programmatic Habitat Project dated August 2, 2010. ISRP comments were received on November 15, 2010, and SRSRB responded January 20, 2011. Since then, the ISRP has again sent comments, dated March 10, 2011, requesting additional clarification in the following areas:

1. Objectives – The objectives for reach-scale restoration actions, how the proposed actions will achieve the objectives, quantification of the contribution that achieving the habitat standards would make to achieving Viable Salmonid Population (VSP) goals.

2. Conditions – Current habitat and fish population conditions at project sites.

3. Selection of habitat restoration actions – Justification for a program to identify and support projects in the future, details about the composition of the review committee, the criteria they will employ in project selection and overall program structure and governance.

4. Research, Monitoring and Evaluation (RM&E) – Description of the RM&E program including interaction with the Integrated Status and Effectiveness Monitoring Program (ISEMP) and a decision framework for modifying restoration actions if sufficient improvement does not occur.

Below we respond to the four categories of information requested by the ISRP. In cases where information is not readily available, we have either identified specific studies underway to obtain the information, or how RM&E activities are or will be focused to collect the information.

Response to Item #1: Describe (A) the objectives for reach-scale restoration actions, (B) how the proposed actions will achieve the objectives, and (C) quantification of the contribution that achieving the habitat standards would make to achieving VSP goals.

(A) Goal and Objectives for Reach-scale Restoration Actions

The primary restoration action goal is to restore physical and biological processes to address the primary habitat limiting factors for spring Chinook salmon and other salmonids in the Tucannon River. We will use the steps outlined in Roni et al. (2002) to prioritize and implement restoration actions as summarized below:

1. Protect and maintain natural processes such as natural hydrologic and sediment routing throughout the system to allow natural migration and wood recruitment.

2. Connect disconnected habitats such as oxbows, wetlands, and former mainstem and side channels. Remove fish barriers.

3. Address roads, levees, and other human infrastructure impairing processes by removing or modifying culverts, levees, dredge spoils, diversion dams, and grade control structures.

4. Restore riparian processes by isolating and protecting healthy riparian areas, eradicating invasive species, and planting native communities.

5. Improve instream habitat conditions by installing large individual trees and large woody debris (LWD) structures in the mainstem channel.

Table 1 below identifies the limiting factors that have been addressed by past assessments and that will be addressed by the proposed restoration through six restoration strategies, and tables provided in Attachment 1 identify how these strategies would be applied at the reach scale. The Tucannon River has been organized into ten restoration reaches as provided in Table 2.

Table 1. Steelhead and Chinook Salmon Limiting Factors Addressed by Proposed Restoration Strategies for the Tucannon River.

Restoration Strategies	**Key Habitat Quantity**	**Sediment Load**	**Temperature**	**Channel Stability**	**Flow**	**Food**	**Habitat Diversity**	**Harassment/Poaching**	**Passage**	**Pathogens**	**Predation**
Reconnect disconnected habitats	●	●	●	●	●		●				●
Reconnect former mainstem and side channels	●	●	●	●	●	●	●				●
Levee removal or setback		●	●	●	●		●				
Modify or remove obstructions		●	●	●	●				●		●
Develop instream habitat complexity	●	●	●	●	●	●	●				●
Riparian zone enhancement		●	●	●		●	●				●

Notes:
1. Limiting factors are summarized from SRSRB (2006).
2. Key limiting factors for summer steelhead and spring Chinook salmonfor the mainstem are shaded in gray.

Table 2. Summary of Reach Locations.

Reach	Extent	Length (RM)	Average Gradient (%)[a]	Approx. Basin Area at Downstream End (mi^2)[b]	Major Tributaries
1	River mile (RM) 0.0 to 0.7	0.7	0.001 [c]	504	None
2	RM 0.7 to 4.5	3.8	0.44	503	None
3	RM 4.5 to 8.9	4.4	0.52	490	Kellogg Creek, Smith Hollow
4	RM 8.9 to 13.2	4.3	0.57	410	Pataha Creek
5	RM 13.2 to 20.0	6.8	0.74	220	Willow Creek
6	RM 20.0 to 27.5	7.5	0.89	178	None
7	RM 27.5 to 32.1	4.6	0.98	159	None
8	RM 32.1 to 40.0	7.9	1.1	144	Tumalum Creek, Cummings Creek
9	RM 40.0 to 44.0	4.0	1.3	95	None
10	RM 44.0 to 50.2	6.2	1.6	87	Little Tucannon River, Panjab Creek

Notes:
[a] Average gradient calculated from 2010 bare-earth LiDAR topography.
[b] Calculated using USGS Streamstats (2010).
[c] The gradient of Reach 1 is likely influenced by backwater from Lake Herbert G West during the LiDAR flight. Gradient when the lake is lower would be steeper.

A description of the restoration actions, rational, and primary objectives of the Tucannon River Programmatic Habitat Project are listed below. Actions are listed in order of overall watershed priority as described by Roni et al. (2002). However, much of the lower Tucannon watershed is privately owned and therefore landowner cooperation is essential to implement any restoration projects.

A draft geomorphic assessment and habitat restoration report has been completed for the lower 88 km of the mainstem Tucannon River that identifies reach-scale restoration actions consistent with the above identified objectives (Anchor QEA 2011). We have attached a summary of the preliminary recommendations for the types of restoration required within each reach (Attachment 1). These recommendations form the basis for the types of restoration actions and their prioritization for implementation. We will use ongoing monitoring efforts and past assessments to refine these recommendations and develop more specific objectives as these data become available.

We will generally be consistent with the Snake River Salmon Recovery Plan (2011) objectives for restoration of the Chinook major spawning area (MSA) which are as follows:

Upper Tucannon River MSA (from Pataha Creek upstream to Tucannon headwaters) and Lower Tucannon River MSA (from Pataha Creek downstream to Tucannon mouth):

Imminent Threats: Improper Fish Screens, Low Stream Flows

1. Riparian: >40 to 75 percent of maximum function
2. Large Woody Debris: >1 key piece per channel width
3. Channel Confinement: <25 to 50 percent of stream bank length
4. Temperature: <4 days >72ºF

Lower Tucannon River MSA (from Pataha Creek downstream to Tucannon mouth):

Imminent Threats: Fish Passage Barriers, Screens, Low Stream Flows

In addition to the four limiting factors and associated objectives for the Upper Tucannon River MSA (1 through 4 above), the following limiting factor and objective applies to the Lower Tucannon River:

5. Embeddedness: <20 percent

These objectives have not yet been evaluated applied at the reach-scale; however, they will start to be evaluated applied by the end of 2011, based upon the conceptual restoration design work currently being conducted by Anchor QEA. Reach-specific objectives will likely be more specific, based upon reach-specific restoration potential and improved understanding of existing conditions.

Description of Restoration Actions and Objectives

This section describes the general restoration objectives of the conceptual restoration design effort underway, and is followed by more specific information on restoration opportunities and how these can help meet VSP objectives.

1. Protect and maintain natural processes – The Tucannon Coordination Committee has worked with various stakeholders and land managers to protect and maintain natural processes at the watershed scale (e.g., land acquisition, best management practices on Forest Service land, changes in farming practices such as no till, and habitat restoration measures).

2. Reconnect Disconnected Habitats – In the Tucannon, several disconnected features exist such as off-channel wetlands and side-channels at lower flow periods. This off-channel habitat would provide critical holding and rearing habitat for juvenile salmonids during moderate to high flows, and also provide more desirable habitat during lower flow conditions.

3a. Modify or Remove Obstructions – Partial obstructions exist at Starbuck Dam and the Hatchery dam; and these may affect juvenile passage and adversely affect habitat quality. These obstructions would be evaluated to identify near and long-term actions to improve passage and geomorphic conditions.

3b. Reconnect Former Mainstem and Side Channels – Similar to disconnected habitat, reconnecting side channels would provide preferred rearing habitat during low flows and provide hydraulic refuge and cover during high flows. This would also increase flow pathways and habitat complexity by diversifying planform, dissipating stream energy, and distributing sediment load.

3c. Levee Removal or Setback – Tens of thousands of linear feet confine the mainstem Tucannon River and prevent or limit surface water connection to the adjacent floodplain. In a majority of the opportunity areas, the floodplain corridor could be widened without significant change to existing land uses. Levee removal and floodplain connection would encourage geomorphic processes while dissipating velocities during high flows.

4. Riparian Zone Enhancement – This includes protecting existing healthy areas; removing undesirable vegetation; and planting native riparian communities on channel banks, high elevation gravel bars, and in the floodplain. This enhancement can provide several habitat and physical process benefits including increased bank and floodplain roughness, cover and nutrients.

5. Develop Instream Habitat Complexity – Increase habitat complexity through LWD placement, engineered logjams and, where appropriate, rock structures to provide fish refuge, pools for holding, create void space for juveniles, and allow for colonization of riparian vegetation. This strategy also promotes the rehabilitation of natural processes by increasing floodplain connectivity and promoting channel migration and associated benefits.

(B) How Proposed Actions will Achieve Restoration Objectives

Habitat restoration in the Tucannon River is expected to improve the survival of juvenile spring Chinook outmigrants by improving habitat conditions during low flow periods, and providing increased habitat complexity through restoring physical and biological processes in-channel and along the floodplain. Survival during high flow events will also likely be increased due to the increase in mainstem channel complexity, off-channel habitat, and velocity refuges created by increases in channel sinuosity and complexity. Overwinter survival could also be greatly increased by better sediment sorting (scour and deposition around new habitat features), increased pool depths, better connection to hyporheic and groundwater flows, both of which can moderate surface water temperature, and increased cover to avoid predators.

Floodplain reconnection and natural process restoration opportunities are many, with disconnected low-lying floodplain ranging from 11 to 27 percent of river length for the river reaches between Starbuck (RM 5) and Panjab Creek (RM 50), and representing more than 400 acres in area (Anchor QEA 2011). Several thousand feet of channel is also disconnected from the floodplain through roads, levees and dikes. The goal is to reconnect these areas to provide off-channel rearing habitat, change the energy direction from down valley to across valley during high flow conditions and increase hyporheic exchange. Off-channel habitat would provide hydraulic refuge and rearing habitat for juvenile salmonids during moderate to high flows, and also provide more desirable habitat during lower flow conditions. It would also increase flow pathways and habitat complexity by diversifying channel shape, dissipating stream energy, and distributing sediment load. Levee removal and floodplain connection would encourage geomorphic processes while dissipating velocities during high flows.

Increased hyporheic exchange can improve temperature conditions and increase the range of suitable habitat available for spawning and rearing. By further improving the area upstream of RM 25 (where most of the usable habitat currently exists) and by improving habitat conditions downstream to at least RM 12.5, increased distribution is anticipated.

Riparian improvements have been identified throughout the basin, with a focus on areas with high hyporheic exchange (gaining reaches) to improve temperature conditions with the expectation of extending cooler temperatures downstream (Ecology 2010). Floodplain restoration can lead to expanded riparian vegetation as natural processes are reestablished in opportunity areas.

Increasing habitat complexity through LWD placement, engineered logjams and, where appropriate, rock structures can provide fish refuge, pools for holding, create void space for juveniles, and allow for colonization of riparian vegetation.

Collectively these improvements can reestablish natural "processes of material and energy transfer across the watershed that enables the formation and maintenance of productive habitat," as characterized in the ISRP March 2011 comments on the Tucannon proposal summary. The expectation with these improvements and reestablishment of natural processes is that they will increase habitat diversity and total rearing area available for juveniles, and should help increase survival and productivity. The habitat improvements should also increase spawning and emergence conditions over time through improved energy dissipation from increases channel complexity, improved temperature conditions and improved distribution of material across the floodplain.

(C) Quantification of the contribution that achieving the habitat standards would make to achieving Viable Salmonid Population (VSP) goals

In the March 10, 2011 comments, the ISRP requested the Snake River Salmon Recovery Board to include "hypothesized effect of the restoration projects on habitat conditions and consequent response of the fish." As the ISRP understands, the relationship between habitat improvements and population response is imprecisely known. However, there is every expectation that habitat improvements that expand areas available and suitable for spawning and rearing will support positive changes in all VSP parameters, while recognizing the myriad of other factors that affect VSP outside the Tucannon (e.g., Snake and Columbia River hydropower system, ocean conditions and marine survival rates). Currently, adult spring Chinook run-timing, spawn–timing, and out-migration age fall within a narrow range, and it is not expected to change in the near term. However, increased habitat complexity is likely to increase the survival,productivity, spatial structure and abundancelepfIn addition, increased habitat complexity is expected to provide more opportunities for successful expression of additional life histories (e.g. resident form, and multiple age classes at outmigration) as well as improve survival of these life history types. Improving water quantity and quality will lead to expanded downstream spawning and rearing, improving watershed carrying capacity and lead to improved life history diversity, spatial structure and abundance.

Changes in VSP from habitat actions are expected to occur on a generational scale, with detectable changes not emerging until several spring Chinook salmon generations have passed. Still, increased spawning area and species distribution should lead to improved life history diversity, spatial structure and species abundance. Increased juvenile off-channel rearing area will contribute to spatial structure and distribution. Increased habitat complexity and quality will lead to improved life-cycle productivity.

Collectively, these improvements should result in more efficient exploitation of habitat opportunities by Tucannon spring Chinook and other salmonid populations, which should result in increased population abundance, productivity, spatial distribution and life history diversity.

Moving from these more qualitative expectations, limited information is available to quantify the contribution that achieving the habitat standards would make to achieving VSP goals. However, Ecosystem Diagnosis and Treatment (EDT) modeling was conducted for Tucannon River spring Chinook salmon in 2004, and provides quantitative results to further support the qualitative expectations described above. EDT was used in 2004 as part of the Subbasin planning process to simulate habitat capacity and fish productivity conditions before and after implementation of actions designed to improve habitat conditions and mitigate for limiting factors. The results of the EDT modeling are summarized in Figure 1 below and predict that the spring Chinook population abundance would double and productivity would increase to a level just below the viability curve, with the increase in intrinsic productivity of the population increasing by 11 percent.

In summary, the actions identified and yet to emerge from this habitat programmatic are intended to restore normative processes because we believe this is a more effective way to achieve the goals than doing a lot of smaller “stick and boulder” work.

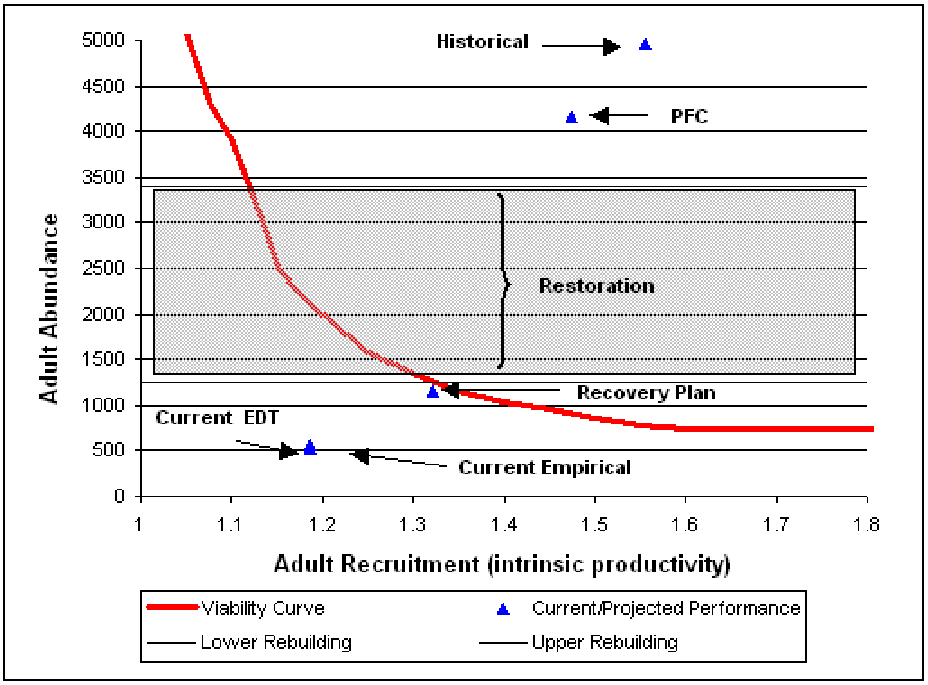


Figure 1. **EDT Viability Analysis for Tucannon Spring/Summer Chinook salmon (2004).**

Response to Item #2: Condition of habitat and fish population conditions at project sites.

Fish Population Conditions

The Tucannon supports four ESA-listed Snake River Basin salmonid populations throughout all or a portion of their life stages, including summer steelhead, spring Chinook. Collectively these species use the main channel from the mouth to the headwaters, as well as major tributaries. Table 3 below shows the spatial distribution of species usage in the mainstem Tucannon River, with darker shades of gray indicating higher densities of fish present during their respective life stages (Anchor 2011). A majority of the fish usage is concentrated between RMs 20 and 45.

Table 3. Distribution of Steelhead, Chinook Salmon, and Bull Trout in the Mainstem Tucannon River (Anchor QEA 2011)

Geographic Area	From (RM)	To (RM)	Summer Steelhead			Spring Chinook			Fall Chinook			Bull Trout		
			Spawning	Juvenile Rearing	Adult Holding	Spawning	Juvenile Rearing	Adult Holding	Spawning	Juvenile Rearing	Adult Holding	Spawning	Juvenile Rearing	Adult Holding
Mouth	0	0.7										Note: Migratory and resident fish. Distribution data are limited.		
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								Note: Juveniles out-migrate as subyearlings				
	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												

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

Building off the information in this study, Anchor QEA is developing conceptual restoration design for the Tucannon between RM 20 (Rkm 32.19) and 51 (Rkm 82.08) (Reaches 6 through 10 as described above with associated action tables provided in Attachment 1). This reach is also the primary summer rearing area for juvenile spring Chinook and steelhead, as provided in Table 3 above. The Washington State Salmon Recovery Funding Board (SRFB) has approved funding to advance the conceptual restoration designs to preliminary project designs for projects in the reach(es) that are yet-to-be prioritized.

The conceptual design report will provide additional detail on current habitat conditions for the project locations and identify conceptual restoration projects specific to each reach. Those concepts will be advanced to preliminary restoration designs. Projects will be prioritized for restoration based upon restoration opportunities consistent with abundance and productivity objectives described above. Thirty-percent design will then be conducted on the highest priority sites, preparing for implementation.

VSP Status - Abundance and Productivity Background Information Summary

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 about 1,500 returning adults occurred in 2010 and the lows of 0 returning natural-origin spawners occurred in 1995 and 1999 (Figure 2 below). The 10-year geometric mean abundance has varied between approximately 100 and 400 returning adults. The Interior Columbia Technical Recovery Team (ICTRT)-estimated minimum abundance threshold of returning adults is 750 and the current average is 371 (SRSRP 2011c).

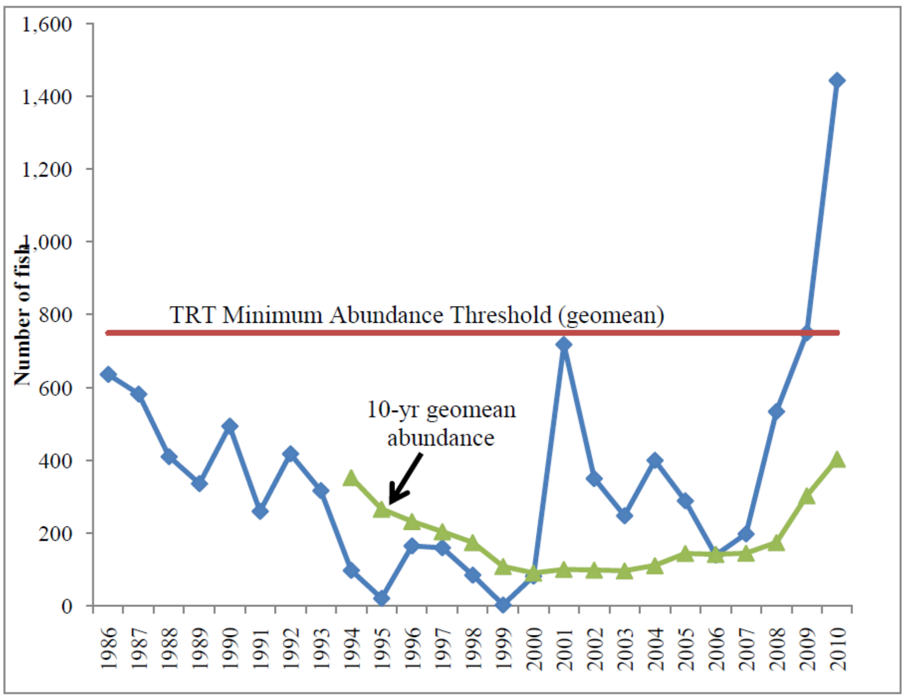


Figure P 2. Estimated abundance of Tucannon River natural-origin spring/summer Chinook salmon adults and 10-year geomean between 1986 and 2010 (Gallinat and Ross 2011).

Based on analyses of PIT-tag data, the 20-year estimated productivity of Tucannon River spring Chinook (recruits/spawner; R/S) is 0.71; well below the level of sustainability (Figure 3 below). This R/S 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 (SRSRP 2011c). The TRT estimated that R/S of 1.8 is needed for an extinction risk of <5 percent and 2.1 for an extinction risk of <1 percent (highly viable criteria) (SRSRP 2011c).

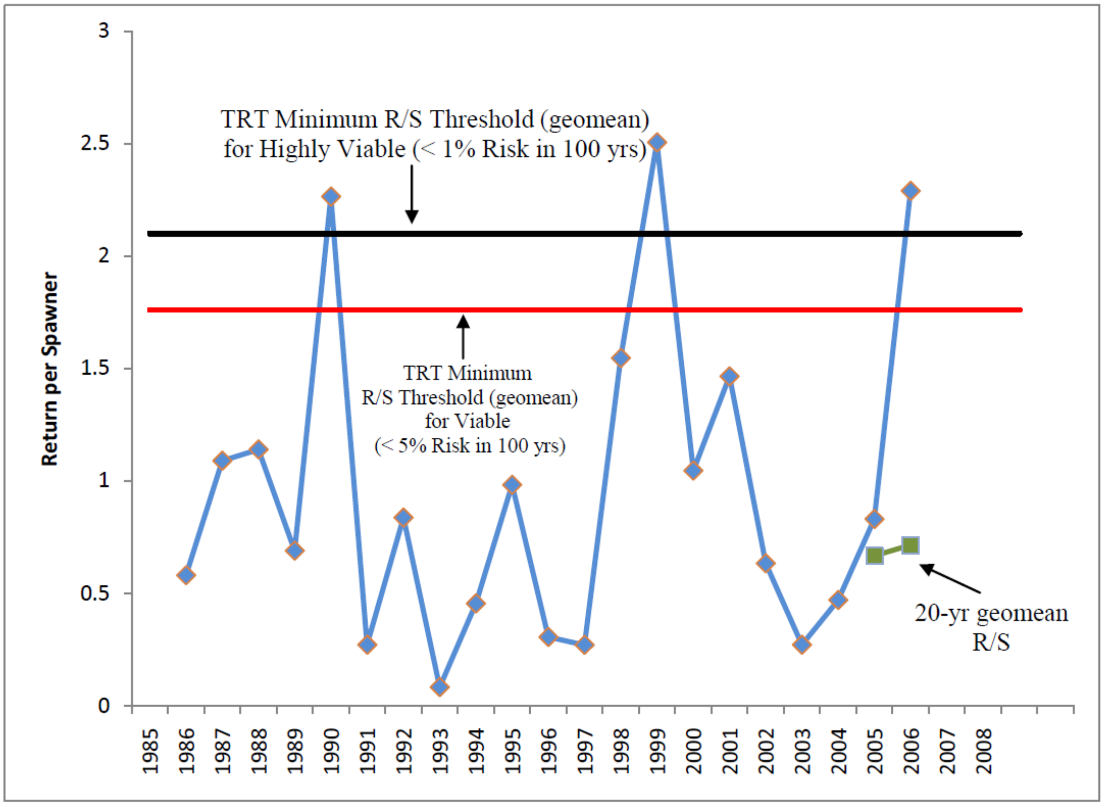


Figure [illegible]3. Estimated productivity of natural-origin spring/summer Chinook salmon adults and 20-year geomean from the Tucannon River (NOAA salmon population summary SPS database: https://www.webapps.nwfsc.noaa.gov/apex/f?p=238:home:0) for 1986-2003. For 2003-2005 from Gallinat and Ross (2010).

Spatial Distribution and Life History Diversity

Spatial distribution (spawning and summer rearing) is restricted primarily upstream of Marengo (RM 25/Rkm 39.9) to the headwaters, yet historically it is presumed that spring Chinook spawned and reared at least down to RM 12.5 (Rkm 20.1) (Pataha Creek). The spring Chinook salmon spawning and rearing distribution is reported in the 2005 Snake River Salmon Recovery Plan. The 2005 Plan is currently being updated and the information from the 2005 plan (Table 4 below) appears as Table B-3 in Appendix B of the draft 2011 SRSRP.

Per Table 4, it is noteworthy that 87.8 percent of the spawning documented over the last 24 years occurs between RM 22.8 (Rkm 20.1)and RM 48.1 (74.5). This correlates with the early action area identified in the Tucannon River Programmatic Habitat Project - Proposal Summary prepared by the SRSRB (Tucannon River Programmatic Habitat Project BiOp #2010-077-00). (NOTE: This project reach is considered an early action area for the proposal, with additional opportunity for downstream restoration below RM 22.8 as habitat conditions improve from upstream restoration measures, and as floodplain reconnection opportunities are further specified in design efforts described in more detail below).

Table 4. Spring/Summer Chinook Redd Distribution in the Tucannon River (1985-2009; Gallinat and Ross 2009).

Section	Rkm	Percent of Total Redds	Average Redds	Redds per Rkm
Mouth to Marengo (Lower)	0-20.1	0	0	0.0
Marengo	20.1-39.9	1.1	2	0.1
Hartsock	39.9-55.5	19.3	29	1.9
HMA	55.5-74.5	67.4	98	5.2
Wilderness	74.5-86.3	12.2	18	1.5
Upstream of Trap	> 59	60.7	87	
Downstream of trap	< 59	39.3	56	

Current life history diversity 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 then outmigrating as 1-year old smolts in the spring. Of interest is the apparent lack of winter rearing habitat and channel complexity (side channels, back water, pools, etc) and data that demonstrates the largest mortality occurs between egg and smolt with the majority of the mortality occurring between egg and parr. Alarming is that from brood year (BY) 1983 to BY 2003 on average less than 6 percent of spring Chinook survived from egg to smolt (Gallinat and Ross 2010).

Increased habitat complexity is expected to provide more opportunities for successful expression of additional life histories (e.g. resident form, and multiple age classes at outmigration) as well as improve survival of these life histories.

It is not the intent of this habitat programmatic to define conditions of habitat at individual project areas but rather it is a programmatic approach at restoring properly functioning conditions with a strong emphasis on the spring Chinook spawning and rearing area. The programmatic describes an adaptive management approach where work will be prioritized and then locations and type of work done may change as conditions improve and information is gathered.

Response to Item #3: Selection of habitat restoration actions: (A) justification for a program to identify and support projects in the future, (B) details about the composition of the review committee, (C) the criteria they will employ in project selection and (D) overall program structure and governance.

Justification for a Program to Identify and Support Projects in the Future; Details about the Composition of the Review Committee; and Overall Program Structure and Governance

These portions of Item #3 were addressed in the Snake River Salmon Recovery Board (SRSRB) response dated January 2011. The March 2011 ISRP response (ISRP 2011) indicated the SRSRB January 2011 response adequately addressed this topic.

(C) Process for Identifying Projects and Selecting Projects, Including Criteria

Selection of habitat restoration actions will be identified through the Anchor QEA Tucannon Habitat Restoration study currently underway for reaches 6 through 10. This study builds off the Tucannon River Geomorphic Assessment and Habitat Restoration Study described above (Anchor QEA 2011). An additional study to address reaches 1 through 5 is planned for no later than 2013 with the possibility of the current Anchor QEA study also being completed in 2011 along with reaches 6 to 10. Conceptual restoration projects will be identified for these reaches.

These projects will be shared with and prioritized by the Regional Technical Team (RTT) based upon criteria that will be developed collaboratively by the RTT and the consultant team in the summer of 2011. Criteria will be developed based upon VSP objectives. Criteria would be developed around the following physical improvements:

1. Improved spawning habitat and increased suitable spawning area.
2. Reconnection of side channels to provide off-channel rearing.
3. Increased habitat complexity and quality to support all applicable life stages.
4. Restored geomorphic processes for floodplain connection and energy dissipation.
5. Improved temperature conditions.
6. Riparian function, condition, size and connectivity improvements.
7. Improved connections to key habitats.

A three-tiered prioritization approach will be applied, with Tier 1 projects being the highest priority.

Specific criteria will be developed and utilized in the prioritization framework, and this will provide the basis for evaluating and funding future habitat actions. Other factors such as landowner support, readiness to proceed, project expected durability, cost share availability, and cost/benefit will also be important considerations.

(A) Structure and governance
Projects will be reviewed and selected for funding by the RTT and SRSRB. The RTT reviews the proposed projects for consistency with technical criteria (to be developed as described above), restoration priorities and findings from RM&E efforts, and then makes funding recommendations to SRSRB.

(B) Review Team Composition
The RTT includes technical experts from Washington State Department of Fish and Wildlife (WDFW), Confederated Tribes of the Umatilla Indian Reservation (CTUIR), U.S. Forest Service (USFS), National Oceanic and Atmospheric Administration (NOAA) and consultants. RM&E results will be reviewed and evaluation criteria adjusted (at least annually), based upon improved understanding and results from performance monitoring as discussed further below.

Response to Item #4: Research, Monitoring and Evaluation (R&ME): (A) description of the RM&E program including interaction with ISEMP and (B) a decision framework for modifying restoration actions if sufficient improvement does not occur.

(A) Description of the RM&E program including interaction with ISEMP

The Tucannon Habitat Restoration Project was not specifically designed to determine the specific linkages between restoration actions and site level fish responses.

Determining linkages and specific mechanisms of fish responses to restoration with empirical data is the goal of numerous within basin and out of basin Intensively Monitored Watersheds Projects (e.g., Asotin, Entiat, Lemhi, and Potlatch IMWs). However, we propose series of actions to determine if any increase in Chinook abundance is related to restoration actions. These actions include: (1) comparison of adult returns and juvenile densities between the Tucannon and untreated watersheds (see "Control Watershed" below); and (2) spatially referencing redd counts in treatment and control reaches pre and post restoration. The comparison with untreated watersheds (i.e., limited restoration or supplementation taking place) and the Tucannon River will allow us to separate restoration effects from naturally variability. Spatially referencing existing redd counts using hand-held global positioning system (GPS) will allow us to make inferences about changes in the density of redds in restoration and control reaches and potentially selection of spawning sites within reaches related to specific restoration features (e.g., new side channels, engineered log jams, etc.).

Control Watersheds

The Independent Scientific Review Panel (ISRP) and the Independent Scientific Advisory Board (ISAB) have stated the need for a comprehensive evaluation of the use of supplementation as a recovery tool for depressed salmon populations in the Columbia River basin (ISRP and ISAB 2005). Development of a comprehensive supplementation evaluation plan was undertaken in 2006-2008 by fisheries researchers and managers. They concluded that there is an "insufficient effort within the basin" to obtain estimates for relative reproductive success (RRS) from non-supplemented (reference) streams, against which RRS values for natural origin fish in supplemented populations can be compared (Beasley et al. 2008). This evaluation would partially meet the regional desire to address programmatic concerns regarding hatchery production and the ESA.

In order to assess the effects of supplementation, comparisons of a number of treated versus untreated streams may be the best method of detecting differences in long-term fitness attributable to supplementation programs (Galbreath, et al., 2006). One approach is to analyze data for parameters collected from a number of treated (supplemented) and reference (i.e., non-supplemented) streams across the basin. Galbreath, et al. (2006) noted that one of the difficulties in evaluating monitoring data for supplementation programs is the limited availability of reference streams. These reference streams provide the best opportunity to determine if there is a change in reproductive success or productivity as a result of supplementation.

Within this context, data from ongoing Lower Snake River Compensation Plan (LSRCP)-funded evaluations are available to populate comparisons between LSRCP supplemented streams and appropriate reference streams, if and when they can be found. Possible reference streams were identified for Tucannon spring Chinook in 2009 (Yakima, Salmon, Wenaha and Upper Columbia River basin tributaries) but the data must be analyzed to determine which of the rivers can serve as reliable references.

The following response describes the RM&E program that is currently being implemented in the Tucannon Watershed. We present this response in four parts: (1) changes in RM&E since 2004; (2) stream habitat monitoring; (3) biological monitoring; and (4) restoration project implementation monitoring.

1. Status of RM&E recommendations since 2004

A series of recommendations were made in 2004 in regards to the RM&E activities in the Tucannon watershed as part of the RME categorical review process. Below is a list of the recommendations and a description of whether they have been implemented as well as the rational for those decisions.

A. *"Fund and implement habitat inventories to collect data necessary to fill data gaps for attributes with high EDT model leverage and evaluation of progress toward subbasin plan objectives."*

Since 2004, several habitat inventories have occurred to fill data gaps for attributes with high EDT model leverage that will be used to evaluate progress toward subbasin and recovery plan objectives. Specifically, the Columbia Conservation District (CCD) has funded the collection and data analysis of suspended sediment using an ISCO gauge at Marengo Bridge. The CCD funded a substrate embeddedness inventory that was conducted by the USFS and several habitat effectiveness studies conducted by WDFW. Additionally, the SRFB funded the previously mentioned geomorphic assessment and LiDAR acquisition of the entire watershed. These inventories will be used to detect change in channel planform which is highly related to the restoration work planned in the Tucannon. Washington Department of Ecology (DOE) installed a continuous, telemetered instream flow monitoring device at Marengo and will conduct habitat status and trend monitoring in 2011. The BPA funded Columbia Habitat Monitoring Program (CHaMP) selected the Tucannon as one of the pilot watersheds in which habitat inventories and monitoring will occur. The CHaMP and DOE habitat inventories and monitoring programs are described in greater detail in the response to Item #4 below, and results from these efforts will also provide monitoring information for evaluating progress.

B. *"Continue to fund existing monitoring and evaluation actions within the subbasin that fulfill critical VSP data needs."*

We are continuing adult and juvenile Chinook 'fish-in fish-out' monitoring in the watershed which provide the basis of information related to VSP data needs. These programs are described below.

C. *"Fund and implement additional actions to complete basic population status monitoring needs for the sub-basin (e.g., monitor adult escapement into the Tucannon basin). To fulfill this example, the specific actions or improvements listed below may be needed:*

   a. *Adult counting or trap at Starbuck dam; and*
   b. *Smolt trap in upper Tucannon above hatchery Intake Dam*

These additional monitoring actions have not been implemented. Trapping adult spring Chinook is not without risks, with the greatest one being fish rejecting the trapping facility and leaving the basin or spawning in downstream unsuitable habitat, or not at all. We already have data showing PIT-tagged Tucannon fish are not returning to the basin. For these reasons, an adult trap has not been installed in the lower Tucannon. Trapping adults in the ladder at the Starbuck Dam remains a possibility but it is at RM 6.2 (Rkm 10) and the likelihood of artificially high counts is a concern because of adult salmon that may "dip in" but not be destined for the Tucannon watershed. This could result in fish that are not native to the Tucannon spawning above the weir, resulting in negative genetic consequences. Fish denial, artificial counts,genetic consequences, and funding are the reasons adult trapping in the lower Tucannon has not occurred.

A smolt trap above the hatchery intake dam has not occurred due to funding constraints. If funding were available, this smolt trap would be paired with the adjacent adult trap where we could calculate survival estimates for a fairly small but productive reach of habitat. Informally, National Marine Fisheries Service (NMFS) is concerned that additional trapping and associated handling may be a greater risk than the information learned.

2. Stream Habitat Monitoring Description

As noted in the SRSRB January response, the ISRP rightfully noted that the RM&E effort associated with this project lacks sufficient detail. The comments include a request for more specific information on how coordination will occur between the proposed Tucannon RM&E effort and ISEMP. The Columbia Habitat Monitoring Program (CHaMP), developed by ISEMP, will be implemented in the Tucannon River in 2011 and the program is expected to run for nine years (Bouwes et al. 2011). The CHaMP program is designed as a Columbia River basin-wide habitat status and trends monitoring program built around a single protocol with a programmatic approach to data collection and management (RM&E Workgroup 2010). CHaMP will result in the collection and analysis of systematic habitat status and trends information that will be used to assess basin-wide habitat conditions. When coupled with biological response indicators, this status and trends information will be used to evaluate habitat management strategies. This program will be integrated with ongoing Pacific Northwest Aquatic Monitoring Program (PNAMP) recovery planning efforts and will be part of the collaborative process across Columbia Basin fish management agencies and tribes and other state and federal agencies that are monitoring anadromous salmonids and/or their habitat. The implementation of CHaMP will characterize stream responses to watershed restoration and/or management actions in at least one population within each steelhead and spring Chinook Major Population Group (MPG) and will have 'fish-in' and ‘fish-out’ monitoring. CHaMP was designed to deliver trends in habitat indicators and requires that monitoring occurs for three cycles of a sampling panel.

The site selection process for CHaMP has been completed in the Tucannon and all the sites are restricted to the Chinook domain as identified in the Tucannon subbasin plan (see Attachment 2, Figure 2-1). This coincides well with the main emphasis of this project., to fill the productivity gap for spring Chinook. The sites were selected using a GRTS design by P. Larsen of NOAA and the entire Tucannon Chinook domain includes 98 possible 1-kilometer long sample sites of which we will be sampling 45 (45.9 percent) over 9 years (Attachment 2, Figure 2-1). We also strategically located sites in known restoration reaches and areas that will not be restored in the next several years to act as controls. We allocated 9 CHaMP sites within control reaches and 9 sites to restoration reaches in a paired design; GRTS designated sites were randomly selected within each of the treatment and control reaches. The remaining CHaMP sites are located in the mainstem (15 sites) that could be either restoration or control sites depending on future restoration actions, and to the lower reaches of tributaries (12 sites). Sites were also allocated within the mainstem Tucannon based on three stream gradient classes (e.g., < 0.5 percent, 0.5 to 1.0 percent, and > 1.0 percent). Further details of the CHaMP design can be provided on request.

The CHaMP protocol has two basic components: topographic surveys and habitat unit surveys. The topographic surveys will use total stations and monumented bench marks to collect detailed topographic surveys of the stream channel and stream bathymetry. These data will be imported into ARC GIS and the River Bathymetry Tool Kit (http://www.essa.com/tools/RBT/index.html) will be used to generate summary statistics for wetted and bankfull widths, sinuosity and a variety of other channel metrics (Attachment 2, Table 2- 1 CHaMP Protocol). The relationship between these metrics and other attributes collected during CHaMP surveys and their relationship to all life stages of salmon growth, survival, and spawning success are summarized in the CHaMP protocol (Attachment 2, Tables 2-2 to 2-5) (from Appendix C of CHaMP). The topographic data will also be used to create digital elevation models (DEM) of each stream reach before and after restoration. By subtracting post restoration DEMs from pre restoration DEMs, changes in channel form and scour/deposition can be detected. The detailed topographic data can also be combined with LiDAR data collected along the mainstem (Anchor 2011) to assess changes in channel and floodplain connectivity.

The habitat unit data will be very similar to other habitat monitoring efforts (PIBO, EMAP, etc.) but will have the added advantage of being spatially referenced and each attribute will be associated with habitat units (pools, riffles, rapids, etc). Standard metrics such as pool volume, pieces of large woody debris/100-meter, substrate composition, and percent fines will be summarized pre and post restoration to make inferences about changes in habitat conditions due to restoration (Attachment 2 - Table 2-1 CHaMP). Because of the high density of sampling and our strategic pairing of sites in restoration and control areas, we are confident that this design will be highly sensitive to changes due to restoration.

The CHaMP protocol is designed to answer specific questions about the status and trend of stream habitat within the Chinook domain. The Washington Department of Ecology (Ecology) will also be initiating a stream habitat monitoring program in the Tucannon in 2011. The Ecology sampling frame is much larger than the CHaMP sampling frame but also uses the generalized random tessellation stratified (GRTS) design (http://www.ecy.wa.gov/programs/eap/stsmf/). The Ecology sample frame includes all freshwater wadeable streams that have perennial flow, are in the NHD layer, not on federal land, and within strahler order 0-4. Unlike CHaMP, the Ecology protocol also calls for one-pass electroshocking to assess relative abundance of aquatic vertebrates (see below). We will use the Ecology information to provide context on the status of Tucannon tributaries outside the Chinook domain.

3. Biological Monitoring Description

Three types of biological monitoring are currently being conducted to support the Tucannon Habitat Restoration program: (1) Juvenile fish monitoring; (2) Adult fish monitoring; and (3) Prey resource monitoring.

The WDFW has been conducting adult and juvenile monitoring at the watershed scale since 1985 (Gallinat and Ross 2010). These monitoring efforts include three survey types: (1) redd counts; (2) adult trapping; and (3) juvenile trapping. Combined, these monitoring efforts provide fish-in fish-out metrics which can be used to calculate metrics relevant to VSP goals. The CHaMP program will also include surveys of invertebrate drift to assess food availability for juvenile salmonids (Bouwes et al. 2011). Below, we describe these survey approaches as they relate to VSP goals.

<u>Abundance</u> – Estimates of total adult abundance (i.e., the numbers of returning fish, known as escapement) are based on carcass counts on spawning grounds (using an approach termed "area under the curve"), numbers of fish harvested by cohort, and results from an adult trap. Spawning ground surveys are typically conducted from RM 12.5 (Rkm 20.1) to RM 53.6 (Rkm 86.3) (Gallinat and Ross 2010). During these spawning ground surveys, WDFW collects information on sex and age structure for use in estimating production by cohort or year-class. Because of the current practice of releasing hatchery fish in the Tucannon and allowing large numbers of fish to spawn naturally, it is also important to document the proportion of wild-spawning fish that are of hatchery vs. natural origin (i.e., HORs and NORs). With the onset of mass marking several years ago, this is done by tracking the numbers of 'adipose fin-present' versus 'adipose fin-absent' fish. An adult trap is also operated at RM 36.7 (Rkm 59) where returning Tucannon hatchery salmon were identified by coded-wire tag (CWT) in the snout or presence of a visible implant elastomer tag. Adipose clipped fish were killed outright as strays. All other Chinook are passed upstream and data is collected on length, weight, and sex.

<u>Life Cycle Productivity</u> – Data needed to estimate life cycle productivity includes a time series (ideally of 20 years or more) of abundance of returning fish (including those harvested) sorted by cohort or year class. This basic census information allows run reconstruction and estimation of the numbers returning adults in sequential generations (i.e. the number of adults produced by the previous generation.)

Although overall life cycle productivity is the population parameter that NMFS considers under its VSP policy, much information can also be gained by distinguishing productivity between the freshwater life phase and the marine phase. Indeed, it is freshwater productivity that would be most affected by proposed habitat restoration activities. Estimation of freshwater productivity requires relating the numbers of spawning adults to the numbers of smolts that are produced and migrate to the marine environment. Estimating the numbers of outmigrating smolts typically requires the operation of smolt traps in the lower reaches of a river and the ability to distinguish between hatchery and natural origin smolts. WDFW has operated a smolt trap in the Tucannon at Rkm 3 since 1985. Hatchery smolts are also tagged with PIT tags to estimate migration timing.

Smolt-to-adult return rates (SAR) of natural Chinook in the Tucannon are five times higher than for hatchery-reared salmon (Gallinat and Ross 2010). Hatchery SARs (mean = 0.21 percent; geometric mean = 0.18 percent) documented from the 1985-2004 broods were well below the LSRCP survival goal of 0.87 percent. Hatchery SARs for Tucannon River salmon need to substantially improve to meet the mitigation goal of 1,152 hatchery adult salmon. Increasing SAR rates for both natural and hatchery smolts is the goal of the restoration project.

<u>Diversity</u> – The current understanding of population structure and life history diversity in the Tucannon is limited to the division of outmigrants into life history trajectories based on rearing location and emigration timing. Hence, estimating life history diversity is probably best approached by estimating the abundance or relative proportions of the different life history trajectories (LHTs). This will be accomplished in at least two different ways:

- Operation of smolt trap to estimate the proportion of the different LHTs, and/or
- Analyzing scales from returning adults to determine early life history.

<u>Spatial Structure</u> – Another characteristic of fish that contributes to life history diversity is spawning distribution. As new spawning habitat is created or restored, this also represents an expansion of life history diversity. In 2005, in anticipation of improved habitat and expanded spawning distribution, WDFW began conducting weekly redd surveys down to King Grade at RM 21 (Rkm 34.1). Prior to 2005, only occasional redd surveys were conducted downstream of Marengo which is located at RM 26 (Rkm 39.9). Further, WDFW is now conducting redd surveys below King Grade, down to Enrich Road near the end of the spawning season to ensure that they are not missing redds in this downstream reach. WDFW has committed to conducting weekly redd surveys downstream of King Grade if data indicate that Chinook begin spawning in this lower reach.

Spatial structure and distribution is a very straightforward VSP parameter to estimate. It will be based on spawning ground surveys to estimate the geographical extent of habitat usage.

(B) decision framework for modifying restoration actions if sufficient improvement does not occur

We plan to utilize a responsive, adaptive management strategy to determine what future habitat work to fund as we evaluate the progress of the project, in the context of all habitat work being funded in the basin, both BPA, and non-BPA. This will both help us decide how to better implement specific actions ourselves, and how to prioritize amongst a suite of future potential actions.

4. Project Implementation Monitoring and Decision framework/decision tree Program

This section describes how project implementation monitoring and restoration effectiveness monitoring will be implemented.

A. Each restoration reach has or will have a specific set of objectives developed (e.g., number of pieces of LWD to be added, km of side channel to be reconnected, etc.). Once the restoration actions have been implemented, post project assessments will be conducted to verify that the actions as designed have been implemented to design specifications.

B. Findings from all RM&E efforts will be linked into a decision framework to improve restoration actions over time. An adaptive management process will be followed using the information derived from physical and biological effectiveness monitoring to inform the design and implementation of future projects of a similar nature. If the desired outcome is not achieved, the general approach is to conduct a detailed evaluation of the data, explore potential reasons for the incomplete outcome, and prepare a list of recommended changes deemed necessary to achieve the desired outcome in future projects. These recommendations would be vetted with the RTT and Tucannon Coordination Committee. Updated approaches could include revised project evaluation criteria, revised project priorities, improved monitoring methods and other applicable changes.

Additionally, the SRSRB leadership team will continue to coordinate efforts with WDFW, CTUIR and others involved in trying to more specifically understand the causes for the existing low R/S value for the Tucannon, and findings from this effort will be incorporated into updated plans. Trends will continue to be tracked over time. In particular, ongoing Intensively Monitored Watershed Projects may provide valuable data of fish responses to a variety of restoration actions we are proposing such as levee setbacks (e.g., Entiat IMW) and addition of LWD (e.g., Asotin IMW).

References

AA/NOAA/NPCC RM&E Workgroup, 2010. *Recommendations for Implementing Research, Monitoring and Evaluation for the 2008 NOAA Fisheries FCRPS BiOp*. Portland, Oregon.

Anchor QEA, 2011. *Tucannon River Geomorphic Assessment and Habitat Restoration Study*. April 2011.

Bouwes, N., J. Moberg, N. Weber, B. Bouwes, S. Bennett, C. Beasley, C.E. Jordan, P. Nelle, M. Polino, S. Rentmeester, B. Semmens, C. Volk, M.B. Ward, and J. White, 2011. *Scientific protocol for salmonid habitat surveys within the Columbia Habitat Monitoring Program*. Prepared by the Integrated Status and Effectiveness Monitoring Program and published by Terraqua, Inc., Wauconda, Washington.

Ecology (Washington State Department of Ecology), 2010. *Tucannon River and Pataha Creek Temperature Total Maximum Daily Load*. Publication no. 10-10-019. July 2010.

FCRPS (Federal Columbia River Power System), 2011. 2010-2013 FCRPS BiOp Implementation Plan. Accessed in June 2011 from: http://www.salmonrecovery.gov/BiologicalOpinions/FCRPS/BiopImplementation.aspx.

Gallinat and Ross, 2010. *Tucannon River Spring Chinook Salmon Hatchery Evaluation Program 2009 Annual Report*. Prepared for U.S. Fish and Wildlife Service Lower Snake River Compensation Plan Office 1387 S. Vinnell Way, Suite 343 Boise, Idaho 83709 Cooperative Agreement: 1411-09-J012.

ISRP (Independent Scientific Review Panel), 2011. *Memorandum (ISRP 2011-8) to Bruce Measure, Chair, Northwest Power and Conservation Council from Eric Loudenslager, ISRP Chair re: Final Review of the BiOp proposal, Tucannon River Programmatic Habitat Project (#2010-077-00)*. March 11, 2011.

NOAA (National Oceanic Atmospheric Administration), 2008. *2008 FCRPS BiOp.* Accessed June 2011 from: http://www.salmonrecovery.gov/BiologicalOpinions/FCRPS/2008Biop.aspx.

NPCC (Northwest Power and Conservation Council), 2011. *Tucannon Subbasin Plan*. Accessed in June 2011 from: http://www.nwcouncil.org/fw/subbasinplanning/tucannon/plan/.

Roni, P., T. J. 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*. 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 (Snake River Salmon Recovery Board), 2010. Proposal Summary – Tucannon River Programmatic Habitat Project. July 2010.

SRSRB (Snake River Salmon Recovery Board), 2011a. *Response from Steve Martin, Executive Director of the SRSRB, to ISRP comments on the BiOp proposal, Tucannon River Programmatic Habitat Project*. January 2011.

SRSRB (Snake River Salmon Recovery Board), 2011b. Email communication with Kris Buelow regarding updated data on fish species distribution and life history in the Tucannon River basin. March 28, 2011.

SRSRB (Snake River Salmon Recovery Board), 2011c. *Snake River Salmon Recovery Plan, Draft*. Appendix B. Current Status Assessment of Southeast Washington Management Unit Populations. April 6, 2011.

SRSRB (Snake River Salmon Recovery Board), 2011d. *Snake River Salmon Recovery Plan*. Accessed in June 2011 from: http://www.snakeriverboard.org/recovery_plan/plandec06.html.

USGS (United States Geological Survey), 2010. *Streamstats in Washington.* Accessed in June 2011 from: http://water.usgs.gov/osw/streamstats/Washington.html.

US&R (Urban Search and Rescue), 2011. *Structural Collapse: Job Performance Requirement Task Time Maximums*. Table 19. Accessed on June 13, 2011 from: http://www.fws.gov/lsnakecomplan/Reports/WDFW/Eval/05AnnualRept.pdf.

Attachment 1

Reach-specific Restoration Recommendations Tables

Table 1-1. Restoration Recommendations for Reach 1 Rm 0 to 0.7

Restoration Framework Actions	Priority for This Reach	Recommendations	Restoration Actions
1. Protect and maintain natural processes	Lower	The reach is backwater-dominated with little riparian vegetation to protect.	TBD by 2013
2. Connect disconnected habitat	Lower	Disconnected habitat areas do not exist in Reach 1, except for areas that get inundated frequently.	TBD by 2013
3. Address roads, levees, other anthropogenic infrastructure impairing processes	Lower	Reach 1 is not impacted by infrastructure.	TBD by 2013
4. Restore riparian processes	High	Riparian areas are severely degraded through most of the reach due to historic clearing of trees. Restoration efforts in this reach should be focused on riparian restoration; frequent inundation should be considered when developing appropriate restoration plans.	TBD by 2013
5. Improve instream habitat conditions	High	Backwater conditions and channelization lead to a highly simplified channel that lacks complexity. LWD structures are recommended to add complexity to the channel and provide cover.	TBD by 2013

Not sure we need the Restoration Actions column – all the "TBD by 2013"s just make me wonder what is meant – will you determine whether you'll implement the recommendations, or will you actually implement? It doesn't seem to add much value, and getting all this stuff done (even just determining whether you'll implement or not) could be a difficult challenge, especially for all the ones you're saying will be done in 2011.

Table 1-2. Restoration Recommendations for Reach 2, Rm 0.7 to 4.5

Restoration Framework Actions	Priority for This Reach	Recommendations	Restoration Actions
1. Protect and maintain natural processes	Lower	Riparian areas currently in the CREP program should be maintained and protected.	TBD by 2013
2. Connect disconnected habitat	High	Potential opportunities to reconnect wetlands and former mainstem and side channels in Reach 2 are near RM 4.0 and 1.3. Developing a more complex channel planform will promote more natural sediment transport dynamics and decrease channel velocities.	TBD by 2013
3. Address roads, levees, other anthropogenic infrastructure impairing processes	High	Levees, dredge spoils, and the Highway 261 road grade are the primary types of infrastructure impacting natural processes in Reach 2. In addition, smaller berms impact channel migration but likely have no effect on flooding. The greatest amount of confinement in the reach is related to Highway 261 and a former railroad grade between RM 1.7 and 2.1.	TBD by 2013
4. Restore riparian processes	Medium	Restoration of riparian conditions should be evaluated, although it is not a primary restoration goal for Reach 2. The most degraded conditions are located downstream of the Highway 261 crossing.	TBD by 2013
5. Improve instream habitat conditions	High	Although LWD is present in Reach 2, additional LWD should be installed to force pools and maintain channel complexity. LWD will distribute flow, maintain sediment transport, and provide hydraulic refuge.	TBD by 2013

Table 1-3. Restoration Recommendations for Reach 3, Rm 4.5 to 8.9

Restoration Framework Actions	Priority for This Reach	Recommendations	Restoration Actions
1. Protect and maintain natural processes	Lower	The area between RM 6.6 and 7.9 may be targeted for protection; however, the existing riparian area in this location lacks diverse and mature vegetation.	TBD by 2013
2. Connect disconnected habitat	Medium	Reach 3 has limited opportunities to reconnect wetlands and former mainstem and side channels. Most opportunities are associated with infrastructure, and are therefore described in the following restoration framework action.	TBD by 2013
3. Address roads, levees, other anthropogenic infrastructure impairing processes	High	97% of the length of Reach 3 has been categorized as confined. Levees and other anthropogenic infrastructure highly impacts natural processes in the reach; channelization and dredging has greatly contributed to this impact Setting back levees through the reach should be evaluated as a part of a comprehensive plan and considered during redevelopment. Due to the confined, modified nature of the channel through this reach, any opportunity to increase the available floodplain area should be evaluated. Potential disconnected floodplain areas include near RM 8.9, from RM 6.6 to 7.2, RM 5.6 to 5.9, and near RM 5.2.	TBD by 2013
4. Restore riparian processes	High	Riparian processes are degraded through most of the reach due to historic clearing of trees and encroachment of infrastructure on the floodplain. Efforts should be made to restore riparian areas where feasible.	TBD by 2013
5. Improve instream habitat conditions	High	LWD is insufficient throughout Reach 3. LWD should be installed to force pools and maintain channel complexity, particularly where there is little opportunity for LWD to naturally accumulate due to the high transport capacity through the confined channel.	TBD by 2013

Table 1-4. Restoration Recommendations for Reach 4, RM 8.9 to 13.2

Restoration Framework Actions	Priority for This Reach	Recommendations	Restoration Actions
1. Protect and maintain natural processes	Medium	Protecting and maintaining natural processes should occur from approximately RM 9.0 to 10.8 and near 11.7 where the channel is mostly unconfined and the channel and floodplain processes presently occurring are providing high value.	TBD by 2013
2. Connect disconnected habitat	Lower	Disconnected habitats are generally not present, although further evaluation is required to confirm.	TBD by 2013
3. Address roads, levees, other anthropogenic infrastructure impairing processes	High	Anthropogenic infrastructure impairing natural processes is primarily associated with the levee extending from approximately RM 10.8 to 11.5. Setting back this levee should be evaluated as to its potential benefit.	TBD by 2013
4. Restore riparian processes	Medium	Restore riparian conditions where vegetation is degraded, in particular between RM 10.9 and RM 11.5 where the floodplain is highly confined.	TBD by 2013
5. Improve instream habitat conditions	High	In the confined reach and in sections of the reach lacking sufficient LWD, install LWD to force pools and maintain channel complexity.	TBD by 2013

Table 1-5. Restoration Recommendations for Reach 5, Rm 13.2 to 20.0

Restoration Framework Actions	Priority for This Reach	Recommendations	Restoration Actions
1. Protect and maintain natural processes	Lower	Protecting and maintaining natural processes should occur from approximately RM 17.5 to 18.5 where the channel is mostly unconfined and the channel and floodplain processes presently occurring are providing high value. In addition, the area near the mouth of Willow Creek should be considered for protection.	TBD by 2013
2. Connect disconnected habitat	Medium	Reach 5 has limited opportunities to reconnect wetlands and former mainstem and side channels. The most significant area identified is near RM 15.8; this location should be evaluated for potential benefit.	TBD by 2013
3. Address roads, levees, other anthropogenic infrastructure impairing processes	High	Through most of the reach the road is located outside of the floodplain or up on the hillside. Several levees are present that appear to limit the available floodplain and potential side channel habitat; the most significant of these locations are near RM 14.4 and RM 16.7.	TBD by 2013
4. Restore riparian processes	Medium	Restore riparian conditions where vegetation is degraded, in particular between RM 18.8 to 19.7, and from RM 13.4 to 14.4.	TBD by 2013
5. Improve instream habitat conditions	High	In confined, channelized sections and sections of the reach lacking sufficient LWD, install LWD to force pools and maintain channel complexity.	TBD by 2013

Table 1-6. Restoration Recommendations for Reach 6, RM 20.0 to 27.5

Restoration Framework Actions	Priority for This Reach	Recommendations	Restoration Actions
1. Protect and maintain natural processes	Medium	Healthy riparian areas in Reach 6, including an approximately 3-mile length between RM 22.1 and 25.0 should be protected. The dynamic nature of channel migration in Reach 6 combined with the relatively high amount of mature vegetation provides opportunity for riparian recruitment and self-sustaining natural processes in the long term.	TBD in 2011
2. Connect disconnected habitat	High	The reach appears to have several opportunities to reconnect large areas of wetlands and former mainstem and side channels, including near RM 24.8, 24.3, and 22.8.	TBD in 2011
3. Address roads, levees, other anthropogenic infrastructure impairing processes	Medium	Throughout most of the reach, the road is located outside of the floodplain or up on the hillside. Some levees are present and appear to isolate floodplain and potential side channel habitat; the most significant of these locations is near RM 25.4.	TBD in 2011
4. Restore riparian processes	Lower	A majority of the riparian area in Reach 6, although not ideal, is relatively healthy compared to other reaches. The most degraded riparian area in Reach 6 is between RM 25.8 and 26.4; this area may be evaluated for restoration benefit.	TBD in 2011
5. Improve instream habitat conditions	High	In areas of the reach lacking sufficient LWD, install LWD to force pools and maintain channel complexity.	TBD in 2011

Table 1-7. Restoration Recommendations for Reach 7, RM 27.5 to 32.1

Restoration Framework Actions	Priority for This Reach	Recommendations	Restoration Actions
1. Protect and maintain natural processes	Lower	Healthy riparian areas that should be protected are located between RM 28.8 and 29.1, and between 30.4 and 30.9.	TBD in 2011
2. Connect disconnected habitat	Medium	The reach has limited opportunities to reconnect wetlands and former mainstem and side channels. Potential areas to be evaluated for restoration benefit are located near RM 28.6, and 31.7.	TBD in 2011
3. Address roads, levees, other anthropogenic infrastructure impairing processes	High	Throughout most of the reach, the road is located along the valley margin outside of the floodplain. We suggest careful consideration be given to bridge spans and approach areas when highway improvements occur, as many crossings appear to constrict the channel. In addition, there appears to be two roadway realignments that would significantly remove the roadway from the floodplain; RM 27.5 to 28.3 and 30.3 to 31.	TBD in 2011
4. Restore riparian processes	Medium	Restore riparian conditions where vegetation is degraded, in particular between RM 29.1 and 29.9, and 30.1 and 30.3.	TBD in 2011
5. Improve instream habitat conditions	High	In confined, channelized sections and sections of the reach lacking sufficient LWD, install LWD to force pools and maintain channel complexity.	TBD in 2011

Table 1-8. Restoration Recommendations for Reach 8, Rm 32.1 to 40.0

Restoration Framework Actions	Priority for This Reach	Recommendations	Restoration Actions
1. Protect and maintain natural processes	Lower	Limited to current forest management BMPs and riparian development; while not necessarily associated with natural processes, it is assumed that Spring Lake, Rainbow Lake, and the hatchery area will also be targeted for protection.	TBD in 2011
2. Connect disconnected habitat	High	The floodplain in Reach 8 contains many opportunities to reconnect wetlands and former mainstem and side channels. The most prominent of these are located near RM 38.6, 37.5, and 36.7 to 39.0. These areas should be evaluated to determine to potential benefit of reconnection.	TBD in 2011
3. Address roads, levees, other anthropogenic infrastructure impairing processes	High	Confining structures that significantly influence floodplain connectivity should be evaluated and removed or modified. The most significant confinement and constriction areas are between 39.1 and 40, and at the Tucannon Road crossing at the confluence of Cummings Creek. We recognize that many of the confining structures are providing protection for vital anthropogenic infrastructure. We suggest careful consideration be given to bridge spans and approach areas when highway improvements occur.	TBD in 2011
4. Restore riparian processes	Lower	Restore riparian conditions where vegetation is degraded, in particular between RM 33.2 and 34.3 and between RM 34.3 and 35.6.	TBD in 2011
5. Improve instream habitat conditions	High	In areas of reach lacking sufficient LWD, install LWD to force pools and maintain channel complexity.	TBD in 2011

Table 1-9. Restoration Recommendations for Reach 9, RM 40.0 to 44.0

Restoration Framework Actions	Priority for This Reach	Recommendations	Restoration Actions
1. Protect and maintain natural processes	Medium	Limited to current forest management BMPs and riparian development; existing healthy riparian areas should be a medium priority because of the lack of shading provided in fire-affected areas.	TBD in 2011
2. Connect disconnected habitat	Medium	Reach 9 is relatively diverse with several secondary channels and off-channel areas that are likely accessible during high flows. However, the benefit of reconnecting wetlands and former mainstem and side channels near RM 42.6, 41.3, and 40.5 should be evaluated.	TBD in 2011
3. Address roads, levees, other anthropogenic infrastructure impairing processes	Medium	Confining structures that significantly influence floodplain connectivity should be evaluated and removed or modified. Evaluate Tucannon Road between RM 41.3 and 41.9) for impacts to floodplain connectivity. Removal or modification of the hatchery dam at the downstream end of Reach 9 was not considered because that structure is not believed to be a salmonid passage barrier.	TBD in 2011
4. Restore riparian processes	High	Aggressive restoration actions to improve riparian area affected by the School Fire.	TBD in 2011
5. Improve instream habitat conditions	High	In areas of reach lacking sufficient LWD, install LWD to force pools and maintain channel complexity.	TBD in 2011

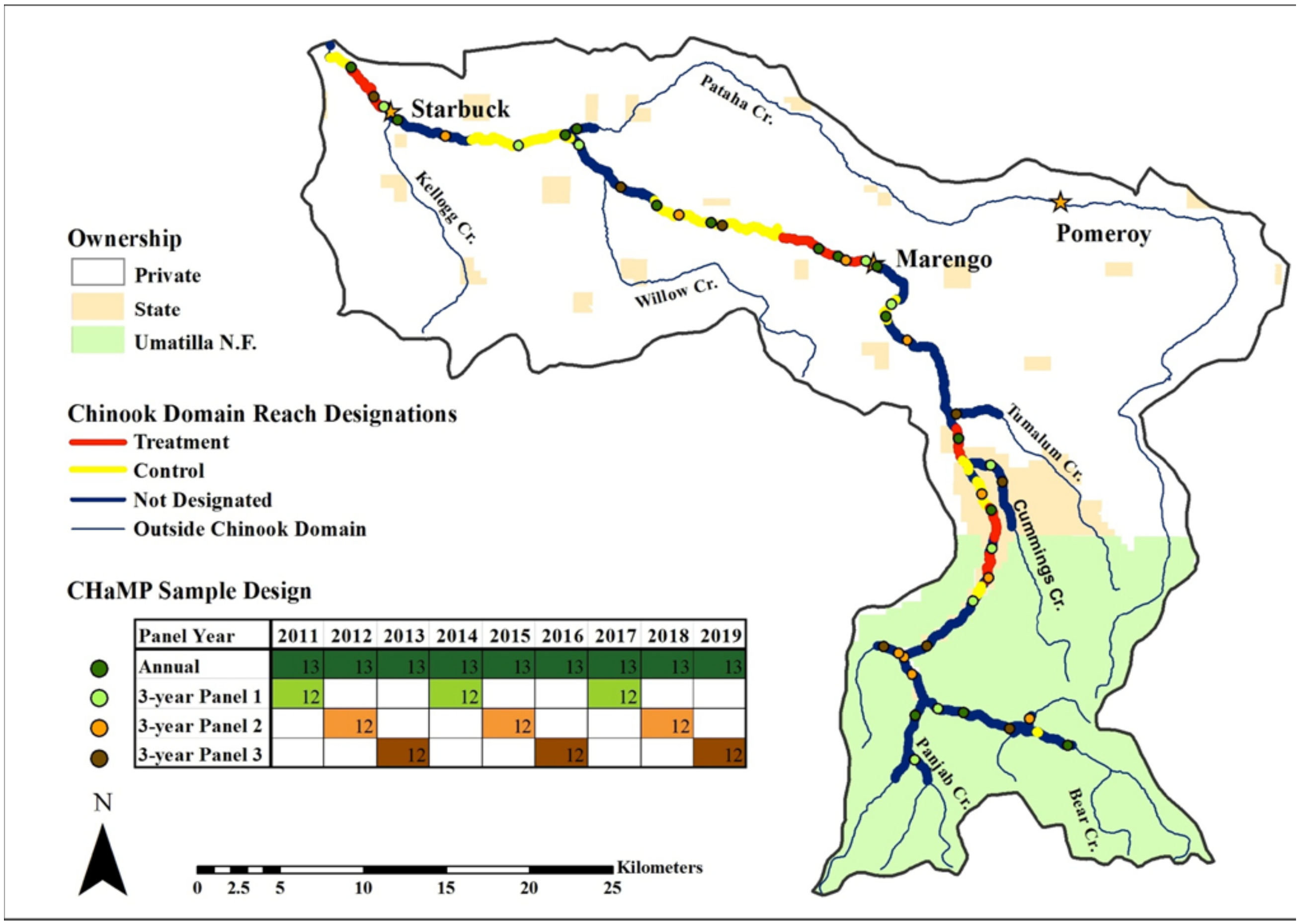
Table 1-10. Restoration Recommendations for Reach 10, RM 44.0 to 50.2

Restoration Framework Actions	Priority for This Reach	Recommendations	Restoration Actions
1. Protect and maintain natural processes	Lower-Medium	Limited to current forest management best management practices (BMPs) and riparian development.	TBD in 2011
2. Connect disconnected habitat	Medium	Evaluate the benefit of reconnecting wetlands and former mainstem and side channels near RM 47.5, 48.1, and 48.4 to 48.9.	TBD in 2011
3. Address roads, levees, other anthropogenic infrastructure impairing processes	Medium	Confining structures that significantly influence floodplain connectivity should be evaluated and removed or modified. Evaluate Tucannon Road near Tucannon Guard Station (between RM 43.9 and 45.2) for impacts to floodplain connectivity. Although the lakes, Camp Wooten, and the campground roads below the Camp downstream may pose significant impact to floodplain connectivity, it is assumed that it is not feasible to modify the levees or other infrastructure associated with these features. However, setting back or reconfiguring levees and lakes would increase the available floodplain area.	TBD in 2011
4. Restore riparian processes	Medium	Restore local riparian areas affected by anthropogenic activities in the lower reach downstream of Panjab Creek. Restore riparian areas lacking canopy cover due to disease.	TBD in 2011
5. Improve instream habitat conditions	High	In areas of reach confined by lakes where reconfiguring the lake's position is not possible, install LWD to force pools and maintain channel complexity.	TBD in 2011

Attachment 2

CHaMP Figures and Tables

Figure 2-1. CHaMP habitat survey locations within the Tucannon Chinook domain and the location of treat (restoration), control, and undesignated reaches.



Annual = sites that are monitored every year; 3 Year panel 1, 2, and 3 = equal sites that will be sampled in the 1st, 2nd, and 3rd year of a three year rotating panel. We will sample 25 sites a year - 15 annual sites and 10 rotating panel sites.

Table 2-1. The metrics and indicators used in the CHaMP protocol and the inference design underlying each indicator.

Indicator	Units	Inference Domain	Inference Design	Inference Method	Metrics	Indicator Generation Process	Software	Fish Response Category	Life Stage
Average Alkalinity	Milli-equivalent per liter	Survey frame	Mean, variance over inference domain, annually	Design-based	Site measurement of alkalinity	Estimated annually for entire survey frame with sampling design-based algorithm.	SP Survey	Survival	Parr to smolt
Average Conductivity	Micro-Siemens per meter	Survey frame	Mean, variance over inference domain, annually	Design-based	Site measurement of conductivity	Estimated annually for entire survey frame with sampling design-based algorithm.	SP Survey	Survival	Parr to smolt
Average pH	pH	Survey frame	Mean, variance over inference domain, annually	Design-based	Site measurement of pH	Estimated annually for entire survey frame with sampling design-based algorithm.	SP Survey	Survival	Parr to smolt
Growth Potential	Degree grams	Survey frame	Mean, variance over inference domain, annually	Design-based	Site measurement of drift biomass and temperature	Estimated annually for entire survey frame with sampling design-based algorithm for the product of drift macroinvertebrate biomass and temperature	SP Survey, Thermal Dynamic Model	Growth	Parr to smolt
Percent Below Summer Temperature Threshold	Percent	Survey frame	Total length estimated over survey domain, annually	Model-based	Year-round temperature logger data from sites	Model-based inference for all stream reaches in the watershed based on a continuous stream temperature model calibrated with site specific temperature logger data	Thermal Dynamic Model	Growth	Parr to smolt
Percent Above Winter Temperature Threshold	Percent	Survey frame	Total length estimated over survey domain, annually	Model-based	Year-round temperature logger data from sites	Model-based inference for all stream reaches in the watershed based on a continuous stream temperature model calibrated with site specific temperature logger data	Thermal Dynamic Model	Growth	Parr to smolt
Velocity Heterogeneity	Index	Valley type nested in survey frame	Mean, variance over inference domain, annually	Design-based	Modeled velocity heterogeneity at a site	Estimated annually for valley types nested in the survey frame with sampling design-based algorithm for variance Froude number across a site.	SP Survey, Hydrologic model	Growth	Parr to smolt

Indicator	Units	Inference Domain	Inference Design	Inference Method	Metrics	Indicator Generation Process	Software	Fish Response Category	Life Stage
Embeddedness of Fast water Cobble	Percent	Valley type nested in survey frame	Mean, variance over inference domain, annually	Design-based	Average of site embeddedness measurements	Estimated annually for valley type nested in the survey frame with sampling design-based algorithm for riffle cobble embeddedness.	SP Survey	Survival	Eggs/Alevin
Pool Frequency	Count per meter	Valley type nested in survey frame	Mean, variance over inference domain, annually	Design-based	Site measurement of pool frequency	Estimated annually for valley type nested in the survey frame with sampling design-based algorithm for pool frequency.	SP Survey, River Bathymetry Toolkit	Growth	Parr to smolt
Channel Complexity	Index	Valley type nested in survey frame	Mean, variance over inference domain, annually	Design-based	Site measurements of depth, width, and thalweg sinuosity	Estimated annually for valley type nested in the survey frame with sampling design-based algorithm for variance in depth, variance in width, and variance in thalweg sinuosity.	SP Survey, River Bathymetry Toolkit	Growth	Parr to smolt
Channel Score	Index	Valley type nested in survey frame	Mean, variance over inference domain, annually	Design-based	Site measurements of channel unit volume, LWD, and substrate	Estimated annually for valley type nested in the survey frame with sampling design-based algorithm metrics necessary for RP100 calculations as used by PIBO, AREMP, and EMAP.	SP Survey, River Bathymetry Toolkit	Growth	Parr to smolt
Residual Pool Volume	Cubic meter	Valley type nested in survey frame	Mean, variance over inference domain, annually	Design-based	Site measurement of residual pool volume	Estimated annually for valley type nested in the survey frame with sampling design-based algorithm for residual depth of all pools as given by the site DEM.	SP Survey, River Bathymetry Toolkit	Growth	Parr to smolt
Pool Tail Fines	Percent	Valley type nested in survey frame	Mean, variance over inference domain, annually	Design-based	Site measurement of pool tail fines	Estimated annually for valley type nested in the survey frame with sampling design-based algorithm for pool tail fines.	SP Survey	Survival	Eggs/Alevin
Total Drift Biomass	Gram per square meter	Survey frame	Mean, variance over inference domain, annually	Design-based	Site measurement of total drift biomass	Estimated annually for valley type nested in the survey frame with sampling design based algorithm for total drift biomass.	SP Survey	Growth	Parr to smolt
Bank Angle	Percent	Valley type nested in survey frame	Mean, variance over inference domain, annually	Design-based	Site measurement of bank angle	Estimated annually for valley type nested in the survey frame with sampling design-based algorithm for bank angle from site DEM and channel unit delineation.	SP Survey, River Bathymetry Toolkit	Growth	Parr to smolt

Indicator	Units	Inference Domain	Inference Design	Inference Method	Metrics	Indicator Generation Process	Software	Fish Response Category	Life Stage
LWD Volume	Cubic meter	Valley type nested in survey frame	Mean, variance over inference domain, annually	Design-based	Site measurement of LWD Volume	Estimated annually for valley type nested in the survey frame with sampling design-based algorithm for LWD volume.	SP Survey	Growth	Parr to smolt
Fish Cover	Percent cover	Survey frame	Mean, variance over inference domain, annually	Design based	Site measurement of fish cover	Estimated annually for valley type nested in the survey frame with sampling design-based algorithm for channel unit type and whole reach total fish cover.	SP Survey	Survival	Parr to smolt
Channel Unit Volume	Cubic meter	Valley type nested in survey frame	Mean, variance over inference domain, annually	Design-based	Site measurement of volume (DEM, photos, site map) and channel unit type	Estimated annually for valley type nested in the survey frame with sampling design-based algorithm for channel unit volume from site DEM and channel unit delineation.	SP Survey, River Bathymetry Toolkit	Growth	Parr to smolt
Channel Unit Complexity	Index	Valley type nested in survey frame	Mean, variance over inference domain, annually	Design-based	Site measurements of channel unit volume, LWD, and substrate	Estimated annually for valley type nested in the survey frame with sampling design-based algorithm for residual pool depth, pool tail fines and wood volume. A multivariate measure of channel unit complexity, similar to DSM approach applied by AREMP and PIBO to habitat metrics to capture complexity.	SP Survey, River Bathymetry Toolkit	Growth	Parr to smolt
Riffle Particle Size (D_{16}, D_{50}, D_{84})	Millimeter	Valley type nested in survey frame	Mean, variance over inference domain, annually	Design-based	Site measurement of D_{50}, D_{16}, D_{84}	Estimated annually for valley type nested in the survey frame with sampling design-based algorithm for D_{16}, D_{50}, and D_{84} from riffles.	SP Survey	Survival	Eggs/Alevin
Riparian Structure	Kilometer by type	Vegetation community types nested in survey frame	Total length estimated over survey domain, annually	Design-based	Site measurement of riparian structure	Estimated annually for posthoc stratified domains of historical riparian vegetation types in the survey frame with sampling design based algorithm for each riparian structure.	SP Survey	Growth	Parr to smolt
Solar Input	Degree day	Valley type nested in survey frame	Mean, variance over inference domain, annually	Design-based	Site measurement of solar input	Estimated annually for valley type nested in the survey frame with sampling design-based algorithm for solar input.	SP Survey, Solar Pathfinder	Growth	Parr to smolt

Table 2-2. Habitat attributes that directly and indirectly affect the growth of juvenile salmonids in stream environments.

Limiting Factor	Direct Mechanism	Direct Habitat Attributes	Indirect Mechanism	Indirect Habitat Attributes
Food	Energy inputs to salmonids come mainly from **drifting invertebrates.**	**Drift biomass** is the most direct measure of food availability. **Benthic biomass** and drift biomass may be correlated	Factors that affect the amount of food, are: inputs from **terrestrial vegetation**, **riffle substrate** available for invertebrates, and **primary production**	**Canopy cover** (AP, LiDAR, solar pathfinder), **riffle substrate** (pebble counts in riffles), **Gross Primary Production,** and **Stream Respiration** can be estimated with a DO sonde
Temperature	**Temperature** affects all physiological processes including consumption rate and metabolism which in turn affect growth rates	**Site temperature** measured with temperature logger year round.	See factors related to temperature but include **shade, bed material, thermal buffers from riparian veg, climate, hyporheic exchange, tributaries, upstream flows, channel form**	**Channel unit geometry, Canopy cover** (AP, LiDAR, solar pathfinder, …) **discharge, air temperature, humidity, substrate composition, valley topography** (estimated from external data sources)
Activity	Activity occurs during **foraging**, and **holding position** in moving water, **migration**, predator and competitor **avoidance** (see below)	Foraging: Requires high velocity (encounter rate) and low velocity (holding) zones found in pool heads (**channel units**) and behind structure in fast moving water (**cobble, lwd**).	**Migration** between resting, foraging, predator avoidance, high velocity currents, and thermal refugia depends on the proximately of microhabitats within the home range and obstacles between them.	**Habitat complexity** is difficult to measure but includes **frequency, size, and location of channel units, and structure.** Location of barriers through inventories and GIS

Table 2-3. Habitat attributes that directly and indirectly affects the mortality of juvenile salmonids in stream environments.

Limiting Factor	Direct Mechanism	Direct Habitat Attributes	Indirect Mechanism	Indirect Habitat Attributes
Starvation	Consumed energy does not meet energy expenses, see above review for **growth**			
Predation	Salmonids must avoid **predators**	**Predator** presence and abundance	**Hiding cover** for salmonids	**Substrate composition, LWD, channel unit geometry, Undercut banks** measured during field surveys
			Habitat suitability for predator species	Presence of predators will be dependent on **climate, channel unit characteristics, water temperature.**
Physical Processes	High **velocity** causes mortality during high flow events.	Temporally continuous **discharge** measurements	Channel complexity as **LWD, substrate composition, channel geometry and planform** offer refuge from flow events	Field surveys of **channel unit characteristics** and **structure (LWD, substrate)**
Water Quality	Extreme levels of **toxins** or low levels of **required components (DO)**	Temporally continuous measure of **temperature,** which is related to levels of **DO**	**Benthic invertebrate** community composition is related to many water quality parameters	Field collections of **benthic macroinvertebrates**

Table 2-4. Habitat attributes that directly and indirectly affects the survival to spawning for adult salmonids in stream environments.

Limiting Factor	Direct Mechanism	Direct Habitat Attributes	Indirect Mechanism
Migration barriers	**Barriers** include dams, culverts, waterfalls, diversions	**Location of barriers** through stream networks through inventories and GIS layers	
Temperature	**Temperature** has to be suitable, and in places isolated thermal refugia is highly selected for and necessary for survival.	**Temporally continuous temperature** monitoring at sites, **spatially continuous temperature** information estimated using GIS models	see Temperature review in juvenile growth
Predation	Avoid predation from terrestrial and aquatic predators. Cover such as **boulders, large wood, undercut banks, and pools** to help avoid predators.	Spatially explicit **location of cover elements to suitable spawning habitat** collected by field surveys	see Predation review in juvenile survival

Table 2-5. Habitat attributes that directly and indirectly affects salmonid egg to fry survival in stream environments.

Limiting Factor	Direct Mechanism	Direct Habitat Attributes	Indirect Mechanism	Indirect Habitat Attributes
Scour	High flows scour substrate which contains deposited eggs		Steep, incised channels have more ability to scour redds during high flows	Measurements of **channel geometry, planform, gradient, and availability of suitable spawning channel types** from field surveys
			Suitable substrate that allows burial of eggs to depths where scour is avoided	Field assessments of f**ine sediment (e.g. pool-tail fines sampling)**
Dissolved Oxygen	Sufficient **DO** to allow diffusion of oxygen to eggs	Field measurements of **DO**	DO is highly dependent on water **temperature**	Temporally continuous **temperature** monitoring
			Certain **channel unit types** (pool tails) have increased **hyporheic exchange**, more flow passing over eggs	Quantity and quality of channel unit types measured during field surveys
			Fine sediment affects flow through substrate to eggs	**Substrate composition** assessments (subsurface fines) assessed during field surveys
Temperature	Temperature affects development time of eggs	Temporally continuous **temperature** monitoring, **cumulative temperature (degree day)** dictates emergence timing		

w:\mf\ww\fy2011\biop projects\tucannon habitat\070511 isrp response 2011_7_5.docx