ATTACHMENT #5

Interdisciplinary Habitat Assessment Plan of the Upper Trinity River:

Work Plan FY 2010

PREPARED FOR:

TRINITY RIVER RESTORATION PROGRAM

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TABLE OF CONTENTS

1. Introduction/Background 1
2. Goals and Objectives 2
   A. Geomorphology 3
   B. Fish Habitat 3
   C. Riparian Vegetation 4
   D. Wildlife 4
      i. Foothill Yellow-Legged Frogs 4
      ii. Western Pond Turtle 4
3. Sampling Strategy and Assessments 1
   A. Systemic Sampling 1
      i. Probabilistic Study Design and Sample Site Selection 1
         a. GRTS-Based Fish Habitat Assessments 8
         b. GRTS Based Riparian Vegetation and Physical Process Relationships 8
         c. GRTS-Based Channel Complexity and Fish Habitat Relationship Assessments 9
         d. GRTS-Based Wildlife Assessments 10
      ii. Census 10
         a. Wildlife-Census 10
   B. Channel Rehabilitation Sites 11
      i. Fish Habitat-Rehabilitation Sites 11
      ii. Riparian vegetation-Rehabilitation Sites 11
         a. Riparian Mapping 11
         b. Large Wood Survey 12
      iii. Wildlife-Rehabilitation Sites 12
      iv. Photomonitoring of-Rehabilitation Sites 12
   C. Integration of Approaches 13
      i. Defining Variables 13
      ii. Integration Approach and Choice of Independent Variables 19
4. Project Management and Organizational Structure 21
5. Schedule and Deliverables 22
6. References 22

Appendix A: Methods and Analysis 26
   A. Fish Habitat-Methods and Analysis 26
      i. 2-D Hydrodynamic Modeling 26

a. Habitat Suitability Criteria 26
b. Cover, Substrate and Topography 27
c. Calibration and Quality Control 28
d. Validation 29
e. Analysis 29
ii. Habitat Mapping 30
a. Rearing Habitat Guild Definitions 30
b. Spawning Habitat Guild Definitions 31
c. Mapping 32
d. Validation 32
e. Analysis 34
B. Riparian Vegetation-Methods and Analysis 34
i. Riparian mapping 34
ii. Riparian –Geomorphology Integration 35
a. Riparian Band Transect Methods and Analysis 35
b. Cross Section Survey Methods and Analysis 37
c. Bed Mobility and Scour Methods and Analysis 37
iii. Characterize Site Geomorphic Features to Relate to Spawning Habitat and Use 38
iv. Large Wood Monitoring at channel rehabilitation sites 39
a. Survey Attributes 39
v. Large Wood monitoring at GRTS sites 41
C. Wildlife-Methods and Analysis 41
i. Foothill Yellow-legged Frog Egg Mass Surveys 41
i. Western Pond Turtle Surveys 42

1. INTRODUCTION/BACKGROUND

The primary goal of the Trinity River Restoration Program (Program) is to restore and sustain natural production of anadromous fish populations downstream of Lewiston Dam to pre-dam levels to facilitate dependent tribal, commercial, and sport fisheries' full participation in the benefits of restoration via enhanced harvest opportunities (Trinity River Restoration Program and ESSA Technologies Ltd. 2009). Actions necessary to restore and maintain the freshwater habitats for anadromous salmonids to achieve this goal are: (1) mechanical rehabilitation of the channel, (2) flow management to restore fluvial processes that create and maintain suitable salmonid habitat and to meet water temperature objectives for juvenile and adult salmonids, (3) coarse sediment augmentation, and (4) watershed restoration (USFWS and HVT 1999, DOI 2000).

The restoration strategy adopted by the Secretary of the Interior by signing the Trinity River Mainstem Fishery Restoration Record of Decision (ROD, DOI 2000) to meet the goal of Program is presented in the Trinity River Flow Evaluation (TRFE, USFWS and HVT 1999):

> *If naturally produced salmonid populations are to be restored and maintained, the habitat on which they depend must be rehabilitated. The most practical strategy to achieve fish habitat rehabilitation is a management approach that integrates riverine processes and instream flow dependent needs. This management approach physically reshapes selected channel sections, regulates sediment input, and prescribes reservoir releases to (1) allow fluvial processes to reshape and maintain a new dynamic equilibrium condition and (2) provide favorable water temperatures. This strategy does not strive to recreate the pre-TRD mainstem channel morphology. Several sediment and flow constraints imposed by the TRD cannot be overcome or completely mitigated. The new alluvial channel will be smaller in scale, but it will exhibit almost all the dynamic characteristics of the 10 alluvial attributes necessary to restore and maintain fisheries resources.*

Prior to the signing of the ROD in 2000, bank rehabilitation projects were implemented at nine pilot sites between 1991 and 1993. Geomorphic, riparian, fish use, and fish habitat monitoring occurred at these sites after implementation, and information gained from that monitoring guided the restoration strategy and management actions contained in the TRFE and ROD. Monitoring of these pilot sites ceased in 2001 in anticipation of implementation of the ROD.

The TRFE and ROD identified an additional 47 (44 mainstem and three side channel) potential channel rehabilitation sites between Lewiston Dam and the North Fork Trinity River. The primary hypothesis of the TRFE and ROD is that the synergistic effects of mechanical manipulation of the channel, coarse sediment augmentation release of geofluvial flows will dramatically increase habitat quantity, quality, and diversity through rehabilitation of alluvial function. Since the TRFE and ROD large wood management has been incorporated into the suite of restoration actions and is incorporated into most bank rehabilitation sites. While we expect habitat quantity, quality, and diversity to improve as a direct result of rehabilitation actions, we also expect the habitat benefits to increase through time as the sites evolve and translate downstream. The design and implementation of these projects are being conducted under an Adaptive Management framework (Holling 1978). The components of the adaptive management process (in the context of the channel rehabilitation effort) include:

- *Hypothesize and predict*: Assess channel restoration site opportunities, predict geomorphic response and resulting habitat response of a given site for different restoration alternatives.

- *Design*: Develop channel restoration designs (and assessments) based on predictions.
- *Implement*: Implement channel restoration designs and assessments.
- *Monitor*: Monitor channel and habitat response, as well as, fish and wildlife use.
- *Assess*: How did the habitat/channel respond compared to predictions? How can we improve our designs to better achieve desired and predicted habitat/channel responses? What were cause-and-effect relationships between habitat/channel responses with channel design, flow management, sediment management, and large wood management?
- *Adapt*: Alter management actions such as restoration designs, annual flow releases, coarse sediment augmentation, and large wood management.

A fundamental assessment necessary to evaluate the effectiveness of Program restoration actions is to determine the changes in salmonid habitat resulting from both mechanical channel rehabilitation and restoration of fluvial processes that improve and maintain riverine habitats. This assessment will evaluate the salmonid habitat response to physical and riparian processes. Assessments described in this proposal will contribute to the Program's adaptive management framework through the evaluation of progress toward achieving Program goals and objectives by providing short-term feedback to improve management actions, specifically channel rehabilitation, coarse sediment augmentation, large wood management and annual flow management, as well as providing information for long-term trend monitoring.

2. Goals and Objectives

The long term goal of the integrated habitat assessment project is to assess the effectiveness of the Program in creating aquatic habitats able to support fish and wildlife populations in the mainstem Trinity River at levels which existed prior to construction of Lewiston and Trinity Dams. Furthermore, we plan to evaluate the linkages among disciplines to gain a better understanding of restoration effects and possible improvements to restoration activities on the Trinity River. Assessments conducted in isolation that focus on one aspect of the ecosystem without considering other ecosystem processes or responses are limited in their ability to explain how management actions are (or are not) achieving programmatic goals. Therefore, the draft Integrated Assessment Plan (IAP; Trinity River Restoration Program and ESSA Technologies Ltd. 2009) and this proposal focus on integration between two key relationships: (1) physical process ➔ riparian vegetation response and channel morphology response (IAP Section 3.A.i.b), and (2) channel morphology/complexity ➔ fish habitat response (IAP Section 3.A.i.c). Due to the difficulties surrounding potential management objectives targeting adult or juvenile fish production, this proposal uses fish *habitat* as the primary dependent variable in analyses of objectives. Fish production and fish habitat use (except for habitat validation studies) are covered under other projects conducted by the Program and not reviewed in this proposal.

The Program developed the IAP to identify assessments that: (1) evaluate long-term progress toward achieving Program goals and objectives; and (2) provide short-term feedback to improve Program management actions. The IAP identifies the priority assessments necessary to evaluate the effectiveness of the restoration efforts (management actions) in meeting intended objectives, as well as, evaluating the overall effectiveness of the restoration strategy in meeting Program goals. Tasks implemented under this investigation plan address a subset of the assessments, listed below, and employ multi-disciplinary monitoring efforts, where appropriate and possible, to address relationships between physical processes and fish habitat creation and availability. The IAP assessments addressed by this investigation are:

- Map and quantify the extent (area) of available fry/juvenile rearing habitat at channel rehabilitation sites (IAP assessment number 1H).
- Quantify the extent (area) of available fry/juvenile rearing habitat throughout the mainstem (IAP assessment number 2H).
- Map and quantify the extent (area) of available spawning habitat at channel rehabilitation sites and quantify throughout the mainstem (IAP assessment numbers 3H and 4H).
- Quantify changes in channel width/geometry and geomorphic features within the wetted channel (including sinuosity, radius of curvature, thalweg crossings, controls, length of wetted edge or bank length, etc.) (IAP assessment number 1P).
- Assess hydraulic parameter variability in 2-D hydrodynamic model applications (IAP assessment number 3P).
- Monitor bed mobility and scour thresholds (IAP assessment number 6P).
- Assess design performance of specific design features (alcoves, side channels, lowered floodplains, etc.) (IAP assessment number 12 P).
- Map and quantify changes in riparian floodplain vegetation (e.g., species, age-class, initiation success, structural attributes) at GRTS sites (IAP assessment number 1R)
- Map and quantify the state of near-channel riparian vegetation (IAP assessment number 3R)
- Monitor plant induced berm-growth within the active channel (450 cfs-2,000 cfs inundation zone) (IAP assessment number 4R).
- Monitor the abundance and distribution of foothill yellow-legged frog egg masses in the mainstem Trinity River from Lewiston to the North Fork Trinity confluence (IAP assessment number 11W).
- Monitor the distribution and abundance of western pond turtle in the mainstem Trinity River from Lewiston to the North Fork Trinity confluence (IAP assessment number 13W).

Listed below are the IAP objectives for each assessment by discipline.

A. Geomorphology

1. Evaluate whether quantitative TRFE bed mobility and scour management objectives are being achieved during natural tributary-induced flood events and ROD flow releases (normal and above water year types) (IAP Objective 1.2.2).
2. Evaluate whether topographic, planform, and geomorphic unit diversity changes with natural tributary-induced flood events and ROD flow releases (normal and above water year types) (IAP Objective 1.1.1, 1.1.2, 1.2.3, and 1.3.1).

B. Fish Habitat

1. Estimate rearing and spawning habitat availability at a range of flows for Chinook salmon, coho salmon and steelhead on the Trinity River from Lewiston Dam to the confluence with the North Fork Trinity River (IAP Objectives 3.2.1.1 and 3.2.1.2).
2. Estimate availability and trends in availability of Chinook salmon and coho salmon rearing habitat in the Trinity River from Lewiston Dam to the confluence with the North Fork Trinity River at summer base flow (IAP Objective 3.2.1.1).
3. Evaluate the changes in rearing habitat availability from pre-construction to post-construction condition at the Sawmill rehabilitation site at a winter base flow (IAP Objective 3.2.1.1).
4. Investigate the relationship between redd distribution, spawning habitat availability (as defined by depth, velocity and substrate) and geomorphic features (IAP Objective 3.2.1.2).

5. Investigate the relationship between salmonid rearing habitat availability and geomorphic features (IAP Objective 3.2.1.1).

C. Riparian Vegetation

1. Evaluate whether TRFE riparian seedling scour mortality objectives are being achieved during natural tributary-induced flood events and ROD high flow releases (IAP Objective 5.2.1).
2. Evaluate whether ROD high flow releases are preventing detrimental riparian encroachment, riparian berm development, and channel simplification (IAP Objective 5.2.1). Detrimental riparian encroachment is defined as re-establishment of dense continuous bands of perennial vegetation near the low flow channel margin that reduces flow velocity, induces fine sediment deposition, and forms berms that leads to channel simplification over time.
3. Evaluate whether TRFE riparian initiation and establishment objectives on upper bar and floodplain surfaces are being achieved during ROD high flow releases for Wet and Extremely Wet water years (IAP Objective 5.1.1 and 5.1.3).
4. Assess the effectiveness of large wood installations at rehabilitation sites in creating anticipated geomorphic and habitat responses (IAP Objective 1.1.1.4).
5. Evaluate whether large wood storage within the active channel is increasing and being maintained (IAP Objective 5.1.2).

D. Wildlife

i. Foothill Yellow-Legged Frogs

1. Investigate if restoration actions lead to an increase in population size, survival, distribution, and recruitment success of Foothill Yellow-legged Frogs (FYF; IAP objective 3.6.41) Census of the river during breeding season to detect egg masses as an indicator of effective population size and follow fate of egg masses to determine if stranding may be related to flow management. Census accessible shoreline on the Trinity River from near the Lewiston Dam to the confluence of the North Fork Trinity River for detection of egg masses. This establishes reproductive effort and distribution of frogs (IAP objective 3.6.4.1).
2. Evaluate if restoration actions lead to an increase in the quality and quantity of breading habitat for foothills yellow legged frogs (IAP objective 3.6.4.2). Develop habitat suitability criteria for foothill yellow legged frog egg masses (e.g. depth, velocity, substrate, shear stress etc.) in the Trinity River that will facilitate habitat assessment.
3. Investigate the thermal diversity at breeding sites at three locations on the Trinity River (IAP objective 3.6.4.2).

ii. Western Pond Turtle

1. Estimate population size and survival at six restoration sites (IAP objective 6.5.3)
2. Estimate population size and survival at eight GRTS sample sites (IAP objective 6.5.3) and integrate the data with habitat and geomorphic disciplines at the same location for habitat use by turtles (IAP objective 6.5.1 and 6.5.2).
3. Utilize iButton temperature probes and radio-transmitters to determine thermal habitats utilized by turtles at three locations on the Trinity River (IAP objective 6.5.2).
4. Revisit the lower site of the Demographic Study reach three times to monitor recruitment, growth and sex ratios of western pond turtles (WPT) for long-term monitoring (IAP objective 6.5.1).

3. Sampling Strategy and Assessments

We are proposing a sampling strategy for FY2010 driven by 1) an interdisciplinary evaluation of systemic changes in the river channel within the mainstem Trinity River from Lewiston Dam to the North Fork Trinity River confluence, (2) interdisciplinary assessments of channel rehabilitation sites, and (3) integration of assessments to evaluate the restoration strategy proposed in the TRFE and ROD. We have developed the sampling strategy for this project based on the sampling framework in Chapter 4 of the IAP and we have provided a summary of the proposed tasks categorized by as encompassing the restoration reach (systemic) and/or channel rehabilitation site specific sampling schemes listed in Table 1. Methods for all assessments are described in Appendix A.

A. Systemic Sampling

The restoration strategy for the Trinity River is designed to restore some of the fluvial-geomorphic processes that will lead to systemic increases in salmonid habitat quantity and quality, particularly above the confluence of the North Fork Trinity River (USFWS and HVT 1999). It is anticipated that the restoration strategy applied on the Trinity River will create synergistic effects to the river channel extending beyond the bank rehabilitation sites and lead to systemic changes (Barinaga 1996). We will apply the following sampling in FY2010 to evaluate systemic status and changes within the upper mainstem Trinity River, building on efforts that were initiated in FY2009. Assessment sampling designs are categorized as either probabilistic or complete census.

i. Probabilistic Study Design and Sample Site Selection

We plan to employ a probabilistic sampling design to evaluate systemic objectives where complete census surveys are not feasible. We plan to employ a generalized linear random tessellation stratified sample unit selection protocol (GRTS) and rotating panel revisit design. We anticipate that this sampling framework will not only be implemented by the multiple disciplines listed in this work plan, but may be adopted by other studies conducted on the Trinity River and lead to additional integration opportunities.

The GRTS sampling protocol is an ideal sampling design for addressing systemic objectives and facilitating integration among disciplines (Trinity River Restoration Program and ESSA Technologies Ltd. 2009). The GRTS sample unit selection protocol ensures spatial balance of sample sites, provides flexibility for integrated assessments with differential sampling intensities, and maintains a probabilistic (random) component of a sample design (Stevens and Olsen 2004). One of the primary benefits of the GRTS sampling procedure is the objective, inferential basis for extrapolating data from sample sites to the project area as well as facilitating integration among disciplines through co-location of study sites (Stevens and Jensen 2007). The spatially balanced nature of the GRTS sample unit selection protocol is ideal to evaluate variables on continuous systems such as the Trinity River. Due to the interdisciplinary nature of this study and the related differences in appropriate stratification variables among disciplines, we have purposefully avoided the use of stratification such as mesohabitat or valley type in the study design. We plan to reevaluate the use of stratification in the study design after analysis of FY2009 data and further evaluation of integration variables.

Table 1. Summary of systemic and site level sampling tasks proposed for 2010 on the Trinity River. Sites refer to either randomly selected sample sites (GRTS), complete census of project area (census), or rehabilitation site by name. The numbers indicate the number of GRTS sample sites surveyed by each discipline, "X" indicates rehabilitation sites that are targeted for assessment while "*" indicates sites that will be surveyed opportunistically as they overlap with selected GRTS sample site locations or occur within a census study area. Rehabilitation sites with uncertain construction dates are indicated by "unk".

Sampling Strategy	Sites	Year of construction	Fish habitat mapping	2-D modeling	Spawning habitat	Topo monitoring	Geomorphic mapping	Physical process integration	Riparian habitat mapping	Large wood inventory	Frog egg mass surveys	Turtle surveys	Photomonitoring
Systemic	GRTS panel 1(# of sites)	-	16										
	GRTS panel 2	-	16	12	12	12	12	12	12	12		8	
	Census	-									X		
Rehabilitation site	Peartree Gulch	2006	*						X	X	*	X	
	Valdor Gulch	2006	*	*		*	*	*	X	X	*	X	
	Connor Creek	2006							X	X	*		
	Hocker Flat	2005							X		*		
	Round House	Unk.	*	*		*	*	*	*		*		X
	Reading Creek	2010	*								*	X	X
	Indian Creek	2007	*	*		*	*	*	X	X	*	X	X
	Vitzhum Gulch	2007							X	X	*		X
	Steel Bridge	Unk.									*		
	Limekiln	Unk.	*								*		
	Trinity House Gulch	2010	*								*		X
	Lowden Meadows	2010	*	*		*	*	*	*		*	X	X
	Dark Gulch/Bucktail	2008	*	*		*	*	*	X	X	*	X	X
	Upper Rush Creek	Unk.									*		X
	Sawmill	2009	X						X	X	*		X
	Hoadley Gulch	2008	*						X	X	*		X
	Lewiston Cableway	2008	*						X	X	*		X
	Deadwood Creek	2008							X		*		X
	Sven Olbertson	2008							X	X	*		X

We define the GRTS sample sites as 400 m segments of the 5000 cfs Trinity River centerline shapefile derived from the HEC-RAS model (Figure 1; Program unpublished data). This sample unit size was selected based on a unit length appropriate for all disciplines involved in Program planning meetings for the systemic sampling design. The sample universe is defined as the Trinity River from Lewiston Dam to the confluence with the North Fork Trinity River.

We have developed a rotating panel revisit design to evaluate system status and through time, trend analyses (McDonald 2003; Table 2). The rotating panel design is composed of five panels with 16 GRTS sample sites within each panel. Two panels are sampled within each year. In the following year of sampling one of the panels is repeated and one new panel is added until all five panels are sampled. In the fifth year the first panel is sampled again and the pattern continues. The five panels make up 50% of the sample universe.

The rotating panel revisit design was initiated in FY2009 and developed for the systemic summer base-flow rearing habitat mapping study. In FY2009, this study evaluated 16 GRTS sample sites from Panel 1 and Panel 2. In FY2010, the systemic summer base-flow rearing habitat mapping study will survey 16 GRTS sample sites from Panels 2 and 3 (Figure 2). In addition, we have added components to the study such as the development 2-D hydrodynamic models, physical process and riparian process monitoring and wildlife studies. The revisit design for these studies has not been established, but integration with the summer base-flow rearing habitat evaluation is critical to meet integration objectives. Therefore, studies other than the systemic summer base-flow rearing habitat mapping will sample 8 to 12 sample sites in FY2010. After this year we will evaluate the development of a revisit design for these components.

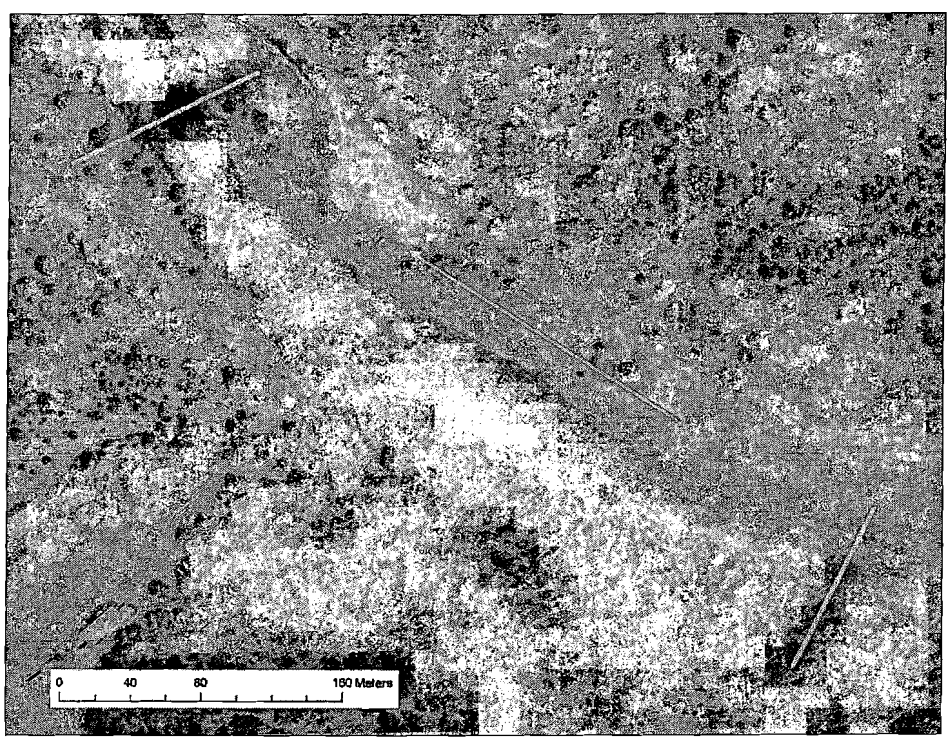


Figure 1. An example of a 400 m GRTS sample site where habitat mapping will be co-located with 2-d habitat modeling, physical, riparian and wildlife habitat integration. Green bars indicate the upstream and downstream extent of the site and the arrow indicates the flow direction.

Table 2. The rotating panel revisit sampling design for the rearing habitat assessment on the Trinity River, CA. Each panel is unique and composed of randomly selected spatially balanced sample sites. The series of periods indicates continuation of the pattern through time.

Panel\Year	2009	2010	2011	2012	2013	2014	....
1	X				X	X	
2	X	X				X	
3		X	X				
4			X	X			
5				X	X		
⋮							....

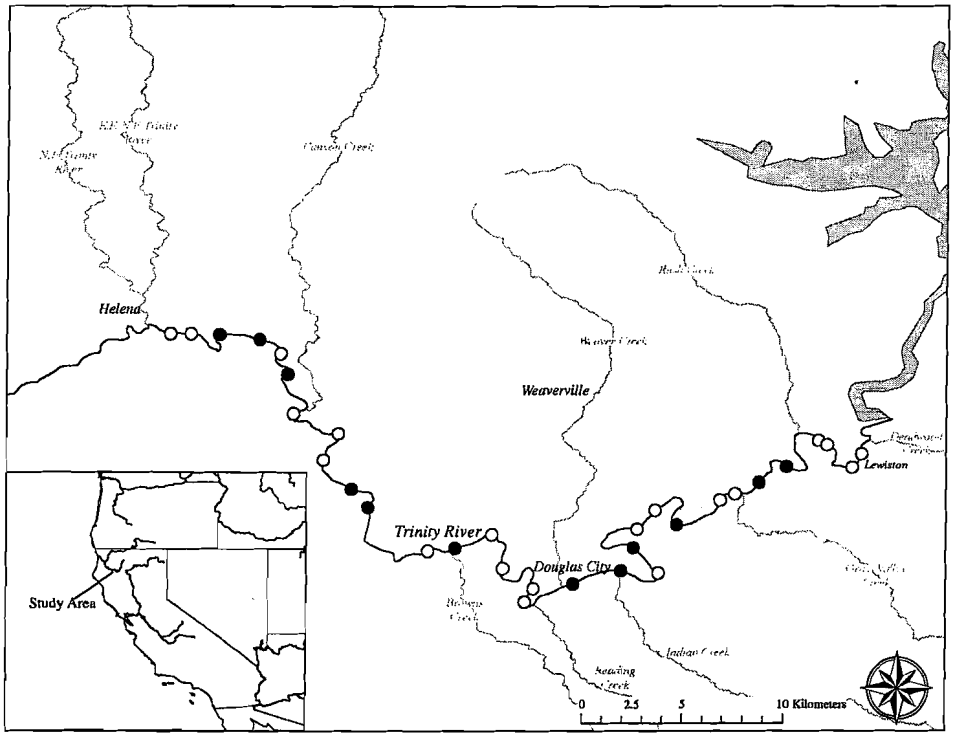


Figure 2. Systemic sampling GRTS sample sites selected for Panel 2 and 3 in the rotating panel revisit design. Black dots indicate sites that will have 2-D habitat modeling, physical, riparian and wildlife integration. We will conduct the base flow rearing habitat assessment at the white and black dots.

a. GRTS-Based Fish Habitat Assessments

We plan to evaluate systemic availability and/or changes in fish habitat using two approaches: (1) a summer base-flow Chinook salmon and coho salmon rearing habitat mapping to evaluate status and trends in habitat availability at an index flow and (2) a 2-D hydrodynamic based habitat modeling approach to evaluate the influence of ROD flow releases on habitat availability of rearing and spawning habitat of Chinook salmon, coho salmon and steelhead. The integration of habitat mapping and 2-D models to develop systemic estimates of status and trends of habitat availability follows the recommendations of the Trinity River Science Advisory Board members at the IAP Physical to Habitat workshop (Arcata, CA, April 1-4, 2008). This strategy brings together the efficiency of the habitat mapping method to develop annual trend analyses to evaluate restoration progress at an index flow while drawing on the strengths of 2-D habitat modeling to evaluate ROD flow releases effects on habitat availability.

The base-flow systemic rearing habitat mapping is a continuation of the sampling design initiated in 2009 to develop an estimate of the availability of Chinook and coho salmon rearing habitat at summer base flow, evaluate trends through time and habitat changes from restoration efforts. We will develop systemic estimates for habitat availability using the inclusion probabilities of sample sites and river length using the population estimate function in SP Survey and calculate the associate variance using a neighborhood estimator (Stevens and Olson 2002, Kinkaid 2008). Under this proposal we will evaluate changes in habitat availability by comparing sites surveyed in 2009 and revisited in 2010 using a paired t-test. We anticipate this study to develop into a habitat availability trend analysis as it is applied through time.

We based the proposed sampling effort for the base-flow systemic habitat assessment on the level of effort used in FY2009 and will adjust the sampling effort, as appropriate, to optimize the study design following the analysis of data collected in 2009. Study design optimization will include an evaluation of annual rigor and trend detection probabilities of the sample. Furthermore, the spatially explicit nature of the data will allow for an evaluation of the precision that could be obtained from different sample site lengths (i.e. 50 m, 100 m, 200 m, etc. sample sites). Due to administrative/contracting deadlines, we developed this investigation plan prior to these analyses and will develop an amendment to this investigation plan following the analyses of the data and subsequent reassessment of the sampling design if necessary.

In FY2010, we plan to initiate the systemic evaluation of the discharge versus habitat relationship in the Trinity River through the application of the Multi-Dimensional Surface-Water Modeling System (MD_SWMS, McDonald et al. in press) at 12 sample sites. The model will be run under steady, 2-D (depth-integrated) conditions. Hydraulic output data (depth, velocity) will be integrated with cover and substrate data to predict habitat based on the habitat suitability criteria (HSC) and validated through fish observations. The model will be run over a range of flows that encompass the managed hydrographs from 300 cfs to 11,000 cfs or the highest flow available for model calibration in 2010. Models will be calibrated to water surface elevation profiles and pressure plates surveyed at each site. The MD-SWMS model will provide the Program with a quantitative tool to predict the effect of Lewiston Dam release schedules on Chinook salmon, coho salmon and steelhead rearing and spawning habitat and provide insight into how changes to the flow schedules will affect habitat availability. If revisited through time, the 2-D hydrodynamic models may also help evaluate how changes in the channel translate into changes in habitat availability from restoration actions.

b. GRTS Based Riparian Vegetation and Physical Process Relationships

Three of the primary physical and riparian management objectives for the TRFE are:

- Achieving bed mobility and scour thresholds for different water years;
- Achieving various riparian seedling scour thresholds for different water years to prevent detrimental riparian encroachment and channel (habitat) simplification; and
- Achieving riparian initiation and establishment on upper bar and floodplain surfaces during above normal water years.

We propose to integrate the assessment of these three objectives by establishing riparian band transects to assess riparian seedling initiation on lower bar surfaces and upper bar surfaces to assess the latter two objectives, and installing tracer rocks and scour chains on the transect along the low water edge to relate geomorphic thresholds to riparian seedling mortality to assess the first two objectives[1]. Beyond the conceptual models presented in the background literature (Trinity River Restoration Program 2005, Trinity River Restoration Program and ESSA Technologies 2009), we are not yet able to develop a predictive analytical model framework at this time.

Riparian vegetation mapping will also be conducted to provide a planform perspective of riparian vegetation response to physical process thresholds. This information will be used to assess whether annual high flow releases are achieving their intended objectives, as well as providing the Program with information on the current risk of detrimental riparian encroachment. We propose to conduct this assessment at 12 sample sites. The riparian vegetation mapping will be collocated with 2-D hydrodynamic habitat modeling, which will facilitate integration by enabling comparison of changes between riparian vegetation, channel complexity, and fish habitat. We will inventory all active bar features at 12 sample sites (bars associated with bank rehabilitation sites as well as naturally formed bars), define these bars as our sample population, and establish at least one riparian transect at each sample site at the apex of the bar. Riparian transects will be placed at all 12 sample sites regardless of whether an active bar is present. Cross sections and riparian band transects will be systematically placed at the apex of bars and/or use previously established cross section locations. If an active bar and previously established cross section are not present at a GRTS site, the cross section and riparian transect location will be randomly selected.

c. GRTS-Based Channel Complexity and Fish Habitat Relationship Assessments

The IAP recommends that various channel complexity parameters be used to characterize changes in the physical state of the channel and that these parameters be related to anticipated changes in fish habitat. Therefore at 12 sample sites, we propose to measure physical parameters that likely relate to changes in fish habitat (see Integration of Approaches Section below). Consistent with the Riparian Vegetation – Physical Process Relationships Section above, we propose to measure these physical parameters at 12 sample sites. These 12 sample sites will be collocated with 2-D hydrodynamic habitat modeling, which will facilitate integration by enabling comparison of the physical parameters to fish habitat (fry, juvenile, and spawning) over a range of flows. The following physical parameters will be measured in the field, measured from the most recent aerial photographs or derived from the 2-D hydrodynamic model:

- Topography
- Wetted channel length

[1] Empirical tracer rock and scour chain experiment results will be compared to 2-D sheer stress outputs at Lewiston Cableway as part of the FY2009 habitat assessment project in winter 2010.

- Radius of curvature
- Large wood storage/density
- Area of exposed active bars
- Riparian vegetation, such as plant age, density, herbaceous vegetation, and/or woody vegetation
- Geomorphic features (pool tails, point bars, medial bars, etc)
- Spawning gravels
- Water surface elevations associated with a range of discharges

Additional variables, such as sheer stress, will be computed using the 2-D hydrodynamic model. Some of these physical parameters are being measured at six sites as part of the FY2009 assessment. Analysis and results from this effort are not yet complete. For the FY2010 effort proposed here, field measurements of the above physical parameters will be collected in summer 2010 to reflect the cumulative effects of winter and spring 2010 high flow events on channel complexity. Based on results of FY2009 and FY2010 integration efforts, these physical parameters may excluded if they correlate poorly with fish habitat, and new parameters may be added for future assessments.

d. GRTS-Based Wildlife Assessments

We will survey eight sample sites three times by snorkeling the reach to encounter WPT. These sample sites will be collocated with the other disciplines that may be used to understand turtle habitat use within the Trinity River compared to sites of non-use. This multidisciplinary information may facilitate comparative analyses of turtle densities in-river and in relation to upland characteristics needed for other aspects of their life history (e.g. sites with increased juveniles encountered may have appropriate upland nesting sites that are reflected in vegetative mapping of open grass meadows).

In addition to following the probabilistic sampling design for the randomly selected sample sites, we will visit the lower reach of the turtle demographic study three times to follow the split panel design [1-0, x-y] (McDonald 2003), as this design is well suited to estimate gross changes and for longer term trend detections at one site (McDonald 2003 and references therein). There will be additional benefits that include learning more about basic biology of the turtles with regards to growth rates, survival estimates over longer time periods, operating sex ratios and long-term population estimates for this site.

ii. CENSUS

a. Wildlife-Census

Reproductive effort of FYF will be assessed by egg mass surveys from below Lewiston Dam to the confluence of the North Fork Trinity River. The detection of an egg mass is used in amphibian research to establish an index of the effective breeding population size in species that lay one egg mass per year, as likely does the foothill yellow-legged frog. Repeated float surveys will be conducted to address three aspects identified in the IAP for foothill yellow-legged frogs: (1) distribution of egg mass breeding sites over the 64 kilometers of river at appropriate breeding areas from near Lewiston Dam to the confluence of the North Fork Trinity River, (2) number of egg masses encountered for estimates of effective breeding size of the population in the study area and (3) the fate of egg masses in relation to the descending limb of the hydrograph to determine the number of egg masses that strand. The monitoring of the breeding phenology over time with repeated

float surveys may also address other abiotic cues that the frogs are using for the onset of oviposition and constitute a better study design than single pass surveys (Yoccoz et al. 2001)

B. Channel Rehabilitation Sites

The overall approach we propose for the site-specific monitoring strategy is a Before-After study design. Many of the channel rehabilitation sites on the Trinity River are expected to increase habitat quantity and quality as the site evolves over time due to geomorphic and riparian processes. As part of the post-construction assessment, we plan to revisit a subset of the channel rehabilitation sites in the future to assess the evolution of these sites. The revisit date or event trigger (i.e., peak geomorphic flow and/or winter flood event) will be determined following discussions with the multidisciplinary project team.

We have purposefully avoided the use of controls and a Before-After/Control-Impact (BACI) study design in our monitoring strategy for several reasons. Although the total amount of channel that will be manipulated with mechanical restoration by the Trinity River Restoration is unknown, the Program has identified 83.5% of the study area to be within the environmental study limits (ESL) of channel rehabilitation actions (Program ESL shapefile 2008). Areas outside of the planned channel rehabilitation sites are also affected by flow management, coarse sediment augmentation, and/or the downstream effects of other channel rehabilitation sites making them inappropriate for use as true control sites. Tributaries and neighboring drainages are also inappropriate control sites because they contain very different geological and hydrological regimes. The use of an inappropriate control site may lead to a misinterpretation of the effects of the rehabilitation actions.

Given these complications, we propose a pre/post/evolution sampling strategy where the changes in habitat resulting from mechanical rehabilitation activities are quantified by comparing the amount of habitat and the flow versus habitat relationships prior to, following construction, and through time with management actions such as geomorphic flow events and coarse sediment augmentation. While we will attempt to conduct post-construction assessments as soon as possible following construction to avoid changes resulting from geomorphic flows, logistic constraints may prevent this from occurring due to the timing of construction and ability to assess habitat at specific flows. In these cases, we will consider any potential fluvial effects on the pre- and post-construction assessment during data analyses. Under this proposal we plan to evaluate 19 bank rehabilitation sites (Figure 3).

i. Fish Habitat-Rehabilitation Sites

We propose to apply habitat mapping to evaluate rearing habitat availability at selected channel rehabilitation sites. We will conduct a base flow post-construction habitat assessment at Sawmill. The Sawmill assessment is a continuation in the preconstruction, post-construction, and site-evolution sample design. Eleven other bank rehabilitation sites overlap with randomly generated GRTS sample sites. We will compare data collected under this proposal with previous samples at those locations. When possible, GRTS sample site surveys will be extended to include the entire rehabilitation site and provide additional information on changes in habitat availability at the rehabilitation sites through time.

ii. Riparian Vegetation-Rehabilitation Sites

a. Riparian Mapping

Riparian vegetation mapping is proposed at 12 constructed channel rehabilitation sites to provide a planform perspective of whether detrimental riparian encroachment is occurring, and whether riparian establishment is occurring on higher geomorphic surfaces. Riparian plant series and cohort ages will be mapped in the field using a sub-foot GPS unit in a similar manner utilized for the fish habitat mapping.

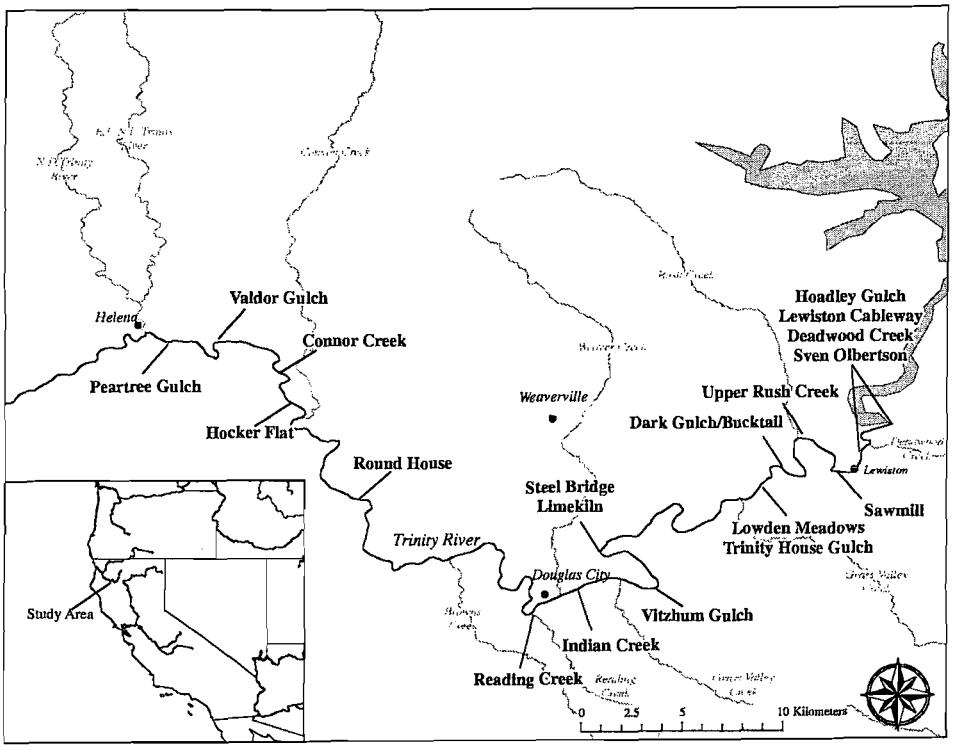


Figure 3. Trinity River Restoration Program channel rehabilitation sites we plan to assess in 2009/2010.

b. Large Wood Survey

A large wood survey is proposed at ten channel rehabilitation sites that have wood installed as part of the channel rehabilitation actions. This survey is intended to evaluate the design and placement effectiveness of large wood installations (i.e., how LWD installation design and placement location influences residence time). A descriptive assessment of how the large wood installations have facilitated improvements in channel complexity and fish habitat will be conducted at most of the ten channel rehabilitation sites. For Sawmill or other channel rehabilitation sites that overlap with the GRTS sample sites described above, the relationship between large wood and fish habitat will be evaluated. The methods for the large wood survey for both the GRTS sample sites and the channel rehabilitation sites are not identical.

iii. WILDLIFE-REHABILITATION SITES

For both FYF and WPT, six channel rehabilitation sites will be monitored for presence of species and possible population estimates (primarily turtles). These six sites will be Peartree Gulch; Valdor Gulch; Reading Creek; Lower Indian Creek; Lowden Meadows and Dark Gulch. The priority questions for these two herpetafauna at the restoration sites are: (1) Are FYF egg masses in constructed habitat features (alcoves, LWD, side channels, point bars), and (2) Are turtles using constructed habitat features (alcoves, LWD, side channels, point bars)?

iv. PHOTOMONITORING OF-REHABILITATION SITES

In addition to the discipline specific tasks listed above, we will conduct photomonitoring at 14 rehabilitation sites. Photomonitoring has been conducted as part of the fish habitat assessment project since 2007. In 2010 we will build on previous photomonitoring datasets and expand it to fit the needs of this multi-disciplinary project. Photomonitoring locations are opportunistic based on site vantage points and are strategically located to document changes of the rehabilitation site and of specific features of interest. .

C. INTEGRATION OF APPROACHES

The Integrated Habitat Assessment builds on the work conducted in developing the IAP and is an ambitious effort to bring together individual assessments in geomorphology, channel complexity, habitat availability, wildlife use and riparian habitat structural evolution to develop a more thorough understanding of how management actions induce in changes channel morphology and riparian vegetation structure, and how these changes relate to increases (or decreases) in aquatic and riparian habitats. The TRFE, Backgrounder (Trinity River Restoration Program 2005), IAP, and other scientific documents produced by the Program have an underlying conceptual model that links management actions increased adult fish populations (Figure 4). The TRFE developed physical process objectives (bed mobility and scour, channel migration, etc) and riparian vegetation objectives (riparian scour and prevention of detrimental riparian encroachment lower in the channel, riparian establishment on higher geomorphic surfaces) that were important to creating and maintaining high quality fish habitat. The primary hypothesis underlying the Program restoration strategy is that salmonid habitat will be created and maintained by restoring fluvial and riparian vegetation processes in concert with mechanical channel rehabilitation and coarse sediment augmentation, but at a smaller scale than occurred prior to completion of the Trinity and Lewiston dams. However, the linkage between physical processes and physical outcome (riparian vegetation and fish habitat) has been less quantitative and/or had greater uncertainty than other objectives. A plan that combines assessments of the different disciplines (fluvial geomorphology, riparian establishment and evolution, salmonid habitat/habitat utilization, wildlife habitat/habitat utilization) is essential to understanding the linkages between processes and habitat creation and maintenance, and to modify management actions to ensure that riverine habitats are created and maintained. At a very basic level, assessments of the various disciplines have to be integrated so that the results of geomorphology and riparian assessments can be related to changes in salmonid habitat availability. In most cases, this will require co-location of monitoring sites for the various disciplines. At a finer level, the assessment of fluvial processes and riparian colonization, and how these processes are affected by high flow releases, tributary floods, coarse sediment augmentation, fine sediment reduction efforts, large wood management, and channel rehabilitation actions, needs to be understood to evaluate the effectiveness and modify management actions as necessary.

Individual assessments described in this proposal were designed to answer specific questions of these physical and biological components of the Trinity River, but were also tailored to fit together (i.e., to be integrated) in a broader sense to be able to evaluate how Program management actions interact with the current river ecosystem to achieve the programmatic fish habitat goals.

i. DEFINING VARIABLES

The IAP summarizes tiered management objectives for the IAP, and provides a plan for assessing those objectives to gauge the success of the Program. The IAP also guides integration, and this proposal attempts to begin implementing it. There are many attributes of integration (e.g., see Table 2.2 of the IAP); however, this proposal focuses on assessing the quantitative functional relationships that link geomorphology, riparian vegetation, and physical habitat. We choose to focus our integrative efforts on these linkages because: 1) many confounding ecological factors are removed (e.g., ocean survival and harvest on adult salmon escapement, effects of downstream tributaries), 2) the time required to assess the effect of our management actions is shorter (years rather than decades), 3) they involve the results of active management actions that can be modified to achieve desired outcomes, and 4) the TRFE and ROD adopted a physical process based approach to fishery restoration. This proposal uses fish *habitat* as the primary dependent variable (the variable on the Y axis that has primary management relevance). Fish habitat modeling conducted by the TRFE found that fry and juvenile Chinook salmon rearing habitat was lowest over the range of flows between 300 cfs and 2,000 cfs. Habitat restoration efforts attempt to improve quantity and quality of rearing habitat over

these flow ranges; therefore, habitat assessments would ideally be conducted over this range of flows. The 12 sample sites selected for 2-D fish habitat modeling, fish habitat mapping, physical complexity and riparian process monitoring will be used to compare changes in fish habitat at a variety of index flows from the 300 cfs or 450 cfs base flow up to 11,000 cfs (or higher if needed) using the 2-D modeling results and base flow habitat mapping results.

There are a wide range of potential independent variables (the variables that may affect the dependent variable), and measuring these variables can be time consuming and costly. Based on the IHAP team's collective experience, cost to collect, ability to measure, ability to detect changes in response to management actions, and the connection to the dependent variable, we have chosen to focus on integrating the following variables to relate to the dependent variable (fish habitat):

- Radius of curvature – radius of curvature of the thalweg for each ½ meander wavelength unit (Figure 5 As channel migration occurs and bar areas increase, we expect the radius of curvature to decrease, and fish habitat to increase.

- Topographic diversity[2] - diversity of topographic elevation residuals from a plane representing average elevation of the site. Using AutoCAD Land Development Desktop, a "regression plane" that slopes with the average channel gradient will be developed through the site that is functionally a linear regression through existing topography. Then a planform grid will be developed for the site with 0.9 sq. m spacing, and a histogram of elevation deviations (residuals) between the regression plane and the existing elevation at each node will be computed (Figure 6). As bars form and the channel migrates, we expect topographic diversity to increase, and fish habitat to increase.

- Shear stress diversity - As topographic and structural diversity increases over time with increased sinuosity, large wood augmentation, removal of riparian berms, coarse sediment augmentation and other ROD restoration actions, we expect shear stress diversity to increase, maximum center-channel shear stresses to decrease, and fish habitat to increase over time. The MD_SWMS 2-D hydraulic model will be used to compute a 0.9 sq. m grid of shear stresses at an index flow that is of magnitude great enough to transport sediment, but largely confined by the existing riparian berm. Shear stress residuals will be computed from a plane representing average shear stress through the site. A histogram of shear stress deviations (residuals) between the regression plane and the computed shear stress at each node will be computed (Figure 7). An initial index flow between 3,000 cfs to 6,000 cfs will likely be used for the analysis, and the pilot analysis currently being conducted by the 20009 project will provide better guidance on which index flow would be most appropriate. The 2009 pilot analysis will also evaluate the proposed 2010 analytical methods, and as well as whether to continue using shear stress diversity as an independent variable.

- Length of low flow channels and wetted edge – length of wetted channel at 450 cfs as measured by the thalweg length and wetted edge length, including the mainstem Trinity River and adjacent side-channels (Figure 8). As channel migration occurs and side-channels are constructed, the length of wetted channel and edge should increase, and fish habitat should increase.

[2] More complex topographical diversity and shear stress fields allow for more complexity with respect to sediment and flow and are "bridge" variables to geomorphic and riparian response. It is the geomorphic and riparian response(s) that have the potential to increase fish habitat.

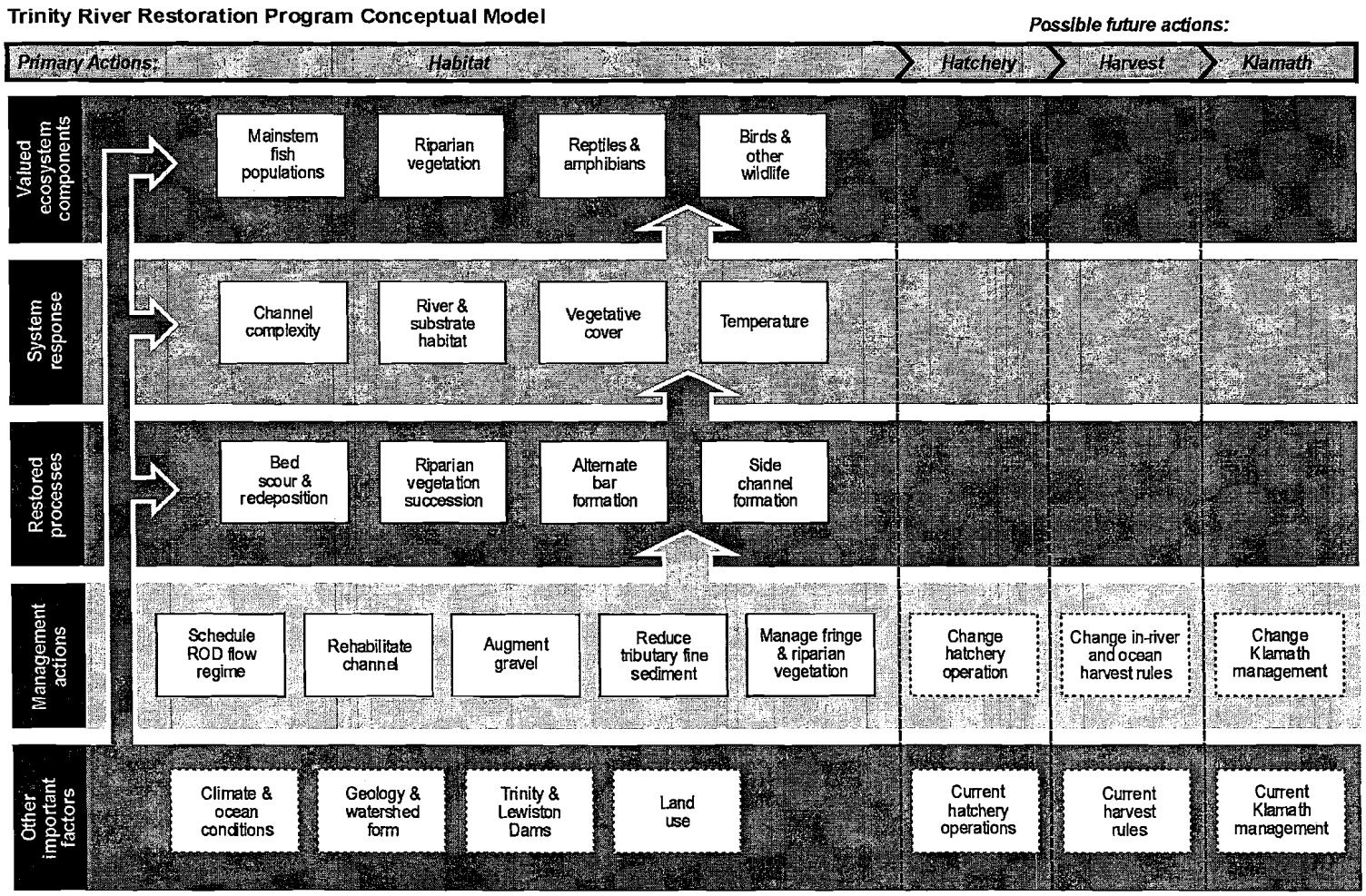


Figure 4. Conceptual model of overall system, showing the cause-effect chain from Program management actions to Valued Ecosystem Components (taken from IAP Figure 1.3). Management actions in the row second from the bottom (to the left of the dashed line) are within the mandate of the Program; actions to the right of the dashed line may be implemented in the future (see IAP Table 1.3). Factors in the bottom row affect various processes and system responses, but are not within the control of the Program, and may confound some of the assessments of Program management action effectiveness.

- Area of exposed active alluvial deposit – planform area of actively mobile gravel/cobble bar above 450 cfs water surface elevation (Figure 9), where "actively mobile" is defined by indicators of recently mobilized bed surface grains and lack of encroaching riparian vegetation (that would otherwise begin fossilizing the bar, making it inactive). As bars are created and evolve with future channel migration and coarse sediment augmentation, we expect bar area to increase, channel complexity to increase, and fish habitat to increase. The bed mobility, bed scour, and riparian initiation assessments will occur on these active alluvial deposits to relate changes in active bar area to changes in physical and riparian processes.

- Large wood storage/density – storage area and density of large wood within certain flow inundation "bins" between 300 cfs and 2,000 cfs. Large wood would include pieces placed during bank rehabilitation site construction, as well as those naturally deposited at the site by a high flow event. A large wood budget is not proposed.

- Riparian vegetation - age classes of mapped riparian vegetation within the 300 cfs to 2,000 cfs inundation elevations. Age classes will be estimated using a visual evaluation of bud scars and size (e.g., no plots or band transects conducted)

- Geomorphic feature mapping – boundaries of geomorphic units suitable for salmon habitat digitally mapped using aerial photographs and GPS surveys in the field (pool tails, low gradient riffles, channel margins, lee deposits, medial bars, etc).

- Channel slope - the slope of the river channel will be measured from 2-D hydrodynamic model topography and compared against habitat availability estimates. We hypothesize that within the channel slope variation within the sampling universe, rearing habitat availability will have an inverse relationship with rearing and spawning habitat availability.

- Channel confinement - channel confinement will be measured from 2-D hydrodynamic model topography and 2009 terrestrial lidar datasets. Confinement will then be compared against habitat availability estimates. We hypothesize that rearing habitat availability to discharge relationships will vary with channel confinement particularly at higher flows. We anticipate an inverse relationship between confinement and rearing and spawning habitat availability.

This long list of potential channel complexity variables are to be evaluated over the short-term; as we gain a better understanding of which variables are most sensitive to changes in fish habitat (and are most cost-effective to assess), we will reduce the number of variables to focus on those that best relate to fish habitat changes. Analyses of the defining variables bulleted above will be conducted at a small number of sites using data from the 2009 Integrated Habitat Assessment project after the completion of this proposal. Specific metrics, indices, and ranges of flows for the above variables for 2010 monitoring will be refined based on the results of analyses conducted from the 2009 study.

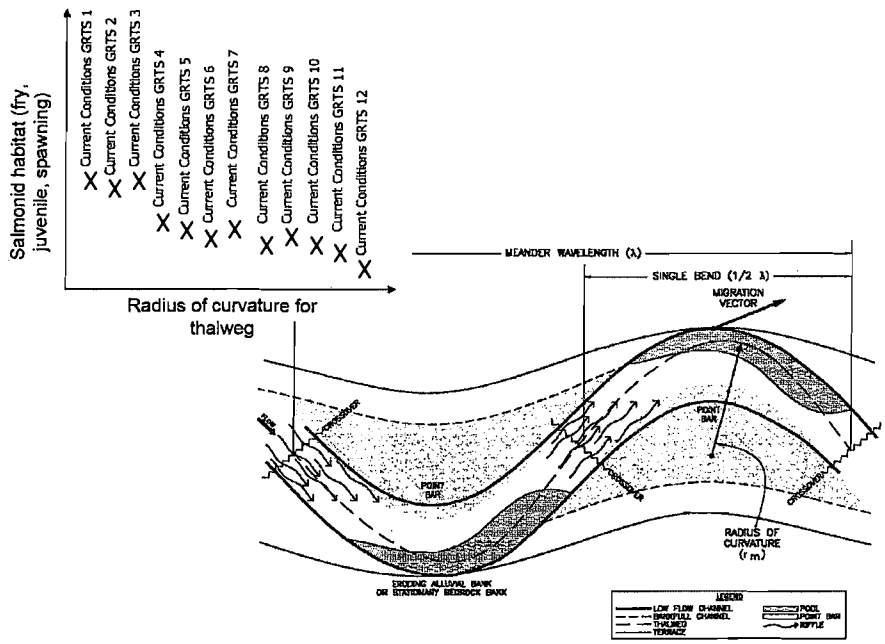


Figure 5. Hypothetical example of using radius of curvature as a primary independent variable with salmonid rearing habitat.

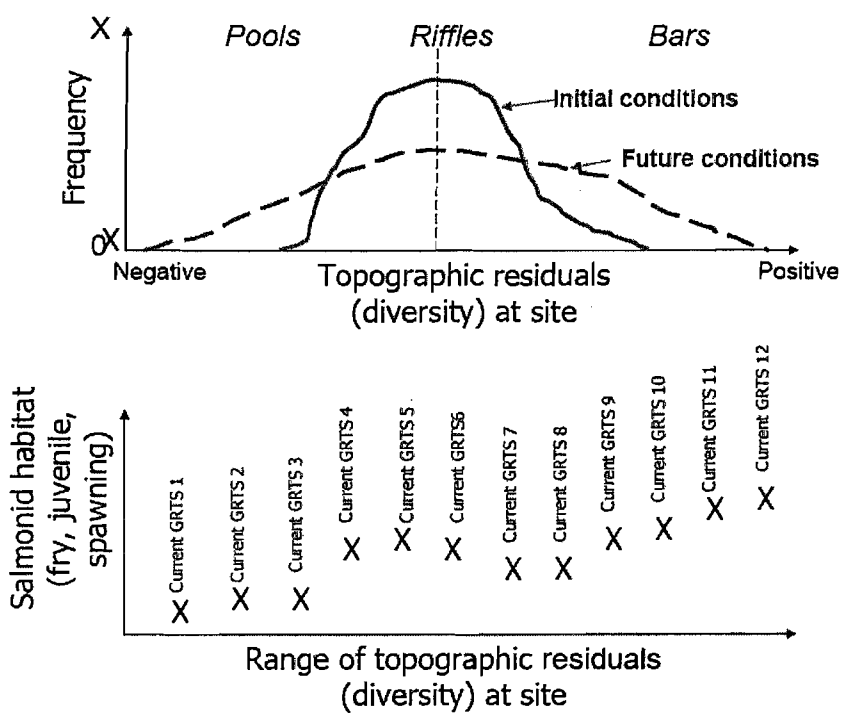


Figure 6. Hypothetical example of using topographic diversity as a primary independent variable with salmonid habitat.

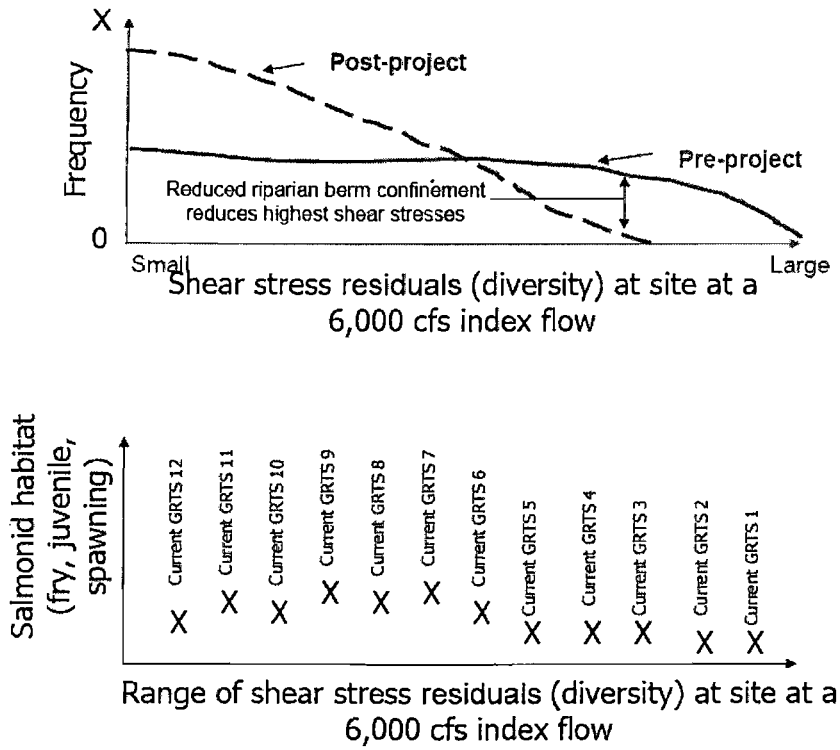


Figure 7. Hypothetical Example of Using topographic diversity as a primary independent variable with salmonid habitat.

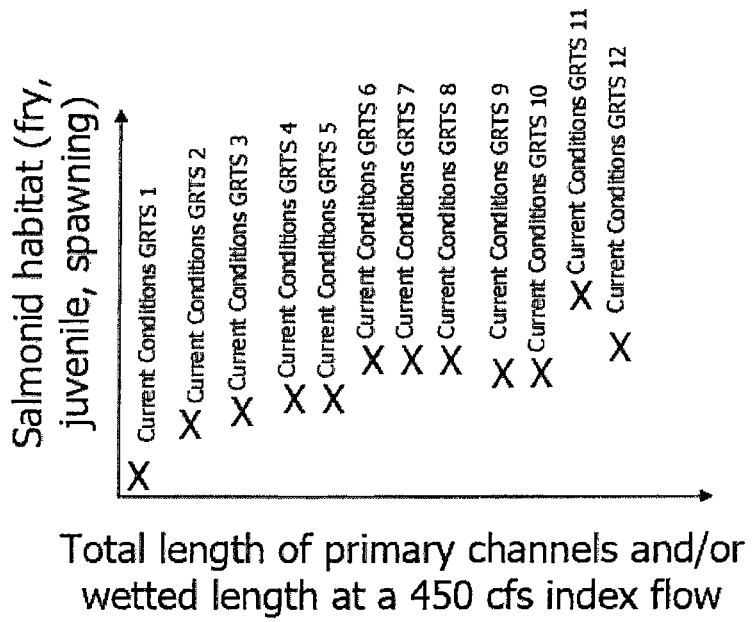


Figure 8. Hypothetical example of using length of primary channels at 450 cfs as a primary independent variable with salmonid habitat.

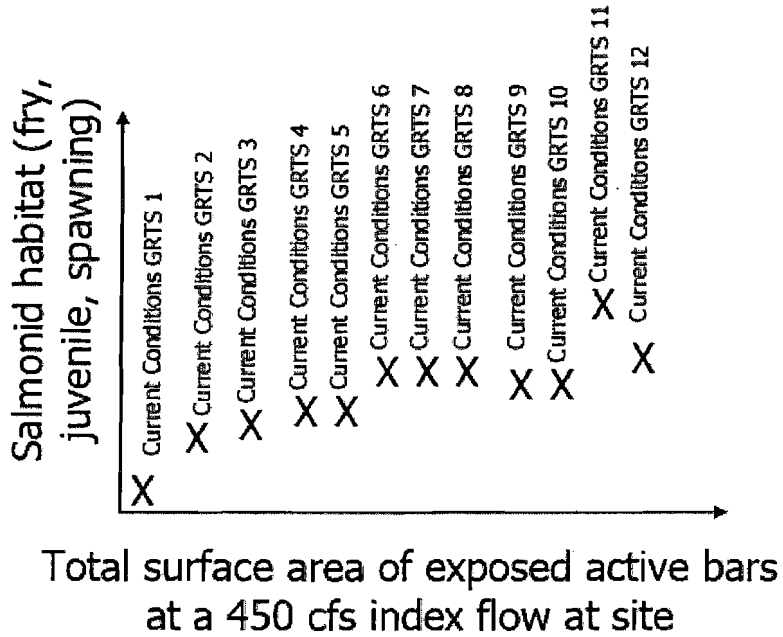


Figure 9. Hypothetical example of using area of exposed bar area at 450 cfs as a primary independent variable with salmonid habitat.

ii. INTEGRATION APPROACH AND CHOICE OF INDEPENDENT VARIABLES

Two approaches were considered for assessing whether Program management actions were creating the desired habitat outcome. The first approach has time on the X-axis (trend analysis), while the second approach has a physical state or process on the X-axis (cause-and-effect analysis). The first approach takes potential independent variables from individual assessments that were thought to be driving changes in habitat, and plots changes in those variables over time. This approach would correlate the changes in the potential driving variables to the changes in aquatic and riparian habitat over the same time period (Figure 10), and would attempt to refine those dependent variables that best correlate with changes in habitat over time.

The second approach would assess how habitat directly responds to changes in potential driving variables (Figures 5-10). By directly comparing habitat changes with those variables thought to drive changes in habitat, we expect to be able to detect responses much faster than using the trend analysis.

We will also pursue a multivariate analysis to determine a correlation relationship that best describes which variables (described above) best relate complexity to fish habitat. While at present an exact approach for a multivariate analysis is not final, the following steps will be taken to ensure the analysis is performed:

- Examine data sets for suitability to multivariate analyses and identify limitations to data sets such as missing data;
- Decide on a model selection procedure (Akaike's information criterion (AIC) (Burnham and Anderson 2002) versus stepwise regression);
- Develop a proposal for multivariate analysis that is distributed to outside expert review before conducting analyses; and

- Perform multivariate analysis after receiving comments from outside experts.

Results from the completed multivariate analysis, along with results from trend analysis and cause-and-effect analysis, will be included in final reporting for this project.

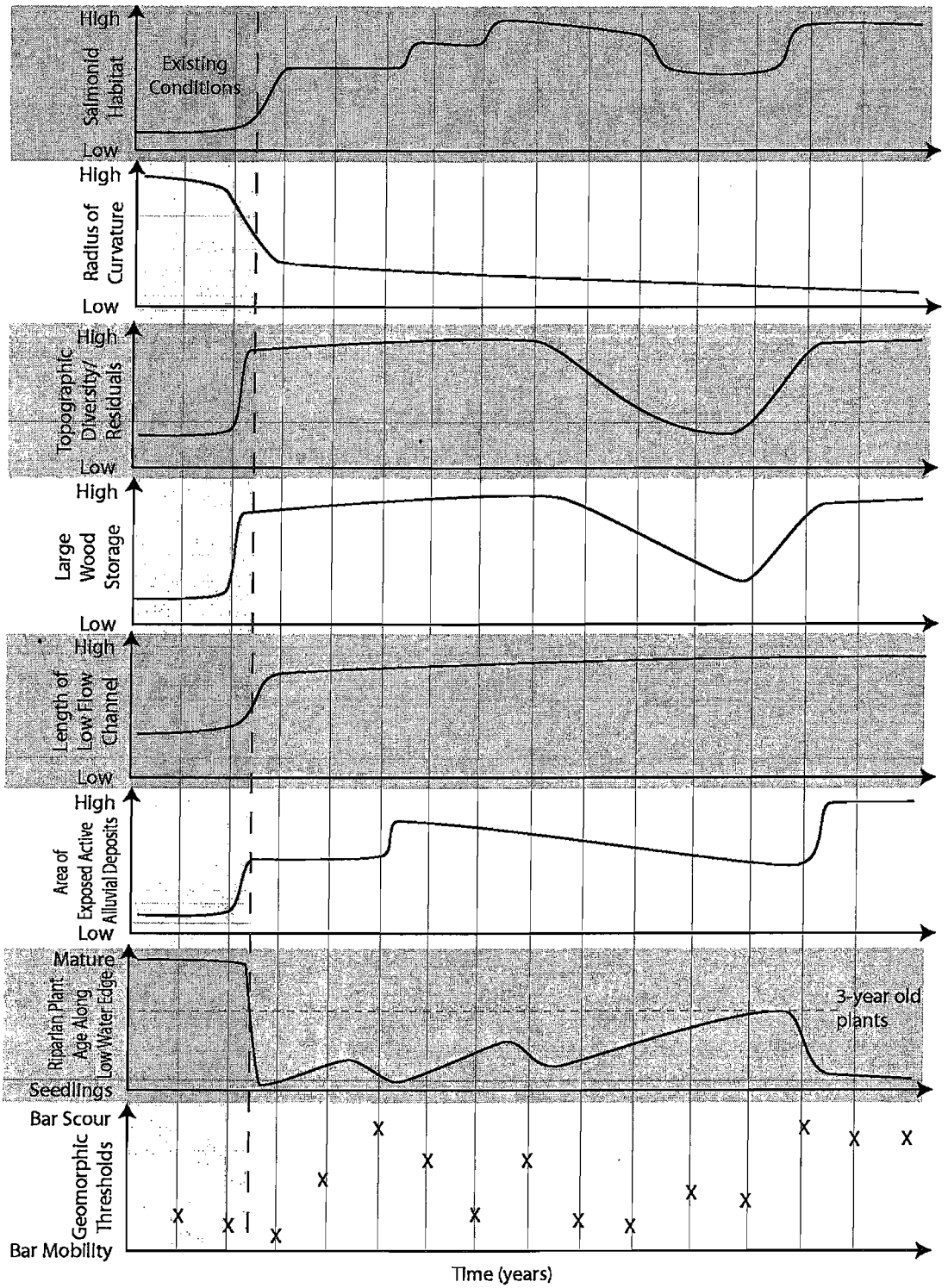
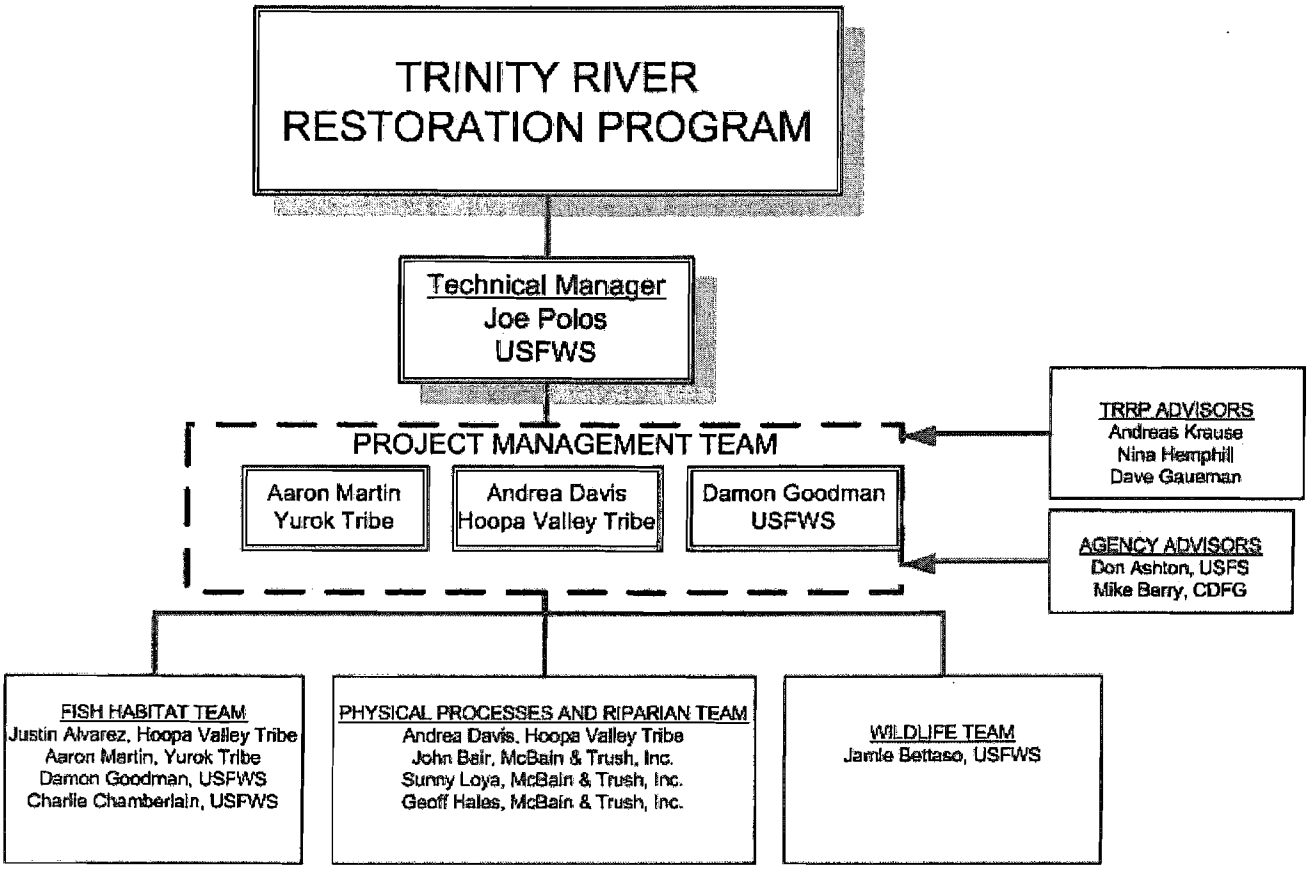


Figure 10. Illustration of correlative time series of various recommended independent variables with a salmonid habitat time series.

4. Project Management and Organizational Structure

The Interdisciplinary Habitat Assessment Plan of the Upper Trinity River is a joint proposal submitted to the Program by the science staff of (in alphabetical order) the Hoopa Valley Tribe, U.S. Fish and Wildlife Service, and Yurok Tribe. Technical staff of all three entities will participate jointly in implementing this proposal. Project management will be provided by the Project Management Team to ensure adequate internal and external coordination, field planning, reporting, and other requisite tasks described in this proposal are completed. Project management tasks include:

(1) Coordination of field work;
(2) Data entry and analysis;
(3) Periodic multi-disciplinary coordination meetings to discuss results, analysis, report writing, and future proposal development; and
(4) Coordination of internal and external report review processes and resultant editing/revising to reporting documents as needed.



Representatives from the California Department of Fish and Game, as well as members of the Program Technical Modeling and Analysis Group, contributed to development and revision of this plan, and will continue to work collaboratively with the project proponents during implementation, analysis, and reporting.

5. SCHEDULE AND DELIVERABLES

Nov 2009	Begin Field work
Oct. 2010	Complete fieldwork for all components except 2-D modeling
Dec 2010	Complete fieldwork for 2-D modeling
Feb. 2011	Complete data entry and reduction for all components except 2-D modeling
April 2011	Complete analysis, collaboration, and interpretation of results – Systemic/GRTS
June 2011	Distribute draft Systemic/Sawmill report
Dec 2011	Complete 2-D modeling
May 2012	Distribute 2D draft report with integration for review and comment
June. 2012	Comments received from reviewers, compiled and distributed to authors
July 2012	Distribute final report

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APPENDIX A: METHODS AND ANALYSIS

A. FISH HABITAT-METHODS AND ANALYSIS

i. 2-D HYDRODYNAMIC MODELING

We propose to develop a 2-D hydrodynamic habitat model at 12 sample sites to simulate salmonid rearing and spawning habitat for discharges up to 11,000 cfs (peak release in ROD hydrographs) or the highest release available to calibrate the models. The methods for model development can be categorized by (1) habitat suitability criteria selection (HSC) (2) cover, substrate, and topography (4) calibration and quality control and (5) biological validation. We plan to collect all channel form, cover and substrate data between spring and fall 2010 to minimize potential errors related to system changes through time and high flow events. We plan use the Multi-Dimensional Surface-Water Modeling System (MDSWMS, McDonald et al. in press) with the visual basic program developed by Thom Hardy for habitat simulations (Hardy pers. Comm.).

a. Habitat Suitability Criteria

Habitat suitability criteria model inputs will employ habitat characteristics typically used in habitat characterization (e.g. Waddle 2001, Hardy et al. 2006). For rearing habitat simulations of Chinook salmon, coho salmon and steelhead fry (<50 mm) and presmolt (50-200 mm) we will use Trinity River datasets. We plan to apply depth and velocity data from Hampton (1997) and cover data collected in 2003-2004 on the Trinity River (Yurok Tribe and USFWS unpublished data). Models will be run using categorical criteria listed in the Habitat Mapping section as well as continuous criteria commonly used in 2-D hydrodynamic habitat modeling. The two criteria will allow a comparison of habitat assessment across methodologies as well as a validation step for the 2-D hydrodynamic model predictions.

The Chinook spawning HSC dataset in Hampton (1997 and 1988) and presented in the TRFE (USFWS and HVT 1999) was evaluated against conditions at redd locations in the 2008 Habitat assessment project. In this study we randomly selected 60 Chinook salmon redds from Old Bridge in Lewiston (RKM 177.3) to downstream extent of Dark Gulch rehabilitation site (RKM 169.5). At each redd location we measured depth, velocity, surface substrate composition and distance to escape cover. Substrate data was collected by randomly selecting 100 rocks within the vicinity of the redd location but outside of the redd pit and measuring the secondary axis. The depth and velocity distribution of redds measured in 2008 were similar to that found by Hampton. Substrate particle size distribution in 2008 was much smaller than that observed by Hampton but similar to that observed by Kondolf and Wolman (1993) in a review of substrate use by Central Valley populations of Chinook salmon (Figure A- 1). These data indicate that the Hampton HSC dataset is not be appropriate for use in the 2-D models and needs further investigation.

Consideration in the FY2011 IHAP project should be given to updating the rearing and spawning habitat HSC datasets in time for the completion of the 2-D hydrodynamic model development (fall and winter 2011). In addition to incorporating potential changes in habitat use due to restoration actions, additional data would facilitate more sophisticated analyses that may improve model performance. Additional variables in the HSC dataset could include: adjacent velocity criteria, an important variable for rearing salmonids that typically reside in slow-water habitats adjacent to faster water where food items (invertebrate drift) are conveyed (Fausch and White 1981, U.S. Fish and Wildlife Service 2008), and pebble count data for continuous substrate distributions at redds. Another benefit is the ability to apply multivariate analytical approaches to developing habitat criteria that address much of the criticism aimed at composite habitat indices (see Jowett and Davey 2007). Multivariate approaches allow for evaluation of the cumulative effects, correlations and interaction

among physical habitat variables that occur in the environment (depth, velocity, cover, substrate, etc.; see Ahmadi-Nedushan et al. 2006).

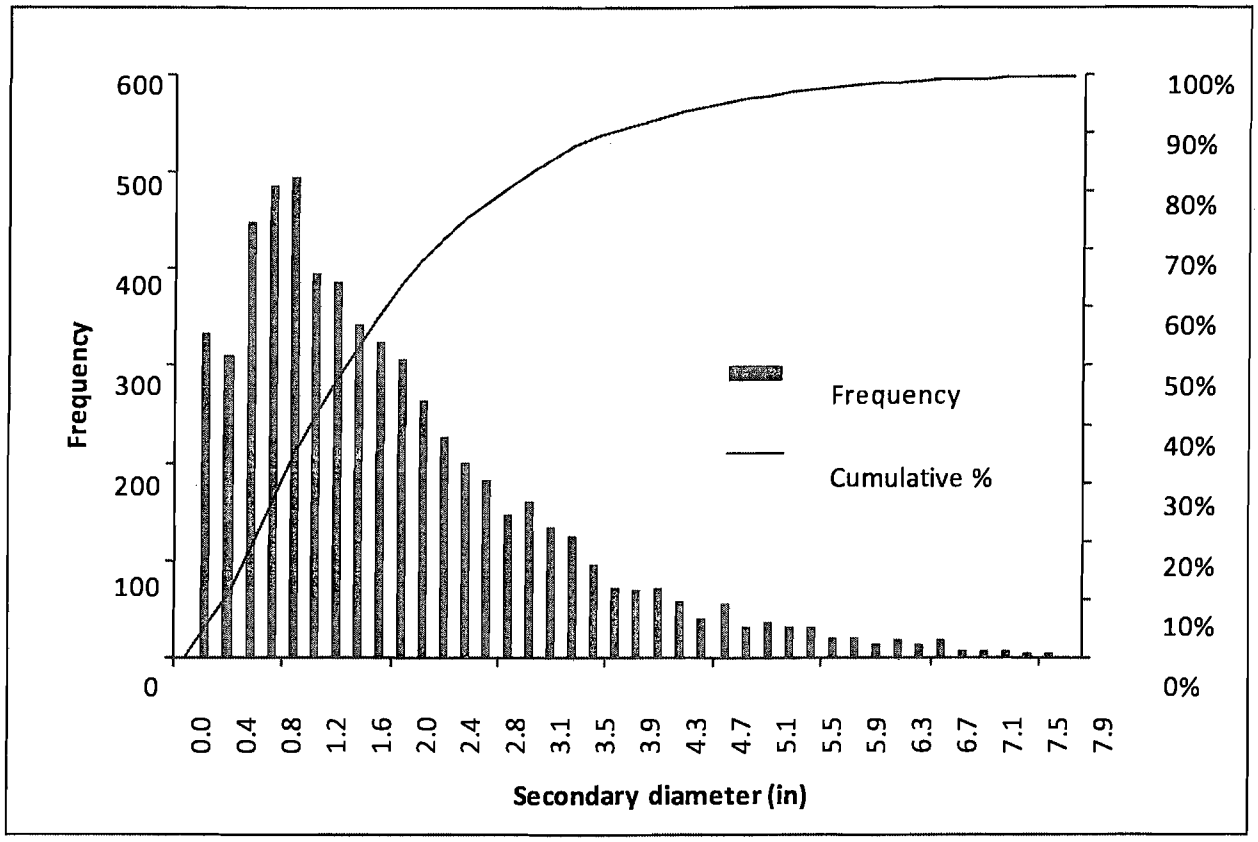

Figure A- 1. Substrate size distribution measured at 60 randomly selected Chinook salmon redds on the Trinity River in 2008. Substrate size was measured on the secondary axis.

b. Cover, Substrate and Topography

We will collect full topography at each model site using a combination of survey grade real-time kinematic (RTK) GPS and geo-referenced total station surveys. Topographic data will be collected up to approximately 3000 cfs, a flow that is greater than the current flow management for habitat purposes. Topographic point density will vary with the complexity of the terrain with higher density of points collected at more complex areas and providing enough detail to characterize site topography. The use of RTK GPS or total station surveys will be related to the specific site conditions (satellite availability, line of site, etc.). Topographic surveys will be conducted to develop the smallest practical mesh density possible at each site (1 m or less). For topography from 3,000 to 11,000 cfs we plan to utilize terrestrial lidar data collected in summer 2009 under contract with the Program. Consideration will be given to using lidar data below 3,000 cfs upon review of data integrity and engineer accuracy certification. Use of the lidar data in the modeling assumes that there were no significant channel changes from the 2009 releases. This assumption will be evaluated at each site by surveyors when the lidar data set becomes available. If areas of significant change do exist, these locations will be resurveyed. Some topography data will be collected to validate the use of the terrestrial lidar above 3,000 cfs and quantify the associated error. If this error is too great than modeling will be limited to 3,000 cfs and consideration will be given to extending topographic surveys in future proposals. Channel bathymetry data below wade-able depths will be collected using an Ohmex Sonarlite depth transducer in combination with RTK GPS antenna.

Cover and substrate data will be collected to develop roughness values for model calibration as well as habitat criteria inputs. We plan to develop substrate and cover inputs by creating planar representations of substrate and cover as follows. Substrate will be defined as diameter of dominant particle size of categories listed in Table A-1. Cover types are listed in Table A-1. We will delineate categorized substrate and cover areas by traversing each site and delineating polygon boundaries up to 11,000 cfs water's edge with a Trimble ProXH receiver using a tablet PC in Trimble Terrasync (ver. 3.21). All data will be collected in projection NAD 1983 State Plane California I FIPS 0401 (feet). When needed, we will offset GPS points using either a Laser Atlanta Advantage or Trupulse 360 laser range finders with internal compass and inclinometer. In the field, we will validate the accuracy of each GPS point using geo-referenced high resolution 2007 aerial photographs on the tablet PC.

Table A- 1. Two-dimensional model escape cover and substrate categories. Substrate diameters refer to dominant substrate size measured along the secondary axis.

Escape Cover or Substrate Type
Aquatic vegetation
Grasses
Horsetails/sedges
Willows
Berry or grape vines
Small woody debris <10.2 by 30.5 cm dbh
Large woody debris >10.2 by 30.5 cm dbh
Exposed roots
Trees <10.2 cm dbh
Tress >10.2 cm dbh
Rootwads
Detritus or leaf litter
Fines <4 mm
Small Gravel 4-25 mm
Medium Gravel 25-50 mm
Large Gravel 50-100 mm
Small Cobble 100-150 mm
Medium Cobble 150-225 mm
Large Cobble 225-300 mm
Small Boulder 300-600 mm
Large Boulder >600 mm
Bedrock

c. Calibration and Quality Control

Model calibration data will include development of PHABSIM transects (Waddle 2001) at the upstream and downstream boundaries of study sites and collection of water surface elevation (WSEL) profiles through each site. The PHABSIM transects will provide water surface elevations at the study site downstream boundary as input to the 2-D hydrodynamic model following methods recommended by Gard (2006). Discharge measurements will be collected at the best discharge measurement location within each study site and will be collected at four flows distributed within the range of modeled flows (i.e. 300, 700, 2,000 and 11,000 cfs) to create a stage/discharge relationship at the downstream boundary of each study site. Discharge data will be

collected with a Teledyne Instruments Workhorse ADCP in conjunction with a Son-Tek/YSI Flowtracker handheld flow meter. The upstream PHABSIM transect along with the WSEL data, will be used to calibrate the 2-D model bed roughness values. Water surface elevation data will be collected using a combination of RTK GPS and total station surveys at four flows distributed within the range of modeled flows (ie 300, 700, 2,000, and 11,000 cfs release from Lewiston Dam) at all study sites.

d. Validation

Biological validation assesses the linkage between habitat characterization and actual use by fish. Biological validation for rearing habitat predictions will occur at four sites at winter base flow to avoid the impacts of potential shifts in habitat utilization due to the release of Chinook salmon from the Lewiston Hatchery in the Spring. We will conduct biological validation at four sample sites. At each selected site, we will randomly select locations and divers will counting fish by species and size class (<50, 50-80, 80-200 mm TL). We plan to measure depth, velocity, distance to cover and adjacent velocity. Observed fish locations will then be compared with predicted habitat areas to evaluate model performance. Redd habitat validation will be conducted by the Trinity River Redd survey that collects locality data on all Chinook redds within the study sites. Performance evaluation will occur on two levels (1) number of observations of fish vs. predicted suitability of habitat and (2) number of observations weighted by the number of fish in the observation vs. predicted suitability of habitat.

Physical validation will be conducted using point measurements of mean column velocity measurements and velocity distribution maps. The point measurements of mean column velocity measurements will be collected at 50 random locations within each site using a handheld SonTek Flow Tracker velocity meter and GPS or if needed using the ADCP. This data will be collected at three flows between 300 and 6,000 cfs or the highest calibrated flow. Velocity distributions will also be validated using plan view velocity fields digitized in the field on aerial photographs (i.e., recirculation zones, shooting zones, stream lines, etc.). Validation will be conducted by comparing mean column velocities at point measurements against the predicted values using a scatter plot. Differences between measured and predicted values will be summarized in box plots and statistical measures. Plan view field maps will be compared against predicted velocity distributions to further validate the hydraulic output of the models.

In addition, we plan to validate the results of the 2-D hydrodynamic model habitat availability estimates using the habitat mapping results. The comparison will be conducted by running the 2-D hydrodynamic models to simulate habitat availability using the same critiera (categorical) and flow evaluated during the habitat mapping. We will then compare the habitat availability estimates from the habitat mapping to the 2-D hydrodynamic model using a paired t-test. Furthermore, we will visually compare the distribution of mapped and predicted habitat at each site.

e. Analysis

We will analyze the 2-D model outputs to develop systemic estimates for habitat availability within the modeled range of flows. Model runs will allow the Program to predict how dam release scenarios change habitat availability for Chinook salmon, coho salmon and steelhead rearing and spawning habitat. We plan to conduct analyses to evaluate habitat availability for the five hydrographs in the ROD (critically dry, dry, normal, wet and extremely wet water year types) and the actual conditions of the 2010 water year. This will provide the Program with insight on how the dam release management is affecting habitat availability for the target species and life stages.

To conduct this analysis, first we plan to develop flow to habitat relationships at each site for each species and life stage using the 2-D hydrodynamic models. Then we will create a hydrograph (taking into account

tributary accretions) for each site for each water year type based on available daily average stream flow gauge data (Table A- 2). Water year simulations will take the Lewiston releases (by each water year type and the actual release from the previous year) to equate habitat availability at each of the 2-D site through the time period of interest (ie winter for Chinook salmon fry, late winter-summer for Chinook presmolt rearing, etc.). The conditions at each of the sites will then be extrapolated to represent project area estimates using the inclusion probabilities of each sample site relative to the hydraulic reach (between `major tributaries) based on channel length (5000 cfs river centerline shapefile developed by the Program in 2006). Systemic estimates for each flow in the simulations will be conducted in SPsurvey (ver. 1.6) using the population estimate analysis package (Kinkaid 2008). The spatially balance nature of the GRTS sampling framework reduces sample variance, resulting in a more efficient sample. To take advantage of this efficiency, we will be implementing a neighborhood variance estimator (Stevens and Olson 2002). This will result in habitat availability vs. time (day of the year) analyses for each ROD water year type release as well as the habitat conditions of the 2010 hydrograph. This habitat evaluation toolset will also be available to the Program flow scheduling group to evaluate future hydrograph proposals. Further model runs are not covered under this proposal but will be considered under future proposals.

Table A- 2. The USGS gauge network in the Trinity River that will be used to develop hydrographs for 2-D model sites.

		Period of Record	
Site Name	**USGS Gauge Number**	**Beginning Date**	**End Date**
Trinity River above Lewiston	11525500	Oct-11	Current
Rush Creek	11525530	Oct-02	Current
Grass Valley Creek	11525630	Oct-04	Current
Trinity River below Limekiln Gulch	11525655	Apr-81	Current
Indian Creek	11525670	Oct-04	Current
Trinity River at Douglas City	11525854	Oct-02	Current
Trinity River at Junction City	11526250	Oct-02	Current
Trinity River above N.F. Trinity	11526400	Mar-05	Current

ii. HABITAT MAPPING

a. Rearing Habitat Guild Definitions

Habitat mapping guilds were developed to combine species and life stages of interest with similar habitat requirements. Rearing habitat guilds included a Fry guild representing habitat requirements for Chinook salmon and coho salmon with a fork length <50 mm and a Presmolt guild for Chinook salmon and coho salmon with a fork length of 50-200 mm. Fry and presmolt life stages were evaluated separately to take into account changes in habitat utilization with development. Definitions for habitat guilds were developed using depth and mean column velocity and cover criteria. The guild definitions and associated criteria were selected to encompass a high percentage of observations from habitat suitability studies conducted on the Trinity River (Table A- 3; Hampton 1988, Hampton 1997, TRFE). Four habitat categories were delineated

within each guild and associated with high, medium and low qualities based on observations in habitat suitability criteria (Table A- 4). Guild variable criteria are listed in Table A- 5.

Table A- 3. The cumulative percent of observations and number of observations from Trinity River habitat suitability studies of Chinook salmon and coho salmon rearing habitat.

		Cumulative percent of HSC observation within each guild (# obs.)		
Life stage	**Species**	**Depth**	**Velocity**	**Distance to Cover**
Fry	Chinook salmon	79 (345)	67 (345)	64 (267)
	Coho salmon	79 (131)	84 (131)	82 (66)
Presmolt	Chinook salmon	67 (251)	63 (251)	53 (126)
	Coho salmon	84 (82)	72 (82)	92 (37)

Table A- 4. Four categories of habitat quality Chinook salmon and coho salmon fry and presmolt.

	Within depth and velocity (DV)	Outside depth and velocity (No DV)
Within cover (C)	DV, C (highest quality)	No DV, C (medium quality)
Outside cover (No C)	DV, No C (medium quality)	No DV, No C (lowest quality)

Table A- 5. Criteria for rearing habitat guild and guild category definitions. Rearing habitat guilds were defined by depth, mean column velocity and in-water escape cover criteria (vegetation or wood).

Guild	Guild Category	Depth (m)		Velocity (m/sec)	Distance to Cover (m)
Fry	DV, C	0-0.61	and	0-0.15	0-0.61
	DV, No C	0-0.61	and	0-0.15	>0.61
	No DV, C	>0.61	or	>0.15	0-0.61
	No DV, No C	>0.61	or	>0.15	>0.61
Presmolt	DV, C	0-1.00	and	0-0.24	0-0.61
	DV, No C	0-1.00	and	0-0.24	>0.61
	No DV, C	>1.00	or	>0.24	0-0.61
	No DV, No C	>1.00	or	>0.24	>0.61

b. Spawning Habitat Guild Definitions

We developed a Spawning guild incorporating the habitat requirements of Chinook salmon, coho salmon and steelhead. We defined the Spawning guild using a combination of depth, velocity and substrate criteria. The criteria were set to include a high percentage (84 to 98%) of redds observed within the range of these variables during habitat suitability studies conducted on the Trinity River (Table A- 6) (Hampton 1988,

Hampton 1997, TRFE). We defined the Spawning guild criteria with depths from 0.15 to 0.76 m, focal velocities from 0.15 to 0.79 m/sec. As described in the 2-D hydrodynamic modeling section above, substrate HSC criteria listed in Hampton (1988) and TRFE do not seem appropriate for contemporary Chinook spawning habitat in the Trinity River. Based on the results of the validation effort from 2008 and comparisons to substrate values listed for Chinook populations in the Sacramento drainage, we modified the substrate criteria to dominant surface substrate with a secondary axis diameter of 10 to 114 mm.

Table A- 6. The cumulative percent of observations from Trinity River habitat suitability studies of three species of salmonids within the criteria of the Spawning Habitat Mapping Guild. Depth and velocity data developed on the Trinity River as part of the Trinity River Flow Study (Hampton 1997).

	Cumulative Percent of HSC Observations Within Each Guild (# obs.)	
Species	**Depth**	**Velocity**
Chinook salmon	88 (311)	84 (311)
Coho salmon	93 (107)	89 (107)
Steelhead	98 (88)	88 (88)

c. Mapping

Habitat mapping applies guild definitions and delineates areas that meet the specific criteria. First, surveyors identify perimeter of areas that meet guild criteria including the edge of water, depth, mean column velocity, in-water escape cover and or substrate criteria. For rearing habitat surveys, attributes are typically measured in a transect starting at the bank and working toward the mid-channel. The edge of water is defined as the farthest extent that water goes into a bank. In the case of undercut banks, the depth of the undercut is measured and a point is taken on the outside extent of water. Depth and mean column velocity are measured using hand held Price AA (JBS energy) and Flow Tracker (Son Tek) flow meters on top setting rods. In-water escape cover is identified by dominant cover type of either vegetation or wood. Dominant surface substrate diameter is identified using an ocular estimate of the secondary axis. When a guild perimeter is identified, GPS points were taken to geo-reference the polygon vertices. We use lines to trace the shape of habitat areas and facilitate post processing into polygons. Only habitat areas greater than two square meters were surveyed in increase survey efficiency. GPS points were taken using a Trimble ProXH GPS receiver with a Zephyr antenna paired with Mobile Demand T-8700 tablet PC. The points are collected in Terrasync (Trimble ver. 4.02). When needed, we offset GPS points using either a Laser Atlanta Advantage or Trupulse 360 laser range finder with internal compass and inclinometer. In the field, we validated the accuracy of each GPS point using geo-referenced high-resolution 2007 aerial photographs on the tablet PC. All GPS data were collected in NAD 1983 State Plane California I FIPS 0401 (feet).

d. Validation

We do not propose to conduct a rearing habitat validation study for habitat mapping in FY2010. A rearing habitat validation study was conducted at Lewiston Cableway and Hoadley Gulch bank rehabilitation sites preconstruction in March and April 2008 (Hoopa Valley Tribe, USFWS and YTFP unpublished data). In summary, the 2008 study investigated fish density differences among three binary factors 1) depth and velocity 2) presence or absence of in-water cover and 3) near shore (<3 m from bank) or mid channel areas (>3 m from shore). The factors were evaluated for Chinook salmon at fry (<50 mm TL) and presmolt (50-200 mm TL) life stages and again for coho salmon. Mapped habitat types were partitioned into segments of

approximately 30 m^2 and selected using a stratified systematic sample with a random start. Sample sites were selected separately for each combination of the binary factors and for each life stage. We sampled 75 fry habitat segments on March 26 and April 7, 2008, and 67 presmolt habitat segments on April 16 and 17, 2008. At each segment, we collected Chinook and coho salmon densities by life stage using single pass snorkel surveys.

We analyzed the data using a general linear model with type III sums of squares estimates of error to compare habitat and channel type to fish densities. We ran this analysis separately for Chinook and coho salmon and fry and presmolt life stages. When the null hypothesis (no difference) was rejected we employed a Tukey post-hoc pair-wise test for honestly significant differences.

We identified significant differences of fish densities against depth, velocity and cover factors using the generalized linear models in all four cases (Chinook and coho salmon for fry and presmolt life stages; $p<0.001$). An example of the density differences among mapped habitat types for the Chinook salmon presmolt life stage is presented as a box plot in Figure A- 2. Significance of the pairwise tests varied by species and life stage and will not be presented here. We failed to identify significant differences among near shore and mid channel units.

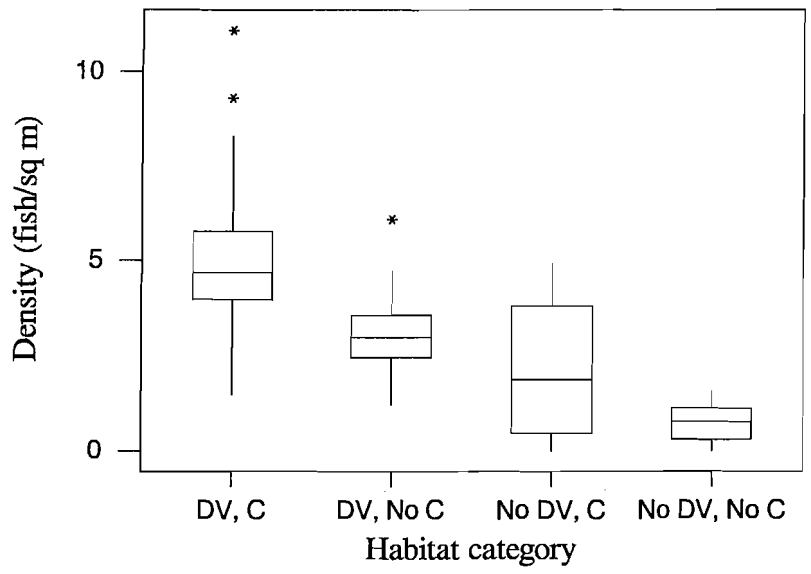

Figure A- 2. Box plot of Chinook presmolt (50-200 mm TL) densities among four mapped habitat types including 1) DV, C or within depth, velocity and cover criteria, 2) DV, No C or within depth, velocity and outside of cover, 3) No DV, C or outside of depth, velocity and within cover and 4) No DV, No C or outside of depth, velocity and cover. Asterisks indicate outliers in the data set.

A spawning habitat validation study was conducted from Old Bridge in Lewiston (RKM 177.3) to downstream extent of Dark Gulch rehabilitation site (RKM 169.5) during Fall and Winter 2009 (Hoopa Valley Tribe, USFWS and YTFP unpublished data). In summary, the FY2009 study investigated redd locations against mapped spawning habitat polygons. Ninety eight of 174 (56%) redds fell within the mapped spawning habitat areas. One-hundred-and-twenty-two (70%) redds fell within a 1 m buffer of the mapped spawning habitat polygons. Many locations that were mapped as spawning habitat in the study did not contain redds. This may be because the spawning habitat in the Trinity River is not fully seeded in the location where we

conducted the study, fish are cueing in on variables not included in the guild definitions, and/or there are errors in our spawning habitat survey methodology.

e. Analysis

The rearing habitat mapping data will be analyzed to develop systemic estimates of habitat availability at summer base flow. Summer base flow was selected as a reference flow for this component of the study because of the long time period with this stable flow, it reoccurs each year and it is similar to the discharge that is experienced by the rearing fish for much of the winter. The systemic estimate will employ a neighborhood variance estimator (Stevens and Olson 2002). Furthermore, we will evaluate systemic trends in habitat availability at summer base flow by comparing the habitat availability estimates at sites evaluated in FY2009 and revisited in FY2010. The revisited sites will allow for a paired evaluation of changes in habitat availability. We plan to assess changes in habitat availability from FY2009 to FY2010 using a paired t-test to test for significant differences in habitat availability between years. Additionally we will conduct visual analyses to evaluate changes in specific features between years.

In 2010 we plan to conduct a spawning habitat study by evaluating the relationship between redd locations, spawning habitat polygons and geomorphic features. Geomorphic feature definitions are listed in section B.iii below. The proposed study focuses on evaluating the potential of geomorphic features to aid in the interpretation of spawning habitat areas. We hypothesize that there are significant differences in redd densities among geomorphic features. If significant redd density differences exist, we will evaluate their potential application to interpreting spawning habitat data and further investigations.

We plan to map redd location, geomorphic features and spawning habitat at 12 GRTS sample sites. Redd locations will be mapped as part of the Trinity River Redd Survey in weekly surveys with GPS equipment (U.S. Fish and Wildlife Service et al. 2009). Redd locations will then be compared against mapped spawning habitat areas and geomorphic features. We will then tally the number of redds within and outside of spawning habitat areas and within each of the geomorphic feature types for each study site. Redd density differences among geomorphic features will then be compared using a GLM analysis. If the null hypothesis (no difference) is rejected we will then employ a Tukey post-hoc pairwise test for honestly significant differences among geomorphic features.

B. Riparian Vegetation-Methods and Analysis

i. Riparian Mapping

The baseline location, composition, and structure of riparian vegetation will be characterized at each channel rehabilitation site and 12 sample sites (GRTS sample). Additionally, vegetation will be characterized to facilitate habitat quality assessments performed by fisheries and wildlife biologists at the sites. Site vegetation characterization consists of field-mapping of riparian vegetation, exotic hardwoods, and substrate on the most recent ortho-rectified aerial photographs (scaled to 1:1,800) at the same scale, but greater detail, as that used in the riparian vegetation inventory (McBain and Trush 2005).

We propose to characterize the baseline location, composition, and structure of riparian vegetation at each site. Discrete patches of riparian vegetation will be mapped and labeled using a modified series classification system (Sawyer and Keeler-Wolf 1995). Mapped patches will also be associated with additional attributes describing whether mapped vegetation patches consist of undisturbed pre-construction stands (i.e., remnant), stands re-growing after construction attempted to remove them (re-growth), or recruiting naturally.

Mapping of current riparian stand types at each site will use current series-level nomenclature (defining patch sizes at the sites prior to any future restoration). Each mapped patch will be attributed to describe patch origin (i.e., remnant, re-growth, YOY etc). Field maps will be digitized in the field on a Toughbook tablet PC using the most recent air photos available at the time of mapping to facilitate GIS analyses.

Following the field mapping component, polygons will be digitized and entered into GIS-compatible software using a state plane coordinate system. The following information will then be collected from the maps:

- Aerial extent of all plant stand types;
- Compare to previously mapped patch areas, types, and locations; and
- Evaluate the locations and extant of patches dominated by 1, 2, and 3 year woody plants.

The GIS database will be updated and queried with each subsequent monitoring event to detect changes in the aerial extent of different patch types.

ii. RIPARIAN –GEOMORPHOLOGY INTEGRATION

a. Riparian Band Transect Methods and Analysis

Band transects will be used to document riparian hardwood recruitment locations, riparian vegetation structural changes, and species distribution along a cross section 12 sample sites. The band transects will be integrated with geomorphic and hydrologic monitoring at each site to relate riparian changes to channel morphology, annual flow regimes, and bed mobility and scour. Changes are flow dependent and can be detected within one year (pre- and post-flow). Active point bars are not the only place where riparian metrics are of interest; however, active point bars are the most probably location for riparian vegetation colonization due to frequent disturbance.

Riparian hardwood establishment trends and vegetation structure have historically been evaluated using band transects (McBain and Trush 1997, Bair 2001, McBain and Trush 2004, McBain and Trush 2006). The band transect sampling designs are useful because they can be used to easily associate water surface elevation and discharge relationships to riparian vegetation colonization patterns. Band transects will be sampled along active alluvial surfaces at 12 GRTS sample sites. Specific tasks include:

1) Establish, monument, and survey vegetation band transects following previously defined protocols (Bair 2001);
2) Survey the ground surface along the band transect;
3) Sample plants in a 1.5 m, 5 m, and 10 m nested band transects along two cross sections at a site following previously defined protocols (McBain and Trush 2006);
4) Take digital photos of band transects;
5) Enter and QA/QC data;
6) Overlay 1-yr, 2-yr, 3-yr, and >3-yr plant locations and patch locations along surveyed ground surfaces for each transect relative to the annual low and high water; and
7) Evaluate the relationship of developing riparian vegetation structure to available hydrologic/geomorphic data available at each site.[3]

To analyze riparian recruitment trends we plan to:

[3] Developing a river-wide target or desired condition remains an IAP Priority Issue to be Addressed (PITA) (Trinity River Restoration Program and ESSA Technologies Ltd. 2009). Resolution of this PITA is expected via the Program Physical Workgroup in 2010.

1) Classify and plot sampled woody plants on selected cross sections in 1-yr, 2-yr, and 3-yr age classes.
2) Associate woody plant densities and bank locations with the 450 cfs, 2,000 cfs, 4,500 cfs, 6,000 cfs, 8,500 cfs, and 11,000 cfs ROD discharges;
3) Compare changes in hardwood densities for different age classes from previous monitoring;
4) Overlay geomorphic monitoring results on cross section to establish the mechanisms that changed hardwood densities; and
5) Evaluate whether we are approaching our 3-year window on woody plants along the low flow channel.

As described above, hardwoods will be classified as 1-yr, 2-yr, and 3-yr old. Then hardwood locations will be overlaid on transects and the current riparian hardwood age structure be related to the benchmark water surface elevations (i.e., those associated with the 450 cfs, 2,000 cfs, 4,500 cfs, 6,000 cfs, 8,500 cfs, and 11,000 cfs discharges).

Hardwood location data collected along transects will be translated into a cross section station and ground surface elevation. (i.e., the coordinate system used in establishing the cross sections). Once the hardwood data is converted, the bank location of hardwoods can be evaluated and zones of seedling initiation and establishment defined. The hardwood location data collected in the field can be translated to cross section coordinates using a spreadsheet formula that interpolates the plant's ground surface elevation from surveyed ground surface elevations and distances from the left bank pin. Using this procedure, the seedlings can be overlaid on the cross section and computed seedling density and frequency for plant species (Bonham 1989, Kent and Coker 1992) and will be used in encroachment risk analyses.

Riparian woody plants typically will encroach and induce berm formation if they establish below the 2,000 cfs water surface elevation and are not scoured within three years of establishment (Bair 2003). Therefore, encroachment risk will be assessed using the "red-yellow-green" analysis for those 1-yr, 2-yr, and 3-yr old hardwoods growing in dense continuous bands below the 2,000 cfs water surface elevation (McBain and Trush 2004b). Those plants with the greatest threat of becoming permanently established along the low water edge, but could still be potentially removed by streamflows achieving deep subsurface scour (e.g., 3-yr old plants), will be coded red; streamflows exceeding 8,500 cfs are hypothesized to cause widespread mortality in the 3-yr old age class growing along the low water edge (Table A- 7). Two year old hardwoods will be coded yellow, because they may induce encroachment but are still vulnerable to channel bed surface scour caused by ROD streamflows of 8,500 cfs or greater. One year old hardwoods will be coded green, because they are highly susceptible to channel bed surface scour induced by flows of 6,000 cfs or greater and are not considered an encroachment risk. Those older than three years will not be considered, because they have passed beyond the threshold of vertical scour that can be induced by managed streamflow releases alone (and will therefore continue to grow to maturity).

Table A- 7. Summary of the age class, encroachment risk and ROD streamflows needed to reduce encroachment risk of woody plants growing in dense bands below the 2,000 cfs water surface.

Dominant plant age	Risk code	Risk description
3 year old	Red	Extreme Risk- 8,500 cfs or 11,000 cfs needed that year, may need to drastically modify hydrograph release for that given water year
2 year old	Yellow	High risk- 6,000 cfs or larger suggested for that year, may recommend subtle adjustments hydrograph release for that given water year
1 year-old	Green	Moderate risk, these hardwoods should be watched to evaluate if these plants get to the 2-yr old stage, no modification of the hydrograph is needed

b. Cross Section Survey Methods and Analysis

One cross section will be established and surveyed at each band transect site across an active bar feature before winter floods (November/December) and after the spring ROD release (July/August). The cross section will be based on the horizontal and vertical control provided by the California Department of Water Resources (DWR). Cross sections will be surveyed with an engineer's level or total station using established field protocols (Harrelson et al 1994). Specific tasks include:

1) Survey cross sections, including water surface elevations at the time of survey; and
2) Enter data and plot cross sections.

After cross section topography at each study site is surveyed, it will be plotted in Excel. If the cross section is already established, it will be graphically compared to prior survey(s) to note changes resulting from the annual peak streamflow. The cross section topography will be used in conjunction with scour and riparian analysis to determine if detrimental riparian encroachment[4], riparian berm formation, and/or habitat simplification is occurring (avoidance of which are management objectives established in the TRFE). Excel-based cross section data will be made available to the Program for inclusion into the Integrated Information Management System (IIMS), with Program staff (or its contractors) responsible for transferring the Excel-based data into the IIMS database.

c. Bed Mobility and Scour Methods and Analysis

Substrate will be characterized and bed mobility thresholds monitored on a variety of geomorphic surfaces (e.g., point bars, medial bars and riffles) at 12 sample sites. Pebble counts will be conducted on geomorphic features within patches of homogenous particle sizes to determine tracer rock sizes intersected by the cross section. Pebble counts will be conducted using the Wolman pebble count method by randomly sampling 100 rocks measured on their B-axis (Leopold 1970).If there is a discernable shift where substrate within a geomorphic feature becomes finer or coarser, an additional pebble count will be sampled to quantify differences. The D_{50} and D_{84} rocks will be quantified from each pebble count and associated to the respective

[4] The IAP defines detrimental riparian encroachment as occurring in the channel area within the 450-2,000 cfs inundation zone and being most prone to the re-establishment of dense continuous bands of perennial vegetation that reduce flow velocity, induce fine sediment deposition, and form berms.

substrate patch the cross section intersects. These key particle sizes will be used to develop tracer rocks of D_{84} and D_{50} particle sizes for a sampled cross section.

Bed mobility will be measured using sets of individually-labeled, brightly-marked tracer rock groups installed along established cross sections. Each group will contain two rocks, representing D_{50} and D_{84} size classes. Tracer rocks will be collected, painted, and placed along cross sections following previously established protocols (McBain and Trush 1997) before spring releases from Lewiston Dam. Tracer rock mobility data will be gathered immediately following the streamflow recession when flows are low enough to wade in the channel. Mobility will be determined if travel distances exceeded two feet (movement less than two feet is considered a hydraulic adjustment to a more stable position). Specific tasks include:

1) Identify grain size patches of target geomorphic surfaces on monitoring cross sections;
2) Gather particle size data using modified Wolman pebble counts (Leopold 1970);
3) Use pebble counts to identify D84 and D50 sizes for tracer rock sets;
4) Gather, paint, and label tracer rocks;
5) Place tracer rocks on cross sections and take digital photos of the placement; and
6) After the spring ROD release, identify which marked rocks were mobilized from the cross section; take digital photos of post-flow cross section to show mobility patterns, and for those rocks that are found downstream, measure the downstream transport distance for each rock.

Channelbed scour and redeposition depth in a variety of geomorphic surfaces (e.g., point bars, medial bars, runs, etc.) will be monitored. Scour chains will be installed along selected cross sections following previously established protocols (McBain and Trush 1997), before spring releases from Lewiston Dam. The effects of the spring dam release (and potentially tributary derived high flows) on channelbed scour and redeposition will be assessed immediately after streamflows recede to levels safe for wading. specific tasks include:

1) Locate, install, and survey scour chains, and take digital photos of the placement; and
2) After each high flow, relocate and survey ground surface and top of recovered tracer gravel at each scour chain, and take digital photos of the recovery.

Scour and deposition will be determined by elevation differences pre- and post-peak flows. The surface of the scour nest is surveyed immediately after installation before the spring ROD release. After the spring ROD release the ground surface at the scour chain location is resurveyed to document redeposition depth. After the ground surface is resurveyed and post release deposition is carefully excavated to expose the chain. The exposed scour chain is surveyed to document scour depth. A complete description of bed mobility, scour, and redeposition monitoring methods is presented in the Trinity River Maintenance Flow Study (McBain and Trush 1997).

iii. Characterize Site Geomorphic Features to Relate to Spawning Habitat and Use

Geomorphic units will be mapped at 12 GRTS sample sites at a winter baseflow discharge. Geomorphic mapping will be performed by a specialist in fluvial geomorphology. There are numerous geomorphic classification schemes available for use; our scheme will need to relate to spawning habitat features. The classification scheme will be developed cooperatively by the geomorphologists and fish biologists, and will likely include some or all of the following definitions:

- Lateral bar – A bar confined mainly to the bank on one side of the channel. If the bar connects to the opposite bank, there may be a shingle sequence present. The measurement unit will be square meter.

- Medial bar – Crest control is near the upstream end that forces flow toward both banks. Flow is swift along both banks below the main control and the convergence zone is near the channel center, possibly with eddies on either side (diagnostic features).
- Obstruction bar – Bar formed upstream, downstream, or adjacent to an obstruction (boulder, bedrock, and/or large wood) with enough gradient to provide suitable depths and velocities for spawning.
- Glide – Gradual longitudinal transition of low gradient (<0.001) from a pool towards a riffle crest, where the vertical topographic convergence may cause increased intragravel flow
- Pool tail – Rapid longitudinal transition from a deep pool into a riffle crest, where the vertical topographic convergence may cause increased intragravel flow.
- Low-gradient riffle – The entire length and width of a riffle with gradient between 0.0010 and 0.002 that provides suitable depths and velocities for spawning.
- Channel Margins in Moderate-gradient Riffle – The lateral margins of a higher gradient riffle (>0.002) that provides suitable depths and velocities for spawning.

Unit boundaries will be mapped using GPS and unit attributes will be added into a GIS layer in the field using a tablet computer with geo-referenced 2007 (or most recent) orthorectified aerial photographs.

iv. LARGE WOOD MONITORING AT CHANNEL REHABILITATION SITES

Large wood surveys will be conducted at the 10 channel rehabilitation sites to document "as built" locations and attributes for installed large wood pieces (see Survey Attributes section) or document their change through time and with flow events. The survey includes all installed large wood pieces within a rehabilitation site and any pieces of wood recruited onto constructed surfaces. Subsequent surveys will be conducted following the spring high flow ROD release to document changes in large wood storage and location. The surveys will be repeated, and GIS layers containing the previous years' large wood locations can be compared. Each large wood piece installation will be photographed from a similar angle to capture visually noticeable changes, and the current attributes will be recorded to provide a qualitative description of how the large wood has changed, and how the large wood has influenced fish habitat, and to inform channel rehabilitation site designers on improved placement methods/locations for future designs. New pieces of large wood that have been recruited will also be recorded. Live or dead trees that have not yet fallen into the channel will not be enumerated in the survey. Post-processing of the data is conducted using GPS Pathfinder Office (Trimble), ArcMap (ESRI), and Excel (Microsoft). The survey uses hardware produced by Trimble, inc. including a ProXH GPS unit and a Zephyr antenna. Data is recorded and stored on a tablet PC using GIS software. The 2006-2008 surveys were conducted using ArcPad (ESRI ver. 7.0) software and 2009 surveys in Terrasync (3.21). All photos are taken with a CANON Coolpix 7.2 MP digital SLR camera.

a. Survey Attributes

- Large wood size- Due to the focus on installed pieces, the minimum size requirement is 30 cm diameter X 3 m length; diameter is measured at breast-height (dbh) and length from root wad to end of stem. This system allows you to speed up the survey and relates to geomorphic variables such as potential residence time (Keller and Swanson 1979), total wood volume, mobilization flow and hydraulic potential (Saldi-Caromile et al. 2004). As stream order increases, so too does the size of large wood needed to exert geomorphic effects (Bilby and Ward 1989).
  - Size 1- Small pieces, under 40cm dbh or 4 m length.
  - Size 2- Medium pieces between 40cm-1m dbh and 4m to 10m in length.
  - Size 3- Key pieces larger than 1m dbh or 10m long.
- Tracking the number of pieces, enumeration of large wood (Roni et al. 2005)
  - New: number of new installed and recruited pieces of large wood.

- Recruits: number of recruited pieces since prior survey. These are naturally transported, as opposed to installed pieces.
- Transported: number of pieces abandoning the installation since prior survey.
- Number: total number of large wood pieces present during survey.

- Installation Location
  - Bank- lateral position of the wood relative to stream bank.
    - MS-main stem wood in center of river; not touching island or bank.
    - LB-left bank; RB-right bank
    - ISL-wood associated with an island
    - SC-Side Channel; no need to specify which bank of side channel.
  - Flow-Location: the position of large wood relative to flow (e.g. at what flow it becomes habitat/inundated). Discrete classes are similar to those of Robison and Beschta in 1990, who recorded the proportion of wood within each of 4 "influence zones". These volumes index the amount of wood that is impeding and altering current patterns during bank full flow, important in determining its influence on the stream channel (Robison and Beschta 1990).
    - P= Peak-flow, wood within the 2,000 to 6,000 cfs banks.
    - S= Spring-flow, wood between the 450-2,000 cfs banks.
    - B= Base flow, wood that is wetted between 300-450 cfs.
- Descriptors-installation specific information.
  - Rootwads with stems- The number of rootwads attached to LWD pieces, not including rootwads without a stem.
  - RW Only- Number of rootwads with no attached stem. The presence of rootwads influences the stability of wood by concentrating the mass of the tree onto a relatively small area of the channel bed (Saldi-Caromile et al. 2004).
  - Height- categorized to assess inundation levels, either >2 m or < 2m. Ensuring that some weight is above the design-discharge elevation contributes to an installation's stability (Saldi-Caromile et al. 2004).
  - Wetted- estimated length of large wood lying within the stream. Quantifying the amount of cover provided by structures is particularly important for evaluating techniques designed to provide cover, and is often visually estimated (Bain and Stevenson 1999).
  - Orientation- Position of large wood relative to stream flow. Orientation is a critical parameter in assessing the drag and friction forces acting upon a structure, critical to the structures stability and retention (Saldi-Caromile et al 2004). The orientation of large wood is also related to stream size, as larger streams tend to have few perpendicular pieces and more diagonally oriented pieces forming "deflector pools" (Robison and Beschta 1990).
    - U= Rootwad upstream; the most common natural configuration.
    - D= Roots downstream
    - P= Perpendicular to channel
    - C= Complex, several pieces of large wood with different arrangements.
- Properties: characteristics relating to or resulting from the placement of large wood. Theoretically, each installation will respond differently to the unique variables acting upon it. Recording the function of an individual piece or an in stream structure, based on its influence on pool formation and channel scour, can be important (Roni et al 2005).
  - Scour-wood is causing a backwater or scour pocket
  - Deposition- Wood is becoming embedded within sand or gravel, and/or causing deposition.
  - Velocity Break, the wood redirects and diffuses stream flow.

- Instability- the wood is causing bank failure or lateral erosion to bank, or unstable bank present.
- Anchored- If the log is partially buried, fixed with boulders, or an engineered structure. The anchoring of large wood is a crucial component contributing to the stability of installations (Saldi-Caromile et al 2004).
- Logjam- If recruitment and formation of a logjam occurs. Two pieces or more of a complex arrangement. Complex logjams provide more structural stability, with greater complexity in logjams resulting in visual and physical isolation for more fish (Saldi-Caromile et al 2004) In large river systems, the proportion of wood associated with jams is greater, compromising the majority of LWD in river systems greater than 5th order (Bilby and Ward 1989).
- Branches- Presence of branches on a significant portion of stem. It is desirable to use trees with intact branches to provide additional complexity, as it provides more living space, refuge and stability (Saldi-Caromile et al 2004).
- Riparian Vegetation- The colonization/establishment of native riparian vegetation (in-stream). Large wood accumulations are sites of initial plant colonization within the developing forested floodplain (Fetherston et al 1995). Monitoring the effectiveness of restoration actions requires measuring riparian vegetation (Pollock et al in Roni et al 2005), as riparian succession involves numerous factors including climate, geology, major disturbance processes (hill slope and fluvial), channel size and form and large wood availability (Fetherstone et al 1995).
- Overgrown- Large wood structure is completely engulfed by vegetation (on bank).
- No Effects- No observable changes from the installation.

Data from the large wood rehabilitation site survey are analyzed to evaluate the attributes of the large wood installations and their change through time. Installation types are also categorized and evaluated for their effectiveness in producing beneficial attributes as well as the persistence of these attributes through time. Data will be explored for correlations and trends that may be useful for the Trinity River Restoration Program Implementation Group in future large wood installation design processes.

v. LARGE WOOD MONITORING AT GRTS SITES

At 12 GRTS sample sites, all large wood contained within the channel will be mapped up to an elevation of approximately the 2,000 cfs water surface elevation. Live trees or dead trees that have not fallen into the channel will not be enumerated in the survey. Mapping will either use GPS with a Tablet PC or a total station with data collector; either method will be used to locate large wood location and elevation, and attach attributes of each piece of wood mapped. Each end of a large wood piece will be located spatially and elevationally to enable a hydraulic model to predict when the large wood piece is inundated, thus available as fish habitat. Attributes of the large wood piece, such as species and trunk diameter, will be recorded. This method will only focus on changes in large wood storage at a site, and will not assess large wood routing or budgeting. Therefore, individual large wood will not be tagged or tracked if it routes downstream.

C. WILDLIFE-METHODS AND ANALYSIS

i. FOOTHILL YELLOW-LEGGED FROG EGG MASS SURVEYS

Foothill yellow-legged frog egg mass monitoring will occur based on appropriate time of year for egg masses to occur and supplemented with four float surveys to census oviposition sites on the Trinity River from near the Lewiston dam to the confluence of the North Fork Trinity River. Visual Encounter Surveys (VES) (Crump and Scott 1994) will be conducted on appropriate habitat (cobble bars) at several flow regimes, with census surveys occurring at two week intervals from late May until early July 2010. Site will be accessed by either drive-up with a vehicle or by floating into a site in an inflatable kayak. Egg mass locations will be mapped as

well as identified by Trimble GPS units for sub-meter accuracy and have the following parameters recorded: depth substrate at egg mass from water surface level; depth of the top of egg mass from water surface level; distance to wetted shore; attachment substrate, velocity and Gosner Stage (developmental stage). Thermal transects at three oviposition sites will be monitored from initial detection of egg masses until subsequent hatch-out. A thermal transect will be established at the two GRTS sample sites to conduct comparative analysis of use versus non-use locations. When an egg mass is located at a site to be used in thermal monitoring, we will use three tidbit temperature recorders set in a transect, one at the site of oviposition, the another one-half the distance from wetted-shore to the egg mass, and one the same distance out away from the egg mass perpendicular to shore (e.g. if an egg mass is located 2 meters from shore, there would be a temperature logger placed at 1 meter, 2 meters and 3 meters from shore). For the two non-use sites, temperature loggers will be placed in a transect based on distances obtained in used areas at the two GRTS sample sites.

Egg mass numbers will be assessed on a per kilometer of shoreline surveyed (e.g. 0.5 Egg Masses/Kilometer). Timing of egg mass appearance per repeatedly surveyed sites will be assessed in relation to flow parameters and temperatures. In 2010, a double-observer method will be utilized to assess delectability of egg masses following the methods described in Grant et al. (2005). In short, the first observer will point to and count egg masses to observer 2, who will record observer 1's detection in one column but will record any additional egg masses not detected by observer 1 in a separate column. The first observer for any single survey will be determined by the flip of a coin. Analysis will be conducted in Program MARK (White and Burham 1999) using occupancy modeling developed by MacKenzie for Program MARK (MacKenzie et al. 2002)

For the parameters to be collected for the habitat suitability criteria (HSC), at a select number of egg masses, the attachment substrate will be recorded (substrate categories will follow Table A-1 in this proposal); both the depth at the midline of the egg mass as well as total depth at egg mass; velocity of water at egg mass and mid-column velocity of water at egg mass will be recorded. If FYF egg masses are identified within the boundaries of a 2-D hydrodynamic modeling site shear stress will be computed. We anticipate that it will take multiple years to develop an HSC dataset for FYF egg masses due to their low abundance in the system. We are targeting at least 150 egg mass observations to complete this dataset and incorporate it into microhabitat modeling. In addition to the HSC modeling of data will be a joint endeavor between Hoopa Tribe (subcontract of McBain and Trush) and USFWS based on where 90% of detections of egg masses occur for each of the three main variables collected: substrate, water depth and water velocity to establish HSC for FYF breeding on the 64 rkm of Trinity River below the Lewiston reservoir.

i. WESTERN POND TURTLE SURVEYS

Mark-recaptures surveys will occur with snorkel dives to encounter WPT (Reese and Welsh 1998). For the six defined number of restoration sites and eight GRTS sample sites, turtles captured will have eight metamorphic measurements taken, gender, age based on growth annuli, and file of unique number patterns in the marginal shields. At least three dives will occur at designated restoration sites to be able to obtain relative abundance as well as map habitat use integrated with fish habitat mapping. When turtles are located in 2010 during any dive surveys, the habitat they are found using (e.g. under boulder, along bedrock, under log) will be recorded. The depth of the turtle location will also be recorded, as well as distant to wetted shore.

Turtle locations will be assessed in relation to habitat maps provided by the habitat assessment group. Movement within habitats will be assessed based on repeated captures of marked animals. Population size will be assessed for restoration sites in relation to area surveyed for the project (e.g. # of turtles/ square meters or # of turtles/ cubed meters). Radio-tracked turtles will be mapped and GPS UTMs at sub-meter

accuracy for each encountered pre, during and post construction to assess turtle behavior to restoration activities or within the eight pre-defined GRT panels where turtle surveys will be conducted.

Data analysis will consist of generating population estimates in Program MARK (White and Burnham 1999) with Closed Models for single season visits (sites visited for the first time in FY09) and with Robust Models for sites that have across year surveys (several of the Restoration sites). These models will provide population estimates, survival estimates and probability of encounter estimates that will better elucidate turtle's reactions to both restoration projects and to system-wide distribution.