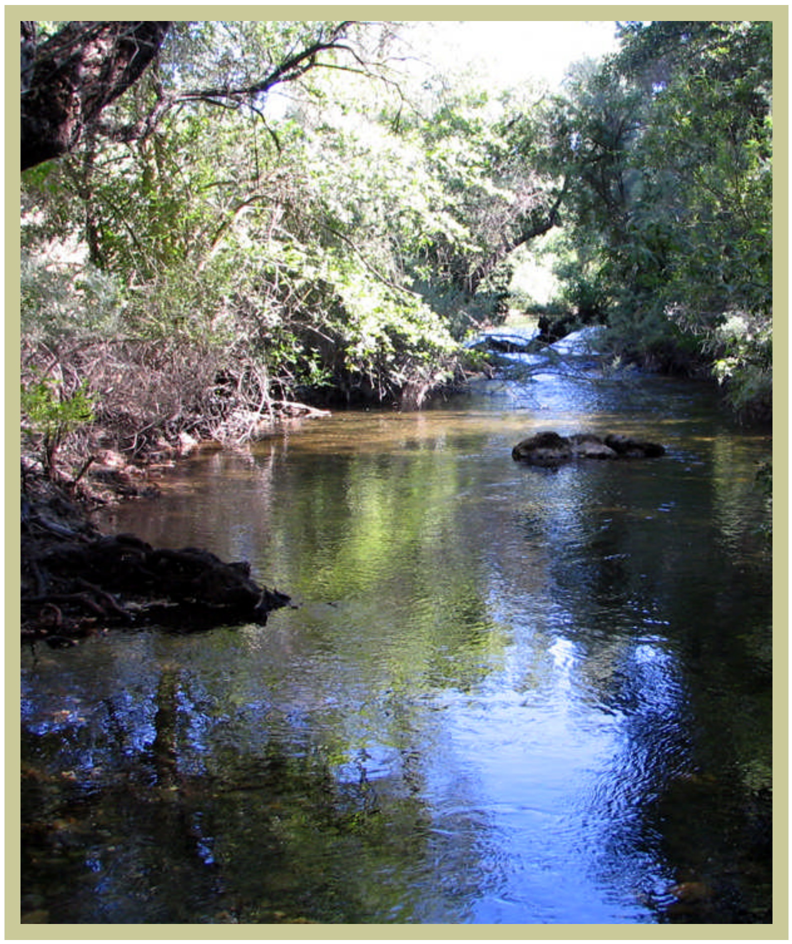
Lancaster Road Side Channel & Floodplain Project
Restoration Monitoring Program



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SUMMARY

The following document is intended to provide a detailed description of the monitoring program associated with the Lancaster Road Floodplain Restoration Project. The project aims to restore critical habitats for juvenile salmonids, in coordination with landowners, to promote the recovery of healthy and diverse Chinook salmon and steelhead populations in the Stanislaus River. The project is funded by the U.S. Fish and Wildlife Service (USFWS) Anadromous Fish Restoration Program (AFRP) and this vision fits into the framework of salmonid population recovery on the Stanislaus River and aligns with the following AFRP goals to: 1) involve local partners in the implementation and evaluation of restoration actions; 2) improve habitat for all anadromous life stages through improved physical habitat; and, 3) collect fish population, health, and habitat data to facilitate evaluation of restoration actions (USFWS 2001). The vision also meets objectives outlined in previous planning efforts for the Stanislaus River (CFS 2009).

The monitoring program consists of three conceptual approaches to monitoring: implementation, effectiveness, and validation. The implementation monitoring will determine if the project was installed according to the design standards. Hydrology, topography/bathymetry, sediment budget and vegetation will be assessed. The central question is: Was the project implemented according to plan? The effectiveness monitoring will determine if the project was effective in recovering habitat conditions suitable to target species. A range of physical and biological traits will be tracked before and after restoration to assess ecosystem function. The central question of effectiveness monitoring is: Was the project effective in meeting its target objectives? The final part of the monitoring program will determine if floodplain restoration projects, like the one at Lancaster Road, recover *productive* habitat for juvenile salmonids and riparian vegetation. This validation monitoring is intended to validate the underlying assumptions of the restoration work. The central question of validation monitoring is: Are the basic assumptions behind the project's conceptual model valid? This monitoring program will collect detailed physical and biological information for evaluation. This evaluation may improve our understanding of restored ecosystem function at Lancaster Road and the potential of side channel and floodplain river restoration projects to contribute to improved salmonid populations.

Metrics outlined in this plan have been focused considering the project's target objectives, the focus of AFRP, and to make use of some of the newest tools available in ecosystem science. The monitoring program for this project has been developed specifically to test hypotheses about habitat recovery processes. Several authors have noted the utility of designing restoration projects as experiments to test hypotheses regarding the physical and biological responses to restoration actions, and to develop a better understanding of process-based approaches in restoration science (Simenstad and Thom 1996; Roni et al. 2005; Merz and Moyle 2006). In order to understand the cause and effect relationships in restoring system processes, both effectiveness and validation monitoring are needed to learn from both failures and successes (Roni et al. 2005). This project integrates restoration actions, landowner partnerships, outreach and education, monitoring, and adaptive management to better restore habitat in the Stanislaus River, and provides an example for other Central Valley rivers.

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INTRODUCTION

Background

As in many Central Valley rivers, historic gold and gravel mining greatly altered geomorphic and hydraulic conditions salmonids evolved with in the Stanislaus River. As gold was retrieved from river sediments, discarded tailings were piled on floodplains (Clark 1970). These actions inverted in-channel gravel composition, disconnected side channels and floodplains, and heavily impacted salmon populations (Kondolf 1997). By removing tailings and recovering side channel and floodplain connectivity, productive rearing habitat for juvenile salmonids can be recreated (Richards et al. 1992; Heady & Merz 2007). Rearing habitat is described as the physical conditions, including water temperature, dissolved oxygen, turbidity, substrate size/composition, water velocity and depth, and available cover (Bjornn & Reiser 1991; Healey 1991; Jackson 1992), which maintain the biological components (e.g., invertebrate prey resources) critical to habitat productivity for fish (Simenstad & Cordell 2000). Stanislaus River riparian areas historically supported a diverse, dynamic ecosystem complex of seasonal wetlands, oxbow lakes and extensive forested floodplains, with meandering side channels (Elias 1924). A diversity of habitats existed in these shallow-water areas characterized by dense overhanging vegetation, cool water temperatures, large woody debris, low water velocity, and ample prey production. Young salmonids exploit food resources in off-channel habitats, find optimal temperatures and escape unfavorable environmental conditions of the main channel such as predators, inadequate cover, and high turbidity (USRFRHAC 1989; Sommer et al. 2001). Extensive alterations to Stanislaus River beds deeply incised the main channel, disconnected side channels and floodplains, and altered riparian vegetation. Regulated flows compounded incision, further eroded beds and banks, coarsened bed material, and degraded spawning habitat value for salmon and trout (Kondolf 1997). The precipitous decline of Central Valley Pacific salmon *Oncorhynchus* spp. has led to extirpation of many populations of this ecologically and commercially important fish (Nehlsen et al. 1991; Merz & Moyle 2006). According to AFRP, current flood control practices require peak flood discharges to be held and released over a period of weeks. Consequently, river mainstems often remain too high and turbid to provide quality rearing habitat. In addition, loss of sinuosity and braiding has reduced total habitat area and degraded remaining habitat with increased velocities. Restoration activities that include floodplain grading and side channel reconnection are among the solutions for this problem. Sommer et al. (2001) and Heady and Merz (2007) have demonstrated the value in recovering shallow-water habitats to improve salmonid rearing conditions. With continued loss of habitat quantity and quality, preserving or enhancing these components is vitally important.

Vision

We have developed the following vision for the Lancaster Road floodplain restoration project:

> *To restore critical habitats for juvenile salmonids, in coordination with local communities and stakeholders, to promote the recovery of healthy and diverse Chinook salmon and steelhead populations in the Stanislaus River, while helping to meet the abundance goals of the Anadromous Fish Restoration Program (AFRP).*

This vision fits into the framework of salmonid population recovery on the Stanislaus River and is aligned with the following AFRP goals to: 1) involve local partners in the implementation and evaluation of restoration actions; 2) improve habitat for all anadromous life stages through improved physical habitat; and, 3) collect fish population, health, and habitat data to facilitate evaluation of restoration actions (USFWS 2001). The vision also meets objectives outlined in previous planning efforts for the Stanislaus River (CFS 2009).

Project Goals

We developed the following goals for the Lancaster Road floodplain restoration project:

1) To serve as an example of publicly-supported applied fisheries and restoration science;
2) To rehabilitate and enhance productive juvenile salmonid rearing habitat in the Stanislaus River; and,
3) To determine project effectiveness with an efficient and scientifically robust monitoring program.

These goals fit into the framework of AFRP, and meet the AFRP and CALFED requirement to use adaptive management in planning, design, and implementation (CALFED 2001). The following provides details and information about the monitoring program, although the Target Objectives for all project goals are included here also.

Target Objectives

Realistic target objectives are an important component of our approach to clearly address project goals. Detailed actions provide the necessary steps to achieve the target objectives. Iterative review of these actions is essential to determining the reliability in each particular step to meet the parameters of the project goal. The following components (i.e., Community Outreach Plan, Design Standards, and Monitoring Plan) and associated target objectives were developed to meet the aforementioned project vision and goal for the Lancaster Road floodplain restoration project:

1) <u>Community Outreach Plan (COP)</u>: To have the project serve as an example of publicly-supported applied fisheries and restoration science, we will:

a) provide a range of outreach opportunities to promote the value of river restoration to stakeholders and local community members;
b) incorporate the values of the community into the project (e.g., aesthetic values, flood control, socio-economic needs of the community, etc.); and,
c) promote a Stewardship Program for the river that integrates individual projects into the framework.

2) <u>Design Standards</u>: To effectively rehabilitate and enhance productive juvenile salmonid rearing habitat in the Stanislaus River, we will:

a) design the project to function under current flow regimes (i.e., magnitude and duration);
b) restore ecological processes at the proposed project site to increase the availability of productive juvenile salmonid rearing habitat;

c) create habitat conditions suitable for juvenile Chinook rearing (i.e., fry and sub-yearling smolts); and,

d) preserve native vegetation and utilize existing habitat features to the maximum extent possible.

3) <u>Monitoring Plan</u>: To determine project effectiveness we will develop an efficient and scientifically-robust monitoring program to:

a) test hypotheses about the benefit of recovered side channels and seasonally inundated floodplain habitats to juvenile salmonids and native plant recruitment

The following outlines the details of our Monitoring Plan. Information on the Community Outreach Plan and Design Standards are available separately.

Monitoring Perspective

Our monitoring program will take an 'Ecosystem Perspective' as described by the Adaptive Management Forum (2002) by tracking physical and biological parameters; and the structural and functional responses by the restored ecosystem. Following suggestions from the Forum, we will consider alternative paradigms of ecosystem restoration when developing our project conceptual designs; develop an action plan to incorporate monitoring information and provide a framework for adaptive management; continue to clearly define quantifiable short- and long-term goals; and, include performance criteria (e.g., fish growth potential) to describe ecosystem function. We will ensure links in scientific input, project design, and implementation factors are intact and continuously refined.

Considerable debate about the effectiveness of restoration projects (Reeves et al. 1991; Kondolf 1995; Kaufman et al. 1997; Roni et al. 2002), in addition to the substantial investment of public funds, make it incomprehensible that monitoring is not an essential element of every restoration project (Roni and Quimby 2005). Monitoring is important to determine the environmental characteristics of a particular site. The parameters measured are critical physical and biological drivers of habitat and are intended to detect environmental change. Specific indicators (e.g., fish performance) are used that determine a value at a specific time (status), and with continued monitoring changes in the value across time at the same location (trend) can be determined. By designing monitoring programs to follow trends, the state of the system, especially restored systems, can be determined. Monitoring is critical for adaptive management. Detecting and recognizing meaningful change in complex natural systems is difficult, because the systems are dynamic and heterogeneous. Ecosystems maintain dynamic variation within predictable bounds (Chapin et al. 1996), but often these bounds are unknown with restoring systems. On-site monitoring is critical to fully understand project success and the recovery of ecosystem function (Roni and Quimby 2005).

The following monitoring program is designed to determine the success of side channel recreation at Lancaster Road in the Stanislaus River, and assess the effectiveness of the project to enhance juvenile salmonid productivity. Metrics outlined in this plan fit the focus of AFRP and make use of some of the newest tools available in ecosystem science.

Integrating with Other Monitoring Programs

This monitoring program will be designed to integrate with the other long-term monitoring occurring in the Stanislaus River, as possible. From 1996–2010, the USFWS supported CFS to monitor juvenile salmonid out-migration in the Stanislaus River. This monitoring program determines annual juvenile Chinook salmon and *O. mykiss* production using rotary screw traps (RSTs) at Caswell Memorial State Park (Caswell; rkm 13), and quantifies emigrants to the San Joaquin River (Watry et al. 2007, 2008). This data set is intended to provide a valuable source of information for evaluating fish responses to in-river management actions (CAMP 1997). The primary objectives of this project are: 1) estimate abundance of juvenile salmonid out-migrants in the lower Stanislaus River using RSTs operated near Caswell; and, 2) determine and evaluate patterns of timing, size, and abundance of juveniles relative to flow and other environmental conditions. This juvenile salmon monitoring program helps AFRP and CAMP address their goals to track population dynamics, evaluate the results of past and future habitat restoration efforts, and to understand the impacts of instream flow schedules and management on the fall-run Chinook salmon population. Tri-Dam has also funded ongoing juvenile salmonid population monitoring at Oakdale (rkm 63). The monitoring effort aims to determine in-river spawning success by tracking the number of fry produced. The effort also provides information about *O. mykiss* and other fish species able to be collected by RST.

During post-project monitoring activities at Lancaster Road, juvenile salmonids may be collected on-site, and marked during processing for additional data collection. The collection of marked fish at Caswell or Oakdale would indicate successful rearing and migration, and document the potential benefits of restored rearing habitat to the population. The size and condition of fish may also indicate improvements in rearing conditions, although a detectable signal may be difficult to obtain due to the overwhelming impact of the other limiting factors in the river. Similar protocols are being conducted in Clear Creek following floodplain rehabilitation (M. Teubert, pers. comm., 2008).

Partnering with AFRP and the Community

This monitoring program will occur with the contribution of AFRP and potentially interested community members. We anticipate AFRP staff members will assist with periodic data collections including aquatic habitat sampling, vegetation and topographic surveys. Anadromous Fish Restoration Program staff will also assist during validation experiments. We also anticipate the potential to meet interested community members at the public outreach functions who may be interested in assisting with data collection on site. Through a coordinated effort, more detailed monitoring can be accomplished and partnerships with interested parties strengthened.

STUDY AREA

The study site is located on the Stanislaus River (rkm 77) accessible via Lancaster Road off HWY 108/120 (Figure 1). Approximately 655 linear feet of remnant side channel and associated floodplain habitat are available to be restored. Owners of adjacent riparian properties (i.e., Kusmeko, Ridgewell, Curtis, and Lowsbery), have partnered with CFS and AFRP to conduct this side channel and floodplain habitat restoration project. Currently, the adjoining properties have a remnant side channel and adjacent alluvial bar that inundates only during high flow periods (e.g., >3,000 cfs). Following the construction of New Melones Dam, flow exceeded 3,000 cfs periodically in only nine of the 28 years (1980 – 2007; 32% of the time). This project will restore the remnant side channel and reconnect the floodplain at flows of >575 cfs, and enhance juvenile salmonid rearing habitat function with annual inundation. Non-native invasive plants will be removed, and the following effectiveness monitoring program will document the recovery of juvenile salmonid rearing habitat.

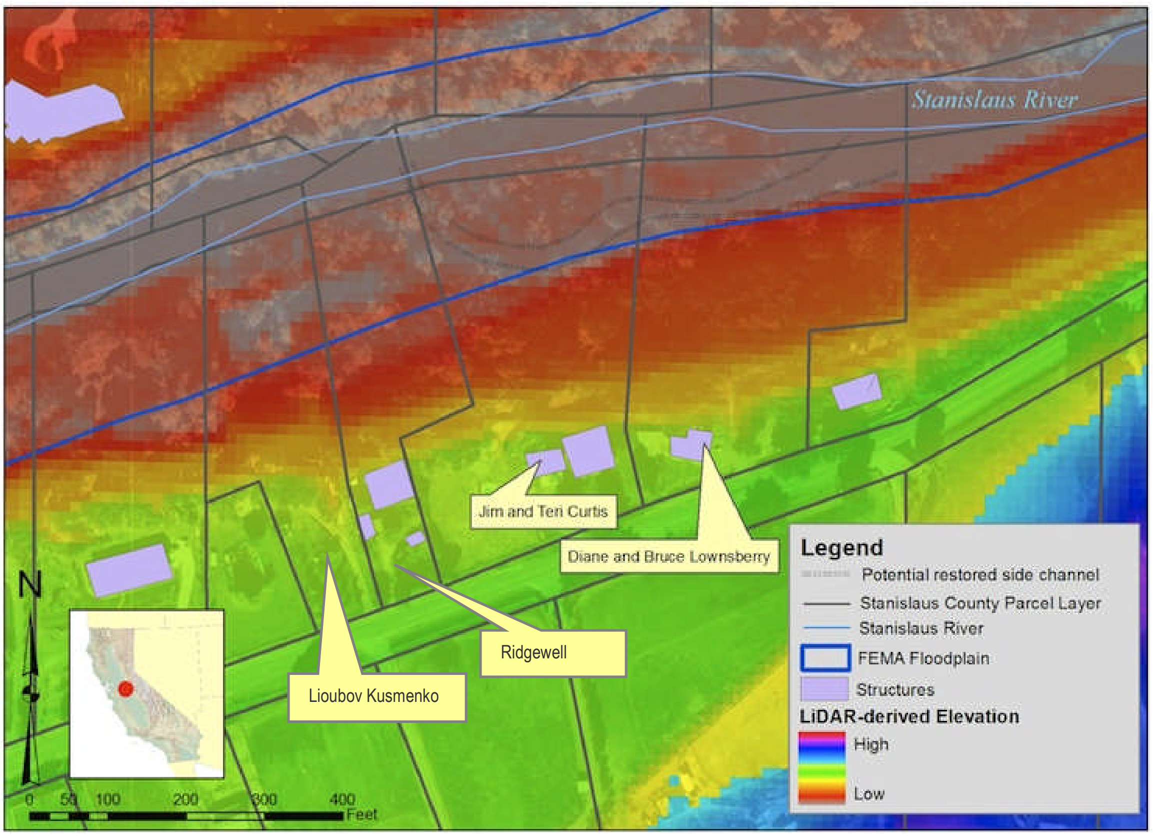

Figure 1. Lancaster Road Side Channel Restoration Project, Stanislaus River, CA with ownership parcels, FEMA floodplain, river extent, and LiDAR-derived topography (see Legend).

Overview

Generally, assessment of restoration actions should include three types of monitoring: implementation; effectiveness; and validation (MacDonald et al. 1991; Kershner 1997; Mulder et al. 1999). Time scales, project aspects, and objectives addressed will vary among types of monitoring, but the basic questions and time frames are included in Table 1.

Table 1. Monitoring types for restoration projects (Stillwater Sciences 2006).

Type of Monitoring	Question Addressed	Time Frame
Implementation	Was the project installed as planned?	1 – 6 months
Effectiveness	Was the project effective at meeting restoration objectives?	1 year to decades
Validation	Are the basic assumptions behind the project conceptual model valid?	5 – 10 years

With the following monitoring program for the Lancaster Road project, we will include each type of monitoring to answer critical questions about project success. Success of implementation will be carefully tracked using physical parameters, the effectiveness of the project will be assessed with a variety of physical and biological parameters important for juvenile salmonid rearing habitat, and the ultimate success of the project in terms of juvenile salmonid growth potential will be tested using a bioenergetics model. The results of the monitoring will serve to validate the basic assumptions about recovering floodplain and side channel habitat. This monitoring program is designed to determine and document project outcomes, and serve to inform fisheries scientists with a regional-level understanding of ecosystem dynamics in the Sacramento-San Joaquin watersheds.

Implementation Monitoring

Implementation monitoring will determine if the restoration project was implemented according to the design plan, and if it met the goals of the project. Generally, monitoring occurs after construction is complete, however some aspects will be carried out during implementation as a check on design appropriateness (Kershner 1997). Mid-course corrections can be made as appropriate. In addition to tracking the success of the implementation in terms of physical structure, we will also investigate the restored channel and floodplain function in terms of hydrology and flooding inundation. The frequency and duration of flooding is among the primary drivers of habitat productivity in terms of accessibility for fish, prey resource production, and habitat maintaining processes (Hill et al. 1991; Tockner et al. 2000). Projections were established during the project design planning for frequency and duration of inundation. To determine if the project was installed as planned, the following monitoring components will be addressed (Table 2):

Table 2. Implementation monitoring components (Stillwater Sciences 2006), revised.

Component	Question(s)	Parameter	Timeline
C1. Constructed topography/bathymetry match those in project design plans.	Does the constructed topography/bathymetry match design plans?	Topography and Bathymetry	During and Immediately following construction; September 2011
C2. Inundation frequency and duration matches target objectives.	Does duration and magnitude of flooding match design plans?	Discharge, flooding inundation, rate of recession	Following construction, then continuous; October 2011 – September 2014

Effectiveness Monitoring

The primary question to be answered by the effectiveness monitoring is: was the project effective at meeting restoration objectives? Site-specific effectiveness monitoring will track physical conditions and biological responses necessary to provide productive rearing for juvenile salmonids. Effectiveness monitoring is complex and requires evaluating the outcomes of multiple objectives relating physical, biological, and biogeochemical factors at work in the river-floodplain ecosystem (Stillwater Sciences 2006). It is important to include the physical parameters of the aquatic and terrestrial environments (i.e., riparian areas). Hydrology and water quality are important parameters to understand when assessing function in aquatic habitats. These physical parameters are likely controlling the biological responses (also important to determine with robust data) in the side channel and floodplain in terms of fish use and residence, invertebrate production, fish foraging success, diet composition and potential growth. Effectiveness monitoring is hypothesis driven. The effectiveness monitoring for the Lancaster Road project is designed to test the following two hypotheses (Table 3).

Table 3. Effectiveness monitoring hypotheses, questions, parameters measured, and timeline.

Hypothesis	Question(s)	Parameters Measured	Timeline
$H1_0$: *Restoring floodplain processes in the Stanislaus River does not result in improved habitat conditions for salmonid rearing habitat.* $H1_a$: *Restoring floodplain processes in the Stanislaus River results in improved habitat conditions for salmonid rearing habitat.*	Are habitat conditions in project area suitable for juvenile salmonid rearing? Are conditions following restoration significantly different than reference sites?	Flooding Inundation Water Velocity/Depth Water Temperature Dissolved Oxygen Turbidity Fish Surveys Macroinvertebrates	February, March 2010 – 2014 April, May 2010 – 2014
$H2_0$: *Restoring floodplain processes in the Stanislaus River does not result in improved conditions for native vegetation communities.* $H2_a$: *Restoring floodplain processes in the Stanislaus River does result in improved conditions for native vegetation communities.*	Was there an increase in native vegetation in the project area? Was the cover of non-native invasive plant species reduced or prevented?	Photo Points Field-Collected Vegetation Data	June, July 2010 – 2014

These questions align with the target objectives for the overall project. Those physical and biological parameters closely aligned with defining productive rearing habitat for salmonids will be tracked with the monitoring program. Those data will enable the CFS team to determine if the project was effective at recovering productive juvenile rearing habitat and conditions to maintain native plant communities. The additional experimentation in the Validation Monitoring will provide quantitative growth potential estimates to further address productivity in the restored site. By using the hypothesis testing approach and answering detailed questions associated with the project, we will be able to monitor the project's effectiveness and provide detailed information to inform ongoing restoration for salmonids throughout the Central Valley.

Validation Monitoring

Validation monitoring is carried out to verify the underlying assumptions of the project conceptual model, and as a consequence this type of monitoring has a research focus (Kershner 1997). These studies are designed to provide support to the previously stated hypothesis and to primarily address the following question: are the basic assumptions behind the project conceptual model valid (i.e., does the project contribute to increased productivity for juvenile salmonid populations in the Stanislaus River)? The studies also investigate the linkages between ecosystem processes and native plant community response to restoration.

We will use a bioenergetics model to assess juvenile Chinook salmon performance in the river mainstem and restored site, as a way to compare the potential improvement in habitat of the side channel restoration. The bioenergetics model is a powerful tool to assess habitat in terms of potential fish growth and has been used by other researchers aiming to assess restoration success (Sommer et al. 2001; Madon et al. 2001; Gray 2005). These experiments will provide critical evidence to support the hypothesis of restoring habitat productivity, and will serve to provide the robust assessment necessary to determine true project success. The model's energy-balance approach estimates growth as food consumed (C) minus the energetic costs of respiration (R), specific dynamic action (cost of processing a meal) (S), and wastes (egestion (F) and excretion (U)). Model inputs will include site-specific temperature, fish size, diet composition and prey energy content. By demonstrating the benefit available to rearing fish, the work should increase our understanding of mechanisms of channel enhancement and floodplain restoration, and the links between healthy ecosystem, hydrologic and geomorphic processes (Merz et al. 2004; Wheaton et al. 2004a, b).

The following hypotheses will be tested to determine the benefit recovered side channels and seasonally inundated floodplain habitats to juvenile salmonids (Table 4).

Table 4. Validation monitoring hypotheses, questions, parameters measured, and timeline.

Hypothesis	Question(s)	Parameters Measured	Timeline
$H1_0$: *Restoring floodplains in the Stanislaus River provide no productive salmonid rearing habitat.* $H1_a$: *Restoring floodplains in the Stanislaus River provides productive salmonid rearing habitat.*	Does restoring floodplain processes recover productive habitat for salmonid rearing?	Juvenile Growth Potential determined with Bioenergetics Model -fish size, diet composition, consumption rate, prey energy content, and temperature conditions	February, March 2012 – 2014

$H2_0$: *Restoring floodplains in the Stanislaus River does not restore ecosystem processes that lead to an increase in native vegetation cover and complexity.* $H2_a$: *Restoring floodplains in the Stanislaus River does restore ecosystem processes that lead to an increase in native vegetation cover and complexity.*	Does restoring floodplains recover ecosystem processes that affect the success of natural native plant recruitment?	Flooding inundation Sediment dynamics Woody plant recruitment Total plant species diversity	June, July 2012 – 2013

Sampling Sites and Study Design

Sampling sites will be selected in a stratified, random manner using ArcGIS (e.g., Hawth's tools) and navigating to the pre-selected sampling locations with a sub-meter GPS. The study design includes sampling from the side channel and river mainstem prior to project construction, including fish use, invertebrates, photo points, and vegetation analysis. After construction, sampling will continue in the same locations to track the physical and biological changes in these parameters after construction. Sediment permeability data will be collected following construction. A vegetation analysis will follow the survival and vigor of the native vegetation, along with documenting species composition and percent cover for three years post-implementation. An illustration of the sampling effort provides an overview of the monitoring program, although true locations of sampling are not reflected (Figure 2). Table 5 provides details about the parameters the CFS team will assess as part of this monitoring program. River discharge will be obtained from gauges at OBB and GDW, and then compared with onsite data obtained from the pressure transducers. Depth, velocity, turbidity, and DO measures are collected concurrently with invertebrate collections, however since invertebrates will be collected in the river mainstem and the side channel with randomly-selected, stratified samples those data can be used to compare conditions in the side channel and those available to rearing juvenile salmonids in the mainstem.

Relevé field sampling (CNPS 2007) is used for vegetation data collection. This protocol follows methods of vegetation community sampling developed by the California Native Plant Society and CDFG to meet the standards developed by the Federal Geographic Data Committee (Jennings et al. 2009). These standards have been submitted to the State Legislature as vegetation mapping standards for California (CDFG Item 3600-001-0001). Furthermore, the San Joaquin Valley has been identified by CDFG as a high priority area for vegetation sampling, classification and mapping (CDFG 2007). The relevé provides detailed quantitative measures of vegetation structure, composition and cover dominance that are collected efficiently, analyzed statistically and are accurately repeatable across time by trained personnel. It also collects habitat information per the California Wildlife-Habitat Relationships System (see http://www.dfg.ca.gov/biogeodata/cwhr/). Additionally, we will map woody stem recruitment within a gridded subplot of each relevé.

Before and after channel bathymetric and floodplain topographic surveys will document the dimensions and elevations within the project area. Additionally, topographic surveys will be conducted on an annual basis to monitor the project area and fluctuations in bed elevation resulting from sediment deposition and scour and, potentially, lateral shifts of the channel. Changes are expected as part of the natural function of the river landscape, and a better understanding between the topographic characteristics and biological function will be enabled by these data collections. Cross-section and longitudinal profile surveys will provide detailed documentation of elevations, dimensions, and forms of the main channel and floodplain.

Relative fish abundance and diet composition will be evaluated at aquatic habitat sampling sites by multi-pass electrofish sampling (Van Deventer & Platts 1989; Reynolds 1993) and gastric lavage (Haley 1998; Koehler et al. 2006). These methods allow collection of information on densities and diet composition *without mortality*. Diet samples will be processed following standard procedures described in Terry (1977) and Gray et al. (2002). Diet composition information may also be available (by gastric lavage) of fish obtained during the ongoing RST operations, if necessary. A relative consumption rate will be determined by assessing the weight of the stomach contents to the weight of the fish (ration). Prey energy will be generalized using literature values. Several studies have suggested the use of models to assess habitat (Madon et al. 2001), or used it to assess relative conditions in a restored floodplain (Sommer et al. 2001). These data will provide critical information to address questions associated with implementation, effectiveness and validation. Our intent is to document that the project was implemented according to design plans, is effective in terms of providing habitat for riparian vegetation and salmonids, and validates project assumptions regarding the potential productivity for salmonids by restored river landscapes.

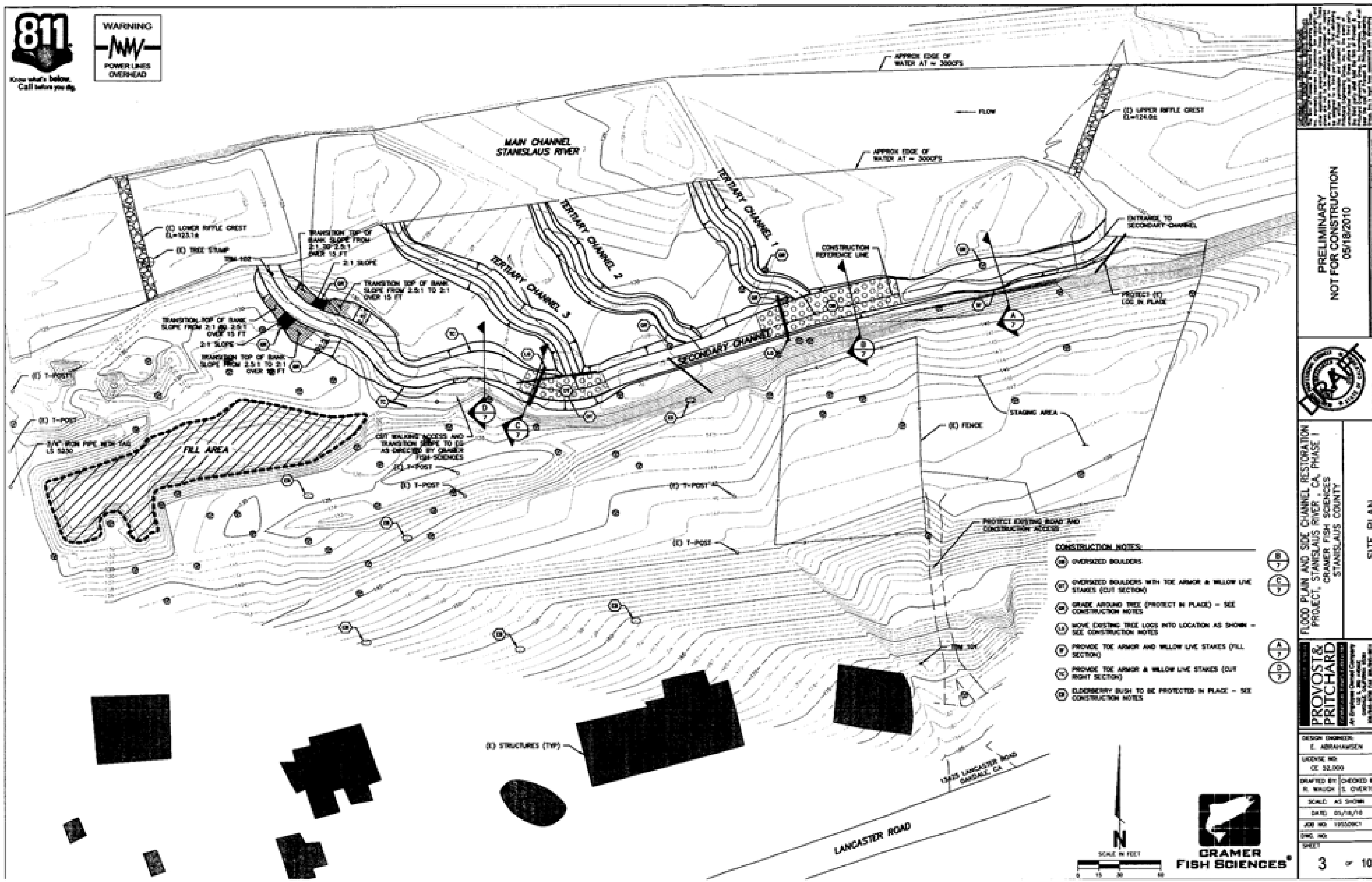

Figure 2. General overview of the Lancaster Road Floodplain Restoration project.

Table 5. Monitoring study design and additional details.

Monitoring Parameter	Description/Use	Field Equipment	Personnel	Time Period Collected	Implementation	Effectiveness	Validation
Hydrology							
Discharge	Determine outflow conditions	NA	USBR	entire project period			
Flooding Inundation and Rate of Flow Recession	Determine frequency and duration of flooding events before and after restoration actions	Pressure Sensors	CFS	entire project period	X	X	
Water Velocity	Assess instantaneous habitat conditions	Flowmeter	CFS	seasonally		X	
Water Depth	Assess instantaneous habitat conditions	Measuring Stick	CFS	seasonally		X	
Topography/Bathymetry							
Topographic Surveys	Determine elevations across project site	Survey Equipment	P&P/CFS	annually	X		
Cross-sectional Surveys	Determine elevations at several randomlly distributed cross-sections	Survey Equipment	P&P/CFS	annually	X		
Sediment Characteristics							
Permeability	Determine level of embeddedness	Stand Pipe	CFS	seasonally		X	X
Surface Composition	Determine surface substract composition	Pebble Counts	CFS	seasonally		X	X
Bulk Composition	Determine % fines	Bulk Sampling	CFS	annually		X	X
Water Quality							
Temperature	Assess instantaneous habitat conditions	TidBit Continuous Data Logger	CFS	continuously		X	X
Dissolved Oxygen	Assess instantaneous habitat conditions	DO Meter	CFS	seasonally		X	
Turbidity	Assess instantaneous habitat conditions	Turbidity Meter	CFS	seasonally		X	
Biological Conditions							
Photo Points	Document general changes in the system following restoration actions	Digitial Camera and tripod	CFS	seasonally	X	X	
Vegetation Characteristics	Track vegetation conditions in the project site and an adjacent reference	Field survey equipment	botanist	annually	X	X	X
Wildlife Surveys	Track wildlife activity and use in the project area	Binoculars, GPS	CFS	seasonally	X		
Fish Surveys	Determine juvenile fish presence and abundance at project site; Use enclosure nets to determine site-specific fish diets and consumption rates;	Beach Seine, Electrofisher, Gastric Lavage Equipment, GPS, etc.	CFS	seasonally	X	X	X
Macroinvertebrates	Determine prey resource availability and composition	Hess Sampler, Drift Collector	CFS	seasonally		X	X

METHODS

The following provides detailed descriptions of the methods used for the various monitoring efforts described in this program. Our objective is to address our questions and hypotheses with targeted, efficient sampling and robust, quality data. Standard methods will be used for most monitoring activities and statistics will be applied to the results appropriately to test our hypotheses. All field activities will be conducted with qualified personnel trained in first aid and all safety precautions.

Spatial Database

Global Position System (GPS)

The CFS team will collect as much monitoring information as possible with location information using the Trimble GeoXT™ (GeoExplorer® 2008 series). Data dictionaries will be built using the PathFinder Office™ software package to simultaneously enable easy collection of survey and location information. Data will be downloaded and post-processed immediately (within 24 – 48 hours), keeping in mind base stations are generally updated every 24 hours. Post-processed data will be checked for errors and stored with backups created periodically.

Geographic Information System (GIS)

The CFS team will use ESRI (www.esri.com) GIS to collate and summarize some of the physical and biological data collected by this monitoring program. The GIS links the spatial information obtained by GPS to photos, data tables, and other files. This spatial database system can be queried to obtain information to apply to other analyses (e.g., bioenergetics, vegetation controls, etc.). Field collected GPS data are exported into .shp files which are then opened with ArcView 9.2 software package. Exchange of data layers is facilitated by this spatial database.

Photo Points

Photo points will be established at 10 sites within the project area. Monuments to mark sites will be established. A standard height platform will be used to take photographs, so all images are collected at the same height. We will take four photos in the cardinal directions at each sampling site. Photos will be labeled and stored as part of the ArcGIS spatial database developed during monitoring activities. Qualitative conditions can be compared using the photo series and change due to restoration activities can be documented.

Hydrology

River Discharge and Flooding Inundation

Understanding the hydrology of the project area is essential for testing the project hypotheses. We will use discharge data from either Goodwin Dam or Orange Blossom Bridge (gages operated by USBR) in conjunction with stage data from pressure transducers and data collected from flow transects to determine flooding inundation in terms of duration and magnitude of flows. A series of five (5) continually recording in-channel and floodplain pressure transducers (e.g., Onset Computer, Inc.; HOBO® U20) will be installed inside channels to determine magnitude and duration of inundation. One logger will remain on the upland as a constant record of local barometric pressure. Loggers will be downloaded monthly and data summarized to evaluate flooding inundation compared with plan estimations. Locations of all pressure transducers will be recorded with sub-meter accuracy GPS and camouflaged as well as possible to reduce chances of vandalism or theft.

Water Velocity/Depth

Depth and water velocity will be measured at each sampling site before and after gravel augmentation and floodplain regarding. A Marsh-McBirney portable velocity meter (Flo-Mate™ Model 2000; Hach® Company) will be used for taking water velocity measurements at each sampling site. The unit uses an electromagnetic sensor to measure the velocity in a conductive liquid such as water. The velocity is in one direction and displayed on a digital display as feet per second (ft/s) or meters per second (m/s). The device measures water velocity using Fixed Point Averaging (FPA), which is defined as: average velocity measured over a fixed period of time (CFS uses a 60 second time interval). At each site the depth of the velocity measurement varies depending on water depth. For depths less than 2 ft (0.6 m), water velocity is taken at 60% of depth (measured from water's surface). For depths greater than 2.0 ft (0.6 m), water velocity is taken at 20% and 80% of depth and then averaged. For each site, total water depth and average velocity is recorded.

Flow Transects

A specific site will be selected to perform flow transect measurements to determine localized river discharge. A 100 m measuring tape will be secured to the opposing banks perpendicular to the flow approximately 1 – 2 ft (0.3 – 0.6 m) above the water surface (Figure 3). The measuring tape will be pulled taught and tied off (Figure 3). Measurements will be taken every 0.5 m across the width of the wetted channel.

Figure 3. Technician stretching measuring tape across a river channel.

Discharge (Q) is then calculated using the following formula:

$$\boldsymbol{Q = \sum (V*D*W \text{ at each station})}$$

where, V= average velocity, D=depth, W=width of station

Bathymetry and Topography

Topographic Surveys

The CFS team will work with Provost & Pritchard Consulting Group, Ltd. to document the topography of the project area, and location and extent of the existing side channel. Topographic surveys were conducted in July 2009 to inform project design plans using a Trimble RTK GPS. Results of the topographic survey were post-processed and corrected as necessary to create a digital elevation model (dem). This dem was used by the CFS project team in ArcView to determine new side channel extent and cut/fill volumes. After project implementation, topographic surveys will be repeated annually to document correct implementation and track side channel morphology for up to three years post-project.

Cross-section and Longitudinal Profile Surveys

A series of five cross-sections will be established in the project site across the mainstem side channel and surveyed annually to document changes due to restoration activities along the extent. Cross-sections will also be used to evaluate if constructed floodplain elevations provide: 1) the desired elevations from groundwater (this will be evaluated in conjunction with groundwater monitoring), and 2) floodplain and secondary channel inundation depths suitable for juvenile Chinook salmon. The surveys of these cross-sections will occur concurrently with topographic/bathymetric work when feasible.

Water Quality

Water quality and temperature monitoring will be used to track water quality conditions (i.e., temperature, dissolved oxygen, and turbidity). Restoration objectives focus on achieving water quality conditions that support rearing and spawning of juvenile Chinook salmon and steelhead. Water quality monitoring will also be a component of regulatory monitoring during project construction activities.

Water Temperature

Continuously recording data loggers (i.e., Hobo® U20; Onset Computer, Inc.) for temperature and water level (i.e., pressure) will be installed in the main channel, side channels, and floodplain to verify that the restored habitats maintain acceptable water temperatures during salmonid rearing life stages. By tracking the water temperatures, non-advantageous changes will also be detected. Specifically, providing a good understanding of the habitat conditions to ensure targets are met, and higher temperatures than expected do not lead to improvements in habitat conditions for non-native species. Data loggers will be installed during pre- and post-project monitoring work to track the temperature conditions both before and after construction activities. Data loggers will be installed at the permanent sampling locations and downloaded according to the manufacturer's specifications.

Dissolved Oxygen

During seasonal field trips, dissolved oxygen data will be collected from each sampling location monthly using a handheld dissolved oxygen instrument (i.e., YSI® Inc.; Model ProODO™). These spot measures are designed to determine if minimum criteria for water quality are met, and to meet effectiveness monitoring objectives by determining if performance criteria for dissolved oxygen are met. The CFS team will also monitor conditions during implementation to track potential impacts to water quality.

Turbidity

During field trips, instantaneous turbidity will be measured in Nephelometric Turbidity Units (NTU) using a turbidity meter (Hach® Company; Model 2100P). These spot measures are also designed to determine if minimum water quality criteria are met, and to meet effectiveness monitoring program guidelines. The CFS team will also monitor turbidity during project construction to insure water quality standards required by permitting are met.

Vegetation Characteristics

We will use two vegetation data collection methods to test project hypotheses regarding natural recruitment following restoration activities. In addition to monitoring the survival and vigor of any planted stems, we will use two vegetation data collection methods to test project hypotheses about the success of revegetation efforts and natural recruitment following restoration activities. To improve the probability of detecting changes in vegetation patterns due to project implementation, we will place permanent plots at an upstream control site and at the project site using a stratified random sampling approach. Measures of vegetation recruitment, composition, dominance and structure over time will be correlated with measures of sediment distribution, hydrology and topography to document project effects and suggest causal mechanisms.

The project area will be stratified by flood recurrence intervals as defined in the project design plans. The secondary channel is predicted to flow at the 1.5-year recurrence interval while tertiary channels 1 and 3 are predicted to flow between the 1.5- and 3-year interval. Tertiary channel 2 and the remainder of the island are predicted to flood above the 3-year recurrence interval. All sampling sites will be surveyed to provide GPS coordinates, and annual monitoring in the early summer (or peak season for herbaceous flowering plants) will occur. The number of plots will provide adequate sample sizes necessary to provide robust data for statistical tests and comparisons. A 100 m^2 (10 m x 10 m) sampling plot will be centrally located within each polygon selected for sampling. This is smaller than the standard for riparian shrub and tree vegetation (CNPS 2007) but allows for increased replication across the project area. The following protocol will be applied to the project area and upstream control sites. All plots will be marked with GPS locations, photographs, and detailed on-the-ground mapping and descriptions. Vegetation and substrate sampling will follow the California Native Plant Society Relevé Protocol (CNPS 2007). A 16 m^2 (4 m x 4 m) subplot will be placed in the northwestern corner of each relevé. A 1 m^2 grid will be laid and all woody seedlings will be mapped with location, species and diameter class. To address questions of recruitment, native and non-native cover and vegetation community organization data listed in Table 7.I, 7.II and 7.III will be collected for all plots.

Table 7. Field Collected Vegetation Data

DATA TYPE	CLASS	SUBCLASS	EXTENT
I. Vegetation. Complete composition by stratum will be identified and cover visually estimated.	Tree Shrub Herb Seedling Sapling Non-vascular		
II. Surface. The percent cover of each surface will be visually estimated.	Basal area of stems Bedrock Litter Water Soil/rock:		
		Fines Gravel Cobble Stone Boulder	<0.2 cm 0.2-7.5 cm 7.5-25 cm 25-60 cm >60 cm
III. Recruitment. Mapping and diameter of all woody seedlings within subplots.	Species Stem diameter	 <1.0 cm 1.0 -10.0 cm	 < 1.0 cm Actual diameter

Wildlife Surveys

Wildlife surveys will occur with qualified personnel following guidelines outlined by USFWS and CDFG (http://www.dfg.ca.gov/wildlife/nongame/survey_monitor.html). These surveys will meet permitting requirements for the protection of listed species, which may potentially occur in the area. There will be a total of three types of surveys before project implementation for species identified in the Environmental Assessment/Initial Study (CFS 2010). The first series of surveys will be conducted for Red legged frog, Western pond turtle, and Spadefoot toad. There will be three day surveys (2.5 hrs) and four night surveys (1 hr) for a total of 12.5 hrs (plus travel, setup time). Day surveys consist of scanning ponds or other suitable habitat to try to visually locate species of interest, and then wading through the area. Night surveys involve using a light and binoculars and locating frogs by eye shine. The second series of surveys will be conducted for California Tiger Salamander. Protocols from the USFWS recommend conducting surveys once a month in March, April, and May for two consecutive seasons. Surveys will be conducted using dipnets, seines, or minnow traps. Drift fences in fall and winter will have pit fall traps. A total of nine surveys need to be conducted which include larval surveys, and setting and collecting pit fall traps for adults for a total of 63 hrs (plus travel, setup time). The third series of surveys will document site use by Swainson's hawk, San Joaquin kit fox, American badger, and the Giant Garter snake. Swainson's hawks are searched for visually; if one is spotted then nesting trees need to be identified in the area. If nesting trees are located, their spatial information is collected with GPS. San Joaquin Kit Fox and American badger surveys must be conducted by walking transects spaced 30 – 100 ft (9.1 – 30.5 m) apart looking for dens and other indication of animals. Once potential dens have been located 10 night surveys need to be done to determine active dens. If an active den is found, then camera/bait stations need to be set up and additional time will be required. Time to survey transects is about 4 hrs, and if any dens are located an additional 46 hrs of survey time may be needed. The USFWS survey protocols for the San Joaquin kit fox require surveyors to have 360 hrs of survey experience in traditional kit fox survey techniques. Giant Garter Snake surveys will occur concurrently with other wildlife surveys, and need to be conducted 24 hours prior to construction.

Fish Surveys

Snorkel Surveys

Snorkel surveys will be conducted to assess juvenile and adult use of the river and restored sites. Snorkeling methods will be consistent with other studies (Edmundson et al. 1968; Hankin and Reeves 1988; McCain 1992; Jackson 1992; Dolloff et al. 1996; Murphy and Willis 1996; Cavallo et al. 2003, O'Neal 2007). Sample units (i.e., 50 m in length) will be snorkeled by two divers moving upstream adjacent to each other for margin habitats and downstream for mid-channel habitats. Fish will be observed, identified and counted by size group as divers proceeded up or down the sampling unit. Counts will be compiled for all divers and recorded as a total for each sample unit. Fish will be categorized by species and size classes (0 – 50 mm, 51 – 80 mm, 81 – 100 mm, 101 – 120 mm, 121 – 150 mm, 151 – 200 mm, 201 – 300 mm, and >301 mm). In addition to the above categorizations, additional mesohabitat quality metrics were assessed. Habitat characterizations include qualitative assessments of: river margins; cover habitat; and dominant and sub-dominant substrate types.

Survey timing will coincide with juvenile Chinook salmon rearing in the early spring. Stream flow conditions must also be considered prior to conducting a survey for safety precautions. All surveys will be lead by an individual with training and experience conducting snorkel surveys. Snorkel surveys are most often conducted using teams moving through a survey area in a concerted manner to ensure complete coverage. Generally, teams spread laterally across a channel with dispersion based on underwater visibility. Teams should move at the same rate in parallel lanes to prevent double counting fish. Movement most often occurs in the upstream direction to: 1) prevent turbidly from obscuring observations; and, 2) maximize fish observations because fish most often orient facing upstream. To help minimize disturbing fish, surveyors attempt to limit fast or sudden movements and wear mud-brown colored Stream Count drysuits (O.S. Systems, Inc.). Dive slates will be used to record fish species, size categories and other observations.

All surveyors will be proficient in the identification of fish present in the Stanislaus River region (McConnell and Snyder 1972). Daytime surveys generally occur when water temperatures range between 10°C and 18°C. Daytime water visibility is generally the best between late morning and early afternoon, and cloudy or overcast days are preferred over clear sunny days to reduce the effects of shadows on the water. Nighttime surveys are preferred when water temperatures are below 10°C or above 18°C. To gather presence/absence data and baseline habitat use, only a one-pass approach is needed.

River margins will be classified according to position in the channel (i.e., left, middle, or right) and margin type (i.e., bar, bank or main channel). Bar margins are generally shallow with a gradual slope and typically limited vegetation due to scour and regular inundation during high flow events. Bank margins are generally deeper with steep eroding banks and more extensive vegetation; these margins often occur opposite of bar areas against bluffs and levees where high flow induces greater erosion and scour. Main channel areas are away from bars and banks in the middle of the channel where velocities and depths are greater. Cover habitat will be broken down into three qualitative classes (i.e., type, size, and quality). Cover types include instream, overhead, both, or flooded terrestrial and aquatic vegetation and will be further defined by size categories of less than 15 cm, 15 – 30 cm, and greater than 30 cm. Cover quality will be defined as a combination of the percent of surveyed habitat affected by the cover and the degree to which fish depend on the cover. Dominant and sub-dominant substrate types will be defined by organic matter/silt, sand, gravel, cobble, boulder, bedrock, and rip-rap.

Side channels and floodplain habitats may be surveyed using snorkeling if sufficient water is available to facilitate the survey. Otherwise, other sampling methods will be used such as a backpack electrofisher.

Backpack Electrofishing and Seining

Small beach seines or a backpack electrofisher will be used to collect juvenile salmonids at the restored site, in-river and at a nearby reference site (i.e., Buttonbush Park). Survey timing will coincide with rearing period for juvenile Chinook salmon (March to June). Stream flow conditions must also be considered prior to conducting a survey for safety precautions. All surveys will be lead by an experienced fish biologist with training and experience conducting fish surveys. All surveyors will be proficient in fish identification in the Stanislaus River region (McConnell and Snyder 1972). Daytime surveys generally occur when water temperatures range between 10°C and 18°C. Sampling sites may be sampled using standard electrofishing methods. Cramer Fish Sciences uses a Smith-Root, Inc. Model 12B backpack electrofisher (BPS). All BPS operators and crew are trained in BPS operation according to NOAA NMFS Guidelines for Electrofishing Waters Containing Salmonids Listed under the Endangered Species Act (NOAA 2000). Equipment will be inspected prior to every field use for serviceability to protect fish and ensure safety. Water temperature and conductivity will be measured and recorded prior to every electrofishing survey. No electrofishing will occur when water temperatures reach or exceed 65°F (18.3°C), or when conductivity exceeds 350 μS/cm. Initial BPS settings will be set to NOAA recommended initial settings (100 volts, 500 µs pulse width, and a 30 Hertz pulse rate). When needed, settings will be gradually increased to a minimum level necessary to capture fish. Direct current will always be used and settings will never exceed max allowable settings (400 volts, 5 ms pulse width, and a 70 Hertz pulse rate). A minimum of one assistant will aid in netting stunned fish and other aquatic vertebrates. Collected fishes will be processed following CFS standard field sampling protocol (Gray et al. 2009).

Determining Diet Composition with Gastric Lavage

Following methods described in Haley (1998) and Koehler et al. (2006), stomach contents of juvenile Chinook salmon will be obtained by gastric lavage. Captured fish will be anesthetized with MS-222 (tricaine methanesulfonate; Tricaine-S, Western Chemical Company). The fish will be weighed to the nearest 0.01 g and measured to the nearest 1 mm forklength (FL). For small fish (>50 mm) a small syringe fitted with a 3-mm diameter rubber tube will be put into the fish's esophagus. The syringe will be gently emptied to flush the stomach contents from the fish into a 106 µm sieve, and the fish will be returned to freshwater to recover. The stomach contents are then washed into a Ziploc™ or Whirlpac™ plastic bag and preserved with 95% ethanol. Organisms in the stomach contents will be examined and identified with a light-dissecting microscope to the smallest taxonomic resolution reasonable (usually species, but in some cases to the family level). Each prey category will be enumerated and weighed (blotted wet weight to the nearest 0.001 g).

Prey Resource (Invertebrates)

A critical component of monitoring habitat function is gathering information on the available prey resource. Juvenile salmonids primarily feed on a variety of drift (available at the surface of the water) and benthic invertebrates, and other insects. Prey resource will be monitored to determine the composition and abundance of various species. Data will be evaluated to determine if the abundance and composition indicates adequate ecosystem health following restoration activities. Invertebrate sampling will occur in replication at the project site and a nearby reference site with samples collected during the rearing period. Less intensive sampling will occur before project implementation; more intensive, monthly sampling will occur during the juvenile rearing period. Benthic macroinvertebrates will be collected with a 330 mm i.d. X 400 mm high, stainless steel 363 µm nitex Hess Stream Sampler (Wildco® Company) (bottom area opening = 0.086 m2) with an attached 368 µm dolphin bucket. Samples are taken to a depth of 15 cm within the substrate. Drift invertebrates will be collected using fallout traps or drift samplers. A fallout trap consists of a shallow pan of soapy water that collects those invertebrates available to fish by falling into water. A drift sampler is used in the main river channel to collect invertebrates floating on the surface of the water. Collected samples are placed in 500 ml bottles with 95% ethanol. Samples will be transported to the laboratory and sorted under a light dissecting scope (e.g., 60X). Taxa will be identified to species as possible; size classes and life stage will be recorded. Organisms will be grouped into functional feeding categories following Merritt and Cummins (1996), Wiggins (1998), and Pennack (1989).

Figure 4. Biologists using Hess Stream Sampler to collect benthic macroinvertebrates in the Stanislaus River (left) and a typical fallout trap (right).

Juvenile Growth Potential Model

To investigate the function of juvenile habitat provided as a result of this restoration project, we will evaluate the change in habitat in terms of modeled growth potential for juvenile salmonids.

Alternative Methods for Obtaining Bioenergetics Model Data

The key parameters to run the bioenergetics model are: temperature, consumption rate, diet composition, prey quality, and fish size. Detailed temperature data will be collected as part of the effectiveness monitoring program. Information on prey quality will use established literature values unless funds support laboratory analysis on energy content. Data on consumption rate and diet composition can be obtained with a variety of methods, considering the proper assumptions.

Method 1: Up to four large enclosure nets (i.e., 10 X 20 ft and X 0.25 in mesh size) will be established in various restored-reference habitat types (as allowable by river conditions). Up to 100 juvenile Chinook salmon will be held in the enclosure nets for 16-24 hours. Diet contents of fish will be determined from samples (n=10-20) collected every eight hours following standard procedures of gastric lavage (see previous description). After 24 hours, any remaining fish will be sampled for stomach contents. Diet information will then be compiled to determine overall diet composition for that habitat type and time of year.

Method 2: Diet information may also be obtained through the fish surveys at the project and control sites. Beach seining or electrofishing may allow low impact capture of juvenile Chinook salmon that could be sampled for diet contents using gastric lavage. Information on consumption rate will have to be based on stomach fullness. Assumptions to this method include assuming the fish have been feeding for the past several hours in the area collected. This method has additional limitations in feasibility due to the very low numbers of wild fish and the inability to collect a suitable sample size.

Method 3: If Methods 1 and 2 are not available, diet information for the local area of the Stanislaus River may be obtained through sampling juvenile Chinook salmon (by gastric lavage) at the RST monitoring operations at Caswell Memorial State Park near Ripon, CA. A sub-sample of juvenile Chinook salmon (up to 10) could be collected during the out-migration. Diet composition information could be collected for early and late out-migrants. Assumptions would include that the fish collected in the RST operations have diets representative of those feeding in the project reach; however, this method would be less suitable for depicting the diets of fish feeding on the restoration floodplain, post-project.

Information from any of the above methods would be used with the "Wisconsin" computer model (Hanson et al. 1997) to simulate fish growth in response to changes in body mass, diet composition, and temperature. Results obtained from these experiments will provide a *relative* measure of potential growth at the various sites.

Data Analysis and Evaluation

Statistical analyses will be performed with several programs (e.g., S+, R, JMP, Origin, PRIMER, and Excel). Multivariate statistics will be used along with linear and multiple regressions to relate various results to explanatory variables, such as vegetation recruitment success, juvenile distribution and abundance, fish use and growth potential to physical conditions. Invertebrate abundance and composition will be compared with univariate and multivariate statistics to evaluate the different conditions present in project site, reference, and main channel habitats. There are a variety of statistical tools available to analyze data from non-replicated BACI studies (Miao et al. 2009).

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WORK SCHEDULE

Table 8. Work schedule for pre- and post-project monitoring activities.

Date	Survey	Method	Goal and Parameters	Personnel Required	Time	Activities	Number and Processing Time of Samples
Pre-project Monitoring							
July 2009	Topography	Ground survey post-processed and integrated with LiDAR	-Document topography in project area -Collect elevation information using an RTK-GPS; post-process data, create dem, integrate with existing LiDAR data.	2 Biologist; 1 P&P surveyor subcontractor	40 hours, including travel time + subcontract	-Determine topography -Map channel extent -Map other notable features, as appropriate	N/A – Post-processing included in subcontract
June 2010 – survey will be conducted while the site is inundated, if possible. If inundation does not occur, fish sampling will be limited.	Biological	Field data collection including GPS information	-Document pre-project biological conditions -Water temperature, flooding inundation, available prey resources, and fish use.	1 Biologist; 1 Bio-Tech	32 hours each, including travel time + 180 hours of processing time	-Establish transects and photo points -Deploy temperature/pressure loggers -Deploy/collect insect fallout traps -Survey for fish use; collect stomach contents, as available	-30 invertebrate samples (10 replicates per sampling type) -up to 10 stomach samples -temperature and inundation data
July 2010	Vegetation	Relevé and recruitment plots are collected in 8-10 randomly selected locations	-Document pre-project vegetation species composition and percent cover conditions	1 Bio-Tech; 1 plant ecologist subcontractor	50 hours, including travel time + subcontract	-Collect photo point data -Determine species composition and cover along 8-10 plots	-process photos -analyze vegetation data -process temperature and inundation data

						-Download data loggers	
August 2010	Wildlife	Surveys to document wildlife community	-Document pre-project wildlife species presence/absence	1 Biologist; 1 Bio-Tech; 1 Wildlife Ecologist subcontractor	60 hours, including travel time + subcontract	-Collect day/night survey data -Determine species presence/absence along transects -Photo-documentation	-process photos -analyze data -process and summarize data
Project Implementation – circa August to September 2011							
Post-project Implementation Monitoring							
October 2011	Post-implementation Topography	Ground survey post-processed and integrated with LiDAR	-Document topography in project area -Collect elevation information using an RTK-GPS; post-process data, create dem, integrate with existing LiDAR.	1 Biologist; 1 P&P subcontractor	32 hours, including travel time + subcontract	-Determine topography -Map channel extent -Map other notable features, as appropriate	N/A – Post-processing included in subcontract
October 2011	Post-implementation Vegetation	Relevé and recruitment plots are re-collected in same 8-10 randomly selected locations	-Document vegetation species composition and percent cover conditions immediately following implementation. Survey will include assessing vegetation planted as part of restoration activities.	1 Bio-Tech; 1 plant ecologist subcontractor	50 hours, including travel time + Subcontract (includes analysis of vegetation data + 8 hours for processing other data	-Collect photo point data -Determine species composition and cover along 8-10 plots -Download data loggers	-process photos -analyze vegetation data -process temperature and inundation data
November 2011	Post-implementation	Field data collection including GPS	-Document biological conditions immediately following project	1 Biologist; 1 Bio-Tech	32 hours each, including travel	-Establish transects (5) and photo points (10)	-40 photos (10 sites, 4

	Biological	information	implementation. -Water temperature, flooding inundation, hyporheic flow, DO, turbidity will be collected in the restored side channel and river.		time + 180 hours of processing time	-Deploy additional data loggers, as needed -Collect stand pipe information	directions) -temperature and inundation data
Post-project Effectiveness and Validation Monitoring							
March to June 2012 – survey will be conducted while the site is inundated, if possible. If inundation does not occur, fish sampling will be limited.	Biological	Field data collection including GPS information	-Document post-project biological conditions -Water temperature, flooding inundation, available prey resources, and fish use.	1 Biologist; 1 Bio-Tech	32 hours each, including travel time + 180 hours of processing time	-Survey established transects and photo points -Download data loggers -Deploy/collect insect fallout traps -Collect benthic and drift invertebrates, and physical data -Survey for fish use; collect stomach samples	-40 photos (10 sites, 4 directions) -30 invertebrate samples (10 replicates per sampling type) -up to 10 stomach samples -temperature and inundation, data
March-June 2012	Validation Experiments	Determine Consumption Rate and Diets with Enclosure nets; Summarize and include temperature data; Use established values for prey energy to run model	-Determine site-specific consumption rates and diets for juvenile Chinook salmon in the project area -Use enclosure nets and marked hatchery fish to evaluate fish performance in the restored site.	1 Biologist II; 1 Biologist I	40 hours each, including travel time + 175 hours of processing time	-Deploy enclosure net and check conditions -Install water temperature logger inside net -Mark and measure 100 hatchery fish, and hold in enclosure net for 48-72 hours -Process fish according to CDFG protocols and determine stomach contents	-up to 100 stomach samples -process temperature data -determine composition rate

June-July 2012	Vegetation	Relevé and recruitment plots are re-collected in same 8-10 randomly selected locations	-Document post-project vegetation species composition and percent cover conditions	1 Bio-Tech; 1 plant ecologist subcontractor	50 hours, including travel time + subcontract	-Collect photo point data -Determine species composition and cover along 8-10 plots -Download data loggers	-process photos -analyze vegetation data -process temperature and inundation, data
November 2012	Sediment characteristics	Field data collection including GPS information	-Document sediment characteristics -Water temperature, flooding inundation, hyporheic flow, DO, turbidity will be collected in the restored side channel and river	1 Biologist; 1 Bio-Tech	32 hours each, including travel time + 180 hours of processing time	-Collect sediment samples -Download data loggers -Collect stand pipe information, if applicable	-process core sample data -process temperature and inundation data
March-June 2013 – survey will be conducted while the site is inundated, if possible. If inundation does not occur, fish sampling will be limited.	Biological	Field data collection including GPS information	-Document biological conditions following restoration -Water temperature, flooding inundation, available prey resources, and fish use -Post-implementation biological surveys will also include validation experiments to assess juvenile salmonid growth potential, if possible	1 Biologist; 1 Bio-Tech	32 hours each, including travel time + 180 hours of processing time	-Download data loggers -Deploy/collect insect fallout traps -Collect benthic and drift invertebrates, and physical data -Survey for fish use; collect stomach samples, as available	-30 invertebrate samples (10 replicates per sampling type) -up to 10 stomach samples -process temperature and inundation data
May 2013	Validation Experiments	Determine Consumption Rate and Diets with Enclosure nets; Summarize and include temperature data; Use established values	-Determine site-specific consumption rates and diets for juvenile Chinook salmon in the project area -Use enclosure nets and marked hatchery fish to evaluate fish performance in the restored site	1 Biologist II; 1 Biologist I	40 hours each, including travel time + 175 hours of processing time	-Deploy enclosure net and check conditions -Install water temperature logger inside net -Mark and measure 100 hatchery fish, and hold	-up to 100 stomach samples -process temperature data -determine

		for prey energy to run model				in enclosure net for 48-72 hours -Process fish according to CDFG protocols and determine stomach contents	composition rate
June-July 2013	Vegetation	Relevé and recruitment plots are re-collected in same 8-10 randomly selected locations	-Document post-implementation vegetation species composition and percent cover	1 Bio-Tech; 1 plant ecologist subcontractor	50 hours, including travel time + subcontract	-Collect photo points -Determine species composition and cover along 8-10 plots -Download data loggers	-process photos -analyze vegetation data -process temperature and inundation data
May 2014 survey will be conducted while the site is inundated, if possible. If inundation does not occur, fish sampling will be limited.	Biological	Field data collection including GPS information	-Document biological conditions -Water temperature, flooding inundation, available prey resources, and fish use -Post-implementation biological surveys will also include validation experiments to assess juvenile salmonid growth potential, if possible	1 Biologist; 1 Bio-Tech	32 hours each, including travel time + 180 hours of processing time	-Download data loggers -Deploy/collect insect fallout traps -Collect benthic and drift invertebrates, and physical data -Survey for fish use; collect stomach contents, as available.	-30 invertebrate samples (10 replicates per sampling type) -up to 10 stomach samples -process temperature and inundation data
May 2014	Validation Experiments	Determine Consumption Rate and Diets with Enclosure nets; Summarize and include temperature data; Use established values for prey energy to	-Determine site-specific consumption rates and diets for juvenile Chinook salmon in the project area -Use enclosure nets and marked hatchery fish to evaluate fish performance in the restored site	1 Biologist II; 1 Biologist I	40 hours each, including travel time + 175 hours of processing time	-Deploy enclosure net and check conditions -Install water temperature logger inside net -Mark and measure 100 hatchery fish, and hold in enclosure net for 48-	-up to 100 stomach samples -process temperature data -determine composition

		run model				72 hours -Process fish according to CDFG protocols and determine stomach contents	rate
June-July 2014	Vegetation	Relevé and recruitment plots are re-collected in same 8-10 randomly selected locations	-Document vegetation species composition and percent cover	1 Bio-Tech; 1 plant ecologist subcontractor	50 hours, including travel time + subcontract	-Collect photo points -Determine species composition and cover along 8-10 plots -Download data loggers	-process photos -analyze vegetation data -process temperature and inundation data