APPENDIX Q

Mokelumne Salmonid Monitoring Plan

This proposal is for Metropolitan Water District of Southern California as prepared by:

Joseph E. Merz, Brad Cavallo, and East Bay Municipal Utility District Fisheries Staff

Project Title:

Mokelumne Salmonid Monitoring Plan for Two-Gate Proposal for November 2008 –November 2009.

Study Overview: The purpose of this study is to provide a preliminary assessment of how proposed changes to Delta hydrodynamics associated with the 2-Gate operation may affect migration and survival of Mokelumne River salmonids moving through or rearing in the Delta. The study is adaptive in that information learned through the 2009 study period will provide guidance for further new study in 2010 that is not part of this proposal.

We will evaluate juvenile Chinook salmon (*Oncorhynchus tschawytscha*) and steelhead (*Oncorhynchus mykiss*) movements from the Mokelumne River (Figure L-1) seaward through the central Delta from 2009 – 2010. Our approach will address various life stages: parr and smolts of both species, and out-migrating steelhead adults (kelts). Additionally, it will examine differences between hatchery and natural fish.

The objective of the proposed project is to determine how migrations of tagged salmonids (both hatchery and natural) through the Delta are affected by the position of the gates (opened or closed). This question will be addressed in terms of fish presence, migration route, migration rate (travel time), and survival. Specifically, we will use active and passive mark-recapture techniques (coded-wire tag [CWT] and acoustic tag [VEMCO]) to test the hypothesis that there is no statistically significant difference with the 2-Gate Barrier open or closed, in terms of migration route, migration rate (travel time), survival or origin of Mokelumne River Chinook parr and smolts, or of Mokelumne River steelhead smolts and kelts. We will also incorporate passive integrated transponder (PIT) technology to assess its ability to strengthen the CWT component of the study.

This project is a collaborative partnership with Metropolitan Water District of Southern California (MWD), East Bay Municipal Utility District (EBMUD), Cramer Fish Sciences, the University of California, the Central Valley Fish Tracking Consortium, and the Vernalis Adaptive Management Plan (VAMP) team. There is also an opportunity to share equipment with the California Department of Water Resources (DWR) and U.S. Geological Survey (USGS), if this can be coordinated with the VAMP group. The project will coordinate with monitoring presently being undertaken by EBMUD, including the tracking of natural and hatchery Chinook salmon and steelhead emigrants.

Background: The 2-Gate Fish Protection Plan (2-Gate Plan) is a mitigation and avoidance measure intended to reduce the take of delta smelt and other listed species, in compliance with the federal Endangered Species Act (ESA). The 2-Gate Plan provides a means of controlling a portion of the Old River to the south and east of Frank's Tract, restricting

entrainment of fish from the western Delta toward the export pumps. This would be accomplished by the installation and operation of gates in key channels of the central Delta. These structures would provide additional control of local tidal and non-tidal flows, thereby modifying the predominant path of flow from the Frank's Tract area into Old and Middle rivers (Figure L-2). Hydrodynamic and particle tracking computer modeling has shown that these changes could substantially reduce (by 72% based on neutrally buoyant particles) the unintended effects of export pumping, thereby minimizing or avoiding entrainment of delta smelt into the conveyance channels and potentially enhancing delta smelt populations in the western and central Delta while allowing for the export of water to meet critical water needs.

Chinook salmon and steelhead rely on the migration corridor and rearing conditions in the Delta. It is critical to understand how changes in diversions or exports might impact these sensitive species. This study will evaluate the potential for impact of the 2-Gate project on protected Mokelumne River Chinook salmon and steelhead. The lower Mokelumne River (LMR) is an approximately 54-km reach of regulated stream between Camanche Dam, the downstream-most non-passable barrier to anadromous fish, and its confluence with the San Joaquin River (Figure L-1). The lower river is primarily managed for fall-run Chinook salmon and steelhead by a partnership between EBMUD, US Fish and Wildlife Service (USFWS), and California Department of Fish and Game (CDFG). The LMR and its mitigation hatchery support fall-run Chinook salmon and winter steelhead runs and a resident steelhead population.

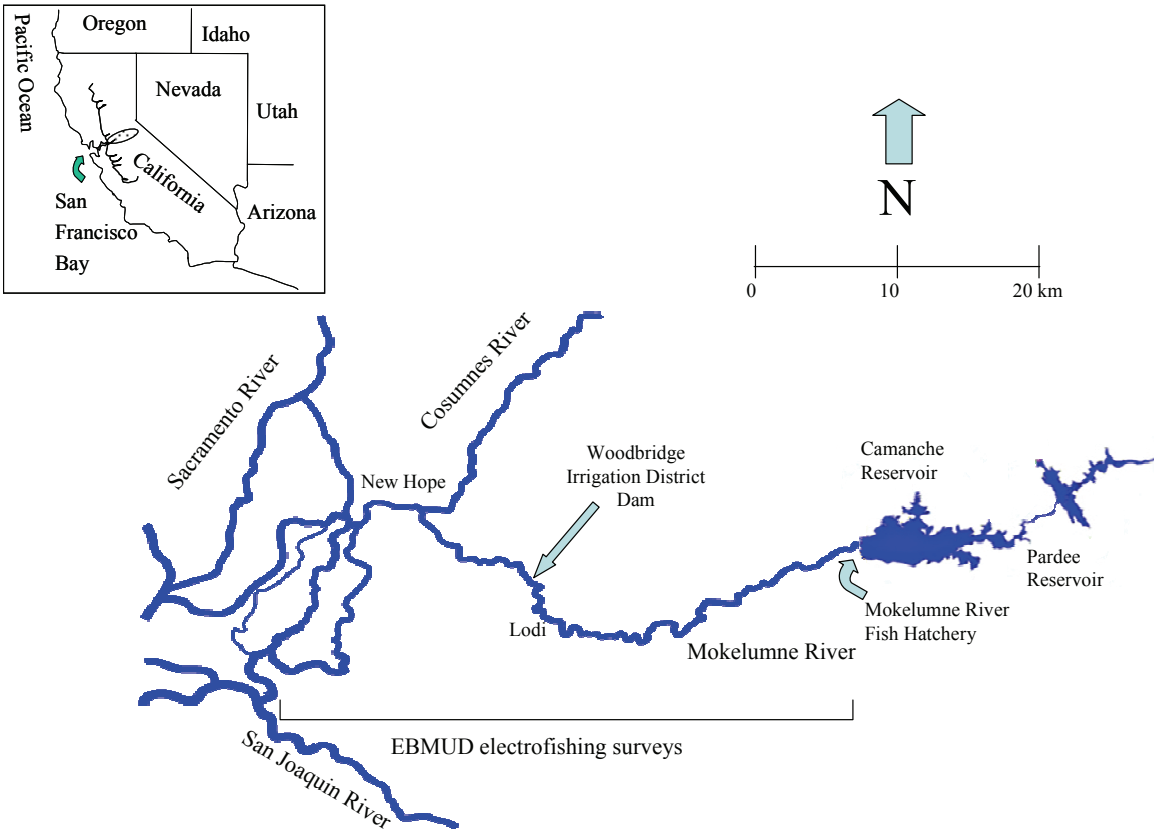

Figure L-1 **The lower Mokelumne River and associated portions of the Sacramento-San Joaquin Delta.**

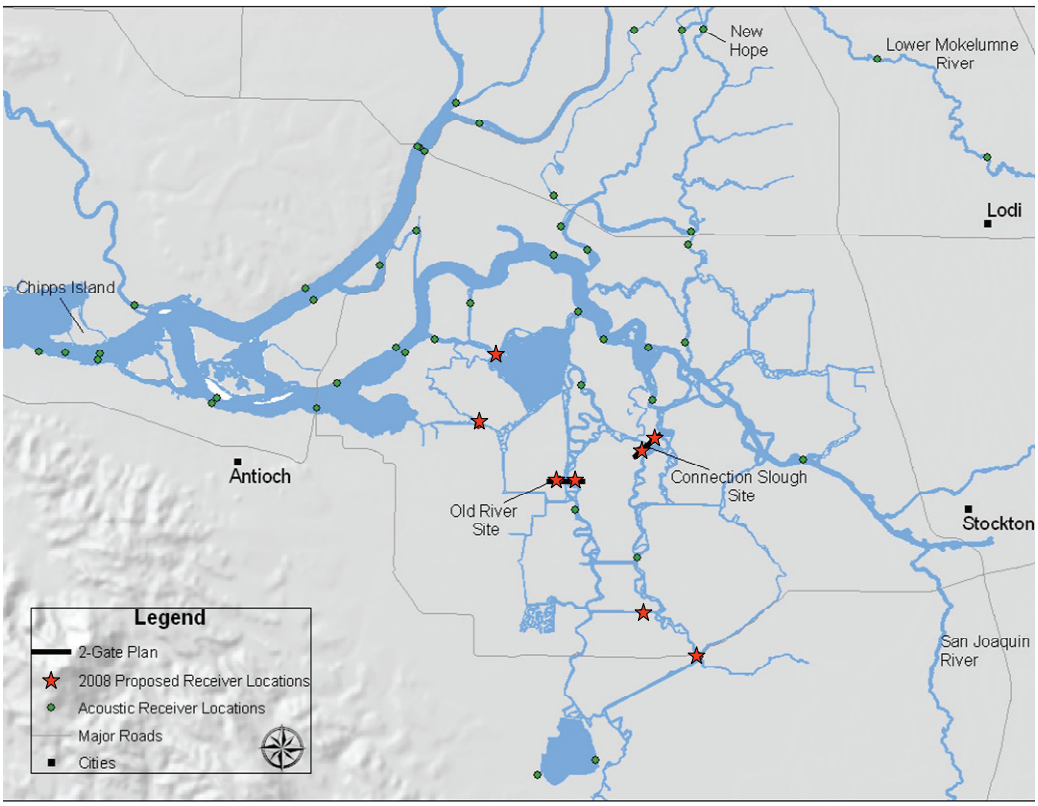

Figure L-2 Study area map depicting location of gates and acoustic receiver locations

Chinook Salmon

Estimated adult Chinook salmon escapement averaged 8,455 (min: 1,588; max: 16,140) over the past 10 years. The Mokelumne River Fish Hatchery (MRFH) spawns 43 – 90% of annual salmon escapement (1995 – 2006) with a production goal of up to 3.4 million fingerlings (3 – 23 grams/fish) released for mitigation near Thornton (tidal) and 2 million fingerlings released for enhancement within San Pablo Bay (CDFG 2005). From 2003 to 2006, ~1.25% of Chinook salmon production was released volitionally as smolts to the river immediately adjacent to the hatchery. Natural origin Chinook salmon fry emergence typically begins in late December with a peak in February. Riverine juvenile production and out-migration to tidewater is estimated using a rotary screw trap (RST) operated from mid-December through June or July. Estimated out-migration past Woodbridge Irrigation District Dam (WIDD) has ranged from 77,923 to 1,848,539 (mean: 452,658) between 1995 and 2006. The majority of migration into the LMR tidal reach (below WIDD) occurs before June, annually. A bi-modal emigration pattern typically occurs on the lower Mokelumne River with a pulse of fry/parr (i.e., < 40 – 65 mm fork length (FL)) emigrating in late-February through March, and a smolt (i.e., > 65 mm FL) pulse typically migrating in the late-April through May period. All volitionally-released, hatchery-produced Chinook salmon are adipose-fin-clipped and coded-wire-tagged (CWT). Annually, a variable portion of naturally-produced fish captured by RST

(based on size and condition at capture), and approximately 3% of total hatchery production released downstream of WIDD have been adipose-fin-clipped and CWT. Beginning in 2006, the MRFH has participated in the Constant Fractional Marking Program, and 25% of production is receiving CWTs.

Steelhead

Smith (2006) estimated the LMR *O. mykiss* population (> 100 mm FL) as 5,537 – 12,893. Estimated adult *O. mykiss* escapement has averaged 41 fish (min: 6; max: 90) over the past 10 years with the average number of *O. mykiss* entering the MRFH at 103 fish (min: 0; max: 412). The MRFH spawns 90% of annual escapement (1995 – 2004) with an egg allotment goal of 50,000 and production goal of up to 25,000 yearlings (9 fish/kg) released for mitigation near New Hope Landing (Figure L-1) (CDFG/EBMUD 2006). Between 1998 and 2007, the MRFH has taken an average of 75,187 eggs (min: 0; max: 326,777) of Mokelumne River origin and imported on average 204,904 eggs (min: 0; max: 431,190) from the Nimbus and Feather River hatcheries. Importation from the Nimbus hatchery was discontinued in 2001, but steelhead eggs from the Feather River hatchery are still imported whenever necessary to meet production goals. Adult river escapement is monitored by ladder trapping, video monitoring at WIDD and/or hatchery counts (Workman 2004). In the lower Mokelumne River, the steelhead spawning migration begins as early as August, peaking in October and November, and extending through March. Unlike Chinook salmon, steelhead do not necessarily die after spawning and may make several annual spawning migrations in a lifetime. The majority of spawning occurs within the upper 16 km of the LMR from December through May (Mulchaey and Setka 2006). *O. mykiss* fry emergence typically begins in late February with a peak in March and April. Juvenile habitat use is monitored via once a month seining and backpack electrofishing surveys (January through June) and quarterly boat electrofishing surveys. Riverine juvenile production and out-migration to tidewater is estimated by RST, which is operated from mid-December through June or July (Workman 2006). Estimated out-migration past WIDD has ranged from 216 to 9750 (mean: 2611) between 1999 and 2006. The majority of migration into the LMR tidal reach (below WIDD) occurs between January and June with a peak between April and June. All hatchery-produced *O. mykiss* are adipose-fin-clipped and CWT. Adipose fin clip data indicates that hatchery-produced and naturally-produced fish enter the MRFH where they are artificially spawned. Post-spawned, adipose-fin-clipped *O. mykiss* have also been observed in the lower river and tracked through the river to the Golden Gate Bridge (Workman et al. 2008).

This Page Intentionally Left Blank

METHODS

The proposed project will assess presence, migration route, migration rate (travel time), and survival of Mokelumne River salmonids in relation to the 2-Gate project. The study will be coordinated with other tagging and monitoring efforts occurring in the Mokelumne River and the Delta.

It is important to note that due to battery size requirements acoustic technology (passive tracking) is not presently available for juvenile salmonids smaller than ~120 mm FL. Therefore, we will rely on CWT tagging, which requires active monitoring (fish capture) for the Chinook parr component of the study. Additionally, a pilot study using Passive Integrated Transponder (PIT) tags will be undertaken to determine the effectiveness of using PIT tag detection trawls for abundance surveys of Chinook parr. Hatchery and wild juvenile Chinook salmon will be marked with CWT or VEMCO acoustic tags, as parr or smolts, respectively. Hatchery and wild steelhead smolts and kelts will be implanted with VEMCO acoustic tags and tracked during their out-migration.

Study Design

Study 1. Mokelumne River Chinook Salmon Parr Migration

We propose to CWT hatchery and natural parr (> 45 mm FL) between 15 January and 30 March, 2009. To reduce costs and coordinate with on-going monitoring and studies, we will coordinate with CDFG hatchery staff and the Pacific States Marine Fisheries Commission (PSMFC) to tag fish during regular operation periods. We will also coordinate the tagging of natural fish to coincide with EBMUD monitoring operations.

In addition to CWT studies, we will conduct a pilot study for use of PIT tags. The low expected recovery rate (<0.1%) for Delta CWT experiments will make it difficult to detect small, but perhaps biologically significant, survival differences resulting from the gate operations. PIT tagging studies paired with an open-ended trawl net outfitted with a PIT tag antenna and reader (see Figure L-3) will make it possible to achieve higher recapture probabilities and more precise survival estimates (Ledgerwood et al. 2004). In the first year of the study (2009), we propose to construct and test such a PIT tag reader trawl net. The net will be deployed with a submersible video camera, and small numbers of PIT tagged hatchery fish will be released to evaluate its performance. If the pilot study proves successful, PIT tagging and recovery may supplant CWT studies for evaluating two gate effects on Chinook salmon parr in future studies.

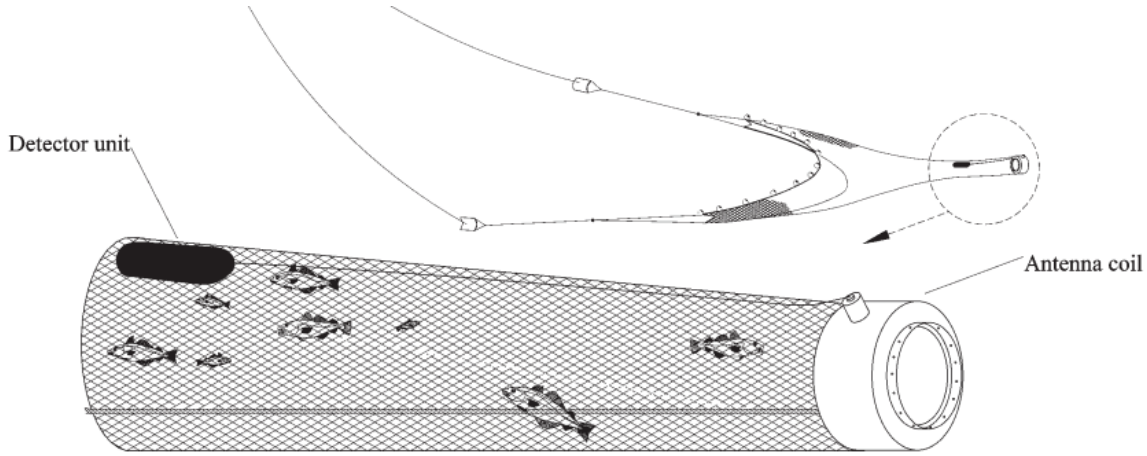

Figure L-3 **Sketch illustrating the mounting of the PIT tag receiver at the end of an open cod end. Adapted from Jorgensen et al. (2003)**

Study 1a -Two groups of hatchery, Mokelumne River origin Chinook salmon (~150,000 each, depending on availability) will be tagged with a unique CWT code for each group. The fish will be acclimated and released following appropriate protocols in the area of New Hope Landing. Releases will be coordinated with the barrier operation (i.e., 1 open; 1 closed).

Study 1b- Natural Mokelumne River Chinook salmon parr actively migrating from the Mokelumne River will be CWT'd at the lower Mokelumne River RST and smolt trap and released just below WIDD. Natural fish will be tagged during normal EBMUD salmonid trapping operations at WIDD. A unique CWT code will be utilized each week for natural origin fish to distinguish them from tagged hatchery fish and make incremental observations that can be coordinated with the barrier operation (i.e., open; closed). Tagging and release period will coincide with the typical fry/parr pulse observed in the Mokelumne River; late February through early April period. A maximum total of 200,000 natural origin Chinook salmon will receive CWTs and be released during that period.

Analysis – We will acquire appropriate information from the various state and federal agencies collecting CWT Chinook salmon data at the State Water Project (SWP) and Central Valley Project (CVP) fish facilities as well as Kodiak trawl sampling performed at Chipps Island. Descriptive summaries (average and SD of catch rate) for gate-in and gate-out results will be used to compare results for migration routes and migration rate. Analysis of variance will be used to test for statistically significant differences in migration rate and survival.

Power analysis conducted for VAMP studies suggest two 150,000 CWT group releases would detect significant differences (alpha 0.05) in 8 of 10 flow and export combinations (Newman 2001). The upstream release location (e.g. Durham Ferry) and more direct influence of exports and San Joaquin River flows likely means that VAMP power analysis are conservative relative to the proposed to two gate salmonid study, which means 150,000 fish per group should be sufficient.

Study 2. Mokelumne River Chinook Salmon Smolt Migration

To test the hypothesis that the 2-Gate Barrier operation has no significant effect on Mokelumne River Chinook salmon smolt migration routes, rates or survival during the spring period, we will acoustically tag (VEMCO technology) hatchery and natural smolts (≥ 140 mm FL) between 15 April and 1 June. The study will be coordinated with efforts of the VAMP group Salmon Smolt Survival Investigations, CDFG operation of the Mokelumne River Fish Hatchery, and EBMUD fisheries monitoring program for the lower Mokelumne River, and the University of California Fish Tracking Consortium (see Figure L-2 for present and proposed VEMCO receivers).

Study 2a- We will surgically implant VEMCO tags in ~400 Chinook salmon smolts from the Mokelumne River Fish Hatchery during the April through June period. Surgical procedures will be performed at the hatchery generally following the methods of Ross and Kleiner (1982), Summerfelt and Smith (1990), and Adams et al. (1998). Prior to surgery, fish will be deprived of food for 48 hours. These fish will then be anesthetized in a bath of tricaine methanesulfonate (MS-222) at a concentration of 50 mg per liter of water. During surgery, fish will be held in a V-shaped aluminum or plastic trough lined with moistened foam rubber. To maintain fish anesthesia during the procedure, we will use a dilute (20 mg/L) solution of MS-222 to continuously irrigate the gills via a tube inserted in the mouth. To maintain aseptic conditions, we will disinfect all instruments with providone iodine (Swanberg et al. 1999). Infection will be minimized by pipetting oxytetracycline (50 mg per kilogram of fish body weight) into the abdomen before closing the incision with sterile surgical sutures. To minimize behavioral effects of the tags, tag weight will not exceed 4% of fish weight with the goal of 2%. Hatchery fish will be held for 48 hours, transported to New Hope and after acclimation, and a group of up to 200 fish will be released upstream of the Mokelumne River Delta forks for each barrier operation period (1 open; 1 closed).

Study 2b- We will capture up to 100 natural Mokelumne River Chinook salmon (60 – 150 mm FL) by boat electrofishing during the EBMUD Mokelumne River winter fish community survey. These fish will be transported to the Mokelumne River Fish Hatchery for controlled rearing. All fish will be grown to beyond the 120 mm FL size limit by April. We will surgically implant VEMCO tags in to these fish and release them of the Mokelumne River Delta forks following the methods above.

Analysis – Fish will be tracked remotely via VEMCO portable receivers. Fixed receiver data (see Figure L-2) will be downloaded following Consortium and EBMUD protocols. Descriptive summaries (average and SD of detections) for gate-in and gate-out results will be used to compare results for migration routes and migration timing. Analysis of variance will be used to test for statistically significant differences in migration rate. Recapture and survival probability at Chipps Island will be estimated using Jolly-Seber multiple mark recapture statistical model.

Study 3. Mokelumne River Juvenile Steelhead Migration

To test the hypothesis that the 2-Gate Barrier operation has no significant effect on Mokelumne River steelhead smolts emigration route, emigration rate or survival during the late winter and spring period, we will acoustically tag natural and hatchery steelhead smolts between March and May. To reduce costs and collaborate with on-going monitoring and

studies, we will coordinate hatchery tagging with CDFG hatchery staff to tag fish during regular operation periods. We will also coordinate the tagging of natural fish to coincide with EBMUD monitoring operations. Fixed receiver locations (Figure L-2) will be downloaded and maintained in coordination with the Central Valley Fish Tracking Consortium and EBMUD protocol.

Study 3a- We will surgically implant VEMCO tags in ~320 steelhead smolts from the Mokelumne River Fish Hatchery during the April through June period. Surgical procedures will be performed at the hatchery generally following the methods described previously in Study 2. To reduce costs while maintaining data quality, Study 3a will be coordinated with the tagging and release of ~80 fish from the EBMUD monitoring program to meet the 400-fish requirement.

Study 3b- Up to 200 natural Mokelumne River steelhead smolts will be captured by RST or smolt trap at RBDD. We will surgically implant VEMCO tags into these fish and release them downstream of the traps (WIDD location).

Analysis – Analysis will be performed per Study 2, above.

Study 4. Mokelumne River Kelt Steelhead Migration

We will surgically implant VEMCO tags in ≤ 60 hatchery and natural steelhead kelts from the Mokelumne River Fish Hatchery and/or EBMUD winter fish community surveys during the February through May period. Surgical procedures and release strategies will follow the same methods as described above.

Analysis – Analysis will be performed per Study 2, above.

Equipment and Facilities

The following will be necessary for project completion: computers and software, coded wire tags and tagging machines (tagging trailer), VEMCO tags, VEMCO remote receivers, additional VEMCO stationary receivers, PIT tags and tag receiver, boats; Mokelumne River Fish Hatchery facilities will be used for tagging activities. EBMUD/CFS equipment will be used for sampling and remote tagging. PSMFC will be employed to economically CWT large groups of hatchery fish and local university graduate students may be included in efforts to obtain university cost-share.

Data Collection

All data will be collected in accordance with established, standardized sampling protocols. Written protocols will be refined for project needs and provided to MWD and EBMUD for review and comment. All data will be collected to the highest standard of accuracy.

Data Handling and Storage

All data will be carefully entered and stored in specifically designed Access databases. These include the UC tracking consortium database, the EBMUD fisheries database and databases created and stored by CFS. Databases will be locked, copied with copies stored off-site.

Analysis

Statistical analyses may be performed with several programs (i.e., S+, R, Origin, PRIMER, JMP and Excel). Results will be downloaded from the VEMCO receiver network, and from CWT recaptures from a variety of ongoing monitoring programs in the Delta (e.g., Chipps Island Trawl). Analyses will be per studies 1-4, above.

Quality Assurance Procedures

These procedures include written protocols, staff training, data checks, fish identification verification, and peer-review procedures. Written protocols will be developed for all sampling and monitoring, and provided during staff trainings to ensure all data are collected according to established standards. Field data will be checked at collection.

Feasibility

The proposed project is feasible as similar projects have occurred with success in the Mokelumne River and other Central Valley rivers. These include past tagging and tracking projects performed by EBMUD and Cramer Fish Sciences (see Workman et al. 2008).

Permits and Agreements

All necessary permits for the project plan and associated activities have been acquired. Permitting includes the following: Section 7 of the Endangered Species Act (16 U.S.C. 1531 et seq.) and CDFG Scientific Collecting Permits (presently held by Principal Investigators).

Caveats

Though this study was designed with the best possible methods and techniques, it does not guarantee definitive findings of two gate project effects on Mokelumne River salmonids. Each experimental release of tagged fish is an extremely intensive effort conducted over a very short window of opportunity during 2009, and coordinated with numerous monitoring programs from various organizations (i.e. CDFG hatchery operations, state and federal trawl and screen operation programs). Conditions beyond the control of the experimenters include water project operations as well as natural events. Large changes in Delta inflow conditions or in export activity may obscure effects resulting from two gate operations. Studies in 2010 will require a new proposal and revisiting the tasks, team, schedule and budget.

This Page Intentionally Left Blank

Results – Products

Deliverables will include monthly progress reports with invoices, alerts and meetings on potential problems or surprises affecting deliveries, brief reports as results become available, quarterly reporting (e-mail status updates), presentations at science conferences, and annual drafts and final reports. Under a follow-on assignment, report sections may be developed and submitted for peer-reviewed publications to broadly disseminate our findings, so other Central Valley projects may benefit from lessons learned here.

This Page Intentionally Left Blank

BUDGET and Schedule

Provided separately

This Page Intentionally Left Blank

References

Ledgerwood, R. and others. 2004. A Surface Trawl to Detect Migrating Juvenile Salmonids Tagged with Passive Integrated Transponder Tags. North American Journal of Fisheries Management 24:440–451, 2004

Newman, K. 2001. Analysis of the probability of detecting flow and export effects on juvenile Chinook salmon survival in the VAMP experiments. Report to USFWS.

Jørgensen, T, J. T. Øvredal and I. Huse. 2003. A new pass-through PIT tag detection system for marine use. Aquatic telemetry: advances and applications. Proceedings of the Fifth Conference on Fish Telemetry held in Europe. Ustica, Italy, 9-13 June 2003. Rome, FAO/COISPA. 2005. 295p.

Workman, M.L. 2006. Downstream Fish Migration Monitoring at Woodbridge Irrigation District Dam, Lower Mokelumne River, December 2005 through July 2006. 26pp.

Workman, M.L., J.E. Merz, and W. Heady 2008. Hatchery and natural Oncorhynchus mykiss emigration from the lower Mokelumne River, California. Distance traveled, migration rates, and paths to the Pacific Ocean Presented at the CALFED 2008 Conference, Sacramento, CA.

National Oceanic and Atmospheric Administration (NOAA). 2008. Fisheries off West Coast states and in the western Pacific; West Coast salmon fisheries; 2008 management measures and a temporary rule. Federal Register 73:23971-23982. Available: http://www.nwr.noaa.gov/Publications/FR-Notices/2008/upload/73FR23971.pdf. (August 2008).

Lichatowich, J. A.. 1999. Salmon without rivers: a history of the Pacific salmon crisis. Island Press, Washington, D.C.

Williams, J. G. 2006. Central Valley salmon: a perspective on Chinook and steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science 4(3): Article 2. Available: http://repositories.cdlib.org/jmie/sfews/vol4/iss3/art2/. (July 2007).

Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical abundance and decline of Chinook salmon in the Central Valley region of California. North American Journal of Fisheries Management 18:487-521.

This Page Intentionally Left Blank