Technical Memoranda #1

M & T/Llano Seco Fish Screen Facility
Short-Term/Long-Term Protection Project

Presented to the Steering Committee

Workshop #1
November 12 – 14, 2003

List of Document(s):

- M&T/Llano Seco Fish Screen Facility - Existing Studies

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TECHNICAL MEMORANDUM

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Subject: **M&T / Llano Seco Fish Screen Facility – Existing Studies**

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BACKGROUND

Chinook salmon belongs to the family Salmonidae and is one of eight species of Pacific salmonids in the genus *Oncorhynchus*. Chinook salmon are easily the largest of any salmon, with adults often exceeding 40 pounds; individuals over 120 pounds have been reported. Chinook salmon are anadromous (adults migrate from a marine environment into the fresh water streams and rivers of their birth) and semelparous (spawn only once and then die).

There are different seasonal "runs" (i.e., spring, summer, fall, or winter) or modes in the migration of Chinook salmon from the ocean to freshwater. These runs have been identified on the basis of when adult Chinook salmon enters freshwater to begin their spawning migration. However, distinct runs also differ in the degree of maturation at the time of river entry, the thermal regime and flow characteristics of their spawning site, and their actual time of spawning. Freshwater entry and spawning timing are believed to be related to local temperature and water flow regimes. The spring-run Chinook is listed as “threatened” and the winter-run as “endangered” in the Sacramento River Basin.

Adult female Chinook will prepare a spawning bed, called a redd, in a stream area with suitable gravel composition, water depth and velocity. The adult female Chinook may deposit eggs in 4 to 5 "nesting pockets" within a single redd. After laying eggs in a redd, adult Chinook will guard the redd from 4 to 25 days before dying. Chinook salmon eggs will hatch, depending upon water temperatures, between 90 to 150 days after deposition. Eggs are deposited at a time to ensure that young salmon fry emerge during the following spring when the river or estuary productivity is sufficient for juvenile survival and growth. Juvenile Chinook may spend from 3 months to 2 years in freshwater after emergence and before migrating to estuarine areas as smolts, and then into the ocean to feed and mature. Coastwide, Chinook salmon remain at sea for 1 to 6 years (more commonly 2 to 4 years), with the exception of a small proportion of yearling males (called jack salmon) which mature in freshwater or return after 2 or 3 months in salt water.

Salmonid species on the West Coast of the United States have experienced dramatic declines in abundance during the past several decades as a result of human-induced and natural factors. There is no single factor solely responsible for this decline. Given the complexity of the salmon species life history and the ecosystem, in which they reside, it is difficult to precisely quantify

the relative contribution of any one factor to the decline of a given species. Rather, given the available data, it is only possible to highlight factors, which have significantly affected the status of a particular species.

Water storage, withdrawal, conveyance, and diversions for agriculture, flood control, domestic, and hydropower purposes have greatly reduced or eliminated historically accessible habitat and/or resulted in direct entrainment mortality of juvenile salmonids. Modification of natural flow regimes have resulted in increased water temperatures, changes in fish community structures, depleted flows necessary for migration, spawning, rearing, flushing of sediments from spawning gravels, gravel recruitment and transport of large woody debris. Physical features of dams, such as turbines and sluiceways, have resulted in increased mortality of both adults and juvenile salmonids. Attempts to mitigate adverse impacts of these structures have to date met with limited success.

Natural resource use and extraction leading to habitat modification can have significant direct and indirect impacts to salmon populations. Land use activities associated with logging, road construction, urban development, mining, agriculture, and recreation have significantly altered fish habitat quantity and quality. Associated impacts of these activities include: alteration of streambanks and channel morphology; alteration of ambient stream water temperatures; degradation of water quality; reduction in available food supply; elimination of spawning and rearing habitat; fragmentation of available habitats; elimination of downstream recruitment of spawning gravels and large woody debris; removal of riparian vegetation resulting in increased stream bank erosion; and increased sedimentation input into spawning and rearing areas resulting in the loss of channel complexity, pool habitat, suitable gravel substrate, and large woody debris. Studies indicate that in most western states, about 80 to 90 percent of the historic riparian habitat has been eliminated.

Salmon have been, and continue to be, an important target species for recreational fisheries throughout their range. During periods of decreased habitat availability, the impacts of recreational fishing on native anadromous stocks may be heightened. Commercial fishing on unlisted, healthier stocks has caused adverse impacts to weaker stocks of salmon, and illegal high seas driftnet fishing in past years may have also been partially responsible for declines in salmon abundance. However, such fisheries cannot account for the total declines in salmon abundance in North America.

Introduction of non-native species and modification of habitat have resulted in increased predator populations and salmonid predation in numerous river and estuarine systems. Piscivorous birds such as terns and cormorants, and pinnipeds such as sea lions and harbor seals are examples of potential salmon predators. Marine predation is also of concern in areas of dwindling salmon run-size. In general, predation rates on salmon are considered by most investigators to be an insignificant contribution to the large declines observed in West Coast populations. However, predation may significantly influence salmonid abundance in some local populations when other prey are absent and physical conditions, such as narrow river mouths or human-made barriers such as fishing locks, lead to the concentration of adult and juvenile salmonids.

Natural environmental conditions have served to exacerbate the problems associated with degraded and altered riverine and estuarine habitats. Recent floods and persistent drought conditions have reduced already limited spawning, rearing, and migration habitat. Furthermore, climatic shifts over a decadal time scale appear to have resulted in decreased ocean productivity which may exacerbate degraded freshwater habitat conditions to some degree. Environmental conditions such as these have gone largely unnoticed until recently, when salmonid populations have reached critical low levels.

For additional information see website:
http://www.nmfs.noaa.gov/prot_res/species/fish/Chinook_salmon.html

M&T Chico Ranch / Llano Seco Pumping Plant

As part of a major effort to reduce the risk of mortality for salmonid species within the Sacramento River Basin, the M&T Chico Ranch diversion pumps, once located on Big Chico Creek, were relocated to the mainstem Sacramento River channel in 1997. This project involved moving the diversion for the Llano Seco Wildlife Refuge and M&T Chico Ranch by constructing a new pumping facility at a new location on the Sacramento River. The pumping station intake consists of four cylindrical tee screens mounted on a pipe manifold with state-of-the-art fish screens. The pumps are driven by natural gas engines. The approach velocity to the screens is limited to a maximum of 0.33 feet/second. The sweeping velocity past the screens is estimated to be 1 to 2 feet/second. The screens are cleaned by an air burst system that may be manually activated or by a timer. At full capacity, the new diversion can supply water at 150 cfs from the Sacramento River to M&T Chico Ranch, Llano Seco Ranch, the Llano Seco Unit of the Sacramento River National Wildlife Refuge, and the Llano Seco Unit of the Upper Butte Basin Wildlife Area. As a year-round pumping facility, water is delivered to 15,000 acres of farmland and refuge land.

The new site is located immediately downstream of the confluence of Big Chico Creek and the Sacramento River on the east bank of the Sacramento River. The City of Chico's wastewater treatment plant outfall, also part of this study area, is located on the east bank approximately 300 feet downstream of the pumping plant. The outfall has recently been enlarged from a 3 million gallons/ day capacity to 6 million gallons/day. The City of Chico has recently awarded a contract for planning and design of an additional expansion to 9 million gallons/day by the year 2005. (See **Attachment 1** for location map)

Subsequent to the time of project completion, geomorphic changes in the Sacramento River channel, in the vicinity of the M&T/Llano Seco diversion pumps, have formed a gravel bar that poses a significant risk to continued pumping and operation of the Chico outfall. In addition to the loss of pumping plant capacity, an additional threat of the gravel bar encroachment is maintaining the fish screen criteria for fish screen operations at the pumping plant facility. This encroaching gravel bar appurtenant to Bidwell State Park just upstream of the M&T/Llano Seco pumping plant also potentially threatens the wastewater treatment outfall. Both facilities are in danger of being severed from the Sacramento River because the pumping plant intake is now in an eddy behind the gravel bar located at the mouth of Big Chico Creek. Subsequently, the intake

screens are no longer receiving sufficient sweeping flows consistent with National Marine Fisheries Service and CDFG) fish screen criteria due to the deposition of sediment. Eddy currents are also unable to maintain a clean screen as originally designed. As a result of these changes, there is a potential that anadromous fish in the Sacramento River and Big Chico Creek would be adversely impacted by nonfunctioning fish screens. Should the M&T/Llano Seco pumps become inoperable, valuable private, state and federal wetland refuges would be impacted from a reduction or loss of water supplied by the M&T/Llano Seco pumps.

Water Rights

The quantity of water pumped at the point of diversion on Big Chico Creek was 120 cubic feet per second (cfs). These water rights were verified with the State Water Resources Control Board and the point of diversion was changed from Big Chico Creek to the relocated pumping plant on the Sacramento River. The water rights were pre-1914 water rights and riparian for a large portion of the area.

The water is diverted for supplying the area farmed by M&T Ranch and also the farmland of Llano Seco. In addition to the agricultural operations both ownerships have lands that are dedicated to waterfowl management and wetlands in addition to the agricultural crops. There are state and national wildlife refuges within Llano Seco that receive a water supply from this diversion on the Sacramento River. All of these uses are dependent on the diversion from the Sacramento River but the same lands also hold a water right from Butte Creek.

Prior to the construction of the relocated pumping plant CA Dept. of Fish and Game negotiated, with both of the landowners, also the holders of the Butte Creek water right, an agreement involving the US Bureau of Reclamation (Central Valley Project). This agreement allowed for exchanging the two landowners Butte Creek water rights by increasing the diversion from the Sacramento River. This exchange was to take place from October 1 to June 30 each season. The landowners agreed to reduce the diversion from Butte Creek by 40 cfs during this period and the water would flow down Butte Creek into the Sutter Bypass and ultimately return to the Sacramento River. CA Fish and Game agreed to protect the additional flow from diversion by various water right holders on Butte Creek. This allowed flows in Butte Creek to enhance the fishery and habitat during this period of time.

Quantities of Diversion

M&T Chico Ranch irrigates about 5,900 acres of land within the ranch. The crops include Dry Beans, Sunflowers and Rice for cultivated land and Plums, Walnuts and Almonds for orchards. The cultivated land is about 1900 acres and the orchards are about 4,000 acres. In addition to these lands that require water for crop growth there are about 1,700 acres of seasonal wetlands and an additional 225 acres of miscellaneous wetlands. Some of these wetlands are maintained for waterfowl management with habitat also.

The Llano Seco Ranch also irrigates 1,325 acres of cultivated land, 195 acres of irrigated pasture and 765 acres of orchards. In addition to this water demand the ranch maintains 3,050 acres of

waterfowl management lands that includes some wetlands. The Llano Seco Ranch has an agreement with M&T Chico Ranch to deliver the water from either the diversion on the Sacramento River or on Butte Creek for these irrigated lands and wetlands.

The Llano Seco Ranch has an agreement to supply water to the State and Federal Wildlife Refuges adjacent to Llano Seco Ranch lands. The M&T Chico Ranch / Llano Seco Ranch water diversion on the Sacramento River and Butte Creek supply the water for all of these agricultural lands and the waterfowl management.

Previous Investigations

Past evaluations of the river channels and levees were made to select the current pumping site on the Sacramento River. Historical maps and aerial photographs compiled by California Department of Water Resources (CDWR) indicate that, since 1896, the river has not meandered east of its current location at the pumping plant that is located on a geologic control. Because the bank is relatively stable, it was chosen as the site for the new pumping plant (**Technical Memorandum by John Crowe of CH2M HILL dated April 14, 1995**). At this location, however, the Sacramento River has historically migrated to the west. As recently as 1935, the west bank was approximately 1,000 feet west of its current location. Between 1995 and 2001, the Sacramento River shifted 500 feet to the west (an average of 83 feet/year). As the river migrated in this direction, flow velocities at the pump intake and outfall were reduced and sediment deposition increased. In addition, aerial photographs indicate that the mouth of Big Chico Creek has shifted both upstream and downstream from its current location over recent decades.

Concurrent with the lateral migration of the Sacramento River channel, a gravel bar at the apex of the meander has enlarged and migrated downstream toward the pump facility. Between 1995 and 1999, the gravel bar migrated over 1,100 feet downstream. Between 1999 and 2001, the gravel bar moved an additional 600 feet downstream. Diving surveys in May 2001 showed that the riverbed aggraded approximately 5 feet relative to past surveys at the City of Chico diffuser, and 2 of the 7 diffuser nozzles were buried by sediment (Sierra View Divers 2001). A similar survey conducted in May 2001 at the M & T/Llano Seco pumps revealed that the channel bed was encroaching on the bottoms of the fish screens. These surveys noted that sediment deposition reduced the clearance under the intake from 6 feet to 2–3 feet. The date of the previous survey was not given in the report, but the divers estimated that the screens would stop functioning normally within two years if the current rate of deposition continues (Sierra View Divers 2001). (**Attachment 2** illustrates the migration of the bed from 1997 to 2001.)

The Sacramento River Conservation Area (SRCA) Program (SB 1086) reviewed this problem and, with funding from CALFED, commissioned Stillwater Sciences to identify near-term and long-term alternatives to maintain operation of the pumps and outfall. (See **Attachment 3**) They examined historical maps and aerial photographs from 1923 through 1999. These maps indicate that river migration historically occurred upstream of the pumping plant. The Sacramento River has historically migrated to the west at this location. As recently as 1935 the east bank was approximately 1,000 feet west of its current location. As noted earlier, the river

did shift 500 feet toward the west bank between 1995 and 2001.

The gravel bar was not visible in the 1964 aerial photographs, but was visible in the 1979 photo about halfway between its present location and the revetment at River Road. Although the bar is at the mouth of Big Chico Creek, Stillwater Sciences concluded that it is comprised primarily of Sacramento River sediment. Some of the material may be coming from bank erosion in the immediate vicinity, but they concluded most of it is likely being transported from further upstream. The report concludes:

The deposition of the gravel bar at the pump intake and the City outfall is not the result of localized processes. Rather, the deposition of the gravel bar is the result of large-scale channel migration processes. As such, measures that address only short-term, local conditions or processes will likely provide only short-term, stop-gap benefits. Larger-scale measures that address longer-term, larger-scale processes will likely provide more persistent benefits.

Stillwater Sciences identified 5 possible alternatives to maintain operation of the pumps and outfall:

Alternative 1 - Dredge (excavate) sediment from the bar upstream of the pump intake and City outfall

Alternative 2 - Cut a channel across the bar to redirect flow in the Sacramento River

Alternative 3 - Dredge the bar and armor the west bank across from the pump intake and City outfall

Alternative 4 - Excavate/dredge sediment from the bar and install spur dikes on the west

Alternative 5 - Redesign or replace the pumping plant

They conclude that Alternative 4 and 5 are the most likely to succeed in the long-term.

In November of 2001 a total of 144,000 yd^3 of material were excavated and removed from the bar. Divers again examined the fish screens in April of 2002. The level of gravel was found to be 2 to 4 feet below the screens at the pumping station. At the Chico outfall, the two diffusers that were buried in 2001 were uncovered but still plugged. In their opinion, the excavation of the gravel bar had temporarily slowed the encroachment of the gravel into the screen structure and the outfall (Sierra View Divers 2002).

Several other hydraulic, sediment transport, and geomorphologic studies have been completed in recent times for this reach of the Sacramento River. Ayres Associates have developed hydrodynamic models for many reaches of the river. The three studies having the most relevance to the project location (RM 193) are:

Ayres Associates, Two-Dimensional Hydraulic Modeling of the Sacramento River, RM 194-202, Including Riparian Restoration, Two Setback Levee Alternatives, & East Levee Removal, Glenn and Butte Counties, California, Prepared for The Natural Conservancy Sacramento River Project, October 11, 2002 **(http://www.sacramentoriverportal.org/modeling/levee_index.htm).**

Ayres Associates, Hydraulic Modeling of the Butte Basin Reach of the Sacramento River, Prepared for The Nature Conservancy, under contract to Jones and Stokes, November 13, 2001.

Ayres Associates, Sacramento River Bank Protection Project (SRBPP), Sacramento River and Tributaries, Hydrodynamic Modeling of Sacramento River and Butte Basin From RM 174 to RM 194. Prepared for the U.S. Army Corps of Engineers, Sacramento District, December 1997

Some of the more recent investigations of sediment transport and geomorphic implications are:

Ayres Associates, Hydraulic Modeling and Geomorphic Analysis of Sacramento River, RM 184-194, Glenn and Butte Counties, California, Prepared for The Natural Conservancy Sacramento River Project, April 26, 2002
(**http://www.sacramentoriverportal.org/modeling/geo_index.htm**)

Eric Larsen, Emily Anderson, Ellen Avery, Krishna Dole, The controls on and evolution of channel morphology of the Sacramento River: A case study of River Miles 201-185, Geology Department University of California Davis - Report to the Nature Conservancy, December 2002
(**http://www.sacramentoriverportal.org/geo_modeling/report.htm**)

It is noted in this report that, "This area on the river (RM 193-189) is the least geologically constrained, and the river migrates freely in this location prior to the installation of riprap, exhibiting classic meander bend forms."

Michael David Singer, Modeling Spatial and Temporary Patterns in Flow and Sediment Transport and Storage in Large Lowland Rivers, University of California Santa Barbara,
June 2003
(**http://www.sacramentoriverportal.org/geo_modeling/singer.htm**)

This report describes a method for computing spatial and temporal patterns of bed-material transport and storage by combining stochastic hydrology with sediment
transport equations calibrated to data from the Sacramento basin.

Long-Term Planning Study

A long-term planning study was proposed and included in an application for CALFED funding. The plan was approved as a Directed Action in October 2002. The revised application was completed early in 2003 and is included as **Attachment 4**.

In summary this plan will consist of gathering existing data, convening a Steering Committee comprised of stakeholders and recognized experts, researching existing conditions in the river,

understanding fluvial geomorphology, monitoring the gravel bar, gathering data from surveyors, hydrologists, bio-engineers and geo-technical engineers, and preparing a river model to assist in determining an appropriate long-term solution. The approach associated with the Long-Term Planning Study is explained below:

1) Gather existing studies and reports on the Sacramento River's fluvial geomorphology to obtain a general understanding of the river and its processes. Determine what information that was used to place the pumps in the current location and compare this data to the compiled data and the existing conditions. Review and analyze proposed alternatives presented by Stillwater Sciences in their report entitled, "Final Draft of M&T Ranch and Llano Seco Wildlife Refuge Pump Intake." Conduct an exhaustive literature search pertaining to research and development of innovative technologies of fish-friendly water diversion technologies/engineering that are designed to operate in or around a dynamic river system. (See Performance Measure #5)

2) Convene a Steering Committee comprised of stakeholders, recognized experts and CALFED representatives to review and evaluate existing data, identify data gaps, and to identify alternatives to be examined and developed in order to reach a long-term solution. This process will be facilitated by Ducks Unlimited, Inc. (See Performance Measure # 1)

3) Ayres Associates and Montgomery Watson Harza will work closely with the Steering Committee to determine the objectives of maintaining an effective, fish-friendly diversion while maintaining a river meander and the concerns of those affected by the project. Performance and model development meetings will be held with the Steering Committee to develop a river model and to receive input for a Long-Term Planning Study. Stakeholders include M&T Chico Ranch, Llano Seco Ranch, City of Chico, Bidwell State Park, U.S. Fish and Wildlife Service, California Dept. of Fish and Game, California Dept. of Water Resources, National Marine Fisheries Service, landowners Walter Stiles Jr., and Val Shaw, M.D., and the Sacramento River Conservation Area. This will likely be an iterative process where various sets of promising project elements are combined, simulated, and brought back for consideration. (See Performance Measure #5)

4) As a short-term protection measure, gravel bar monitoring will be performed to document the current size and outer boundaries of the existing gravel bar. Divers will inspect the gravel bar annually and collect necessary data on the southern migration of the gravel bar. A general monitoring plan will be detailed and initiated to supplement existing data and augment ongoing monitoring. A physical monitoring plan will be developed to establish a firm understanding of existing conditions and enable informative assessments of pre and post-project performance with respect to natural processes in the Sacramento River. (See Performance Measure #3)

5) Collect various data such as hydraulic and geotechnical information to compile a list of design criteria to be used in developing a river model and in the final design of the preferred alternative. (See Performance Measure #5)

6) Develop a river model to analyze the hydraulic effects of implementing various alternatives. Ayers Associate will prepare the model. (See Performance Measure #6)

7) Using the river model, develop conceptual designs of selected alternatives to determine a cost efficient and feasible alternative that will be recommended as the long-term solution to the sediment deposition at M&T/Llano Seco Pumping Station while maintaining and protecting native habitat. (See Performance Measure #8)

8) Conduct a Biological Assessment to determine the environmental effects on the natural habitat within the Sacramento River. (See Performance Measure #7)

9) Prepare the Long-Term Planning Study. The study will explain the problem, list the alternatives, justify the preferred alternative, and summarize the benefits associated with implementing the preferred alternative. The Long Term Planning Study will be reviewed by Steering Committee, City of Chico Public Works, and CALFED Technical Committees (See Performance Measures #9 and #10)

References