UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213

APR 25 2008

In Response Refer To:
2006/07495: MTM

Nancy Haley
Chief, California North Branch
U.S. Army Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

Dear Ms. Haley:

This letter transmits NOAA's National Marine Fisheries Service's (NMFS) biological opinion (Enclosure 1) based on our review of the City of Chico Water Pollution Control Plant (WPCP) Expansion project in Butte County, California, and its effects on Federally listed endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*), threatened Central Valley steelhead (*O. mykiss*), and their designated critical habitat, as well as the threatened southern Distinct Population Segment (DPS) of North American green sturgeon (*Acipenser medirostris*) in accordance with section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). Your initial request for formal section 7 consultation on this project was received on October 12, 2006. A response was sent on December 1, 2006, stating the information provided by the Corps was insufficient to begin formal consultation. On August 21, 2007, all additional information necessary to initiate formal consultation was received by NMFS' Sacramento Area Office.

This biological opinion is based on information provided between October 12, 2006, and August 21, 2007. The information provided includes a City of Chico Wastewater Pollution Control Plant Expansion Project Biological Assessment, California Regional Water Quality Control Board NPDES permit #CA0079081, Diffusion Analysis Final Report, Mitigation and Monitoring Plan, Administrative Draft Biological Assessment, Draft and Final Environmental Impact Report, and a response letter dated August 1, 2007, from the City of Chico addressing our concerns. A complete administrative record of this consultation is on file at the Sacramento Area Office of NMFS.

Based on the best available scientific and commercial information, the biological opinion concludes that the City of Chico WPCP, as presented by the Corps and the applicant, is not likely to jeopardize the continued existence of the listed species or destroy or adversely modify designated critical habitat. NMFS also has included an incidental take statement with reasonable and prudent measures and non-discretionary terms and conditions that are necessary and appropriate to avoid, minimize, or monitor incidental take of listed salmonids associated with the project. While the terms and conditions also address take of North American green sturgeon, the section 9 prohibitions against taking of listed species and the terms and conditions of this

This letter also transmits NMFS' Essential Fish Habitat (EFH) conservation recommendations for Pacific salmon (*O. tshawytscha)* as required by the Magnuson-Stevens Fishery Conservation and Management Act (MSA) as amended (16 U.S.C. 1801 *et seq.*; Enclosure 2). The document concludes that the City of Chico WPCP Expansion project will adversely affect the EFH of Pacific salmon in the action area and adopts certain terms and conditions of the incidental take statement and the ESA conservation recommendations of the biological opinion as the EFH conservation recommendations.

The Corps has a statutory requirement under section 305(b)(4)(B) of the MSA to submit a detailed response in writing to NMFS within 30 days of receipt of these conservation recommendations that includes a description of the measures proposed for avoiding, mitigating, or offsetting the impact of the activity on EFH (50 CFR 600.920 (j)). If unable to complete a final response within 30 days, the Corps should provide an interim written response within 30 days before submitting its final response.

Please contact Ms. Madelyn Martinez in our Sacramento Area Office at (916) 930-3605 or via e-mail at Madelyn.Martinez@noaa.gov, if you have any questions regarding this response or require additional information.

Sincerely,

Russell M Strach for

Rodney R. McInnis
Regional Administrator

Enclosures (2)

cc: Copy to file – ARN# 151422SWR2006SA00631
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Enclosure 1

BIOLOGICAL OPINION OUTLINE

Agency:	U.S. Army Corps of Engineers
Activity:	City of Chico Water Pollution Control Plant Expansion Project
CONSULTATION CONDUCTED BY:	National Marine Fisheries Service, Southwest Region
FILE NUMBER:	F/SWR/2007/07495
DATE ISSUED:	4/25/08

I. CONSULTATION HISTORY

On February 19, 2004, the City of Chico, Department of Public Works informed NOAA's National Marine Fisheries Service (NMFS) of preparation of an Environmental Impact Report (EIR) for the proposed City of Chico Water Pollution Control Plant (WPCP) expansion project.

On April 16, 2004, NMFS reviewed the EIR and provided comments to the applicant (letter from Mike Aceituno, NMFS to Claudia Sigona, City of Chico, Department of Public Works).

On July 29, 2004, and on November 8, 2004, the applicant and staff from Robertson-Bryan, Inc. discussed the project with Mr. Howard Brown from NMFS.

On June 6, 2006, the State Water Resources Control Board sent a letter and requested informal consultation with NMFS.

On August 28, 2006, Mr. Howard Brown discussed the proposed project with Kim Wittorff, State Water Resources Control Board. During that conversation, he indicated that there was a potential for take of listed species and that a formal consultation was required. Kim indicated that the U.S. Environmental Protection Agency (EPA) would send a letter of clarification requesting formal consultation. Also, on August 28, 2006, Mr. Jeff McLain from NMFS contacted Kim Wittorff indicating that he would be NMFS lead consulting biologist for the project. Kim affirmed that the EPA would be initiating formal consultation in approximately two weeks. Mr. McLain, also, contacted David Thomas of Robertson-Bryant, Inc. and requested a digital copy of the February 2005, biological assessment for the proposed project.

On October 12, 2006, the U.S. Army Corps of Engineers (Corps) sent a letter requesting initiation of formal consultation on a permit application for the Chico WPCP.

On November 7, 2006, a technical assistance letter was sent from NMFS to the SWRCB. The letter was in response to the June 6, 2006, letter that NMFS received. NMFS stated that they could not enter into consultation until a letter was received from the EPA indicating that the SWRCB is the designated non-Federal representative. To this date, NMFS has not received a letter from the EPA initiating section 7 formal consultation.

On December 1, 2006, NMFS responded to the Corps' October 12, 2006, request for consultation with a letter stating that the information provided by the Corps was insufficient to begin formal consultation. NMFS requested that the Corps provide a variety of supplemental information on the project.

On April 17, 2007, the Corps wrote a letter to NMFS to remind us that our biological opinion was over due. NMFS called the Corps and indicated that we did not have all of the information necessary to begin formal consultation with the Corps and that a due date for the biological opinion could not be set until NMFS received all the information necessary to initiate consultation.

On June 6, 2007, a copy of the December 1, 2006, NMFS insufficiency letter to the Corps was provided by the Corps to the applicant for the project.

On August 3, 2007, Madelyn Martinez and Susan Boring of the NMFS Sacramento Area Office went on a site visit with City of Chico representatives. At that meeting they discussed what additional information had been provided to date and what was still missing.

Between August 3 and August 21, 2007, all necessary information was received to begin formal consultation. NMFS sent a formal consultation initiation letter to the Corps on August 21, 2007.

II. DESCRIPTION OF THE PROPOSED ACTION

The Chico WPCP is located approximately 4 miles southwest of the City of Chico in the western portion of Butte County, approximately 100 miles north of Sacramento (Figure 1). The WPCP is bordered by Chico River Road to the north and Little Chico Creek to the south (Figure 2). The plant site covers approximately 123 acres, with approximately 85 acres of ponds on the eastern and southeastern portions of the property. The WPCP's current outfall, where treated effluent is discharged into the Sacramento River, is located approximately 1.5 miles west of the WPCP and is located on the east bank of the river, just south of the junction with Big Chico Creek (Figure 2). The outfall diffuser extends approximately 100 feet into the river. The objective of the proposed project is to increase the Chico WPCP's treatment capacity from 9 million gallons per day (mgd) to 12 mgd average-day, average-month (ADAM) flow. The purpose of the proposed project is two fold:

1. Meet the National Pollutant Discharge Elimination System (NPDES) permit requirements for the discharge of effluent; and

2. Meet the City's needs to support projected growth in the Chico WPCP service area.

Expanding the WPCP capacity to 12 mgd ADAM would require the expansion of many plant processes. A summary of the proposed project processes is provided in Table 1 below. Only those project processes and associated elements that could directly or indirectly affect Federally listed salmonids and sturgeon or their habitats are described in detail in this biological opinion. As the proposed project is an upgrade to an existing system, facility upgrades to increase the quality and quantity of the discharge and the effluent disposal system upgrades are addressed in terms of operations and maintenance portions of the project. Primary elements of the proposed project addressed in this biological opinion include construction, operation, and maintenance of the outfall and diffuser system and the impacts of operation and maintenance of the expanded project.

Table 1 provides a list of the plant process and the required elements that must be expanded or improved to meet the objectives of the project. Those components addressed in this biological opinion are denoted with an asterisk.

Table 1. Facilities requiring improvements and expansion to achieve 12 mgd ADAM capacity. Note those components addressed in this biological opinion are denoted with an asterisk.

Process	Elements to be Expanded / Improved
Facility Upgrades	
Headworks	Influent screening, influent sewers, grit removal, grit classification and dewatering, flow metering, odor control, and chemical addition
Primary Treatment	Primary effluent pumping
Secondary Treatment	Aeration tanks, secondary clarifiers, RAS pumping, blowers
Effluent Disinfection System	Effluent gates, chemical storage
Onsite Solids Handling	Anaerobic digestion, mechanical dewatering, sludge stockpile area
Utility Improvements	Electrical power supply, standby generator, cogeneration, Instrumentation and control system
Support Facilities	No. 3 water pumping
Effluent Disposal and Pond Conversion	
Effluent Disposal System*	Outfall, diffuser
Oxidation Pond Conversion	Optional components to convert the Southwest Pond into a demonstration wetlands

A. Construction Activities

1. Outfall Pipeline

Based on recent growth and migration of the gravel bar just upstream of the existing outfall, and associated ongoing geologic and geomorphic processes, the current location of the outfall is no longer suitable. As part of the proposed project, the current outfall will be abandoned, capped and sealed. This is based on previous studies completed on the meander migration of this reach of the river.

The new outfall will be located approximately 1,200 feet south of the current location (Figure 3). The effluent will continue to flow through the existing pipeline from the WPCP to the site of the existing junction box. A new junction box will be constructed to accommodate increased flows and to connect a new parallel outfall pipeline to the existing outfall pipeline. The junction box will be approximately 20 feet by 10 feet with a depth of 14 feet. With open excavation, the disturbed area would be approximately 48 feet by 38 feet. The placement of outside fill material would not be required.

The outfall pipeline will be placed in a trench and then will be backfilled with 2-inch crushed rock, a minimum of 12 inches above the top of the pipe. A geotextile fabric will be placed above this backfill to limit the fine material from being removed from the trench. Above the geotextile fabric, rock backfill will be placed to the original riverbed elevation.

A new junction box will be constructed in the levee to connect the pipeline to the diffuser. The existing riprap on the levee will be removed and stored for reuse, and the levee area will be excavated for pipeline placement. Soil excavated from the levee, also, will be stockpiled for reuse. After the junction box has been installed, the side slopes of the levee will be restored using the stockpiled riprap to protect the levee and outfall from erosion and scour. No new riprap will be placed at the construction site and no concrete will be poured on the riverside of the levee.

2. River Diffuser

The diffuser will extend approximately 95 feet from the stream bank into the river and will be buried 3 to 5 feet deep in the riverbed. The work area in the river is expected to be approximately 25 feet by 105 feet. A total of 32 eight-inch ports will be set at a horizontal angle with 3 feet centerline spacing with ports extending 2 feet above the river bottom with risers (Flow Sciences 2004). Work at this site is expected to last 3 months and be conducted from July through September in accordance with the time schedule defined by NMFS and the California Department of Fish and Game (CDFG) (Howard Brown, NMFS pers. comm., 2004). Construction of the diffuser will be accomplished with a typical sheet pile cofferdam. The sheet piles will be driven into the stream bed with a vibratory hammer to limit noise impacts. Once the cofferdam is in place, the area inside the cofferdam will be dewatered to expose the river bed for excavation and installation of the diffuser. Any fish that are trapped by the installation of the cofferdam will be removed by electrofishing or seining by a qualified fishery biologist. Once construction is complete on the diffuser, the cofferdam will be removed.

B. Operations and Maintenance

The objective of the proposed project is to increase the Chico WPCP's treatment capacity from 9 million gallons per day (mgd) to 12 mgd ADAM flow. The operation and maintenance of the WPCP will occur year around and comply to the conditions of the California Regional Water Quality Control Board's (RWQCB) National Pollutant Discharge Elimination System (NPDES) permit (permit #CA0079081) (Table 2) with pH level maintained no less than 6.0 and no greater than 9.0. The maintenance includes monitoring of water quality by sampling the effluent on a set schedule (Table 3).

C. Conservation Measures

The following conservation measures have been incorporated into the project design to avoid or minimize potential adverse effects of the proposed project on special status fish species and their habitats. These include water quality and construction-related measures. Each of these is described below.

In order to minimize the long-term impacts on surface water quality, the following measure has been incorporated into the project.

> The City of Chico will ensure compliance with the conditions of the NPDES Permit # CA0079081, which includes waste discharge requirements, to ensure that discharge will not cause or substantially contribute to the exceedence of a water quality standard in the Sacramento River.

To minimize construction-related impacts, the following measures have been incorporated into the proposed project.

1. In-channel construction will be limited to the period July 1 through September 30 to limit effects on immigrating and emigrating fishes.

2. Staging areas will be located off channel and parking will be provided along orchard access roads, mainly near the junction box at Angel Slough.

3. Compliance with the NPDES General Construction Permit. Compliance with this permit will entail implementation of standard best management practices (BMPs) to minimize stormwater pollution caused by erosion and sedimentation from construction activities.

D. Action Area

The action area is defined as all areas to be affected directly or indirectly by the proposed action and not merely the immediate area involved in the action (50 CFR § 402.02). The action area, for the purposes of this biological opinion, is the proposed outfall location at Sacramento River mile (RM) 192.5 extending 0.5 mile downstream of the proposed outfall location where the effluent plume becomes fully mixed with the river cross-section. In addition, the action area extends approximately 300 feet upstream from the proposed outfall location. This area encompasses the width of the expected construction area (25 feet) and the upstream extent of anticipated acoustic effects of the pile drivers, used during in-channel construction activities on fish movements/ behavior (Figure 3). The existing diffuser will be abandoned in place, capped, and sealed. The pipes which fed this outfall will be rerouted to the new outfall.

Table 2. Effluent limitations within two 6 month periods.

Effluent Limitations Between April 15 and December 15

Constituents	Units	Monthly Average	Weekly Average	Monthly Median	4-day Average	Daily Maximum
BOD[a]	mg/L	30	45	-	-	90
	lbs/day[b]	2,300	3,400	-	-	6,800
Total Suspended Solids	mg/L	30	45	-	-	90
	lbs/day[b]	2,300	3,400	-	-	6,800
Chlorine Residual	mg/L	-	-	-	0.01	0.02[c]
Total Recoverable Copper	µg/L	13	-	-	-	26
	lbs/day[b]	0.98	-	-	-	2
Total Recoverable Lead	µg/L	3.9	-	-	-	7.8
	lbs/day[b]	0.29	-	-	-	0.59
Total Recoverable Zinc	µg/L	220	-	-	-	440
	lbs/day[b]	17	-	-	-	33
Bromodichloromethane	µg/L	5.2	-	-	-	10
	lbs/day[b]	0.39	-	-	-	0.75
Dibromochloromethane	µg/L	3.6	-	-	-	7.2
	lbs/day[b]	0.27	-	-	-	0.54
Total Coliform Organisms	MPN/100ml	-	-	23	-	500

[a] 5-day, 20°C Biochemical Oxygen Demand (BOD).

[b] Based upon a design treatment capacity of 9.0 mgd

[c] 1-hour average

Effluent Limitations Between December 16 and April 14

Constituents	Units	Monthly Average	Weekly Average	Monthly Median	4-day Average	Daily Maximum
BOD[a]	mg/L	30	45	-	-	90
	lbs/day[b]	2,300	3,400	-	-	6,800
Total Suspended Solids	mg/L	30	45	-	-	90
	lbs/day[b]	2,300	3,400	-	-	6,800
Chlorine Residual	mg/L	-	-	-	0.01	0.02[c]
Total Recoverable Copper	µg/L	3.3	-	-	-	6.7
	lbs/day[b]	0.25	-	-	-	0.5
Total Recoverable Lead	µg/L	0.96	-	-	-	1.9
	lbs/day[b]	0.072	-	-	-	0.14
Total Recoverable Zinc	µg/L	31	-	-	-	62
	lbs/day[b]	2.3	-	-	-	4.7
Bromodichloromethane	µg/L	0.56	-	-	-	1.1
	lbs/day[b]	0.042	-	-	-	0.083
Dibromochloromethane	µg/L	0.41	-	-	-	0.82
	lbs/day[b]	0.031	-	-	-	0.062
Total Coliform Organisms	MPN/100ml	-	-	23	-	500

[a] 5-day, 20°C Biochemical Oxygen Demand (BOD).

[b] Based upon a design treatment capacity of 9.0 mgd

[c] 1-hour average

Table 3. Sampling protocols downstream from the outfall.

Constituents	Unit	Type of Sample	Sampling Frequency
Daily Flow	mgd	Continuous	Daily
Chlorine Residual	mg/L	Continuous	Continuous[a]
pH[b]	pH units	Grab	Daily
$20^0C\ BOD_5$	mg/L, lbs/day	24-hour Composite	Weekly
Suspended Solids	mg/L, lbs/day	24-hour Composite	Weekly
Total Coliform Organisms	MPN/100 ml		Weekly
Temperature[b]	^0F	Grab	Weekly
Ammonia[b,c]	mg/l	Grab	Monthly
Total Copper	µg/L	Grab	Monthly
Total Lead	µg/L	Grab	Monthly
Mercury	µg/L	Grab	Quarterly[f]
Total Zinc	µg/L	Grab	Monthly
Bromodichloromethane	µg/L	Grab	Monthly
Dibromochloromethane	µg/L	Grab	Monthly
Electrical Conductivity @ 25^0C	µmhos/cm	Grab	Monthly
Total Dissolved Solids	mg/L	Grab	Quarterly
Priority Pollutants	µg/L	Grab	Annually[d]
Acute Toxicity[e]	% Survival	Grab	Quarterly

[a] Report peak 1-hour average for each day and peak 4-day average for the month.

[b] Concurrent with biotoxicity monitoring.

[c] Report as both total and un-ionized ammonia.

[d] Receiving water hardness and pH shall be determined at R-1 at the same time as effluent samples are taken.

[e] Rainbow trout shall be used as the test species.

[f] This testing can be seasoned following the reporting of the first quarterly sample results after adoption of the permit, provided all samples are below CTP Criterion of 0.050 µg/L

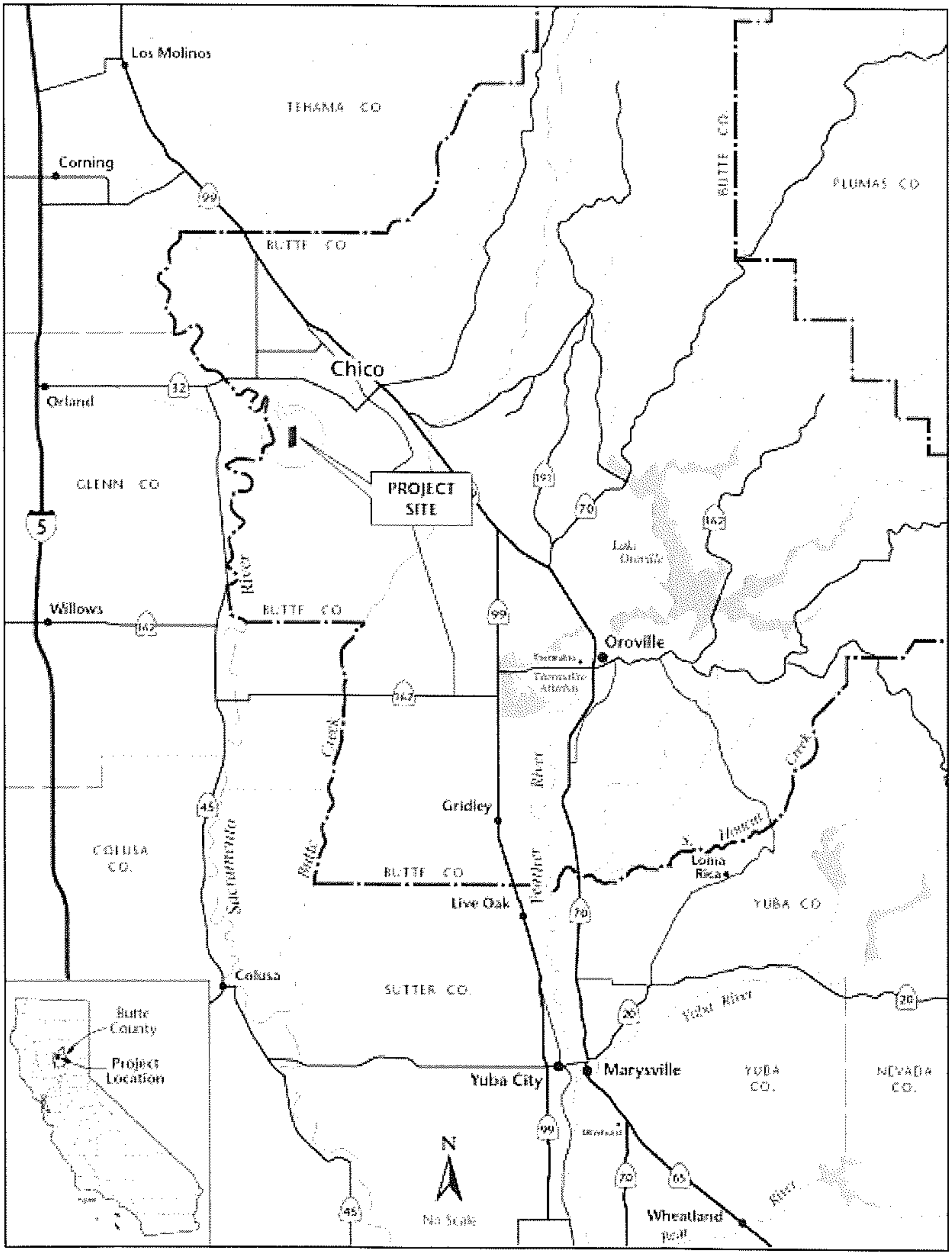

Figure 1. Regional map of Chico WPCP expansion project area.

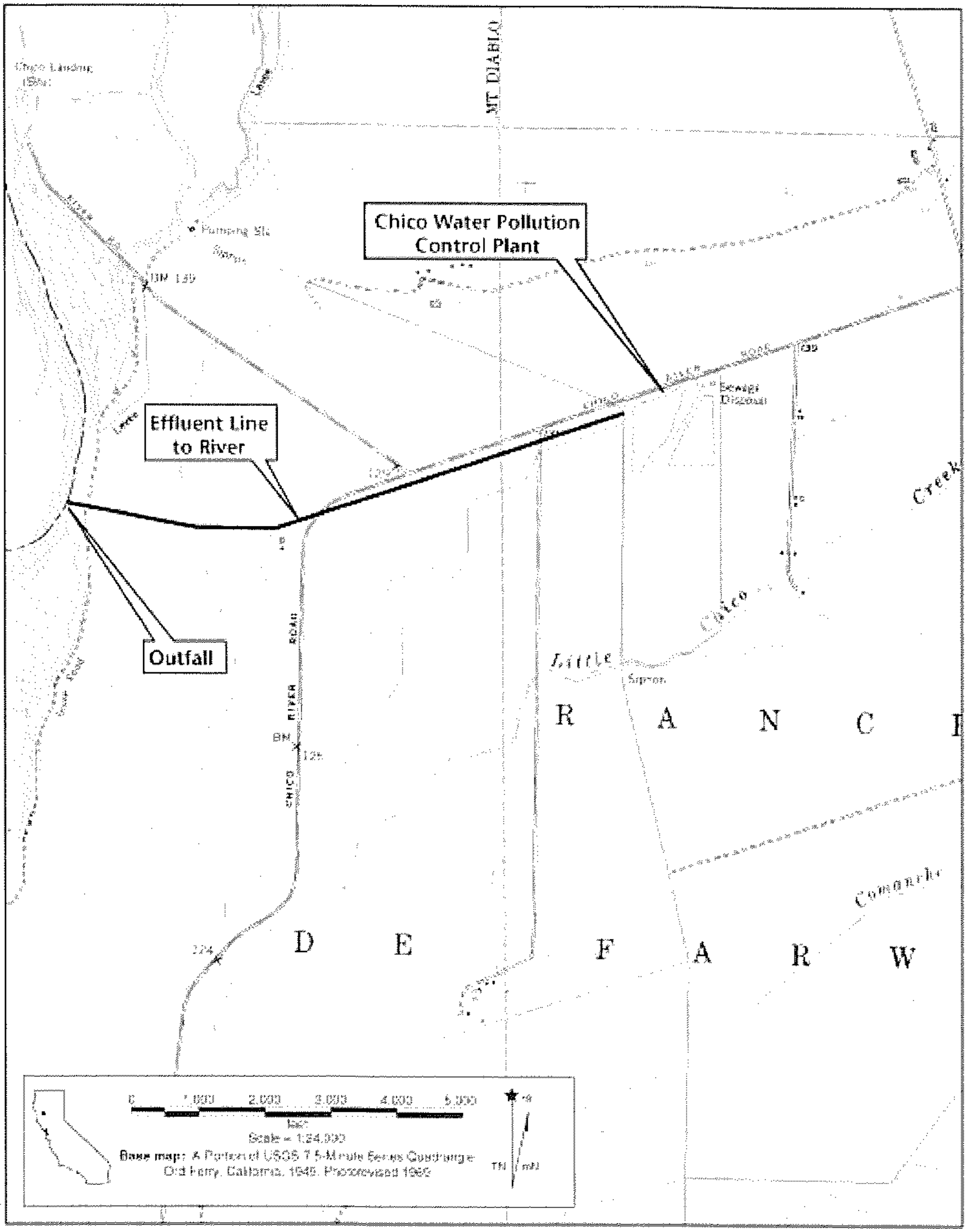

Figure 2. Map of project area showing the locations of the Chico WPCP, effluent line, and outfall.

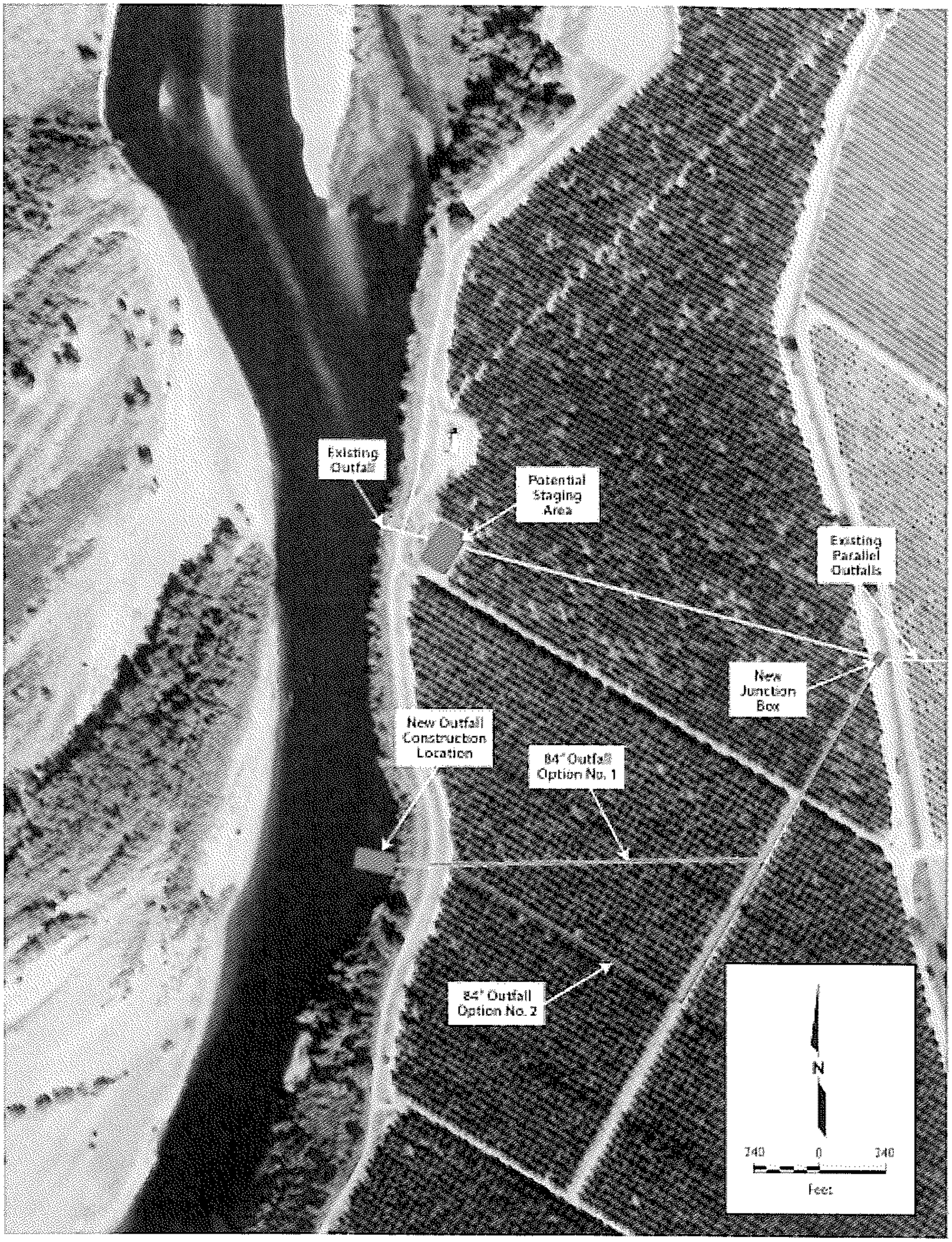

Figure 3. Location of Chico's WPCP existing and proposed new outfall, pipeline, and junction box.

III. STATUS OF THE SPECIES AND CRITICAL HABITAT

The following Federally listed species evolutionary significant units (ESU) or distinct population segments (DPS) and designated critical habitat occur in the action area and may be affected by the proposed project:

Sacramento River winter-run Chinook salmon ESU (*Oncorhynchus tshawytscha*)
endangered (June 28, 2005, 70 FR 37160)
Sacramento River winter-run Chinook salmon designated critical habitat
(June 16, 1993, 58 FR 33212)
Central Valley spring-run Chinook salmon ESU (*Oncorhynchus tshawytscha*)
threatened (June 28, 2005, 70 FR 37160)
Central Valley spring-run Chinook salmon designated critical habitat
(September 2, 2005, 70 FR 52488)
Central Valley steelhead DPS (*Oncorhynchus mykiss*)
threatened (December 22, 2005)
Central Valley steelhead designated critical habitat
(September 2, 2005, 70 FR 52488)
Southern DPS of North American green sturgeon (*Acipenser medirostris*)
threatened (April 7, 2006, 70 FR 17386)

A. Species Life History, Population Dynamics, and Likelihood of Survival and Recovery

1. Chinook Salmon

Chinook salmon exhibit two generalized freshwater life history types (Healey 1991). "Stream-type" Chinook salmon, enter freshwater months before spawning and reside in freshwater for a year or more following emergence, whereas "ocean-type" Chinook salmon spawn soon after entering freshwater and migrate to the ocean as fry or parr within their first year. Spring-run Chinook salmon exhibit a stream-type life history. Adults enter freshwater in the spring, hold over summer, spawn in fall, and the juveniles typically spend a year or more in freshwater before emigrating. Winter-run Chinook salmon are somewhat anomalous in that they have characteristics of both stream- and ocean-type races (Healey 1991). Adults enter freshwater in winter or early spring, and delay spawning until spring or early summer (stream-type). However, juvenile winter-run Chinook salmon migrate to sea after only 4 to 7 months of river life (ocean-type). Adequate instream flows and cool water temperatures are more critical for the survival of Chinook salmon exhibiting a stream-type life history due to over-summering by adults and/or juveniles.

Chinook salmon typically mature between 2 and 6 years of age (Myers *et al.* 1998). Freshwater entry and spawning timing generally are thought to be related to local water temperature and flow regimes. Runs are designated on the basis of adult migration timing; however, distinct runs also differ in the degree of maturation at the time of river entry, thermal regime and flow characteristics of their spawning site, and the actual time of spawning (Myers *et al.* 1998). Both spring-run and winter-run Chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months. For comparison, fall-run Chinook salmon enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of the rivers, and spawn within a few days or weeks of freshwater entry (Healey 1991).

Information on the migration rates of Chinook salmon in freshwater is scant and primarily comes from the Columbia River basin where information regarding migration behavior is needed to assess the effects of dams on travel times and passage (Matter *et al.* 2003). Keefer *et al.* (2004) found migration rates of Chinook salmon ranging from approximately 10 kilometers (km) per day to greater than 35 km per day and to be primarily correlated with date, and secondarily with discharge, year, and reach, in the Columbia River basin. Matter *et al.* (2003) documented migration rates of adult Chinook salmon ranging from 29 to 32 km per day in the Snake River. Adult Chinook salmon inserted with sonic tags and tracked throughout the Delta and lower Sacramento and San Joaquin rivers were observed exhibiting substantial upstream and downstream movement in a random fashion while migrating upstream (California Bay-Delta Authority (CALFED) 2001) several days at a time. Adult salmonids migrating upstream are assumed to make greater use of pool and mid-channel habitat than channel margins (Stillwater Sciences 2004), particularly larger salmon such as Chinook, as described by Hughes (2004). Adults are thought to exhibit crepuscular behavior during their upstream migrations; meaning that they primarily are active during twilight hours. Recent hydroacoustic monitoring conducted by LGL Environmental Research Associates showed peak upstream movement of adult Central Valley spring-run Chinook salmon in lower Mill Creek, a tributary to the Sacramento River, occurring in the four hour period before sunrise and again after sunset.

Spawning Chinook salmon require clean, loose gravel in swift, relatively shallow riffles or along the margins of deeper runs, and suitable water temperatures, depths, and velocities for redd construction and adequate oxygenation of incubating eggs. Chinook salmon spawning typically occurs in gravel beds that are located at the tails of holding pools (USFWS 1995). Upon emergence, fry swim or are displaced downstream (Healey 1991). Similar to adult movement, juvenile salmonid downstream movement is crepuscular. Documents and data provided to NMFS in support of ESA section 10 research permit applications depict that the daily migration of juveniles passing RBDD is highest in the four hour period prior to sunrise (Martin *et al.* 2001). Once started downstream, fry may continue downstream to the estuary and rear, or may take up residence in the stream for a period of time from weeks to a year (Healey 1991).

Migrating and rearing fry seek nearshore habitats containing beneficial aspects such as riparian vegetation and associated substrates important for providing aquatic and terrestrial invertebrates, predator avoidance, and slower velocities for resting (NMFS 1996). The benefits of shallow water habitats for salmonid rearing also have recently been realized as shallow water habitat has been found to be more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001). Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as tidally influenced sandy beaches and vegetated zones (Meyer 1979, Healey 1980). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson *et al.* 1982, MacFarlane and Norton 2001, Sommer *et al.* 2001).

As juvenile Chinook salmon grow they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energy expenditures (Healey 1991). Catches of juvenile Chinook salmon in the Sacramento River near West Sacramento by the USFWS (1997) exhibited larger juvenile captures in the main channel and smaller sized fry along the margins. When the channel of the river is greater than 9 to 10 feet in depth, juvenile salmon tend to inhabit the surface waters (Healey 1980). Stream flow and/or turbidity increases in the upper Sacramento River basin are thought to stimulate emigration (Kjelson *et al.* 1982, Brandes and McLain, 2001).

Juvenile Chinook salmon migration rates vary considerably presumably depending on the physiological stage of the juvenile and hydrologic conditions. Kjelson *et al.* (1982) found fry Chinook salmon to travel as fast as 30 kilometers (km) per day in the Sacramento River and Sommer *et al.* (2001) found rates ranging from approximately 0.5 miles up to more than 6 miles per day in the Yolo Bypass. As Chinook salmon begin the smoltification stage, they prefer to rear further downstream where ambient salinity is up to 1.5 to 2.5 parts per thousand (Healey 1980, Levy and Northcote 1981).

Within the estuarine habitat, juvenile Chinook salmon movements are dictated by the tidal cycles, following the rising tide into shallow water habitats from the deeper main channels, and returning to the main channels when the tide recedes (Levy and Northcote 1981, Healey 1991). Kjelson *et al.* (1982) reported that juvenile Chinook salmon demonstrated a diel migration pattern, orienting themselves to nearshore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column, but would school up during the day into the upper 3 meters of the water column. Juvenile Chinook salmon were found to spend about 40 days migrating through the Sacramento-San Joaquin Delta to the mouth of San Francisco Bay and grew little in length or weight until they reached the Gulf of the Farallone Islands (MacFarlane and Norton 2001). Based on the mainly ocean-type life history observed (*i.e.*, fall-run Chinook salmon) MacFarlane and Norton (2001) concluded that unlike other salmonid populations in the Pacific Northwest, Central Valley Chinook salmon show little estuarine dependence and may benefit from expedited ocean entry.

a. *Sacramento River Winter-run Chinook Salmon*

Sacramento River winter-run Chinook salmon originally were listed as threatened in August 1989, under emergency provisions of the Endangered Species Act (ESA), and formally listed as threatened in November 1990 (55 FR 46515). The ESU consists of only one population that is confined to the upper Sacramento River in California's Central Valley. The ESU was reclassified as endangered on January 4, 1994 (59 FR 440), due to increased variability of run sizes, expected weak returns as a result of two small year classes in 1991 and 1993, and a 99 percent decline between 1966 and 1991. NMFS reaffirmed the listing of Sacramento River winter-run Chinook salmon as endangered on June 28, 2005 (70 FR 37160). The Livingston Stone National Fish Hatchery population has been included in the listed Sacramento River winter-run Chinook salmon population as of June 28, 2005 (70 FR 37160). NMFS designated critical habitat for winter-run Chinook salmon on June 16, 1993 (58 FR 33212).

Sacramento River winter-run Chinook salmon adults enter the Sacramento River basin between December and July; the peak occurring in March (Table 4; Yoshiyama *et al.* 1998, Moyle 2002). Spawning occurs primarily from mid-April to mid-August, with the peak activity occurring in May and June in the Sacramento River reach between Keswick Dam and Red Bluff Diversion Dam (RBDD) (Vogel and Marine 1991). The majority of Sacramento River winter-run Chinook salmon spawners are 3 years old.

Sacramento River winter-run Chinook salmon fry begin to emerge from the gravel in late June to early July and continue through October (Fisher 1994), with emergence generally occurring at night. Post-emergent fry disperse to the margins of the river, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris, and begin feeding on small insects and crustaceans.

Emigration of juvenile Sacramento River winter-run Chinook salmon past RBDD may begin as early as mid July, typically peaks in September, and can continue through March in dry years (Vogel and Marine 1991, NMFS 1997). From 1995 to 1999, all Sacramento River winter-run Chinook salmon outmigrating as fry passed RBDD by October, and all outmigrating pre-smolts and smolts passed RBDD by March (Martin *et al.* 2001). Juvenile Sacramento River winter-run Chinook salmon occur in the Delta primarily from November through early May based on data collected from trawls in the Sacramento River at West Sacramento (RM 57) (USFWS 2001). The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type. Winter-run Chinook salmon juveniles remain in the Delta until they reach a fork length of approximately 118 millimeters (mm) and are from 5 to 10 months of age, and then begin emigrating to the ocean as early as November and continuing through May (Fisher 1994, Myers *et al.* 1998).

Historical Sacramento River winter-run Chinook salmon population estimates, which included males and females, were as high as near 100,000 fish in the 1960s, but declined to under 200 fish in the 1990s (Good *et al.* 2005). Population estimates in 2003 (8,218), 2004 (7,701), and 2005 (15,730) show a recent increase in the population size (California Department of Fish and Game [CDFG] Grandtab, February 2005, letter titled "Winter-run Chinook Salmon Escapement Estimates for 2005" from CDFG to NMFS, January 13, 2006) and a 3-year average of 10,550. The 2005 run was the highest since the listing. Overall, abundance measures suggest that the abundance is increasing (Good *et al.* 2005). Two current methods are utilized to estimate the juvenile production of Sacramento River winter-run Chinook salmon: the Juvenile Production Estimate (JPE) method, and the Juvenile Production Index (JPI) method (Gaines and Poytress

2004). Gaines and Poytress (2004) estimated the juvenile population of Sacramento River winter-run Chinook salmon exiting the upper Sacramento River at RBDD to be 3,707,916 juveniles per year using the JPI method between the years 1995 and 2003 (excluding 2000 and 2001). Using the JPE method, they estimated an average of 3,857,036 juveniles exiting the upper Sacramento River at RBDD between the years of 1996 and 2003 (Gaines and Poytress 2004). Averaging these 2 estimates yields an estimated population size of 3,782,476.

Based on the RBDD counts, the population has been growing rapidly since the 1990s with positive short-term trends. An age-structured density-independent model of spawning escapement by Botsford and Brittnacker in 1998 (as referenced in Good *et al.* 2005) assessing the viability of Sacramento River winter-run Chinook salmon found the species was certain to fall below the quasi-extinction threshold of 3 consecutive spawning runs with fewer than 50 females (Good *et al.* 2005). Lindley *et al.* (2003) assessed the viability of the population using a Bayesian model based on spawning escapement that allowed for density dependence and a change in population growth rate in response to conservation measures found a biologically significant expected quasi-extinction probability of 28 percent. Although the status of the Sacramento River winter-run Chinook salmon population is improving, there is only one population, and it depends on cold-water releases from Shasta Dam, which could be vulnerable to a prolonged drought (Good *et al.* 2005).

Lindley *et al.* (2007), in their framework for assessing the viability of Chinook salmon and steelhead in the Sacramento-San Joaquin basin, concluded that the population of winter-run Chinook salmon that spawns below Keswick dam satisfies low-risk criteria for population size and population decline, but increasing hatchery influence is a concern that puts the population at a moderate risk of extinction. Furthermore, Lindley *et al.* (2007) point out that an ESU represented by a single population at moderate risk, is at a high risk of extinction over the long term. In the last two years, adult population estimates have declined dramatically from 17,334 in 2006 to 2,542 in 2007, further illustrating the volatility and instability of this single population ESU (Bruce Oppenheim, NMFS, pers comm.2008)

b. *Central Valley Spring-run Chinook Salmon*

NMFS listed the Central Valley spring-run Chinook salmon ESU as threatened on September 16, 1999 (64 FR 50394). In June 2004, NMFS proposed that Central Valley spring-run Chinook salmon remain listed as threatened (69 FR 33102). This proposal was based on the recognition that although Central Valley spring-run Chinook salmon productivity trends are positive, the ESU continues to face risks from having a limited number of remaining populations (*i.e.*, 3 existing populations from an estimated 17 historical populations), a limited geographic distribution, and potential hybridization with Feather River Hatchery (FRH) spring-run Chinook salmon, which until recently were not included in the ESU and are genetically divergent from other populations in Mill, Deer, and Butte Creeks. On June 28, 2005, after reviewing the best available scientific and commercial information, NMFS issued its final decision to retain the status of Central Valley spring-run Chinook salmon as threatened (70 FR 37160). This decision also included the FRH spring-run Chinook salmon population as part of the Central Valley spring-run Chinook salmon ESU. Critical habitat was designated for Central Valley spring-run Chinook salmon on September 2, 2005 (70 FR 52488).

Adult Central Valley spring-run Chinook salmon leave the ocean to begin their upstream migration in late January and early February (CDFG 1998) and enter the Sacramento River between March and September, primarily in May and June (Table 5; Yoshiyama *et al.* 1998, Moyle 2002). Lindley *et al.* (2006a) indicates adult Central Valley spring-run Chinook salmon enter native tributaries from the Sacramento River primarily between mid April and mid June. Typically, spring-run Chinook salmon utilize mid- to high-elevation streams that provide appropriate temperatures and sufficient flow, cover, and pool depth to allow over-summering while conserving energy and allowing their gonadal tissue to mature (Yoshiyama *et al.* 1998).

Spring-run Chinook salmon fry emerge from the gravel from November to March (Moyle 2002) and the emigration timing is highly variable, as they may migrate downstream as young-of-the-year (YOY) or as juveniles or yearlings. The modal size of fry migrants at approximately 40 mm between December and April in Mill, Butte, and Deer Creeks reflects a prolonged emergence of fry from the gravel (Lindley *et al.* 2006a). Studies in Butte Creek (Ward *et al.* 2002, 2003, McReynolds *et al.* 2005) found the majority of Central Valley spring-run Chinook salmon migrants to be fry occurring primarily during December, January and February; and that these movements appeared to be influenced by flow. Small numbers of Central Valley spring-run Chinook salmon remained in Butte Creek to rear and migrated as yearlings later in the spring. Juvenile emigration patterns in Mill and Deer Creeks are very similar to patterns observed in Butte Creek, with the exception that Mill and Deer Creek juveniles typically exhibit a later young-of-the-year (YOY) migration and an earlier yearling migration (Lindley *et al.* 2006a).

Once juveniles emerge from the gravel they initially seek areas of shallow water and low velocities while they finish absorbing the yolk sac (Moyle 2002). Many also will disperse downstream during high-flow events. As is the case in other salmonids, there is a shift in microhabitat use by juveniles to deeper faster water as they grow. Microhabitat use can be influenced by the presence of predators which can force fish to select areas of heavy cover and suppress foraging in open areas (Moyle 2002). Peak movement of juvenile Central Valley spring-run Chinook salmon in the Sacramento River at Knights Landing occurs in December, and again in March and April. However, juveniles also are observed between November and the end of May (Snider and Titus 2000).

On the Feather River, significant numbers of spring-run Chinook salmon, as identified by run timing, return to the FRH. In 2002, the FRH reported 4,189 returning spring-run Chinook salmon, which is 22 percent below the 10-year average of 4,727 fish. However, coded-wire tag (CWT) information from these hatchery returns indicates substantial introgression has occurred between fall-run and spring-run Chinook salmon populations within the Feather River system due to hatchery practices. Because Chinook salmon are not temporally separated in the hatchery, spring-run and fall-run Chinook salmon have been spawned together, thus, compromising the genetic integrity of the spring-run Chinook salmon stock. The number of naturally-spawning spring-run Chinook salmon in the Feather River has been estimated only periodically since the 1960s, with estimates ranging from 2 fish in 1978 to 2,908 in 1964. However, the genetic integrity of this population is questionable because of the significant temporal and spatial overlap between spawning populations of spring-run and fall-run Chinook salmon (Good *et al.* 2005). For the reasons discussed above, the Feather River spring-run Chinook population numbers are not included in the following discussion of ESU abundance.

The Central Valley spring-run Chinook salmon ESU has displayed broad fluctuations in adult abundance, ranging from 1,403 in 1993 to 25,890 in 1982. The average abundance for the ESU was 12,590 for the period of 1969 to 1979, 13,334 for the period of 1980 to 1990, 6,554 from 1991 to 2001, and 16,349 between 2002 and 2005 (for the purposes of this biological opinion, the average adult population is assumed to be 16,349 until new information is available. Sacramento River tributary populations in Mill, Deer, and Butte Creeks are probably the best trend indicators for the Central Valley spring-run Chinook ESU as a whole because these streams contain the primary independent populations with the ESU. Generally, these streams have shown a positive escapement trend since 1991. Escapement numbers are dominated by Butte Creek returns, which have averaged over 7,000 fish since 1995. During this same period, adult returns on Mill Creek have averaged 778 fish, and 1,463 fish on Deer Creek. Although recent trends are positive, annual abundance estimates display a high level of fluctuation, and the overall number of Central Valley spring-run Chinook salmon remains well below estimates of historic abundance. Additionally, in 2003, high water temperatures, high fish densities, and an outbreak of Columnaris Disease (*Flexibacter Columnaris*) and Ichthyophthiriasis (*Ichthyophthirius multifiis*) contributed to the pre-spawning mortality of an estimated 11,231 adult spring-run Chinook salmon in Butte Creek.

Lindley *et al.* (2006a) concluded that Butte and Deer Creek fish are at low risk of extinction, satisfying viability criteria for population size, decline/growth rate, hatchery influence, and catastrophe. The Mill Creek population is at a low to moderate risk, satisfying some, but not all viability criteria. Lindley *et al.* (2006a) found Feather and Yuba River populations as data deficient and did not assess their viability. However, because the existing Central Valley spring-run Chinook salmon populations are spatially confined to relatively few remaining streams in only one of four historic diversity groups, the ESU remains vulnerable to catastrophic disturbance, and it therefore remains at a moderate to high risk of extinction.

2. Central Valley Steelhead

Central Valley steelhead was originally listed as threatened on March 19, 1998 (63 FR 13347). This DPS consists of steelhead populations in the Sacramento and San Joaquin River basins in California's Central Valley. In June 2004, NMFS proposed that Central Valley spring-run Chinook salmon remain listed as threatened (69 FR 33102). On June 28, 2005, after reviewing the best available scientific and commercial information, NMFS issued its final decision to retain the status of Central Valley steelhead as threatened (70 FR 37160). This decision also included the Coleman National Fish Hatchery and FRH steelhead populations. These populations were previously included in the DPS but were not deemed essential for conservation and thus not part of the listed steelhead population. Critical habitat was designated for Central Valley steelhead on September 2, 2005 (70 FR 52488).

Steelhead can be divided into two life history types, summer-run steelhead and winter-run steelhead, based on their state of sexual maturity at the time of river entry and the duration of their spawning migration, stream-maturing and ocean-maturing. Only winter steelhead currently are found in Central Valley rivers and streams (McEwan and Jackson 1996), although there are indications that summer steelhead were present in the Sacramento river system prior to the commencement of large-scale dam construction in the 1940s (Interagency Ecological Program (IEP) Steelhead Project Work Team 1999). At present, summer steelhead are found only in North Coast drainages, mostly in tributaries of the Eel, Klamath, and Trinity River systems (McEwan and Jackson 1996).

Central Valley steelhead generally leave the ocean from August through April (Busby *et al.* 1996), and spawn from December through April with peaks from January though March in small streams and tributaries where cool, well oxygenated water is available year-round (Hallock *et al.* 1961, McEwan and Jackson 1996) (Table 6). Timing of upstream migration is correlated with higher flow events, such as freshets or sand bar breaches, and associated lower water temperatures. Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning more than once before death (Busby *et al.* 1996). However, it is rare for steelhead to spawn more than twice before dying; most that do so are females (Busby *et al.* 1996). Iteroparity is more common among southern steelhead populations than northern populations (Busby *et al.* 1996). Although one-time spawners are the great majority, Shapolov and Taft (1954) reported that repeat spawners are relatively numerous (17.2 percent) in California streams.

Spawning occurs during winter and spring months. The length of time it takes for eggs to hatch depends mostly on water temperature. Hatching of steelhead eggs in hatcheries takes about 30 days at 51 °F. Fry emerge from the gravel usually about four to six weeks after hatching, but factors such as redd depth, gravel size, siltation, and temperature can speed or retard this time (Shapovalov and Taft 1954). Newly emerged fry move to the shallow, protected areas associated with the stream margin (McEwan and Jackson 1996) and they soon move to other areas of the stream and establish feeding locations, which they defend (Shapovalov and Taft 1954). Steelhead rearing during the summer takes place primarily in higher velocity areas in pools, although young-of-the-year also are abundant in glides and riffles. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small woody debris. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Meehan and Bjornn 1991).

Juvenile steelhead emigrate episodically from natal streams during fall, winter, and spring high flows. Emigrating Central Valley steelhead use the lower reaches of the Sacramento River and the Delta for rearing and as a migration corridor to the ocean. Juvenile Central Valley steelhead feed mostly on drifting aquatic organisms and terrestrial insects and will also take active bottom invertebrates (Moyle 2002).

Some may utilize tidal marsh areas, non-tidal freshwater marshes, and other shallow water areas in the Delta as rearing areas for short periods prior to their final emigration to the sea. Hallock *et al.* (1961) found that juvenile steelhead in the Sacramento River basin migrate downstream during most months of the year, but the peak period of emigration occurred in the spring, with a much smaller peak in the fall. Nobriga and Cadrett (2003) also have verified these temporal findings based on analysis of captures at Chipps Island, Suisun Bay.

Historic Central Valley steelhead run sizes are difficult to estimate given the paucity of data, but may have approached 1 to 2 million adults annually (McEwan 2001). By the early 1960s the steelhead run size had declined to about 40,000 adults (McEwan 2001). Over the past 30 years, the naturally-spawned steelhead populations in the upper Sacramento River have declined substantially. Hallock *et al.* (1961) estimated an average of 20,540 adult steelhead through the 1960s in the Sacramento River, upstream of the Feather River. Steelhead counts at the RBDD declined from an average of 11,187 for the period of 1967 to 1977, to an average of approximately 2,000 through the early 1990s, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations.

Recent estimates from trawling data in the Delta indicate that approximately 100,000 to 300,000 (mean 200,000) smolts emigrate to the ocean per year representing approximately 3,600 female Central Valley steelhead spawners in the Central Valley basin (Good *et al.* 2005). This can be compared with McEwan's (2001) estimate of one million to two million spawners before 1850, and 40,000 spawners in the 1960s.

Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill Creeks and the Yuba River. Populations may exist in Big Chico and Butte Creeks and a few wild steelhead are produced in the American and Feather Rivers (McEwan and Jackson 1996). Recent snorkel surveys (1999 to 2002) indicate that steelhead are present in Clear Creek (J. Newton, USFWS, pers. comm. 2002, as reported in Good *et al.* 2005). Because of the large resident *O. mykiss* population in Clear Creek, steelhead spawner abundance has not been estimated.

Until recently, Central Valley steelhead were thought to be extirpated from the San Joaquin River system. Recent monitoring has detected small self-sustaining populations of steelhead in the Stanislaus, Mokelumne, and Calaveras rivers, and other streams previously thought to be devoid of steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (S.P. Cramer and Associates Inc. 2000, 2001).

It is possible that naturally-spawning populations exist in many other streams but are undetected due to lack of monitoring programs (IEP Steelhead Project Work Team 1999). Incidental catches and observations of steelhead juveniles also have occurred on the Tuolumne and Merced Rivers during fall-run Chinook salmon monitoring activities, indicating that steelhead are widespread, throughout accessible streams and rivers in the Central Valley (Good *et al.* 2005). CDFG staff has prepared juvenile migrant Central Valley steelhead catch summaries on the San Joaquin River near Mossdale representing migrants from the Stanislaus, Tuolumne, and Merced Rivers. Based on trawl recoveries at Mossdale between 1988 and 2002, as well as rotary screw trap efforts in all three tributaries, CDFG staff stated that it is "clear from this data that rainbow trout do occur in all the tributaries as migrants and that the vast majority of them occur on the Stanislaus River" (Letter from Dean Marston, CDFG, to Madelyn Martinez, NMFS, January 9, 2003). The documented returns on the order of single fish in these tributaries suggest that existing populations of Central Valley steelhead on the Tuolumne, Merced, and lower San Joaquin Rivers are severely depressed.

Lindley *et al.* (2006b) indicated that prior population census estimates completed in the 1990s found the Central Valley steelhead spawning population above RBDD had a fairly strong negative population growth rate and small population size. Good *et al.* (2005) indicated the decline was continuing as evidenced by new information (Chipps Island trawl data). Central Valley steelhead populations generally show a continuing decline, an overall low abundance, and fluctuating return rates. The future of Central Valley steelhead is uncertain due to limited data concerning their status. However, Lindlely *et al.* (2007), citing evidence presented by Yoshiyama *et al.* (1996); McEwan (2001); and Lindley *et al.* (2006), concluded that there is sufficient evidence to suggest that the ESU is at moderate to high risk of extinction.

3. <u>Southern Distinct Population Segment of North American Green Sturgeon</u>

The southern DPS of North American green sturgeon was listed as threatened on April 7, 2006, (70 FR 17386) and includes the North American green sturgeon population spawning in the Sacramento River and utilizing the Sacramento River, the Delta, and the San Francisco Estuary.

North American green sturgeon are widely distributed along the Pacific Coast and have been documented offshore from Ensenada Mexico to the Bering Sea and found in rivers from British Columbia to the Sacramento River (Moyle 2002). As is the case for most sturgeon, North American green sturgeon are anadromous; however, they are the most marine-oriented of the sturgeon species (Moyle 2002). In North America, spawning populations of the anadromous green sturgeon currently are found in only three river systems, the Sacramento and Klamath Rivers in California and the Rogue River in southern Oregon.

Two green sturgeon DPSs were identified based on evidence of spawning site fidelity (indicating multiple DPS tendencies), and on the preliminary genetic evidence that indicates differences at least between the Klamath River and San Pablo Bay samples (Adams *et al.* 2002). The Northern DPS includes all green sturgeon populations starting with the Eel River and extending northward.

The southern DPS would include all green sturgeon populations south of the Eel River with the only known spawning population being in the Sacramento River.

The southern DPS of North American green sturgeon life cycle can be broken into four distinct phases based on developmental stage and habitat use: (1) adult females greater than or equal to 13 years of age and males greater than or equal to 9 years of age, (2) larvae and post-larvae less than 10 months of age, (3) juveniles less than or equal to 3 years of age, and (4) coastal migrant females between 3 and 13, and males between 3 and 9 years of age (Nakamoto *et al.* 1995, Jeff McLain, NMFS, pers. comm., 2006).

New information regarding the migration and habitat use of the southern DPS of North American green sturgeon has emerged. Lindley (2006c) presents preliminary results of large-scale green sturgeon migration studies. Lindley's analysis verified past population structure delineations based on genetic work and found frequent large-scale migrations of green sturgeon along the Pacific Coast. It appears North American green sturgeon migrate considerable distances up the Pacific Coast into several bays and estuaries, particularly the Columbia River estuary. This information also agrees with the results of green sturgeon tagging studies completed by CDFG where they tagged a total of 233 green sturgeons in the San Pablo Estuary between 1954 and 2001. A total of 17 tagged fish were recovered: 3 in the Sacramento-San Joaquin Estuary, 2 in the Pacific Ocean off of California, and 12 from commercial fisheries off of Oregon and Washington. Eight of the 12 recoveries were in the Columbia Estuary (CDFG 2002).

Kelley *et al.* (2006) indicated that green sturgeon enter the San Francisco Estuary during the spring and remain until autumn. The authors studied the movement of adults in the San Francisco Estuary and found them to make significant long-distance movements with distinct directionality. The movements were not found to be related to salinity, current, or temperature and the authors surmised they are related to resource availability (Kelley *et al.* 2006). The majority of green sturgeon in the Rogue River emigrated from freshwater habitat in December after water temperatures dropped (Erickson *et al.* 2002). Green sturgeon were most often found at depths greater than 5 meters with low or no current during summer and autumn months (Erickson *et al.* 2002). The authors surmised that this holding in deep pools was to conserve energy and utilize abundant food resources. Based on captures of adult green sturgeon in holding pools on the Sacramento River above the GCID diversion (RM 205) and the documented presence of adults in the Sacramento River during the spring and summer months and the presence of larval green sturgeon in late summer in the lower Sacramento River indicating spawning ocurrence, it appears adult green sturgeon could possibly utilize a variety of freshwater and brackish habitats for up to nine months of the year (Ray Beamesderfer, S.P. Cramer & Associates, Inc., pers. comm. 2006).

Adult green sturgeon are believed to feed primarily upon benthic invertebrates such as clams, mysid and grass shrimp, and amphipods (Radtke 1966, Adams *et al.* 2002, Jeffrey Stuart, NMFS, pers. comm. 2006). Adult sturgeon caught in Washington State waters were found to have fed on Pacific sand lance (*Ammodytes hexapterus*) and callianassid shrimp (Moyle *et al.* 1992).

Based on the distribution of sturgeon eggs, larva, and juveniles in the Sacramento River, CDFG (2002) indicated that southern DPS of green sturgeon spawn in late spring and early summer above Hamilton City possibly to Keswick Dam. Adult green sturgeon are believed to spawn every 3 to 5 years and reach sexual maturity only after several years of growth (*i.e.*, 10 to 15 years based on sympatric white sturgeon sexual maturity (CDFG 2002). Adult female green sturgeon produce between 60,000 and 140,000 eggs each reproductive cycle, depending on body size, with a mean egg diameter of 4.3 mm (Moyle *et al.* 1992, Van Eenennaam *et al.* 2001). Southern DPS Green sturgeon adults begin their upstream spawning migrations into the San Francisco Bay in March, reach Knights Landing during April, and spawn between March and July (Heublein *et al.* 2006). Peak spawning is believed to occur between April and June (Table 7) and thought to occur in deep turbulent pools (Adams *et al.* 2002). Substrate is likely large cobble but can range from clean sand to bedrock (USFWS 2002). Newly hatched green sturgeon are approximately 12.5 to 14.5 mm in length. According to Heublein (2006) all adults leave the Sacramento River prior to September 1.

After approximately 10 days, larvae begin feeding, growing rapidly, and young green sturgeon appear to rear for the first 1 to 2 months in the Sacramento River between Keswick Dam and Hamilton City (CDFG 2002). Juvenile green sturgeon first appear in USFWS sampling efforts at RBDD in June and July at lengths ranging from 24 to 31 mm fork length (CDFG 2002, USFWS 2002). The mean yearly total length of post-larval green sturgeon captured in rotary screw traps at the RBDD ranged from 26 mm to 34 mm between 1995 and 2000 indicating they are approximately 2 weeks old. The mean yearly total length of post-larval green sturgeon captured in the GCID rotary screw trap, approximatley 30 miles downstream of RBDD ranged from 33 mm to 44 mm between 1997 and 2005 (CDFG, unpublished data) indicating they are approximately 3 weeks old (Van Eenennaam *et al.* 2001).

Green sturgeon larvae do not exhibit the initial pelagic swim-up behavior characteristic of other *Acipenseridae*. They are strongly oriented to the bottom and exhibit nocturnal activity patterns. Under laboratory conditions, green sturgeon larvae cling to the bottom during the day, and move into the water column at night (Van Eenennaam *et al.* 2001). After six days, the larvae exhibit nocturnal swim-up activity (Deng *et al.* 2002) and nocturnal downstream migrational movements (Kynard *et al.* 2005). Juvenile green sturgeon continue to exhibit nocturnal behavioral beyond the metamorphosis from larvae to juvenile stages. Kynard *et al.*'s (2005) laboratory studies indicated that juvenile fish continued to migrate downstream at night for the first six months of life. When ambient water temperatures reached 46 ^{o}F, downstream migrational behavior diminished and holding behavior increased. This data suggests that 9-to 10-month-old fish would hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds. Juvenile green sturgeon have been salvaged at the Harvey O. Banks Pumping Plant and the John E. Skinner Fish Facility (Fish Facilities) in the South Delta, and captured in trawling studies by the CDFG during all months of the year (CDFG 2002). The majority of these fish were between 200 and 500 mm indicating they were from 2 to 3 years of age based on Klamath River age distribution work by Nakamoto *et al.* (1995). The lack of a significant proportion of juveniles smaller than approximately 200 mm in Delta captures indicates juvenile southern DPS North American green sturgeon likely hold in the mainstem Sacramento River as suggested by Kyndard *et al.* (2005).

Population abundance information concerning the southern DPS green sturgeon is described in the NMFS status reviews (Adams *et al.* 2002, NMFS 2005a). Limited population abundance information comes from incidental captures of North American green sturgeon from the white sturgeon monitoring program by the CDFG sturgeon tagging program (CDFG 2002). By comparing ratios of white sturgeon to green sturgeon captures, CDFG provides estimates of adult and sub-adult North American green sturgeon abundance. Estimated abundance between 1954 and 2001 ranged from 175 fish to more than 8,000 per year and averaged 1,509 fish per year. Unfortunately, there are many biases and errors associated with these data, and CDFG does not consider these estimates reliable. Fish monitoring efforts at RBDD and GCID on the upper Sacramento River have captured between 0 and 2,068 juvenile North American green sturgeon per year (Adams *et al.* 2002). The only existing information regarding changes in the abundance of the southern DPS of green sturgeon includes changes in abundance at the John E. Skinner Fish Facility between 1968 and 2001. The average number of North American green sturgeon taken per year at the State Facility prior to 1986 was 732; from 1986 on, the average per year was 47 (70 FR 17386). For the Harvey O. Banks Pumping Plant, the average number prior to 1986 was 889; from 1986 to 2001 the average was 32 (70 FR 17386). In light of the increased exports, particularly during the previous 10 years, it is clear that the abundance of the southern DPS of North American green sturgeon is dropping. Additional analysis of North American green and white sturgeon taken at the Fish Facilities indicates that take of both North American green and white sturgeon per acre-foot of water exported has decreased substantially since the 1960s (70 FR 17386). Catches of sub-adult and adult North American green sturgeon by the IEP between 1996 and 2004 ranged from 1 to 212 green sturgeon per year (212 occurred in 2001); however, the portion of the southern DPS of North American green sturgeon is unknown as these captures were primarily located in San Pablo Bay which is known to consist of a mixture of Northern and southern DPS North American green sturgeon. Recent spawning population estimates using sibling based genetics by Israel (2006) indicates a maximum spawning population of 32 spawners in 2002, 64 in 2003, 44 in 2004, 92 in 2005, and 124 in 2006 above RBDD (with an average of 71). Based on the length and estimated age of post-larvae captured at RBDD (approximately two weeks of age) and GCID (downstream; approximately three weeks of age), it appears the majority of southern DPS North American green sturgeon are spawning above RBDD. Note, there are many assumptions with this interpretation (*i.e.*, equal sampling efficiency and distribution of post-larvae across channels) and this information should be considered cautiously.

There are at least two records of confirmed adult sturgeon observation in the Feather River (Beamesderfer *et al.* 2004); however, there are no observations of juvenile or larval sturgeon even prior to the 1960s when Oroville Dam was built (NMFS 2005a). There are also unconfirmed reports that green sturgeon may spawn in the Feather River during high flow years (CDFG 2002).

Spawning in the San Joaquin River system has not been recorded, but alterations of the San Joaquin River tributaries (Stanislaus, Tuolumne, and Merced Rivers) and its mainstem occurred early in the European settlement of the region. During the later half of the 1800s impassable barriers were built on these tributaries where the water courses left the foothills and entered the valley floor. Therefore, these low elevation dams have blocked potentially suitable spawning habitats located further upstream for over a century. Additional destruction of riparian and stream channel habitat by industrialized gold dredging further disturbed any valley floor habitat that was still available for sturgeon spawning. It is likely that both white and green sturgeon utilized the San Joaquin River basin for spawning prior to the onset of European influence, based on past use of the region by populations of Central Valley spring-run Chinook salmon and Central Valley steelhead. These two populations of salmonids have either been extirpated or greatly diminished in their use of the San Joaquin River basin over the past two centuries.

The freshwater habitat of North American green sturgeon in the Sacramento-San Joaquin drainage varies in function, depending on location. Spawning areas currently are limited to accessible upstream reaches of the Sacramento River. Preferred spawning habitats are thought to contain large cobble in deep cool pools with turbulent water (CDFG 2002, Moyle 2002).

Migratory corridors are downstream of the spawning areas and include the mainstem Sacramento River and the Delta. These corridors allow the upstream passage of adults and the downstream emigration of outmigrant juveniles. Migratory habitat condition is strongly affected by the presence of barriers which can include dams, unscreened or poorly screened diversions, and degraded water quality. Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their 1 to 3 year residence in freshwater. Rearing habitat condition and function may be affected by variation in annual and seasonal flow and temperature characteristics.

Table 4. The temporal occurrence of adult (a) and juvenile (b) Sacramento River winter-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.

a) Adult

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River basin[1]	Medium	Medium	High	Medium	Medium	Medium	Medium	Low	Low	Low	Low	Medium
Sac. River[2]	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low	Low	Low	Medium	Medium

b) Juvenile

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River @ Red Bluff[3]	Low	Low	Low	Low	Low	Low	Low / Medium	Medium	Medium	Medium	Medium	Medium
Sac. River @ Red Bluff[2]	Medium	Medium	Low	Low	Low	Low	Low	High	High	High	Medium	Medium
Sac. River @ Knights L.[4]	Medium	Medium	Medium	Low	Low	Low	Low	Low	Low	Low	High	High
Lower Sac. River (seine)[5]	High	High	Medium	Low	Low	Low	Low	Low	Low	Low	Medium	High
West Sac. River (trawl)[5]	Medium	High	High	High	Low	Low	Low	Low	Low	Low	Low	Medium

Source: [1]Yoshiyama *et al.* 1998; Moyle 2002; [2]Myers *et al.* 1998; [3]Martin *et al.* 2001; [4]Snider and Titus 2000; [5]USFWS 2001

Relative Abundance: ▒ = High ░ = Medium ☐ = Low

Table 5. The temporal occurrence of adult (a) and juvenile (b) Central Valley spring-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.

(a) Adult

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[1,2]Sac.River basin	Low	Low	Medium	Medium	High	High	Medium	Medium	Medium	Low	Low	Low
[3]Sac. River	Low	Low	Medium	Medium	Medium	Medium	Medium	Low	Low	Low	Low	Low
[4]Mill Creek	Low	Low	Low	Medium/High	High	High/Medium	Medium/Low	Low	Low	Low	Low	Low
[4]Deer Creek	Low	Low	Low	Medium/High	High	High/Medium	Medium/Low	Low	Low	Low	Low	Low
[4]Butte Creek	Low	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low	Low	Low	Low

(b) Juvenile

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[5]Sac. River Tribs	Medium	Medium	Medium	Low	Low	Low	Low	Low	Low	Medium	High	High
[6]Upper Butte Creek	High	High	Medium	Medium	Medium	Low	Low	Low	Low	Low	Low	High
[4]Mill, Deer, Butte Creeks	High	High	Medium	Medium	Medium	Low	Low	Low	Low	Low	Low	Low
[3]Sac. River at RBDD	High	Low	Low	Low	Low	Low	Low	Low	Low	Low	High	High
[7]Sac. River at Knights Landing (KL)	Medium	Medium	High	High	Medium	Low	Low	Low	Low	Low	Medium	High

Source:[1]Yoshiyama *et al.* 1998; [2]Moyle 2002; [3]Myers *et al.* 1998; [4]Lindley *et al.* 2006a; [5]CDFG 1998; [6]McReynolds *et al.* 2005; Ward *et al.* 2002, 2003; [7]Snider and Titus 2000

Relative Abundance: [dark shading] = High; [light shading] = Medium; [white] = Low

Table 6. The temporal occurrence of adult (a) and juvenile (b) Central Valley steelhead in the Central Valley. Darker shades indicate months of greatest relative abundance.

(a) Adult

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[1,3]Sac. River								/Medium	Medium/High	High/Medium		
[2,3]Sac R at Red Bluff									Medium/Medium	High/Medium		
[4]Mill, Deer Creeks		High/Medium	Medium/							/High	High/Medium	Medium/Medium
[6]Sac R. at Fremont Weir								Medium/Medium	High/High	Medium/Medium		
[6]Sac R. at Fremont Weir								Medium/Medium	High/High	Medium/Medium		
[7]San Joaquin River	Medium/Medium	Medium/Medium	Medium/Medium						Medium/Medium	Medium/Medium	Medium/Medium	High/High

(b) Juvenile

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[1,2]Sacramento River			Medium/Medium	Medium/Medium	Medium/Medium	Medium/Medium				Medium/Medium	Medium/Medium	
[2,8]Sac. R at Knights Land			High/High									
[9]Sac. River @ KL	Medium/Medium	Medium/Medium	High/High	High/High	Medium/Medium							
[10]Chipps Island (wild)			High/High	High/High	Medium/Medium	Medium/Medium						
[8]Mossdale				High/High	High/High							
[11]Woodbridge Dam	Medium/Medium	Medium/Medium	Medium/Medium	Medium/Medium	Medium/Medium	Medium/Medium	Medium/Medium					
[12]Stan R. at Caswell		Medium/Medium	High/High	Medium/Medium	Medium/Medium							
[13]Sac R. at Hood		High/High	High/High	High/High	High/High							

Source: [1]Hallock 1961; [2]McEwan 2001; [3]USFWS unpublished data; [4]CDFG 1995; [5]Hallock *et al.* 1957; [6]Bailey 1954; [7]CDFG Steelhead Report Card Data 1995; [8]CDFG unpublished data; [9]Snider and Titus 2000; [10]Nobriga and Cadrett 2003; [11]Jones & Stokes Associates, Inc., 2002; [12]S.P. Cramer and Associates, Inc. 2000 and 2001; [13]Schaffter 1980

Relative Abundance: [dark shading] = High; [light shading] = Medium; [blank] = Low

Table 7. The temporal occurrence of adult (a) larval and post-larval (b) juvenile (c) and coastal migrant (d) southern DPS of North American green sturgeon. Locations emphasize the Central Valley of California. Darker shades indicate months of greatest relative abundance.

(a) Adult (≥13 years old for females and ≥9 years old for males)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[1,2,3]Upper Sac. River	L / L	L / L	M / M	M / H	H / H	H / M	M / M	M / M	M / M	M / M	M / M	L / L
[4,8]SF Bay Estuary	L / L	L / L	M / M	M / M	M / M	M / M	M / M	M / M	M / M	L / L	L / L	L / L

(b) Larval and post-larval (≤10 months old)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[5]RBDD, Sac River	L / L	L / L	L / L	L / L	M / M	H / H	H / H	M / M	L / L	L / L	L / L	L / L
[5]GCID, Sac River	L / L	L / L	L / L	L / L	M / M	H / H	H / H	M / M	L / L	L / L	L / L	L / L

(c) Juvenile (> 10 months old and ≤3 years old)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[6]South Delta*	M / M	M / M	M / M	M / M	M / M	M / M	M / M	M / M	M / M	M / M	M / M	M / M
[6]Sac-SJ Delta	M / M	M / M	M / M	M / M	M / M	M / M	M / M	M / M	M / M	M / M	M / M	M / M
[5]Sac-SJ Delta	L / L	L / L	L / L	M / M	M / M	M / M	M / M	M / M	M / M	M / M	L / L	L / L
[5]Suisun Bay	M / M	M / M	M / M	M / M	M / M	M / M	M / M	M / M	M / M	M / M	M / M	M / M

(d) Coastal migrant (3-13 years old for females and 3-9 years old for males)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[3,7]Pacific Coast	M / M	M / M	M / M	M / M	M / M	M / M	M / M	M / M	M / M	M / M	M / M	M / M

Source: [1]USFWS 2002; [2]Moyle *et al.* 1992; [3]Adams *et al.* 2002 and NMFS 2005a; [4]Kelley *et al.* 2006; [5]CDFG 2002; [6]Interagency Ecological Program Relational Database, fall midwater trawl green sturgeon captures from 1969 to 2003; [7]Nakamoto *et al.* 1995; [8]Heublein *et al.* 2006

* Fish Facility salvage operations

Relative Abundance: H = High; M = Medium; L = Low

B. Critical Habitat Condition and Primary Constituent Elements

The designated critical habitat for Sacramento River winter-run Chinook salmon includes the Sacramento River from Keswick Dam (RM 302) to Chipps Island (RM 0) at the westward margin of the Delta; all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Estuary to the Golden Gate Bridge north of the San Francisco/Oakland Bay Bridge. In the Sacramento River, critical habitat includes the river water column, river bottom, and adjacent riparian zone used by fry and juveniles for rearing. In the areas westward of Chipps Island, critical habitat includes the estuarine water column and essential foraging habitat and food resources used by Sacramento River winter-run Chinook salmon as part of their juvenile emigration or adult spawning migration.

Critical habitat for Central Valley spring-run Chinook salmon includes stream reaches such as those of the Feather and Yuba Rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear Creeks, and the Sacramento River and Delta. Critical Habitat for Central Valley steelhead includes stream reaches such as those of the Sacramento, Feather, and Yuba Rivers, and Deer, Mill, Battle, and Antelope Creeks in the Sacramento River basin; and, the San Joaquin River its tributaries, and the Delta. Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line. In areas where the ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation (70 FR 52488). The bankfull elevation is defined as the level at which water begins to leave the channel and move into the floodplain; it is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series (MacDonald *et* al. 1991, Rosgen 1996). Critical habitat for Central Valley spring-run Chinook salmon and steelhead is defined as specific areas that contain the primary constituent elements (PCE) and physical habitat elements essential to the conservation of the species. Following are the inland habitat types used as PCEs for Central Valley spring-run Chinook salmon and Central Valley steelhead, and as physical habitat elements for Sacramento River winter-run Chinook salmon.

1. <u>Spawning Habitat</u>

Freshwater spawning sites are those with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development. Most spawning habitat in the Central Valley for Chinook salmon and steelhead is located in areas directly downstream of dams containing suitable environmental conditions for spawning and incubation. Spawning habitat for Sacramento River winter-run Chinook salmon is restricted to the Sacramento River primarily between RBDD and Keswick Dam. Central Valley spring-run Chinook salmon also spawn on the mainstem Sacramento River between RBDD and Keswick Dam and in tributaries such as Mill, Deer, and Butte Creeks. Spawning habitat for Central Valley steelhead is similar in nature to the requirements of Chinook salmon, primarily occurring in reaches directly below dams (*i.e.*, above RBDD on the Sacramento River) throughout the Central Valley. Natural spawning habitats (those not downstream from large dams) require adequate water temperatures, stream flows, and gravel conditions to support successful reproduction. Some areas below dams, especially for steelhead are degraded by fluctuating flow conditions related to water storage and flood management, that scour or strand redds. Spawning habitat has a high conservation value as its function directly affects the spawning success and reproductive potential of listed salmonids.

2. Freshwater Rearing Habitat

Freshwater rearing sites are those with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams, beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their outmigration. Non-natal, intermittent tributaries also may be used for juvenile rearing. Rearing habitat condition is strongly affected by habitat complexity, food supply, and presence of predators of juvenile salmonids. Some complex, productive habitats with floodplains remain in the system (*e.g.*, the lower Cosumnes River, Sacramento River reaches with set-back levees [*i.e.*, primarily located upstream of the City of Colusa]). However, the channeled, leveed, and riprapped river reaches and sloughs that are common in the Sacramento-San Joaquin system typically have low habitat complexity, low abundance of food organisms, and offer little protection from either fish or avian predators. Freshwater rearing habitat also has a high conservation value as the juvenile life stage of salmonids is dependant on the function of this habitat for successful survival and recruitment. Thus, although much of the rearing habitat is in poor condition, it is important to the species.

3. Freshwater Migration Corridors

Ideal freshwater migration corridors are free of obstruction with adequate water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility, survival and food supply. Migratory corridors are downstream of the spawning area and include the lower Sacramento River and the Delta. These corridors allow the upstream passage of adults, and the downstream emigration of outmigrant juveniles. Migratory habitat condition is strongly affected by the presence of barriers, which can include dams, unscreened or poorly- screened diversions, and degraded water quality. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. For adults, upstream passage through the Delta and the much of the Sacramento River is not a problem, but problems exist on many tributary streams, and at the RBDD. For juveniles, unscreened or inadequately screen water diversions throughout their migration corridors, and a scarcity of complex in-river cover have degraded this PCE. However, since the primary migration corridors are used by numerous populations, and are essential for connecting early rearing habitat with the ocean even the degraded reaches are considered to have a high conservation value to the species.

4. Estuarine Areas

Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and salt water are included as a PCE. Natural cover such as submerged and overhanging large wood, aquatic vegetation, and side channels, are suitable for juvenile and adult foraging. The remaining estuarine habitat for these species is severely degraded by altered hydrologic regimes, poor water quality, reductions in habitat complexity, and competition for food and space with exotic species. Regardless of the condition, the remaining estuarine areas are of high conservation value because they function as predator avoidance and as a transition to the ocean environment.

C. Factors Affecting the Species and Critical Habitat

1. Sacramento River Winter-run Chinook Salmon, Central Valley Steelhead, and Spring-run Chinook Salmon

A number of documents reviewed by NMFS for this biological opinion address the history of human activities, present environmental conditions, and factors contributing to the decline of salmon and steelhead species in the Central Valley. For example, NMFS prepared range-wide status reviews for west coast Chinook salmon (Myers *et al.* 1998) and steelhead (Busby *et al.* 1996). Also, the NMFS Biological Review Team (BRT) published a draft updated status review for west coast Chinook salmon and steelhead in November 2003 (NMFS 2003), and an additional updated and final draft in 2005 (Good *et al.* 2005). NMFS also assessed the factors for Chinook salmon and steelhead decline in supplemental documents (NMFS 1996, 1998). Information also is available in Federal Register notices announcing ESA listing proposals and determinations for some of these species and their critical habitat (*e.g.*, 58 FR 33212; 59 FR 440; 62 FR 24588; 62 FR 43937; 63 FR 13347; 64 FR 24049; 64 FR 50394; 65 FR 7764). The Final Programmatic Environmental Impact Statement/Report (EIS/EIR) for the CALFED Program (CALFED 2000), and the Final Programmatic EIS for the CVPIA provide a summary of historical and recent environmental conditions for salmon and steelhead in the Central Valley. The following general description of the factors affecting Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead, and their critical habitat is based on a summarization of these documents.

In general, the human activities that have affected listed anadromous salmonids and the PCEs of their critical habitats consist of: (1) the present or threatened destruction, modification, or curtailment of habitat or range; (2) over-utilization; (3) disease or predation; (4) the inadequacy of existing regulatory mechanisms; and (5) other natural and manmade factors, including habitat and ecosystem restoration, and global climate change. All of these factors have contributed to the ESA-listing of these fish and deterioration of their critical habitat. However, it is widely recognized in numerous species accounts in the peer-reviewed literature that the modification and curtailment of habitat and range have had the most substantial impacts on the abundance, distribution, population growth, and diversity of salmonid ESUs. Although habitat and ecoystem restoration has contributed to population stability and increases in abundance throughout the ESUs, global climate change remains a looming threat.

a. Modification and Curtailment of Habitat and Range

Modification and curtailment of habitat and range from hydropower, flood control, and consumptive water use have permanently blocked or hindered salmonid access to historical spawning and rearing grounds resulting in the complete loss of substantial portions of spawning, rearing, and migration PCEs. Clark (1929) estimated that originally there were 6,000 linear miles of salmon habitat in the Central Valley system and that 80 percent of this habitat had been lost by 1928. Yoshiyama *et al.* (1996) calculated that roughly 2,000 linear miles of salmon habitat actually was available before dam construction and mining, and concluded that 82 percent is not accessible today. Yoshiyama *et al.* (1996) surmised that steelhead habitat loss was even greater than salmon loss, as steelhead migrated farther into drainages. In general, large dams on every major tributary to the Sacramento River, San Joaquin River, and the Delta block salmon and steelhead access to the upper portions of their respective watersheds. The loss of upstream habitat has required Chinook salmon and steelhead to use less hospitable reaches below dams. The loss of substabtial habitat above dams also has resulted in decreased juvenile and adult salmonid survival during migration, and in many cases, has resulted in the dewatering and loss of important spawning and rearing habitats.

The diversion and storage of natural flows by dams and diversion structures on Central Valley waterways have depleted stream flows and altered the natural cycles by which juvenile and adult salmonids have evolved. Changes in stream flows and diversions of water affect spawning habitat, freshwater rearing habitat, freshwater migration corridors, and estuarine habitat PCEs. As much as 60 percent of the natural historical inflow to Central Valley watersheds and the Delta have been diverted for human uses. Depleted flows have contributed to higher temperatures, lower dissolved oxygen (DO) levels, and decreased recruitment of gravel and IWM. More uniform flows year-round have resulted in diminished natural channel formation, altered food web processes, and slower regeneration of riparian vegetation. These stable flow patterns have reduced bedload movement, caused spawning gravels to become embedded, and decreased channel widths due to channel incision, all of which has decreased the available spawning and rearing habitat below dams.

Water withdrawals, for agricultural and municipal purposes have reduced river flows and increased temperatures during the critical summer months, and in some cases, have been of a sufficient magnitude to result in reverse flows in the lower San Joaquin River (Reynolds *et al.* 1993). Direct relationships exist between water temperature, water flow, and juvenile salmonid survival (Brandes and McLain 2001). High water temperatures in the Sacramento River have limited the survival of young salmon.

The development of the water conveyance system in the Delta has resulted in the construction of more than 1,100 miles of channels and diversions to increase channel elevations and flow capacity of the channels (Mount 1995). Levee development in the Central Valley affects spawning habitat, freshwater rearing habitat, freshwater migration corridors, and estuarine habitat PCEs. The construction of levees disrupts the natural processes of the river, resulting in a multitude of habitat-related effects that have diminished conditions for adult and juvenile migration and survival.

Many of these levees use angular rock (riprap) to armor the bank from erosive forces. The effects of channelization, and riprapping, include the alteration of river hydraulics and cover along the bank as a result of changes in bank configuration and structural features (Stillwater Sciences 2006). These changes affect the quantity and quality of nearshore habitat for juvenile salmonids and have been thoroughly studied (USFWS 2000, Schmetterling *et al.* 2001, Garland *et al.* 2002). Simple slopes protected with rock revetment generally create nearshore hydraulic conditions characterized by greater depths and faster, more homogeneous water velocities than occur along natural banks. Higher water velocities typically inhibit deposition and retention of sediment and woody debris. These changes generally reduce the range of habitat conditions typically found along natural shorelines, especially by eliminating the shallow, slow-velocity river margins used by juvenile fish as refuge and escape from fast currents, deep water, and predators (Stillwater Sciences 2006).

Large quantities of downed trees are a functionally important component of many streams (NMFS 1996). Large woody debris influences channel morphology by affecting longitudinal profile, pool formation, channel pattern and position, and channel geometry. Downstream transport rates of sediment and organic matter are controlled in part by capture of this material within and behind large wood. Large wood affects the formation and distribution of habitat units, provides cover and complexity, and acts as a substrate for biological activity (NMFS 1996). Wood enters streams inhabited by salmonids either directly from adjacent riparian zones or from riparian zones in adjacent non-fish bearing tributaries. Removal of riparian vegetation and instream woody material (IWM) from the streambank results in the loss of a primary source of overhead and instream cover for juvenile salmonids. The removal of riparian vegetation and IWM and the replacement of natural bank substrates with rock revetment can adversely affect important ecosystem functions. Living space and food for terrestrial and aquatic invertebrates is lost, eliminating an important food source for juvenile salmonids. Loss of riparian vegetation and soft substrates reduces inputs of organic material to the stream ecosystem in the form of leaves, detritus, and woody debris, which can affect biological production at all trophic levels. The magnitude of these effects depends on the degree to which riparian vegetation and natural substrates are preserved or recovered during the life of the project.

In addition, the armoring and revetment of stream banks tends to narrow rivers, reducing the amount of habitat per unit channel length (Sweeney *et al.* 2004). As a result of river narrowing, benthic habitat decreases and the number of macroinvertebrates, such as stoneflies and mayflies, per unit channel length decreases affecting salmonid food supply.

b. *Ecosystem Restoration*

The CVPIA, implemented in 1992, requires that fish and wildlife get equal consideration with other demands for water allocations derived from the CVP. From this act arose several programs that have benefited listed salmonids: the Anadromous Fish Restoration Program (AFRP), the Anadromous Fish Screen Program (AFSP), and the Water Acquisition Program (WAP). The AFRP is engaged in monitoring, education, and restoration projects geared toward doubling the natural populations of select anadromous fish species residing in the Central Valley. Restoration projects funded through the AFRP include fish passage, fish screening, riparian easement and land acquisition, development of watershed planning groups, instream and riparian habitat improvement, and gravel replenishment. The AFSP combines Federal funding with State and private funds to prioritize and construct fish screens on major water diversions mainly in the upper Sacramento River. The goal of the WAP is to acquire water supplies to meet the habitat restoration and enhancement goals of the CVPIA and to improve the Department of Interior's ability to meet regulatory water quality requirements. Water acquisition has been used successfully to improve fish habitat for Central Valley spring-run Chinook salmon and Central Valley steelhead by maintaining or increasing instream flows in Butte and Mill Creeks and the San Joaquin River at critical times.

Two programs included under CALFED; the Ecosystem Restoration Program (ERP) and the EWA, were created to improve conditions for fish, including listed salmonids, in the Central Valley. Restoration actions implemented by the ERP include the installation of fish screens, modification of barriers to improve fish passage, habitat acquisition, and instream habitat restoration. The majority of these actions address key factors affecting listed salmonids and emphasis has been placed in tributary drainages with high potential for Central Valley steelhead and Central Valley spring-run Chinook salmon production. Additional ongoing actions include new efforts to enhance fisheries monitoring and directly support salmonid production through hatchery releases. Recent habitat restoration initiatives sponsored and funded primarily by the CALFED-ERP have resulted in plans to restore ecological function to 9,543 acres of shallow-water tidal and marsh habitats within the Delta. Restoration of these areas primarily involves flooding lands previously used for agriculture, thereby creating additional rearing habitat for juvenile salmonids.

The CDWR's Four Pumps Agreement Program has approved approximately $49 million for projects that benefit salmon and steelhead production in the Sacramento-San Joaquin basins and Delta since the agreements inception in 1986. Four Pumps projects that benefit Central Valley spring-run Chinook salmon and steelhead include water exchange programs on Mill and Deer Creeks; enhanced law enforcement efforts from San Francisco Estuary upstream to the Sacramento and San Joaquin Rivers and their tributaries; design and construction of fish screens and ladders on Butte Creek; and, screening of diversions in Suisun Marsh and San Joaquin tributaries. Predator habitat isolation and removal, and spawning habitat enhancement projects on the San Joaquin tributaries benefit steelhead.

c. *Climate Change*

The world is about 1.3 °F warmer today than a century ago and the latest computer models predict that, without drastic cutbacks in emissions of carbon dioxide and other gases released by the burning of fossil fuels, the average global surface temperature may rise by two or more degrees in the 21st century (Intergovernmental Panel on Climate Change [IPCC] 2001). Much of that increase will likely occur in the oceans, and evidence suggests that the most dramatic changes in ocean temperature are now occurring in the Pacific (Noakes 1998). Using objectively analyzed data Huang and Liu (2000) estimated a warming of about 0.9 °F per century in the Northern Pacific Ocean.

An alarming prediction is the fact that Sierra snow packs are expected to decrease with global warming and that the majority of runoff in California will be from rainfall in the winter rather than from melting snow pack in the mountains (CDWR 2006). This will alter river runoff patterns and transform the tributaries that feed the Central Valley from a spring/summer snowmelt dominated system to a winter rain dominated system. It can be hypothesized that summer temperatures and flow levels will become unsuitable for salmonid survival. The cold snowmelt that furnishes the late spring and early summer runoff will be replaced by warmer precipitation runoff. This should truncate the period of time that suitable cold-water conditions exist below existing reservoirs and dams due to the warmer inflow temperatures to the reservoir from rain runoff. Without the necessary cold-water pool developed from melting snow pack filling reservoirs in the spring and early summer, late summer and fall temperatures below reservoirs, such as Lake Shasta, potentially could rise above thermal tolerances for juvenile and adult salmonids (*i.e.* Sacramento River winter-run Chinook salmon and Central Valley steelhead) that must hold below the dam over the summer and fall periods.

2. <u>Critical Habitat for Salmonids</u>

According the NMFS CHART report (2005b) the major categories of habitat-related activities affecting Central Valley salmonids include: (1) irrigation impoundments and withdrawals (2) channel modifications and levee maintenance, (4) the presence and operation of hydroelectric dams, (5) flood control and streambank stabilization, and (6) exotic and invasive species introductions and management. All of these activities affect PCEs via their alteration of one or more of the following: stream hydrology, flow and water-level modification, fish passage, geomorphology and sediment transport, temperature, DO levels, nearshore and aquatic vegetation, soils and nutrients, physical habitat structure and complexity, forage, and predation (Spence *et al.* 1996). According to the NMFS CHART report (2005b), the condition of critical habitat varies throughout the range of the species. The condition value of existing spawning habitat ranges from moderate to high quality, with the primary threats including changes to water quality, and spawning gravel composition from rural, suburban, and urban development, forestry, and road construction and maintenance. Downstream, river and estuarine migration and rearing corridors range in condition from poor to high quality depending on location. Tributary migratory and rearing corridors tended to rate as moderate quality due to threats to adult and juvenile life stages from irrigation diversion, small dams, and water quality. Delta (*i.e.*, estuarine) and mainstem Sacramento and San Joaquin river reaches tended to range from poor to moderately-high quality, depending on location. In the alluvial reach of the Sacramento River between Red Bluff and Colusa, the PCEs of rearing and migration habitat are in better conditions than the lower river because, despite the influence of upstream dams, this reach retains natural, and functional channel processes that maintain and develop anadromous fish habitat. The river reach downstream from Colusa and including the Delta is poor in quality due to impaired hydrologic conditions from dam operations, water quality from agriculture, degraded nearshore and riparian habitat from levee construction and maintenance, and habitat loss and fragmentation.

Although there are degraded habitat conditions within the action area, NMFS considers the value of this area for the conservation of the species to be high because its entire length is used for migration and rearing during extended periods of time by a large proportion of all Federally listed anadromous fish species in the Central Valley. NMFS considers an area to be of high conservation value, regardless of its current condition, where conservation of the area's habitat PCEs is highly valuable to the ESUs that depend on that area.

3. Southern Distinct Population Segment of North American Green Sturgeon

The principal factors for the decline in the southern DPS of North American green sturgeon are reviewed in the proposed listing notice (70 FR 17386) and status reviews (Adams *et al.* 2002, NMFS 2005b), and primarily consist of: (1) the present or threatened destruction, modification, or curtailment of habitat or range; (2) poor water quality; (3) over-utilization; (4) increased water temperatures; (5) non-native species, and (6), other natural and manmade factors, including habitat and ecosystem restoration, and global climate change.

NMFS (2005) concluded that the principle threat to green sturgeon is impassible barriers, primarily Keswick and Shasta Dams on the Sacramento River and Oroville Dam on the Feather River that likely block and prevent access to historic spawning habitat (NMFS 2005a). Spawning habitat may have extended up into the three major branches of the Sacramento River; the Little Sacramento River, the Pit River system, and the McCloud River (NMFS 2005a). In contrast, recent modeling evaluations by Mora (2006) indicate little or no habitat in the little Sacramento River or the Pit River exists above Shasta dam; however, a considerable amount of habitat exists above Shasta on the mainstem Sacramento River. Green and white sturgeon adults have been observed periodically in the Feather and Yuba River (USFWS 1995, Beamesderfer *et al.* 2004, Jeff McLain, NMFS, pers. comm., 2006) and habitat modeling my Mora (2006) suggests there is sufficient habitat above Oroville Dam. There are no records of larval or juvenile white or green sturgeon being captured on the Feather River; however, there are reports that green sturgeon may reproduce in the Feather River during high flow years (CDFG 2002), but these are unconfirmed.

No green sturgeon have been documented in the San Joaquin River; however, the presence of white sturgeon has been documented (USFWS 1995, Beamesderfer *et al.* 2004) making the historical presence of green sturgeon likely as the two species require similar habitat and their ranges overlap in the Sacramento River. Habitat modeling by Mora (2006) also suggests sufficient conditions are present in the San Joaquin River to Friant Dam, and in the Stanislaus, Tuolumne, and Merced Rivers to the dams. In addition, the San Joaquin River had the largest spring-run Chinook salmon population in the Central Valley prior to the construction of Friant Dam (Yoshiyama *et al.* 2001) with escapements approaching 500,000 fish. Thus it is very possible, based on prior spring-run Chinook salmon distribution and habitat use of the San Joaquin River, that green sturgeon were extirpated from the San Joaquin basin in a similar manner to spring-run Chinook salmon. The loss of potential green sturgeon spawning habitat on the San Joaquin River also may have contributed to the overall decline of the southern DPS of North American green sturgeon.

The potential effects of climate change were discussed in the Chinook Salmon and Central Valley Steelhead sections and primarily consist of altered ocean temperatures and stream flow patterns in the Central Valley. Changes in Pacific Ocean temperatures can alter predator prey relationships and affect migratory habitat of the southern DPS of North American green sturgeon. Increases in rainfall and decreases in snow pack in the Sierra Nevada range will affect cold-water pool storage in reservoirs affecting river temperatures. As a result, the quantity and quality of water that may be available to maintain habitat for the southern DPS of North American green sturgeon will likely significantly decrease.

IV. ENVIRONMENTAL BASELINE

The environmental baseline "includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process" (50 CFR §402.02). The action area considered in this biological opinion is the vicinity (i.e., within 2000 feet) of RM 192.5R on the Sacramento River (Figure 3).

A. Status of the Listed Species within the Action Area

1. <u>Status of the Species within the Action Area</u>

The action area functions as a migratory corridor for adult Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon, and provides migration and rearing habitat for juveniles of these species. The status of the listed ESUs and DPSs in the action area is very similar to that which is discussed in the previous section concerning the overall status of these species because there are no specific spawning populations or spawning habitat within the action area, and a large proportion of all Central Valley salmonids and sturgeon are expected to utilize the action area since the action area is located downstream from most of the primary spawning populations. Because the general status is provided in detail in the preceding section, this section has been condensed, and will concentrate primarily on which populations are expected to utilize the action area and the timing of that expected utilization.

a. *Sacramento River Winter-run Chinook Salmon*

The entire in-river population of winter-run Chinook salmon (both adults and juveniles) is expected to pass through the action area due to its location downstream of the only remaining spawning area for this ESU. Adult Sacramento River winter-run Chinook salmon are expected to be present in the Sacramento River between November and June (Myers *et al.* 1998, Good *et al.* 2005) as they migrate to spawning grounds. Juvenile Sacramento River winter-run Chinook salmon migration patterns in the action area can be determined by evaluating juvenile salmonid outmigration timing at the GCID rotary screw trap, located less than 15 miles upstream of the action area. Because of the close proximity of GCID, we expect similar presence and abundance trends at the action area. The GCID traps generally start capturing juvenile winter-run Chinook salmon in November with increasing numbers through December and peaking in mid-January. By the end of February winter-run smolts have passed GCID and are no longer found in the area by March.

b. *Central Valley Spring-run Chinook Salmon*

Only those spring-run populations who's spawning habitat occurs upstream of the action area are expected to be affected by the proposed action. These include independent populations in Mill and Deer Creeks and dependent populations in Big Chico, Battle, Antelope, Cottonwood, Thomes and Clear Creeks, and the mainstem Sacramento River. Adult Central Valley spring-run Chinook salmon from these upstream populations are expected to migrate through the action area between March and July (Myers *et al.* 1998, Good *et al.* 2005). Peak presence is believed to be during February and March (CDFG 1998). Juveniles may begin migrating downstream almost immediately following emergence from the gravel with most emigration occurring from December through March (Moyle *et. al.* 1989, Vogel and Marine 1991). Snider and Titus (2000) observed that up to 69 percent of spring-run Chinook salmon emigrate during the first migration phase between November and early January. The remainder of the Central Valley spring-run Chinook salmon emigrate during subsequent phases that extend into early June of the following year. The age structure of emigrating juveniles is comprised of YOY and yearlings. The exact composition of the age structure is not known, although populations from Mill and Deer Creek primarily emigrate as yearlings (Colleen Harvey-Arrison, CDFG, pers. comm., 2004).

c. *Central Valley Steelhead*

Due to a general lack of monitoring and information on steelhead distribution and abundance in the upper Sacramento River and its tributaries, it is unknown how many of the small tributaries below Keswick Dam might support steelhead. Several larger tributaries that are thought to support steelhead spawning upstream of the action area include Mill, Deer, Big Chico, Battle, Antelope, Cottonwood, Thomes, Cow and Clear Creeks, as well as the mainstem Sacramento River. Spawning populations downstream from the action area include those in Butte Creek, and the Yuba, Feather and American Rivers as well as the entire San Joaquin basin. These downstream populations would not be affected by the proposed action.

Adult steelhead may be present in all parts of the action area from June through March, with the peak occurring between August and October (Bailey 1954, Hallock *et al.* 1957). The highest abundance of adults and juveniles is expected in the Sacramento River part of the action area. Juvenile steelhead emigrate through the Sacramento River from late fall to spring. Snider and Titus (2000) observed that juvenile steelhead emigration primarily occurs between November and May at Knights Landing. The majority of juvenile steelhead emigrate as yearlings and are assumed to be primarily utilizing the center of the channel rather than the shoreline.

d. *Southern DPS of North American Green Sturgeon*

The exact location of spawning habitat for North American green sturgeon in the Sacramento River has not been documented. However, monitoring data indicates that most, if not all, Sacramento River spawning occurs upstream of the action area, and thus, the entire Sacramento River population would utilize the action area as migration, holding and rearing habitat. There have also been observations of a small number of green sturgeon in the Yuba and Feather rivers, though recent spawning in these tributaries has not been confirmed. Any green sturgeon that remain downstream of the action area would not be affected by the proposed action. Adult green sturgeon migrate upstream through the action area primarily between March and June (Adams *et al.* 2002). Larva and post-larvae are present on the lower Sacramento River between May and October, primarily during June and July (CDFG 2002). Small numbers of juvenile green sturgeon have been captured at various locations on the Sacramento River as well as in the Delta during all months of the year (IEP Database, Borthwick *et al.* 1999).

2. Status of Critical Habitat Within the Action Area

The action area is within designated critical habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead. Habitat requirements for these species are similar. The PCEs of salmonid habitat within the action area include: freshwater rearing habitat and freshwater migration corridors containing adequate substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, space, and safe passage conditions. Habitat within the action area is primarily used for juvenile and smolt freshwater rearing and migration and for adult freshwater migration. The condition and function of this habitat has been severely impaired through several factors such as constriction of the river through a levee system for flood control, loss of water through diversions, and degraded water quality from agricultural practices and increased urban development. The result has been the reduction in quantity and quality of several essential elements of migration and rearing habitat required by juveniles to grow, and survive. In spite of the degraded condition of this habitat, the conservation value of the action area is high because its entire length is used for extended periods of time by a large proportion of all Federally listed anadromous fish species in the Central Valley.

The diversion and storage of natural flows by dams and diversion structures on Central Valley waterways have depleted streamflows and altered the natural cycles by which juvenile and adult salmonids have evolved. Changes in streamflows and diversions of water affect freshwater rearing habitat and freshwater migration corridor PCEs in the action area. Various land-use activities in the action area such as urbanization and agricultural encroachment have resulted in habitat simplification. Runoff from upstream residential and industrial areas also contributes to water quality degradation (Regional Board 1998). Urban stormwater runoff contains pesticides, oil, grease, heavy metals, polynuclear aromatic hydrocarbons, other organics and nutrients (Regional Board 1998) that contaminate drainage waters and destroy aquatic life necessary for salmonid survival (NMFS 1996). In addition, juvenile salmonids are exposed to increased water temperatures as a result of thermal inputs from municipal, industrial, and agricultural discharges in the action area.

B. Factors affecting species and critical habitat within the action area

1. Altered Flows and Temperatures

The magnitude and duration of peak flows during the winter and spring are reduced by water impoundment in upstream reservoirs affecting listed salmonids in the action area. Instream flows during the summer and early fall months have increased over historic levels for deliveries of municipal and agricultural water supplies. Overall, water management now reduces natural variability by creating more uniform flows year-round. Current flood control practices require peak flood discharges to be held back and released over a period of weeks. Consequently, the mainstream of the river often remains too high and turbid to provide quality rearing habitat.

2. Levies and Bank Stabilization

The west bank of the action area, opposite the primary construction site, is un-levied and supports a large area of natural sand and gravel bars mixed with highly functioning riparian forest. During high flows this area becomes inundated, providing high quality rearing and migratory habitat for juveniles.

The east bank of the action area, where construction activities are scheduled to occur, has been levied and artificially stabilized, and has lost the natural riverine morphology found on the opposite bank. Bank protection and levies can cause adverse effects to anadromous fish and their habitat. The effects of bank protection projects on anadromous fish have been thoroughly studied (USFWS 2000, Schmetterling *et al.* 2001, Garland *et al.* 2002), and modeled (Corps 2004, Stillwater Sciences 2006). Bank protection projects affect salmonid habitat availability and the processes that develop and maintain preferred habitat by reducing floodplain connectivity, changing riverbank substrate size, and decreasing riparian habitat and shaded riverine aquatic (SRA) habitat.

Simple slopes protected with rock revetment generally create nearshore hydraulic conditions characterized by greater depths and faster, more homogeneous water velocities than occur along natural banks. Higher water velocities typically inhibit deposition and retention of sediment and woody debris. These changes reduce habitat quality along the shoreline by eliminating the shallow, slow-velocity river margins preferred by juvenile fish as refuge and escape from fast currents, deep water, and predators.

3. Water Contaminants and Pollution

Point source and non-point source pollution resulting from agricultural discharge and urban and industrial development occurs in the action area. The effects of these impacts are discussed in detail in the *Status of the Species and Habitat* section. Environmental stresses resulting from poor water quality can lower reproductive success and may account for low productivity rates of salmonids and green sturgeon (Klimley 2002). Organic contaminants from agricultural drain water, urban and agricultural runoff from storm events, and high trace element concentrations may deleteriously affect early life-stage survival of fish in the Sacramento River (USFWS 1995).

The M&T diversion in the action area on the Sacramento River is a potential threat to the southern DPS of North American green sturgeon. NMFS assumes larval green sturgeon may be susceptable to entrainment primarily from benthic water diversion facilities during the first 5 days of development and suseptable to diversion entrainment from facilities drawing water from the bottom and top of the water column when they are exhibiting noctornal "swim-up" behavior.

C. Likelihood of species survival and recovery in the action area

In their recent evaluation of the viability of Central Valley salmonids, Lindley et al. (2007) found that extant populations of Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon appear to be fairly viable. These populations meet several viability criteria including population size, growth, and risk from hatchery strays. The viability of the ESU to which these populations belong appears low to moderate, yet the ESU remains vulnerable to extirpation due to their small-scale distribution and high likelihood of being affected by a significant catastrophic event. Lindley et al. (2007) were not able to determine the viability of existing steelhead populations, but believe that the DPS has a moderate to high risk of extirpation since most of the historic habitat is inaccessible due to dams, the remaining accessible habitat has been severely degraded by human activities, and because the anadromous life-history strategy is being replaced by residency.

Recent population estimates for the southern DPS of North American green sturgeon indicate that there are few fish relative to historic conditions, and that loss of habitat has affected population size and distribution. However, the southern DPS of North American green sturgeon remain widely distributed along the Pacific coast from California to Washington, and recent findings of fish in the Feather and the Yuba River indicate that their distribution in the Central Valley may be more broad than previously thought. This suggests that the DPS probably meets several viable species population criteria for distribution and diversity, and indicates that the southern DPS of North American green sturgeon faces a low to moderate risk of extirpation.

V. EFFECTS OF THE ACTION

A. Approach to the Assessment

Pursuant to section 7(a)(2) of the ESA (16 U.S.C. §1536), Federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat. NMFS will evaluate destruction or adverse modification of critical habitat by determining if the action reduces the value of critical habitat for the conservation of the species. This biological opinion assesses the effects of the proposed action on endangered Sacramento River winter-run Chinook salmon, threatened Central Valley spring-run Chinook salmon, threatened Central Valley steelhead, their designated critical habitat, and threatened southern DPS of North American green sturgeon.

In the *Description of the Proposed Action* section of this biological opinion, NMFS provided an overview of the action. In the *Status of the Species* and *Environmental Baseline* sections of this biological opinion, NMFS provided an overview of the threatened and endangered species and critical habitat that are likely to be adversely affected by the activity under consultation.

Regulations that implement section 7(b)(2) of the ESA require biological opinions to evaluate the direct and indirect effects of Federal actions and actions that are interrelated with or interdependent to the Federal action to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. §1536; 50 CFR 402.02). Section 7 of the ESA and its implementing regulations also require biological opinions to determine if Federal actions would destroy or adversely modify the conservation value of critical habitat (16 U.S.C. §1536).

NMFS generally approaches "jeopardy" analyses in a series of steps. First, we evaluate the available evidence to identify the direct and indirect physical, chemical, and biotic effects of proposed actions on individual members of listed species or aspects of the species' environment These effects include direct, physical harm or injury to individual members of a species; modifications to something in the species' environment (*i.e.*, reducing a species' prey base, enhancing populations of predators, altering its spawning substrate, altering its ambient temperature regimes; or adding something novel to a species' environment - such as introducing exotic competitors or a sound). Once we have identified the effects of an action, we evaluate the available evidence to identify a species' probable response (including behavioral responses) to those effects to determine if those effects could reasonably be expected to reduce a species' reproduction, numbers, or distribution (*i.e.*, by changing birth, death, immigration, or emigration rates; increasing the age at which individuals reach sexual maturity; decreasing the age at which individuals stop reproducing; among others). We then use the evidence available to determine if these reductions, if there are any, could reasonably be expected to appreciably reduce a species' likelihood of surviving and recovering in the wild.

To evaluate the effects of the proposed action, NMFS examined proposed construction activities, O&M activities, habitat loss, and conservation measures, to identify likely impacts to listed anadromous salmonids and sturgeon within the action area based on the best available information.

The information used in this assessment includes fishery information previously described in the *Status of the Species* and *Environmental Baseline* sections of this biological opinion; studies and accounts of the impacts of construction and operation activities involving wastewater treatment outfalls on anadromous fish and ecosystem function; and documents prepared in support of the proposed action, including the February 2005 Biological Assessment (BA) for the proposed project (Robertson-Bryan, Inc. 2005) and the diffusion analysis for the proposed project (Flow Science 2004).

In the absence of definitive data or conclusive evidence, NMFS will make a logical series of assumptions to overcome the limits of the available information. These assumptions will be made using sound, scientific reasoning that can be logically derived from the available information. The progression of the reasoning will be stated for each assumption, and supporting evidence cited.

B. Assessment

The effects of the City of Chico Water Pollution Control Plant Expansion project fall into two categories: short-term construction related effects and persistent long-term effects of the wastewater treatment plant's operations. Construction effects will primarily be related to the acoustic impacts of the installation of the coffer dam for the diffuser system construction and associated fish rescue to remove fish from the coffer dam. The long-term operation of the wastewater discharge diffuser array will result in increased wastewater discharge to the Sacramento River and is expected to alter the migration passage and contribute low levels of pollutants to the Sacramento River year-round. Some of these increases in pollutants are expected to cause mainly sublethal effects to listed salmonids and sturgeon.

This assessment will consider the nature, duration, and extent of the effects of the proposed action relative to the migration timing, behavior, and habitat requirements of Federally listed Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and the southern DPS of North American green sturgeon. Specifically, this assessment will consider the potential impacts related to construction (short-term) and operation (long-term) activities. The assessment of effects considers the potential occurrence of Federally listed species relative to the magnitude, timing, frequency, and duration of project activities. The action area does not contain spawning habitat of Chinook salmon, steelhead, or North American green sturgeon. Therefore, no short- or long-term effects on spawning habitat are expected.

1. Construction Effects

The Proposed construction activities are expected to last 3 months and be conducted from July through September. The effects would be short-term and temporary. The construction site is in an area where juvenile salmon and juvenile and adult green sturgeon are likely to be present during the construction period. The in-water construction activities particularly the installation and removal of the coffer dam with a vibratory hammer could result in direct effects to salmon and green sturgeon as described below.

The primary migration period of juvenile winter-run Chinook salmon through the action area occurs between September and October. Thus, juvenile winter-run are expected to be most prevalent in the action area during the final month of the construction activities (September). Green sturgeon larvae and post-larvae may be present in the action area throughout the construction period, but are most abundant during June and July (CDFG 2002), and would therefore be most heavily affected by activities occurring during the first month of construction (July). Although the proposed construction period avoids the primary emigration periods for juvenile spring-run Chinook salmon and steelhead, a small proportion of emigrating and rearing juveniles of these species may linger in the action area throughout the summer, and there remains the potential for very small numbers of these fish to be present in the action area during the construction period. Adult winter- and spring-run Chinook salmon and steelhead are not expected to be present in the action area during construction activities, but adult green sturgeon primarily migrate through the action area between March and July (USFWS 2002) and could therefore be present during the early stages of construction of the proposed project.

a. *Cofferdam*

The installation and removal of the coffer dam would result in localized, temporary disturbance of habitat conditions that may alter natural behavior patterns of adult and juvenile fish and cause the injury or death of individuals. These effects may include displacement, or impairment of feeding, migration, or other essential behaviors by juvenile salmon and green sturgeon from noise, suspended sediment, turbidity, and sediment deposition generated during in-water construction activities. Some of these effects could occur in areas downstream of the project sites, because noise and sediment may be propagated downstream. Additionally, the closure of the cofferdam would block a portion of the migratory passage and may entrain and strand fish within the enclosed dam. Having a fish rescue prior to dewatering would also have a direct effect on fish. Depending on the methodology of the fish rescue, capturing and releasing the fish could result in injury, harm, or mortality.

(1) Acoustic Effect. The driving of the sheet piles for the coffer dam will cause noise and physical disturbance that could displace juvenile and adult fish into adjacent habitats. The utilization of vibratory hammers for the installation of the sheet piles for the cofferdam is expected to produce underwater sound levels above 150 dB_{rms} (Reyff and Anderson 2006), but the intensity is not expected to reach a level that would result in physical injury to fish. Thus, fish within the immediate vicinity are expected to experience temporary hearing damage or behavioral changes such as elicitation of a startle response or other behavior associated with stress. This response may decrease a fish's ability to avoid predators. Observations by Feist *et al.* (1992) suggest sound pressure levels (not measured during their study) produced during pile driving may disrupt normal migratory behavior of salmon and steelhead. The results of this study did not ascertain whether the fish actively avoided entering the area or left the area following the initiation of pile driving. Fish were present in the areas affected by the pile driving, but were at lower numbers than the unaffected areas. If adult or juvenile green sturgeon or juvenile salmonids respond by avoiding the area where underwater sound pressure levels are greater than 150 dB_{rms}, then it is reasonable to expect that migration may be slowed or halted until the noise created by the placement of each sheet pile stops.

(2) Water Quality. Based on in-water construction projects conducted by USFWS, CDWR, and the Corps, located upstream and downstream of the action area, construction activities are expected to result in periodic turbidity levels that exceed 25 to 75 Nephelometric Turbidity Units (NTUs). These levels are capable of affecting normal feeding and sheltering behavior. Based on observations during the construction activities in the Sacramento River, turbidity plumes are not expected to extend across the Sacramento River, but rather the plume is expected to extend downstream from the site along the side of the channel. Turbidity plumes will occur during daylight hours during in-water construction. At a maximum, these plumes are expected to be as wide as 100 feet, and extend downstream for up to 1,000 feet. Most plumes extend into the channel approximately 10 to 15 feet, and downstream less than 200 feet. In contrast, the channel of the Sacramento River is several hundred feet wide. Once construction stops, water quality is expected to return to background levels within hours. Adherence to erosion control measures and BMPs such as use of silt fences, straw bales and straw wattles will minimize the amount of project-related sedimentation and minimize the potential for post-construction turbidity changes. Since project-related turbidity plumes will be limited to shoreline construction areas, and the Sacramento River is much wider than any plume that could be generated, NMFS expects that individual fish will mostly avoid the turbid areas of the river and use alternate migration corridors or rearing habitat. For those fish that do not avoid the turbid water, exposure is expected to be brief (*i.e.*, minutes to hours) and not likely to cause injury or death from reduced growth, or physiological stress. This expectation is based on the general avoidance behaviors of salmon and the BMPs to suspend construction when turbidity exceeds Regional Board standards.

There is a potential for juveniles that are exposed suddenly to turbidity plumes to be injured or killed by predatory fish that take advantage of disrupted or abnormal behavior. The installation and removal of the sheet piles of the cofferdam will disrupt the river flow and disturb the water column; resulting in increased turbulence and turbidity. Migrating juveniles react to this situation by suddenly dispersing in random directions (Carlson *et al.* 2001). This displacement can lead them into predator habitat where they can be targeted, and injured and killed by opportunistic predators taking advantage of juvenile behavioral changes. Carlson *et al.* (2001) observed this behavior occurring in response to routine channel maintenance activities in the Columbia River. Some of the fish that did not immediately recover from the disorientation of turbidity and noise from channel dredges and pile driving swam directly into the point of contact with predators. Once fish migrate past the turbid water, normal feeding and migration behaviors are expected to resume.

Biological studies conducted at GCID also support that predation may be higher in areas where juveniles are disoriented by turbulent flows or are involuntarily routed into high-quality predator habitat or past areas with higher predator densities (Vogel 2006). Behavioural observations of predator and salmon interactions at GCID also surmised that predators responded quickly to the release of fish during the biological tests and preyed on fish soon after they were released into the water, even when the release locations were periodically changed (David Vogel, Natural Resource Scientists, pers. comm. 2006). This is a strong indication that predators quickly respond to changes in natural juvenile salmonid behavioural responses to disturbance.

Short-term increases in turbidity and suspended sediment may disrupt feeding and migratory behavior activities of juvenile and adult of green sturgeon. The installation and removal of the cofferdam and the construction activities within the coffer dam could result in localized displacement and likely behavioral modifications to individual green sturgeon that do not readily move away from the channel or nearshore areas directly affected by the project. Turbidity and sedimentation events are not expected to affect visual feeding success of green sturgeon, as they are not believed to rely heavily on visual cues (Sillman *et al.* 2005); however, olfaction appears to be a key feeding mechanism and could be affected by such events. In addition, green sturgeons are known to immediately stop swimming and drift toward the substrate upon changes in light conditions (Sillman *et al.* 2005). Thus, the effects of sedimentation on light levels could elicit green sturgeon behavioral changes. Construction activities also may increase sediment, silt, and pollutants that could adversely affect the production of food sources, such as aquatic invertebrates, necessary for juvenile green sturgeon and salmonid survival.

The toxic substances used at construction sites, including gasoline, lubricants, and other petroleum-based products could enter the Sacramento River as a result of spills or leakage from machinery or storage containers and injure or kill listed species. These substances can kill aquatic organisms through exposure to lethal concentrations or exposure to non-lethal levels that cause physiological stress and increased susceptibility to other sources of mortality. Petroleum products also tend to form oily films on the water surface that can reduce DO levels available to aquatic organisms. NMFS expects that adherence to BMPs that dictate the use, containment, and cleanup of contaminants will minimize the risk of introducing such products to the waterway because the prevention and contingency measures will require frequent equipment checks to prevent leaks, will keep stockpiled materials away from the water, and will require that absorbent booms are kept on-site to prevent petroleum products from entering the river in the event of a spill or leak. NMFS does not expect the project to result in water contamination that will injure or kill individual fish.

*(3) **Strand and Rescue.*** The closure of the cofferdam has the potential to entrain juvenile and adult green sturgeon and juvenile salmon. Stranded fish would likely be subjected to low water quality when enclosed within the coffer dam, direct mortality upon water removal from the area enclosed by the cofferdam, or various levels of impacts associated with capture of the fish rescued from the enclosure. Juvenile salmonids and sturgeon would be most prone to stranding as their ability to escape from such a situation is lower than adult salmonids or sturgeon that have greater swimming ability. Although the vibrations and sediment re-suspension that would occur during installation of the cofferdam would be expected to cause most juvenile fish residing in/passing through the area to relocate and, therefore, avoid stranding behind the cofferdam, some fish may become stranded. The July through September period is a key migration period for larval and post-larval southern DPS of North American green sturgeon. However, it is likely that the cofferdam will be completed during the first month of in-water construction (July), which would minimize the collective potential for stranding juvenile salmonid outmigrants. Additionally, installation of the cofferdam is a relatively slow process (*i.e.*, occurs over days), and because juvenile salmonids and green sturgeon are transitory, and because the area to be enclosed by cofferdams is small relative to the action area and the river as a whole, any losses of juvenile anadromous salmonids and sturgeon associated with cofferdam placement is expected to be very small relative to the total number of outmigrants.

Once the cofferdam is in place, larval, post-larval, and juvenile salmonids and green sturgeon trapped within the cofferdam risk injury or death due to stranding and or removal by fish rescue efforts (*i.e.*, seining or electrofishing). However, NMFS believes, based on the analysis of previous cofferdam-related projects, that the entrainment risk to juvenile salmonids and sturgeon is low. On August 18, 2005, a fish rescue was performed by Hanson Environmental Inc. for the Sutter Mutual Water Company at the Tisdale Positive Barrier Fish Screen construction project site. The fish rescue was performed to remove fish from a construction zone within the Sacramento River that had been isolated from the river by use of coffer dams for construction of a positive barrier fish screen. Use of a specially constructed net to capture fish yielded one Sacramento splittail. Hanson Environmental Inc., also, sampled behind a coffer dam at the Reclamation District 108 Wilkins Slough Pumping Plant on October 4, 1997 (Hanson Environmental Inc. 1997). A total of five fish were collected behind the coffer dam: four tule perch, and one lamprey amnocete. Additionally, three separate passes with a seine net were completed behind a partially dewatered section of Wilkins Slough, bordered by an earthen dam, resulting in a total of 687 fish. No Chinook salmon, steelhead, or sturgeon were captured.

*(4) **Migratory Delay/Blockage.*** The presence of the cofferdam will obstruct passage of approximately 20 percent of the river channel's cross-sectional width for a linear (downstream) distance of approximately 25 feet. River flow in the constricted portion (*i.e.*, remaining 80 percent of cross-section) of the channel would have somewhat higher current velocities than conditions without the cofferdam in place, due to the channel restriction. According to Flow Science (2004), the average river velocities are estimated to range from 1.5 feet per second (ft/s) at 2,800 cubic feet per second (cfs) to 2.2 ft/s at 7,500 cfs in the project area. Because less than 20% of the channel width would be blocked from the cofferdam, velocities would not be expected to exceed a range

of 2.0 to 4.0 ft/s, which is similar to the velocities within a natural riffle in the Sacramento River (Robertson-Bryan, Inc. 2005). Therefore, Chinook salmon, steelhead, and green sturgeon upstream migration would not be disrupted or blocked due to placement of the cofferdam and associated increased current velocities in the remainder of the river cross-section. Emigrating fish that may encounter the cofferdam when traveling along the east bank of the river would be delayed only long enough for them to find their way around the cofferdam.

Since 80 percent of the river cross-section at the cofferdam site will remain unobstructed, outmigration of juvenile salmonids and sturgeon is not expected to be blocked while the cofferdam is in place. Juveniles that encounter the cofferdam when traveling along the east bank of the river would be forced to leave the protection of the shallow, near-shore habitat and travel out into deep water to get around the cofferdam, where they would be more exposed and susceptible to predation. However, a relatively small proportion of juvenile outmigrating green sturgeon and salmonids would be affected because the cofferdam will not be in place during their peak emigration period.

b. *Degradation of Habitat*

Approximately 0.06 acres (2,625 square feet) of benthic substrate will be removed and subsequently replaced with gravel and clean fill to cover the diffuser pipe alignments. This new substrate will be devoid of benthic invertebrates which may be used as food by listed species, and vegetation which may be used as cover for resting and protection from predators. NMFS believes that recolonization of this "virgin" material with invertebrates and vegetation will occur relatively quickly following completion of the diffuser pipeline installation. The areal extent of the dredging for the placement of the diffusers pipelines is relatively small (25 feet by 105 feet footprints). Suitable stocks of organisms and vegetation to serve as "seed" stock for the recolonization are present in the channel surrounding the action area. Typically recolonization of new substrate occurs when these drifting invertebrate larvae and plants encounter open substrate as they are dispersed into the barren fill area by river flows sweeping through the channel. Although initially the community composition of the newly colonized substrate is likely to be different than the surrounding channel, a mature benthic community resembling the surrounding area is expected to form with the passage of time if the substrate does not encounter any further disturbances. Due to the temporary nature of the disturbance and the small amount of benthic substrate that will be impacted compared to its overall availability, NMFS believes that this short-term alteration will not have any adverse effects on listed salmonids and green sturgeon.

Approximately 0.02 acre of levee face will be disturbed by the placement of the diffuser pipelines into the Sacramento River. Currently the levee slopes are sparsely vegetated with native shrubs and non-native weedy plants, some of which overhang the waters of the channel. Although not high quality habitat, this vegetation can provide some shade and cover for salmonids and green sturgeon migrating through the area. It also may serve as a source of terrestrial insects for salmonids and green sturgeon foraging along the margins of the river channel. The removal of all vegetation along these portions of the levee face for pipeline installation will further degrade the already diminished riparian habitat. The applicant has stated that they will replace any vegetation removed during the pipeline installation at a 3:1 ratio. Due to the temporary nature of the disturbance and the small amount of levee face that will be affected compared to the overall availability of this habitat type, NMFS believes that adverse effects of this disturbance to listed salmonids and green sturgeon will be minor.

2. Long-Term Operational Effects

a. Habitat Alterations

The installation of subsurface structures in the channel of the Sacramento River has the potential to create holding habitat for predatory fish (*i.e.*, striped bass, largemouth bass, catfish (*Ictalurus* spp.), *etc.*) by creating alterations in the bathymetry and underwater topography of the receiving water body. The permanent structure of the diffuser in the Sacramento River will consist of 32 eight-inch ports set at horizontal angles, spaced three feet apart and at a height of two feet above the river bottom. These structures and associated changes in the bottom profile may create holding habitat or velocity refugia for piscine predators. The discharge of effluent through the diffuser would create turbulent conditions similar to those found near dam bypasses, turbine outfalls, water conveyances, and spillways, which may result in disorientation of juvenile salmon and green sturgeon migrants. This would increase their avoidance response time, thus improving predator success. Human-induced habitat changes such as alteration of natural flow regimes and installation of bank revetment and structures such as dams, bridges, water diversions, piers, and wharves often provide conditions that both disorient juvenile salmonids and attract predators (Stevens 1961). However, the design criteria for the diffuser pipeline indicate that following the installation of the buried diffuser pipeline, bottom topography and bathymetry will be returned to the original pre-construction conditions. Since the streambed will be re-contour to the original topography and the small diameter of the diffusers would result in minimal hydraulic disruption, NMFS does not anticipate the diffuser structure creating sufficient habitat alterations to cause above normal predation rates.

b. *Effluent Discharge*

The most significant effects of the project are expected to result from the WPCP expansion effluent discharge to the Sacramento River. In particular, the discharge is expected to contain low levels of certain pollutants, and increase the water temperature and reduce the DO level in the Sacramento River near the outfall, which are likely to contribute to chronic, sub-lethal effects on listed fish. The discharge will occur year-round, and therefore all migrating fish that pass through the project area may be exposed to the adverse effects of project operation. This includes the majority of adult and juvenile listed Central Valley salmonids and sturgeon, as most of the spawning habitat for these species occurs upstream of the action area. One significant exception to this is the Butte Creek population of Central Valley spring-run Chinook salmon (currently the largest population in the ESU), which enter Butte Creek well downstream of the project site, and therefore are not expected to be affected by the proposed project.

Adult Sacramento River winter-run Chinook salmon would be exposed to effluent when migrating to upstream spawning grounds primarily between December and May; juveniles when they are emigrating primarily between August and February. Adult Central Valley spring-run Chinook salmon would be exposed to effluent between March and July; and juveniles would be exposed between November and April. Adult Central Valley steelhead would be exposed to effluent primarily between July and March; juveniles primarily between December and May. Southern DPS of North American green sturgeon also would be exposed to effluent during upstream adult migrations (between March and July); larval and post-larval life stages between May and October, and juveniles year-round.

The EPA and the California Regional Water Quality Control Board (Regional Board) have classified the proposed project as a major discharge activity, subject to requirements of the Water Quality Control Plan, Fourth Edition, for the Sacramento and San Joaquin River Basins. In addition, the EPA adopted the National Toxics Rule (NTR) and the California Toxics Rule (CTR) containing water quality standards that apply to the proposed discharge. Guidance on the application of the NTR and the CTR can be found in the State Water Resources Control Boards adopted Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California.

In order to comply with the Regional Board's NPDES Permit (NPDES permit #CA0079081), the applicant must meet effluent limitations for all pollutants that are or may be discharged at a level that will cause or have a reasonable potential to cause, or contribute to an in-stream excursion above a narrative or numerical water quality standard. The Regional Board found potential excursions for the following constituents: copper, lead, zinc, bromodichloromethane, dibromochloromethane, total chlorine residual, total suspended solids and biochemical oxygen demand, total coliform organisms, and pH (NPDES permit #CA0079081). NMFS analyzes the impacts of 4 of these nine pollutants in this biological opinion, as these constituents concentration levels in the effluent known to affect listed salmonids and sturgeon. These pollutants are: copper, total dissolved solids, biochemical oxygen demand, and pH. In addition, NMFS has assessed the affects of increased flow, water temperature, dissolved oxygen, cyanide, and ammonia on listed salmonids and sturgeon as a result of the proposed project.

The applicant prepared several reports assessing the impacts of the proposed project on Federally listed species. Flow Science (2004) conducted modeling using UM3, an EPA approved visual plume model to characterize the effluent plume produced by discharge from the diffusers (EPA 2003). The model also can be used to evaluate the effect on dilution of a range of receiving water conditions, including variations in depth, temperature, salinity, and current speed. The UM3 modeling selected five constituents (copper, lead, zinc, bromodichloromethane, and dibromochloromethane) for analysis based on California Toxics Rule water quality criteria and existing quality of treated wastewater produced by the City of Chico WPCP. Because proposed sewage treatment methods remain the same as existing methods, the existing quality of effluent was used in the modeling analysis. Modeling evaluated the concentrations of these constituents downstream of the effluent outfall against RWQCB water quality criteria for the protection of freshwater aquatic life. The assessment was based on the "worst-case scenario" set of low-flow conditions and maximum effluent levels. The flow condition evaluated, termed "1Q10" is the lowest 1-day mean flow with a 10-year recurrence. Based on historical data, this flow is 2,800 cubic feet per second (cfs) in the Sacramento River (Flow Sciences 2004). The results of this assessment and an analysis of the future impacts of the proposed project on water quality and listed salmonids and sturgeon in the Sacramento River is discussed below.

Additional modeling was completed assessing flow, geometry, and design of the diffuser system. The BA for the City of Chico Water Pollution Control Expansion Project (Robertson-Bryan, Inc. 2005) assessed additional constituents and impacts of the proposed project, such as construction effects, thermal effects, and effects of increased ammonia, cyanide, and metals. Additional analysis also was completed in the final environmental impact report for the City of Chico Water Pollution Control Plant Expansion project (Jones & Stokes 2005). These documents are helpful in characterizing the extent of the effluent plume in the action area; however, other sources of information were also used to create the following assessment of the specific effects of effluent constituents on Federally listed salmonids and sturgeon.

NMFS also expects local benthic invertebrate fauna to be affected by the chemical constituents contained in the discharge of the WWTP effluent. These invertebrate populations are typically exposed for much greater periods of time then the listed fish and are relatively non-motile in comparison to them. Therefore accumulations of contaminants in the sediments surrounding the diffuser outfalls expose these invertebrate populations to higher levels of contaminants than are typically seen in the overlying water column (EPA 1994, Ingersoll 1995). These populations of invertebrates are important to the successful rearing of the listed fish within the action area by providing a suitable forage base for their nutritional needs. Diminishment in their population numbers or changes in the community structure to less desirable prey species can have significant detrimental effects on rearing salmonids and green sturgeon in the action area which depend upon them for their forage base.

(1) Flow. The proposed project would result in the discharge of up to 12 million gallons per day (mgd) of effluent in the Sacramento River resulting in up to approximately 20 cfs. This increase would result in 0.7 percent of the Sacramento River flow during the 1Q10 flow, and 0.3 percent of the long-term harmonic mean flow (based on analysis in Robertson-Bryan, Inc. 2005). This small increase in discharge would not exert a noticeable change in natural Sacramento River flow regime downstream of the outfall. Therefore, NMFS does not believe the increase in flow will adversely affect listed salmonids and sturgeon.

(2) Water Temperature. Anadromous fish can potentially be blocked or delayed if they encounter sufficiently high river temperatures while migrating to upstream spawning areas (Evans and Johnson 1980; Bell 1986; Boles 1988). The temperature of effluent from the new proposed outfall is expected to be similar to the existing effluent, which was found to be around 68 degree Fahrenheit (°F) during the winter and 79°F during the summer. Sacramento River temperature 10 feet upstream of the existing outfall is generally around 51°F in the winter and 61°F in the summer

(Table 2; Flow Science 2004). To assess this issue, two-dimensional graphics of the thermal plume below the diffuser were prepared from dilution model simulations for two seasons: winter (November through April) and summer (May through October (Robertson-Bryan Inc. 2005)). These graphics depict the thermal contours within the plume, for the initial 45 feet downstream of the diffuser, based on the simulated reasonable worst-case river and effluent temperatures and flow rates presented in Table 8. The modeling shows the portions of the Sacramento River in the area of the plume and downstream, that remains thermally unaffected or negligibly affected, providing a "zone of passage" as well as the modeled plume location in the river channel. The thermal plume would extend up to 45 feet downstream of the effluent source in the lower half of the water column.

Table 8. River temperature and effluent temperature conditions evaluated for the thermal assessment during winter (November to April) and summer (May to October) conditions (Robertson-Bryan, Inc. 2005).

	Flow		Temperature (°F)			
Scenario	**River cubic feet per second (cfs)**	**Effluent Million gallons per day (MGD)**	**Season**	**River**	**Effluent**	**Difference**
1	1Q10 - 2,800	15 MGD	Winter	49	70	21
2	1Q10 - 2,800 cfs	15 MGD	Summer	52	85	33

Where a thermal plume exists, immigrating adult fish will seek a migration route where river temperatures are more favorable, thereby facilitating passage. In the case of the Sacramento River at the Chico WPCP outfall, a zone of passage where the ambient water temperatures are completely unaffected by the effluent discharge would occur on both sides of the diffuser along the entire length of the plume. The zone of passage would be approximately 25 feet wide along the east-bank and 450 feet wide along the west-bank. Together, these two passage zones comprise approximately 80 percent of the river's 575-foot width. Under the "reasonable worst case" 1Q10 river flow of 2,800 cfs and effluent discharge rate of 15 mgd, the top half of the water column is essentially unaffected by the thermal plume, all the way across the river (Figure 4). This is due to rapid effluent mixing and rapid temperature attenuation by the river. Adult migrating salmonids and green sturgeon are believed to migrate in deeper portions of the river (Hughes 2004). Thus, a portion of immigrating adults in the action area in the lower half of the water column will encounter the thermal plume. Assuming adults are equally distributed across the channel in the action area, approximately 20 percent of migrating adults would encounter the thermal plume. When fish moving in the lower half of the water column encounter the plume at 45 feet downstream of the diffuser, the temperature difference, relative to river background, would be negligible throughout the affected portions of the water column. As fish move closer to the diffuser, temperature differences from river background would become greater; however, a zone of passage unaffected by the effluent plume would remain along the river margins. When adult fish moving low in the water column approach the diffuser, they would have the option to move laterally within the river channel until they encounter more tolerable temperatures or they could move up higher in the water column seeking more favorable temperatures. In doing the latter, they could continue along a mid-channel migration route with temperatures similar to river background temperatures. In either case, should fish "drift" back toward the affected area of the plume before passing the diffuser, the same behavioral response would be repeated until the fish pass the diffuser. Therefore, the resultant temperature increases are not likely to adversely affect adult salmonids or green sturgeon.

Emigrating juvenile salmonids tend to migrate along the river margins in shallow, slower-moving waters rather than in the higher velocity water near the center of the channel (Bell 1986; Healey 1991; Moyle 2002). Here they use the structure of fallen trees, undercut banks, roots wads, and other near-shore structure to reduce predation pressures and provide shade and food resources. In the Hanford reach of the Columbia River Estuary, Dauble et al. (1989) found juvenile fall-run Chinook salmon residing primarily in areas near shore where current velocities were reduced. Similarly, Healey (1991) reports that in rivers deeper than about 3 meters, Chinook salmon fry prefer the surface waters. When migrating downstream, the juvenile and smolt life stages of anadromous salmonids also are believed to use the upper one-third of the water column and the river margins, with the larger smolts more likely to use the center of the channel (Dauble et al. 1989). Emmett et al. (2004) concluded that juvenile salmonids migrated in the upper portion of the water column. Based on this information, the majority of actively swimming anadromous salmonid emigrants would pass the diffuser along the river margins and within the upper portion of the water column. These areas are either unaffected or negligibly thermally affected by the Chico WPCP discharge. The emigrants that would pass over the diffuser would likely be within approximately the upper one-third of the water column. Temperature differences in the upper one-third of the river water column, within the zone of initial effluent mixing, would be affected minimally, if at all, relative to river background temperatures. Therefore, whether moving along the river margins or more centrally in the upper portion of the water column, actively swimming salmonid emigrants would primarily pass through portions of the river channel having water temperatures similar or equivalent to river background temperatures and thus would be thermally unaffected by the plume. Even if juveniles were to swim directly through the center of the thermal plume, exposure to elevated temperatures would be brief (*e.g.*, seconds), due to the river flow velocities in the portion of the channel affected by the plume and juvenile fish swimming speeds. Therefore, the resultant temperature increases are not likely to adversely affect juvenile salmonids.

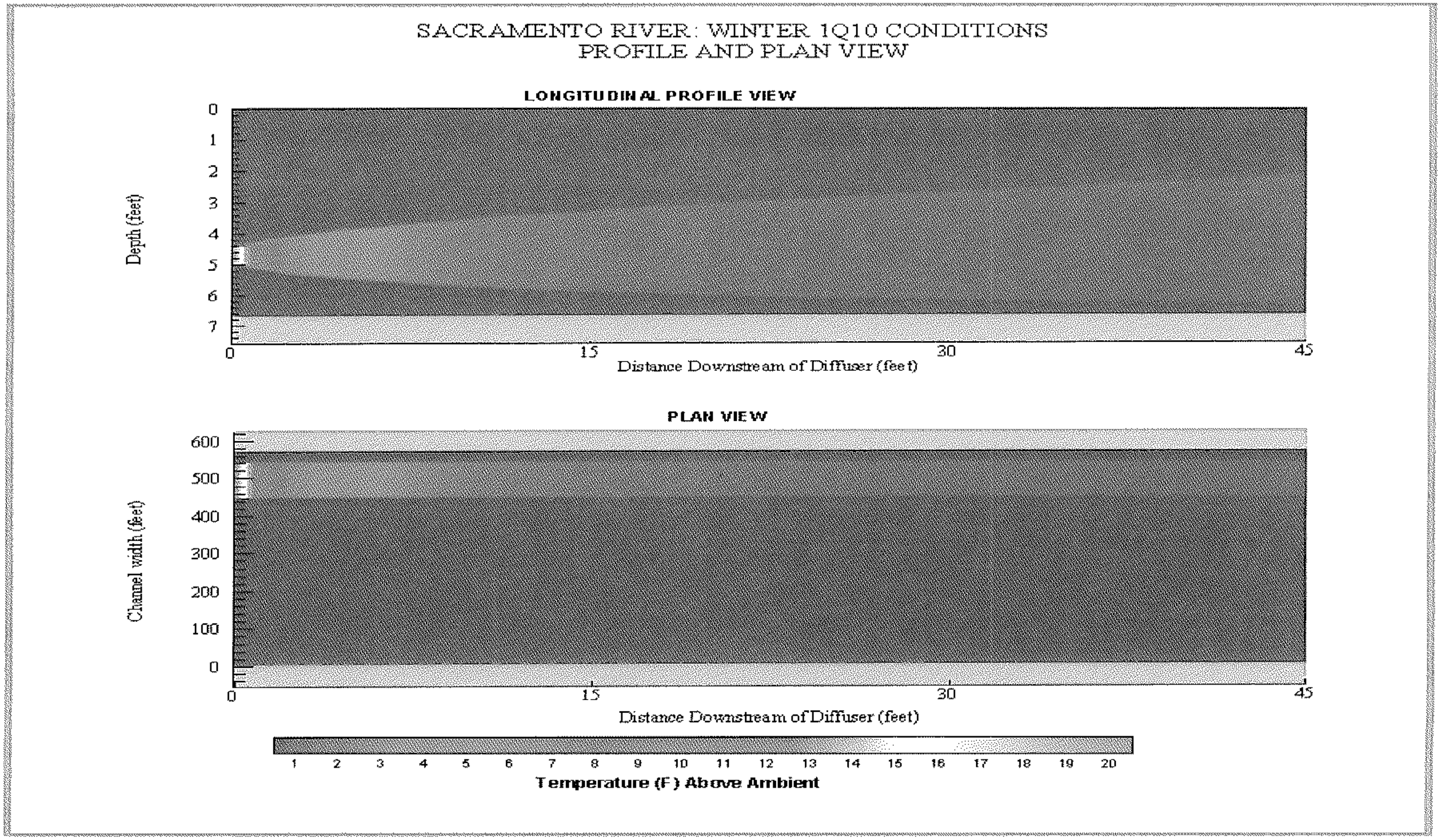

Figure 4. Temperature increase above background Sacramento River temperature due to discharge of Chico WPCP effluent at a rate of 15 mgd and river flow of 2,800 cfs (1Q10 flow) under winter temperature conditions. Simulated using a background river temperature of 49°F and an effluent temperature of 70°F (Robertson-Bryan, Inc. 2005)

Adult North American green sturgeon are known to migrate and hold along the bottoms of channels in rivers (Erickson *et al.* 2002) and could be exposed to increased effluent temperatures, however, they are likely to avoid the thermal plume in a similar manner to salmonids. Juvenile North American green sturgeon also could be exposed to the thermal plume while rearing and emigrating through the action area. Because juvenile North American green sturgeon exhibit nocturnal downstream migrational movements, they would likely be exposed to increased effluent temperatures during the day when clinging to the bottom, or during the night when moving in the water column (Deng *et al.* 2002). Because the larva are expected to be approximately 33 to 44 mm fork length in the action area (based on captures at GCID) and at an early maturation stage, they are not expected to be capable of escaping the temperature plume until they have passively migrated beyond its scope. It is likely that up to 20 percent of all larval North American green sturgeon passing the action area will be exposed to increased temperatures. The severity of the exposure will decrease from the location of effluent diffusers downstream 45 feet, until the effluent is fully mixed in the Sacramento River. Total exposure time for those larvae in the thermal plume is expected to be a minimum of 30 seconds assuming the larva are passively moving with the current (this is based on average river velocities of 1.5 ft/s at 2,800 cfs; 45 feet/1.5 feet per second = 30 seconds). The maximum temperature of the effluent is expected to be 29°C (85°F) during the summer when larval green sturgeon are expected to be passing through the action area. Allen *et al.* (2006) found that extended exposure to elevated temperatures between 19 °C (66°F) and 24°C (75°F) did not adversely affect juvenile green sturgeon when food and oxygen was abundant. Based on this information, and the limited exposure time of larval North American green sturgeon to the elevated temperatures (approximately 30 seconds), NMFS does not believe juvenile North American green sturgeon will be adversely affected by the effluent temperatures.

(3) Total Dissolved Solids. Total dissolved solids (TDS) in the effluent from the new outfall is expected to be the same as that found in the effluent from the existing outfall, which averages 376 milligrams per liter (mg/L) during the winter and 681 mg/L during the summer, whereas Sacramento River TDS levels 10 feet upstream of the existing outfall were found to be 70 mg/L during both seasons (Table 9; Flow Science 2004).

Table 9. Total dissolved solids (TDS) in the Sacramento River and in the effluent of existing City of Chico Water Pollution Control Plant River Outfall based on Flow Sciences (2004).

Source	Winter	Summer
River TDS	70 mg/L	70 mg/L
Effluent TDS	376 mg/L	681 mg/L

TDS represents concentrations of common ions (*e.g.*, sodium, potassium, calcium, magnesium, chloride, sulfate, and bicarbonate) in freshwater. Scannell and Jacobs (2001) reviewed 28 publications related to the effects of TDS on aquatic organisms and found key exposure of salmonids to be during the fertilization and egg hardening phase. In addition, they found fish did not appear to be affected by elevated concentrations of TDS up to 2,000 mg/L and aquatic invertebrate growth and survival to be affected by concentrations of TDS >1,500 mg/L. Based on this information, and the lack of spawning habitat within the action area, the relatively low levels of TDS expected in the proposed effluent would be unlikely to adversely affect listed salmonids and sturgeon.

(4) ***Copper.*** Maximum and average copper concentrations of receiving water and pre-project effluent are identified in Table 10 below. The proposed project constituent levels are expected to be similar to current constituent levels. Sacramento River copper levels during 2001 and 2002 upstream of the existing outfall averaged 2.5 micrograms per liter (µg/L) and exhibited a maximum of 3.3 µg/L and concentrations in the existing effluent averaged 4.7 µg/L and exhibited a maximum of 6.3 µg/L (Table 10). Based on the worst case scenario, a 2:1 dilution would be achieved within 2 feet of the outfall diffusers, which would return the solution back to normal background conditions for the Sacramento River, assuming the 1Q10 river flow of 2,800 cfs and effluent discharge rate of 12 mgd. With the river velocity of 1.5 feet per second (Flow Science 2004), aquatic organisms passing through the zone of initial mixing would be exposed to copper, lead, silver, and zinc concentrations exceeding acute or chronic criteria for less than 2 seconds.

Though a 2:1 dilution occurs within 2 feet of the diffusers, the SWRCB developed a Total Maximum Daily Load (TMDL) water management strategy for cadmium, copper, and zinc loading into the upper Sacramento River because the river periodically contains levels of dissolved cadmium, copper, and zinc that exceed water quality standards developed to protect aquatic life. These numeric levels are based on Chinook salmon and steelhead as they are known to be highly sensitive to these dissolved metals (SWRCB 2002). The dissolved copper acute and chronic targets are 5.6 µg/L and 4.1 µg/L respectively.

A considerable amount of work has been completed documenting the deleterious affects of copper on salmonids. Hansen et al. (1999a) found Chinook salmon avoided copper concentrations as low as 0.7 µg/L (with a water hardness of 25 mg/l) and rainbow trout avoided concentrations at 1.6 µg/L. Furthermore, Hansen et al. (1999b) found reduced olfactory receptors in Chinook salmon exposed to 25 µg/L copper for 1 to 4 hours indicating a substantial decrease in olfaction ability. Diminished olfactory (i.e., taste and smell) sensitivity reduced the ability of the exposed fish to detect predators and to respond to chemical cues from the environment, including the imprint of smolts to their home waters, avoidance of chemical contaminants, and diminished foraging behavior (Hansen et al. 1999b). Baldwin et al. (2003) found low doses of copper on coho salmon (*O. kisutch*) caused the fish to exhibit declines in odorant sensitivity within 10 minutes of exposure at levels only 2.3 to 3.0 µg/L above the dissolved copper background.

Based on this information and flow analysis, NMFS believes that copper concentrations present in the effluent will contribute to adverse effects such as habitat avoidance and reduced olfactory function of listed salmonids and green sturgeon that are exposed. This ultimately may increase the vulnerability of affected individuals to predators, reduce feeding efficiency, and reduce the likelihood of successful migration. However, the effects attributable to the proposed action are expected to be chronic and sub-lethal as the movement of fish should limit their exposure to concentrated effluent from the project outfall and if exposed, the duration would be in less than 2 seconds. Because the duration of exposure would be a matter of seconds, discharges of copper under the proposed project would not be expected to harm fish or organisms moving through the zone of initial effluent mixing. Therefore, concentration levels of copper in the effluent is not expected to adversely affect listed salmonids or gren sturgeon.

Table 10. Six-day maximum and average effluent values and river values for copper (Jones & Stokes 2005).

Constituent	Effluent Sample (µg/L)		River Sample (µg/L)	
	6-Day Max	6-Day Average	Max	Average
Copper	6.3	4.7	3.3	2.5

(5) Cyanide. Based on review of effluent quality data, cyanide was detected in the effluent at a maximum concentration greater than applicable criteria for the protection of aquatic life. Applicable criteria include the CTR acute (*i.e.*, short-term, 1-hour) and chronic (*i.e.*, 4-days) criteria and the Basin Plan objective. Table 11 summarizes the maximum effluent and river concentrations and the applicable water quality criteria for the protection of aquatic life.

Table 11. Concentrations of cyanide in the Chico WPCP effluent and Sacramento River upstream of the Chico WPCP during the period July 2001 through November 2002.

Constituent	Maximum Concentration (µg/L)		Water Quality Criteria (µg/L)			Dilution Required to Meet Most Stringent Criterion (parts river to parts effluent)
	Sacramento River	Effluent	CTR Acute (CMC) [a]	CTR Chronic (CCC) [b]	Basin Plan	
Cyanide	3.8	6.5	22	5.2	10	0.9

[a]CMC = criterion maximum concentration [b]CCC=criterion continuous concentration

The maximum effluent concentration of cyanide is greater than the chronic CTR criterion, but less than the acute CTR criterion and the Basin Plan objective. Based on the maximum effluent and river concentrations, upon dilution of the effluent with up to 0.9 parts river water, all chronic and acute cyanide criteria would be met. Based on dilution analyses performed by Flow Science (2004), 0.9:1 dilution would be achieved within 0.4 feet of the outfall diffuser, assuming the 1Q10 river flow of 2,800 cfs and an effluent discharge rate of 12 mgd.

Cyanide's toxicity primarily is due to the inhibition of the cellular respiration through the binding of cyanide with enzymes such as cytochrome oxidase. This prevents the transfer of electrons to oxygen in the mitochondrial electron transport chain, and greatly diminishes the formation of high-energy compounds (*i.e.*, ATP) for cellular metabolism. Therefore, under prolonged exposure to chronic levels of cyanide, the energy available for activities such as feeding, migration, and reproduction is reduced which may impair growth, likelihood of survival, and reproductive output. When comparing the lethal toxicity of cyanide among different fish species, the salmonids exhibited the greatest susceptibility to cyanide toxicity with LC_{50} values less than 100 μg/l for acute toxicity and chronic toxicities of less than 50μg/l. The toxicity of cyanide is exacerbated in low DO conditions due to the inhibition of the electron transport chain and the reduction of metabolic energy production.

Current EPA National Recommended Water Quality Criteria and the CTR standards promulgate a CMC of 22 μg/l and a CCC of 5.2 μg/l for cyanide. The applicant's discharge data indicates that the maximum effluent concentration of total cyanide was 6.5 μg/l. NMFS believes that cyanide concentrations present in the effluent could affect listed salmonids and green sturgeon exposed to these concentrations over long periods of time by causing slowed reactions to stimuli (*e.g.*, food or predators) and reduced reproductive output. However, based on a river velocity of 1.5 ft/s (Flow Science 2004), aquatic organisms passing through the zone of initial mixing would be exposed to cyanide concentrations exceeding chronic criterion for less than 1 second, and would not be exposed to acutely lethal concentrations (Robertson-Bryan Inc. 2005). Because the duration of exposure to concentrations exceeding the chronic criterion would be less than 1 second, the level of exposure would not be lethal to fish or other organisms moving through the zone of initial effluent mixing. Therefore, NMFS does not anticipate adverse effects to listed salmonids or North American green sturgeon due to cyanide exposure.

(6) Dissolved Oxygen and Biochemical Oxygen Demand. Average monthly dissolved oxygen (DO) conditions 500 feet upstream and downstream of the existing diffuser were analyzed by Jones & Stokes (2005). Upstream DO conditions ranged from 9.9 mg/L to 11.8 mg/L and downstream conditions were slightly lower ranging from 9.8 to 11.7 mg/L. To assess gross oxygen demand of the effluent on the Sacramento River, an instantaneous demand was calculated based on average effluent concentrations of ammonia-nitrogen and the biological oxygen demand consumed in 5 days (BOD_5) by Jones & Stokes (2005). A total instantaneous oxygen demand was calculated in the effluent and divided by the total oxygen demand of the Sacramento River under the worst-case scenario. Based on this assessment, it is estimated that the proposed project will result in a 1.4 percent increase in oxygen demand in the Sacramento River.

Reductions in DO levels are primarily a concern for listed salmonids when they will be present in the late fall, winter, and spring. Based on the modeled DO levels, the end of the pipe DO levels are expected to be adequate for survival of listed salmonids, and reductions to ambient DO levels in the Sacramento River will be small and not likely to adversely affect listed salmonids and green sturgeon.

(7) pH. pH is a unit for measuring the concentration of hydrogen ion in water. pH is reported on a scale from 0 to 14. A pH 7 is neutral. A pH level less than 7 is acidic while a pH level above 7 is basic, or alkaline. Many biological functions can occur only within a narrow range of pH values.

In general, the pH range of 6.5 to 8.5 is the optimal pH range for most organisms. Though it is unknown exactly the lethal pH range for salmonids and green sturgeon, reduced pH is known to be toxic for all fish. An acidic solution between pH 3.5 and 4.0 is lethal to all salmonids while all fish as well as mayflies and other insects would not be present in a pH range of 4.0 to 5.0. Between pH 5.0 and 5.5, most bottom-dwelling decomposing bacteria begin to die off. An alkaline solution between 9.0 and 10.6 is harmful to salmonids at prolong exposures and a pH range between 11.0 and 11.5 is lethal to all species of fish.

Geen *et al* (1985) found fry were more tolerant than alevin in low pH between pH 4.5 and 5.0. Alevin mortality was high with the low pH levels. In Kirches and Dill studies on Atlantic salmon (NMFS K2006), smolts exposed to acidic waters can cause ionoregulatory failure, which inhibits the increase in gill Na+, K+-ATPase activity resulting to a reduce seawater intolerance. Smolt transformation become sensitive to acidic water. Also, smolts exposed to acidic waters causes the loss of plasma ions which result in cardiovascular disturbances. Hence, a slightly acidic water may not be regarded toxic to other salmonids but would be toxic to smolts. This is true even in rivers that are not chronically acidic and not normally considered as being in danger of acidification. In addition, the affect would be on the rearing since juvenile salmon depends on insects for food. The same affect is expected on green sturgeon since they are bottom feeders. Most bottom-dwelling bacteria begin to die off at low pH levels between 5.0 and 5.5.

The existing outfall discharge was found to have a minimal impact on Sacramento River pH by Jones & Stokes (2005). Minimum and maximum pH values upstream of the existing outfall were 7.49 and 8.28, respectively, and downstream were 7.52 and 8.17 respectively. The largest difference in pH units between 1999 and 2003 between upstream and downstream was found to be 0.14 units (Jones & Stokes 2005).

Based on the Jones & Stokes studies (2005) and Robertson-Bryan, Inc. (2005) effluent dilution model, the maximum effluent and river pH levels would maintain pH levels between 6.5 and 8.5 without altering the pH level of the receiving water more than 0.5 units (Basin Plan objectives). Thus, NMFS finds the pH level of the effluent is not likely to adversely affect listed salmonids and green sturgeon.

(8) Ammonia. Effluent ammonia concentrations have the potential to exceed the EPA recommended criteria for the protection of aquatic life when undiluted. Table 12 summarizes the highest measured pH and temperature (ammonia levels are a function of pH and temperature) in the Sacramento River downstream of the current discharge from January 1999 through August 2004, along with the maximum ammonia concentrations in the existing effluent.

Table 12. Concentrations of ammonia in the Chico WPCP effluent during the period January 1999 through August 2004, and corresponding EPA recommended criteria for the protection of aquatic life.

Maximum pH		Maximum River Temperature (°C)	EPA Ammonia Criteria (mg/L as N)		Effluent Ammonia Concentration (mg/L as N)		River Ammonia Concentration (mg/L as N) [a]
River Downstream of Outfall	Effluent		Acute (1-hour)	Chronic (30-day)	Maximum 1-Day	Maximum 30-Day average	
8.2	8.2	17.3	3.83	1.50	12.4	8.2	0.06

[a] Maximum concentration in the Sacramento River at Freeport during the period 1988 through 1992 (SRCSD 2004).

The maximum 1-day and 30-day average effluent ammonia concentrations are greater than the EPA recommended criteria for the protection of aquatic life, when calculated using the highest measured river pH and temperature. Because there are no river ammonia data upstream of the existing outfall, data collected from the Sacramento River at Freeport is shown. Maximum background ammonia concentration was found to be 0.06 mg/L (as nitrogen (N)) from the period 1988 to 2000 (Robertson-Bryan, Inc. 2005). Based on the maximum effluent and river ammonia concentrations, the acute criterion would be met upon the effluent mixing with 3 parts river water and the chronic criterion would be met upon the effluent mixing with 5 parts river water. This dilution is achieved within 5 feet of the diffuser, at the worst-case scenario flow of 2,800 cfs and effluent discharge rate of 12 mgd. Thus, ammonia levels at 3 feet from the diffusers would be 3.83 mg/L and at 5 feet levels would be at 1.50 mg/L under the worst-case scenario.

Salmonids are very sensitive to the level of un-ionized ammonia in the aqueous environment. Thurston and Russo (1983) found median acute toxicity levels of NH_3 in rainbow trout (*O. mykiss*) to range from 0.16 to 1.1 mg/liter in 96-hour exposures. The exposed fish ranged from 1-day old fry (<0.1 g) to 4-year old adults (2.6 kg). Sensitivity to NH_3 decreased as the fish developed from fry to juveniles, and then subsequently increased as fish matured. Sensitivity to ammonia as measured by the concentration lethal to 50 percent of the exposed population (LC_{50}) (Rand *et al.* 1995) did not appreciably change in concurrent exposures for 12- and 35-day test by the same authors. Thurston *et al.* (1984) measured chronic toxicity of rainbow trout to several low dose concentrations of ammonia (0.01-0.07 mg/l un-ionized ammonia) over a 5-year period, exposing 3 successive generations of trout to the toxicant. The trout exhibited dose dependent changes in the level of ammonia in their blood, and fish exposed to ammonia concentrations of 0.04 mg/l or higher of un-ionized ammonia exhibited pathological lesions in their gills and kidneys. There were no gross signs of toxicity at any of the test dose exposures, even though the histological examinations indicated abundant sublethal pathologies.

Lesions within the gill tissues create adverse conditions for oxygen exchange in exposed fish. Common types of pathologies observed in chronically exposed trout were "clumping" of gill filaments, separation of epithelial cells from their underlying base membranes, and micro-aneurisms (Thurston *et al.* 1984). The resulting abnormalities in the gill tissues can be expected to reduce the efficiency of oxygen transfer across the gill epithelial cells, which may reduce the energy available for feeding, migration, and reproduction. In addition, the injured tissues are more susceptible to pathogens and increase the likelihood of morbidity in exposed fish.

Lesions in the renal (kidney) tissues can be expected to impair blood flow and filtration, and eventually induce renal failure. In an anadromous fish, such as Chinook salmon or steelhead, a properly functioning renal system is imperative for osmotic regulation in its freshwater life stages. The renal system produces the dilute urine necessary to maintain the proper level of hydration.

Current EPA National Recommended Water Quality Criteria and the CTR standards promulgate a CMC of 2.89 mg/l and a CCC of 2.54 mg/l for ammonia. The NPDES permit for the proposed project allows average monthly and daily discharge concentrations of ammonia to be 1.0 and 3.0 mg/l, respectively. NMFS believes that ammonia concentrations present in the effluent will contribute to adverse effects such as reduced renal function, impaired gill function, and reduced growth of listed salmonids and green sturgeon that are exposed. This ultimately may impair the ability of smolts in their transition to the saltwater environment, reduce the efficiency of oxygen uptake, increase the vulnerability of affected individuals to predators, and reduce their likelihood of survival. The limits to ammonia concentrations reported in the NPDES permit indicate that potentially lethal levels may be reached in the undiluted effluent. Lower concentrations below the lethal thresholds are expected to cause effects that are chronic and sub-lethal because the movement of fish should limit their exposure to concentrated effluent from the project outfall.

VI. CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

1. Agricultural practices and water use

Non-Federal actions that may affect the action area include ongoing agricultural activities and increased urbanization. Agricultural practices in the along the Sacramento River near the City of Chico, Hamilton City, Marysville, and Yuba City may adversely affect riparian and wetland habitats through upland modifications of the watershed that lead to increased siltation or reductions in water flow in stream channels flowing into the Sacramento River. Numerous unscreened small agricultural diversions from 40 to 100 cfs upstream and downstream from the project area entrain fish including juvenile salmonids (Rick Wantuck, NMFS, pers com 2008). Grazing activities from dairy and cattle operations can degrade or reduce suitable critical habitat for listed salmonids by increasing erosion and sedimentation as well as introducing nitrogen, ammonia, and other nutrients into the watershed, which then flow into the receiving waters of the Sacramento River. Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may adversely affect salmonid reproductive success and survival rates (Dubrovsky *et al.* 1998, 2000; Daughton 2003a,b).

2. Development

The General Plans for the cities of Chico, Yuba City, Marysville, Hamilton, and other surrounding communities in the Sacramento Watershed anticipate rapid growth for several decades to come. Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns.

VII. INTEGRATION AND SYNTHESIS OF EFFECTS

The purpose of this section is to summarize the effects of the action and then add those effects to the impacts described in the *Environmental Baseline* and *Cumulative Effects* sections of this biological opinion. The integration and synthesis of these conditions and effects provides the basis for the conclusion as to whether or not the proposed action is likely to jeopardize their continued existence.

A. Summary of Impacts of the Proposed Action on Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead and Southern DPS of North American Green Sturgeon

NMFS expects that the proposed action will result in short-term, adverse, construction-related impacts that will have the potential to injure and kill juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead and North American green sturgeon. North American green sturgeon which may occur year-round in the Sacramento River are most likely to be affected by the construction activities. Juvenile salmonids and green sturgeon are expected to be affected most significantly because of their small size, reliance on aquatic food supply (allochthonous food production), and vulnerability to factors that affect their feeding success and exposure to predation. Construction-related effects include noise from the installation of the cofferdam and reduced water quality that may cause temporary modification of natural behavior and may expose juvenile fish to increased predation. Adults should not be injured or killed because their size, preference for deep water, and their crepuscular migratory behavior will enable them to avoid most temporary, nearshore disturbance.

A small percentage of listed fish are expected to be caught inside of the coffer. During the installation, noise from the vibratory hammer is expected to deter fish from entering the construction site. If listed species are found inside the cofferdam, fish rescue efforts will be implemented, which may result in injury, harm, and/or death of individuals.

The implementation of BMPs and other on-site measures will minimize impacts to the aquatic environment and reduce project-related effects on fish. As the construction activities are completed and the cofferdam removed, a small percentage of early emigrating juvenile winter-run Chinook could potentially be present in September. Their migration downstream may be slightly delayed. However, by avoiding the peak of migratory movements from late winter through late spring (February through May) for listed salmonids in the Sacramento River basin, the impacts resulting from the sheet pile driving will be minimized. Thus, NMFS expects that actual injury and mortality levels will be low relative to the overall population abundance of these ESUs/DPSs. Because of this consideration, construction-related impacts will be a small, spontaneous impact, and not likely to persist or result in negative population trends.

Construction related impacts on the PCEs of critical habitat will be short-term and will not significantly reduce the conservation value within the action area, partially due to the existing poor condition of the habitat and partially because of the low level of short-term affects from the project. The restoration and enhancement of riparian vegetation along the bank of the action area following construction is expected to provide a higher value of future rearing and refugia habitat than what currently exists in the area. It is expected to take up to 5 years for the new riparian vegetation to become established and cover the wetted perimeter of the river channel. Because the impacts to riparian vegetation will be limited to one small site for a short period of time (up to 5 years), and the existing habitat value in the area to be affected is low, NMFS expects individual fish will seek out and rear in nearby habitat with higher values, and will be unaffected by the minor, short-term impacts to riparian habitat.

Listed adult salmonids are not expected to be affected by the short term construction effects of the proposed project because they are not likely to be present in the action area during the proposed in-water work window (July through September). Adult green sturgeon have the potential to be present during in-water construction activities but are not expected to be significantly impacted due to their large size, high level of mobility, and their tendency to migrate through deep, mid-channel habitats. Neither adult salmonids nor adult green sturgeon are expected to be affected by the longer-term changes in nearshore riparian habitat conditions because they generally migrate through deep, mid-channel habitats and do not rely on overhanging vegetation for cover or food production.

Other effects of the project are expected to occur over the long term, resulting from the effluent discharge to the Sacramento River. In particular, the discharge is expected to contain low levels of certain pollutants (*i.e.*, dissolved oxygen, pH, temperature, total dissolved solids, copper, ammonia, and cyanide), which are likely to contribute to primarily chronic, sub-lethal effects on listed fish. The discharge will occur year-round, and therefore all migrating salmonids that occur in the Sacramento River near the diffuser array may be exposed to the effects of the WPCP operation. Outmigrating juveniles may rear and migrate in the Sacramento River for up to 3 months, and are more likely to be adversely affected than adults which tend to migrate quickly to their spawning grounds upstream.

In addition to the direct exposure of the listed fish species, exposure of the local benthic invertebrate population to the contaminants will lead to indirect adverse effects upon these fish by diminishing the value of the forage base in the action area. NMFS anticipates that there will be a direct change in the invertebrate population numbers and community structure within the action area as a result of the WWTP discharge. These changes will have corresponding effects upon the listed salmonid species and the green sturgeon rearing in the action area.

B. Impacts of the proposed action on the Survival and Recovery of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and Southern DPS of North American Green Sturgeon.

The short term impacts from the construction phase of the project (pile driving noise, increased turbidity, and entrapment and rescue from within the cofferdam) are expected to have low-level effects on a very small proportion of a single year class of juvenile salmonids, and juvenile and adult green sturgeon. While a very small proportion of the fish affected by the construction impacts may actually be killed or severely injured, the level of effects described in the previous section are not expected to appreciably reduce the population size, reproductive potential or distribution of any of the listed ESUs or DPSs.

The long term operation of the WPCP is expected to result in the continuous release of low concentrations of pollutants into the Sacramento River including dissolved solids, copper, cyanide and ammonia, and result in slightly decreased pH, and increased water temperature immediately downstream of the effluent release point. The effects analysis indicates that the effluent will meet the Regional Water Quality Board's NPDES Permit (CA0079081) requirements to prevent water quality degradation for aquatic species. Concentrations of these pollutants will be diluted to harmless levels within 5 feet of the discharge point and migrating fish are expected to be exposed to elevated levels of these pollutants for less than 3 seconds if they pass directly through the effluent plume (which is expected to occupy less than 20 percent of the river channel). Given these expected conditions and in light of the current baseline water quality in the action area, it is unlikely that the long term effects of the proposed operation of the WPCP would appreciably reduce the population size, reproductive potential or distribution of any of the listed ESUs or DPSs that utilize the action area.

The combined effects of the construction and operation of the WPCP are expected to result in the injury and death of a small number of individuals, and low level chronic exposure to increased pollutants and water temperatures immediately below the diffusers. These minor effects are expected to have little or no impact on the population size, reproductive potential or distribution of any of the listed ESUs or DPSs that utilize the action area, and when added to the baseline conditions in the action area and the cumulative effects of future impacts to the area, are not expected to appreciably reduce the likelihood of survival and recovery of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and southern DPS of North American green sturgeon.

C. Impacts of the proposed action on Critical Habitat

The purpose of this section is to consider the effects of the action on critical habitat in light of the current condition and function of the PCEs and their contribution to the conservation value of habitat, in order to inform the conclusion of whether or not the proposed action is likely to destroy or adversely modify designated critical habitat.

Impacts to critical habitat of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead include the short- and long-term modification of approximately 0.06 acres of aquatic and 0.02 acres of riparian habitat within the action area. PCEs in the action area include riverine areas for rearing and migration. NMFS CHART (2005b) described existing PCEs within the action area as ranging from good condition to degraded, with isolated fragments of high quality habitat. Even with these degraded conditions, the CHART report rated the conservation value of the entire action area as high because it is used as a rearing and migration corridor for the entire population of winter-run Chinook salmon and a large proportion of Central Valley spring-run Chinook salmon and Central Valley steelhead.

Because of the project's integrated conservation measures and BMPs, include restoring and enhancing the stream banks with a higher density of vegetation, NMFS expects that the action will contribute positively to the growth and survival of fish using the habitat, and ultimately improve rearing and migration PCEs. State and Federal permit requirements for controlling the discharge of pollutants into the Sacramento River are also expected to be strictly adhered to, preventing degradation of water quality within critical habitat. Therefore, NMFS does not expect project-related impacts to reduce the conservation value of designated critical habitat of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead.

VIII. CONCLUSION

After reviewing the best scientific and commercial data available, including the environmental baseline, the effects of the proposed project, and the cumulative effects, it is NMFS biological opinion that the City of Chico Water Pollution Control Plant Expansion project is not likely to jeopardize the continued existence of endangered Sacramento River winter-run Chinook salmon, threatened Central Valley spring-run Chinook salmon, threatened Central Valley steelhead and the threatened southern DPS of North American Green Sturgeon, and is not likely to destroy or adversely modify designated critical habitat.

IX. INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS as an act which kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are nondiscretionary, and must be undertaken by the Corps and the City of Chico so that they become binding conditions of any licenses, permits or contracts issued, as appropriate, for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activities covered by this incidental take statement. If the Corps: 1) fails to assume and implement the terms and conditions; or 2) fails to require the applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Corps must report the progress of the action and its impact on the species to NMFS as specified in this Incidental Take Statement (50 CFR §402.14(i)(3

A. Amount or Extent of Take

NMFS anticipates incidental take of Sacramento River winter-run Chinook salmon, Central Valley steelhead, Central Valley spring-run Chinook salmon, and North American green sturgeon from impacts related to construction and effluent discharge through direct construction impacts and impairment of essential behavior patterns as a result of reductions in the quality of their habitat.

NMFS cannot, using the best available information, quantify the anticipated incidental take of individual listed fish because of the variability and uncertainty associated with the population size of each species, annual variations in the timing of migration, and uncertainties regarding individual habitat use of the project area. However, it is possible to designate ecological surrogates for the extent of take anticipated to be caused by the project, and to monitor those surrogates to determine the level of take that is occurring. The three most appropriate ecological surrogates for the extent of take caused by the project are the level of instream turbidity created by construction activities associated with the project, the amount and duration of pile driving conducted during project construction, and the levels of toxic or hazardous compounds found in the effluent released into the river during the long term operation of the project.

1. Ecological Surrogates

- The analysis of the effects of the proposed project anticipates that construction-related turbidity will extend a maximum of 100 feet from the shoreline, and 1,000 feet downstream, of any construction related activities. Turbidity levels exceeding the Regional Board standards listed in the Description of the Proposed Action section, between July and September would result in an exceedence of the anticipated take levels.

- The analysis of the effects of the proposed project anticipates that the construction of a sheet pile coffer dam would require driving 155 feet of sheet piles for 15 days (8 hours per day), over a period of 3 months (July 1 through September 30).

- The analysis of the effects of the proposed project anticipates that specific effluent requirements defined in the City of Chico WPCP, NPDES permit #CA0079081, will be met throughout the life of the project as listed in Table 2.

If these ecological surrogates are not met and maintained, the proposed project will be considered to have exceeded anticipated take levels, triggering the need to reinitiate consultation on the project.

B. Effect of the Take

NMFS has determined that the level of take resulting from the construction and continued operation of the proposed project is not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley steelhead, Central Valley spring-run Chinook salmon, or the southern DPS of North American green sturgeon, and is not likely to destroy or adversely modify the respective designated critical habitat for the salmonid species.

C. Reasonable and Prudent Measures

Pursuant to section 7(b)(4) of the ESA, the following reasonable and prudent measures are necessary and appropriate to avoid or minimize take of endangered Sacramento River winter-run salmon, threatened Central Valley spring-run Chinook salmon, threatened Central Valley steelhead, and threatened southern DPS of North American green sturgeon:

1. The Corps and the City of Chico shall avoid or minimize entrainment or stranding of juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and southern DPS of North American green sturgeon within the project cofferdam.

2. The Corps and the City of Chico shall avoid or minimize adverse effects of the long-term operation of the WPCP on Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and southern DPS of North American green sturgeon by monitoring and maintaining the effluent discharge concentration levels as described in the City of Chico's NPDES permit CA0079081.

3. The Corps and the City of Chico shall assess bank restoration designs on salmonids using the Standard of Assessment Model (SAM) for the Sacramento River Bank Protection Project (SRBPP).

D. Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, Reclamation must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline prescribed reporting/monitoring requirements. These terms and conditions are non-discretionary:

1. **The Corps and the City of Chico shall avoid or minimize entrainment or stranding of juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and Southern DPS of North American green sturgeon within the project cofferdam.**

    a. Cofferdam construction will be completed at the downstream end to minimize the potential for entrainment of salmonids and green sturgeon within the closed cofferdam.

    b. A qualified fishery biologist shall sample the closed cofferdam to ensure that no salmonids and green sturgeon have been trapped within the cofferdam.

        i. All rescued salmonids and green sturgeon shall be removed and returned to the river. The fishery biologist shall note the number of individuals entrained, the number of individuals relocated, and the date and time of collection and relocation; and provide a report to the address below.

        ii. One or more of the following NMFS-approved capture techniques shall be used: dip net, seine, throw net, minnow trap, or hand.

        iii. Electrofishing may be used if NMFS has reviewed the biologist's qualifications and provided written approval.

        iv. The fishery biologist shall be empowered to halt work activity and to recommend measures for avoiding adverse effects to salmonids and green sturgeon and their habitat.

2. **The Corps and the City of Chico shall avoid or minimize adverse effects of the long-term operation of the WPCP on Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and southern DPS of North American green sturgeon by monitoring and maintaining the effluent discharge concentration levels as described in the City of Chico's NPDES permit CA0079081.**

a. A draft operations and maintenance plan to monitor the concentration levels of the effluent discharge shall be developed and submitted to NMFS at least 60 days prior to initiating operations of the diffuser array. The plan shall act as a manual for operating and maintaining the diffuser array. The plan shall be developed in accordance with the guidelines described in the City of Chico's NPDES permit CA0079081. Draft plans can be sent to the address below.

   i. The operation and maintenance plan shall include a monitoring plan that measures and records the concentration levels of the effluent discharge to ensure the concentration levels of each constituents outlined in the NPDES permit does not exceed the discharge requirements.

   ii. The operation and maintenance plan shall include notifying NMFS by fax within 24 hours if any of the concentration levels of the monitored constituents exceed the NPDES permit discharge requirements.

   iii. A yearly monitoring report of the effluent discharge for the first three years of operation shall be provided to NMFS; hence after, a fifth and ten year report shall be provided to NMFS. The reports can be sent to the address below.

b. An operations and maintenance log shall be maintained on a daily basis. The logbook shall contain recorded concentration levels of constituents as outlined in the City of Chico's NPDES permit #CA007981. The logbook shall be made available for inspection to NMFS personnel with 24 hours notice to the City of Chico.

c. The City of Chico shall curtail effluent discharge to the greatest extent possible when any portion of the diffuser array structure is damaged or removed for maintenance or repair. The City of Chico's WPCP operations may resume when the diffuser structure becomes fully operational.

3. The Corps and the City of Chico shall assess bank restoration designs on salmonids using the Standard of Assessment Model (SAM) for the Sacramento River Bank Protection Project (SRBPP).

a. A written report regarding the results of the SAM modeling for the bank restoration plan shall be submitted to NMFS for approval prior to construction. The report shall include fish response indices and bank length (or wetted area) for each season, target year, and relevant species and life stage.

b. The Corps and the City of Chico shall develop an irrigation schedule appropriate for establishing vegetation plantings consistent with the SAM assumptions for riparian survival.

c. These reports and documents shall be sent to the address below in a minimum of 60 days prior to their implementation to allow NMFS personnel sufficient time to review them.

d. Prior to the outfall structure becoming operational, a post-construction inspection of the diffuser array must be conducted by NMFS, to insure that the streambank is planted according to the design plans as suggested by the SAM analysis to ensure the loss of riparian habitat is properly planted and restored.

Reports and notifications required by these terms and conditions shall be submitted to:

Sacramento Area Office
National Marine Fisheries Service
650 Capitol Mall, Suite 8-300
Sacramento California 95814-4706
FAX: (916) 930-3629
Phone: (916) 930-3600

X. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. These conservation recommendations include discretionary measures that the Corps and the City of Chico can implement to avoid or minimize adverse effects of a proposed action on a listed species or critical habitat or regarding the development of information. NMFS provides the following conservation recommendations that would avoid or reduce adverse impacts to listed salmonids:

1. The Corps, under the authority of section 7(a)(1) of the Act, should implement recovery plan-based actions within and outside of traditional flood damage reduction projects. Such actions may include, but are not necessarily limited to restoring natural river function and floodplain development, maintaining water quality from degrading and adversely affecting federally listed species.

2. The Corps and the City of Chico should continue to focus on acquiring, retaining, restoring and creating river riparian corridors to assist in the recovery of the listed salmonid and sturgeon species within their right of way property along the Sacramento River.

3. The Corps and the City of Chico should implement biotechnical measures in place of traditional revetment techniques should any of the project riprap begin to cause scour and require additional bank stabilization in the future.

4. The Corps and the City of Chico should consider developing a recycling and reuse program of stormwater and effluent discharges to accommodate future growth and development and minimize effluent discharge to the Sacramento River (*i.e.,* Mountain House Development in conjunction with the City of Tracy's wastewater treatment plant in which treated effluent are used to water lawns).

5. The Corps and the City of Chico should conduct or fund studies to help quantify fish predation and changes of migration patterns in the area of the diffuser structure.

6. The Corps and the City of Chico should continue to work cooperatively with other State and Federal agencies, private landowners, governments, and local watershed groups to identify opportunities for cooperative analysis and funding to support salmonid habitat restoration projects within the Sacramento River.

To be kept informed of actions minimizing or avoiding adverse effects, or benefiting listed or special status species or their habitats, NMFS requests notification of the implementation of any conservation recommendations.

XI. REINITIATION OF CONSULTATION

This concludes formal consultation on the City of Chico WPCP Expansion project. Reinitiation of formal consultation is required if: (1) the amount or extent of taking specified in any incidental take statement is exceeded; (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) the action, including the avoidance, minimization, and compensation measures listed in the *Description of the Proposed Action* section is subsequently modified in a manner that causes an effect to the listed species that was not considered in the biological opinion; or (4) a new species is listed or critical habitat is designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately.

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Enclosure 2

MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSERVATION RECOMMENDATIONS

Agency:	U.S. Army Corps of Engineers
Activity:	City of Chico Water Pollution Control Plant Expansion Project in the Sacramento River near Chico, California
Consultation Conducted By:	Southwest Region, National Marine Fisheries Service
File Number:	151422SWR2006SA00631 F/SWR/2007/07495
Date Issued:	

I. IDENTIFICATION OF ESSENTIAL FISH HABITAT

This document represents the National Marine Fisheries Service's (NMFS) Essential Fish Habitat (EFH) consultation based on our review of information provided by the U.S. Army Corps of Engineers (Corps) and the applicant, City of Chico on the proposed Water Pollution Control Plant Expansion Project downstream from river mile (RM) 192.5. The Magnuson-Stevens Fishery Conservation Act (MSA) as amended (U.S.C 180 et seq.) requires that EFH be identified and described in Federal fishery management plans (FMPs). Federal action agencies must consult with NMFS on activities which they fund, permit, or carry out that may adversely affect EFH. NMFS is required to provide EFH conservation and enhancement recommendations to the Federal action agencies. The geographic extent of freshwater EFH for Pacific salmon in the Sacramento River includes waters currently or historically accessible to salmon within the Sacramento River.

EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat, "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means habitat required to support a sustainable fishery and a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers all habitat types used by a species throughout its life cycle.

The biological opinion for the City of Chico's Water Pollution Control Plant (WPCP) Expansion project addresses Chinook salmon listed under the both the Endangered Species Act (ESA) and the MSA that potentially will be affected by the proposed action. These salmon include

Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), and Central Valley spring-run Chinook salmon (*O. tshawytscha).* This EFH consultation will concentrate on Central Valley fall-/late fall-run Chinook salmon (*O. tshawytscha*) because they are covered under the MSA but not listed under the ESA.

Historically, Central Valley fall-run Chinook salmon generally spawned in the Central Valley and lower-foothill reaches up to an elevation of approximately 1,000 feet. Much of the historical fall-run spawning habitat was located below existing dam sites and the run therefore was not as severely affected by water projects as other runs in the Central Valley.

Although fall-run Chinook salmon abundance is relatively high, several factors continue to affect habitat conditions in the Sacramento River, including loss of fish to unscreened agricultural diversions, predation by warm-water fish species, lack of rearing habitat, regulated river flows, high water temperatures, effluents from wastewater treatment plants, and reversed flows in the Delta that draw juveniles into State and Federal water project pumps.

A. Life History and Habitat Requirements

Central Valley fall-run Chinook salmon enter the Sacramento River from July through December, and late fall-run enter between October and March. Fall-run Chinook salmon generally spawn from October through December, and late fall-run fish spawn from January to April. The physical characteristics of Chinook salmon spawning beds vary considerably. Chinook salmon will spawn in water that ranges from a few centimeters to several meters deep, provided that there is suitable sub-gravel flow (Healey 1991). Spawning typically occurs in gravel beds that are located in marginally swift riffles, runs and pool tails with water depths exceeding one foot and velocities ranging from one to 3.5 feet per second. Preferred spawning substrate is clean loose gravel ranging from one to four inches in diameter with less that 5 percent fines (Reiser and Bjornn 1979).

Fall-run Chinook salmon eggs incubate between October and March, and juvenile rearing and smolt emigration occur from January through June (Reynolds *et al.* 1993). Shortly after emergence, most fry disperse downstream towards the Sacramento-San Joaquin Delta and estuary while finding refuge in shallow waters with bank cover formed by tree roots, logs, and submerged or overhead vegetation (Kjelson *et al.* 1982). These juveniles feed and grow from January through mid-May, and emigrate to the Delta and estuary from mid-March through mid-June (Lister and Genoe 1970). As they grow, the juveniles associate with coarser substrates along the stream margin or farther from shore (Healey 1991). Smolts generally spend a very short time in the Delta and estuary before entry into the ocean.

II. PROPOSED ACTION.

The City of Chico proposes to expand and upgrade their WPCP. The proposed action is described in detail in the *Description of the Proposed Action* section of the preceding biological opinion (Enclosure 1).

III. EFFECTS OF THE PROJECT ACTION

The effects of the proposed action on Pacific Coast salmon EFH would be similar to those discussed in the *Effects of the Proposed Action* section of the associated biological opinion (Enclosure 1) for endangered Sacramento River winter-run Chinook salmon, threatened Central Valley spring-run Chinook salmon, and threatened Central Valley steelhead. These impacts include temporary disturbance and degradation of water quality from in-channel construction activities; an additional 0.02 acres of bank slope that will be covered with riprap to protect the diffuser array (Roberts-Bryan, Inc., 2005), altered flows and temperature from the discharge of the diffuser array, and an increase of water contaminants and pollutants from the effluent.

IV. CONCLUSION

Upon review of the effects of the City of Chico's Water Pollution Control Plant Expansion Project NMFS believes that the project will result in adverse effects to the EFH of Pacific salmon protected under the MSA.

V. EFH CONSERVATION RECOMMENDATIONS

Considering that the habitat requirements of fall-run within the action area are similar to the Federally listed species addressed in the preceding biological opinion (Enclosure 1), NMFS recommends that all the Terms and Conditions as well as all the Conservation Recommendations in the preceding biological opinion prepared for the Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead ESUs be adopted as EFH Conservation Recommendations.

VI. ACTION AGENCY STATUTORY REQUIREMENTS

Section 305(b)(4)(B) of the MSA and Federal regulations (50 CFR § 600.920) to implement the EFH provisions of the MSA require Federal action agencies to provide a detailed written response to NMFS, within 30 days of its receipt, responding to the EFH conservation recommendations. The response must include a description of measures adopted by the Agency for avoiding, mitigating, or offsetting the impact of the project on Pacific salmon EFH. In the case of a response that is inconsistent with NMFS' recommendations, the Agency must explain their reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(j)).

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