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October 8, 2010

Via: e-mail: kharder@waterboards.ca.gov
and U.S. Mail

Ms. Kathleen Harder
California Regional Water Quality Control Board
Central Valley Region
11020 Sun Center Drive, Suite 200
Rancho Cordova, CA 95670-6114

Re: Comments of Westlands Water District (Westlands) and the San Luis & Delta-Mendota Water Authority (Authority) on Tentative Waste Discharge Requirements Renewal (NPDES Permit No. CA0077682) for Sacramento Regional County Sanitation District, Sacramento Regional Wastewater Treatment Plant

Dear Ms. Harder:

Westlands Water District (Westlands) and the San Luis & Delta-Mendota Water Authority (Authority) respectfully submit these comments in response to the Central Valley Regional Water Quality Control Board's (Regional Board's) tentative wastewater discharge permit for the Sacramento Regional County Sanitation District's (Sacramento Regional's) Sacramento Regional Wastewater Treatment Plant (SRWTP or "Treatment Plant"). In addition to these comments, Westlands and the Authority have joined comments with a group of other water agencies, authorities and associations (Water Agencies' Comments) that will be submitted separately, and we incorporate fully those comments by reference. The purpose of this letter is to explain Westlands' and the Authority's unique interests in this proceeding and highlight four specific issues.

First, Westlands and the Authority commend the Regional Board for proposing to require the SRWTP to remove ammonia/ammonium (ammonia/um) and nitrogen from its wastewater discharge. Each day, the Treatment Plant is degrading water quality and impairing beneficial uses in the Sacramento River, the Sacramento-San Joaquin River Delta, and San Francisco Bay (Bay-Delta) by discharging *14 tons of untreated ammonia* and other nutrients. The overwhelming scientific evidence demonstrates that this untreated ammonia is a key contributor to the decline of the food web that is essential to aquatic species in the Bay-Delta. That science supports the tentative permit's proposed effluent limitations, which would reduce the harmful ammonia/um and nitrogen load by implementing full nutrient removal (or nitrification and denitrification).

Second, while the Regional Board has provided appropriate effluent limits, Westlands and the Authority submit that the proposed interim limits would authorize Sacramento Regional to continue a discharge that causes the take of listed species, in violation of the federal Endangered Species Act (ESA) and the California ESA (CESA) in at least two ways.

That is, one, the tentative permit's interim limits, which would be effective for at least ten years, would allow ammonia levels to *potentially more than double* from the current, already devastating levels. An additional decade of untreated ammonia discharges could pour up to 250,000,000 more pounds of ammonia/um into the Delta ecosystem. These ongoing and potentially increasing ammonia discharges would continue to degrade water quality and alter the food web and ecology of the Bay-Delta, causing unauthorized, actual injury and death to aquatic life, including the threatened delta smelt and endangered and threatened salmon and steelhead species, in violation of the ESA and CESA. Sacramento Regional has no plan to minimize or mitigate those impacts.

Accordingly, Westlands and the Authority urge the Regional Board to remove the interim limits and the extended compliance schedule from the proposed permit. We ask the Regional Board instead to adopt a separate Cease and Desist Order that would impose interim limits that are more stringent, direct the SRWTP to implement interim measures that reduce ammonia/um discharges while full nutrient removal is developed, and require Sacramento Regional to implement full nutrient removal as soon as feasible, and, in any event, sooner than the proposed deadline of November 2020.

Further, the tentative permit would also cause the direct take of aquatic species by granting Sacramento Regional – the largest discharger into the River and Bay-Delta – an exception from the State Water Resources Control Board's *Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Water and Enclosed Bays and Estuaries of California* (Thermal Plan). The Thermal Plan is designed to protect the beneficial uses of the River and Bay-Delta, including the habitat of all native species. The proposed exception, however, would allow SRWTP discharges to create a thermal impediment for aquatic species, an impediment that is harmful, if not lethal, to species protected under the ESA and CESA. With the delta smelt spawning just downstream of the discharge and salmon migrating past the discharge, the proposed temperature exception presents a further direct threat to the delta smelt, salmon and steelhead and, therefore, should not and must not be granted. The final permit should remove the proposed exception, and the Cease and Desist Order should require that steps be taken to comply with the applicable Thermal Plan.

Third, the tentative permit would violate the state's "antidegradation" policy by allowing an increase in the ammonia discharge over the next decade. With the existing discharge already exceeding the Sacramento River and Bay-Delta water quality objectives, "best practicable treatment or control" (BPTC) must be installed, as properly proposed by the Regional Board staff. However, the tentative permit's interim limits would expressly permit dramatic increases in ammonia discharges that would further degrade water quality and impair beneficial use and are therefore contrary to any reasonable interpretation of "antidegradation."

Fourth, the two alternatives to full nutrient removal set forth in a separate document entitled "Tentative Permit Alternatives" should not be adopted, as the data are clear that neither alternative would adequately protect water quality and the beneficial uses of the River and Bay-Delta. Regardless, neither of the two alternatives is supported by the administrative record. Accordingly, if the Regional Board were inclined to adopt either alternative, the Regional Board must issue a new tentative permit, provide the requisite supporting documentation, and provide another opportunity for public comment. Any failure to follow these basic requirements of administrative procedure would render the final permit legally indefensible.

Background

Westlands is a water district established under California law. Formed in 1952, Westlands is the largest single agricultural water district in the United States, encompassing more than 600,000 acres of farmland in western Fresno and Kings counties. The District supplies water to serve farmers who produce dozens of high quality commercial food and fiber crops sold for the fresh, dry, canned and frozen food markets, both domestic and export, that generate more than $3 billion annually in agricultural-related economic activity. Westlands also supplies water to families, businesses, municipalities, and industrial users in the Central Valley.

Westlands receives water through the Central Valley Project (CVP), a federal water project that stores water in large reservoirs in Northern California for use throughout the State. After water is released from CVP reservoirs, the water flows to the Delta. From there, water is pumped through the Delta-Mendota Canal for direct use or to the San Luis Reservoir for later use by our farmers.

Many communities depend on the agricultural economy that relies on the water provided by Westlands, including Mendota, Huron, Tranquility, Firebaugh, Three Rocks, Cantua Creek, Helm, San Joaquin, Kerman, Lemoore and Coalinga. More than 50,000 people live and work in these communities and depend on the water provided by Westlands for their livelihoods.

The Authority was formed in 1992 as a joint powers authority and consists of 29 member agencies, including Westlands. Most of the Authority's member agencies contract with the federal Bureau of Reclamation for supply of water from the CVP. In total, the Authority's member agencies hold contracts with Reclamation for the delivery of approximately 3.3 million acre-feet of CVP water. CVP water made available to the Authority's member agencies supports approximately 1.2 million acres of agricultural land, as well as 51,500 acres of private waterfowl habitat, in California's Central Valley. The Authority's member agencies' CVP water supplies are also used by more than 1 million people in the Silicon Valley and the Central Valley.

The SRWTP's discharge to the Sacramento River has a substantial, direct, and severe impact on the ability of Westlands and other member agencies of the Authority to serve the many people who depend on them for water service. The SRWTP currently discharges approximately 141,000,000 gallons per day of treated sewage into the Sacramento River—enough sewage to fill almost 3,000,000 bathtubs every day. As the Regional Board staff acknowledges, the discharge contains many contaminants including approximately 28,000 pounds of untreated ammonia each day and many other toxic materials. *See* Tentative Permit at K-1. This massive discharge flows down the Sacramento River to the Bay-Delta, harming the ecology, aquatic life and habitat. These impacts within the Sacramento River and Bay-Delta caused by SRWTP's discharge have led to water restrictions that have resulted in severe human hardship, irretrievable resource losses, and economic and environmental harms. Federal regulators have imposed conditions that restrict water flows out of the Delta due to, among other things, the alleged impacts on the delta smelt of exporting water from the Delta to supply Westlands, the Authority and other water users.[1] These harsh restrictions on water supply have severely impacted the agricultural economy that Westlands and other member agencies of the Authority serve.

As a federal court recently found, the restrictions "will contribute to and exacerbate the current catastrophic situation" faced by Westlands and other member agencies of the Authority, "whose farms, businesses, water service areas, and impacted cities and

[1] *See* Fish and Wildlife Services, Biological Opinion on the Proposed Coordinated Operations of the Central Valley Project and State Water Project at pp. 279-285 (Dec. 15, 2008) (Smelt BiOp), *available at* http://www.fws.gov/sacramento/es/documents/SWP-CVP_OPs_BO_12-15_final_OCR.pdf; *see also* National Marine Fisheries Service, Southwest Region, Endangered Species Act Section 7 Consultation Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project at pp. 581-659 (June 4, 2009), *available at* http://swr.nmfs.noaa.gov/ocap.htm.

counties, are dependent, some exclusively, upon CVP" and "other restricted water deliveries."[2] The water restrictions have caused destruction of permanent crops, fallowed lands, destruction of farming businesses, as well increased groundwater consumption, land subsidence, reduction of air quality, and social disruption and dislocation.[3]

Westlands and the Authority thus have a substantial and unique interest in the Regional Board approving a final NPDES permit for the SRWTP that requires nutrient removal (full nitrification and de-nitrification), as well as other requirements. Sacramento Regional cannot continue to impair beneficial uses and degrade water quality. It must be stopped from polluting the waters of the Sacramento River and the Bay-Delta and causing its regulatory burdens to be borne by the farmers and communities who rely on the water they receive from Westlands and other member agencies of the Authority for their lives and livelihoods.

I. The Tentative Permit Appropriately Requires Full Nitrification And Denitrification Of The SRWTP's Wastewater.

The tentative permit would appropriately require full nitrification and de-nitrification to remove ammonia/um and nitrogen from the SRWTP's wastewater discharge. Westlands and the Authority support these requirements and the tentative permit's final effluent limitations: the proposed average monthly ammonia limits would be 1.8 mg/L or 2720 lbs/day, with a maximum daily limit of 2.2 mg/L or 3320 lbs/day.[4] Tentative Permit at 13. The findings described in attachments F and K of the tentative permit, and the underlying evidence cited there, provide a strong, fully adequate basis for these requirements. For additional support for these findings, we refer the Regional Board to the Water Agencies' Comments submitted separately, as well as to the comments that the Water Agencies submitted in June 2010, on the Aquatic Life and Wildlife Preservation Issues Paper.[5]

The Water Agencies' Comments detail the harms caused by the millions of pounds of ammonia and nutrients in the SRWTP's discharge. Among other impacts, scientific evidence shows the SRWTP discharge, particularly the relentless nitrogen loading from thousands of tons of untreated ammonia/ammonium every year, is severely impairing the

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[2] The Consolidated Delta Smelt Cases, No. 1:09-cv-00407, Findings of Fact and Conclusions of Law Re Plaintiffs' Request for Preliminary Injunction Against Implementation of RPA Component 2, at page 73 (May 27, 2010) (excerpt attached).

[3] *See id.* at pages 72-87.

[4] These limits would not be effective until November 30, 2020. Until then, the permit would allow up to 68,000 lbs/day (substantially more than the plant's current discharge). *Id.* at 15. As discussed in other sections of this letter, this interim limit is far too high and is proposed to be in place for an unreasonably long period of time.

[5] *See* Comments of Alameda County Water District, et al. on Aquatic Life and Wildlife Preservation Issues Concerning the Sacramento Regional Wastewater Treatment Plant NPDES Permit Renewal (June 1, 2010).

food web that supports aquatic life throughout the Sacramento River and Bay-Delta and contributing to the decline of salmon and pelagic organisms, including the delta smelt. The ammonia discharged by the SRWTP is also having toxic effects on aquatic species, as the current discharges do not meet EPA's proposed ammonia criteria. For these and other reasons described in the Water Agencies' comments, the adverse affect of the discharge must be controlled through nitrification/de-nitrification treatment.

II. The Tentative Permit Should Be Revised To Remove The Authorization Of Discharges That Will Continue To Cause A "Take" Of Salmon And Delta Smelt, In Violation Of The ESA And CESA.

Notwithstanding the final effluent requirements for ammonia, the tentative permit has proposed interim limits that would allow a discharge that continues to cause serious violations of the ESA[6] and CESA[7] over the next ten years. The Regional Board should not – and indeed cannot – authorize continued uncontrolled discharges for another decade, particularly since Sacramento Regional proposes to increase discharges and has no plans to minimize or mitigate for the effects of any of those discharges. As such, we urge the Regional Board to remove the proposed interim limits and make the final limits applicable upon issuance the permit. The Board should issue a separate Cease and Desist Order that restricts interim discharges of ammonia/um and nitrogen and requires installation of full nutrient removal as soon as feasible. The Board should also remove the proposed exception to the Thermal Plan and require Sacramento Regional to take the steps needed to comply with the applicable Thermal Plan as soon as possible.

A. The Current Discharge – And The Proposed Interim Limits – Cause A "Take" In Violation Of The ESA And CESA.

At least two elements of the discharge are causing the violations of the ESA and CESA: the many tons of untreated ammonia/um discharged and the temperature of the discharge. The SRWTP's discharges of ammonia/um into the Sacramento River have had and will continue to have significant impacts on the quality of the Sacramento River and the Bay-Delta, resulting in the "take" of the threatened delta smelt, in violation of Section 9 of the ESA and Section 2080 of the California Fish and Game Code (the take prohibition

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[6] The ESA lists the delta smelt and spring-run Chinook salmon as threatened, winter-run Chinook salmon as endangered, and the fall- and late fall-run Chinook salmon as species of concern. *See* U.S. Fish & Wildlife Service Sacramento Fish & Wildlife Office Species Account*, available at* www.fws.gov/sacramento/es/animal_spp_acct/delta_smelt.pdf; Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead, *available at* www.nwr.noaa.gov/Publications/Biological-Status-Reviews/loader.cfm?csModule=security/getfile&pageid=21346.

[7] The CESA lists the delta smelt and winter-run Chinook salmon as endangered and the spring-run Sacramento River Chinook salmon as threatened. *See* Department of Fish and Game, State and Federally Listed Endangered & Threatened Animals of California (July 2010), *available at* http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/TEAnimals.pdf.

under the CESA). The tentative permit asserts that it "does not authorize any act that results in the taking of a threatened or endangered species . . . ." Tentative Permit at 11.[8] However, scientific evidence has demonstrated that the SRWTP's discharge has been contributing to the decline of listed species dependent upon the Bay-Delta. The Tentative Permit would not only let similar discharges continue for an entire decade, the proposed interim limits for ammonia would allow a *doubling* of ammonia during that time. This discharge will directly (through increased toxicity) and indirectly (through adverse habitat modification and degradation) injure or kill delta smelt. Also, the tentative permit would allow for discharges that increase the temperature in the Sacramento River to levels near lethal or lethal to delta smelt, multiple runs of salmon, and steelhead. Those results violate the ESA and the CESA

Section 9 of the ESA makes it unlawful for any person to "take" a listed species. 16 U.S.C. § 1538(a)(1) (prohibiting take of endangered species); 50 C.F.R. §§ 17.21, 17.31(a) (applying same regulatory take prohibitions to threatened species). "Take" means "harass, harm, pursue, hunt, wound, kill, trap, capture, or collect" any listed species, or "to attempt to engage in any such conduct." 16 U.S.C. § 1532(19). Take has been defined "in the broadest possible manner to include every conceivable way in which a person can 'take' or attempt to 'take' any fish or wildlife." *Strahan v. Coxe*, 127 F.3d 155, 162 (1st Cir. 1997) (citations omitted). The term "harass" means "an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering." 50 C.F.R. § 17.3. The term "harm" is any act "which actually kills or injures wildlife," including "significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering." 50 C.F.R. § 17.3; *Babbitt v. Sweet Home Chapter of Communities for a Great Oregon,* 515 U.S. 687 (1995) (upholding regulation as reasonable). Therefore, courts have held that the ESA is violated if "significant modification or damage to the habitat of an endangered or threatened species is likely to occur so as to injure that species." *U.S. v. Town of Plymouth*, 6 F. Supp. 2d 81, 90 (D. Mass. 1998) (citing *Tennessee Valley Authority v. Hill*, 437 U.S. 153, 172 (1978)); *see Environmental Prot. Info. Ctr. v. The Simpson Timber Co.*, 255 F.2d 1073, 1075 (9th Cir. 2001) ("Eliminating a threatened species' habitat thus can constitute 'taking' that species for purposes of section 9 [of the ESA].") Similar to the ESA, the CESA prohibits "take" of any State-listed threatened or endangered species. Cal. Fish & Game Code § 2080. California defines take as "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill." *Id.* at § 86.

Government agencies, like the Regional Board, violate the ESA's take prohibition when they authorize others to undertake activities that cause take. "The statute not only

[8] Regardless, we request that the Regional Board revise the language to remove any suggestion that the permit could authorize a take under the ESA or CESA.

prohibits the acts of those parties that directly exact the taking, but also bans those acts of a third party that bring about the acts exacting a taking." *Strahan*, 127 F.3d at 163 (Massachusetts' commercial fishing regulatory scheme violated the ESA because the issuance of licenses to fishermen to use gillnets and lobster pots would likely take endangered whales); *see also Sierra Club v. Yeutter*, 926 F.2d 429, 438-39 (5th Cir. 1991) (Forest Service caused take of endangered red-cockaded woodpeckers because its authorization of a timber management plan would allow timber companies to clear-cut critical habitat and thus take the species); *Plymouth*, 6 F. Supp. 2d 81 (town of Plymouth's decision to allow off-road vehicles to drive on beach would cause take of threatened piping plovers unless appropriate precautions were taken). The CESA's take prohibition would also apply to the Regional Board. *See Watershed Enforcers v. Department of Water Resources*, 185 Cal. App. 4th 969, 988 (2010) ("In any event, express statutory language supports the application of section 2080 to state agencies."). Therefore, the Regional Board's act of authorizing Sacramento Regional to continue discharging wastewater that directly or indirectly injures or kills delta smelt, salmon, or steelhead would itself violate the ESA and CESA.

The Delta provides critical habitat for many species listed under the ESA. The area of the SRWTP's discharge—in the Sacramento River at a point just south of the Freeport Bridge—is within the designated critical habitat for the delta smelt.[9] As the United States Fish and Wildlife Service (FWS) has found, the location of the SRWTP's discharge is "just upstream of where delta smelt have been observed to congregate in recent years during the spawning season." Smelt BiOp, *supra* at n.1, at 245. The FWS listed the delta smelt as a threatened species[10] in 1993 and designated critical habitat for the smelt in 1994. *See* 58 Fed. Reg. 12854 (March 5, 1993); 59 Fed. Reg. 65256 (Dec. 19, 1994). At the same time, a growing number of scientific studies show that the SRWTP's historic and ongoing discharges, particularly of ammonia, are causing acute and/or chronic toxicity to delta smelt and causing significant habitat modification and degradation that is harming the delta smelt's food sources and otherwise injuring and killing members of the species.

The Tentative Permit would authorize take by permitting Sacramento Regional's discharge to contain ammonia levels—for another decade—that will cause increased injury and death to the delta smelt. Ammonia concentrations downstream of the SRWTP regularly exceed accepted toxicity criteria for the protection of aquatic life. At current levels, the ammonia in the SRWTP's discharges is causing acute and/or chronic toxicity to delta smelt, in violation of the take prohibition. The Tentative Permit's interim limits would

[9] It is also critical habitat for four other listed fish species: the winter- and spring-run Chinook salmon (Oncorhynchus tshawytscha), steehead (O. mykiss), and green sturgeon (Acipenser medirostris).

[10] Threatened species are defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." 16 U.S.C. § 1532(20). Endangered species are those which are "in danger of extinction throughout all or a significant portion of its range." 16 U.S.C. § 1532(6).

allow this level of ammonia discharge to continue and, potentially more than double over the next ten years. As the tentative permit recognizes, the research of Dr. Inge Werner, et al. shows that delta smelt are acutely sensitive to ammonia and that the concentrations are of concern with respect to chronic smelt toxicity because of the higher pH values that were measured during the study. Tentative Permit at K-2 n.1. In fact, Dr. Werner's research demonstrated that the long-term average concentrations of ammonia/um downstream of the SRWTP already exceed the acute to chronic toxicity ratios in the Sacramento River. The extensive research of Johnson, Teh, Parker, et al., Glibert, Kendall, Slaughter and Kimmerer, Cloern and Dufford, Wilkerson, et al., Dugdale, et al., Sommer, et al., Marchi, Lehman, and others further demonstrates the impacts being caused by the discharge. *See* Water Agencies Comments.

The tentative permit would also authorize take by allowing "significant habitat modification or degradation" that will injure and/or kill members of the threatened delta smelt species, in violation of the take prohibition. As explained in the Water Agencies' Comments, the SRWTP's ammonia/um discharge is adversely affecting the pelagic food web, which is a significant factor in the pelagic organism decline. The discharge substantially alters the ratio of nitrogen and phosphorus (the "N:P ratio") in the Sacramento River and the Bay-Delta. These discharges degrade the aquatic ecosystem that would otherwise exist and impair aquatic life-related beneficial uses throughout the Bay-Delta.

Specifically, increases in ammonia change the nutrient ratios and (1) inhibit phytoplankton primary production; (2) shift the speciation of algal communities from nutritious species to less desirable species; and (3) create conditions favorable for the spread of invasive species and unfavorable for native species. A growing body of scientific evidence demonstrates that these conditions will significantly impair essential behavioral patterns, such as feeding, and thus injure or kill individual delta smelt. For example, as the tentative permit again recognizes, studies by Dr. Teh show that the ammonia from the SRWTP is causing acute toxicity and possibly chronic toxicity to *Eurytemora affinis* and *Pseudodiaptomus fobesi*, which are an important food source for larval and juvenile delta smelt. *Id.* at K-2 n.3. In addition, the shift in the algal community from nutritious species such as diatoms to less desirable forms like *Microcystis* is also disrupting the delta smelt's behavioral patterns. *See* Water Agencies' Comments.

The recent work of Dr. Patricia Glibert of University of Maryland also shows the relationship between the ammonia/um discharged from the SRWTP and actual injury to the smelt. Glibert found that variations in the nutrient composition of the Treatment Plant's discharges were highly correlated to the variation in nutrient concentrations in the receiving waters. These nutrient variations are, in turn, related to variations in the base of the food web, primarily the composition of algae, to variations in the composition of zooplankton, and to variations in the abundance of several fish species.[11]

The fact that nutrient ratios materially impact the underlying food web is well established in the scientific literature studying ecosystems here and around the world. In fact, the N:P ratio has specifically been shown to influence phytoplankton composition and the presence – or absence – of native species and vegetation. Extensive studies have repeatedly demonstrated this relationship in study after study across a range of systems in the United States – such as in Florida, Michigan, North Carolina, Tampa, and Washington DC – and around the world – in Denmark, Germany, Hong Kong, Japan, Korea, Norway, Spain, and Tunisia. *See* Water Agencies Comments (citing scientific literature).

Thus, the decline in delta smelt and several other fish species abundance are ultimately related to the ammonia/um loadings from Sacramento Regional's discharge. These injuries to the delta smelt and other listed species constitute a take under the ESA. *Cf. e.g. Forest Conservation Council v. Rosboro Lumber Co.*, 50 F.3d 781 (9th Cir. 1995)(allegations that proposed clearcutting was reasonably certain to injure Northern spotted owls by significantly impairing their essential behavioral patterns were actionable under the ESA). The SRWTP's discharge thus causes significant modification or degradation to the delta smelt's habitat in violation of the ESA. *See* 50 C.F.R. § 17.3.

Notably, even if the affect of an action on habitat will not result in the take of individuals of the species, the courts have held that the ESA is violated if the action would jeopardize the survival of a listed species, or if the action appreciably diminishes the value of critical habitat for the recovery of the listed species. *See Gifford Pinchot Task Force v. U.S. Fish & Wildlife Serv.*, 378 F.3d 1059, 1069-70 (9th Cir. 2004); *Sierra Club v. U.S. Fish & Wildlife Serv.*, 245 F.3d 434, 441-42 (5th Cir. 2001). The ESA is enacted not merely to forestall the extinction of species, but also to allow species to recover to the point where they can be delisted. *Gifford Pinchot*, 378 F.3d at 1070. Advanced nutrient removal has proven effective at restoring native systems in areas that had been impacted by nutrient discharges from large wastewater treatment plants, such as Tampa Bay and the

[11] Glibert, P., "Long-term changes in nutrient loading and stoichiometry and their relationships with changes in the food web and dominant pelagic fish species in the San Francisco Estuary, California," *Reviews in Fisheries Science* (2010); Glibert, P. , "Changes in the quality and quantity of nutrients over time and the relationships with changes in phytoplankton composition." Oral Presentation at 6th Biennial Bay-Delta Science Conference, Sacramento, CA, September 27-29, 2010; Glibert, P., "Nutrients and the food web of the Bay Delta," Oral Presentation to the National Academy of Sciences Committee on Sustainable Water and Environmental Management in the California Bay-Delta, Sacramento, CA, July 13, 2010; Glibert, P., C.A. Heil, D. Hollander, M. Revilla, A. Hoare, J. Alexander, S. Murasko, "Evidence for dissolved organic nitrogen and phosphorous uptake during a cyanobacterial bloom in Florida Bay," *Mar. Ecol. Prog. Ser.* 280:73-83 (2004); Lomas, M.W. and P.M. Glibert, "Temperature regulation of nitrate uptake: A novel hypothesis about nitrate uptake and reduction in cool-water diatoms," *Limnol Oceanogr* 44:556-572 (1999); Lomas, M.W. and P.M. Glibert, "Interactions between NH_4 and NO_3 uptake and assimilation: comparison of diatoms and dinoflagellates at several growth temperatures," *Marine Biology* 133:541-551 (1999).

Chesapeake Bay. *See* Water Agencies' Comments. As Dr. Glibert has concluded, reduction of the ammonium effluent into the Delta "is essential to restoring historic pelagic fish populations," like the delta smelt. *See* Glibert, P., "Long-Term Changes In Nutrient Loading and Stoichiometry and Their Relationships With Changes In The Food Web and Dominant Pelagic Fish Species in the San Francisco Estuary, California," *Reviews in Fisheries Science* (2010).

The Tentative Permit would also authorize take of delta smelt, salmon, and steelhead by allowing exceptions from the Thermal Plan. These exceptions would allow temperatures that could be fatal to delta smelt and salmon, and, even if not fatal, could significantly degrade the habitat such that the temperature would harm or harass them or interfere with the timing of spawning. It is well established that endangered delta smelt spawn just downstream of Sacramento Regional's outfall. As NOAA's National Marine Fisheries Service noted in its biological opinion regarding the endangered delta smelt, the Sacramental Regional "discharge places it upstream of the confluence of Cache Slough and the mainstem of the Sacramento River, a location just upstream of where delta smelt have been observed to congregate in recent years during the spawning season."[12] *See also* Water Agencies' Comments *and* Water Agencies' June 1, 2010 Issue Paper Comments at 24-26. The proposed Thermal Plan exemption, however, would allow temperatures to rise to levels lethal to delta smelt, salmon, and steelhead and could have chronic impacts on their essential behavioral patterns, such as the timing of spawning and migration. *See* Entrix, R. Thomson & J. Baldrige, *Review of the Sacramento Regional Wastewater Treatment Plant's (SRWTP) Tentative Order and Thermal Exemption Technical Report's Temperature Impact on Delta Smelt* (Oct. 6, 2010); Cramer Fish Science, S. Cramer, P. Gaskill & J. Vaughan, *Impact of Sacramento Regional Wastewater Treatment Plant, Effluent Discharges on Salmonids Technical Review Report* (September, 2010) (attached). The technical reviews explain that the thermal effect of the SRWTP discharge could have adverse effects on the physical habitat for delta smelt, salmon, and steelhead that could render spawning conditions unsuitable, on water quality conditions that could negatively affect all life stages, and/or on river flow that could inhibit larval and juvenile transport and adult migration. *Id.*[13]

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[12] Smelt BiOp, *supra* at n.1, at page 245.

[13] To our knowledge, neither Sacramento Regional nor the Regional Board has received a Section 10 permit under the ESA that would authorize any such take. Nor have they received an incidental take permit under California law. Moreover, it does not appear that any Federal agency has consulted with the Fish and Wildlife Service or the National Marine Fisheries Service over the impacts of the discharges, despite an apparent obligation to do so. The U.S. Army Corps of Engineers (Corps) likely had an obligation to consult on the impacts of the SRWTP's discharge on listed species, under Section 7 of the ESA. Because the Sacramento River is a navigable water, the Corps is required by Section 10 of the Rivers and Harbors Act to issue permits to sources—like the SRWTP—that install devices, *e.g.* the SRWTP's outfall diffuser, that may interfere with its navigation. *See* 33 U.S.C. § 403; 33 C.F.R. Part 322, 325. The issuance of a Rivers and Harbors Act permit is a Federal action that triggers the Corps' duty to consult under Section 7 of the ESA. Therefore, the

B. The Regional Board Should Revise The Tentative Permit And Address The Continued Take Of Endangered Species.

The Board should revise the Tentative Permit to address the continued take of endangered species. Foremost, we urge the Board to remove the interim limits and 10-year compliance schedule from the final permit, and remove the exclusion from the Thermal Plan. Instead, the permit limits for Ammonia Nitrogen in Table 6 of the Tentative Permit should be final limits that are effective immediately upon issuance of the final permit. Contemporaneous with issuing the permit, the Regional Board should issue a Cease and Desist Order to address permitting and construction of nutrient removal and the interim limits that would govern until the work is completed. Again, this change is particularly necessary because Sacramento Regional proposes to increase discharges and has no plan to minimize or mitigate for any of those discharges. We further urge the Regional Board to use the following framework in developing the Order:

- An expedited schedule to construct full nutrient removal should be established. There are options available to Sacramento Regional that potentially could accomplish full nutrient removal more expeditiously -- and at a lower cost -- than contemplated by the Tentative Permit. *See* Water Agencies' Comments (citing Trussell Technologies, October 2010). We urge the most expedited schedule be adopted reflecting the ongoing take of species from the continued discharge.

- The dramatic increase in ammonia concentration and ammonia loadings above current levels that are proposed in the Tentative Permit must not be adopted. The Tentative Permit sets an interim daily limit of 45 mg/L and a mass limit of almost 68,000 pounds per day. The daily mass limit – which equates to almost 34 tons per day – would allow the Discharger *more than double* its current discharge, which is generally in the range of 14 tons per day.[14] This limit was based on the *maximum* concentration measured on *one single* day out of nearly 1,000 measurements over the last 9 years. That is not a reasonable limit to govern this Treatment Plant for the next decade, when the daily average for ammonia over the same time period was 23 mg/L.

Corps had an obligation to consult at the time it issued any Rivers and Harbors Act permit and to reinitiate consultation if "new information [has since] reveal[ed] effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered." 50 C.F.R. § 402.16(b). To the extent that the SRWTP does not have a current Rivers and Harbors Act permit, that would be a separate violation of law.

[14] To put this proposal in perspective: the amount of ammonia in the current discharge is the equivalent of 64 1,000-gallon tanker trucks dumping household ammonia into the Sacramento River every day. To allow the discharge to increase to as much as 34 tons per day would be like allowing as many as 150 1,000-gallon tanker trucks to dump ammonia into the river.

- There should be an Interim Measures Plan developed and approved by the Regional Board, with public input. SRWTP should be directed to submit an Interim Measures Plan within 60 days that would propose interim measures to reduce the mass of total ammonia/um and nitrogen loadings in the effluent until the full nitrification and denitrification are completed. There are available options available to accomplish interim reductions, including sidestream treatment and expanded use of Sacramento Regional's recycled water program. *See* Water Agencies' Comments (citing Trussell Technologies, October 2010). The Plan should be made available to the public for comment. Sacramento Regional should have the burden to show that it could not achieve the required reduction.

- Interim concentration and mass limits should be set that reflect the ongoing harm being caused by Sacramento Regional's discharge. The Regional Board should impose interim limits that are the lowest feasible limits for ammonia/um and nitrogen. In no respect should the Treatment Plant be permitted to increase its mass total ammonia/um and nitrogen loadings beyond the current monthly average discharge.

- The interim limits should include weekly and monthly average mass loading and concentration limits for ammonia. It is common for dischargers like Sacramento Regional to not only have a daily effluent concentration limit, but to also have either a weekly and/or 30-day average discharge limit. That affords some flexibility to the discharger in the event that an issue arises that causes an unforeseen change in the discharge on a particular day, but ensures that overall, the system is operated to ensure the maximum possible reductions. The mean monthly average over last 9 years is 22 mg/L. The Regional Board should set a monthly concentration that is as protective as possible for River and the Bay-Delta, but in all events the monthly concentration limit should not exceed the historic average.

- The interim limits should also specifically include daily, weekly and monthly mass loading and concentration limits for total nitrogen. Currently, the Tentative Permit only set interim daily limits on ammonia. A mass loading limit on total nitrogen should be established to prevent further degradation of the N:P ratio in the effluent and thereby reduce the ongoing harm from the discharge.

- The Regional Board should include sufficient monitoring of each ammonia/um and nitrogen limit. Sufficient daily monitoring should be required to determine whether the Plant is in compliance with the ammonia/um and nitrogen loadings and concentration limits. Further, the monitoring should be representative of the discharge, which can vary at different times during the day.

- The Regional Board should include a schedule for implementing the required measures to address the temperature of the discharge. Again, we urge the most expedited schedule be adopted reflecting the ongoing take of species from the continued discharge.

III. The Tentative Permit Would Fail To Properly Implement The Antidegradation Policy.

NPDES permits must include technology-based effluent limitations, as well as any more stringent limitations necessary to meet water quality objectives. Cal. Wat. Code, §§ 13170, 13170.2, 13240-13247. State water quality objectives must include an antidegradation policy. *See* 33 U.S.C. § 1313; 40 C.F.R. §§ 131.6, 131.12. The SRWTP's discharge must meet the requirements of 40 C.F.R. § 131.12 and California's antidegradation policy, set forth in State Water Resources Control Board Resolution No. 68-16 (Oct. 28, 1968).[15] Because Resolution No. 68-16 is a state water quality policy, it is enforceable under California Water Code § 13301.

The existing discharge is already degrading the receiving waters: the Sacramento River and Bay-Delta. *See* Tentative Permit at F-91 and Table F-19. These are high quality waters of exceptional recreation, economical, and ecological significance to the people of California. Tentative Permit at F-91. Therefore, to comply with the antidegradation policy in State Water Board Control Board Resolution No. 68-16,[16] the SRWTP must use the "best

[15] The Antidegradation Policy is available at www.swrcb.ca.gov/board_decisions/adopted_orders/resolutions/1968/rs68_016.pdf. *See also* State Water Resources Control Board, Anti-degradation Policy Implementation for NPDES Permitting, Administrative Procedures Update No. 90-004 (July 2, 1990), *available at* http://www.swrcb.ca.gov/water_issues/programs/npdes/docs/apu_90_004.pdf; EPA, *Water Quality Standards Handbook: Second Edition* at Ch. 4 (1997, select sections revised 2007), *available at* http://www.epa.gov/waterscience/standards/handbook.

[16] Resolution No. 68-16 protects high quality surface waters, like the Sacramento River, from degradation. Reductions in water quality are allowed only if the changes are (1) consistent with maximum benefit to the people of the state, (2) do not unreasonably affect present and anticipated beneficial uses, and (3) do not result in water quality less than applicable water quality objectives. Any activity that can lower the quality of high quality waters must comply with waste discharge requirements that "will result in the best practicable treatment or control of the discharge necessary" to prevent pollution and nuisance and to maintain "the highest water quality consistent with maximum benefit to the people of the State."

practicable treatment or control" (BPTC). As the tentative permit correctly finds (*id.* at F-91-F-92), BPTC includes implementation of nitrification and denitrification to remove ammonia/um and nitrogen from the sewage and tertiary filtration, and Westlands and the Authority support these findings. Ammonia removal is the appropriate BPTC to respond to the discharge's significant water quality degradation to aquatic life uses, including acute and chronic toxicity, depletion of dissolved oxygen, and water quality problems. *E.g. id.* at F-92.

In contrast, the tentative permit's interim limits would allow discharges that further impair water quality.[17] The tentative permit sets an interim daily limit of 45 mg/L and a maximum daily limit 67, 929 lbs/day, which is more than double the plant's current discharge. Tentative Permit at 15. Given the finding that the SRWTP's discharge is degrading the receiving waters at its current levels, any interim limits that allow increased levels of ammonia would necessarily result in a violation of the antidegradation requirements. The Regional Board should reject the proposed interim daily maximum limit on that basis alone.

Moreover, BPTC certainly cannot be a *lesser* degree of treatment or control than is in place today. In determining BPTC, State Water Board Order WQ 2000-07 directs that the "water quality achieved by other similarly situated dischargers and the methods used to achieve water quality" should be considered. Tentative Permit at K-11. Here, similarly-situated waste treatment facilities have already been issued permits that require a form of the nitrification/de-nitrification technology that would be required under the tentative permit. Some two dozen wastewater treatment plants, including Stockton, Roseville-Dry Creek, Manteca, Tracy, Roseville-Pleasant Grove, Vacaville, Woodland, Lodi, Davis, Brentwood, Discovery Bay, Turlock, Mountain House, Olivehurst, Linda County Water District, Galt (tentative permit), El Dorado Irrigation District – El Dorado Hills, El Dorado Irrigation District – Deer Creek, Grass Valley, Placerville, Placer County Sewer Maintenance District, Auburn, Live Oak (tentative permit), Willows, and Rio Vista – Northwest all have nitrification/de-nitrification requirements. *See* Table (attached); see *also* Tentative Permit at K-9-K-10. In addition, as noted, measures are available to reduce ammonia loading in the near term.

As such, and for the reasons further described in the Water Agencies' Comments, full nitrification and denitrification is clearly BPTC. We urge the Regional Board to require the Sanitation District to implement BPTC as soon as possible and to cap interim ammonia/um limits, at most, at the SRWTP's current levels.

[17] The tentative permit also fails to require temperature controls despite significant thermal impacts on aquatic life, including threatened and endangered species. *See* Water Agencies' Comments. Westlands and the Authority urge the Water Board to require temperature control as the BPTC in the final permit.

IV. The Alternative "Permitting Options" Would Not Be Protective Of The Bay-Delta And Cannot Be Adopted Without The Board Proposing A New Tentative Permit.

The Regional Board staff has also proposed a number of permitting options for public review and consideration, including alternatives for ammonia removal and nitrate removal. Tentative NPDES Permitting Options at 4-10.

The ammonia removal alternatives would not protect the waters and habitat in the Bay-Delta. No ammonia treatment (Ammonia Removal Alternative 1) – essentially allowing Sacramento Regional to do nothing – would further degrade water quality in the Bay-Delta. Partial nitrification (Ammonia Removal Alternative 2) is likewise not a viable solution, as the remaining ammonia loadings would not fully re-adjust the N:P ratio. Recent modeling of these options by Dr. Dugdale's research team confirms that partial nitrification would not avoid the continued impacts on water quality, algal growth, the food web, and aquatic life. *See* Water Agencies' Comments.

Regardless, the Tentative Permit has not detailed a sufficient justification or outlined the factual bases for the alternatives, which are dramatically different from the limitations and requirements proposed in the Tentative Permit and that were documented in the draft Attachments. Therefore, we submit that these alternatives would not be ripe for any final action by the Regional Board. In this regard, Westlands and the Authority join the concerns expressed by the State Water Contractors on this topic. *See* Letter of State Water Contractors to the Central Valley Regional Board (Sept. 10, 2010). If, for example, the Regional Board were inclined to adopt a permit that did *not* provide for full nitrification/de-nitrification, the Regional Board should re-propose the tentative permit for public participation and adjudication.

Under California law, administrative decisions, such as the SRWTP permit renewal, need to be "supported by the findings" and the findings need to be "supported by the evidence." Cal. Civil Proc. Code § 1094.5. Indeed, it is a basic principle of administrative law that an agency must provide an explanation for its decision that includes "a 'rational connection between the facts found and the choice made.'" *Motor Vehicle Mfrs. Ass'n v. State Farm Mut. Automobile Ins. Co.*, 463 U.S. 29, 43 (1983) (*quoting Burlington Truck Lines, Inc. v. United States*, 371 U.S. 156, 168 (1962)).

As such, if the Regional Board were inclined to consider one of the alternative permitting options proposed by the staff, the Regional Board has the legal obligation to publish a new tentative permit along with what the Board believes are the supporting documentation, and to allow for an additional adjudication on that proposal. While the final permit need not be identical to the tentative permit, the dramatic differences in the alternatives outlined by Board staff from the tentative permit would require a further proceeding. *Natural Resources Defense Council v. EPA*, 279 F.3d 1180, 1186 (9th Cir.

2002) (citing *NRDC v. EPA*, 863 F.2d at 1429 (9th Cir. 1988))(analyzing the adequacy of EPA's notice of and opportunity to comment on a NPDES permit).

Very truly yours,

Very truly yours,

SAN LUIS & DELTA-MENDOTA WATER AUTHORITY

Dan Nelson, Executive Director

WESTLANDS WATER DISTRICT

Thomas W. Birmingham, General Counsel

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ATTACHMENT 1

UNITED STATES DISTRICT COURT

FOR THE EASTERN DISTRICT OF CALIFORNIA

The Consolidated Delta Smelt Cases	1:09-CV-00407 OWW DLB 1:09-cv-00480-OWW-GSA 1:09-cv-00422-OWW-GSA 1:09-cv-00631-OWW-DLB 1:09-cv-00892-OWW-DLB FINDINGS OF FACT AND CONCLUSIONS OF LAW RE PLAINTIFFS' REQUEST FOR PRELIMINARY INJUNCTION AGAINST IMPLEMENTATION OF RPA COMPONENT 2 (a/k/a Action 3)(Doc. 433)

I. INTRODUCTION

Plaintiffs, San Luis & Delta Mendota Water Authority (the "Authority") and Westlands Water District ("Westlands"), move for a preliminary injunction ("PI") against the implementation of Reasonable and Prudent Alternative ("RPA") Component 2 set forth in the United States Fish and Wildlife Service's ("FWS") December 15, 2008 Biological Opinion, which addresses the impacts of the coordinated operations of the federal Central Valley Project ("CVP") and State Water Project ("SWP") on the threatened delta smelt (*Hypomesus transpacificus*) ("2008 adaptive management and additional analyses that permit regular review and adjustment of strategies as knowledge improves." 4/2/10 Tr. 195; BiOp at 279 ("[t]he specific flow requirements, action triggers and monitoring stations prescribed in the RPA will be continuously monitored and evaluated consistent with the adaptive process. As new information becomes available, these action triggers may be modified without necessarily requiring re-consultation on the overall proposed action.").

109. Although the record shows that FWS's -5,000 OMR ceiling is not based on the best available science, the record does not contain sufficient information to conclude that the imposition of Plaintiff's suggested -5,600 OMR ceiling would be sufficiently protective of the smelt, particularly in light of the fact that Plaintiffs do not propose any flexibility in the management regime that would permit greater restrictions if a large salvage event was approaching or ongoing.

110. Providing flexibility to permit adaptive management for delta smelt is justified.

D. <u>Irreparable Harm.</u>

111. The record evidence has established a variety of adverse impacts to humans and the human environment from

reduced CVP and SWP deliveries, including irretrievable resource losses (permanent crops, fallowed lands, destruction of family and entity farming businesses); social disruption and dislocation; as well as environmental harms caused by, among other things, increased groundwater consumption and overdraft, and possible air quality reduction.

(1) <u>Water Supply Impacts.</u>

112. Any lost pumping capacity directly attributable to the 2008 Smelt BiOp will contribute to and exacerbate the currently catastrophic situation faced by Plaintiffs, whose farms, businesses, water service areas, and impacted cities and counties, are dependent, some exclusively, upon CVP and/or SWP water deliveries.

113. Every acre-foot of pumping foregone during critical time periods is an acre-foot that does not reach the San Luis Reservoir where it can be stored for future delivery to users during times of peak demand in the water year.

114. It is undisputed that, in the three water years prior to the 2009-2010 water year, California has experienced three consecutive years of drought conditions. Gov't Salmon Ex. 5 at (internal) Exhibit 1 at 18. This influences the amount of run-off forecasted

for 2010 and is indicative of why reservoir storages were at a low state entering the 2009-2010 water year. 4/1/10 Tr. 208:7-15. Hydrologic conditions are not within the control of the parties and have materially contributed to water service reductions to contractors.

115. It is also undisputed that other, non-project factors, such as tides, wind events, storm surges, San Joaquin River flows, Contra Costa Water District operations, and diversions by in-Delta water users effect how Reclamation must operate the project to meet flow targets. *See id.* at 202:12-204:1.

116. The projects are subject to export reductions required to protect species listed under the California Endangered Species Act, including longfin smelt, delta smelt, winter-run Chinook salmon, and spring-run Chinook salmon, which subject the water project operators to controls under state law that are similar, and, in some cases, identical to those contained in the 2008 Smelt BiOp and the National Marine Fisheries Service's ("NFMS") June 4, 2009 Biological Opinion ("2009 Salmonid BiOp") concerning various ESA-listed anadromous and oceanic species. *See id.* at Tr. 212:4-213:8. In the absence of the BiOps' RPAs, those protections are argued to have likely limited export pumping to levels below those

allowable under State Water Resources Control Board Decision 1641 ("D-1641"), which also limits Project pumping at certain times of the year. *See, e.g.,* SWC Ex. 938 (DWR's 3/30/10 allocation announcement considered several "SWP operational constraints" including "the incidental take permit for longfin smelt").

117. Plaintiffs' estimates of water losses do not account for or otherwise offset losses attributable to proposed remedies in the consolidated Delta Smelt and Salmon cases. *See* 4/7/10 Tr. 17:10-20:14.

118. The quantity of exportable water has been reduced by the implementation of the Salmonid and Smelt BiOp's RPAs. *Id.* From January 20 through March 24, 2010, Mr. Erlewine testified that potential and actual exports were diminished by 522,561 acre feet ("AF"), of which a 433,000 AF loss was attributable to the SWP and a 89,000 AF loss was attributable to the CVP. 4/6/10 Tr. 185:16-19; SWC Demonstrative Ex. 903.

119. DWR made its initial water supply allocation announcement on November 30, 2009, allocating 5% of Table A contracted amounts for SWP water contractors. 4/6/10 Tr. 240:16-22; SWC Ex. 923, Ex. B. As of March 30, 2010, DWR increased the SWP allocation for 2010 to 20%. 4/6/10 Tr. 189:15-17; SWC Ex. 938; 4/1/10 Tr. 249:22-25. On

April 23, 2010, DWR again increased its allocation of SWP deliveries to 30%. *See* Doc. 323-2 (DWR Press Release).

120. Reclamation announced its initial allocation of CVP water on February 26, 2010. Fed. Gov't Salmon Ex. 5 (Third Milligan Decl.) at ¶11. Under the 90% exceedance forecast, Reclamation allocated CVP agricultural users 5% of their contract amounts, and CVP municipal and industrial ("M&I") contractors 55% of their contract amounts. *Id.* at ¶12. Under the 50% exceedance forecast, north-of-Delta agricultural and M&I contractors were allocated 100% of their contract amounts, while south-of-Delta agricultural contractors were allocated 30% and M&I contractors 75%. *Id.*

121. CVP water users faced similar reductions to their individual allocations. Farmers on the west side of the San Joaquin Valley have received reduced CVP water supply allocations in the 2007-2008, 2008-2009, and 2009-2010 water years, and face similar reductions in 2010-2011. SLDMWA Ex. 153 at ¶3; SLDMWA Ex. 154 at ¶4; SLDMWA Ex. 156 at ¶4. In 2007-2008, Reclamation allocated to Westlands 40% of its contract supply. In 2008-2009, that allocation was 10%. SLDMWA Ex. 155 at ¶8. For the 2009-2010 water year, Westlands was advised the initial allocation was zero percent. SLDMWA Ex. 155 at ¶9.

122. On March 16, 2010, Reclamation raised the allocation for south-of-Delta agricultural users to 25% under a 90% forecast and 30% under a 50% forecast. 4/1/10 Tr. 210:14-22; Fed. Gov't Salmon Exh. 13.

123. These incremental increases do not alter the fact that water deliveries will likely increase further if the two RPAs are enjoined. 4/1/10 Tr. 213:14-20 (acknowledging that deliveries would increase by 5% - 10% if the RPAs were enjoined).

124. The quantity of water lost through pumping reductions translates directly into water losses for urban and agricultural water users. In the SWP service area, one acre-foot of water serves about five to seven people for one year. 4/6/10 Tr. 186:25-187:1-3. An SWP loss of 433,000 AF, if available to urban users, would have supplied approximately 2.6 million people for one year. 4/6/10 Tr. 187:8-11. Seventy-five to eighty-five percent of SWP supply is provided for urban uses, with the remainder provided to agricultural users. 4/6/10 Tr. 187:15-17. The Metropolitan Water District of Southern California alone serves approximately 20 million urban users.

125. Water loss for agricultural users results in reduction in the number of acres that may be sustained

with actual water supply. Water duty is the amount of water that a crop needs per acre for a growing season. 4/6/10 Tr. 187:21-22. DWR information indicates that for the SWP service area, the water duty is approximately three AF per acre. 4/6/10 Tr. 187:22-25. If 433,000 AF were withheld from almond crops, for example, almond production would be reduced by approximately 140,000 acres. 4/6/10 Tr. 188:1-4.

126. Reduced CVP and SWP water supply allocations have increased the cost of supplemental water. Farmers have been forced to purchase supplemental water at drastically increased cost. SLDMWA Ex. 154 at ¶7; SLDMWA Ex. 155 at ¶17; SLDMWA Ex. 156 at ¶6. Since 2007, the cost of securing supplemental water has more than tripled. SLDMWA Ex. 156 at ¶6; SLDMWA Ex. 154 at ¶7. As of January 2010, the cost for buying replacement water for transfer in a dry year is at least $300 per acre foot, plus transportation costs. SLDMWA Ex. 157 at ¶12.

127. Increased water allocations may lessen this increased cost, and will mitigate anticipated harms from reduced water allocations. Farmers anticipate that increased water allocations would mitigate anticipated damage to crops in proportion to the amount of water received and prevent further layoffs of farm employees.

SLDMWA Ex. 156 at ¶10.

128. In 2009, the Federal Defendants accounted for actions taken under the Delta smelt biological opinion as (b)(2) actions, pursuant to section 3406(b)(2) of the CVPIA. 4/1/10 Tr. 213:24-214:2. Federal Defendants have indicated their intent to follow the same accounting procedure for federal export reductions related to both BiOps in 2010, to the extent that (b)(2) assets are available at the time the action is taken. *Id.* at 214:3-7.

(2) <u>Other Resource Impacts Caused or Exacerbated by the 2008 Smelt BiOp RPA Actions.</u>

129. Plaintiffs attribute a number of other human impacts to reductions in the water supply. There is considerable dispute among the parties regarding the extent to which the 2008 Smelt BiOp RPA is responsible for these other impacts. It is undisputed that the RPA is, at the very least, exacerbating the following impacts.

(1) <u>Permanent Crops.</u>

130. Reductions in the quantity of water supply deliveries have resulted in changes to farming practices, including an increased reliance on permanent crops. SLDMWA Ex. 154 at ¶6; SLDMWA Ex. 155 at ¶¶ 18, 22; SLDMWA

Ex. 157 at ¶11.

131. Permanent crops place farmers at greater risk than row crops, as farmers cannot cut back on the water to permanent crops without destroying them. SLDMWA Ex. 154 at ¶6; SLDMWA Ex. 155 at ¶¶ 18, 22; SLDMWA Ex. 157 at ¶11.

(2) <u>Fallowed Lands.</u>

132. Because of reduced water forecasts and uncertainty regarding future water supply, farmers have fallowed hundreds and thousands of acres of fields. SLDMWA Ex. 155 at ¶10; SLDMWA Ex. 153 at ¶3; SLDMWA Ex. 156 at ¶5.

133. Fallowed lands and reduced water supply have caused the loss of thousands of acres of crops. Todd Allen, a third-generation farmer in Fresno County, was able to salvage and harvest only 40 acres of a wheat crop out of a total arable 616 acres on his farm in 2009. SLDMWA Ex. 153 at ¶3.

134. For every 1,000 AF of water lost by the San Luis Plaintiffs' member agencies, approximately 400 acres of land may remain out of production. SLDMWA Ex. 157 at ¶13.

135. Fallowing fields also negatively impacts the air quality of the San Joaquin Valley by increasing dust and

particulate matter. SLDMWA Ex. 155 at ¶20. Reduced air quality in turn impairs major transportation routes through the valley. SLDMWA Ex. 155 at ¶20.

(3) <u>Lack of Access to Credit.</u>

136. The more unreliable the water supply, the more difficult it is for farmers to secure necessary financing for their farming operations. SLDMWA Ex. 153 at ¶4; SLDMWA Ex. 154 at ¶13; SLDMWA Ex. 155 at ¶26; SLDMWA Ex. 156 at ¶7; SLDMWA Ex. 157 at ¶15. In some cases, lenders deny loan applications because of a lack of reliable water supply. SLDMWA Ex. 153 at ¶4; SLDMWA Ex. 154 at ¶13; SLDMWA Ex. 155 at ¶26; SLDMWA Ex. 156 at ¶7; SLDMWA Ex. 157 at ¶15. In others, lenders' concerns about availability to lands irrigated by federally-supplied water has required farmers to make a 50% down payment to secure any loans. SLDMWA Ex. 156 at ¶7.

(4) <u>Social Disruption and Dislocation.</u>

137. It is undisputed that farm employees and their families have faced devastating losses due to reductions in the available water supply. The impact on the farm economy from the combination of a three-year drought and diversion limitations relating to the delta smelt has already been severe. SLDMWA Ex. 157 at ¶14.

138. Lost water supply has decreased the number of

productive agricultural acres, which has resulted in reductions in employee hours, salaries, and positions, devastating farm employees and their families. SLDMWA Ex. 154 at ¶11; SLDMWA Ex. 156 at ¶8.

139. The removal of 250,000 acres from production translates to a loss of approximately 4,200 permanent agricultural worker positions. SLDMWA Ex. 155 at ¶19. Water shortages also cause jobs to be lost in agriculture-related businesses, such as packing sheds, processing plants, and other related services. *Id.* The projected agriculture-related wage loss for the San Joaquin Valley stands at $1.6 billion. *Id.*

140. Dr. Michael, Defendant Intervenors' economist with expertise in regional and environmental economics, counters that "[a]lthough water impacts have affected parts of the west side, there is no evidence that reduced water deliveries have had a severe effect on farm or non-farm employment in the Central Valley as a whole." D-I Exh. 1006 (Michael Decl.) ¶10. Instead, it is a combination of factors, including the three-year drought, the global economic recession, the foreclosure crisis, and the collapse of the real estate market and construction industry, not RPA Component 3, that are mainly driving crop and job losses, food bank needs, and

credit problems in the Central Valley. *Id.* at ¶¶ 6-10. Dr. Michael estimates that ESA-related pumping restrictions have resulted in the loss of less than 2,000 jobs. *See id.* at ¶4.

141. Unemployment has led to hunger on the west side of the San Joaquin Valley. SLDMWA Ex. 158 at ¶8. The Community Food Bank, serving Fresno, Madera and Kings Counties, estimates 435,000 people in its service area do not have a reliable source of food. SLDMWA Ex. 158 at ¶4. The Chief Executive Officer of the Community Food Bank, Dana Wilkie, believes that hunger in the communities served by the Food Bank in the western San Joaquin Valley will continue to increase in 2010 because of ongoing water shortages. SLDMWA Ex. 158 at ¶5. Ms. Wilkie understands that at least 42,000 people served by the Food Bank in October 2009 were employed by farm-related businesses before losing their jobs. SLDMWA Ex. 158 at ¶8.

(5) <u>Groundwater Consumption and Overdraft.</u>

142. Reductions in the available water supply have caused water users to increase groundwater pumping in attempts to make up the difference between irrigation need and allocated water supplies. SLDMWA Ex. 155 at ¶¶ 4, 7; SLDMWA Ex. 157 at ¶10; 4/6/10 Tr. 216:6-7.

143. However, groundwater is not always available, and cannot be used in all areas or for all crops. SLDMWA Ex. 155 at ¶11. Increased groundwater pumping reduces the quality of water applied to the soil by increasing soil salinity. SLDMWA *Id.* at ¶15. Not all fields and crops can be irrigated with groundwater. *Id.* at ¶¶ 11, 15.

144. Increased reliance on and overuse of groundwater has caused groundwater overdraft, which occurs when pumping exceeds the safe yield of an aquifer. *Id.* at ¶12. Overdraft causes increased land subsidence and potential damage to CVP conveyance facilities, *id.* at ¶¶ 12-13, although it is not clear that any subsidence of Project facilities has occurred as a result of the implementation of the 2008 Smelt BiOp RPA Actions, as the only reported incident of subsidence at a SWP conveyance facility predates current implementation, 4/7/10 Tr. 16:1-13.

145. Increased groundwater pumping also increases demand for energy. SLDMWA Ex. 155 at ¶16. Due to the falling water table, wells require increased amounts of energy. *Id.* Westlands estimates that pumping of groundwater in 2009 required approximately 425,000,000 kWh. *Id.* Adverse environmental impacts are associated

with such increased demand for and use of energy. *Id.*

146. Increased groundwater pumping has depleted groundwater reserves. Groundwater reserves that were at 2 million AF in the beginning of 2007 are now less than 900,000 AF. 4/6/10 Tr. 216:21-24. Within MWD's service area, storage levels are at 1.3 million AF, about half of normal storage levels. 4/6/10 Tr. 217:4-8.

(6) Related, Recent Impacts on Naval Air Station Lemoore.

147. Captain James Knapp testified as a fact witness on behalf of Naval Air Station Lemoore, which is located approximately 30 miles south of Fresno, eight miles west of the town of Lemoore, California. 4/7/10 Tr. 208:12-14. Its daytime population is approximately 14,000 people, including residents, who are sailors and dependent families. *Id.* at 208:15-21.

148. The air station's location was selected at a time when the Navy was transitioning from propeller-driven aircraft to jet aircraft, the latter being incompatible with urban environments such as the Naval Air Station Alameda in the San Francisco Bay Area. *Id.* at 211:17-212:21. The air station's 18,000 acres of agriculture-compatible land and neighboring land under permanent agricultural easements help to ensure there will be no urban build-out to interfere with the Navy's

operations. *Id.* at 211:17-212:21, 213:2-19. From its location, the installation supports aircraft carrier activities along the Pacific Coast. *Id.*

149. Active agricultural operations on the air station's 18,000 acres and in the surrounding areas also serve "to control bird and animal strike hazards, grass fires, rodent activity, dust, and the release of Coccidioidomycosis (Valley Fever) spores carried by dust." SLDMWA Ex. 390 at p. 3. These risks are interrelated; for example, fallowed fields attract rodents and predatory birds. 4/7/10 Tr. at 213:10-25. An increased bird presence increases the chances of bird strikes by naval aircraft. *Id.* at 214:1-6.

150. Ongoing agricultural activities are vitally important to the Navy's ability to safely train and support flight operations at Naval Air Station Lemoore. 4/7/10 Tr. at 214:7-24; SLDMWA EX. 390 at p. 2.

151. Lemoore Naval Air Station's principal source of municipal, industrial, and agricultural water is Westlands Water District. 4/7/10 Tr. 208:24-209:2.

152. The past water year began with a zero percent water allocation which increased to a ten percent allocation, resulting in 6,000 acres of fallow fields. SLDMWA Ex. 390 at p. 3. Pilots training at low altitude

witnessed an increase in bird activity, with one aircraft suffering thousands of dollars in damage as a result of a bird strike. *Id.*

43. Captain Knapp testified that Naval Air Station Lemoore had requested and received emergency supplemental water allocations from Reclamation for these properties. *Id.* at 210, 217-18; SLDMWA Ex. 391.

44.This post-record evidence is received for the limited purpose of showing the action agency's ability to respond to conditions that pose imminent harm to the human environment.

(3) **Harm to Species.**

45. To the extent such information is in the record, the potential harms to the species of enjoining Component 2 (Action 3) are discussed above.

VI. CONCLUSIONS OF LAW

A. Jurisdiction.

1. Jurisdiction over claims brought under NEPA exists under 28 U.S.C. § 1331 (Federal Question) and the Administrative Procedure Act ("APA"), 5 U.S.C. § 702 et seq. Jurisdiction over the ESA claims exists under the ESA citizen-suit provision, 16 U.S.C. § 1540(g)(1)(A). Personal jurisdiction over all the parties exists by virtue of their participation in the lawsuit as

ATTACHMENT 2

Review of the Sacramento Regional Wastewater Treatment Plant (SRWTP)

Impact of Tentative Order and Thermal Exception on Delta Smelt

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List of Acronyms

Bay Delta	San Francisco Bay/Sacramento San Joaquin Delta Estuary
° C	degrees Celsius
° F	degrees Fahrenheit
FR	Federal Register
in	inches
mm	millimeters
O_2	oxygen
PCE	primary constituent elements
SRWTP	Sacramento Regional Wastewater Treatment Plant
SRCSD	Sacramento Regional County Sanitation District
USFWS	U.S. Fish and Wildlife Service

Biology and Life History in Brief

The delta smelt is a member of the Osmeridae family (northern smelts)and is a slender-bodied fish, generally about 60 to 70 millimeters (mm) (2 to 3 inches [in]) long, although they can reach lengths of up to 120 mm (4.7 in) (Moyle 2002). They are weakly anadromous pelagic species that inhabit open waters away from the bottom and shore-associated structural features and usually aggregate but do not appear to be a strongly schooling species (U.S. Fish and Wildlife Service [USFWS] 2008). The species is endemic to the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta) and is restricted to the area from San Pablo Bay upstream through the Delta in Contra Costa, Sacramento, San Joaquin, Solano, and Yolo counties (Moyle 2002). Their range extends from San Pablo Bay upstream to at least the City of Sacramento on the Sacramento River, above the Sacramento Regional Wastewater Treatment Plan (SRWTP) (USFWS 2008).

Temperature Preferences

Temperature also affects delta smelt distribution. Swanson and Cech (1995) and Swanson et al. (2000) indicate delta smelt tolerate temperatures from 8 to 25 degrees Celsius (ºC) (46 to 77° Fahrenheit [°F]). However, water temperatures above 25^{o}C can be lethal (Bennett 2005), can restrict their distribution more than colder water temperatures (Nobriga and Herbold 2008), and can constrain delta smelt habitat especially during summer and early fall (Swanson et al. 2000 as cited in Bennett 2005).

Because fish are cold-blooded animals, water temperature, as well as a number of other factors (e.g., fish size, physical state, and pollutants present), influence their oxygen consumption; higher consumption rates occur as metabolic rate increases with increasing temperature (Lenntech website, Van Maaren et al. no date).

Spawning

Delta Smelt undergo a spawning migration from brackish water to freshwater annually (Moyle 2002). In early winter, mature delta smelt migrate from brackish, downstream rearing areas in and around Suisun Bay upstream to freshwater spawning areas in the Delta (USFWS 2008). Spawning occurs primarily in sloughs and shallow edge areas in the Delta and the Sacramento River above Rio Vista. However, since 2003 the highest-density spawning aggregations of delta smelt have been observed in the Cache Slough/Sacramento River Deepwater Ship Channel complex (http://www.delta.dfg.ca.gov/). Spawning may occur from mid-winter through spring (February through June), with most spawning occurring when water temperatures range from about 15-20°C (59-68°F) (Moyle 2002), although spawning may occur at temperatures up to 22°C (71.6°F) with very low hatching success (Bennett 2005). Most adult delta smelt die after spawning (Moyle 2002). Some fraction of the population may hold over as two-year-old fish and spawn in the subsequent year (USFWS 2008).

Predation

The delta smelt compete with and are prey of several native and introduced fish species in the Delta (USFWS 2008). Centrarchid fishes and coded wire tagged Chinook salmon smolts released in the Delta for survival experiments since the early 1980s are thought to prey on larval delta smelt (Brandes and McLain 2001; Nobriga and Chotkowski 2000 as cited in USFWS 2008). The USFWS believes that striped bass are likely the primary predator of juvenile and adult delta smelt given their spatial overlap in pelagic habitats. Studies during the early 1960s found delta smelt were only an occasional prey fish for striped bass, black crappie, and white catfish. More recent studies of predator stomach contents did not find delta smelt (Nobriga and Feyrer 2008). This may be attributed to the fact that the delta smelt is a rare fish for at least the past several decades (Nobriga and Herbold 2008), and it would be expected that delta smelt would be a rare find in predator stomach content analyses.

Delta Smelt Critical Habitat Existing Conditions

The USFWS designated critical habitat for the delta smelt on December 19, 1994 (59 FR 65256). The geographic area encompassed by the designation includes all water and all submerged lands below ordinary high water and the entire water column bounded by and contained in Suisun Bay (including the contiguous Grizzly and Honker Bays); the length of Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma sloughs; and the existing contiguous waters contained within the legal Delta (as defined in section 12220 of the California Water Code) (Federal Register 1994). This definition includes all of the Sacramento River up to the confluence with the American River, which is above the SRWTP.

In designating critical habitat for the delta smelt, the USFWS determined that, "The primary constituent elements (PCEs) essential to the conservation of the delta smelt are physical habitat, water, river flow, and salinity concentrations required to maintain delta smelt habitat for spawning, larval and juvenile transport, rearing, and adult migration." They then went on to define the following (full text is available at http://www.fws.gov/sacramento/es/delta_smelt.htm):

1. **Spawning Habitat**—Delta smelt adults seek shallow, fresh or slightly brackish backwater sloughs and edgewaters for spawning. To ensure egg hatching and larval viability, spawning areas also must provide suitable water quality (i.e., low concentrations of pollutants) and substrates for egg attachment (e.g., submerged tree roots and branches and emergent vegetation).
2. **Larval and Juvenile Transport**—To ensure that delta smelt larvae are transported from the area where they are hatched to shallow, productive rearing or nursery habitat,…. suitable water quality must be provided so that maturation is not impaired by pollutant concentrations. The specific geographic area important for larval transport is confined to waters contained within the legal boundary of the Delta, Suisun Bay, and Montezuma Slough and its tributaries.
3. **Rearing Habitat**—Maintenance of the 2 parts per thousand isohaline according to the historical salinity conditions described above and suitable water quality

(low concentrations of pollutants) within the estuary is necessary to provide delta smelt larvae and juveniles a shallow, protective, food-rich environment in which to mature to adulthood.

4. **Adult Migration**—Adult delta smelt must be provided unrestricted access to suitable spawning habitat in a period that may extend from December to July. Adequate flow and suitable water quality may need to be maintained to attract migrating adults in the Sacramento and San Joaquin River channels and their associated tributaries.

Analysis and Findings

A review of the September 3rd Tentative order for the SRWTP and select supporting documents has resulted in the following issues that would need to be addressed prior to any final Order or Thermal Plan exception being issued or authorized.

Exceptions to the Thermal Plan and Use of a Mixing Zone Negatively Impact Delta Smelt and Their Habitat

The Sacramento Regional County Sanitation District's (SRCSD's) Thermal Plan Exception Justification study (RBI 2010) argues that Section 316(a) of the Clean Water Act allows for the development of thermal effluent limitations less stringent than the Thermal Plan, provided the propagation of a balanced, indigenous aquatic community is protected.

The study was framed to determine whether the Thermal Plan objectives are more stringent than necessary and whether proposed alternative temperature limitations would be adequately protective. The findings of this plan are lacking certain analyses of the effects of temperature that would provide a complete understanding and magnitude of the potential effects of granting such an exception on delta smelt. These analyses are described below.

Temperature Analysis

The SRCSD analyzed the effects of a modified diffuser configuration on the beneficial uses of the Sacramento River and delta (RBI 2007). The report evaluates a number of diffuser configuration modifications, including the current, existing diffuser configuration (25 blocked ports corresponding to a diffuser with 74 open ports). A companion analysis was conducted by Flow Science (2007) and characterized the temperature regime in the plume under the different diffuser configurations. Flow Science did not use DYNTOX or FLOWMOD to conduct their analysis. Rather, they used the 2003 Draft Environmental Impact Report for the Sacramento Regional County Sanitation District Sacramento Regional Wastewater Treatment Plant 2020 Master Plan's thermal impact assessment methodologies and applied a scaling analysis to those results in order to assess the different blocked port scenarios. The modeled results, as shown in Tables 3 and 4 of the RBI (2007) report, depict the scaled thermal impacts associated with the current diffuser configuration (25 blocked ports) and assume a temperature difference of 25°F between the effluent and the ambient river temperature. The time of year this could occur was not specified. The temperature differences between the ambient Sacramento River temperature (measured at Freeport) and the calculated average plume temperature at 60, 175, and 700 feet downstream of the diffuser range from 10.7°F (60 feet downstream of diffuser) to 2.5°F (700 feet downstream of diffuser). The maximum temperature differences between the ambient Sacramento River temperature and the calculated peak plume temperature at 60, 175, and 700 feet downstream of the diffuser were 24.3°F (60 feet downstream of diffuser) to 4.7°F (700 feet downstream of diffuser. Table 1, below, summarizes the results of the RBI (2007) analysis.

Table 1 Modeled Results of Thermal Plume Downstream of Diffuser

Distance Downstream of Diffuser (ft)	Mean Temp Increase due to Effluent (°F) [1]	Maximum Temp Increase due to Effluent (°F) [1]
60	10.7	24.3
175	4.9	12.2
700	2.5	4.7

1. Modeled temperature increases due to effluent taken from RBI (2007) Tables 3 and 4, p. 28.

Note: Modeled condition assumes 25ºF differential between effluent and river temperature.

Effects of Temperature on Delta Smelt Individuals

Direct Mortality

The RBI (2007) modeling indicates an increase of up to 24.3°F at 60 feet downstream of the diffuser (Table 1). However, the analysis does not indicate at which times during the year these thermal conditions would be encountered nor how long they would persist. Consequently, the potential for delta smelt to encounter lethal temperatures within the effluent plume from December through June cannot be quantified. Considering that an increase of 3°F in river temperature due to the discharge during maximal river temperatures in May and June would produce conditions lethal to delta smelt, further investigation is warranted to determine the three-dimensional distribution of monthly mean and maximum river temperatures that are predicted to occur downstream of the diffuser (with field verification) in order to quantify the potential for and extent of temperatures lethal to delta smelt.

Similarly, under the terms of the proposed Thermal Plan exception, when the Sacramento River is 52°F or higher (monthly means in March through November and maximum temperatures in all months, see Table 2), a 25°F temperature differential could elevate temperatures to levels that are lethal to delta smelt. In addition, the mean and maximum water temperatures downstream of the outfall could have chronic impacts such as interference with the timing of spawning and migration and potentially increasing the rate of predation on delta smelt moving past or through the mixing zone plume.

Table 2 Sacramento River Temperature at Freeport from January 1, 1993 to October 31, 2009

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Mean Temp (F)[1]	47.9	49.9	53.9	58	63	67.1	69.2	69.4	67.1	61.6	55	49
Max Temp (F)[1]	52.9	56	63	68	74	74.2	74.7	75	72.6	69.2	61.8	56

[1] Temperature data from RBI (2010) Figure 1, p. 10.

Juvenile and adult delta smelt are poor swimmers with a maximum swimming speed of approximately 28 centimeters/second (cm/sec) (0.9 feet/second) and swim in short bursts followed by a glide (rest period) at swim speeds below 10 cm/sec (Swanson et al. 1998). With such weak swimming abilities, individuals that come in contact with lethal temperatures may not be able to move away to cooler waters.

Interference with Spawning

Delta smelt spawning may occur from mid-winter through spring, with most spawning occurring when water temperatures range from approximately 59-68°F. At Freeport, mean river temperatures are within that range in April through June while maximum river temperatures are suitable for spawning in March and April (Table 2). The current operations of the outfall and use of a mixing zone may result in river temperatures that are not suitable for spawning over an unknown area downstream of the discharge. Again, the potential for encountering problematic spawning temperatures during mid-winter through spring cannot be quantified due to the limitations of existing analyses. Further investigation is warranted to determine the three-dimensional distribution of monthly mean and maximum river temperatures that are predicted to occur downstream of the diffuser (with field verification) in order to quantify the potential for spawning interference due to elevated temperatures.

Increased Predation

The discharge effluent and mixing zone have elevated temperatures that can attract piscivorous species, especially during the winter and early spring when species such as largemouth bass (*Micropterus salmoides*) prefer temperatures above of 65°F. This is evident by the popularity of the discharge location with fisherman, as it is known as a high-quality fishing area by Sacramento River anglers. Species taken include introduced piscivorous species such as the largemouth bass and striped bass (*Morone saxatilis*). The effects of these predators on migrating delta smelt life stages and potential predator-concentrating effects of the plume are unknown and not analyzed within the Tentative Order or the Thermal Plan exception report. Consequently, this warrants further investigation to ensure the proposed operations do not detrimentally affect delta smelt adults, migration routes, spawning locations, or juvenile out migration. The results of these studies should then be considered in the determination of mixing zone allowances to ensure protection of the species.

In addition, the applicant's request for an exception to the Thermal Plan objective that would allow the daily average temperature of the effluent to exceed the daily average natural receiving water temperature by more than 20°F 1 April through 30 September, or by 25°F 1 October through 31 March, should also be subjected to similar predator studies prior to incorporation into the final discharge permit. The study should specifically address the potential effects of the creation of seasonal thermal refugia for non-native piscivores and predator concentrating effects on delta smelt and migratory species. This information is currently lacking in the applicant's Thermal Plan Exception Justification (RBI 2010) document and is needed to assess the effects to the species.

Temperature and Thermal Plume Effects on Delta Smelt and Designated Critical Habitat

The outfall at Freeport is located wholly within the critical habitat of 5 federally-listed species, including the delta smelt. The discharge effluent and mixing zone could result in unsuitable temperatures for delta smelt downstream of the discharge point. The thermal effect on delta smelt designated critical habitat PCEs includes:

1. Physical habitat (Spawning Habitat) — Exact delta smelt spawning habitat is not known, but to ensure egg hatching and larval viability spawning areas must provide suitable water quality (i.e., low concentrations of pollutants) and substrates for egg attachment. Effluent temperatures and thermal plume mixing zone conditions could create unsuitable spawning conditions over an undetermined area downstream of the discharge point for up to the entire delta smelt spawning period.
2. Water — Suitable water quality is needed to support various delta smelt life stages with the abiotic elements that allow for survival and reproduction. Effluent temperatures and thermal plume mixing zone conditions could create unsuitable water quality conditions for all life stages of delta smelt.
3. River flow (Transport) — Larval and juvenile transport would be affected as suitable water quality must be provided within the legal boundary of the Delta to ensure successful transport from the area where they are hatched to rearing or nursery habitat. Effluent temperatures and thermal plume mixing zone conditions could create unsuitable conditions for larval and juvenile transport throughout the mixing zone.
4. River flow (adult Migration) — Adult migration could be affected if the effluent temperatures and thermal plume mixing zone conditions do not allow "unrestricted access" to suitable spawning habitat from December to July because the thermal profile of the mixing zone would not provide suitable thermal conditions.

In addition, the applicant's request for an exception to the Thermal Plan objective would allow the daily average temperature of the effluent to exceed the daily average natural receiving water temperature by 20°F or 25°F. This would result in similar, but potentially greater, impacts to delta smelt critical habitat as detailed in 1 through 4 above. These temperatures would result in water quality that does not meet the requirements under the physical habitat, water, and river flow PCEs. Furthermore, the amount of critical habitat affected by higher temperatures could be increased with the exception.

References

Bennett, W.A. 2005. Critical assessment of the delta smelt population in the San Francisco Estuary, California. San Francisco Estuary and Watershed Science [Internet] 3(2) http://repositories.cdlib.org/jmie/sfews/vol3/iss2/art1.

Brandes, P.L., and J.S. McClain. 2001. Juvenile Chinook salmon abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. In R.L. Brown (ed.), Contributions to the biology of Central Valley salmonids. Fish Bulletin 179, pp 39-137.

Brown, R., and W. Kimmerer. 2002. Delta Smelt and CALFED's Environmental Water Account: A Summary of the 2002 Delta Smelt Workshop. October.

Flow Science, Inc. 2007. Analysis of Water Quality Effects of Modified Diffuser Scenarios, Sacramento Regional Wastewater Treatment Plan. Prepared for the Sacramento Regional County Sanitation District. July.

Federal Register. 1994. Vol. 59, No. 242 / Monday, December 19.

Lenntech. Why oxygen dissolved in water is important. http://lenntech.com/why_the_oxygen_dissolved_is_important.htm. Website accessed on 5 October 2010.

Moyle, P.B. 2002. Inland fishes of California. University of California Press, Berkeley and Los Angeles, California.

Nobriga, M., and F. Feyrer. 2008. Diet composition in San Francisco Estuary striped bass: does trophic adaptability have its limits? Environmental Biology of Fishes 83 (4): 495-503.

Nobriga, M., and B. Herbold. 2008. Conceptual model for delta smelt (*Hypomesus transpacificus*) for the Delta Regional Ecosystem Restoration and Implementation Plan (DRERIP).

RBI. 2007. Sacramento Regional Wastewater Treatment Plant Diffuser Modification Project: Assessment of Effects on Surface Water Quality and Beneficial Uses of the Sacramento River and Delta. Final Report. July

RBI. 2010. Thermal Plan Exception Justification for the Sacramento Regional Wastewater Treatment Plant. July.

Regional Water Board (Central Valley Regional Water Quality Control Board). 2009. The Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board Central Valley Region, Fourth Edition, Revised September 2009 (With Approved Amendments), the Sacramento River Basin and the San Joaquin River Basin. Rancho Cordova, CA.

Sacramento Regional County Sanitation District. 2003. Draft Environmental Impact Report for the Sacramento Regional County Sanitation District Sacramento Regional Wastewater Treatment Plant 2020 Master Plan, Plus Appendices. Prepared by EDAW for the Sacramento Regional County Sanitation District. Control Number 97-PWE-0594, State Clearinghouse Number: 2002052004. August 2003.

Swanson, C., and J.J. Cech, Jr. 1995. Environmental tolerances and requirements of the delta smelt, Hypomesus transpacificus. Final Report. California Department of Water Resources Contracts B-59499 and B-58959. Davis, California. July 20, 1995.

Swanson, C., P.S. Young, and J.J. Cech, Jr. 1998. Swimming Performance of Delta Smelt: Maximum Performance, and Behavioral and Kinematic Limitations on Swimming at Submaximal Velocities. J. Experimental Biology 201: 333-345.

Swanson, C., T. Reid, P.S. Young, and J. Cech, Jr. 2000. Comparative environmental tolerances of threatened delta smelt (*Hypomesus transpacificus*) and introduced wakasagi (*H. nipponensis*) in an altered California estuary. Oecologia 123: 384-390.

State Water Board (State Water Resources Control Board). 2006 (December). Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Division of Water Rights. Sacramento, CA.

State Water Contractors. 2010. Comments on Aquatic Life and Wildlife Preservation Issues Concerning the Sacramento Regional Wastewater Treatment Plant NPDES Permit Renewal, June.

U.S. Fish and Wildlife Service. 2008, Final Biological Opinion for the Long-Term Operational Criteria and Plan (OCAP) of the Central Valley Project and the State Water Project. December.

Van Maaren, C.C., J. Kita, and H.V. Daniels. No Date. Temperature Tolerance and Oxygen Consumption Rates for Juvenile Southern Flounder *Paralichthys lethostigma* Acclimated to Five Different Temperatures. UJNR Technical Report No. 28: 135-140.

ATTACHMENT 3

Impact of Sacramento Regional Wastewater Treatment Plant Effluent Discharges on Salmonids

Technical Review Report
September 2010

Steve Cramer, Phil Gaskill, and Jason Vaughan

Introduction

The Sacramento Regional Wastewater Treatment Plant (SRWTP), owned and operated by the Sacramento Regional County Sanitation District (SRCSD), discharges treated effluent into the Sacramento River near the town of Freeport. These discharges are permitted by the Central Valley Regional Water Control Board (Water Board), with limits placed on volume in million gallons per day (mgd) and on temperature differentials between the effluent and receiving water. The SRCSD is requesting exceptions which would allow for increased volumes and temperature differentials (Robertson-Bryan, Inc. 2010). In support of this request, the SRCSD has submitted various reports which conclude that both current and projected operations pose little threat to a balanced, indigenous aquatic community in the Sacramento River.

The purpose of this report is to evaluate the current and projected impact of effluent discharge on salmonids present in the Sacramento River, with a particular focus on potential acute and chronic effects from elevated temperatures and reduced dissolved oxygen. Two questions of central importance are:

1) Is there an intersection in time and space between adverse conditions created by the presence of effluent and significant numbers of salmonids likely to be affected by those conditions?
2) Do such adverse conditions have the potential to significantly impact salmonid survival?

Intersection of Adverse Conditions and Salmonids

The timing of juvenile Chinook passage through the Delta, and thus their times of potential exposure to the SRCSD effluent at Freeport, follows consistent seasonal patterns across years. As explained below, the timing and environmental circumstances of these migrations indicate that risks they face from elevated temperatures and reduced DO would likely be greatest during April through mid June. Juvenile steelhead primarily migrate during the same period. For the sake of brevity, the below analysis of salmonid passage through the Delta will focus on juvenile Chinook.

Roughly 90% of juvenile Chinook in the Central Valley are fall run, and the majority of these juveniles pass through the Delta as smolts migrating directly to the ocean from mid March to mid June, with peak abundance during mid-April to mid-May (Figure 1; Table 1). The emigration time of juvenile spring-run and fall-run Chinook both show this peak in mid-April to mid-May (Figure 1). Winter-run juveniles primarily emigrate from December through March. Prior to fall-run juveniles reaching the smolt stage (generally 80-100 mm fork length), there is also a strong downstream movement of newly emerged fry (35-45 mm) in January through early March, and many of these fish are delivered all of the way to the Delta in high flow years (Brandes and McLain 2001) where they then rear until smolting. This is reflected in captures of migrating juveniles by the trawl at Sacramento (Figure 2), and by the numbers of juvenile Chinook captured along shallow channel margins at beach seining stations in the Delta (Table 2). Between the life stages of fry and smolts, juveniles are referred to as parr and are focused on rearing until they reach the smolting size, with limited downstream movement unless prompted to move by competition for space or a sharp increase in flow and turbidity. Thus, presence of the abundant juvenile fall Chinook in the Delta progresses from fry arriving in mid to late winter in conjunction with sharp flow increases, rearing of these fish along the channel margins until reaching smolt size in the spring, and then arrival and passage of smolts through the spring. Migration of juvenile Chinook through the Delta becomes rare during mid June through September. The same timing holds for fall-run juvenile Chinook migrating down the San Joaquin Basin (Williams 2006).

Only a small fraction of juveniles remain in the Sacramento Basin through the summer, principally in the main stem Sacramento above Red Bluff and in the coolest portion of tributaries. These fish that over-summer, plus the late-fall run and winter-run juveniles that emerge as fry during summer in the upper Sacramento River, begin gradually migrating downstream in autumn as temperatures drop, and may be delivered all of the way to the Delta as early as November or December (USFWS 2007). These fish generally depart from the Delta as smolts to enter the ocean during February through April (USFWS 2007), and smolts that have over-wintered in freshwater are referred to as yearling smolts.

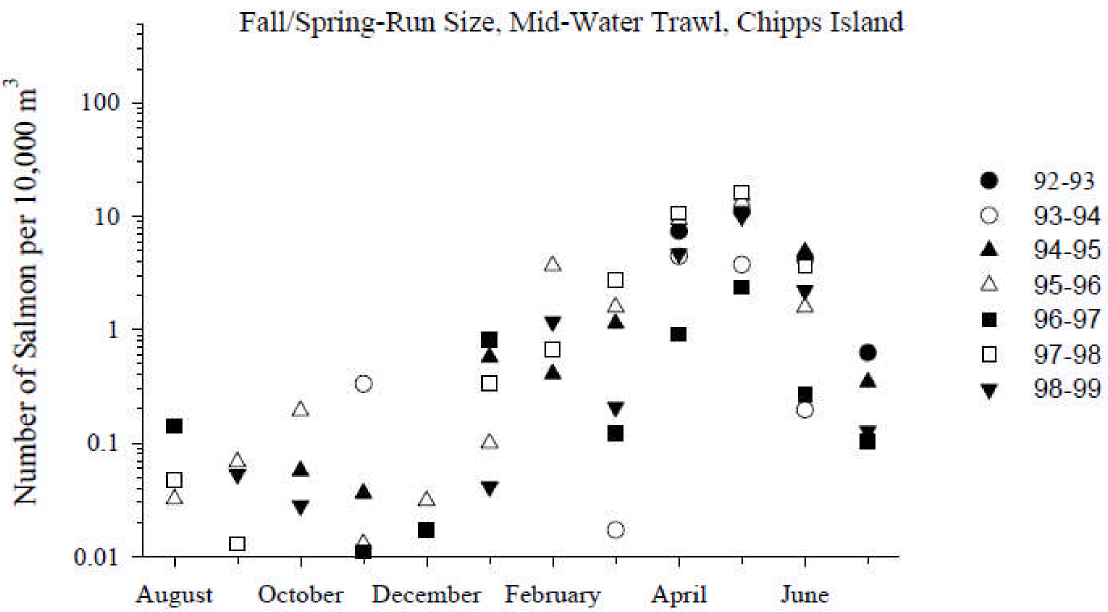

Figure 1. Monthly average capture rates of sub-yearling Chinook in the Chipps Island trawl by USFWS, 1993-1999. These data indicate timing of departure from the Delta. Graph from Williams (2006) based on data from SSJEFRO (2003).

Field Season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly mean (SE)
1993 MWTR	AN	--	0.0182	0	0.0416	0.263	1.80	2.47	2.38	50.9	58.3	8.37	--	12.0 (4.87)
1994 MWTR	C	--	0.0416	0	0.00738	0.0865	2.61	14.1	0.781	93.7	30.8	1.53	--	15.9 (7.75)
1995 MWTR	W	--	0	0	0	0.0861	--	--	18.0	18.1	13.6	4.06	0.293	5.87 (1.74)
1995 KDTR	W	--	--	--	--	0	12.4	8.17	58.80	9.43	--	--	--	14.5 (4.33)
1996 MWTR	W	0.0834	0	0	--	--	--	--	--	31.4	30.8	1.47	0.204	8.96 (3.47)
1996 KDTR	W	--	--	0	0	2.52	32.5	172	18.2	51.2	--	--	--	36.7 (17.2)
1997 MWTR	W	0	0	0	--	--	2.48	0.913	1.67	56.6	13.2	0.881	0.598	9.35 (4.12)
1997 KDTR	W	--	--	0	0.00964	1.22	20.4	4.23	3.33	--	--	--	--	2.27 (0.982)
1998 MWTR	W	0.167	0	0	--	--	--	--	7.35	25.9	19.3	8.77	--	10.0 (3.06)
1998 KDTR	W	--	--	0	0.0129	0.309	72.6	53.0	12.2	--	--	--	--	28.8 (13.1)
1999 MWTR	W	--	--	--	--	0	--	--	5.46	32.8	52.6	2.07	0.140	17.9 (6.88)
1999 KDTR	W	--	0	0	0.0167	0.145	14.5	35.4	4.57	--	--	--	--	8.02 (3.02)
2000 MWTR	AN	0.0643	0	0	--	--	--	--	17.5	55.8	12.2	0.321	0.0212	9.38 (5.23)
2000 KDTR	AN	--	--	0	0	0	12.3	18.6	4.72	--	--	--	--	6.18 (2.06)
Yearly mean 1993-2000 MWTR (SE)		0.0787 (0.0344)	0.00854 (0.00607)	0 (0)	0.0163 (0.0128)	0.109 (0.0553)	2.30 (0.253)	5.83 (4.17)	7.59 (2.76)	45.7 (8.53)	28.9 (6.39)	3.43 (1.19)	0.251 (0.0973)	11.2 (1.40)
Yearly mean 1995-2000 KDTR (SE)		--	0 (0)	0 (0)	0.00785 (0.00340)	0.699 (0.409)	27.5 (9.55)	48.6 (25.8)	16.97 (8.69)	30.3 (20.9)	--	--	--	16.1 (5.60)
2001 MWTR	D	0	0	--	--	--	--	--	0.251	23.5	29.9	0.803	0.930	22.8 (11.8)
2001 KDTR	D	--	--	0	0	0	3.28	40.8	7.01	--	--	--	--	9.34 (4.58)
2002 MWTR	D	0.0605	0.0469	--	--	--	--	--	1.35	33.2	17.0	0.957	0.203	22.1 (14.3)
2002KDTR	D	--	--	0	0.0256	0.857	4.43	14.4	3.66	--	--	--	--	4.02 (1.90)
2003 MWTR	AN	0	0	--	--	--	--	--	--	48.2	6.25	0.573	0.0455	25.7 (15.1)
2003 KDTR	AN	--	0	0	0	2.90	10.1	10.1	6.15	--	--	--	--	5.06 (1.59)
2004 MWTR	BN	0.0302	0	--	--	--	--	57.8	25.5	83.3	21.0	0.601	0.0508	50.2 (27.3)
2004 KDTR	BN	--	--	0	0	9.50	7.83	22.1	11.8	--	--	--	--	6.80 (2.23)
2005 MWTR	AN	0.0358	0.032	--	--	--	--	--	--	21	49.1	0.939	0.129	28.4 (12.8)
2005 KDTR	AN	--	--	0	0	0.572	1.96	4.44	6.94	--	--	--	--	2.29 (0.762)

Table 1. Summary of subyearling juvenile Chinook per unit effort (fish/m3 x 10-4) in midwater (MWTR) and Kodiak (KDTR) trawls near Sacramento (Sherwood Harbor). Shaded boxes indicate peak monthly CPUE. Water year (CDEC, 2006): AN = above normal; BN = below normal; D = dry; C = critical; W = wet. From USFWS (2007).

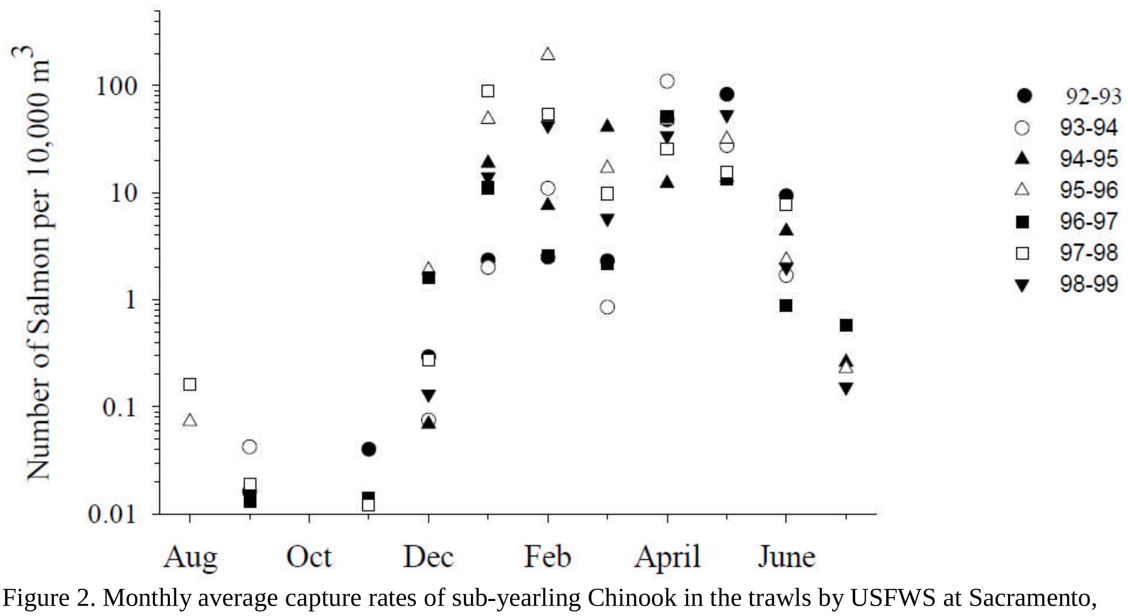

Figure 2. Monthly average capture rates of sub-yearling Chinook in the trawls by USFWS at Sacramento, 1993-1999. These data represent timing of arrival in the Delta. Graph from Williams (2006) based on data from SSJEFRO (2003).

Field Season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly mean (SE)
1993	AN	--	0	0	0	41.6	1320	1630	4960	2670	405	124	--	1240 (346)
1994	C	--	0	0	6.64	36.3	325	4000	1430	496	53.0	2.58	0	723 (150)
1995	W	0	1.93	0	0	31.1	8760	5260	6350	2640	499	65.9	2.81	2560 (876)
1996	W	0	0	0	0	894	3300	9260	5360	1780	327	16.0	8.23	1960 (511)
1997	W	0	0	0	0	1000	2490	2640	2170	886	83.5	5.54	0	961 (206)
1998	W	1.56	0	0	0	60.4	4620	7690	4990	2710	754	121	0	1820 (425)
1999	W	0	0	0	13.6	429	3100	6870	7980	2770	572	51.3	0.855	2080 (495)
2000	AN	0	5.79	0	0	4.42	7340	34400	8970	3840	445	2.24	0	4860 (1640)
Yearly mean 1993-2000 (SE)		0.260 (0.260)	0.543 (0.358)	0 (0)	2.54 (1.78)	312 (148)	3340 (890)	6210 (1260)	4530 (777)	1910 (323)	355 (88.4)	48.4 (18.3)	1.70 (1.16)	2026 (459)
2001	D	0	14.9	12.4	0	1.19	1610	3820	40900	398	64.2	4.93	1.37	21000 (6170)
2002	D	0	0	0	11.2	519	2190	2470	4180	460	212	19	1.67	19600 (5130)
2003	AN	0	0	0	0	420	5150	8430	2240	603	394	33.7	1.02	35700 (11900)
2004	BN	0	0	0	0	1078	4980	6880	6880	1670	389	13.8	0	49200 (10600)
2005	BN	0	0	0	0	181	2060	3840	3810	2530	661	114	3.19	30100 (6230)

Table 2. Summary of subyearling juvenile Chinook per unit effort (fish/m3 x 10-4) by beach seining at interior Delta stations. Shaded boxes indicate peak monthly CPUE. Water year (CDEC, 2006): AN = above normal; C = critical; W = wet. From USFWS (2007).

The timing at which sub-yearling smolts enter the ocean corresponds to the close of the season during which freshwater temperatures have historically been suitable for their growth and survival. Temperatures of the lower Sacramento and San Joaquin generally remain near 10° C through the winter and begin rising in March toward summer highs of 22°-25°C during June through September (Figure 3). The optimum range for growth of juvenile typically ranges from 10°-16°C; they begin to die from heat exposure at temperatures near 24°C (Baker, Speed, and Ligon 1995). Although temperatures above 24°C are directly lethal, temperatures above 18°C accelerate other causes of mortality. A variety of studies indicate that, in a natural stream setting with competitors, predators and diseases, survival begins to decline as temperatures rise above 18°C (Baker and Morhardt 2001; Newman 2003; USFWS 2007).

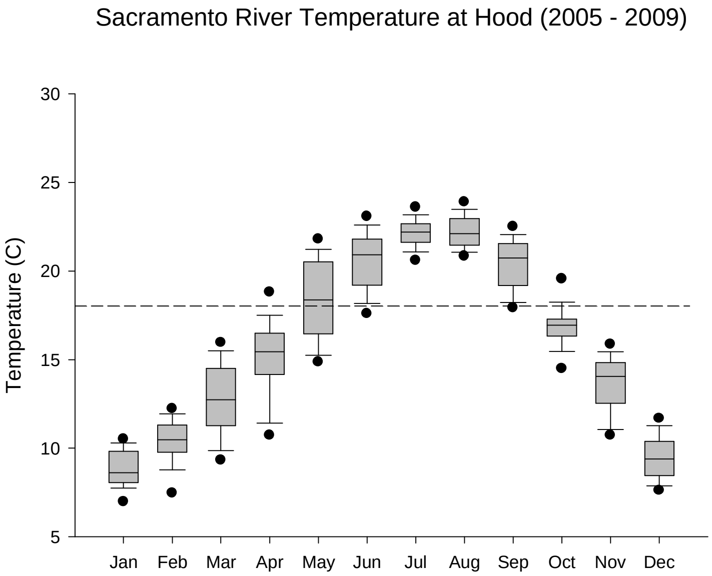

Figure 3. Median monthly temperatures in the Sacramento River at Hood, 2005-2009. The bottom and top boundaries of the box indicate the 25th and 75th percentiles, a line within the box marks the median, the error bars represent the 10th and 90th percentiles and the dots show the 5th and 95th percentiles (CA-DWR data). The dashed line is at 18°C, above which mortality increases due to a variety of stressors, including predation and disease.

Survival of Chinook smolts migrating through the Sacramento-San Joaquin Delta has been studied with numerous experimental releases of Chinook smolts marked with coded-wire tags (CWT). Recoveries of these marked fish in the Chipps Island trawl and in ocean fisheries has provided the means to estimate survival specifically through the Delta region, and to estimate the effects of environmental factors on survival. Temperatures above 18°C have consistently been correlated with reduced survival, (Figure 4) (Baker and Morhardt 2001; Newman 2003; USFWS 2007). These relationships indicate that any increase in temperature above 18°C can increase mortality of Chinook smolts. The distance that fish have to migrate through these temperatures will determine the duration of exposure to these adverse circumstances, and will also influence mortality. Rate of juvenile movement changes with time of day, channel velocity, and also is influenced by physiological readiness for ocean entry (smolting). Horn and Blake (2004) have shown that the combination of these factors results in fish slowing their migration, which could prolong their exposure to conditions in a local area such as the SRWTP plume which extends several hundred feet downstream. To predict the percentage decrease in smolt survival below Freeport from the temperature effects of the SRWTP effluent would require data from mark-recapture, CWT, or other fish tracking studies in the specific area where effluent discharge occurs. Neither SRCSD nor the Water Board has conducted such studies, to our knowledge. It is safe to say, however, based on studies of passage through the larger region of the Delta, that any incremental increase in temperature above 18° in a local area such as that affected by the SRWTP plume would cause an incremental increase in mortality of smolts. Temperatures in the Sacramento River at Hood are frequently in this range during May and June (Figure 3) when passage of Chinook smolts through the area is at its peak. Thus, available data on juvenile Chinook behavior indicate it is likely that some portion of fish passing Freeport, depending on the circumstances they encounter at the time (tidal, diurnal, physiological state), are exposed to the SRCSD plume for a number of minutes or hours. Evidence is lacking to discount that harmful exposure would occur, and such exposure may be substantial under certain conditions.

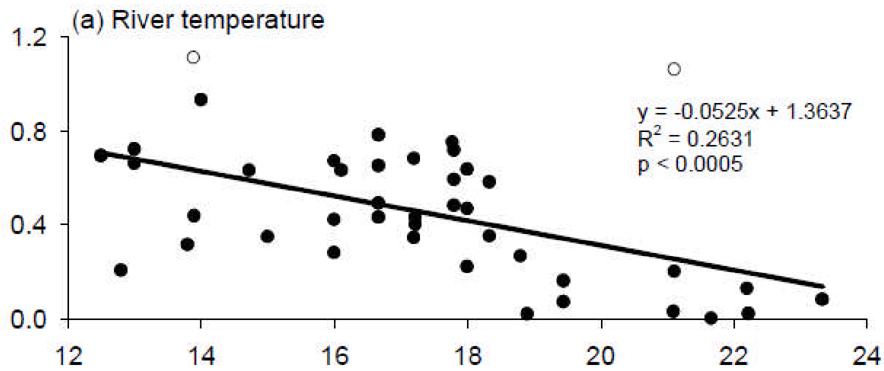

Figure 4. Relationship between survival index for coded-wire tagged Chinook smolts and river temperature from 1988-2005. The survival index should indicate 100% survival at a value of 1.0 and 0% survival at a value of 0.0. The two open circles indicate releases where survival index >1.0. Note the sharp drop in observed survivals (dots) at temperatures above 18°C. From USFWS (2007).

Acute Effects

Introduction

As outmigrating juvenile Chinook salmon and steelhead move past the location where effluent is discharged into the Sacramento River from the Sacramento Regional Wastewater Treatment Plant (SRWTP), they are likely to encounter a thermal plume associated with the effluent discharge. The greatest potential for harmful impact in the near-field of the diffuser would result from reactions to the margins of the thermal plume or from brief exposure to elevated temperatures within the thermal plume. The impact of these effects on the survival of salmonids cannot be discounted and may lead to increased predation in the discharge area, particularly when ambient Sacramento River temperatures exceed 18°C, as would be expected in low-flow or unusually warm years.

Thermal Plume Impacts on Salmonids

The most significant impact of a brief encounter with a thermal plume is expected to be an increased vulnerability to predation due to 1) fish exhibiting a startle response when encountering the thermal plume, and 2) a period of elevated stress levels which diminish avoidance abilities. However, there is likely a wide range of responses from individual fish, both behaviorally and physiologically, depending on the physical circumstances at the time of encounter and on differences between individual fish.

Quigley and Hinch (2006), noting that most research evaluating the effects of rapid temperature increases on fish behavior has been focused on laboratory settings, conducted a study in which they manipulated thermal conditions of small streams to simulate conditions that would be expected to result from thermal discharges and observed the response of juvenile Chinook salmon in the wild (p.430). They found that fish acclimated to high water temperatures displayed behaviors "*indicative of stress and avoidance*", including "*very rapid*" movement and "*erratic swimming*", and "*appeared to be searching for cooler water*" in response to rapid increases in temperature (p.437). Such rapid and erratic movements could be described as a "startle response" and may increase the risk of predation as they are likely to attract the attention of nearby predators. Most outmigrating juvenile salmonids would be expected to exhibit a startle response when encountering the margins of the thermal plume associated with effluent discharged into the Sacramento River from the SRWTP diffuser, and such a response would be expected to increase their risk of mortality from predation.

Some fish may also be briefly exposed to the elevated temperatures within the thermal plume. This, too, can increase the risk of mortality from predation. Sylvester (1972) demonstrated that brief exposure to sub-lethal temperatures of 17, 22, or 27°C for durations as short as 60 seconds could place salmonids at higher risk for predation, depending on acclimation temperature. Cherry, Dickson, Cairns, and Stauffer (1977) demonstrated that fish acclimated to near 7-day lethal temperatures "*may have the best ability to actively avoid potentially hazardous lethal temperatures and select a* *temperature range most conducive to optimal environmental interaction.*" (p.246), and Myrick and Cech (2004) note that acclimation to higher temperatures typically raises upper thermal tolerances (p.116). However, as discussed above, Quigley and Hinch (2006) demonstrated that fish already acclimated to high temperatures exhibit the greatest startle response to yet higher temperatures. Thus, acclimation temperature is a key consideration in attempting to gauge the impact of effluent temperatures on salmonids, and acclimation temperatures follow a seasonal pattern (see Figure 3 above).

Coutant reported that a minimum exposure time, varying by temperature, is required before exposed fish exhibit adverse effects from thermal stress (Coutant 1973, pp.969-970). An exposure duration of approximately 30 minutes is required at 26° C (78.8°F), which is well within the range of both the expected temperature on the margins of the thermal plume associated with the effluent and the expected time of exposure. However, since the adverse effects from thermal stress appear "*reversible to some degree with holding time in cool water*" (Coutant 1973, p.970), it is possible that some fish which encounter the elevated temperatures of the plume would make a relatively quick recovery if they were able to divert to areas of cooler water after only brief exposure. Other fish that are exposed to the thermal plume for sufficient duration may experience significant consequences to their overall health. These may include advanced ageing and skin deterioration, elevated levels of heat shock proteins, hypercortisolemia, and acute thermal shock (Quigley and Hinch 2006, p.429). In addition, the stress response evident from elevated levels of cortisol (i.e. hypercotisolemia) can be delayed by 30 minutes or longer (Donaldson et al. 1984), leaving the fish vulnerable to predation even after they have left the immediate vicinity of the thermal plume. Thus, exposure to the thermal plume would be expected to reduce the probability of survival for some of the juvenile salmonids migrating past the SRWTP diffuser.

Interaction of Effluent and Salmonids

As discussed below, outmigrating juveniles would be expected to concentrate along the east bank of the Sacramento River in the vicinity of the SRWTP diffuser where the effects of the effluent may be more significant on the flood tide, precisely when the fish would tend to be less mobile and therefore at greater risk for harmful exposure. If fish tracking studies in the vicinity of the SRWTP diffuser had been done, it would be possible to estimate the fraction of fish that would be exposed for a duration long enough to induce thermal stress during these conditions. However, these studies have not been done. Therefore, the potential for a significant effect cannot be discounted.

A study by Horn and Blake (2004) demonstrated that outmigrating juvenile Chinook tend to be distributed largely in the upper half of the water column and largely toward an outside bend in a river (pp.47,49). The SRWTP discharge location near Freeport is located on a shallow outside bend of the Sacramento River. It would be expected, then, that a large percentage of outmigrating juvenile Chinook – and steelhead which exhibit similar behavior – would be present in the upper half of the water column along the eastern bank of the river (the outside of the river bend) in the vicinity of the diffuser, and for some distance downstream. Thus, the potential for harmful exposure likely would be greatest in this area. The Effluent Discharge Dilution and Velocity Profiling Field Study presented by SRCSD in support of their argument does not provide sufficient data to discount the potential for effluent to be present in this area and in sufficient concentrations and at sufficient temperatures to adversely affect salmonids.

The Flow Science final report states that dye concentrations of less than 2.5 ppb were measured in all cases at or near the surface during very low flows (Paulsen et al. 2008, p.17). It is important to note, however, that the measurements were taken along the 175 ft. downstream, 60 ft. downstream, and 30 ft upstream transects starting just prior to 14:00 and ending just prior to 14:30, while the surface measurements were taken between 14:30 and 15:25 as shown in Figure 3-2 (Brown and Caldwell 2008, p.3-4). The figure is reproduced as Figure 5 below with the relevant time period shown within the added black box. The surface measurements were near the midpoint of the flood tide and show surface dye concentrations in excess of 6 ppb for a considerable distance along the east bank – from more than 1000 ft downstream up to 60 ft downstream of the diffuser, as shown in Figure 3-12 (Brown and Caldwell 2008, p.3-14) which is reproduced as Figure 5 below. The order in which measurements were taken along the transects is significant as data collection proceeded upstream and therefore stayed ahead of the influence of the flood tide. Thus, even though there is a strong indication from the surface measurements that the flood tide concentrated effluent on the east bank and moved it upstream as the tide elevation increased, the magnitude and extent of this concentration is unknown since measurements were not taken along the relevant transects when these areas were significantly affected by the flood tide. This is a key limitation of the data set because fish would be expected to exhibit behaviors ranging from significantly reduced downstream movement on the waxing of the flood tide to milling about in slack water at or near the peak of the flood tide (Horn and Blake 2004, p.49). Such behaviors would increase the duration of their exposure to elevated temperatures associated with the presence of effluent along the east bank. Thus, the most critical period for fish is not represented in the November 2007 dye study data set.

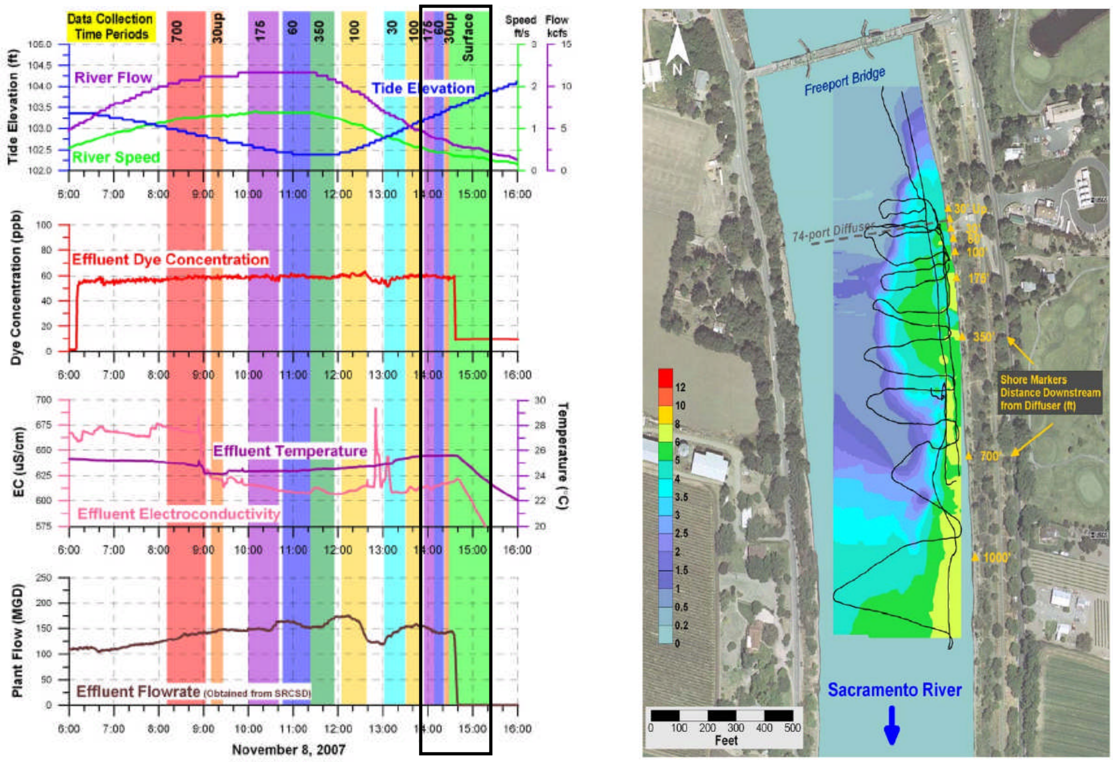

Figure 3-2. Time History Plots for River Dye, and Plant Parameters

Figure 3-12. Surface Dye Concentration Contours 14:30 – 15:25 (Nov 8, 2007)

Figure 5. Reproduced from p.3-4 and p.3-14 of Brown and Caldwell (2008).

In addition, no measurements were taken along the 700 ft downstream or 350 ft downstream transects during the flood tide, but were instead taken during the middle and end of the ebb tide, respectively (see Figure 5 above). This represents another key limitation of the study, since the November 2006 data indicated that dye was detected across the entire width and depth of the river at the 700 ft. transect. Whether or not this also occurred in November 2007 – and what distribution of dye resulted – is an unanswered question, as no data collection was done for this transect at flood tide in November 2007. An examination of Figure 3-29 from Brown and Caldwell (2008, p.3-31), reproduced as Figure 6 below, clearly shows the mismatch in tide elevation (black arrows in the upper half of the graphs indicate the time of day the measurements were taken). Presenting these two graphs side-by-side, as done in the Brown and Caldwell report, obscures the fact that the measurements were taken at approximately opposite tidal stages and therefore do not represent a meaningful comparison of effluent distribution before and after diffuser ports were shut along the east bank. Thus, the extent of the effluent distribution after the ports were shut (i.e. the current state) cannot be accurately determined from the November 2007 dye study data set.

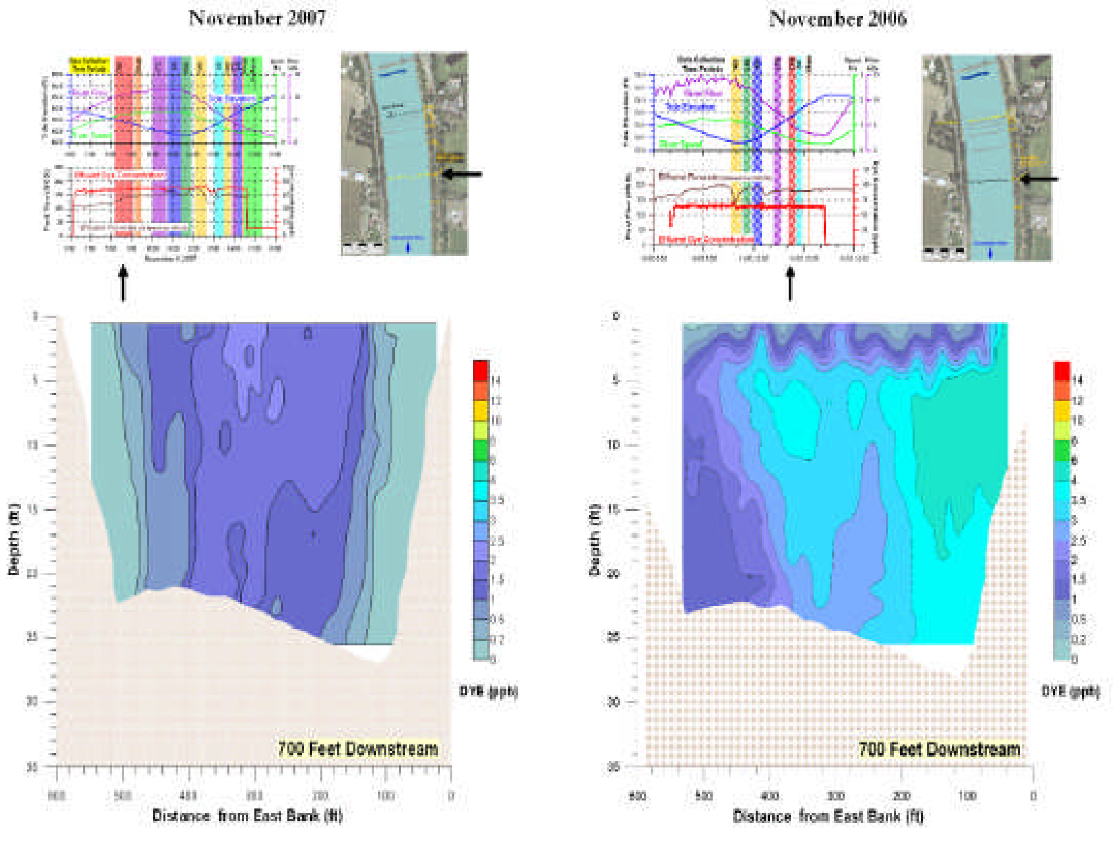

Figure 3-29. Dye Cross-Section from November 2007 (left) compared to November 2006 (right) for 700 Feet Downstream Transect

Figure 6. Reproduced from p.3-31 of Brown and Caldwell (2008).

What is clear is that the distribution of effluent is significantly influenced by the flood tide for more than 1000 ft downstream of the diffuser, and that the tide tends to concentrate the effluent along the east bank. Due to the complex interplay between river and tidal flows, a reasonable potential exists for elevated concentrations of effluent to occur not only along the east bank but also across the river at various locations and times of day as well. The increases in temperature associated with these locations may be sufficient to elevate stress levels and/or induce a startle response in the salmonids which encounter them. This potential has not been adequately investigated and therefore cannot be ruled out.

In view of this there is insufficient basis to conclude, as SRCSD does, that fish are exposed to little or no effluent in “passage zones” along both banks of the river and in the upper half of the water column for some distance downstream. Further, the concept of passage zones is itself problematic. As fish migrate downstream, they spread across the water column both horizontally and vertically due to preferences related to body size, degree of smoltification, and other factors (Horn and Blake 2004). SRCSD offers no evidence to support the assertion that fish entering the area of the SRWTP diffuser are aware of and actively move toward passage zones, leaving otherwise preferred portions of the water column. Furthermore, as noted in the discussion of Horn and Blake (2004) above, a large percentage of fish passing by the SRWTP diffuser would be expected to be near the eastern bank. It is therefore unlikely that a significant percentage of the fish would consistently use passage zones that avoid exposure to the SRWTP effluent. Additional studies are needed before conclusions can be drawn with any reasonable degree of confidence regarding the actual exposure of fish to the effluent and its associated thermal plume.

Summary of Acute Effects on Salmonids

Potentially harmful exposure to the thermal plume resulting from SRWTP effluent discharge into the Sacramento River could occur. The greatest impact of effluent discharge would be expected for outmigrating juvenile fall-run, spring-run, and winter-run Chinook and steelhead during low-flow years. The most significant acute effects are expected to be indirect: an increased vulnerability to predation due to 1) fish exhibiting a startle response when encountering the thermal plume, and 2) a period of elevated stress levels which diminish avoidance abilities. However, the lack of mark-recapture, CWT, or other fish tracking studies in the specific area where effluent discharge occurs precludes reliable conclusions regarding the impact of the discharge on salmonid survival. In addition, the extent of the interaction between effluent and salmonids is not well known and the critical periods for salmonids are not covered in the effluent discharge study presented by SRCSD. Thus, the potential for harmful exposure to occur cannot be discounted. The full consequences of that occurrence are uncertain, but include the potential for substantial mortality. Under future scenarios, wherein temperature differentials and discharge volumes are increased relative to current levels, the potential for substantial mortality would be expected to increase as well.

Chronic Effects

Introduction

The greatest potential for harmful impact from effluent discharge into the Sacramento River would be due to chronic effects in the far-field (i.e. after the effluent becomes fully mixed with river water). The two primary causes of chronic effects are long-term elevated temperatures and low dissolved oxygen (DO) concentrations. Among the most significant effects resulting from these conditions are reduced migratory fitness, increased vulnerability to predators, increased vulnerability to disease, and reduced swimming performance.

Long-Term Elevated Temperature Impact on Salmonids

It has been known for some time that sub-lethal but elevated water temperatures have detrimental effects on salmonids. For example, water temperatures in excess of 55°F (12.8°C) have been found to interfere with the formation and efficiency of ATPase in steelhead, impacting migratory behavior and seawater survival (Zaugg and Wagner 1973; Adams et al. 1975). Additionally, a 1988 review of the relevant literature concluded that "*Seaward migratory behavior of steelhead trout and coho salmon has been found to be* *inhibited in juvenile fish at temperatures greater than 54°F* [12.2°C].” (State of California 1988, p.10). In some cases, prolonged exposure to elevated temperatures may result in smolt-to-parr reversion requiring “*additional time in fresh or brackish water to adapt to higher salinities, thus lengthening residency in the lower reaches of rivers or estuaries and increasing predation risk.*” (Marine and Cech 2004, p.206). Temperatures in the Sacramento River during the period of peak salmonid migration (i.e. mid-April through mid-May) regularly reach levels expected to inhibit migratory fitness, particularly in low-flow or unusually warm years (see Figure 3 above). The additional elevation in temperature resulting from current or future discharges of effluent during the peak migration period will likely contribute to these adverse conditions.

Elevated temperatures can increase predation risk not only by reducing migratory fitness, but by reducing overall fitness as well. As discussed in the Acute Effects section above, even brief exposure to elevated temperatures can result in high stress levels and increased vulnerability to predation. Prolonged exposure to elevated temperatures has a similar effect. Quigley and Hinch (2006), comparing their own observations to those of previous studies, conclude that chronically elevated temperatures resulting in high stress levels “*can impair the ability of juvenile salmonids to avoid predators (Sylvester, 1972; Olla et al., 1992; Olla and Davis, 1989) and it is well established that <u>predators capture substandard prey disproportionately</u> from prey populations (Mesa et al., 1994; Temple, 1987).*” (p.438) [emphasis added, citations in original].

Quigley and Hinch (2006) also point out that brief exposure to elevated temperatures results in increased production of cortisol (commonly used as an indicator of acute stress in fish) (p.432) and that “*chronic elevations of cortisol are known to <u>reduce disease resistance</u>, fecundity and tolerance to additional non-thermal stressors (Thomas, 1990; Fagerlund et al., 1995; Feist and Schreck, 2002).*” (p.438) [emphasis added, citations in original]. Thus, prolonged exposure to harmful temperatures would be expected to significantly increase vulnerability to diseases which commonly affect fish. In addition, the characteristics of the diseases themselves exacerbate the problem. A 1988 study of the relevant literature concluded that:

> “…**most of the important diseases afflicting chinook salmon increase in virulence as temperatures increase**. Water temperatures greater than 56°F favor bacteria causing columnaris and furnunculosis, while temperatures greater than 65°F favor the protozoan causing ichthyophthiriosis (or ich). A common fungus infecting fish, <u>saprolegnia parasitica</u>, occurs over a wide range of temperatures, but develops most rapidly at higher temperatures.” (State of California 1988, p.6) [emphasis added].

Thus, any increase in water temperature caused by the discharge of effluent into the Sacramento River during high temperature periods, especially in low-flow years, would make already difficult conditions for salmonids even worse. This effect would be particularly problematic under future scenarios wherein temperature differentials and discharge volumes are increased relative to current levels.

Low Dissolved Oxygen Impact on Salmonids

The optimum range of DO concentrations is different for different species of salmonids and changes depending on life history stage (EPA 1988). Temperature also has an effect on the oxygen requirements for salmonids. A 1988 review of the relevant literature concluded that "*Oxygen requirements of fish depend on metabolic rates, which are highest in the egg stage and decrease through successive developmental stages, but increase in response to increasing water temperatures*." (State of California 1988, p.6). [emphasis added]. Thus, warm river temperatures are doubly problematic as warming the water tends to decrease the DO levels while at the same time increasing the oxygen demand of fish. The peak of the Chinook and steelhead migrations is in mid-April through mid-May, just as the river begins to warm significantly. As a result, an increase in water temperature of just a degree or two caused by the discharge of effluent during the late spring to early summer has the potential to be harmful for outmigrating juvenile salmonids. More significantly, an increase in the volume of discharged effluent may lower DO levels to a greater extent than would be expected from increased temperatures alone due to increased biochemical oxygen demand (Larry Walker Associates 2009, p.1). The potential for these adverse effects from low DO would be greatest during low-flow periods of warm years.

The United States EPA has determined that 6 mg/L is the acceptable standard for DO concentrations for adult salmonids (EPA 1988). Concentrations below this level have been demonstrated in multiple studies to adversely affect both juvenile and adult salmonids (Geist et al. 2006; Kramer 1987). Avoidance behavior of salmonids to habitats of low oxygen concentration has been reported, and prolonged exposure to low oxygen concentration can be lethal (Whitmore et al. 1960; McGreer and Vigers 1983; Birtwell 1989). Based on a projection from historical measurements, DO concentrations in the Sacramento River are not expected to approach lethal levels. Instead, DO concentrations typically reach highs of 12 mg/L or more during winter months and lows of 7 mg/L in the late spring and summer, occasionally reaching lows of 6 mg/L or less during low-flow or unusually warm years (CA-DWR data). During such years, DO levels are very close to the "danger zone" for salmonids. Exposure to concentrations of 6 mg/L or less of DO, especially for extended periods, can have significant adverse effects for salmonids (Kramer 1987; EPA 1988).

One of the most significant effects of low DO levels for juvenile and adult salmonids is a reduction in swimming performance. Davis et al. (1963) found that progressively lower DO concentrations below saturation had increasingly negative impact on swimming speed. Specifically, DO levels of 7, 6, 5, 4, and 3 mg/L resulted in maximum sustained swimming speeds reduced by 10, 14, 20, 27, and 38 percent compared to those at saturation (Davis et al. 1963) Jones (1971) observed a 43% decline in sustained swimming speed for juvenile *O. mykiss* at a temperature of 14.1°C and DO of 5.2 mg/L as well as a 30% decline in sustained swimming speed for juvenile *O. mykiss* at 22.4°C and 3.9 mg/L DO concentration.

The significance of this impaired swimming ability due to low DO levels is difficult to assess, but the logical conclusion to be drawn is that impaired swimming ability would adversely affect such essential functions as feeding, escape from predation, interspecific competition, and migration. Maintaining sufficient DO levels, then, is particularly important for salmonids.

Dissolved Oxygen Modeling Issues

The SRCSD presents the Low Dissolved Oxygen Prevention Assessment in support of its argument that current DO levels are in compliance with the Basin Plan objective of a minimum 7 mg/L DO concentration downstream of the SRWTP and that future effluent discharges would not significantly lower these levels, assuming seasonal control of effluent ammonia concentrations.

The Assessment calculates DO levels under various scenarios based on a modified Streeter-Phelps model. However, the authors acknowledge that a Streeter-Phelps model is not directly applicable to the SRWTP discharge location since it is tidally influenced (Larry Walker Associates 2009, p.3). Application of the Streeter-Phelps model in this case, then, requires an additional mechanism to address the tidally-induced dispersal patterns and thus arrive at an appropriate simulation (Larry Walker Associates 2009, p.3). The modified Streeter-Phelps model is developed in Appendix A and this development raises some issues regarding the accuracy of the model. These issues are explored below.

Selective Use of Data

The Sacramento River characteristics of flowrate, channel geometry, and water quality are important parameters in the dissolved oxygen model relied on by SRCSD. River flowrate effects the dilution of effluent and the speed at which the mixed effluent moves downstream. For this reason, flowrate is a key input parameter utilized in the Streeter-Phelps model (Larry Walker Associates, 2009, p.3) and is used in the calculation of water velocity. In the Low Dissolved Oxygen Prevention Assessment, daily average water velocity was calculated for daily average flowrates and compared to field measurements of water velocity over a period of approximately 8 years. The results are displayed in Figure 11 of Appendix A (p.A5) and are reproduced as Figure 7 below. It is clear that the calculated and measured values are in agreement only for the data collected prior to October 1, 2007. The authors acknowledge this fact in both the figure caption and in the text (p.A3), but simply ignore any potential implications and choose the older data set (i.e. the December 2000 – September 20007 data), while the marked deviation of the more recent data is left unexplained. This reliance on the older data set raises the prospect that modeling results do not accurately simulate current conditions.

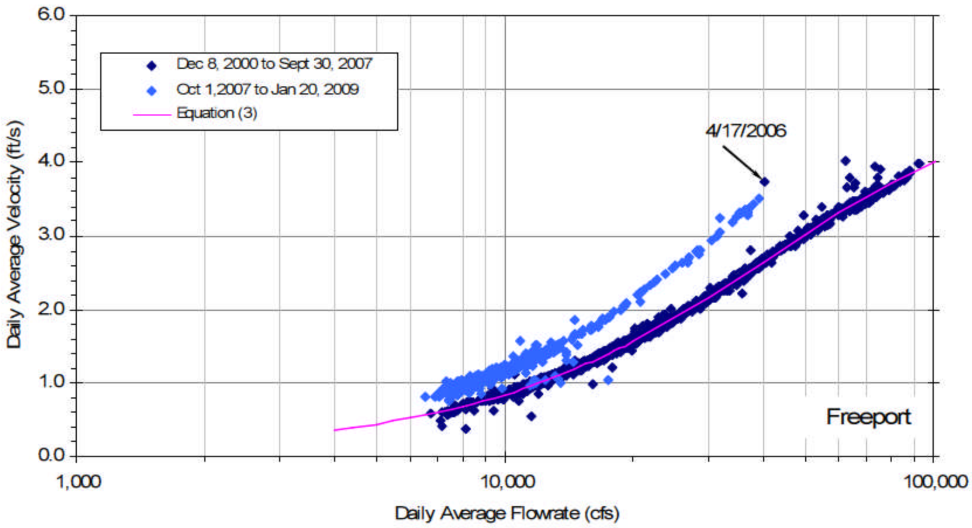

Figure 11: Sacramento River Velocity at Freeport as a Function of the Natural Log of the Corresponding Flowrate. Data Recorded Prior to October 1, 2007 Follow Different Pattern from Data Collected After October 1, 2007.

Figure 7. Reproduced from p.A5 of Larry Walker Associates (2009).

Adjustment of Data

The report authors relied on DO measurements provided by DWR to calibrate their model. However, the measured DO concentrations at Hood for February 2008 through December 2008 are 1mg/L to 2 mg/L lower than the DO saturation concentration predicted by the model. (*See* Figure 23 from Larry Walker Associates 2009, p.A17, reproduced as Figure 8 below.)

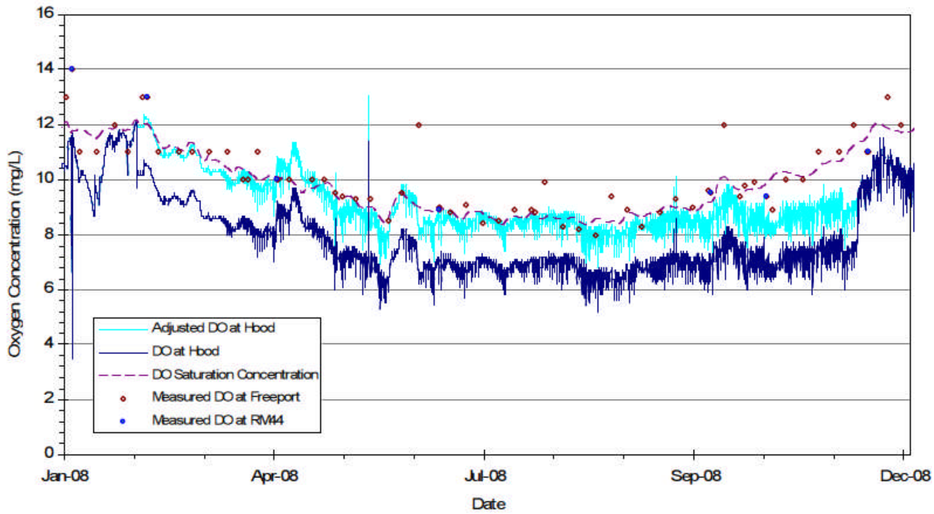

Figure 23: DWR Continuous Dissolved Oxygen Measurements at Hood.

Figure 8. Reproduced from p.A17 of Larry Walker Associates (2009).

The authors acknowledge the discrepancy between calculated and measured values, but argue that the low measurements are erroneous and the data thus unreliable (Larry Walker Associates 2009, p.A16). As a result, they simply assume that the DO measurements are too low and adjust them upward to fit the DO saturation concentration predicted by the model. However, our analysis of the data reveals only a few apparently erroneous measurements, and none of these occur during the periods in question. Adjusting the data, therefore, does not appear to be warranted. This is significant since the comparison of calculated DO saturations and DO measurements was used to calibrate the modified Streeter-Phelps model (Larry Walker Associates 2009, p.A16). The end result is that the model used to support SRCSD's case may not be calibrated correctly and thus may not provide sufficiently accurate predictions for DO levels under future discharge scenarios. This assertion is further supported by a review of the model validation.

Lack of Model Resolution

The model validation curve appears to indicate that, though the model matches up well with seasonal trends in DO levels, it lacks the resolution to accurately predict precise DO values. Comparison of model predictions with field measurements of DO from 1985 to 1992 reveals that the actual values of DO are often 1mg/L or more lower than model predictions, as seen in the model validation curve presented as Figure 25 of Appendix A (Larry Walker Associates 2009, p.A19) and reproduced as Figure 9 below.

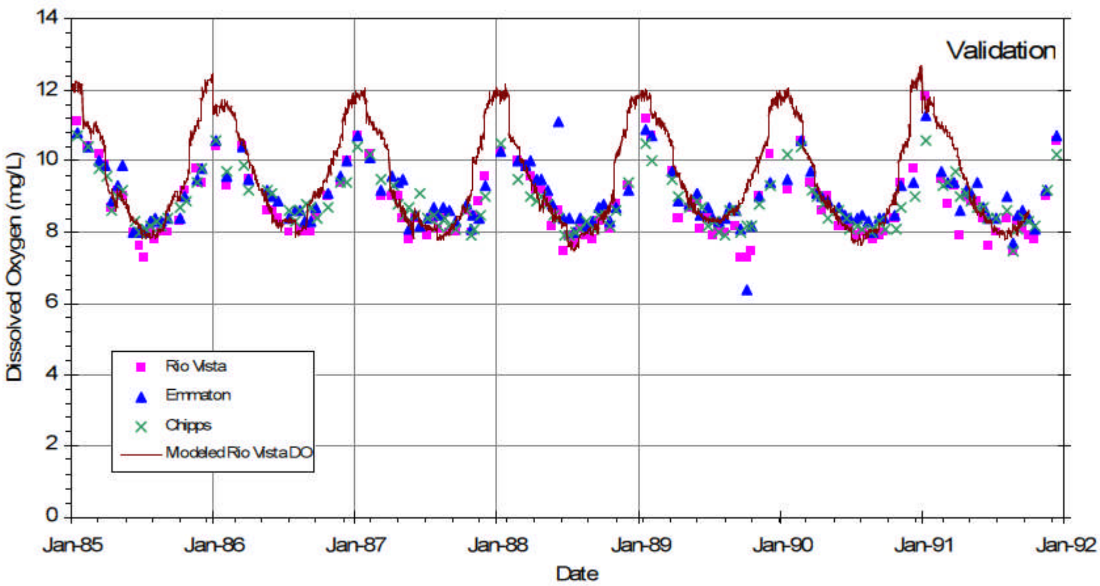

Figure 25: Validation Run of Streeter-Phelps Model with Measured Dissolved Oxygen Data.

Figure 9. Reproduced from p. A19 of Larry Walker Associates (2009).

Summary of DO Model Issues

The SRCSD's argument that future discharges will not adversely impact DO levels is based on the accuracy of the modified Streeter-Phelps model they present. As such, the selective use of an older data set when a newer one did not match model calculations, the adjustment of DO measurements at Hood when those measurements did not agree with model calculations, and the apparent lack of sufficient model resolution evident in the validation run do not lend confidence to SRCSD's conclusions. Others have pointed to these and other issues as grounds for concern regarding the accuracy of the model and SRCSD's conclusions based on it (Butcher 2010). Since it is clear that DO levels in the Sacramento River are already close to the "danger zone" of adverse conditions for salmonids (i.e. below 6 mg/L) during at least some years, the lack of sufficient resolution in the modeling of future scenarios is troubling. The modeling results presented by SRCSD are questionable and simply do not discount the potential for salmonid exposure to harmful levels of DO in the Sacramento River.

Summary of Chronic Effects on Salmonids

The potential for harmful exposure to elevated water temperatures and low DO levels to be increased by the discharge of SRWTP effluent discharge into the Sacramento River is cause for concern. The greatest impact of effluent discharge would be expected for outmigrating juvenile fall-run, spring-run, and winter-run Chinook and steelhead during the late spring of low flow or unusually warm years. Potential chronic effects include reduced migratory fitness, increased vulnerability to predators, increased vulnerability to disease, and reduced swimming performance. The lack of mark-recapture, CWT, or other fish tracking studies in the specific area where effluent discharge occurs precludes reliable conclusions regarding the impact of the discharge on salmonid survival. The impact of proposed increases in the volume of discharges is unclear since there are a number of issues with the dissolved oxygen modeling presented by the SRCSD, resulting in its apparent inability to accurately predict DO levels with the required resolution. This is particularly troubling as DO levels in the Sacramento River are already close to the danger zone for salmonids during at least some years. Thus, the potential for harmful exposure to occur cannot be discounted. The full consequences of that occurrence are uncertain, but include the potential for substantial mortality.

Summary and Conclusions

Potentially harmful exposure of salmonids to elevated temperatures and low dissolved oxygen resulting from SRWTP effluent discharge into the Sacramento River could occur. The greatest impact of effluent discharge would be expected for outmigrating juvenile fall-run, spring-run, and winter-run Chinook and steelhead during low-flow years.

Expected acute effects include a startle response when fish encounter the margins of the thermal plume and elevated stress levels from brief thermal exposure. Both of these effects increase vulnerability to predation and may lead to substantial mortality.

Chronic effects are expected to be more substantial and include reduced migratory fitness, increased vulnerability to predators, increased vulnerability to disease, and reduced swimming performance.

The lack of mark-recapture, CWT, or other fish tracking studies specific to the area in question precludes reliable conclusions regarding the overall impact of acute effects on salmonid survival, and the extent of the interaction between effluent and salmonids is not well known and was not meaningfully addressed by the effluent discharge study presented by SRCSD. In addition, a number of issues have been identified which undermine the accuracy of the dissolved oxygen modeling presented by SRCSD, preventing confidence in SRCSD's conclusion that proposed increases in the volume of effluent discharges will not push dissolved oxygen levels closer to or well within the danger zone of adverse effects for salmonids.

In conclusion, the potential for harmful exposure of salmonids to elevated temperatures and low dissolved oxygen resulting from SRWTP effluent discharged into the Sacramento River cannot be discounted. The full consequences of that occurrence are uncertain, but include the potential for substantial mortality. Proposed increases in temperature differentials between effluent and river water, as well as anticipated increases in the volume of discharged effluent, would likely increase this potential.

References Cited

Adams, B.L., W.S. Zaugg, and L.R. McLain. 1973. Temperature effect on parr-smolt transformation in steelhead trout (Salmo gairdneri) as measured by gill sodium-potassium stimulated adenosine triphosphatase. Comp. Biochem. Physiol. 44A: 1333-1339.

Baker, P.F. and J.E. Morhardt. 2001. Survival of chinook salmon smolts in the Sacramento-San Joaquin Delta and Pacific Ocean. Contributions to the Biology of Central Valley Salmonids. Fish Bulletin 179(2): 163-182.

Baker, P.F., T.P. Speed., and F.K. Ligon. 1995. Estimating the influence of temperature on the survival of chinook salmon smolts (*Oncorhynchus tshawytscha*) migrating through the Sacramento – San Joaquin River Delta of California. Can. J. Fish. Aquat. Sci. 52: 855-863.

Birtwell, J.K. 1989. Comments on the sensitivity of salmonids to reduced levels of dissolved oxygen and to pulp mill pollution in Neroutsos Inlet, BC. Can. Tech. Rep. Fish. Aquat. Sci. 1695: 27 pages.

Brandes P.L. and J.S. McLain. 2001. Juvenile chinook salmon abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. In: Brown RL, ed. Contributions to the Biology of Central Valley Salmonids. Fish Bulletin 179. Volume 2. Sacramento (CA): California Department of Fish and Game. p.39-136.

Brown and Caldwell. 2008a. November 2007 Data Report: Effluent Discharge Dilution and Velocity Profiling Field Study in the Sacramento River. 124 pages.

State of California. 1988. Water Temperature Effects on Chinook Salmon (*Oncorhynchus tshawytscha*) With Emphasis on the Sacramento River: A

Butcher, J. 2010. Technical Memo[illegible]acramento Regional County Sanitation District's Low Diss[illegible]tion Assessment. Tetra Tech. Submitted to: Central Valley R[illegible]y Control Board. 10 pages.

California Department of Water R[illegible] Bay Delta and Tributary (BDAT) Data Center. 2010. Available [illegible]ta.ca.gov/index.html.

Cherry, D.S., K.L. Dickson, J. Cairns Jr., and J.R. Stauffer. 1977. Preferred, avoided, and lethal temperatures of fish during rising temperature conditions. J. Fish. Res. Bd. Canada. 34: 239-246.

Coutant, C.C. 1973. Effect of thermal shock on vulnerability of juvenile salmonids to predation. J. Fish. Res. Bd. Canada. 30: 765-973.

Davis, G.E., J. Foster, C.E. Warren, and P. Doudoroff. 1963. The influence of oxygen concentration on the swimming performance of juvenile pacific salmon at various temperatures. Trans. Am. Fish. Soc. 92: 111-124.

Donaldson, E.M., U.M. Fagerlund, and J.R. McBride. 1984. Aspects of the endocrine stress response to pollutants in salmonids. In: Cairns, V.W., P.V. Hodson, and J.O. Nriagu (Eds.), Contaminant Effects on Fisheries. Wiley, New York, New York. p.213-221.

Environmental Protection Agency (EPA). 1988. Water Quality Standards Criteria Summaries: A Compilation of State/Federal Criteria. United States, Environmental Protection Agency, Office of Water Regulations and Standards. EPA 4-0/5-88/024.

Geist D.R., C.S. Abernethy, K.D. Hand, V.I. Cullinan, J.A. Chandler, and P.A. Groves. 2006. Survival, development, and growth of fall chinook salmon embryos, alevins, and fry exposed to variable thermal and dissolved oxygen regimes. Transactions of the American Fisheries Society 135:6, 1462-1477.

Horn, M.J. and A. Blake. 2004. Acoustic tracking of juvenile chinook salmon movement in the vicinity of the Delta Cross Channel. 2001 study results. Prepared for Technical Service Center, Denver, Colorado as Technical Memorandum No. 8220-04-04.

Jones, D.R. 1971. The effect of hypoxia and anemia on the swimming performance of rainbow trout (Salmo gairdneri). J. Exp. Biol. 55: 541-551.

Kramer D.L. 1987. Dissolved oxygen and fish behavior. Environmental Biology of Fishes, 2: 81-92.

Larry Walker Associates. 2009. Low Dissolved Oxygen Prevention Assessment – Administrative Draft. Prepared for Sacramento Regional County Sanitation District. 41 pages.

Marine, K.R. and J.J. Cech, Jr. 2004. Effects of high water temperature on growth, smoltification, and predator avoidance in juvenile Sacramento River chinook salmon. N. Am. J. of Fish. Mgmt. 24:198–210.

McGreer, E.R. and G.A. Vigers. 1983. Development and Validation of an In Situ Fish Preference-Avoidance Technique for Environmental Monitoring of Pulp Mill Effluents. In: Aquatic Toxicology and Hazard Assessment: Sixth Symposium, ASTM STP 802. W.E. Bishop, R.D. Cardwell and E.C. Heidolph, (Eds.), ASTM, Philadelphia. p.519-529.

Myrick, C.A. and J.J. Cech, Jr. 2004. Temperature effects on juvenile anadromous salmonids in California's central valley: what don't we know? Reviews in Fish Biology and Fisheries. 14: 113-123.

Newman, K. B. 2003. Modeling paired release–recovery data in the presence of survival and capture heterogeneity with application to marked juvenile salmon. Statistical Modeling 3:157–177.

Paulsen, S., A. Mead, and E.J. List. 2008. Results of November 2007 Dye Study of Effluent Discharge to the Sacramento River at Freeport, California. Prepared for Sacramento Regional County Sanitation District. 51 pages.

Quigley, J.T., and S.G. Hinch. 2006. Effects of rapid experimental temperature increases on acute physiological stress and behaviour of stream dwelling juvenile chinook salmon. Journal of Thermal Biology. 31: 429-441.

Robertson-Bryan, Inc. 2010. Thermal Plan Exception Justification for the Sacramento Regional Wastewater Treatment Plant. Prepared for Sacramento Regional County Sanitation District. 56 pages.

Sacramento San-Joaquin Estuary Fishery Resource Office (SSJEFRO). 2003. Abundance and Survival of Juvenile Chinook Salmon in the Sacramento-San Joaquin Estuary. Stockton, California: U.S. Fish and Wildlife Service.

State of California. 1988. Water Temperature Effects on Chinook Salmon (*Oncorhynchus tshawytscha*) With Emphasis on the Sacramento River: A Literature Review. 49 pages.

Sylvester, J.R. 1972. Effect of thermal stress on predator avoidance in sockeye salmon. J. Fish. Res. Bd. Canada. 29: 601-603.

U.S. Fish and Wildlife Service (USFWS). 2007. Abundance and Survival of Juvenile Chinook Salmon in the Sacramento-San Joaquin Estuary. 2001-2005 Annual Progress Report. U.S. Fish and Wildlife Service Stockton, California. 148 pages.

Whitmore, C.M., C.E. Warren, and P. Doudoroff. 1960. Avoidance reaction of salmonid and cetrarchoil fishes to low oxygen concentrations. Trans. Am. Fish. Soc. 89: 17-26.

Williams, J.G. 2006. Central Valley Salmon: A perspective on Chinook and steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science, 4(3). Retrieved from: http://escholarship.org/uc/item/21v9x1t7.

Zaugg, W.S., and H.H.Wagner. 1973. Gill ATPase activity related to parr-smolt transformation and migration in steelhead trout (Salmo gairdneri): Influence of photoperiod and temperature. Comp. Biochem. Physiol. 45B: 955-965.

ATTACHMENT 4

Treatment Requirements for Central Valley Wastewater Treatment Plants

Discharger	Permitted Average Dry Weather Flow, mgd	Treatment Requirements	
		Nitrification/ Denitrification	Tertiary Filtration
Sacramento (tentative)	181	✓	✓
Stockton	55	✓	✓
Turlock	20	✓	✓
Roseville - Dry Creek	18	✓	✓
Manteca	17.5	✓	✓
Tracy	16	✓	✓
Roseville - Pleasant Grove	15	✓	✓
Vacaville	15	✓	✓
Woodland	10.4	✓	✓
Lodi	8.5	✓	✓
Davis	7.5	✓	✓
Mountain House	5.4	✓	✓
Olivehurst	5.1	✓	✓
Brentwood	5.0	✓	✓
Linda County Water District	5.0	✓	✓
Galt (tentative)	4.5	✓	✓
El Dorado Irrigation District – El Dorado Hills	4.0	✓	✓
El Dorado Irrigation District – Deer Creek	3.6	✓	✓
Grass Valley	2.78	✓	✓
Placerville	2.3	✓	✓
Placer County Sewer Maintenance District	2.18	✓	✓
Auburn	1.67	✓	✓
Live Oak (tentative)	1.4	✓	✓
Willows	1.2	✓	✓
Rio Vista – Northwest	1.0	✓	✓