ROBERTSON - BRYAN, INC.
Solutions for Progress

9888 Kent Street • Elk Grove CA 95624
Phone: (916) 714-1801 • Fax: (916) 714-1804

TECHNICAL MEMORANDUM

Date: April 25, 2014

Prepared for: City of Stockton Municipal Utilities Department

Prepared by: Ben Giudice, Ph.D., P.E., and Michael Bryan, Ph.D.

Subject: Effects of Nitrate Plus Nitrite Discharged from the Stockton Regional Wastewater Control Facility on Algal Communities in the San Joaquin River and Delta, and Their Effects on Beneficial Uses

1 Introduction

This Technical Memorandum responds to general statements made in the Tentative Waste Discharge Requirements for the City of Stockton Regional Wastewater Control Facility (Tentative Order) with respect to nutrient impacts in the Delta, and in particular to statements regarding nitrates contributing to excessive algal growth and effects on beneficial uses. Such statements were made in the Tentative Order to justify the denial of a mixing zone for nitrate plus nitrite for discharges from the City of Stockton's (City) Regional Wastewater Control Facility (RWCF), but these statements were not supported by information, studies, or data. Prior to providing responses to such statements, this Technical Memorandum first summarizes current findings from the scientific literature regarding factors affecting algal community composition and biomass in the Sacramento-San Joaquin Delta (Delta), in general, and the San Joaquin River, specifically. Next, the Technical Memorandum responds directly to statements made within the Tentative Order, and identifies evidence and information that addresses such statements within the context of nitrate plus nitrite discharges from the RWCF. In addition, the Technical Memorandum provides additional information regarding the practical effect of restricting the permitted average monthly effluent limitation (AMEL) for nitrate plus nitrite to 10 mg/L-N, rather than permitting seasonal limitations of 26/30 mg/L-N, as presented in Nitrate Option 1.

2 Overview of Delta Algal Community

2.1 Community Composition

The Delta phytoplankton community is composed of diatoms, green algae, flagellates, cyanobacteria, and cryptophytes, with the overall assemblage in any given year being a function of region, season, and flow (Lehman 1996). Diatoms are washed into the Delta from the San Joaquin River and Sacramento River early in the year when water temperatures are low and turbidity is high. The extent of diatom dominance downstream is a function of river flows, in that low velocities facilitate deposition of heavy diatoms, increased phytoplankton grazing pressure in river channels, and retention in deep up-stream non-productive river channels (Lehman 1996, Litton et al. 2008). Green algae, flagellates, cyanobacteria (also referred to as blue-green algae), and cryptophytes also occur throughout the Delta with greater

proportions of these algae observed when exports are low and water temperatures high (Lehman 1996; Lehman 2000; Kimmerer 2005).

2.2 Biomass

Algae levels in the Delta have historically been, and continue to be, lower than levels in most other temperate river-dominated estuaries (Jassby 2008). In terms of chlorophyll *a* concentrations, the current status of the Delta is one of food limitation (Sobczak et al. 2002, Jassby 2005, Mueller-Solger et al. 2002)). Chlorophyll *a* levels less than 10 µg/L can cause adverse consequences on the growth rate and egg production of some zooplankton species of the Delta (Mueller-Solger et al. 2002; Kimmerer et al. 2005). Although chlorophyll *a* levels have increased modestly over the past 15 years, the five-year median chlorophyll *a* level in the Delta as of 2005 was 3.4 µg/L, up from 2.7 in 1995 (Jassby 2008). The Delta has also been characterized as nutritionally poor due to substantial decline in diatom biomass since the 1970s (Lehman 1996). In fact, food limitation due to a long standing lack of algae and decline of diatoms is a concern with regard to Delta pelagic organism decline (POD) (Sommer et al. 2007, Jassby 2005).

2.3 Role of Nitrate and Other Factors in Controlling Algal Composition and Biomass

Nutrient levels in Delta waters are high enough that they do not control the growth of algae (i.e., nutrients levels are not a factor limiting algae communities). Nutrients determine the maximum possible algal biomass attainable. However, the availability of light appears to be the primary limiting factor for Delta algae growth, although grazing (particularly by filter feeders) and hydraulic residence time limitations also play an important role (Jassby et al. 2002). Nutrient levels in the Delta would have to be an order of magnitude lower than they currently are for nutrients to regularly control algae abundance (Jassby 2005). The most thorough and comprehensive evaluations on factors controlling algal composition and biomass conducted to date have not identified nitrate concentrations as being closely related to either algal composition or biomass (Jassby et al. 2002, Jassby 2008, Lehman 2000, Lehman 2007, Lehman 1996).

3 Overview of San Joaquin River Algal Community

3.1 Community Composition

The predominant algae groups present in the San Joaquin River from Vernalis to Turner Cut are similar to the Delta as a whole: diatoms, green algae, cryptophytes, and cyanobacteria. All groups are present throughout the San Joaquin River. However, diatoms are more abundant from Vernalis, downstream to between Mossdale and the Deep Water Ship Channel (DWSC), where their abundance decreases considerably. Concurrent with the decrease in diatoms, there is an increase in dinoflagellates and other flagellates, which are not algae but are another type of phytoplankton.

3.2 Biomass

RBI (2013) found that despite San Joaquin River nitrate levels being higher in the RWCF mixing zone and at sites downstream of the RWCF outfall compared to upstream reference sites, there is greater primary productivity overall, greater chlorophyll *a*, and greater algal biomass in the reference sites upstream of the RWCF outfall. RWCF receiving water monitoring data from 2010 through 2012 show

that chlorophyll *a* concentrations in the vicinity of the RWCF outfall (at site RSW-002/002A) were less than those measured at the upstream monitoring site outside the influence of the RWCF discharge (RBI 2013; Figure D-4). Additionally, results of algal sampling conducted by RBI (2013) indicated that total algal biomass and density were significantly greater at the reference sites (4.75 to 6.25 miles upstream of the RWCF outfall) compared to the reach influenced by the RWCF discharge. These data are shown in Figure 1. The data show that there was no measurable contribution to excessive algal growth due to the locally higher nitrate levels near the RWCF outfall.

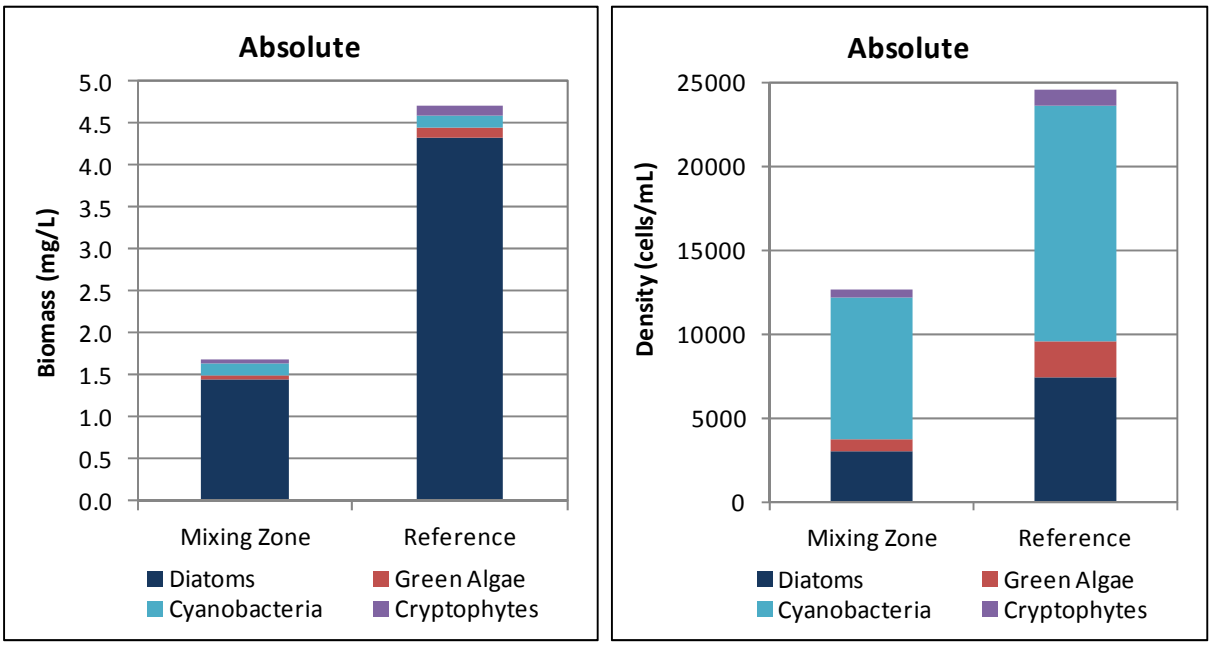

Figure 1. Absolute algal biomass and density of the dominant algal phyla observed at the reference sites and the mixing zone sites. (Means of sites/months all combined).

The three year median chlorophyll *a* concentration from 2010–2012 at Vernalis was 7.2 µg/L, while at Garwood Bridge (near the RWCF outfall) it was 5.4 µg/L (CDEC 2013). These levels, particularly at Vernalis, are generally higher than most other locations in the Delta, as "the [San Joaquin] river is one of the few productive habitats for an estuarine food web that otherwise appears to be relatively unproductive and food-limited." (Sobczak et al. 2002, as cited by Jassby 2005).

3.3 Role of Nitrate and Other Factors Controlling Algal Composition and Biomass

Nutrient concentrations, including nitrate, have not been identified as factors controlling algal composition or biomass in the San Joaquin River. As with the Delta generally, light availability, residence time, and grazing pressure are the most significant controls on algae growth (Lehman 2007, Litton et al. 2008, Jassby 2005, RBI 2013).

The loss of algal biomass in the San Joaquin River between Vernalis and the DWSC observed in the City's study (RBI 2013) is well documented in the scientific literature and has been attributed to physical and hydrodynamic changes in the river over this reach and grazing pressure within the reach.

- Lehman (2007) reported a shift from diatoms and green algae upstream of the RWCF to flagellates with increasing distance downstream of the RWCF. This shift was attributed mostly to hydrodynamics because the river in this reach shifts from a riverine to lake-like habitat in the DWSC. Turbulent mixing keeps heavy diatom cells suspended in the water column in shallow water habitats, such as the San Joaquin River upstream of the RWCF, but when velocity drops and mixing decreases, such as in the DWSC, heavy diatom cells are lost to sedimentation (Reynolds 1994). Because diatoms are fairly large, the loss of diatoms resulted in a disproportionate overall loss of phytoplankton biomass. This seaward decrease in diatom density has been reported in other estuaries as well, including the Westerschelde estuary, Elbe estuary, Schelde River estuary, and Parana River (Rijstenbil et al. 1993; Kies 1997; Muylaert et al. 2000; Izaguirre et al. 2001). There was no correlation between nutrient concentration and primary productivity in the Lehman (2007) study.

- Following on Lehman's work, a three-year field study by Litton et al. (2008) attributed algal loss between Vernalis and the DWSC to light limitation due to the increased depth of the non-photic zone and to an exponential increase in grazing pressure (primarily by filter-feeding clams) below the head of Old River. Net river flows less than 1,800 cubic feet per second (cfs) provided sufficient residence time for these mechanisms to contribute substantially to algal loss, which represented 20–80% of total algal biomass, depending on flow (Litton et al. 2008).

4 Evaluation and Response to Statements made in Tentative Order

4.1 Presence of Algae that Cause Taste and Odor Issues for Municipal Water Supplies Diverted from the Delta

The Tentative Order states:

> "Increased nutrient loads can create excessive algal growth in the Delta, resulting in impacts to municipal drinking water supplies . . . .In addition, some species of bluegreen algae are associated with the production of compounds such as geosmin and 2-methyllisoborneol (MIB) that impart objectionable odors and tastes to waters, even at very low concentration. These impacts are occurring, therefore, any increased nutrient loading contributes to the impairment of the beneficial uses." (Tentative Order, Attachment F, p. F-23.)

As stated above, nutrient concentrations, including nitrate, have not been identified as factors controlling algal composition or biomass in the San Joaquin River. As with the Delta generally, light availability, residence time, and grazing pressure are the most significant controls on algae growth (Lehman 2007, Litton et al. 2008, Jassby 2005, RBI 2013).

The taste and odor (T&O) issues reported for municipal water supplies diverted from the Delta have been directly linked to the presence of two chemicals – 2-methylisoborneo and geosmin. These compounds are mostly sourced to a small subset of blue-green algae which reside in the Delta, conveyance aqueducts, or drinking water source reservoirs. For example, cyanobacteria blooms in Martinez Reservoir are cited as the cause of T&O issues affecting Contra Costa Water District (Caroompas 2012), which withdraws water from three locations in the west and south Delta. No evidence was found in the literature reviewed

to indicate that elevated nitrate concentrations were related to or responsible for cyanobacteria blooms in Martinez Reservoir. Additionally, the contribution of RWCF effluent and nitrate to Contra Costa Water District intakes is low (discussed further below), and is unlikely to make a measurable difference in the potential for algae blooms in that area, based on background nitrate levels.

The Sanitary Survey update for the State Water Project (SWP) (SWP 2011) describes T&O issues throughout the SWP. The two primary T&O issues highlighted were related to the discharge of algae-rich, impounded water, to the Delta. A discharge of impounded water from Campbell Lake, located upstream of Barker Slough in the North Delta, to the Delta resulted in the first T&O issue observed in the North Bay Aqueduct, and has spurred annual efforts to control algae in the lake. Additionally, after the flooding of Jones Tract, algae grew within the levees of the island and were pumped out into the Delta when the island was drained. Some of this water made it into Clifton Court Forebay and the California Aqueduct. As a result, SWP's Lake Skinner was inoculated with a problematic cyanobacteria, where it blooms annually and requires chemical treatment. The T&O issues of the North Bay Aqueduct and Lake Skinner reported in the literature are related to unique events, where planktonic cyanobacteria grew under unique conditions (of high residence time and surface water temperature) and were discharged to the Delta, and then exported from the Delta. The scientific literature reviewed does not indicate that the T&O issues are common in the Delta, nor does the literature reviewed indicate T&O events are due to excessive nitrate levels, or specifically nitrate loads from the RWCF.

Geosmin and MIB have been detected at levels greater than the public sensory threshold of 10 ng/L in the California Aqueduct's reservoirs (Castaic Lake, O'Neill Forebay, Silverwood Lake) and aqueducts downstream of the Delta. Geosmin is a problem in Castaic Lake when the water levels drop and water withdraws are made closer to the lake surface, where cyanobacteria populations are more dense. In the South Bay Aqueduct, T&O issues are related to benthic diatom mats which also clog filters at the pumping plants.

Key factors affecting algal growth differ in the aqueducts vs. the Delta from where the water originates – namely shallow canal depth, sunlight throughout the water column, warmer water temperatures (SWP 2011), and a lack of grazers and other components of the Delta ecosystem. Only a small fraction of the cyanobacteria community may be responsible for the geosmin and MIB detections (SWP 2011), and many of the T&O producing cyanobacteria are able to utilize atmospheric nitrogen (dissolved in the water) as a nutrient source (Janik 2008). Research to date has not identified nitrate as a primary factor causing changes in algal abundance in the Delta or downstream of the Delta in the aqueducts and reservoirs (Hutton, as cited in Lee 2008).

Nearer to the RWCF, the density of potentially harmful algal species (i.e., those known to contribute to T&O issues in water supplies) was evaluated in the San Joaquin River at reference sites upstream of the influence of the RWCF discharge and within the proposed RWCF mixing zone for compliance with the MCL for nitrate plus nitrite (RBI 2013). The density observed in river samples was generally greater in the reference reach upstream of the influence of the RWCF discharge than in the proposed mixing zone (Figure 2). The data show that there were no measurable adverse algal community effects due to the locally higher nitrate levels around the RWCF. This adds to the previously available body of science for the Delta that, collectively, has not identified nitrate levels as being a factor causing potentially harmful algal species.

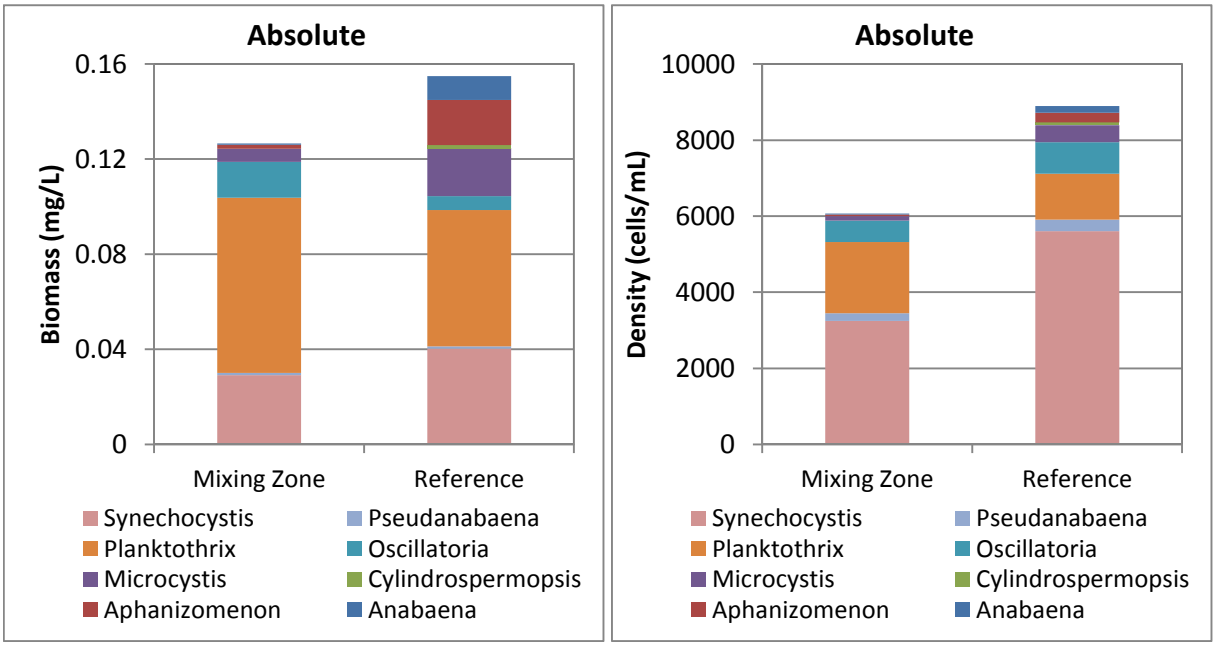

Figure 2. Absolute biomass and density of cyanobacteria with the potential to produce toxins or taste/odor compounds observed at the reference sites and the mixing zone sites. (Means of sites/months all combined)

In summary, the Tentative Order claims that algal related T&O impacts are occurring in the Delta and, therefore, any increased nutrient loading from the RWCF would contribute "to the impairment of the beneficial uses." Neither the San Joaquin River nor the Delta is listed on the State's 303(d) list as impaired for excessive algae and related municipal water supply T&O problems. Moreover, the scientific literature reviewed does not indicate that the T&O issues are common in the Delta, nor does the literature reviewed indicate T&O events are due to excessive nitrate plus nitrite levels in general, or specifically, nitrate loads from the RWCF.

4.2 Excessive Algal Growth and Cultural Eutrophication

The Tentative Order states:

> "Increased nutrient loads can create excessive algal growth in the Delta, resulting in impacts to municipal drinking water supplies. Increased algal growth can result in increased concentrations of total organic carbon that negatively impacts municipal drinking water suppliers, because it may result in the creation of harmful byproducts during chlorination. High algae levels in source water can also impact water treatment plants, because algae can clog filters and reduce the efficiency of filtration. . . . . These impacts are occurring, therefore, any increased nutrient loading contributes to the impairment of beneficial uses." (Tentative Order, Attachment F, p. F-23.)
>
> "Excessive nitrogen in the form of nitrates can also contribute to excessive algal growth and change the ecology of a waterbody, which has impacts to aquatic life and municipal uses." (Tentative Order, Attachment F, p. F-22 and F-56.)

> "There is evidence in the record that eutrophication is a problem in the Delta, therefore, there is no assimilative capacity for additional loading of nutrients, such as nitrate." (Tentative Order, Attachment F, p. F-57.)
>
> "Since the Delta is presently exhibiting cultural eutrophication at the current nutrient loading levels, discharge at the current nutrient loading will not be protective of downstream beneficial uses. Nutrient reduction is necessary to protect the beneficial uses of the Delta." (Tentative Order, Attachment F, p. F-58.)

It should be noted that Nitrate Option 1 that was publically noticed by the Regional Board along with the Tentative Order defines seasonal nitrate plus nitrite limitations of 26 mg/L-N April-September and 30 mg/L-N (October-March) for the RWCF. These seasonal limitations are 25-35% more restrictive than the 40 mg/L-N year-round limitation for nitrate plus nitrite in the current NPDES permit. Consequently, adoption of Nitrate Option 1 for the RWCF would not allow for "additional loading of nutrients" to the San Joaquin River, relative to existing conditions, as stated in the Tentative Order.

While it is true that in certain environments increased nutrient loads can result in excessive algal growth, this has not been demonstrated in the reach of the San Joaquin River influenced by the RWCF discharge specifically, or for the Delta generally. The Tentative Order findings suggest that nitrate plus nitrite loading could contribute to excessive algal growth, but fail to cite any scientific evidence that links nitrate plus nitrite loading from the RWCF, or any other sources, to the San Joaquin River and Delta to excessive algal growth. Contrary to the implication in the Tentative Order, studies to date have shown that increased nutrient loads generally do not affect algal growth in the Delta, and that nitrate plus nitrite loading from the RWCF does not increase algae abundance. Data collected by the City (RBI 2013) as well as studies conducted by others cited above conclusively demonstrate that algae biomass and cell density are significantly lower in the reach of the San Joaquin River influenced by the RWCF discharge than in areas upstream that are unaffected by the discharge.

Excessive algal growth issues can be broadly related to benthic and planktonic algal forms. Eutrophic systems are typically thought to have high annual phytoplankton productivity followed by low dissolved oxygen concentrations when dead algal material is decomposed. However, low dissolved oxygen levels are not widely observed throughout the Delta. In fact, the low dissolved oxygen issue in the DWSC has largely been resolved now that: 1) ammonia from the RWCF is nitrified prior to its discharge to the San Joaquin River, and 2) aerators are operated as needed in the DWSC, itself. Wide-spread algal blooms resulting in low dissolved oxygen levels are not currently observed in Delta.

With regards to organic carbon, it represents an important disinfection by-product (DBP) precursor, and thus is an important parameter describing the quality of water for use as a drinking water source. The Tentative Order, however, incorrectly links algal growth and algal abundance to total organic carbon (TOC) and the formation of DBPs.

Methodologically, a measurement of TOC represents the sum of both particulate organic carbon (POC) and dissolved organic carbon (DOC). In Delta waters, DOC typically represents 85-90% of TOC (CALFED 2007). In other words, practically all of the organic carbon in a typical Delta water sample is DOC. While algae contribute to water column TOC, they do so as part of the POC fraction. DOC most influences DBP formation potential in Delta waters (CALFED 2007). Algae are not estimated to be a

major source of DOC in the Delta, nor are they estimated to be a major source of DOC when they die and decay in exported Delta water, which includes water removed from the Delta for drinking water treatment (CALFED 2008). Moreover, the POC fraction, which includes algae, would be largely removed through conventional drinking water treatment (SWP 2007), and thus would not contribute significantly to DBP formation upon disinfection at drinking water treatment plants.

Regarding the statement made in the Tentative Order that excessive algal growth has impacts on aquatic life, Sommer et al. (2007) stated that phytoplankton biomass, as indexed by chlorophyll *a*, has declined over the past four decades. These researchers further stated that species composition has shifted, with a decline in diatom abundance in Suisun Bay and the western Delta, with key groups of zooplankton also showing declines in abundance and biomass. Calaniod copepods, a member of the zooplankton community and a primary prey for early life stages of pelagic fishes, have experienced great declines as well. None of the literature reviewed for preparing this Technical Memorandum states that excessive algal growth is responsible for the declines in zooplankton species cited above, or for other adverse effects on aquatic life in the Delta.

The topic of nutrients and algal biomass in the San Joaquin River was specifically addressed by Jassby (2005). In this article, Dr. Jassby states:

> "Most estuaries exhibiting eutrophic conditions are also moderately to highly influenced by anthropogenic nutrient inputs (e.g., wastewater treatment plant effluent and agricultural drainage), which have therefore been identified as the most important management targets on a national basis. It is natural to assume that such a course is also warranted for the San Joaquin River because of intense agriculture and animal husbandry throughout its watershed, resulting in nutrient inputs within and upstream of the estuary. However, many uncertainties surround the regulation of phytoplankton biomass in tidal rivers, and regional differences in nutrient sources and estuarine functioning are significant. Cloern (2001) has emphasized the spectrum of estuarine responses to increased nutrient loading—from resistant to highly sensitive. He showed that a variety of attributes can act as a filter to modify effects of excessive nutrients, including strength of tidal mixing, magnitude of horizontal transport, water clarity, and abundance of benthic suspension-feeders. The early conceptual model linking nutrient loading inexorably to biomass accumulation, derived largely from experience with lakes, is now understood to be inadequate for understanding estuarine systems, including their tidal river reaches.
>
> What, then, controls phytoplankton biomass in the tidal San Joaquin River upstream of major diversions and low dissolved oxygen conditions; how will reduction in nutrient loading affect existing phytoplankton levels; and what other opportunities exist to manage phytoplankton in this river reach? Strategies for phytoplankton regulation in this subregion of the estuary must also consider the negative consequences of low phytoplankton biomass. The tidal river is one of the few productive habitats for an estuarine food web that otherwise appears to be relatively unproductive and food-limited (Sobczak et al. 2002), and the small centric diatoms that dominate the reach are a highly nutritious base for the food web supporting higher organisms. The goal, then, should not be to aim for arbitrarily low [nutrient] levels, but rather to explore ways in which phytoplankton biomass can be regulated more finely, if possible."

In summary, available scientific information indicates that the lower portions of the San Joaquin River and Delta, downstream of the RWCF, are not experiencing excessive algal growth that is adversely impacting aquatic life as claimed by the Tentative Order. Rather, algal biomass is lower near the RWCF and downstream compared to upstream reaches unaffected by the discharge, despite nitrate plus nitrite levels being higher near and downstream of the RWCF. Moreover, researchers have found that the lower portion of the San Joaquin River and much of the Delta appear to be relatively unproductive with regards to phytoplankton communities and thus may be food-limited to higher trophic levels of aquatic life. These scientific findings do not support the contention in the Tentative Order that excessive algal growth is adversely impacting aquatic life in the Delta.

The published findings cited above do not support the Tentative Order's claims that:

- there is no assimilative capacity for additional loading of nutrients, such as nitrate
- discharge from the RWCF at the current nutrient loading will not be protective of downstream beneficial uses, and thus nutrient reduction is necessary to protect the beneficial uses of the Delta.

4.3 Historical Changes in Delta Algal Community Composition

The Tentative Order states:

> "Excessive nitrogen in the form of nitrates can also contribute to excessive algal growth and change the ecology of a waterbody, which has impacts to aquatic life and municipal uses." (Tentative Order, Attachment F, p. F-22 and F-56.)

The composition of the phytoplankton community over the last 40 years has generally shifted from diatoms toward green algae, cyanobacteria, and miscellaneous flagellate species. The abundance of diatoms in the west Delta and Suisun Bay decreased in the early 1980s, whereas dinoflagellates, cryptophytes, and chlorophytes were generally dominant from the late 1980s to mid-1990s. Cyanobacteria, including *Microcystis aeruginosa*, increased from the late 1990s to the mid-2000s. The changes in phytoplankton composition, and especially *Microcystis aeruginosa* blooms, have been implicated as possible factors in POD (Ballard et al. 2009).

These shifts in algal community composition are identified as being caused by a multitude of factors. Analyses have indicated that the most prominent driving factors are likely: the introduction of the invasive clam *Corbula amurensis* in 1986, seasonal Delta inflow/outflow which affects residence time, a long-term decrease in TSS, (Jassby 2002, 2005, 2008; Lehman 1996; Kimmerer 2004, 2005), and another unidentified factor which plays a role in winter, and may be related to another clam *Corbicula amurensis* (Jassby 2002, Kimmerer 2004). Glibert et al.'s discussion of nutrient stoichiometry in the Delta (2011) is one of the only articles to argue that nutrients may have played a role. Using historical data from Suisun Bay, which integrate nutrient concentrations and loading from both the Sacramento and San Joaquin Rivers, the authors show that the N:P ratio increased through the same period that saw many problematic ecosystem variable shifts (i.e., increases in flagellates, cyanobacteria, piscivorous fish, and invasive vegetation and bivalves; and declines in the zooplankton *Eurytomea* sp., delta smelt, and diatoms). As noted in RBI 2013, because the historical N:P ratio in Suisun Bay is dominated by the concentration of ammonia arriving via the Sacramento River, most if not all of the correlations described in the study hold

equally true for both the N:P ratio and ammonia. Since high levels of ammonia have been linked through laboratory experiments and study of the Sacramento River and Suisun Bay to potential effects on algae, it could be argued that a correlation between ammonia and negative effects represents a more compelling relationship than N:P ratio generally, though there are certainly numerous other factors involved, not least of which are the impacts of the invasive clam as mentioned above.

Researchers have recently investigated the role of elevated ammonia concentrations in limiting algae blooms in Suisun Bay and northern San Francisco Bay. The research has indicated that ammonia, while stimulating diatom growth at very low concentrations, also can inhibit uptake of nitrate in diatoms as concentrations increase above about 4 micromoles per liter (µmol/L) (0.056 mg/L-N) (Dugdale et al. 2007). This inhibition is of concern in Suisun Bay, where algal blooms may be prevented when conditions otherwise would be favorable (Wilkerson et al. 2006). Ammonia has thus been hypothesized to have contributed to the shift from a diatom-based community to one of smaller zooplankton in Suisun Bay.

The degree to which long-term composition shifts in the Delta phytoplankton communities affect higher trophic levels has yet to be fully determined. Along with the biomass/chlorophyll *a* decreases observed in the Delta since 1970, there has been a shift away from a diatom-dominated phytoplankton community, particularly in the west Delta and Suisun Bay, to a community principally composed of green algae, flagellates, and cyanobacteria (Lehman 1996; Kimmerer 2005, Jassby 2008). This shift is hypothesized to have led to a decline in the annual recruitment of Delta zooplankton, and in turn to have contributed to POD (Jassby 2008), although this hypothesis remains largely unproven. For example, recent studies have shown that Delta zooplankton community may prefer a diet besides diatoms, including heterotrophic ciliates and protozoa (Gifford et al. 2007; Bouley and Kimmerer 2006; Rollwagen-Bollens and Penry 2003). Other factors also affect zooplankton success in the Delta. Zooplankton may directly compete for food with the invasive clam *Corbula amurensis* (Kimmerer et al., 1994). *Corbula*, which has been widely cited as one of the causes of the dramatic decline in phytoplankton biomass, diatoms in particular (Lehman 1996, Lehman 2000, Kimmerer 2005), may also cause directly mortality of copepod nauplii by entrainment (Kimmerer et al., 1994). Compositional shifts in the phytoplankton community may affect the Delta food web, but as these studies suggest, the extent of this impact cannot currently be determined due to the complicated nature of predator-prey interactions among zooplankton, clams, protozoa, and phytoplankton.

None of the literature reviewed suggests that elevated nitrate is the cause of or is contributing to community shifts, with the exception of Glibert et al. (2011), discussed above, which argues that the N:P ratio may have played a role. As mentioned above, this article's conclusions are based mostly on historical changes in ammonia concentrations in the west Delta and Suisun Bay, from Sacramento River flow. Thus, nitrate has not been implicated in the shifts in community composition by any of the literature reviewed in general, nor has nitrate loading from the RWCF specifically been implicated in the scientific literature.

4.4 *Microcystis* in the Delta

The Tentative Order states:

> "Other species of blue green algae, in particular *Anabaena flos-aquae, Microcystis aeruginosa, and Aphanizomenon flos-aquae*, produce neurotoxins that are toxic to humans, fish, and wildlife. These species of algae have also been reported in the Delta according to the Department of Public Health." (Tentative Order, Attachment F, p. F-57)

Among the three species of blue-green algae listed above as being present in the Delta, *Aphanizomenon* and *Anabaena* spp. can form heterocysts that fix nitrogen from the atmosphere, rendering water column concentrations of nitrogen as non-limiting for growth. Therefore, this section focuses on *Microcystis aeruginosa* (*Microcystis*), which does not contain heterocysts. Moreover, *Microcystis* has been the subject of much more research than either of the other two cited species.

Microcystis is a harmful cyanobacterial algal bloom species. In addition to producing surface scums that interfere with recreation and cause aesthetic problems, it also causes taste and odor in drinking water and produces toxic microcystins that are associated with liver cancer in humans and wildlife. *Microcystis* blooms can cause toxicity to phytoplankton, zooplankton, and fish, and also can affect feeding success or food quality for zooplankton and fish. Blooms of *Microcystis* require high levels of nitrogen and phosphorus to develop, but also require high water temperature and long residence time, since the species is fairly slow growing (Lehman et al. 2008). In addition, low vertical mixing allows *Microcystis* colonies to float to the surface of the water column, where they outcompete other species for light.

In a study conducted in 2004 (Lehman et al. 2008), the San Joaquin River exhibited the highest *Microcystis* concentrations in the Delta, although levels throughout the Delta were rarely above the World Health Organization (WHO) threshold of 20,000 cells/mL (WHO 2003). This threshold was designated by WHO to limit the irritant and allergenic effects of cyanobacterial compounds to those using the water for recreation purposes; the threshold for protecting against toxic health outcomes is even higher (WHO 2003). In the study, *Microcystis* occurred within a narrow range of environmental conditions, when water temperature was greater than 20°C, TSS was between 100 and 500 mg/L, specific conductance was between 100 and 300 microSiemens per centimeter (µS/cm), ammonia was between 0.01 and 0.03 mg/L, and flow in the San Joaquin River was between 1,000 and 1,250 cfs. Nutrient concentration was not significantly related to variation in *Microcystis* abundance around the Delta. Although the nutrient (nitrogen and phosphorus) concentrations found throughout the Delta were cited as prerequisites for the bloom, the persistence of the bloom was not related to nutrients because nutrient concentrations are not limiting algal growth in the Delta (Lehman et al. 2008).

In a later study conducted by Lehman et al. (2010), *Microcystis* concentrations were correlated with water quality conditions across the Delta. About 72% of the variation was correlated with chloride, total organic carbon, and total suspended solids. Among water quality parameters, *Microcystis* concentrations were positively correlated with nitrate-N, soluble phosphorus, and total nitrogen (total-N), and negatively correlated with chloride, TSS, and organic carbon. However, *Microcystis* concentrations were generally fairly low, and made up a substantial amount of the total algal biomass at only one site, in Old River. *Microcystis* is known to be able to use alternative forms of nutrients, and rapidly assimilates ammonium over nitrate (Lehman et al. 2010). In fact, a recent sampling survey measured the isotope signatures of nitrate and ammonia in San Joaquin River and Sacramento River water samples to show that *Microcystis* blooms occurring in the Delta selectively utilize ammonia from the Sacramento River rather than nitrate from the San Joaquin River (Kendall et al. 2011).

The Tentative Order simply stated that *Anabaena flos-aquae, Microcystis aeruginosa, and Aphanizomenon flos-aquae*, which produce neurotoxins that are toxic to humans, fish, and wildlife have also been reported in the Delta, but did not relate these facts to development of nitrate plus nitrite limitations for the RWCF. *Microcystis* has received the most scientific research attention of these species in the Delta. The review of available scientific literature presented above indicates that nutrient concentrations have not been found to be a primary factor affecting *Microcystis* abundance around the Delta. Rather, *Microcystis* blooms have been found to occur under a rather unique set of hydrologic and water quality conditions, when flows are low, residence times are high, water temperatures are high, grazing pressure is low, and ammonia is available as a nitrogen source. None of the studies reviewed indicated that the nitrate plus nitrite loading from the RWCF is affecting blue-green algal blooms in the San Joaquin River or Delta. In fact, to the contrary, Kendall et al. (2011) showed that *Microcystis* blooms occurring in the Delta selectively utilize ammonia from the Sacramento River rather than nitrate from the San Joaquin River. Hence, the scientific literature does not support the contention that further limiting nitrate plus nitrite loading from the RWCF will control or lessen the occurrence of blue-green algal blooms in the San Joaquin River or Delta.

5 Effects of Permitting the RWCF to 10 mg/L vs. 26/30 mg/L

The current NPDES permit for the RWCF includes a nitrate plus nitrite AMEL of 40 mg/L-N. The City requested seasonal nitrate plus nitrite AMELs be included in the renewed permit, based on the scientific and regulatory findings of RBI (2013). The requested AMELs, which the Regional Board publically noticed as Nitrate Option 1 when the Tentative Order was noticed, are:

- 26 mg/L-N, applicable 1 April–30 September and
- 30 mg/L, applicable 1 October–31 March.

These limitations are based on the performance capability of the RWCF, and are lower than the current limitation by 35% and 25%, respectively, resulting in a reduction in the current permitted load and use of assimilative capacity.

Table 1 and Figure 3 show the modeled RWCF contribution to nitrate plus nitrite concentrations in the Delta at the current discharge concentrations (i.e., when complying with the requested seasonal AMELs cited above) and when complying with the Tentative Order AMEL of 10 mg/L-N. As shown in Table 1, restricting the nitrate plus nitrite AMEL to 10 mg/L-N, when compared to the City's requested AMELs, would result in long-term average nitrate plus nitrite contributions to the DWSC near Rough and Ready Island being reduced on the order of about 0.35 mg/L-N, and would result in slight to negligible differences at most Delta locations.

In the areas that would show the greatest reduction (i.e., in the mixing zone), as indicated previously, algae levels are already low due to other factors (i.e., hydrodynamics, light limitation, and grazing). As described in the previous section, because nitrate plus nitrite levels are not controlling algae biomass or community composition in the San Joaquin River or Delta, maintaining current nitrate levels in the effluent would not cause excessive algal growth, adverse ecological changes, or impacts to municipal drinking water supplies in the Delta, as claimed but not supported by evidence in the Tentative Order.

Table 1. Nitrate plus nitrite concentrations at locations in the Delta, RWCF effluent concentrations (%), and incremental nitrate plus nitrite contributions under 10 mg/L-N and 26/30 mg/L-N effluent limitation scenarios.

Delta Location	Average Nitrate Plus Nitrite Background Concentration (mg/L-N) [1]	Average Effluent Concentration (%) [2]	Long-term Average Effluent Nitrate plus Nitrite Contribution to the Location (mg/L-N)	
			AMEL = 26/30 mg/L-N [3]	AMEL = 10 mg/L-N [4]
San Joaquin River at Vernalis [5]	1.11	0	0	0
San Joaquin River near Brandt Bridge [6]	1.01	0.83	0.12	0.08
San Joaquin River, Stockton Deep Water Ship Channel at Rough and Ready Island [7]	1.54	4.67	0.82	0.47
San Joaquin River at Venice Island (Stockton Delta Water Supply Project drinking water intake) [8]	0.56	0.08	0.01	0.01
Clifton Court Forebay (Banks Pumping Plant) [9]	0.53	0.44	0.08	0.04
Delta Mendota Canal (Jones Pumping Plant) [10]	0.76	0.32	0.05	0.03
Victoria Canal (CCWD AIP) [11]	0.63	0.77	0.13	0.08
CCPP Rock Slough Intake [12]	0.15	0.33	0.06	0.03
Barker Slough / North Bay Aqueduct [13]	0.28	0.00	0.00	0.00
Sacramento River at Mallard Island [14]	0.42	0.02	0.00	0.00
San Joaquin River at Antioch [15]	0.23	0.03	0.01	0.00

Notes:
[1] ND counted as ½ RL.
[2] Discharge rate was 25 mgd, which was the average discharge rate from 2010-2013.
[3] At the City's requested AMELs, no change in operations/treatment would occur. Thus, effluent concentrations used in the simulation were current (2010-2013) seasonal average discharge concentrations: 14.3 mg/L-N for May-August; 20.0 mg/L-N for January-April and September-December.
[4] Effluent concentration used was the tentative permit AMEL, 10 mg/L-N.
[5] Data obtained for nitrate concentrations from CDEC station VNS. Data spanned 1/2010 through 12/2012.
[6] Data obtained for nitrate concentrations from CIWQS for RWCF station no. RSW-001. Data spanned 6/2010 through 9/2012.
[7] Data obtained for nitrate concentrations from CIWQS for RWCF station no. RSW-004. Data spanned 6/2010 through 9/2012.
[8] Data obtained for nitrate concentrations from CIWQS for RWCF station no. RSW-008, approximately 3.5 miles upstream of Delta Location. Data spanned 6/2010 through 9/2012.
[9] Data obtained for nitrate concentrations from Water Data Library (DWR 2014) for station no. KA000331. Data spanned 10/1990 through 9/2012.
[10] Data obtained for nitrate concentrations from Water Data Library (DWR 2014) for station no. B9C74781352 and B9C74901336. Data spanned 10/1990 through 5/1999 and 3/2009 through 7/2012.
[11] Data obtained for nitrate concentrations from Water Data Library (DWR 2014) for station no. B9D75171329. Data spanned 10/1990 through 10/1991.
[12] Data obtained for nitrate concentrations from Water Data Library (DWR 2014) for station no. B9D75861372. Data spanned 5/2011 through 9/2012.
[13] Data obtained for nitrate concentrations from Water Data Library (DWR 2014) for station no. B9D81661478 and KG000000. Data spanned 1/1990 through 2/2014.
[14] Data obtained for nitrate concentrations from Water Data Library (DWR 2014) for station no. E0B80261551. Data spanned 1/1990 through 3/2014.
[15] Data obtained for nitrate concentrations from Water Data Library (DWR 2014) for station no. B9D80311413. Data spanned 4/1964 through 10/1991.

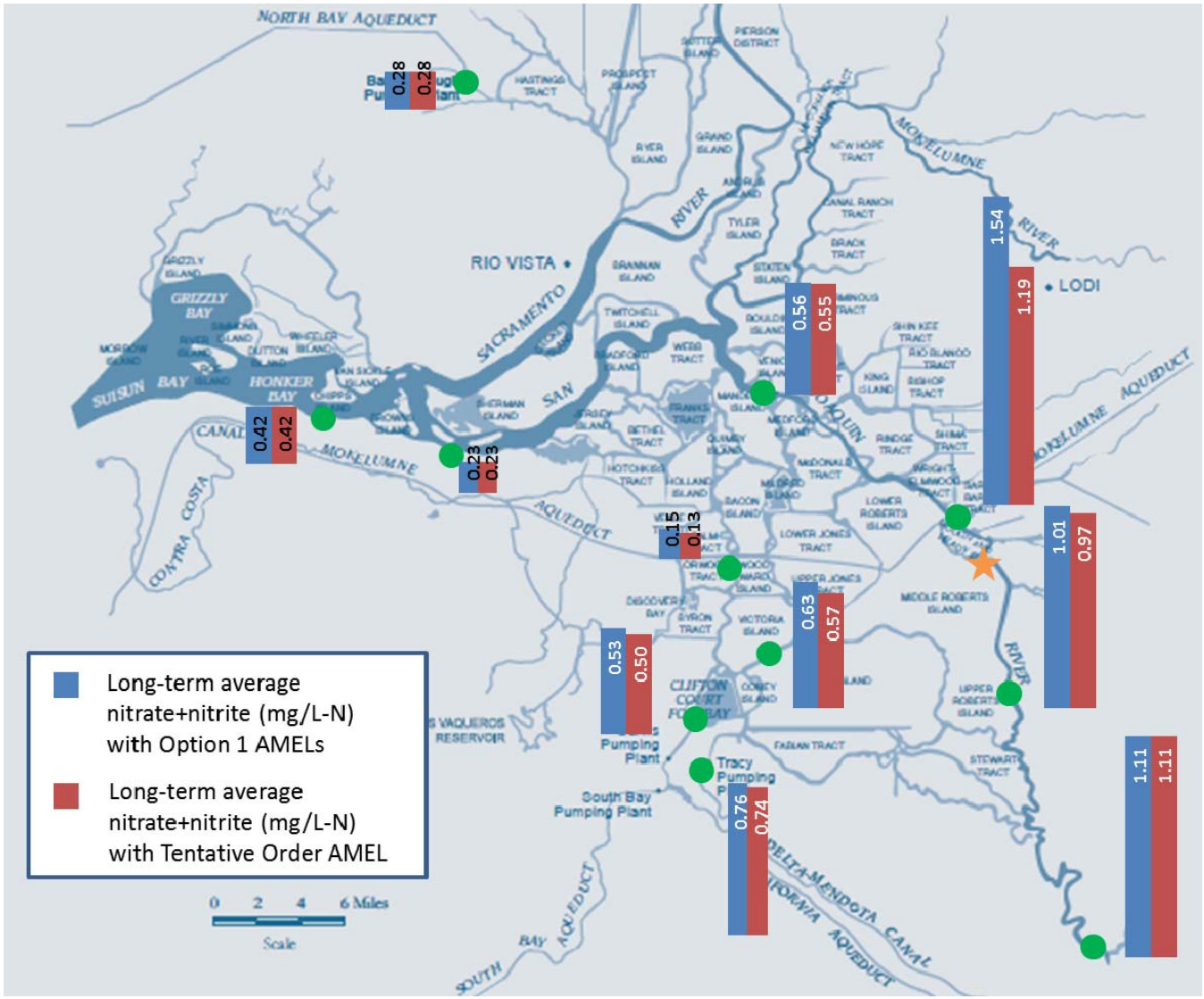

Figure 3. Map of the Delta showing current long term average nitrate plus nitrite (as N) concentrations (i.e., with Option 1 AMELs), and modeled concentrations under the AMEL in the Tentative Order

As discussed above, there is no direct link between the level of nutrients currently in the Delta, or specifically the nitrate plus nitrite discharged from the Stockton RWCF, and algae growth. That is to say, if nitrate plus nitrite levels in the RWCF discharge were to decrease (even to zero), remain the same, or marginally increase, the science indicates that there would be little to no impact on algae growth and thus no adverse impacts to beneficial uses in the San Joaquin River and Delta. Thus, there is assimilative capacity for nitrate plus nitrite. That said, the seasonal limitations in Nitrate Option 1 are lower than the current permit's limitations, and adoption of the seasonal nitrate plus nitrite limitations defined in Nitrate Option 1as part of the permit renewal would not result in use of any additional amount of the available assimilative capacity, relative to existing conditions.

Accordingly, the Tentative Order cites no definitive scientific evidence that reduction in nitrate plus nitrite in the discharge from the RWCF from its current limitations to 10 mg/L-N is necessary to protect beneficial uses. The available scientific evidence indicates that the reduction in nitrate plus nitrite loading required under the Tentative Order would not be expected to have any measurable effect on the type or quantity of algae in the San Joaquin River or Delta, and thus will have no effect on the protection of beneficial uses.

6 References

Ballard, A., R. Breuer, F. Brewster, C. Dahm, C. Irvine, K. Larsen, A. Müller-Solger, and A. Vargas. 2009. *Background/summary of ammonia investigations in the Sacramento-San Joaquin Delta and Suisun Bay*. March 2, 2009.

Bouley, P., W. Kimmerer. 2006. Ecology of a highly abundant, introduced cyclopoid copepod in a temperate estuary. *Mar. Ecol. Prog. Ser.* 324:219-228.

CALFED. 2007. CALFED Water Quality Program, Stage 1 Final Assessment, Final Report. Prepared by CALFED Water Quality Program. October 2007.

CALFED. 2008. Science in Action: *Tracking Organic Matter in Delta Drinking Water*. April 2008.

Caroompas, J. 2012. "The Algae Bloom is Back to Haunt Martinez Tap Water". Martinez Patch. August 10.

CDEC (California Data Exchange Center). 2013. Data retrieval. Site accessed March 2013.

Cloern, J.E. 2001. Our evolving conceptual model of the coastal eutrophication problem. *Marine Ecology Progress Series.* 210:223-253.

Dugdale, R., F. Wilkerson, V. Hogue, and A. Marchi. 2007. "The Role of Ammonium and Nitrate in Spring Bloom Development in San Francisco Bay." *Estuarine Coastal and Shelf Science* 73:17–29.

DWR (Department of Water Resources). 2014. Water Data Library. Data retrival. Site accessed April, 2014.

Gifford, S., G. Rollwagen-Bollens, S. Bollens. 2007. Mesozooplankton omnivory in the upper San Francisco Estuary. 348:33-46.

Izaguirre, I., I. O'Farrell, and G. Tell. 2001. "Variation in Phytoplankton Composition and Limnological Features in a Water-Water Ecotone of the Lower Parana´ Basin (Argentina)." *Freshwater Biology* 46:63–74.

Jacoby, J.M., D.C. Collier, E.B. Welch, F.J. Hardy, and M. Crayton. 2000. "Environmental Factors Associated with a Toxic Bloom of *Microcystis aeruginosa*." *Canadian Journal of Fisheries and Aquatic Sciences* 57:231–240.

Janik, J. 2008. Delta and Aqueduct Tastes and Odors and Algal Cyanotoxins. Presentation to the Delta Nutrient Water Quality Modeling Workshop. March 25, 2008.

Jassby, A. 2005. "Phytoplankton Regulation in a Eutrophic Tidal River (San Joaquin River, California)." *San Francisco Estuary and Watershed Science* 3:1–22.

Jassby, A. 2008. "Phytoplankton in the Upper San Francisco Estuary: Recent Biomass Trends, Their Causes and Their Trophic Significance." *San Francisco Estuary and Watershed Science* 6:1–24.

Jassby, A., J. Cloern, and B. Cole. 2002. "Annual Primary Production: Patterns and Mechanisms of Change in a Nutrient-Rich Tidal Ecosystem." *Limnology and Oceanography* 47:698–712.

Kendall, C., P. Lehman, S. R. Silva, M.B. Young, M. Guerin. 2011. Tracing sources of nutrients fueling *Microcystis* blooms in the Sacramento-San Joaquin Delta using a multi-fingerprinting approach. Reference submitted by the State and Federal Water Contractors as part of the workshop on the Comprehensive Review of the 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (excluding San Joaquin River Flows and Southern Delta Salinity) - Water Quality Control Planning Phase.

Kies, L. 1997. "Distribution, Biomass and Production of Planktonic and Benthic Algae in the Elbe Estuary." *Limnologica* 27:55–64.

Kimmerer 2005: Kimmerer, W. 2005. Long-term changes in apparent uptake of silica in the San Francisco estuary. *Limnol. Oceanogr*. 50(3): 293-298.

Kimmerer**,** W.J., E. Gartside, and J.J. Orsi. 1994. Predation by an introduced clam as the probable cause of substantial declines in zooplankton in San Francisco Bay. Marine Ecology Progress Series, 113:81-93.

Kimmerer, W.J. and J.J. Orsi. 1996. Changes in the zooplankton of the San Francisco Bay Estuary since the introduction of the clam *Potamocorbula amurensis*. Pages 403-424. *in* J.T. Hollibaugh, editor. San Francisco Bay: the ecosystem. Pacific Division of the American Association for the Advancement of Science. San Francisco, California, USA.

Lee, G.F. 2008. *Stormwater Runoff Water Quality Newsletter Devoted to Urban/Rural Stormwater Runoff Water Quality Management Issues* 11:1–14.

Lehman, P. 1996. Changes in chlorophyll a concentration and phytoplankton community composition with water-year type in the upper San Francisco bay estuary. In San Francisco Bay: The Ecosystem. p. 351-374.

Lehman, P. 2000. The influence of climate on phytoplankton community biomass in San Francisco Bay Estuary. *Limnol. Oceanogr*. 45(3): 580-590.

Lehman, P.W. 2007. "The Influence of Phytoplankton Community Composition on Primary Productivity along the Riverine to Freshwater Tidal Continuum in the San Joaquin River, California." *Estuaries and Coasts* 30:82–93.

Lehman, P. W., G. L. Boyer, M. Stachwell, and S. Walker. 2008. "The Influence of Environmental Conditions on the Seasonal Variation of *Microcystis* Cell Density and Microcystins Concentration in San Francisco Estuary." *Hydrobiologia* 600:187□204.

Lehman, P., S.J. Teh, G.L. Boyer, M.L. Nobriga, E. Bass, and C. Hogle. 2010. "Initial Impacts of *Microcystis aeruginosa* Blooms on the Aquatic Food Web in the San Francisco Estuary." *Hydrobiologia* 637:229–248.

Litton, G.M., M. Brunnell, and J.C. Monroe. 2008. *Linking the San Joaquin River to the Stockton Deep Water Ship Channel.* San Joaquin River Up-Stream DO TMDL Project ERP-02D-P63 Task 8. 148 pp.

Mueller-Solger, A., A. Jassby, D. Müller-Navarra. 2002. Nutritional quality of food resources for zooplankton (*Daphnia*) in a tidal freshwater system (Sacramento-San Joaquin River Delta). *Limnol. Oceanogr.* 47(5): 1468-1476.

Muylaert, K., K. Sabbe, and W. Vyverman. 2000. "Spatial and Temporal Dynamics of Phytoplankton Communities in a Freshwater Tidal Estuary (Schelde, Belgium)." *Estuarine Coastal and Shelf Science* 50:673–687.

RBI (Robertson-Bryan, Inc.). 2013. *Evaluation of the Potential Effects of Nitrate Plus Nitrite Discharged from the Stockton Regional Wastewater Control Facility on the San Joaquin River in Support of Dilution Credit for NPDES Permitting*. Prepared for the Regional Water Quality Control Board, Central Valley Region, on behalf of the City of Stockton. Elk Grove, CA. July. 140 pp.

Reynolds, C.S. 1994. "The Long, the Short and the Stalled: On the Attributes of Phytoplankton Selected by Physical Mixing in Lakes and Rivers." *Hydrobiologia* 289:9–24.

Rijstenbil, J.W., C. Bakker, R.H. Jackson, A.G.A. Merks, and P.R.M. De Visscher. 1993. "Spatial and Temporal Variation in Community Composition and Photosynthetic Characteristics of

Phytoplankton in the Upper Westerschelde Estuary (Belgium, SW Netherlands)." *Hydrobiologia* 269/270:263–273.

Rollwagen-Bollens, G., D.L. Penry. 2003. Feeding dynamics of *Acartia* spp. Copepods in a large, temperate estuary (San Francicso Bay, CA). *Mar Ecol Prog Ser*. 257:139-158.

Royer, T.V., M.B. David, L.E. Gentry, C.A. Mitchell, K.M. Starks, T. Heatherly II, and M.R. Whiles. 2008. "Assessment of Chlorophyll-a as a Criterion for Establishing Nutrient Standards in the Streams and Rivers of Illinois." *Journal of Environmental Quality* 37:437–447.

Sobczak W.V., J.E. Cloern, A.D. Jassby, A.B. Müller-Solger. 2002. "Bioavailability of organic matter in a highly disturbed estuary: The role of detrital and algal resources." *Proceedings of the National Academy of Sciences* 99(12):8101-8105.

Sommer, T. R., C. Armor, R. Baxter, R. Breuer, L. Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingas, B. Herbold, W. Kimmerer, A. Müller-Solger, M. Nobriga, and K. Souza. 2007. "The Collapse of Pelagic Fishes in the Upper San Francisco Estuary." *Fisheries* 32:270–277.

SWP (State Water Project). 2007. California State Water Project Watershed Sanitary Survey, 2006 Update. Prepared by Archibald Consulting and Palencia Consulting Engineers. Prepared for State Water Project Contractors Authority and the California Department of Water Resources. June.

SWP (State Water Project). 2012. California State Water Project Watershed Sanitary Survey, 2011 Update. Prepared by Archibald Consulting, Palencia Consulting Engineers, and Starr Consulting. Prepared for State Water Project Contractors Authority and the California Department of Water Resources. June.

Wilkerson, F., R. Dugdale, V. Hogue, and A. Marchi. 2006. "Phytoplankton Blooms and Nitrogen Productivity in San Francisco Bay." *Estuaries and Coasts* 29:401–416.

WHO (World Health Organization). 2003. *Guidelines for Safe Recreational Water Environments, Volume 1: Coastal and Fresh Waters*. Chapter 8—Algae and Cyanobacteria in Fresh Water. Geneva, Switzerland.

ROBERTSON - BRYAN, INC.
Solutions for Progress

Michael D. Bryan, Ph.D.

Partner / Principal Scientist

Dr. Michael Bryan has over 28 years of combined consulting and research experience focused on water quality, fisheries biology, and aquatic toxicology. Dr. Bryan's research background provides a strong foundation for conducting specialized water quality and aquatic ecological studies, including experimental design, study implementation, data analyses and interpretation, and report preparation. His work includes conducting biological assessments of fish, benthic macroinvertebrates, and algae to identify potential effects of wastewater discharges on aquatic ecosystems and endangered species.

Dr. Bryan applies his extensive knowledge of fisheries and water quality in his management and technical oversight of CEQA/NEPA assessments for water supply and conveyance, flood control, and wastewater treatment and disposal projects. Dr. Bryan has developed a deep understanding of CVP/SWP operations, and the fish resources and water quality of the foothill and valley floor creeks, American River, Yuba River, Sacramento River, and the Sacramento-San Joaquin Delta. Dr. Bryan's expertise in preparing CEQA/NEPA assessments includes refinement of alternatives and development of defensible impact assessment thresholds.

Dr. Bryan served as the technical lead, working closely with the Central Valley Regional Water Quality Control Board, State Water Resources Control Board, U. S. Environmental Protection Agency staff; the Central Valley Clean Water Association; and individual dischargers to develop new Region-wide and site-specific water quality standards for temperature, pH, turbidity, chloroform, chlorodibromomethane, and dichlorobromomethane. He is currently assisting Central Valley Regional Water Quality Control Board staff with Basin Plan amendments for the Municipal and Domestic Supply beneficial use in agriculturally dominated water bodies.

EDUCATION

Ph.D., Environmental Toxicology & Fisheries Biology, 1993, Iowa State University

M.S., Fisheries Biology, 1989, Iowa State University

B.S., Fisheries Biology & Biology, 1986, University of Wisconsin, Stevens Point

REPRESENTATIVE PROJECT EXPERIENCE

NPDES PERMITTING / WASTEWATER DISCHARGER STUDIES

NPDES PERMIT RENEWAL

Provides technical and strategic services to negotiate waste discharge requirements in NPDES permits for wastewater treatment plants (WWTPs) issued by state regional water quality control boards (RWQCB). This includes conducting detailed reviews and preparing detailed comments on tentative NPDES permits to establish an evidentiary record, and discussions with RWQCB staff and other resources agencies, including California Department of Fish and Game, National Marine Fisheries Service, and Department of Public Services staff, over permit terms. Also prepares discharger

presentations and provides public testimony at NPDES permit adoption hearings. These services have been provided for:

- El Dorado Irrigation District – Deer Creek and El Dorado Hills WWTPs (1996–present)
- Sacramento Regional County Sanitation District (1997-present)
- City of Roseville – Dry Creek and Pleasant Grove Creek WWTPs (1998–present)
- City of Vacaville – Easterly WWTP (1999-present)
- City of Placerville – Hangtown Creek Water Reclamation Facility (1999–present)
- City of Brentwood WWTP (2003–present)
- Mountain House Community Services District – Mountain House WWTP (2006–present)
- Ironhouse Sanitary District WWTP (2006–present)
- City of Stockton Regional Wastewater Control Facility (2008–present)
- Placer County – Sewer Maintenance District 1, Sewer Maintenance District 3, Sheridan, and Applegate WWTPs (1998–2011)
- City of Ione (2010-2012)
- Nevada County – Lake Wildwood, Lake of the Pines, and Cascade Shores WWTPs (2003–2009)
- Colusa Industrial Properties (2007–2008)
- City of Santa Rosa (2005–2007)
- Los Angeles County Sanitation Districts – Los Coyotes Water Reclamation Plant and Long Beach Water Reclamation Plant (2002–2005)
- City of Lincoln/Del Webb – Lincoln Wastewater Treatment and Reclamation Facility (2000–2005)

THERMAL PLAN EXCEPTIONS

Principal-in-charge and technical lead to conduct special studies in support of obtaining Clean Water Act section 316(a) exceptions to California Thermal Plan temperature objectives applied in NPDES permits and facilitate the exceptions' approval by the Central Valley Regional Water Quality Board (RWQCB) and fish resource agencies – California Department of Fish and Game, National Marine Fisheries Services, and U.S. Fish and Wildlife Service. Has developed or is currently developing exceptions as follows:

- *California Department of General Services (DGS).* Completed study evaluating the temperature-related effects the Central Heating and Cooling Plant discharges to the Sacramento River

on migrating fish. Based on this study, its findings, and concurrency on findings by the fish resource agencies, the RWQCB issued a Thermal Plan Exception to DGS, resulting in a cost-effective solution to DGS's temperature compliance issue.

- *Brentwood Wastewater Treatment Plant*. Completed study evaluating the temperature regime of Marsh Creek under the influence of the discharge and whether the regime could continue to support the indigenous aquatic life, as part of developing information to support a Thermal Plan exception. Developed alternative temperature limitations to protect the Marsh Creek aquatic life and also resolve the temperature compliance issue. Currently facilitating concurrence of alternative temperature limitations by the fish resource agencies.
- *Sacramento Regional County Sanitation District*. Completed study evaluating the effects of the Sacramento Regional Wastewater Treatment Plant discharge on the Sacramento River near-field and far-field temperature regime in support of renewing Thermal Plan exceptions for this discharge. Currently conducting a related temperature and fisheries study requested by the fish resource agencies to further examine the effects of the discharge on Sacramento River aquatic life.

ANTIDEGRADATION ANALYSES

Principal-in-charge for conducting antidegradation analyses for municipal wastewater dischargers consistent with state and federal policies and guidance, in support of new or expanded discharge capacity. Antidegradation analyses completed include:

Surface Water

- Ironhouse Sanitary District Wastewater Treatment Plant - new discharge
- Sewer Maintenance District 1 Wastewater Treatment Plant – upgrade and expansion
- City of Galt Wastewater Treatment Plant – new summer discharge and expansion
- El Dorado Hills Wastewater Treatment Plant – upgrade and expansion

Groundwater

- Ironhouse Sanitary District Master Reclamation Permit

- City of Roseville Aquifer Storage and Recovery

TOXICITY REDUCTION EVALUATIONS(TREs)

Principal-in-charge for TREs/TIEs performed for municipal wastewater dischargers, including the preparation of TRE work plans and action plans required by NPDES permits, interpretation of toxicity test results, and negotiations with regional water quality control board staffs to conclude the TRE. Dischargers for which TREs have been, or are currently being, performed include:

- City of Stockton Regional Wastewater Control Facility, *Selenastrum capricornutum* and *Ceriodaphnia dubia*
- Town of Windsor Wastewater Treatment, Reclamation and Disposal Facility, *Selenastrum capricornutum*
- City of Davis Water Pollution Control Plant, *Selenastrum capricornutum*
- City of Woodland Wastewater Treatment Plant, *Selenastrum capricornutum*
- City of Brentwood Wastewater Treatment Plant, *Ceriodaphnia dubia*

WATER-EFFECT RATIO STUDIES

Principal-in-charge for conducting water-effect ratio (WER) studies for municipal wastewater dischargers consistent with U.S. EPA and state guidance. Studies include:

- Deer Creek Wastewater Treatment Plant Copper WER
- El Dorado Hills Wastewater Treatment Plant Copper WER
- Town of Windsor Wastewater Treatment, Reclamation, and Disposal Facility Copper WER
- Placer County Sewer Maintenance District 1 Aluminum WER
- City of Colfax Wastewater Treatment Plant Copper WER

RECEIVING WATER TEMPERATURE STUDIES

Principal-in-charge on studies conducted to evaluate seasonal temperature regimes and compliance with receiving water limitations stipulated in NPDES permits. Provided oversight in study plan development, managed field staff, and managed preparation of study reports for studies on the following receiving waters.

- Deer Creek – El Dorado County, CA for El Dorado Irrigation District
- Hangtown Creek – Placerville, CA for City of Placerville

- Old Alamo Creek, New Alamo Creek, and Ulatis Creek – Solano County, CA for City of Vacaville
- Marsh Creek – Contra Costa County, CA for City of Brentwood
- Sacramento River – for Sacramento Regional County Sanitation District and California Department of General Services
- Dry Creek and Pleasant Grove Creek – Placer County, CA for City of Roseville
- Atwater Drain – Atwater, CA for City of Atwater
- Dredger Cut, Highline Canal, and White Slough – San Joaquin County, CA for City of Lodi

EFFLUENT AND RECEIVING WATER QUALITY ASSESSMENTS

Principal-in-charge on effluent and receiving water quality assessments for the following dischargers:

- Hangtown Creek Water Reclamation Facility
- El Dorado Hills Wastewater Treatment Plant
- Deer Creek Wastewater Treatment Plant
- Sewer Maintenance District 1 Wastewater Treatment Plant – Placer County
- Sewer Maintenance District 3 Wastewater Treatment Plant – Placer County
- Sheridan Wastewater Treatment Plant – Placer County
- Stockton Regional Wastewater Control Facility
- Easterly Wastewater Treatment Plant – City of Vacaville

Assessments documented effluent and receiving water concentrations of over 180 constituents, including all California Toxics Rule/National Toxics Rule constituents, to determine whether contaminant-specific waste discharge requirements are warranted in the dischargers' NPDES permits.

VINEYARD SURFACE WATER TREATMENT PLANT - SACRAMENTO COUNTY WATER AGENCY

As principal-in-charge, assisted RMC Water and Environment for the permitting of a temporary surface water discharge of test water resulting from the startup of a large (80 mgd) water treatment plant in southern Sacramento County. RBI prepared a technical report characterizing projected effluent quality of the testing and startup discharges, and assessment of potential effects to the small ephemeral stream channel (Gerber Creek) which will serve as the receiving water for temporary discharges lasting approximately 6 months with discharge rates varying up to 15 mgd. RBI assisted with preparation of permit application requirements for consistency with the Central Valley RWQCB's "limited threat general NPDES permit," which was an adopted streamlined permit procedure at the time of

the project. The permit strategy involved development of a request, with supporting justification, of a temporary exception for the discharge to exceed applicable state water quality objectives for trihalomethane compounds. RBI also prepared the assessments of potential impacts to hydrology, water quality, and fisheries and aquatic resources for an amended CEQA Initial Study and Mitigated Negative Declaration that was prepared for the project.

PORT OF STOCKTON STORMWATER ADMINISTRATIVE ORDER ON CONSENT NEGOTIATION AND TOXICITY MONITORING REVIEW

Developed and negotiated stormwater toxicity monitoring requirements in the U.S. EPA's Administrative Order to achieve reasonable and scientifically defensible requirements. Technically reviewed and interpreted bioassay laboratory reports from stormwater monitoring events in support of maintaining compliance with the Order. Directed toxicity identification evaluations (TIEs), when needed.

SEASONAL COLIFORM BACTERIA LIMITATIONS

Negotiated alternative winter coliform bacteria limitations to be included in NPDES permits, which involved extensive technical analyses, technical report preparation, and negotiations with Central Valley Regional Water Quality Control Board policy and permitting staff and Department of Health Services (now Department of Public Health) technical staff. Dischargers assisted include: El Dorado Irrigation District's Deer Creek Wastewater Treatment Plant and Placer County's Sewer Maintenance District 1 Wastewater Treatment Plant.

ECOLOGICAL, WATER QUALITY, AND HYDROLOGIC EVALUATION OF DEER CREEK

Project manager and technical lead on a study documenting the ecological, water quality, and hydrologic conditions of Deer Creek upstream and downstream of the Deer Creek Wastewater Treatment Plant discharge. Conducted reconnaissance survey, developed experimental approach, and supervised/participated in field data collection. Documented fish and benthic macroinvertebrate taxa. Prepared final project report, which served, in part, as the basis for NPDES permit renewal.

Receiving Water Dissolved Oxygen Studies

As principal-in-charge and project manager, evaluated the effects of municipal wastewater treatment plant effluent discharges on downstream dissolved oxygen profiles using U.S. EPA's STREAMDO IV model. Studies conducted on Deer Creek for El Dorado Irrigation District, and Old Alamo, New Alamo, and Ulatis creeks for the City of Vacaville.

Basin Plan Amendments / Use Attainability Analyses

Site-Specific Objectives – pH, Turbidity, and Temperature

Principal-in-charge and lead water quality/aquatic ecology specialist for development of site-specific amendments to the Central Valley Regional Water Quality Control Board (RWQCB) Water Quality Control Plan (Basin Plan) for Deer Creek pH, turbidity, and temperature. Developed supporting technical studies/information, drafted RWQCB Staff Report/Functional Equivalent Document, and prepared responses to peer review and public comments.

Region-wide Basin Plan Objectives – pH and Turbidity

Provided technical and strategic services to the Central Valley Regional Water Quality Control Board, on behalf of Central Valley dischargers, to develop and adopt region-wide amendments to the Central Valley Region Water Quality Control Plan (Basin Plan) for pH and turbidity. Work tiered from the development of site-specific objectives for pH and turbidity for Deer Creek.

Aquatic Life Use Attainability Analysis – Old Alamo Creek

Examined the suitability of Old Alamo Creek to support anadromous salmonids by examining the available instream and riparian habitat, flow regime, thermal regime, water quality, and existing fish and benthic macroinvertebrate communities and participated in preparation of the Use Attainability Analysis (UAA) report. The UAA supported de-designating the cold freshwater habitat and cold migration beneficial uses assigned to Old Alamo Creek.

Municipal and Domestic Supply (MUN) Use Attainability Analysis – New Alamo Creek and Ulatis Creek

Principal-in-charge for the preparation of a Use Attainability Analysis (UAA) of the MUN use of New Alamo and Ulatis creeks, located in Solano County, consistent with U.S. EPA guidance. The project consisted of assembling hydrologic and water quality characteristics of the watersheds and documenting the extent of MUN use historically occurred or could be attained in the creeks. The UAA supported development of site-specific objectives for trihalomethane

compounds for the protection of human health.

Site-specific Objectives – Chloroform, Dibromochloromethane, and Dichlorobromomethane

Principal-in-charge and co-author of technical report for the development of site-specific objectives (SSOs) for three trihalomethane (THM) compounds for New Alamo and Ulatis creeks, Solano County. SSOs were developed to be protective of human health-related uses and resolve the THM criteria compliance issues resulting from the City of Vacaville's Easterly Wastewater Treatment Plant discharge. Also participated in the review and drafting of key sections of the Regional Water Quality Control Board's (RWQCB) Staff Report supporting a Basin Plan amendment for the SSOs, and meetings with RWQCB and U.S. Environmental Protection Agency Region 9 staff overseeing the SSO development and approval.

Municipal and Domestic Supply (MUN) Use Attainability Analysis – Atwater Drain

Principal-in-charge for the preparation of a Use Attainability Analysis report for Atwater Drain, located in Merced County, to evaluate the suitability of its MUN designation. Required the evaluation of watershed land use, hydrology, and water quality information, as well as the documentation of past and current diversions from the drain.

Other Water Quality Studies

South Fork American River Watershed Assessment

Principal-in-charge responsible for compilation and evaluation of available water quality data collected in the South Fork American River watershed. Project used a geographic information systems approach to prioritize sub-basins within the watershed for future water quality monitoring and restoration.

Sediment Total Maximum Daily Load (TMDL)

Project manager and technical lead for providing fisheries and water quality expertise to assist the Imperial Irrigation District with participating in the development of a silt TMDL for the Alamo River, the main tributary to the Salton Sea, Imperial Valley, CA. Using available scientific literature, characterized the effects of suspended sediments on freshwater aquatic life. Reviewed and provided comments on the Draft Problem Statement prepared by the Colorado River Basin Regional Water Quality Control Board.

Effluent Discharge Impact Assessment

Project manager and technical lead on evaluation of potential

impacts to human health and aquatic life from discharging tertiary-treated municipal wastewater treatment plant effluent into Folsom Reservoir or Lake Natoma as part of dry year water conservation measures under the Sacramento Area Water Forum Proposal. Met with California Department of Health Services (now Department of Public Health) staff to discuss the proposed action and its potential effects on human health associated with downstream municipal purveyor diversions.

FOLSOM DAM TEMPERATURE CONTROL DEVICE (TCD) ASSESSMENT

Project manager and technical lead for assessing the potential impacts of operating a TCD at the urban water supply intakes at Folsom Dam. Identified seasonal impacts to Lower American River water temperatures and fish resources, and the quality of raw and finished urban water supplies diverted from Folsom Dam and the Lower American River.

SEDIMENT CONTAMINANT MONITORING

Project manager and technical lead for a North American-wide sediment contaminant monitoring survey designed to define the range of polydimethysiloxanes in surface sediments of marine and freshwater systems receiving large municipal wastewater discharges. Supervised preparation of site-specific sampling plans, developed an experimental approach for the overall project, prepared a comprehensive quality assurance project plan, and contributed to preparation of project reports. Study served as the basis for subsequent bioassays and ecological risk assessments.

ECOLOGICAL RISK ASSESSMENT

Directed the aquatic assessment of component of a probabilistic ecological risk assessment that quantified the potential risk posed to wildlife and aquatic populations from opening and operating a gold mine in northern Washington.

STORMWATER QUALITY MONITORING

Project manager and technical lead for the Laguna West stormwater runoff water quality mitigation-monitoring project, Sacramento County. Developed the experimental design and field operating procedures, statistically analyzed laboratory bioassay and contaminant data, directed activities for field personnel, and wrote project progress and final reports.

FISHERIES BIOLOGY

BIOLOGICAL ASSESSMENT – NEW MOUNTAIN HOUSE WASTEWATER TREATMENT PLANT OUTFALL IN OLD RIVER

Prepared a Biological Assessment addressing the potential effects on Endangered Species Act-listed anadromous fish species that could result from placing a new diffuser outfall into the Old River, and operating the outfall to discharge up to 5.4 mgd of treated municipal effluent at buildout. Developed conservation measures to be implemented as part of the project to avoid/minimize effects on listed fishes. Worked closely with National Marine Fisheries Service in preparing the associated Biological Opinion.

BIOLOGICAL ASSESSMENT – IRONHOUSE SANITARY DISTRICT WASTEWATER TREATMENT PLANT OUTFALL IN THE SACRAMENTO RIVER

Prepared a Biological Assessment addressing the potential effects on Endangered Species Act-listed anadromous fish species that could result from placing a new diffuser outfall into the San Joaquin River, and operating the outfall to discharge up to 8.6 mgd of treated municipal effluent at buildout. Developed conservation measures to be implemented as part of the project to avoid/minimize effects on listed fishes. Worked closely with National Marine Fisheries Service in preparing the associated Biological Opinion.

BIOLOGICAL ASSESSMENT – CITY OF CHICO WASTEWATER TREATMENT PLANT EXPANSION

Prepared a Biological Assessment for project to address potential project construction and operational effects on ESA listed fish species and their habitats that could result from placing a new diffuser outfall in the Sacramento River and operating the outfall to discharge up to 12 mgd of treated municipal effluent. Developed conservation measures to be implemented as part of the project to avoid/minimize effects on listed fishes.

COSUMNES RIVER FLOW AUGMENTATION PROJECT

Lead fisheries consultant on project that provides up to 5,000 acre-feet of American River water annually routed through the Folsom South Canal to pre-wet the lower Cosumnes River channel to provide earlier and more prolonged hydraulic continuity throughout the lower river during the fall-run chinook salmon spawning season. Assessed potential fish resource impacts of implementing the project on the fish resources of the lower American River, Cosumnes River, and Mokelumne River.

AQUATIC BIOLOGICAL RESOURCES ASSESSMENT OF HANGTOWN CREEK

Principal-in-charge for study design and implementation of fish sampling (electrofishing), benthic macroinvertebrate sampling, habitat assessment, and temperature monitoring. Benthic macroinvertebrate sampling was conducted using the California

Department of Fish and Game California Stream Bioassessment Procedure. Study focused on evaluating the thermal effects of the Hangtown Creek Wastewater Treatment Plant's discharge on the aquatic ecology of Hangtown Creek.

PUTAH CREEK FLOW RESTORATION PROJECT

Served as principal-in-charge of the Putah Creek fisheries assessment to determine how the project, developed to address debris buildup below the Putah Creek Diversion Dam through dam and channel modifications, could incorporate elements to achieve a secondary objective of protecting, maintaining, and possibly enhancing Putah Creek's aquatic habitats and fish resources.

LOWER YUBA RIVER CALFED PROJECT

Co-Principal-in-charge and technical lead for developing a local-level Implementation Plan for Lower Yuba River anadromous fish habitat restoration. Project involved working with the Lower Yuba River Fisheries Technical Working Group, which has representatives from all state and federal fishery agencies, to perform a comprehensive review of available fishery, ecological, and hydrologic information and to develop a conceptual model for the Yuba River aquatic ecosystem. This model is a framework to guide the refinement, evaluation, and prioritization of restoration actions proposed by Calfed's Ecosystem Restoration Program Plan, U.S. Fish and Wildlife's Anadromous Fish Restoration Program, California Department of Fish and Game's 1991 Plan, and other fish management plans already developed for the river. The conceptual model identifies testable hypotheses related to key ecosystem processes, habitat conditions, stressors, and fish population trends and behavior, including habitat use. Based on this work, restoration actions, pilot projects, and studies are prioritized for near-term and long-term implementation in a manner consistent with long-term ecosystem and watershed management goals.

LOWER AMERICAN RIVER OPERATIONS WORKING GROUP PARTICIPANT

Provided technical assistance to staff from U.S. Bureau of Reclamation, California Department of Fish and Game, U.S. Fish and Wildlife Service, and National Marine Fisheries Services in evaluating alternative Folsom Dam shutter operational scenarios for the summer/fall period to maximize thermal benefits to Lower American River fall-run chinook salmon and steelhead, and to balance benefits to these two species.

CDFG/YCWA INTERIM SETTLEMENT AGREEMENT

Initiated and led the development of a California Department of Fish and Game-Yuba County Water Agency (YCWA) Interim Settlement

Agreement and Interim Study Plan for the Lower Yuba River. Facilitated negotiations between CDFG and YCWA, which were conducted to reach agreement on several issues, including minimum instream flow, water temperature, and flow fluctuation requirements associated with operation of the Yuba River Development Project. This process ultimately culminated in the Lower Yuba River Accord. The Accord resolved a nearly 20-year legal and political fight over water rights and fisheries flows. The Accord received the State's highest environmental award.

LOWER AMERICAN RIVER SALMON MORTALITY MODEL DEVELOPMENT

Project manager and technical lead for refinement of the U.S. Bureau of Reclamation's Lower American River early life stage fall-run chinook salmon mortality model. Compiled historic data defining temporal distributions of immigration and temporal and spatial distributions of spawning. Worked with Reclamation computer programmers to make code changes that resulted in an improved model that reflected the best available biological data for the river's fall-run chinook salmon population.

LOWER SACRAMENTO RIVER AND DELTA TRIBUTARIES TECHNICAL TEAM APPOINTEE

Appointed to the Lower Sacramento River and Delta Tributaries Technical Team, as part of the Anadromous Fish Restoration Program of the Central Valley Project Improvement Act. Developed technical reports outlining the key factors currently limiting chinook salmon and steelhead populations in the Lower American and Yuba rivers. Worked cooperatively with California Department of Fish and Game and U.S. Fish and Wildlife Service biologists on the project.

CENTRAL VALLEY PROJECT RESTORATION TECHNICAL LIAISON

Served as a technical liaison between the Northern California Power Agency, a contributor to the Central Valley Project (CVP) Restoration Fund, and the state and federal fish resource agencies charged with applying these funds to restore Central Valley anadromous fish populations. Developed a strategic process for establishing a shared understanding among these and other stakeholders regarding CVP restoration goals, objectives, and criteria for prioritizing expenditures from the CVP Restoration Fund to achieve basin-wide, fish population-restoration goals.

BAY/DELTA FISHERIES REPORT

Prepared a technical report for the Northern California Power Agency that identified the major factors that have contributed to recent declines in San Francisco Bay/Sacramento-San Joaquin Delta fishery resources. The factors contributing to recent declines of anadromous

and resident fish populations were ranked according to their relative importance or contribution to observed population declines.

SACRAMENTO SPLITTAIL DISTRIBUTION AND RELATIVE ABUNDANCE STUDY

Project manager and technical lead for a large interagency (Department of Water Resources, California Department of Fish and Game, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, U.C. Davis, State Water Contractors, and Interagency Ecological Program) gill net survey that documented the distribution and relative abundance of Sacramento splittail in the Sacramento and San Joaquin rivers and Delta. Developed the experimental design and field operating procedures for the project, and supervised field personnel. Performed all statistical analyses of catch data, and prepared the project report.

CEQA/NEPA

BAY DELTA CONSERVATION PLAN EIR/EIS

Served as Principal-in-Charge for development and preparation of the water quality chapter for the Bay Delta Conservation Plan EIR/EIS. Integrated use of CALSIM II, DSM2, and other models used to assess water quality impacts resulting from the implementation of the proposed project and its 8 alternatives. Worked with multiple local, State, and Federal agencies to resolve issues and participated in stakeholder and public outreach efforts.

TERTIARY FILTRATION, ULTRAVIOLET DISINFECTION, AND BIOSOLIDS DEWATERING PROJECT CEQA INITIAL STUDY/MITIGATED NEGATIVE DECLARATION - CITY OF GALT

As principal-in-charge, assisted the City of Galt (under contract to West Yost Associates) with environmental compliance documentation, NPDES permit acquisition, and environmental permitting for the proposed Phase 1 upgrade of selected unit processes at the wastewater treatment plant. Phase I of the project provides upgraded facilities (i.e., add tertiary treatment and ultra-violet disinfection) and will initiate a new discharge in the summer (previously permitted as a seasonal (winter) discharge). Phase II of the project involves further upgrades of the treatment facilities (improved nitrogen removal) and expansion in capacity from 3.0 million gallons per day (mgd) to 4.5 mgd. RBI prepared the CEQA Initial Study/Mitigated Negative Declaration (IS/MND) for the Phase 1 upgrades and necessary construction-related permits.

IRONHOUSE SANITARY DISTRICT WASTEWATER TREATMENT PLANT EXPANSION AND UPGRADE – CEQA AND PERMITTING

As principal-in-charge, assisted the Ironhouse Sanitary District (ISD) with environmental compliance, NPDES permit acquisition, and environmental permitting for the proposed expansion and upgrade of the ISD municipal wastewater treatment plant that serves the communities of Oakley, Bethel Island, and outlying communities. RBI prepared the water quality and the fishery and aquatic resources chapters of the environmental impact report, which was prepared by Jones & Stokes. RBI developed thresholds of significance for interpreting the effects of anticipated receiving water quality changes on aquatic resources. Addressed Endangered Species Act issues related to listed fish species.

RBI was instrumental in securing authorization of a new NPDES permit for ISD's proposed surface discharge outfall in the San Joaquin River at Jersey Island. RBI led the consulting team to negotiate and secure the NPDES permit through the Central Valley RWQCB and prepared the key elements of the Report of Waste Discharge. In addition, RBI assisted ISD in securing environmental permits to authorize the dredging and dredge-material disposal necessary to construct and install a new surface discharge outfall pipe and diffuser in the San Joaquin River. RBI prepared the sampling and analysis plan for sediment and dredge material characterization, and secured authorization under the Central Valley RWQCB's general waiver of waste discharge requirements for dredge material disposal to land. RBI provided monitoring and ongoing permit implementation services to ISD for the construction project.

IRONHOUSE SANITARY DISTRICT HIGHWAY 4 PIPELINE PROJECT CEQA COMPLIANCE

As principal-in-charge, worked with the ISD in implementing a strategic phased approach to CEQA compliance for ISD's proposed construction of a new sanitary sewer gravity trunk, and forcemain conveyance pipelines and recycled water pipeline within its service area. Phase 1 involved the upfront identification of potential project development constraints, regulatory requirements, and identification of the appropriate CEQA documentation and process. Phase 2 of the project involved preparation of an Initial Study/Mitigated Negative Declaration to meet CEQA requirements and support future regulatory permitting. Additionally, RBI managed technical subconsultants for the conduct of botanical rare plant surveys, and air quality, noise and cultural resource assessments.

PLACER COUNTY SEWER MAINTENANCE DISTRICT 1 WASTEWATER TREATMENT PLANT UPGRADE AND EXPANSION – CEQA INITIAL STUDY/MITIGATED NEGATIVE DECLARATION

Principal-in-charge of the hydrology and water quality section of the Initial Study/Mitigated Negative Declaration for the Sewer Maintenance District 1 Wastewater Treatment Plant Upgrade and Expansion project, and assisted with the biological resources section of the document by preparing the impact assessment for fisheries and aquatic resources. RBI assessed potential construction-related impacts and direct and cumulative long-term operations-related impacts of treatment plant upgrades and the increased effluent discharge rate to Rock Creek and Dry Creek, and water bodies further downstream. RBI assessed the potential water quality impacts on a constituent-by-constituent basis, incorporating key information from the antidegradation analysis and other technical reports that RBI had prepared for Placer County under separate contracts for work on the plant's NPDES permitting compliance.

SACRAMENTO REGIONAL WASTEWATER TREATMENT PLANT 2020 MASTER PLAN EIR

Lead consultant for preparing water quality and fishery and aquatic habitat chapters of the EIR. Responsible for coordinating all hydrologic and water quality modeling, and the use of modeled output for impact assessment purposes. Contributed to development of alternatives to be evaluated and thresholds of significance for the water quality and fisheries/aquatic habitat resources. Also assisted in conducting stakeholder and technical workshops associated with development of the 2020 Master Plan.

LAKE OF THE PINES WASTEWATER TREATMENT PLANT UPGRADE EIR

Lead consultant for preparing the water quality/hydrology and fishery and aquatic resources chapters of the EIR, which was prepared by EDAW for Nevada County. Contributed to development of alternatives to be evaluated and developed thresholds of significance for the water quality/hydrology and fisheries chapters. Also assisted in conducting stakeholder and technical workshops associated with development of the facilities Master Plan.

CITY OF CHICO WASTEWATER TREATMENT PLANT EXPANSION EIR

Lead consultant for preparing the fishery and aquatic resources chapter of the EIR, which was prepared by Jones & Stokes. Contributed to development of alternatives to be evaluated and developed thresholds of significance for the chapter. Also assisted in refinement of water quality assessments used to make determinations regarding potential impacts to aquatic resources in the Sacramento River.

DEL WEBB TEHAMA PROJECT

Lead consultant for preparing the fishery and aquatic resources chapter of the EIR, which was prepared by Impact Sciences. Conducted site surveys and habitat characterizations. Consulted with National Marine Fisheries Service to obtain a concurrence letter of not likely to adversely affect steelhead using adjacent water bodies.

HANGTOWN CREEK WASTEWATER TREATMENT PLANT UPGRADES IS/MND

Principal-in-charge for preparing an Initial Study/Mitigated Negative Declaration in support of planned upgrades to the Hangtown Creek Wastewater Treatment Plant. This environmental document was prepared to meet CEQA requirements and to support application for a State Revolving Fund loan to fund, in part, the planned improvements.

LOWER CASCADE CANAL MODERNIZATION PROJECT EIR

Lead technical consultant for preparing the aquatic biological resources chapter of the EIR. Responsible for conducting detailed fisheries habitat and hydraulic assessments on the Lower Cascade Canal and presenting information to stakeholders. Contributed to the development of alternatives to be evaluated and thresholds of significance for determining impacts.

CITY OF LINCOLN WASTEWATER TREATMENT AND RECLAMATION FACILITY EIR

Provided technical review and oversight for the fisheries and aquatic biological resources chapter of EIR. Assisted project team with addressing potential impacts and preparing supplements and addendums to EIR. Consulted with National Marine Fisheries Service on anadromous fish issues, including Endangered Species Act issues, related to new wastewater discharges to Auburn Ravine.

DEER CREEK WASTEWATER TREATMENT PLANT EXPANSION EIR

Lead author for water quality and fisheries chapters of the EIR, prepared for the El Dorado Irrigation District, which involved compiling and assessing effluent and receiving water quality data and evaluating acute and chronic bioassay testing results.

EASTERN SACRAMENTO COUNTY REPLACEMENT WATER SUPPLY PROJECT

Lead consultant for preparing the water quality and fishery and aquatic resources chapters of the EIR, which was prepared by EDAW for Sacramento County. Contributed to development of alternatives to be evaluated and developed thresholds of significance for the water quality and fisheries chapters. Performed detailed analysis of effects on American River and tributary water quality and compliance with water quality standards that would result from inputting

remediated groundwater into the system. Also assessed effects on fish resources in the American, Cosumnes, and Mokelumne rivers of using up to 5,000 acre-feet of remediated water, annually, to pre-wet the Cosumnes River channel to provide earlier and more prolonged hydraulic continuity throughout the lower river during the fall-run chinook salmon spawning season.

BAY DELTA CONSERVATION PLAN EIR/EIS

Provided strategic input to HDR, lead author of the EIR/EIS, regarding assessment of the plan's effects on water quality in the Sacramento-San Joaquin Delta and primary tributaries. Developed thresholds of significance for assessing water quality effects and participated in development of the water quality assessment framework, which required analysis of multiple alternatives and future time steps to address phased implementation of project elements. Directed assessments of multiple constituent-specific assessments, including boron, pathogens, trace metals, nutrients, temperature, PCBs, pesticides, constituents of emerging concern, and DBP formation potential.

SUCTION DREDGING PERMITTING PROGRAM SUPPLEMENTAL EIR, CALIFORNIA DEPARTMENT OF FISH AND GAME

Principal-in-charge of water quality and toxicology impacts assessment for the Initial Study and supplemental EIR, which was prepared by Horizon Environmental. The EIR addresses the potential project-level environmental impacts of statewide suction dredging activity regulations. The focus of the analysis was on effects of dredging-related discharge of mercury in streams that have remnant contamination from historic gold mining activity.

EL DORADO IRRIGATION DISTRICT WATER SUPPLY MASTER PLAN EIR

Lead technical consultant for preparing the hydrology, water quality, and aquatic biological resources chapters of the programmatic EIR. Responsible for evaluating Master Plan demands and District operations to meet projected demands to determine how such operations could impact these resources. Provided strategic guidance for integrating other District facilities into the assessment to produce a more real-world assessment.

EDWPA SUPPLEMENTAL WATER RIGHTS PROJECT EIR

Directed the development of the water quality chapter for the El Dorado County Water and Power Authority (EDWPA) Supplemental Water Rights Project EIR. The proposed project is to establish permitted water rights allowing diversion of 40,000 AFA water from the American River basin to meet planned future water demands in

the EID and GDPUD service areas and other areas located within El Dorado County that are outside of these service areas. The assessment addressed effects of the proposed project on American River watershed, Sacramento River, and Delta water quality.

SACRAMENTO AREA WATER FORUM PROPOSAL EIR

Prepared the fisheries and surface water quality chapters of the EIR and regularly presented technical information on effects of reservoir operations and water management on fish resources and water quality to the Water Forum, a coalition of 46 stakeholders representing agriculture, business, public agencies, and environmental groups collectively developing a strategic water-planning platform for the greater Sacramento area. Served as liaison between hydrologic/water temperature/salmon mortality modelers, Fischer-Delta (water quality) modelers, and other technical staff and CEQA consultants/City-County management staff responsible for preparing the EIR. Contributed to preparation of a Habitat Management Program (HMP) for the Lower American River, designed to preserve the wildlife, fisheries, recreational, and aesthetic values of the Lower American River, as well as mitigate for any potential impacts of the Water Forum Proposal.

NATOMA PIPELINE REPLACEMENT AND FOLSOM WATER TREATMENT PLANT EXPANSION PROJECT EIR/EA

Managed preparation of fisheries sections of the EIR/EA. The project involved analyzing the construction and operational impacts associated with pipeline replacement and water treatment plant expansion, as well as a 7,000 AFA increment of additional water planned to be diverted from Folsom Reservoir. Worked closely with modelers to develop hydrologic simulations to depict hydrologic effects of the project. Assessed output from the hydrologic, temperature, and salmon mortality models to identify project-specific and cumulative impacts to reservoir, river, and Delta fish resources. The project required compliance with federal and state regulations, including the Endangered Species Act and Clean Water Act.

NARROWS II POWERHOUSE INTAKE EXTENSION MITIGATED NEGATIVE DECLARATION/INITIAL STUDY

Technical lead for assessing the potential effects on the fish resources of Englebright Reservoir and the Lower Yuba River from drawing water into the Narrows II Powerhouse from a lower elevation within Englebright Reservoir as a result of extending the current intake structure. Prepared a technical report on findings, with an emphasis on temperature-related effects on Lower Yuba River anadromous fish resources.

PLACER COUNTY WATER AGENCY AND NORTHRIDGE WATER DISTRICT GROUNDWATER STABILIZATION PROJECT EIR

Managed preparation of fisheries chapter of the EIR. Analyzed the hydrologic effects of the project as they would affect Folsom Reservoir seasonal storage levels, lower American and Sacramento River flows, and Delta inflow/outflow, and water temperatures, and the potential for such changes to impact fish resources in these water bodies. Worked closely with modelers to develop hydrologic simulations to depict hydrologic effects of the project.

LONG-TERM REOPERATION OF FOLSOM DAM AND RESERVOIR EIR

Fisheries lead to determine the feasibility of indefinitely extending Sacramento Area Flood Control Agency's Folsom Dam and Reservoir Reoperation Agreement with the U.S. Bureau of Reclamation. Worked closely with modelers to develop hydrologic simulations to depict hydrologic effects of the project. Output from hydrologic, temperature, and salmon mortality models was assessed to identify project-specific and cumulative impacts to reservoir, river, and Delta fish resources. Additional activities included meeting with National Marine Fisheries Service, U.S. Fish and Wildlife Service, and California Department of Fish and Game to determine the need for consultation under the federal and state endangered species acts and determination of potential impacts to fishery resources throughout the Central Valley Project resulting from integrated reservoir operations.

CVP WATER SUPPLY CONTRACTS EIS/EIR

Lead author for the fisheries and water quality chapters of the joint programmatic EIS/EIR prepared for the Central Valley Project (CVP) Water Supply Contracts under Section 206 of Public Law 101-514. Evaluated hydrologic, river and reservoir water temperature, and salmon mortality model output to determine potential impacts to CVP reservoir, lower American and Sacramento rivers, and Delta fish resources that could result from diverting a portion of the water from Folsom Reservoir. Worked closely with project engineers to design the hydrologic modeling studies and determine output needed to conduct the necessary environmental assessments. Also participated in development and evaluation of project alternatives capable of fulfilling project purposes, with an emphasis on water supply, affected hydrology, and environmental constraints.

HAMILTON CITY PUMPING PLANT FISH SCREEN IMPROVEMENT PROJECT EIR/EIS

Developed technical approach to assessing the effects of the proposed project and its alternatives on fisheries and aquatic habitats. Lead author for all fisheries sections of the EIR/EIS. Fisheries and aquatic habitat chapter received U.S. EPA's highest review score. Key issues included analyses of alternative means of simultaneously protecting fish (including the endangered winter-run chinook salmon) while re-establishing reliability in Glenn-Colusa Irrigation District's diversions from the Sacramento River. This project involved many state and federal agencies, including California Department of Fish and Game, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Army Corps of Engineers, California Department of Water Resources, and the State Reclamation Board.

INTERIM REOPERATION OF FOLSOM DAM AND RESERVOIR EIR/EA

Evaluated the potential impacts of interim reoperation on the fish resources of Folsom, Trinity, and Shasta reservoirs; the Lower American, and Sacramento rivers; and the Sacramento-San Joaquin Delta, with an emphasis on anadromous salmonids. Assessments were based on output from U.S. Bureau of Reclamation's hydrologic, temperature, and salmon mortality models. Also performed an evaluation to determine the optimal shutter configuration at Folsom Dam to maximize beneficial use of Folsom Reservoir's coldwater pool for downstream temperature control. Assessed effects of seasonal temperature regimes that would occur under various shutter configurations on Lower American River steelhead and fall-run chinook salmon.

PROFESSIONAL AFFILIATIONS / CERTIFICATIONS

American Fisheries Society

Society of Environmental Toxicology and Chemistry, Northern California Chapter Member

ROBERTSON - BRYAN, INC.
Solutions for Progress

Ben D. Giudice, Ph.D., P.E.
Senior Environmental Engineer

Dr. Ben D. Giudice is an environmental engineer with 9 years of experience studying and practicing environmental and water resources engineering. His expertise includes environmental fate and transport, risk assessment, ecotoxicology, constituents of emerging concern, analytical chemistry, and field and laboratory data collection, compilation, and analysis. His academic work includes site, watershed, and regional scale risk assessments of roadside applied herbicides in highway runoff; studies of endocrine disruptors, pharmaceuticals, and personal care products in runoff from land applied municipal biosolids; and studies on the effects of endocrine disruptors on reproduction in aquatic invertebrates. His professional work includes serving as project manager and technical lead of the water quality chapter of the Bay Delta Conservation Plan EIR/EIS, the City of Stockton Nitrate Mixing Zone and Dilution Study, and conducting water quality and engineering studies for numerous other agencies and facilities in the Central Valley, Delta, and San Francisco Bay. Ben joined RBI in 2009 and performs technical evaluations for wastewater and stormwater permitting and compliance and in support of environmental impact assessments.

EDUCATION

Ph.D., Environmental and Water Resources Engineering, 2012, University of California, Davis
M.S., Environmental Engineering, 2007, University of California, Davis
B.S.E., Civil Concentration, 2005, Calvin College, Grand Rapids, MI.

REPRESENTATIVE PROJECT EXPERIENCE

BAY DELTA CONSERVATION PLAN EIR/EIS

Served as project manager and technical lead, and led development of the water quality methodology, including assessment of over 190 constituents, detailed assessment of 15 constituent categories, and integrated use of three models used to assess water quality impacts resulting from the implementation of the proposed project and its alternatives. Developed post-processing tools necessary to assess impacts in the Delta. Led or assisted with all constituent-specific assessments. Worked with multiple local, State, and Federal agencies to resolve issues and participated in stakeholder and public outreach efforts.

CITY OF STOCKTON NITRATE MIXING ZONE AND DILUTION STUDY

Prepared the final report regarding effects of nitrate from the City of Stockton's 55 mgd Regional Wastewater Control Facility discharge on the San Joaquin River. The assessment included running the Delta Simulation Model (DSM2, physically based model of the Sacramento-San Joaquin Delta) to determine far-field dilution of effluent and its effects on nitrate in drinking water canals in the long term, and near-field tidal and mixing dynamics during the study period. Also analyzed effects on algae communities, submerged and emergent vegetation, and benthic macroinvertebrates.

Post-processed, organized, presented, and interpreted results.

EL DORADO IRRIGATION DISTRICT DEER CREEK WASTEWATER TREATMENT PLANT REDUCTION IN MINIMUM DISCHARGE

Conducted a feasibility study which included field flow-monitoring and stream gauging, biological and aquatic life surveys/assessment, assessment of flow loss during the summer period, and estimates of minimum discharge required to maintain surface flow throughout the riparian corridor of a 4 mile reach of Deer Creek downstream of a 3 mgd wastewater treatment plant. Developed a Hydrologic Engineering Centers River Analysis System (HEC-RAS) hydraulic model of the reach of interest, and performed calibration and validation studies to ensure the model would meet the project objectives. Performed field surveys of the creek to obtain geometric data for the hydraulic model. Applied the model under reasonable worst-case upstream flow conditions and typical summer flow losses to a range of potential plant discharge rates and compared the results to assess potential effects on aquatic, terrestrial, and riparian resources.

LEHIGH SOUTHWEST CEMENT COMPANY

Assisted with negotiating the terms of a regulatory action by the Regional Water Board, which was issued to generate data in preparation of a forthcoming NPDES permit for the Permanente Quarry and Cement Plant (Santa Clara, CA). Used selenium bioaccumulation modeling in an initial feasibility analysis to help determine regulatory and treatment options to address elevated selenium levels in the facility's discharge. Managed implementation of routine chronic toxicity monitoring and a Ceriodaphnia dubia Toxicity Reduction Evaluation on the quarry discharge. Developed and currently implementing a regional study to investigate the impacts of selenium in the Facility's discharge on beneficial uses of Permanente Creek and Stevens Creek. This effort includes bioaccumulation modeling of selenium in the food webs that inhabit the creeks and the areas of San Francisco Bay to which they drain.

MOUNTAIN HOUSE COMMUNITY SERVICES DISTRICT TEMPERATURE STUDY

Performed modeling of the MHCSD 3 mgd wastewater treatment plant diffuser using USEPA's Visual Plumes software to determine whether the District was complying with regulatory requirements. Developed and implemented a field validation study to monitor the thermal plume to determine whether modeling performed was giving accurate results.

CITY OF BRENTWOOD RECYCLED WATER FEASIBILITY STUDY

Conducted a feasibility study of expanding and maximizing recycled water use in the City. The study included regulatory and permitting considerations, a recycled water market assessment, estimation of irrigation demands for future customers,

development and evaluation of project alternatives and phases, and preliminary cost estimation. Included preparation of a model of the City's current nonpotable distribution system infrastructure to assist in assessing the feasibility and cost of expanding recycled water use. Assisted the City with seeking funding opportunities, including State and Federal grants and low-interest loans.

CITY OF BRENTWOOD CHLORIDE COMPLIANCE ALTERNATIVES STUDY

Performed technical evaluations as part of an analysis to bring the City's 5 mgd wastewater treatment plant into compliance with effluent limitations for chloride associated with discharge to Marsh Creek. Alternatives included alternative seasonal water supplies, reduction on reliance on water softeners, reduced effluent discharge to Marsh Creek (including a zero discharge land application assessment), reverse osmosis treatment, and conveyance of treated wastewater to an existing outfall in the Delta. Technical services included: preparation of a potable water distribution system and wastewater collection system chloride and hardness model to assess the optimal blending of surface and groundwater supplies and the impact of reduced reliance on water softeners; preliminary design of pumps and a pipeline that would be necessary to convey treated wastewater to an existing outfall; and preliminary design calculations for a zero discharge land application facility.

CITY OF STOCKTON EFFLUENT TRIHALOMETHANE INVESTIGATION

Performed statistical analyses of process control parameters and process and effluent water quality constituents to determine contributing factors to the City's 55 mgd Regional Wastewater Control Facility effluent trihalomethane spikes in the fall. Developed a weekly sampling routine of additional constituents and performed investigations and analyses to support recommendations to minimize production of trihalomethanes.

CITY OF IONE SEEPAGE DISCHARGE COMPLIANCE PLAN

Provided professional services to assist the City with implementation of its wastewater program, including preparation of a Seepage Discharge Compliance Plan required by the Central Valley Regional Water Quality Control Board. Conducted a preliminary design of components of a 0.75 mgd land discharge wastewater treatment plant upgrade to achieve compliance with seepage discharge requirements, performed water balance calculations, critically evaluated an Isotope Study to assess whether water from the City's wastewater ponds was seeping into Sutter Creek, and evaluated effects of seepage on groundwater levels and quality.

CITY OF VACAVILLE PHASE II MS4 PERMIT ASSISTANCE

Assisted the City in responding to new requirements in the State Water Resources Control Board's (SWRCB) draft Phase II MS4 general permit by revising its stormwater program to comply with the more complex and prescriptive renewed general permit.

Specific services included estimating current and future costs to the City associated with administering its stormwater program to comply with the permit, attendance and participation in SWRCB and California Stormwater Quality Association (CASQA) Phase II MS4 permit renewal meetings, preparation of written comments on the city's behalf for submittal to the SWRCB, and review of the draft permit and advising the City on significant changes and implications for city's overall program.

CITY OF VACAVILLE DILUTION STUDY

Determined optimal flow measurement technology and techniques for multiple sites in a complex system of agricultural channels upstream and downstream of an 11 mgd wastewater treatment plant. Designed a flow monitoring regime (including locations, frequency, gauging, equipment) to meet monitoring objectives; specified, installed, and maintained all equipment, established rating curves, used weir equations for calculation of flow over dams. Downloaded, processed, and analyzed data, and presented findings.

CITY OF VACAVILLE CONSTITUENTS OF EMERGING CONCERN STUDY

Designed and implemented a receiving water study to assess occurrence, fate, and transport of CECs downstream of the City of Vacaville's Easterly Wastewater Treatment Plant. Target analytes included 8 steroid hormones, 12 PPCPs, 5 consumer/industrial products, 4 nitrosamines, and 6 perfluorinated compounds. These were analyzed in effluent and in upstream and downstream receiving water monthly for 12 months. Seasonal and spatial trends were assessed, along with comparisons to results from other studies and to literature based thresholds of concern for human health and aquatic life.

EL DORADO IRRIGATION DISTRICT FINNON RESERVOIR PASSIVE DECHLORINATION SYSTEM

Designed field experiments, analyzed experimental data, derived chlorine decay constants, and performed preliminary sizing/design calculations of a natural/engineered passive dechlorination system.

TOXICITY REDUCTION EVALUATIONS: CITY OF WOODLAND, CITY OF BRENTWOOD, CITY OF DAVIS, PLACER COUNTY

Performed facility performance reviews and evaluations, including analysis and interpretation of plant monitoring data trends and comparison to historical toxicity profile. Results provided insight into potential causes of toxicity and helped direct efficient TIEs. Reviewed chronic monitoring laboratory reports and TIE results and helped design customized TIEs to investigate suspected causes of toxicity.

CALIFORNIA DEPARTMENT OF FISH AND GAME SUCTION DREDGING EIR

Conducted an exhaustive literature review concerning the water quality and toxicological impacts of recreational suction dredging. The review included published

and unpublished scientific studies, reviews, and public comments, and focused on suction dredging impacts on turbidity and mercury release, fate, transport, and effects. Used results to direct development of a methodology for assessing impacts of mercury discharged from suction dredging and performed assessment.

PORT OF STOCKTON STORMWATER ADMINISTRATIVE ORDER ON CONSENT AND MS4 PERMIT NEGOTIATION AND TOXICITY MONITORING REVIEW

Negotiated stormwater toxicity monitoring requirements in the US EPA's administrative order to achieve reasonable and scientifically defensible requirements. Performed ongoing technical review of bioassay laboratory reports in support of maintaining compliance with the order and directing toxicity identification evaluations.

CRITICAL REVIEW OF CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD DRAFT PESTICIDE CRITERIA IN SUPPORT OF PUBLIC COMMENTS FOR THE CITY OF ROSEVILLE

Critically reviewed and evaluated UC Davis methodology for deriving pesticide criteria. Reviewed and critiqued implementation of the methodology in draft criteria for diuron, malathion, chlorpyrifos, bifenthrin, lambda-cyhalothrin, cyfluthrin, permethrin, and cypermethrin. Prepared comments for City to transmit to Regional Water Board.

DEVELOPMENT OF A REGIONAL SOLUTION FOR WASTEWATER EFFLUENT CYANIDE COMPLIANCE

Worked with the Central Valley Clean Water Association to develop a regional solution for ongoing cyanide compliance problems associated with analytical interferences in EPA approved methods. Presented overview of the problem and the latest scientific advances to Central Valley Regional Water Quality Control Board staff to educate staff on the nature of the issue. Worked with Central Valley dischargers to develop work plans for cyanide investigations.

TOXICITY OF HERBICIDES IN HIGHWAY RUNOFF

Integrated results of Monte-Carlo simulation of a fate and transport model to model frequency of acute toxicity exceedance for all roadside applied herbicides in California. Performed a sensitivity analysis on results to determine effectiveness of management decisions in reducing environmental risk. Determined roadside soil sorption isotherms for four commonly applied herbicides with very different properties.

ENDOCRINE DISRUPTOR TOXIC EFFECTS AND OCCURRENCE IN BIOSOLIDS RUNOFF

Developed a LC/MS/MS method for the analysis of over ten steroidal hormones and endocrine disrupting chemicals in surface water. Designed and performed experiments to determine the effects of the wastewater associated personal care product active ingredient triclocarban on embryo production in a freshwater mudsnail. Designed and performed rainfall simulations to determine mobilization of endocrine disrupting compounds, PPCPs, and metals in surface runoff from land-applied biosolids.