July 1, 2013

VIA EMAIL: davids@sfei.org

Dr. David Senn, Senior Scientist
San Francisco Estuary Institute
4911 Central Avenue
Richmond, CA 94804

Re: Comment Letter – San Francisco Bay Nutrient Conceptual Model (Draft May 1, 2013)

Dear Dr. Senn:

The City of Sunnyvale appreciates the opportunity to submit comments on the Nutrient Conceptual Model (NCM) draft report. This is a very comprehensive and well researched document. We understand that much of the work to date synthesizing nutrient related information on San Francisco Bay (SFB) has been focused on the North Bay, and specifically on ammonium related issues in Suisun Bay. Accordingly, as the NCM is finalized, it is important that the authors be specific when describing whether particular issues and results are known to be existent and/or applicable Bay-wide, or primarily to Suisun Bay and the Delta. Otherwise, readers may infer that issues/problems unique to Suisun Bay apply throughout the Bay.

Sunnyvale understands that work will be commencing soon on a similar synthesis of nutrient and eutrophication related information for the Lower South Bay (LSB) (i.e. south of Dumbarton Bridge). Sunnyvale looks forward to working on this LSB synthesis that is expected to provide significant information pertinent to the three LSB wastewater treatment plant NPDES permit reissuances in 2014. It is critical to evaluate and synthesize Lower South Bay data and loadings differently from other South Bay dischargers due to the fact that all the three LSB dischargers are advanced-secondary treatment facilities with nitrification processes as well as have the requirements to meet stringent effluent ammonia limits applicable to shallow water discharges. Additional monitoring and data may be needed from locations south of Dumbarton Bridge to develop conceptual models pertinent to LSB dischargers.

Sunnyvale provides the following comments on the NCM. They are primarily directed towards clarifying the Problem Statements (Section 3) and the complexities and uncertainties associated with assessing eutrophication trends in the LSB.

Problem Statement

Figure 3.1 shows nitrogen areal loadings being 2-3 times higher to Suisun Bay and LSB than to other estuaries and other segments of the Bay. To put these loadings in perspective, it is suggested that the NCM include a parallel graphic (or second y-axis on this graph) showing flushing/residence times or perhaps turbidity for the various estuaries and subembayments. This would be a way to provide context, within this graphic, as to why chlorophyll a (chl a) levels are low in Suisun and LSB at these higher loading rates.

Figure 3.4 shows an increasing trend in chl a levels since the late 1990's in the South Bay (by USGS definition, as south of the Bay Bridge). Viewed alone, this conveys a very different message than when similar information is presented later in the report in Figures 7.9 and 7.10A. Those figures show the same increase in chl a, but together with data on the concurrent decrease in bivalve biomass and phytoplankton grazing rates (due to increased bivalve predators). Papers by Jim Cloern and Bruce Jassby (2007, 2012) referenced in the NCM, document the multiple factors and complicated ecology affecting chl a concentrations, and that nutrients do not appear to be the primary driver of change (see quotation below from the NCM p. 28, lines 1230-1241).

Cloern et al (2007) observed sharp increases in chl-a and in gross primary production in the South Bay beginning in the late 1990s (Figure 7.9). After ruling out several potential drivers (e.g., changes in nutrient loads, SPM), they determined that the increase in phytoplankton biomass was due to pronounced loss of benthic suspension feeders, and that the decline of benthos abundance was due to an increase in benthivorous predators (sole, Bay shrimp, Dungeness crab; Figure 7.10). The increase in predator abundance was attributed to large scale climate forcings (a change in the Pacific Decadal Oscillation) that brought colder waters to SFB and allowed these predators to prey heavily over multiple 1237 years on benthic suspension feeders in SFB. Grazing by benthic filter feeders is considered to be one of the main controls on phytoplankton biomass accumulation.

It is recommended that whenever NCM Figure 3.4 is presented, it should be accompanied by (or at least include a reference to), some version of Figure 7.10A. If the data exist, it is recommended to add to the NCM a South Bay version of Figure 7.6 (for Suisun Bay), showing chl a on the left y-axis and clam numbers or biomass on the right y-axis. This would assist readers in understanding that the apparent trend towards increasing eutrophication is predominately due to trophic level ecosystem changes (i.e. more clam predators) in the South Bay and LSB. These ecosystem changes in turn were driven by global scale ocean-atmospheric Pacific Decadal Oscillation (PDO) induced changes (i.e. uncontrollable natural factors and not simply ambient nutrient concentrations). This linkage analysis is touched on but only briefly on pages 28-29. Adding cross references in Section 3.1 to Section 7.2.3 and vice versa would help the reader better understand the cause and effect nature of these issues.

The importance of grazing in controlling phytoplankton biomass is identified in multiple places in the report, but primarily in the context of adverse impacts (low biomass) in Suisun Bay. The opposite condition is noted for LSB but not highlighted as much as for Suisun Bay (e.g., Section 11.3.4 on p. 55). Benthos monitoring is identified as one of the priority data gaps (R.1.2.6 p. 64, Table 7.1 benthic grazing). Investigating the relative importance of fundamental drivers such as grazing relative to high biomass in LSB and South Bay is appropriately identified as a high priority science question in Table 11.3 (CT.1).

Limiting Nutrient Concentrations

The Nutrient Conceptual Model minimally addresses the issue of how much ambient nutrient concentrations (and/or loadings) would have to be reduced to limit phytoplankton growth. Figure 3.2 shows the dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphate (DIP) concentrations in various estuaries including SFB. Figure 3.2 also shows half-saturation constant levels (green horizontal lines) that have been proposed by Cloern and Jassby (2012) as "indices of nutrient levels that potentially could limit phytoplankton growth.)

It is suggested that Figure 13 (copy attached) from page 15 of the Cloern and Jassby (2012) paper, be added to the NCM. It shows box plots of 1969-2010 DIN and DIP concentrations from the USGS monitoring stations from the Golden Gate Bridge to the extreme LSB. In Figure 13 the right-most box (Station 36) represents the southern-most USGS station in LSB with a median DIN concentration of about 50 umol/L. USGS station 19 (left hand side of graph) located just inside the Golden Gate Bridge shows median DIN concentrations of about 20 umol/L.

The green horizontal line shows that ambient DIN concentrations would need to be reduced to below about 1.6 umol/L to potentially reduce phytoplankton growth (other factors being equal). It is recommended that the NCM at least qualitatively assess whether is it appropriate to consider DIN concentrations near the Golden Gate Bridge as "background" concentrations. If 20 umol/L is a background level, the NCM should asses the implications for the likely success of potential loading reductions in reducing ambient concentrations to growth limiting levels. It is recognized that the proposed nutrient modeling is necessary to fully assess this issue.

Desirable Nutrient Concentrations

It is suggested that the NCM address the issue of what might be considered a desirable/optimum range of phytoplankton (chl a) biomass. The figure used in recent presentations of the NCM showing a bell-shaped curve representing low, to "desirable," to excessive (eutrophic) level biomass would be informative to include in the final NCM.

As a point of reference, Cloern and Jassby (2012, p. 12) note that "chlorophyll a concentrations of about 10 ug/L represent a threshold below which zooplankton reproduction can become food limited." Based on this benchmark, phytoplankton concentrations could be limiting to the food web in South/LSB based on the maximum ~8 ug/l chl a concentrations shown in Figure 3.4.

Dissolved Oxygen

Sunnyvale provided comments on Dissolved Oxygen (DO) and eutrophication related issues in its June 25, 2013 letter on the NNE Assessment Framework document. The NCM (page 34) notes that there can be low DO conditions in the SFB's shallow margin habitats. The NCM raised the question of "To what extent the low DO levels in SFB's shallow margins be the result of anthropogenic perturbations, in particular high nutrient loads?"

For the LSB, Sunnyvale notes that nitrification and filtration facilities have been in operation at the three LSB wastewater treatment plants since approximately 1979. The discharge of oxygen demanding substances was thereafter reduced to *de minimus* levels. The discharges were found to provide net environmental benefits to the LSB sloughs based on the volume of highly oxygenated effluent generated.

Moffett Channel and Guadalupe Slough are surrounded by dense growths of rooted aquatic vegetation. Die-off and decay of this vegetation is likely to be the dominant source of sediment oxygen demand in these areas. Sunnyvale conducted monthly depth profile monitoring at 10 stations along Moffett Channel and Guadalupe Slough in 2010-2012. That monitoring showed turbidity levels typically over 100 NTU, indicating minimal potential for light penetration and support of phytoplankton growth. Data sonde measurements showed that DO concentrations were primarily influenced by tidal conditions (higher at high tide and lower at low tide). Nutrient levels (primarily nitrate) appear to have minimal impact on DO conditions.

Uncertainty Analyses

It is suggested that the NCM include an expanded discussion, from the literature, of the challenges that will be faced in efforts to predict for the SFB subembayments the future course of eutrophication (e.g., chl a concentrations) under either 1) do nothing or 2) reduced loading scenarios. This aspect of the NCM uncertainty analysis is significant enough that it is recommended that it be addressed in a new Subsection 3.4 (e.g., What has been learned about nutrient/chl a related eutrophication and oligotrophication response in other estuaries?). It would also be helpful to be addressed and cross referenced in Sections 11.3.1 (N and P load reductions through POTWs) and in Section 12.1 (Key Observations).

Prioritization

It is suggested that the approach taken to prioritizing impairment pathways and issues for near term attention (Tables 6.1, 7.1, 8.1, 9.1, 11.4, 11.5) be revisited. There are so many rankings of "Very High" that it will be difficult to use the information presented in making management decisions about which potential problems and associated studies to fund and in what order.

The City of Sunnyvale appreciates the opportunity to provide these comments on the San Francisco Bay Nutrient Conceptual Model draft report. If you have any questions, please contact Alo Kauravlla, Laboratory Manager, at (408) 730-7704 or Dr. Tom Hall of EOA at (510) 832-2852 x110.

Sincerely,

Melody Tovar, P.E.
Regulatory Programs Division Manager

Attachment: Cloern and Jassby (2012, pp. 15-16)

cc: Naomi Feger, SFB RWQCB
Martha Sutula, SCCWRP
David Williams, BACWA
Tom Hall, EOA

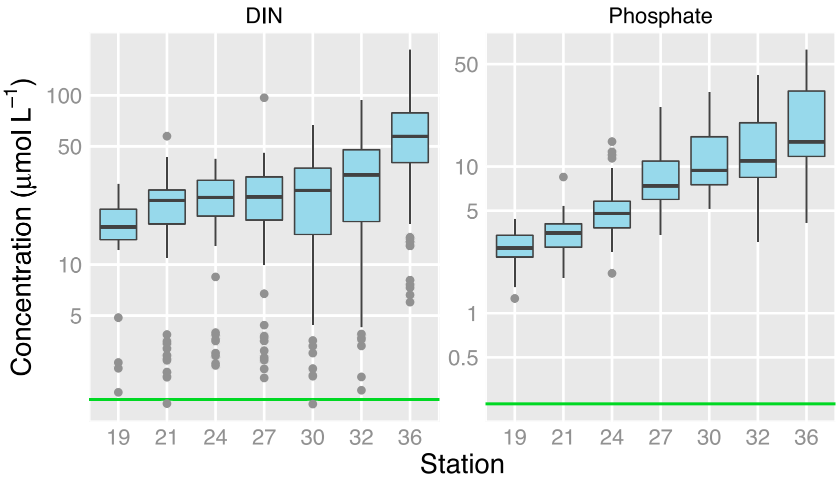

Figure 13. Boxplots showing spatial distributions of dissolved inorganic nitrogen (DIN) and phosphate (dissolved inorganic phosphorus, DIP) in surface waters (0–3 m) of South San Francisco Bay, 1969–2010 (sampling locations shown in Figure 2). Five extreme DIN values >200 or <1 μmol L^{-1} are omitted. The green lines represent characteristic half-saturation constants for DIN and phosphate uptake, respectively, as indices of nutrient levels that potentially limit phytoplankton growth.

DIP concentration in South San Francisco Bay is 3.8 and 8.8 times the median values in Tomales and Willapa bays, respectively. As a result of its setting in an urban landscape, South San Francisco Bay is highly enriched with sewage-derived nitrogen and phosphorus.

6.3. Significance of the Changes

[40] The nutrient concentrations in South San Francisco Bay are typically well above those that limit the growth rate of algae. This is illustrated by comparing DIN and DIP concentrations to the half-saturation constants (K_N, K_P) for phytoplankton growth as an index of potential nutrient limitation (Figure 13). Of 4096 DIN measurements made in South San Francisco Bay from 1969 to 2010, only 126 (0.03%) were smaller than the mean K_N for marine diatoms (1.6 μM [*Sarthou et al.*, 2005]). Only 1 of 4330 DIP measurements was smaller than the mean K_P (0.24 μM [*Sarthou et al.*, 2005]).

[41] Based on these high N and P concentrations, South San Francisco Bay has the potential to produce phytoplankton biomass at levels that severely impair other nutrient-enriched estuaries, such as Chesapeake Bay, where occurrences of large algal blooms have led to summer hypoxia in bottom waters, loss of submerged vascular plants and alteration of biogeochemical processes such as denitrification [*Kemp et al.*, 2005]. The nitrogen input to South San Francisco Bay from sewage disposal is almost twice the total N input from all sources to Chesapeake Bay and its tributaries (Table 3). As a result, N and P concentrations are substantially higher in South San Francisco Bay than in Chesapeake Bay (Figure 14). However, South San Francisco Bay paradoxically has low phytoplankton biomass relative to other enriched estuaries. The median chlorophyll *a* concentration in South Bay is only 4.1 μg L^{-1} (Table 1), but the potential chlorophyll *a* concentration—that expected if the median DIN concentration were converted into phytoplankton biomass—is about 28 μg L^{-1} (assuming a chl-*a*:N ratio of 1 [*Gowen et al.*, 1992]). This high-nutrient low-chlorophyll state implies that San Francisco Bay is inefficient at converting nutrients into algal biomass and, therefore, resistant to the harmful consequences of enrichment observed in other estuaries such as Chesapeake Bay (we show in section 8, however, that this resistance is weakening).

[42] San Francisco Bay has (at least) three attributes that confer resistance to the harmful consequences of nutrient enrichment. First, its strong tidal currents generate sufficient turbulence to break down stratification caused by surface heating and freshwater inflow. Chesapeake Bay has weaker tides, weaker turbulent mixing, and stratification that persists long enough (months) for bottom waters to become and remain hypoxic or anoxic. Salinity stratification can develop in South San Francisco Bay during weak neap tides, and these stratification events promote fast growth of phytoplankton biomass in the surface layer. But the surface blooms dissipate on the subsequent spring tide when the water column is mixed [*Cloern*, 1996]. Second, San Francisco Bay is more turbid than Chesapeake Bay because it receives large river inputs of sediments and is shallow, so sediments are maintained in suspension by wind waves and tidal currents [*May et al.*, 2003]. As a result, the median light attenuation coefficient in South San Francisco Bay (1.4 m^{-1}; Table 1) corresponds to a photic depth of only 3.3 m, and phytoplankton growth rate is limited by low availability of sunlight energy [*Cloern*, 1999]. Third, accumulation of phytoplankton biomass is controlled by bivalve mollusks (clams, mussels) that can filter a volume of water equal to the South San Francisco Bay volume each day during summer [*Cloern*, 1982]. In Chesapeake Bay, this filter-feeding function was provided historically by an oyster population that could filter that bay's volume in less than 4 d. That filtration time is now hundreds of days because the oyster population has been decimated by overharvest, disease, and hypoxia [*Kemp et al.*,

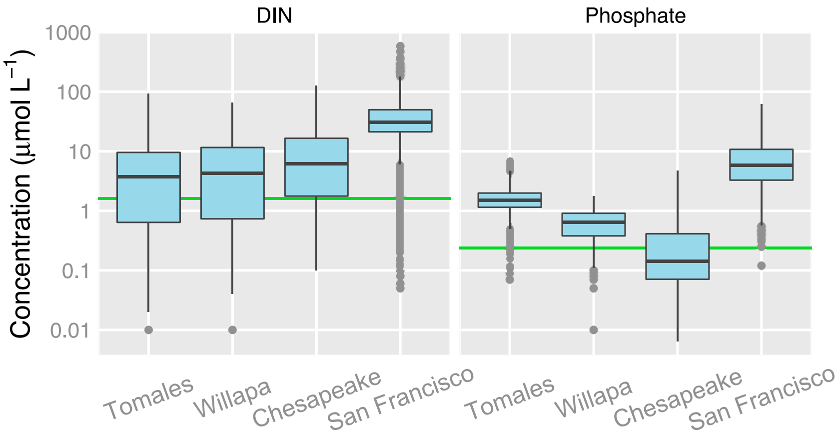

Figure 14. Boxplots of dissolved inorganic nitrogen (DIN) and phosphate in South San Francisco Bay (1969–2010), Tomales Bay (1987–1995), Willapa Bay (1991–2006), and the deep channel of Chesapeake Bay (2006–2010). The data are from all available depths. The green lines represent characteristic half-saturation constants for phytoplankton growth rate.

2005]. Comparative analyses of Chesapeake Bay and San Francisco Bay reveal that estuaries have inherent attributes, such as hydrodynamic, optical and biological properties, that control the efficiency with which nutrients are converted into phytoplankton biomass and, therefore, the expression of nutrient enrichment as a driver of environmental change.

[43] Nutrient pollution from municipal wastewater is a globally significant problem that has degraded water quality, reduced biological diversity, and altered biogeochemical functioning of urban coastal areas such as Boston and New York harbors [*NRC*, 1993], Tampa Bay [*Greening et al.*, 2011], Osaka Bay [*Yasuhara et al.*, 2007], Mersey Estuary [*Jones*, 2006], Hong Kong's Tolo Harbor [*Xu et al.*, 2011], Rio de Janeiro's Guanabara Bay [*Kjerfve et al.*, 1997], Turkey's Golden Horn Estuary [*Taş et al.*, 2006], and Australia's Swan-Canning Estuary [*Hamilton and Turner*, 2001]. Environmental degradation by nutrient overenrichment has motivated local, national and multinational policies to reduce nutrient inputs from urban and agricultural sources to coastal ecosystems. For example, a goal of the Chesapeake 2000 Agreement is to reduce N and P inputs to Chesapeake Bay by 48% and 53%, respectively [*Kemp et al.*, 2005]. These are similar to goals of multinational agreements to halve nutrient inputs to the Baltic Sea and North Sea [*Conley et al.*, 2002]. The Danish government has enacted even more aggressive plans to reduce N inputs to its aquatic environments by 50% and point sources of P by 80% [*Conley et al.*, 2002].

[44] The establishment of such quantitative targets for nutrient reduction is a challenging policy application of estuarine science. Early responses of the Dutch Wadden Sea, Chesapeake Bay, and Danish fjords to nutrient reduction strategies have not all met the expectations of policy makers [*Carstensen et al.*, 2011]. The contrasting responses of San Francisco Bay and Chesapeake Bay to N and P enrichment teach that nutrient loading rate alone is not a good predictor of algal biomass or the impairments associated with high algal biomass, such as hypoxia and harmful blooms. This lesson appears to be general because a broad range of empirical relationships exists between nutrient (e.g., total N) and chl-*a* concentrations measured in 28 coastal systems, providing "overwhelming evidence that system-specific attributes modulate the response of phytoplankton to nutrient enrichment" [*Carstensen et al.*, 2011, p. 9127]. As explained above, these system-specific attributes go far beyond just hydraulic retention time, noted long ago as a factor differentiating water bodies with respect to nutrient loading [*Vollenweider*, 1975]. Policies to remediate overfertilized coastal waters therefore might be most effective and cost efficient if they are tailored to the attributes of individual estuaries and bays. The urgency for place-based nutrient-reduction strategies will likely accelerate in step with continued urbanization and population and economic growth: global sewage emissions are projected to increase from 6.4 Tg of N and 1.3 Tg of P in 2000 to emissions as high as 15.5 Tg N and 3.1 Tg P by 2050, with the fastest increases in southern Asia [*Van Drecht et al.*, 2009].

7. ENVIRONMENTAL POLICY: THE U.S. CLEAN WATER ACT

7.1. Background

[45] In 1972 the U.S. Congress unanimously passed Public Law 92-500, which we know as the Clean Water Act (CWA), to "restore and maintain the chemical, physical and biological integrity of the nation's waters" and attain "fishable and swimmable waters" across the United States. This landmark legislation established the first federal regulation of sewage disposal by requiring secondary treatment of municipal wastewater to reduce inputs of solids, oxygen-consuming chemicals, and pathogens to the nation's waters. The CWA provided funding for construction and improvement of STPs, and it established effluent standards for BOD, suspended solids, fecal coliform bacteria, and pH. Enactment of the CWA and similar policies in other countries reflected growing public concern about the accelerating and increasingly visible degradation of water quality caused by municipal and industrial sources of pollution. The Potomac Estuary of "the Nation's River" was an iconic example of environmental