SAN LUIS & DELTA-MENDOTA WATER AUTHORITY

October 26, 2012

Sent via electronic mail to:

commentletters@waterboards.ca.gov



State Water Resources Control Board
1001 I Street
Sacramento, California 95814

Subject: Grassland Area Farmers Comments for Workshop 3: Analytical Tools for Evaluating Water Supply, Hydrodynamic and Hydropower Effects and Bay-Delta Plan Review - Other Comments

Dear Chairman Hoppin and Board Members:

I am writing as the Drainage Coordinator for the Grassland Bypass Project, to present comments on behalf of participants in the Project, referred to as the "Grassland Area Farmers." The Grassland Area Farmers are organized under an Activity Agreement within the umbrella of the San Luis & Delta-Mendota Water Authority. These comments, however, represent only the Grassland Area Farmers. They are not submitted on behalf of other members of the Water Authority.[1]

For the September 5-6, 2012, Workshop 1, the State Water Resources Control Board ("State Water Board") received written information prepared by Tim Stroshane, Senior Research Associate, California Water Impact Network ("C-WIN"). During the public comment portion of that meeting on September 6, I briefly responded to points made by C-WIN and indicated that the Grassland Area Farmers would submit further comments, which is the purpose of this letter. Given the focus on the Presser-Luoma papers, a modeling tool, these comments are also responsive to the Revised Notice of Public Workshops and Request for Information, for Workshop 3: Analytical Tools for Evaluating Water Supply, Hydrodynamic and Hydropower Effects.

Response to C-WIN's Comments on Selenium

[1] The current participants in the Grassland Basin Drainage Management Activity Agreement include: Camp 13 Drainage District; Charleston Drainage District; Firebaugh Canal Water District; Pacheco Water District; and Panoche Drainage District. Broadview Water District is within the drainage area but has been idled from active irrigation and no longer actively participates.



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With regard to C-WIN's comments on selenium, the Grassland Area Farmers make two points.

First, C-WIN assumes there is an unregulated and inexhaustible "reservoir" of selenium threatening the Bay-Delta. That assumption is completely misplaced. Selenium is certainly widespread, especially in marine sediments in the Coast Range, and has been distributed into the Central Valley by natural processes. However, much like salt, only the concentration of selenium that has been mobilized by water can have an effect on living organisms.

Selenium is mobilized and transported through water, sometimes via rainfall or flooding streams and sometimes through irrigation. There are physical limits on how much selenium can be mobilized at any time by rain or floods. The TMDL for selenium in the San Joaquin River takes into account all sources, allocates load to each of them, and imposes clear annual limits for the quantity of selenium that can enter the River from irrigated agriculture. The allocation is principally to the Grassland Bypass Project, since it has been identified as the largest source.

In fact, the existing Basin Plan limits the quantity of such selenium discharged from the Grassland Bypass Project to 4,480 pounds of selenium in a wet year type and 1,658 pounds in a critical year type. The total discharge from the Grassland Bypass Project in 2011 was 1,972 pounds. The 2009 Use Agreement for the San Luis Drain, under which the Grassland Bypass Project operates, limits the discharge to no more than 900 pounds by 2019. Thus, selenium concentrations in the San Joaquin River have been declining, are well below Basin Plan objectives of 5 ppb, and are even lower as the San Joaquin River enters the Delta.

Second, C-WIN relies heavily on the Presser-Luoma papers. Those papers do not provide a reliable model for estimating selenium loading for at least four reasons.

1. The Presser-Luoma papers suffer from wildly unrealistic factual assumptions. For example, they assume discharges of up to 128,000 pounds of selenium per year to the Delta from the San Joaquin River, ignoring the TMDL for selenium. They do so based on the premise that a drain to the Delta could carry subsurface irrigation drainage from all potential problem land on the westside of the San Joaquin Valley. In fact, there is no such drain and no plan or possibility of any such drain being constructed, nor of such discharge avoiding regulation. C-WIN incredibly expands this number and suggests discharges could approach 180,000 pounds per year.

2. The Presser-Luoma papers do not adequately recognize the importance of speciation of selenium to its effects on aquatic organisms. Biological effects of selenium depend on uptake of selenium by phytoplankton [referred to by Presser & Luoma as "partitioning of selenium into the particulate phase"] that brings selenium into the food web. Most of the selenium entering the San Joaquin River from irrigated agriculture is selenate. In the sulfate-dominated waters of the Bay-Delta and the Central Valley, sulfate interferes with the selenate uptake channels of phytoplankton, so very little selenium in the selenate form gets into the food web. In sharp contrast, the selenite form of selenium common in refinery discharges is

readily drawn into the food web. This is obvious from looking at selenium levels in Suisun Bay biota. Selenium levels in Delta biota, where selenate predominates, are relatively low. Selenium levels in biota rise downstream to Carquinez Strait where the refinery selenite discharges are concentrated and then decline downstream into the Bay where tides dilute the discharges.

3. The Presser-Luoma papers do not make this critical distinction regarding the bioavailability of selenium and instead lumps that entire and variable process of selenium uptake by phytoplankton into a single constant, "($K_d$)", purporting to represent a constant ratio between selenium in phytoplankton ("Particulate selenium") and the total selenium in the water, regardless of its speciation. Tom Grieb of Tetratech's recent presentation to the Bay-Delta Science Conference showed that $K_d$ is not constant, illustrating a major limitation of the Presser-Luoma model.

4. Finally, as recognized by its authors, the Presser-Luoma papers reflect a high degree of scientific uncertainty with regard to hydrodynamic relationships, chemistry, Delta species behavior and appropriate levels of protection concerning selenium. Their later papers acknowledge the need for development of extensive information and modeling to support their conclusions about how selenium and various plant and animal species interact in the Delta environment and in different areas within the Delta. In the meantime, their model for projecting loading and specific recommended selenium values uniformly resolves these cascading uncertainties by assuming the worst case scenario, resulting in over-protective selenium values, without any consideration of the potential cost or skewing effect such over-protection may have on the Board's charge to achieve protection while allowing California to continue to use its precious water supplies.

For all of these reasons, the tools in the Presser-Luoma papers need to be viewed with a high degree of skepticism and should not be relied upon by the State Water Board.

We are attaching hereto two Cardno ENTRIX papers. The first directly addresses the issues identified above in the Presser-Luoma papers and the second further addresses the C-WINWorkshop 1 submittal. C-WIN's conclusions about such changing conditions as a new isolated conveyance facility, sea level rise, and climate change rely on the flawed Presser-Luoma papers to extrapolate conclusions that lack factual basis and are at best speculation. The C-WIN Workshop 1 submittal therefore is not useful.

Response to C-WIN's Comments on Salinity

Use of old data leads to an over-projection of salinity loads. Any modeling of salinity in the San Joaquin River must reflect current conditions. Modeling current conditions is critical, given Westside farmers' significant reductions in salt discharges. For example, the salt load reaching the San Joaquin River from the Grassland Bypass Project has decreased by 170,000 tons from 1995 to the present. This amounts to a 17% reduction in the average salt load at Vernalis, which totals approximately 1 million tons per year. The regulations and agreements governing the Grassland Bypass Project require further drainage reductions that will continue to reduce discharges of salinity, while drainage management through the

Project will allow viable agriculture to be maintained. These are real, demonstrated achievements that contradict the "looming disaster" approach of C-WIN's submittal. We would be happy to work with those using analytical tools to provide them the actual data under these current conditions.

Further, the Grassland Bypass Project is not the only program addressing salinity. The Irrigated Lands Regulatory Program ("ILRP") is addressing drainage discharges that reach the San Joaquin River. Besides program requirements for monitoring the discharge of salts, priority management practices, such as installation of drip irrigation and tailwater recirculation systems to avoid sediment discharges, are expected to have incidental but immediate benefits in reducing discharges of salts. The ILRP, along with the waste discharge requirements for the Grassland Bypass Project, will be used to implement the TMDL for salinity in the lower San Joaquin River. The United States Department of the Interior, Bureau of Reclamation, has entered into and is updating a Management Agency Agreement with the Central Valley Regional Water Quality Control Board that is engaging stakeholders, including state and federal refuges, among others, in the development of a real time program for managing discharges to address salinity concerns.

In sum, as the State Water Board considers the tools available to it for evaluating and assessing the effects of changes in the Water Quality Control Plan, we urge it to assess with open eyes the limitations of the Presser-Luoma model and to make certain that any models selected make use of current data being produced by positive trends in selenium and salinity regulation and management.

The Grassland Area Farmers appreciate the opportunity to provide these comments.

Very truly yours,

Joseph C. McGahan

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Enclosures

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**Subject: Response to C-WIN Submittal**

1. ***Issue: Selenium occurs naturally in mineral deposits and has numerous sources, but this fact is minimalized in the discussions.***

***Statement in C-WIN Submittal:***

*Selenium occurs naturally in mineral deposits like coal and oil, as well as other marine-derived sediments. (Presser 1999). Wastes from agriculture, industry, mining, and gas and oil refineries can increase selenium contamination in estuaries and bays. (p. 21)*

**Response:**

The basic concept remains that selenium is a naturally-occurring element in the environment of the West Coast. Although this fact is mentioned several times throughout the C-WIN submittal and supporting references (e.g., Presser and Luoma 2006), the consequences of this fact are not explored. In almost every comment provided in the C-WIN submittal, this fact is relevant and should not be dismissed. It is an integral part of the story and therefore, it should be given a relative weight when discussing potential sources, as well as fate and transport. It should also be noted that selenium contamination is not caused by agricultural practices. The statement above appears to be assigning agriculture as a "source" of selenium, which again, is a naturally-occurring element in the region.

2. ***Issue: Selenium is chemically similar to sulfur and interferes with or adversely affects proteins and genes. Substitution by selenium for sulfur can result in adverse ecological impacts.***

***Statement in C-WIN Submittal:***

*As a chemical element, selenium is chemically similar to sulfur in how they both react with both mineral and organic compounds. Selenium can readily substitute for sulfur in salts (such as selenates for sulfates) as well as in certain amino acids (e.g., seleno-cysteine and seleno-methionine; Presser 1999; Presser and Luoma 2006: 40), the building blocks of proteins. Selenium's ability to substitute chemically for sulfur in both salt chemistry and organic amino acids clears pathways to toxicity, increased gene mutation, and ecological damage. (p. 21)*

**Response:**

This premise in the C-WIN submittal is not scientifically valid. C-WIN continually suggests that selenium can promote or magnify toxicity via subtle and sublethal pathways without including any discussion of the actual pathways, the exposure concentrations required to illicit these adverse effects, or substantiation of the presence of the effects in the Bay-Delta. Furthermore, the mention of selenocysteine as an abnormal organic chemical is misleading. Selenocysteine is a critical component of certain proteins (e.g., glutathione peroxidases, tetraiodothyronine 5' deiodinases, and thioredoxin reductases) that are important for normal cellular metabolism, and its formation in the cell is tightly regulated (Stadtman 1996).

The second sentence in the submittal passage above is not supported by scientific references. There are several orders of biological organization between a gene mutation and ecosystem damage. Without supporting discussion and references, the conclusion is speculative.

The substitution of selenium for sulfur in amino acids during protein synthesis would not lead to "increased gene mutation." Selenium can substitute for sulfur, such as in disulfide bridges within the tertiary structure of proteins. This substitution can lead to impacts on protein function; however, there is no evidence for resulting toxic effects (Agency for Toxic Substances and Disease Registry, 2003). The substitution of selenium for sulfur in amino acids during protein synthesis would not lead to genetic mutation. Gene mutations are caused by changes in the genomic sequence of DNA and not by alterations in amino acids and protein synthesis.

Throughout the document, C-WIN continually makes these unsupported predictions that any exposure to selenium is likely to produce adverse effects. In fact, the concentration of selenium in the exposure medium must be quite high to cause adverse effects. This is because selenium properties are altered significantly to the toxic entity only with a series of physical and chemical changes. The toxic effects of selenium often reported in laboratory studies require long exposures at high concentrations in their substrate. Laboratory testing with selenium are further confounded by the lack of selenate/sulfate interactions often observed in waters where sulfates essentially block the uptake of selenate into phytoplankton, reducing bioavailability. This results in over estimates of potential toxicity and risk in laboratory studies.

For example, laboratory experiments have shown adverse effects to several species when they are exposed to high concentrations of selenium for long periods of time, such as : 1) mallard adults and ducklings exposed to concentrations of selenomethionine in food ranging from 8-60 μg/L for 14–112 days; and 2) in various fish species exposed to concentrations of selenomethione in the diet ranging from 9-54 μg/L for 44-260 days (reviewed in Hamilton et al. 2004).

The typical laboratory exposure scenarios to develop these toxicity values are unrealistic in that they do not replicate conditions actually occurring in the environment and skew the potential risk estimates to overly conservative levels.

***Statement in C-WIN Submittal:***

*At higher tissue concentrations, selenium can substitute for sulfur in amino acids, altering the structure of proteins in metabolic and reproductive systems of the body. When proteins in predator species mutate from excessive exposure to selenium, it can lead to sterility and suppression of the immune system "at critical development stages when rapid cell reproduction and morphogenic movement are occurring." Changes in the structure of many antibodies (such as from substitution of selenium atoms for sulfur atoms) can compromise the organism's immune defenses, making it more susceptible to disease.(Presser 1999: 555). (p.21)*

**Response:**

Genes may mutate and lead to translational changes (i.e., changes in protein synthesis) or the alteration of protein physical structure; proteins do not mutate. Moreover, it has been proposed that the substitution of selenomethionine for methionine in proteins does not alter the function or structure of proteins due to the placement of selenium in selenomethionine (Exponent Technical Memo, 2010). The conclusions in the paragraph above and those of Presser (1999) in the cited publication are not supported by references or in the literature and instead reflect the author's speculation.

Apart from the disconnect between selenium integration into protein and gene mutation, the term "higher" is not defined here. At what "higher" concentrations have the above effects been observed in the laboratory? In addition, what types of organisms have exhibited these alterations? It is no longer fully accepted that the phenomenon of selenium replacing sulfur is the predominant mechanism of selenium toxicity, while the C-WIN submittal implies that this phenomenon occurs as a result of routine exposures. Although these effects may occur in the laboratory at very high exposures, such changes would require similarly extensive and unlikely exposures outside the laboratory. In addition, information on selenium speciation is integral to evaluating bioavailability and toxicity to aquatic organisms.

3. ***Issue: There is an unlimited reservoir of selenium in the region, which will be with Californians for a long time.***

***Statement in C-WIN Submittal:***

*Other parts of the San Joaquin Valley are also naturally contaminated with salts, selenium, and high levels of other toxic elements like boron, arsenic, and molybdenum (Figure 5; San Joaquin Valley Drainage Program 1990: 58--63). Because of the extent of the geologic deposits and rocks containing selenium in the western San Joaquin Valley, it is important to recognize that at time scales relevant to society, "there are, for all practical purposes, unlimited reservoirs of selenium and salt stored within the aquifers and soils of the valley and upslope in the Coast Ranges." (Presser and Schwarzbach 2008: 2) The selenium reservoir will be with Californians for a very long time to come. (p.23)*

**Response:**

It is correct that selenium concentrations in the San Joaquin Valley are naturally occurring and will be present for an extended time. In several discussions, this analogy is used to indicate that the selenium concentrations will be problematic for a long time and result in adverse impacts. However, these discussions ignore any consideration of the fact selenium has always been carried to the Delta by the San Joaquin River by flooding and rainfall as well as by drainage from irrigation. It ignores that the amount of selenium mobilized at any one time by natural events is physically limited, while such discharges from irrigated agriculture are strictly regulated. The selenium TMDL for the San Joaquin River takes into account and allocates selenium from all such sources and imposes a maximum load from the Grassland Bypass Project of 1,658-4,480 pounds of selenium, based upon water year type. It ignores the fact that huge areas of the San Joaquin Valley have no drainage outlet for agricultural drainage to reach the San Joaquin River and that no outlet for such lands is proposed. And it ignores the fact that the Grasslands Bypass Project has made significant progress in reducing selenium loads discharged to the water ways and in fact, , are 85% less than pre-Project loads, are significantly less than loads authorized in the current Basin Plan, and based on existing regulation and Project history, will continue to reduce.

4. ***Issue: According to models, juvenile salmon are especially at risk from selenium exposure in the San Joaquin River.***

***Statement in C-WIN Submittal:***

*Beckon and Maurer estimate that up to 20 percent of all juvenile salmon at a tissue concentration of 2.45 µg/g dry weight reaching the San Joaquin River from the Merced River die in low flow years. (Beckon and Maurer 2008; Beckon 2009; Presser and Luoma 2010, 2011) Presser and Luoma (2006) warn that San Joaquin River Restoration Program efforts to reintroduce fall-run Chinook salmon must address the potential for selenium poisoning of reintroduced salmon between Sack Dam and reaches of the River downstream of Mud Slough (north, which releases Grassland Bypass Project drainage flows that have passed through the San Luis Drain; Presser and Luoma 2006, 2010; 2011). (p. 31)*

**Response:**

This summary of a model that Beckon and Maurer applied to data from a study completed by Hamilton et al. (1990) is over-simplified, inaccurate, and inappropriate. Beckon and Maurer applied a biphasic model to a dose-response curve composed of data from Hamilton et al. (1990), in which swim-up salmon larvae were fed mosquitofish containing various selenium concentrations for 90 days in freshwater. Beckon and Maurer (2008) state that "the model predicts that fish with a selenium concentration of 2.45 μg/g (whole body dry weight) after 90 days of exposure would experience 20 percent mortality due to selenium." Based on selenium levels measured in young salmon in 1987 (3 μg/g whole body dry weight), they note the possibility for mortality to occur upstream of the Merced River. However, concentrations of selenium in the river have decreased since 1987, and the San Joaquin River Restoration Program does intend to introduce fish here supported by additional flow, while selenium discharged from the Grassland Bypass Project continues to drop. The alarmist extrapolation made by C-WIN is not based on current conditions.

5. ***Issue: Delta smelt are considered to be at risk from selenium exposure in the Bay Delta Estuary.***

***Statement in C-WIN Submittal:***

*Beckon and Maurer (2008) report that Delta smelt larvae are "ecologically similar to larval and juvenile striped bass" in that they are not motile, but instead float in the water column where feeding occurs through random particle interactions.[7] (Bennett 2005: 18) Beckon and Maurer further note that Delta smelt obtained from the area of Chipps Island during the springs of 1993 (a wet year) and 1994 (a dry year, the seventh out of the previous eight) had whole body selenium concentrations of 1.5 μg/g dw (n=41, range from 0.7 to 2.3 μg/g dw; Beckon and Maurer 2008: 32), which are substantially lower than concentrations found in clams in the same region. (p. 31)*

*Presser and Luoma (2010b) and Beckon and Maurer (2008) both consider the Delta smelt to be at risk of selenium exposure in the Bay-Delta estuary. Presser and Luoma cite as reasons for its at-risk classification that its overall threatened status as an endemic Delta fish species, and the fact that it feeds on insect larvae that may take up selenium (2010b: Table 4, 8). They agree with Beckon that it does not feed in a clam-based food web since zooplankton are the more important component of Delta smelt diets. They write, "the sensitivity of delta smelt to selenium is unknown; population numbers are alarmingly low, so this species is particularly vulnerable to any adverse effect." (Presser and Luoma 2010b: Table 4, 8, footnote 10). (p.33)*

**Response:**

In essence, this paragraph seeks to refute information from Beckon and Maurer indicating low selenium tissue in Delta Smelt with the generalized concern for the species in Presser and Luoma 2010b. However, each of the projections used to build the risk estimates using the Presser-Luoma model result in an overly conservative selenium risk estimate. This is due to the large uncertainties associated with the parameters employed to estimate risk. While the authors of the model acknowledge the uncertainties, they do not present and discuss the range of potential impacts or the effects on their projections, leaving only a generalized conclusion suggesting the worst-case maximum impact. The paper represents that there could be discharges of up to 180,000 pounds of selenium per year to the Delta from the San Joaquin River. This is misleading. Discharge from the Grassland Bypass Project in 2011 was 1,972 pounds. There is an approved TMML for allowable loads in the San Joaquin River below the Merced River which allow a maximum discharge of 4,480 pounds of selenium in a wet year type and 1,658 pounds in a critical year type. In addition, the 2009 Use Agreement for the San Luis Drain, under which the Bypass Project operates, commits to annual discharges of no more than 900 pounds by 2019.

There is an important difference between typical food web bioaccumulation and what occurs in semi-motile biota such as the Delta smelt. These estimates of potential uptake and exposure, and the resulting statements that whole body selenium concentrations are substantially lower than clams, supports the argument that exposure and effects cannot be extrapolated easily between trophic levels.

Building the hypothetical food web uptake scenario suggesting that invertebrate-feeding smelt may accumulate selenium would need to be validated by measured tissue concentrations in the smelt, as well as their insect larvae prey. Vulnerability to selenium purely based on a threatened status cannot be assumed without data supporting species sensitivity. Smelt are exposed to numerous environmental contaminants and it is not possible to elucidate the effects of these confounding factors both individually and combined.

Delta smelt have been observed with selenium tissue residues well below Lemly's proposed 4 µg/g toxicity threshold, which itself is a conservative and disputed threshold based on his review of laboratory- and field-observed adverse effects occurring at selenium concentrations in fish ranging from 3-40 µg/g (Lemly, 1993). In addition, Delta smelt spawning sites are "nearly absent from the south-Delta channels associated with the selenium-contaminated San Joaquin River" (Beckon and Maurer 2008), and they principally feed on zooplankton, not clams or other invertebrates. Thus, no field or experimental data nor their life history indicates they are susceptible to selenium exposure in the Bay-Delta Estuary. Further, the model fails to consider the fact that selenium from agriculture in the San Joaquin River water column is the less bioavailable selenate.

The testimony contradicts itself and the Beckon and Maurer 2008 document it references. Earlier in the testimony, it is stated that "*Beckon and Maurer (2008: 31) characterize the risk of selenium exposure by Delta smelt to be low. Delta smelt adults reach a maximum of about 4.7 inches in length. They feed on zooplankton, primarily which is not a significant selenium partitioning pathway into Delta food webs, but Delta smelt also consume aquatic insect larvae when available (McGinnis 2006: 197).*" *(p. 32)* Beckon and Maurer (2008) state that *"Delta smelt, salvaged from the Chipps Island area during the springs of 1993 and 1994, had whole-body selenium concentrations of 1.5 µg/g dw (n=41, range 0.7 - 2.3 µg/g) (Bennett et al. 2001). Delta Smelt spawning sites are almost entirely restricted to the north-Delta* *channels associated with the selenium-normal Sacramento River and are nearly absent from the south-Delta channels associated with the selenium-contaminated San Joaquin River (USFWS 1996). Therefore, Delta smelt would appear to be at low risk to selenium exposure*." *(p. 32)*

The testimony notes that "*There are many sensitive species for whom selenium exposures and possible food web pathways to selenium exposure have not been identified. Two key listed species in the Delta for which either no or limited data are available are the Delta smelt and Chinook salmon, discussed above*." *(p. 34)* Presser and Luoma (2010) state that "*the extent of selenium bioaccumulation (the concentration achieved by the organism) is driven by physiological processes that are specific to each species.*" (p. 686) Field- and laboratory-based research and monitoring are necessary to determine the sensitivity of these species.

6. ***Issue: White sturgeon and four species of sea ducks are especially at risk of elevated selenium concentrations based on loading projections.***

***Statement in C-WIN Submittal:***

*Presser and Luoma (2006) earlier concluded from their selenium loading projections that white sturgeon (an Endangered Species Act-listed species) and greater and lesser scaup, surf and black scoters are at risk of significantly elevated selenium exposure given these selenium loading projections. (Presser and Luoma 2006: Table 33: 93; 2010a; 2010b) White sturgeon is a migratory fish, while the scaups and scoters are migratory estuary-based water birds that dive to prey on clams and other bottom-dwelling organisms. (p. 33)*

**Response:**

There is a continued suggestion that the hypothetical selenium loading projections will result in increased risk to sturgeon, scoters, and scaup. Because the projections of selenium loading have been shown to be significantly overestimated, the risk estimate is equally overestimated.

To clarify, only certain populations of white sturgeon are endangered, which does not include those inhabiting the Bay-Delta Estuary (Nechako River, Upper Columbia River population and Kootenai River population in Montana and Idaho – Beckon and Maurer 2008). In addition, Beckon and Maurer (2008) state that reduced selenium loads to the San Joaquin River and the Bay-Delta Estuary as a result of implementation of selenium TMDLs and the Grassland Bypass Project, should lead to diminished potential impacts to sturgeon over time. (p. 31)

7. ***Issue: The Bay-Delta Estuary system is at risk due to major changes in hydrologic regimes.***

***Statement in C-WIN Submittal:***

*A great risk to the Delta's future health and quality are systemic changes that are likely to lengthen the residence time of waters passing through the Bay-Delta Estuary on their way to the Pacific Ocean, and in* *so doing increase risks of selenium poisoning and ecological damage in the Bay-Delta Estuary (Presser and Luoma 2006, 2010). These risks originate with agricultural drainage accumulating in the San Joaquin River Basin due to irrigation of lands with soils impregnated with naturally occurring high selenium, salt, and other toxic contaminant concentrations and loads that must eventually be disposed of, else cultivation of western San Joaquin Valley lands will eventually go out of production. (p. 34)*

*Under current hydrologic regimes, residence times of water in the south Delta and the North Bay can last from 16 days to three months in Suisun Bay during low flow, depending on levels of through-Delta discharge and mixing activity. (Presser and Luoma 2006: 17; Smith 1987; Presser and Luoma 2010: 707) Removal of Sacramento River flows from the Delta will result in less overall fresh water reaching central Delta channels, such as through Georgiana Slough (or via the Delta Cross Channel, a Central Valley Project facility that serves the same purpose to get fresh water across the central Delta to the pumping plants in the south Delta). To compensate, far more water would have to flow into the Delta from the San Joaquin River, but this river on average has the capability of delivering only a fraction of Sacramento River flows under unimpaired conditions. (p. 35)*

*Selenium concentrations in subsurface drain water in the San Joaquin River Basin exceed US Environmental Protection Agency aquatic selenium criterion for rivers and streams by 13 to 20 times (depending on whether the arithmetic or geometric mean is compared); by 32 to 50 times the aquatic criterion for westlands in California, and 130 to 200 times the level recommended as non-toxic in animal tissues by the US Geological Survey in recent research. (Presser and Luoma 2010, 2011; California Department of Water Resources 2010: see data in Table B-3, Appendix B, this testimony) This is the reservoir of selenium toxicity that builds up. Selenium regulation needs to catch up with this reality. (p. 35)*

**Response:**

This paragraph does not give the basis for discussing reduced Sacramento River flows. It appears to conflate selenium concentration information from subsurface agricultural drains with San Joaquin River water quality, even though San Joaquin River at Vernalis currently meets the salinity water quality objective. It does not note that selenium in the San Joaquin River was so low that several segments below the Merced River have been removed from the 303(d) list for selenium. It does not discuss whether or not the selenium concentrations indicative of total selenium, dissolved selenium, particulate selenium, bioavailable selenium. There is simply no scientific or factual basis cited in the paper to support the conclusion that the San Joaquin River is a "reservoir of selenium toxicity that builds up."

Presser and Luoma 2006 state: "*Changes in residence times of water in the south Delta and the North Bay could result from changes in water management.*" (p. 17) While potentially correct, the authors provide no parameters to support any conclusions on selenium effects from any such potential changes. Thus, the likelihood of increased residence time is not substantiated.

With regard to the USGS recommended non-toxic selenium tissue levels, various authors (Adams et al., 2010; Brix et al., 2000) have indicated that many of the USFWS proposed thresholds for selenium in fish tissues and bird eggs are overly conservative and do not appear to be well supported by the scientific literature. Because the details of many studies and raw data are not readily available, it is difficult to ascertain whether previous studies have adequately controlled for confounding factors such as disease, predation, weather, and other contaminants. In addition, in many instances, the field data do not agree with results from controlled laboratory studies evaluating the same endpoint.

Alternative reported thresholds for fish tissue (6-17 mg/kg dw) and diet (10-11 mg/kg dw) and a bird egg threshold of 16 mg/kg dw appear to be more reasonable (Brix et al., 2000). These changes to the overly conservative (multiple cascading safety factors) thresholds used in the discussions about selenium in the Bay-Delta directly impact the estimates of selenium exposures that could result in adverse impacts and result in unrealistic risk estimates.

***8. Issue: Selenium has multiple routes through which it can expose fish and wildlife to its toxicity.***

***Statement in C-WIN Submittal:***

*Partitioning coefficients ($K_d$) that characterize the relative rates of selenium partitioning (wherein selenium comes out of solution into particulate phase, available for bioaccumulation into food) link ecological relationships and hydrologic environments through which selenium moves. (Presser and Luoma 2010a: 704, 707) Selenium has multiple routes through which it can expose fish and wildlife to its toxicity. (p. 33)*

**Response:**

The author's sweeping conclusion is not substantiated by the cited document. Suggesting that selenium partitioning into various particulate and other phases increases the routes of exposure to aquatic species and wildlife appears to imply that all of these exposure routes can occur simultaneously. Bioaccumulation from particulates is the primary route by which selenium enters the food web (Presser and Luoma, 2006). For example, uptake of dissolved selenium accounts for less than 5 percent of selenium found in animal tissues (Presser and Luoma 2010). Further, Presser and Luoma fail to address the relatively low bioavailability of the selenate form of selenium that predominates in the San Joaquin River.

Furthermore, Presser and Luoma (2010) state: *"Use of a partitioning descriptor can be controversial because Kd formally implies an equilibrium constant. Indeed, thermodynamic equilibrium does not govern Se distributions in the environment (Cutter and Bruland 1984; Oremland et al. 1989), and partitioning coefficients for Se are known to be highly variable (McGeer et al. 2003; Brix et al. 2005), but Kd can be a useful construct if it is recognized that the instantaneous ratio is not intended to differentiate processes or to be predictive beyond the specific circumstance in which it is determined."* (p. 690)

**9. *Issue: Selenium concentrates in depositional environments posing elevated risk to ecological receptors.***

***Statement in C-WIN Submittal:***

*Selenium concentrates naturally in the depositional environments of estuaries and marshes. Hydrologic conditions provide important reasons for this. Selenium dissolved in water represents only a small proportion of exposures. (Presser and Luoma 2006; Presser and Luoma 2009: 8485; Schlekat et al 2004; Roditi et al 1999 Alquezar et al 2008) Selenium can undergo "partitioning" reactions in the water column that determine whether selenium remains dissolved or enters what chemists refer to as its "particulate phase." (Presser and Luoma 2006: 41; Presser and Luoma 2010) (p.25)*

**Response:**

This statement is contradicted by the C-WIN's own hypothesis, stated on page 33 of the submittal and cited in Item 8 above; a hypothesis that high levels of selenium exposure occur due to the potential for selenium to be present in several media simultaneously." The final analysis of the potential risk of selenium to aquatic and terrestrial biota in the Delta should be evaluated and considered only through monitoring and measure of tissue levels in receptor biota. Otherwise all of the conjecture and hypothetical scenarios are irrelevant.

**10. *Issue: Climate change poses toxic challenges to the Delta's future.***

***Statement in C-WIN Submittal:***

*Sea level rise also poses toxic challenges to the Delta's future. With the water in Delta channels at present sea level, direct concerns focus on additional hydrostatic pressures that rising sea levels will place on Delta levees. For this discussion, however, sea level rise is likely to result in two other aspects of hydraulic pressures upstream of the Delta. (p. 35)*

*This potential impact of climate change in the San Joaquin River Basin and the Delta would be further compounded by the trend, now seen in reduced snowpack and spring snowmelt, and increased rainfall and runoff. While extreme events like flooding and droughts may occur with greater frequency in the future in California, it is also anticipated that overall water supplies will decrease. In that event, residence time of waters in the Delta can be expected to increase as well with its implications of toxic damage in slow-water environments of the lower reaches of the San Joaquin River Basin and the Bay-Delta Estuary. (p. 36)*

*Yet these cumulating loads would likely be highly toxic, especially in dry and drought years, of which more are expected as California's climate changes. Expressed in kestersons, these load projections by Presser and Luoma convert to 1.7 to 10.3 kestersons per year in the San Luis Drain under relaxed assumptions of selenium concentration. (p. 24)*

**Response:**

Projecting significant impacts from "potential" sea level changes, which would be required to cause major changes in hydrostatic pressure in the watersheds, is not supportable. This is merely another overly conservative estimate of potential impact of selenium. In reality, sea level "rise" is transient and has been suggested at 2.5 millimeters (approximately 1/10 inch) over the last decade, while the computer models that project flooding and terrestrial inundation incorporate sea level rise numbers approaching 20 feet. Even assuming that there is a measureable rise in sea level, at the estimated current rate, it would take about 2,400 years to reach that level. The natural geologic events are driven at glacial speeds. Inclusion of such an extreme concept based upon projected selenium loading that does not reflect any real-world possibilities (e.g., a drain collecting drainage from some 700,000 acres and transporting it to the Delta) only further reduces the credibility of many of the statements and positions presented by C-WIN.

***11. Issue: The model uses inaccurate assumptions to estimate future selenium loadings.***

***Statement in C-WIN Submittal:***

*At high flows selenium loads may differ significantly depending on the concentration maintained either in the river or the drain. At the current Total Mean Monthly Load (TMML) level for the lower San Joaquin River (California Regional Water Quality Control Board 2000) of 5 micrograms per liter (µg/L) can yield large loads in high flows (up to 40,800 pounds during a 3 million acre/feet wet year) or small loads in low flows (or nearly 3,000 pounds during low ‹low in the San Joaquin River or capacity flow of the San Luis Drain. (p. 24)*

**Response:**

It is entirely unrealistic to assume that in times of flood, every acre/foot of water in the San Joaquin River would carry 5 µg/l of selenium. Instead, the TMMLs set for the San Joaquin River have not been exceeded. There is an approved TMDL in the San Joaquin River below the Merced River, which allows a maximum discharge of 4,480 pounds of selenium in a wet year type and 1,658 pounds in a critical year type. Discharge in 2011 was 1,972 pounds. In addition, the 2009 Use Agreement for the San Luis Drain, under which the Bypass Project operates, commits to annual discharges of no more than 900 pounds by 2019. Therefore, future selenium discharge reductions are built into the operation of the San Luis Drain (SWRCB, 2012 - The Grassland Bypass Project Summary: Presentation to State Water Resources Control Board. July 16, 2012), the major source of actual discharges of selenium into the River. Most of the comments and arguments presented in this testimony are based on projections of discharges through a drain that does not exist and is not proposed and ignore both current data and existing regulatory controls.

***Statement in C-WIN Submittal:***

*Presser and Luoma (2006) quantify this reservoir by conceiving the reservoir of selenium as a stream of yearly time step flows that can be modeled using reasonable assumptions about drainage projections, selenium concentrations and loadings from recognized plans and studies.*

*Their scenarios are as follows:*

- *Existing discharges from the Grassland subarea (the northern part) through extension of the San Luis Drain to the Delta.*[4]
- *Westlands Water District subarea-only use of a San Luis Drain extension to the Delta or San Joaquin River.*
- *Grassland subarea plus Westlands subarea, both carried to the Bay-Delta.*[5]
- *Drainage is collected valleywide from all five subareas (Northern; Grassland, Westlands; Tulare, and Kern subareas).*[6]

[4] *"It seems unlikely that demand [for use of the San Luis Drain] would remain at this level once an out-of-valley conveyance was available. Increasing acreages of saline soils, rising ground water tables, and the availability of a conveyance facility are likely to generate strong pressures from other areas to use the facility." (Presser and Luoma 2006: 31)*

[5] *"This seems a likely outcome if a conveyance is constructed." (Presser and Luoma 2006: 31)*

[6] *"This would require extensions of the San Luis Drain into Kern and Tulare subareas, in addition to an extension to the Bay-Delta" (Presser and Luoma 2006: 31-31) (p. 23)*

**Response:**

The testimony and its quoted statements from Presser and Luoma (2006) do not provide references for the conjecture that demand for a conveyance facility will increase. In reality, there are no plans to complete any master drain to the Delta, and the only area currently drained, the Grassland Drainage Area, is subject to stringent regulation and moving toward a maximum allowable discharge of 900 lbs.

Each of the projections used to build this overly conservative risk to selenium have a large uncertainty associated with them. It is important to note that each of these projections and the range of potential impacts should be discussed rather than the worst-case maximum impact.

*Attachments: References*

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**Subject:** **Appendix: Key statements from Presser and Luoma documents**

The following bullets in black are statements/content taken directly from the various documents, and corresponding page numbers are indicated. Responses to the Presser and Luoma statements are indicated in red.

**Key statements made by Presser and Luoma 2006 - Forecasting Selenium Discharges to the San Francisco Bay-Delta Estuary: Ecological Effects of a Proposed San Luis Drain Extension, Professional Paper 1646.**

- San Joaquin Valley agricultural drainage loads disposed of in a San Luis Drain extension could range from 45 to 117 pounds of selenium per day across a set of historical and future conditions. Components of this valley-wide load include five source subareas (i.e., Grassland, Westlands, Tulare, Kern, and Northern) defined by water and drainage management. (p. 1)

- Surf scoter, greater and lesser scaup, and white sturgeon appear to be most at risk because these Bay-Delta predators feed on deposit and filter-feeding bivalves. Recent findings add Sacramento splittail and Dungeness crab to that list. (p. 1)

    Response

    - There is a continued overly conservative suggestion that the hypothetical selenium loading projections will result in increased risk to sturgeon, scoters, and scaup. Because the projections of selenium loading have been shown to be significantly overestimated, the risk estimate is equally overestimated.

    - In Suisun Bay, downstream from the Delta, bioaccumulation of selenium in sturgeon, splittail, striped bass and diving ducks was observed in the past. However, as a result of reductions in selenium discharges, selenium concentrations in Suisun Bay are now substantially lower than in the past [S. Meseck, 2002 PhD thesis, pgs 25 and 27] and the Bay is now a selenate-dominated system. Recent data on selenium levels in Suisun Bay birds and fish indicate:

- Selenium in diving ducks is below toxic thresholds [Stewart and Luoma, 10/5/00 CalFed Science Conference]
- Median selenium levels in sturgeon, splittail and striped bass are below EPA's March 2002 draft criterion of 7.9 ppm dry weight. (Pers. Comm., T. Mongan, 2012).

- The threat to the estuary is greatest during low flow seasons and critically dry years. During the low flow season of critically dry years, forecasted selenium concentrations in water, particulate matter, prey (diet), and predator tissue exceed guidelines with a high certainty of producing adverse effects under the most likely load scenario from a proposed San Luis Drain extension. (p. 1)

- High flows afford some protection under certain conditions in modeled San Joaquin River scenarios. However, meeting a combined goal of releasing a specific load during maximum flows and keeping selenium concentrations in the river below a certain objective to protect against bioaccumulation may not always be attainable. Management of the San Joaquin River on a constant concentration basis also could create problematic bioaccumulation during a wet year, especially during the low flow season, because high flows translate to high loads that are not always offset by seasonal river inflows. (p. 1)

<u>Response</u>

- Environmental effects of selenium are determined by selenium concentrations, not selenium loads, because only selenium concentrations in food items, water and surface sediment can affect birds and fish. Selenium can be buried in sediments below the biologically active zone, volatilized to the air, or diluted by greater water volumes during high flow periods. Therefore, changes in the total load of selenium discharged are only relevant to the extent they change selenium concentrations in food items, water and surface sediment (Pers. Comm., T. Mongan, 2012).

- Pathway-specific models allow consideration of (1) speciation and transformation between dissolved and particulate forms (2) biotransfer from different types of suspended/particulate matter (for example, phytoplankton, detritus, and sediment); (3) bioaccumulation via the lower trophic food web; and (4) uptake of food by predator species. Because selenium concentrations can biomagnify during food web transfer (see, for example, USEPA, 1980; Saiki, 1986; Maier and Knight, 1994; Reinfelder and others, 1998; Stewart and others, 2004; Luoma and Rainbow, 2005), upper trophic level species are the species most vulnerable to adverse effects from selenium contamination. (p. 3)

- Failure to consider the full sequence of interacting processes is a major cause of controversy surrounding many interpretations of selenium effects on the environment. (p. 3)

<u>Response</u>

- We, Cardno ENTRIX, agree and propose that the relative abundance of the different forms of selenium must be monitored and considered.

- In addition to reproductive toxicity and teratogenesis effects, inhibition of growth, mass wasting, depression of the immune system, and oxidative stress also are toxicity endpoints of concern, with winter stress syndrome known to increase the toxicity of dietary selenium to birds and fish during low winter temperatures. (p. 7)

- Selenium concentrations in the San Joaquin River have exceeded USEPA criteria 50 percent of the time for the period 1987 to 1997 at Crows Landing (figs. 3 and 4) (Central Valley Board, 1996a, b, 1998f). (p. 13)

  Response
  - These values are outdated and from before the Grassland Bypass Project was implemented. Since 2005 the selenium water quality objective in the San Joaquin River at Crows Landing has been met at all times. Because of this accomplishment selenium has been removed from the State Board 303(d) list in the San Joaquin River below the Merced River.

- Selenium concentrations were below recommended water quality protection guidelines (2 to 5 µg/L) in both the Delta and the Bay in all surveys of the Bay-Delta from 1982 to the mid-1990s. (p. 13)

  Response
  - At the January 2003 CalFed Science Conference, Dr. Stewart (USGS) reported on selenium in organisms at Mildred Island in the southern Delta. She found "selenium concentrations in the Delta food webs were lower than those observed in Suisun Bay and did not exceed toxicity thresholds." (Pers. Comm., T. Mongan, 2012)

- The probability is high in the future that discharges of selenium will increase to the Bay-Delta. A proposed 100-mile extension of the existing San Luis Drain would convey subsurface agricultural drainage from the western San Joaquin Valley to a discharge point near Chipps Island in Suisun Bay (figs. 3 and 4). The drain extension would help alleviate the build-up of salt and selenium in agricultural soils and the aquifers of the valley by exporting them from the valley and disposing of them in the Bay-Delta. (p. 15)

  Response
  - This discussion ignores the fact that huge areas of the San Joaquin Valley have no drainage outlet for agricultural drainage to reach the San Joaquin River and that no outlet for such lands is proposed. And it ignores the fact that the Grasslands Bypass Project has made significant progress in reducing selenium loads discharged to the water ways and in fact, , are 85% less than pre-Project loads, are significantly less than loads authorized in the current Basin Plan, and based on existing regulation and Project history, will continue to reduce.

- Because of the nature of valley conditions, selenium is mainly oxidized to mobile selenate. (Presser and Ohlendorf, 1987). (p. 15)

- Scenarios are given for (1) 50 µg/L representing an overall average given in testimony that treatment technologies or blending could achieve and near present day discharge from Grassland Bypass Channel Project to the San Joaquin River (62 to 67 µg/L); (2) 150 µg/L selenium representing an average for current subsurface drainage without blending in the Grassland subarea (Central Valley Board, 1996c) and near the mean (163 µg/L) presented for shallow ground water from 42,000 acres in the Westlands subarea (Wanger, 1994); and (3) 300 µg/L representing a concentration approaching that discharged from Westlands Water District to Kesterson Reservoir from 1981 to 1985. (p. 32)

Response

- The validity and likelihood of these concentrations occurring under proposed projects is not supported.

- In March 1988, refineries accounted for 74 percent of the internal discharges of selenium to the Bay-Delta; in May 1988, they accounted for 96 percent (Cutter and San Diego-McGlone, 1990). Using these estimates, refinery inputs declined by about two-thirds (to about 1,100 lbs selenium per year), from the amount measured from 1986 to 1992. (p. 35)

- Recent data suggest the selenite concentration peak near the refineries has declined after the treatment technologies were implemented and selenate concentrations have increased (Cutter and Cutter, 2004). (p. 35)

- Se speciation:
  - Organo-Se (-2 or -II) substituting for S-2 in proteins seleno-methionine and seleno-cysteine
  - Selenite (+4 or IV) the oxyanion selenite (SeO3-2), an analog to the sulfur compound sulfite
  - Selenate (+6 or VI), the oxyanion selenate (SeO4-2), an analog to the sulfur compound sulfate
  - Selenate and selenite usually are the common dissolved forms. (p. 40)

- Particulate selenium concentrations can differ by as much as 100-fold at the same dissolved concentration depending on biogeochemical transformation reactions governing dissolved particulate interactions. Thus, forecasts of effects depend on understanding what transformations will occur. (p. 41)

- Bioaccumulation of selenium into food webs can be more proficient and biotic consequences to birds and fish more severe when a source water is selenite-dominated, than when it is selenate dominated (Skorupa, 1998a). Overall conclusions about bioavailability are dependent on linking receptors to foodweb components using very detailed species-specific analysis. (p. 41)

Response

- We concur with this statement. The USFWS rarely distinguishes between selenite and selenate even though 1 ppb selenite has about the same biological effects as 10 ppb selenate (Pers. Comm., T. Mongan, 2012).

- No systematic selenium studies have been done in the Delta after San Joaquin River inflows to the Delta increased in the mid-1990s. (p. 44)

Response

- This correlates to a very large data gap with respect to selenium levels, speciation, sensitive species, etc.

**Key statements made by Presser and Luoma 2010a - A Methodology for Ecosystem-Scale Modeling of Selenium, Integrated Environmental Assessment and Management, 6: 685-710.**

- The paper presents "an ecosystem-scale methodology that reduces uncertainty by systematically quantifying each of the influential processes that links source inputs of Se to toxicity. In particular, we emphasize a methodology for relating dissolved Se to bioaccumulated Se. The methodology allows us to 1) model Se exposure with greater certainty than previously achieved through traditional approaches that skip steps, 2) explain or predict Se toxicity (or lack of toxicity) in site-specific circumstances, and 3) translate proposed Se guidelines among media under different management or regulatory scenarios." (p. 685)

- $K_d$ represents the environmental partitioning between dissolved and particulate phases. It is used to characterize the uptake and transformation (bioconcentration) of dissolved Se into the base of the food web. (p. 686)

- $K_d$ is environment specific (i.e., dependent on site hydrology, dissolved speciation, and type of particulate material) and is the ratio of the particulate material Se concentration (in dry weight, dw) to the dissolved Se concentration observed at any instant. (p. 686)

- Tissue Se attributable to dissolved exposure makes up less than 5% of overall tissue Se in almost all circumstances (Fowler and Benayoun 1976; Luoma et al. 1992; Roditi and Fisher 1999; Wang and Fisher 1999; Wang 2002; Schlekat et al. 2004; Lee et al. 2006). (p. 686)

- There has been considerable discussion about choices of protective levels for fish and wildlife (Skorupa 1998; DeForest et al. 1999; Hamilton 2004; Lemly 2002; Adams et al. 2003; Ohlendorf 2003). (p. 687)

    Response

    - There is large variability based on field and laboratory exposures, species, life stage, and other confounding factors.

- Selenate is dominant in agricultural drainage, mountaintop coal mining and/or valley fill leachate, and Cu mining discharge (Presser and Ohlendorf 1987; Naftz et al. 2009; West Virginia Department of Environmental Protection 2009). (p. 689)

- Selenite is dominant in oil refinery and fly-ash-disposal effluents (Bowie et al. 1996; Cutter and Cutter 2004). Combinations of selenite and organo-Se are common in pond-treated agricultural drainage (Amweg et al. 2003) and the oceans (Cutter and Bruland 1984). Speciation in phosphate mining overburden leachate in streams depends on season and flow conditions: selenate during maximum flow, selenite and organo-Se during minimum flow (Presser, Hardy, et al. 2004). (p. 689)

- Particulate Se is the primary form by which Se enters food webs (Cutter and Bruland 1984; Oremland et al. 1989; Luoma et al. 1992). (p. 689)

- Partitioning coefficients for Se are known to be highly variable (McGeer et al. 2003; Brix et al. 2005), but $K_d$ can be a useful construct if it is recognized that the instantaneous ratio is not intended to differentiate processes or to be predictive beyond the specific circumstance in which it is determined. The sole intention is to describe the particulate to water ratio at the moment when the sample is taken. (p. 690)

- Repeated observations of $K_d$ can narrow uncertainties about local conditions. However, $K_d$ will vary widely among hydrologic environments (i.e., in parts of a watershed such as wetlands, streams, or estuaries) and potentially among seasons. (p. 690)

- $K_d$ will increase as selenite and dissolved organo-Se concentrations increase. (p. 690)

- Uptake from the dissolved phase is irrelevant compared with uptake from particulate sources such as phytoplankton, detritus, or sedimentary material (Fowler and Benayoun 1976; Luoma et al. 1992; Wang and Fisher 1999; Wang 2002; Schlekat et al. 2004; Lee et al. 2006). (p. 691)

- Specificity in several variables based on experimental conditions when referencing a Se guideline is desirable. These variables include 1) endpoint (e.g., toxicity, reproductive, survival, growth, immunosuppression); 2) life stage (e.g., larvae, fry, adult); 3) form (e.g., selenate, selenite, selenomethionine, selenized yeast); 4) route of transfer (e.g., dietary, maternal); 5) definition of protection (e.g., threshold, toxicity level, criterion, target); and 6) toxicity basis (e.g., EC10). In general, for Se, reproductive endpoints are more sensitive than toxicity and mortality in adult birds and fish (Skorupa 1998; Lemly 2002; Chapman et al. 2010). Within reproductive endpoints, larval survival in fish and hatchability (i.e., embryo survival) in birds are considered the most sensitive endpoints. (p. 697)

- The paper tested the proposed methodology by comparing predictions and observations from 29 locations that were either historically, or are presently, affected by Se.

- The equations used for validation begin with a particulate material Se concentration, and thus do not incorporate the uncertainties associated with dissolved and/or particulate transformations ($K_d$). (p. 697)

  Response
  - This is a huge caveat to the model, particularly because dissolved or total Se concentrations in the water column are often measured as representative of the Se in the environment. Furthermore, the biotransformation of Se by phytoplankton and bacteria is not taken into account.

- Model shows that if particulate Se concentrations are known and food webs are considered in an ecologically based way, bioaccumulation in the different food webs of an ecosystem can be reliably predicted. (p. 699)

  Response
  - This requires well-defined knowledge of the food webs of an ecosystem and prey choices of species of concern.

- In the absence of well-developed site models, the choice of $K_d$ is usually the greatest source of uncertainty among model parameters. (p. 701)

  Response
  - This is another large issue because the amount of selenium in an ecosystem that is transformed from a dissolved and largely not bioavailable form to a particulate and potentially more bioavailable form is of utmost importance for determining exposure and thus toxicity. As stated by the document itself "*Uptake from the dissolved phase is irrelevant compared with uptake from particulate sources such as phytoplankton, detritus, or sedimentary material*."

- Estuaries require the lowest water-column Se concentrations (0.24 μg/L) because of the potential for very high $K_d$s and the presence of clam-based food webs. (p. 703)

- An additional factor would be necessary to illustrate a scenario, for example, in which birds in an estuary are feeding on fish that prey on aquatic insects. (p. 704)

- Field-and laboratory-derived TTFs for individual species also appear to agree well (within 2-fold) in the few cases in which comparisons are possible. (p. 704)

- The database of $K_d$s suggests that uncertainties in the transformation coefficient could range from 2-fold to 10-fold in the absence of local data.). (p. 705)

  Response
  - This suggests a large degree of uncertainty in these default numbers when information for an ecosystem of concern is not available.

- The following could address uncertainty: 1) clearly defining food webs in conceptual models of fauna and their feeding relationships from empirical knowledge of the investigated site can identify details of species-specific exposure, 2) life cycles of habitat species can be displayed on a yearly basis to identify details of spatial and temporal exposure, 3) identifying feeding areas for wildlife can help determine what percentage of diet comes from the polluted site, 4) dissolved-and particulate-material Se speciation can be related to hydrologic conditions (e.g., high-or low-flow season or residence time), and 5) bioaccumulation dynamics can be related to particulate material characterization. (p. 705)

- Continued work on quantitatively modeling transformation from dissolved to particulate Se under different circumstances is essential. More data are needed on physiological TTFs for invertebrates, fish, and bird species derived from kinetic experiments. Comparisons are also needed for experimental vs. field-derived TTFs (with the latter derived from matched data sets across different field sites). Few biodynamic studies are available for different fish species, so determining the range of TTFs from experimental studies would further assess the importance of the role of fish physiology in understanding food webs. Biodynamic kinetic studies are not available for avian species, and data available for derivation of TTF for different bird species in different dietary settings are limited, so further experiments to develop egg–diet relationships are needed with particular attention to mimicking the bioavailability of a diet found in nature. Inclusion of a database of factors for translation to fish ovary Se concentrations would be an important addition to allow connection of modeling of fish directly to reproductive effects. Developing TTFs specific to the dietary exposure concentration being modeled would require systematic experimental studies of common food web species to generate a set of generalized TTF equations as a function of dietary Se. (p. 705)

- Analysis from the model shows that 1) a crucial factor ultimately defining Se toxicity is the link between dissolved and particulate phases at the base of the food web (i.e., $K_d$); 2) collection of particulate material phases and analysis of their Se concentrations are key to representing the dynamics of the system; 3) bioaccumulation in invertebrates is a major source of variability in Se exposure of predators within an ecosystem, although that variability can be explained by invertebrate physiology (i.e., $TTF_{invertebrate}$; Figure 5); 4) $TTF_{fish}$ is relatively constant across all species considered here; and 5) Se concentrations are at least conserved and usually magnified at every step in a food web (Figure 6). (p. 707)

- The methodology also shows the need for a better understanding of the aspects of ecosystems, such as water residence time and dissolved and particulate speciation, that contribute to the environmental partitioning and bioavailability of Se. In lieu of this, determining Se concentrations in the suspended particulate material phase is the preferred measure of the complex water, sediment, and particulate milieu that forms the base of the food web and is consumed as food by invertebrates. Monitoring invertebrate Se concentrations in food webs that are the most likely to be heavily contaminated may be a practical initial step in a monitoring plan, because the first and second most variable aspect of Se dynamics (i.e., $K_d$ and $TTF_{invertebrate}$) are integrated into invertebrate bioaccumulation. Policy choices such as 1) the predator species to represent an ecosystem (e.g., toxicologically sensitive, ecologically vulnerable based on food web, resident or migratory, commercially or esthetically valuable) and 2) the food web to represent an ecosystem (e.g., potentially restored food webs in addition to current food webs) also serve as important initial inputs into the development of protective scenarios for a site or watershed. (p. 707)

**Key statements made by Presser and Luoma 2010b - Ecosystem-Scale Selenium Modeling in Support of Fish and Wildlife Criteria Development for the San Francisco Bay-Delta Estuary, California, USGS Administrative Report.**

- For regulators and scientists, our approach offers an understanding that 1) diet drives protection and 2) the choice of food web and predator species is critical because the kinetics of bioaccumulation differs widely among invertebrates. Further, adequately characterizing the transformation of dissolved Se to particulate Se and the type and phase of the resulting particulate material quantifies the effect of Se speciation on both Se partitioning and Se exposure to prey through the base of the food web (i.e., particulate material to prey kinetics). (p. 1)

    Response
    - Once again, this requires well-defined knowledge of the food webs of an ecosystem and prey choices of species of concern.

- Profiles across the estuary within a series of specified freshwater residence times (e.g., June, 1998, 11 days; November, 1999, 70 days) show the range of dissolved Se concentrations is narrowly defined as 0.070-0.320 µg/L. The profiles of suspended particulate material Se concentrations show a less narrow definition with a range of 0.15-2.2 µg/g dry weight. In the more restricted approach used for Suisun Bay-Carquinez Strait that eliminates freshwater and ocean interfaces, the range of dissolved Se concentrations is 0.076-0.215 µg/L, with the range of suspended particulate material Se concentrations as 0.15-1.0 µg/g dry weight. The range for the Bay-Delta continuum is 712-26,912, with mean Kds shown to increase with increasing residence time. (p. 2)

- National freshwater water quality Se criteria (5 µg/L chronic and 20 µg/L acute) for the protection of aquatic life are directed at protection of fish and are based on field data for effects in fish at Belews Lake (USEPA, 1987). National water quality Se criteria for the protection of marine aquatic life allow a maximum concentration of 290 µg/L and a continuous concentration of 71 µg/L, concentrations approximately an order of magnitude higher than freshwater criteria. What evidence is available from estuarine environments suggests that these guidelines are seriously under-protective for at least some predator species (Luoma et al., 1992; Presser and Luoma, 2006; Luoma and Presser, 2009). (p. 4)

  Response
  - This 5 ppb criterion is based on experience at Belews Lake in North Carolina, under conditions greatly different from those in the San Joaquin Valley. Bioaccumulation at Belews Lake involved selenite-dominated waters, instead of the selenate-dominated water prevalent in the San Joaquin Valley (Pers. Comm., T. Mongan, 2012).

- Current major sources of Se to the Bay-Delta are:
  - irrigation drainage from seleniferous agricultural lands of the western San Joaquin Valley conveyed through the San Joaquin River; and
  - oil refinery wastewaters from processing of seleniferous crude oils at North Bay refineries. (p. 6)

- Previous refinery mass emissions were reduced by 75% (cumulative reduction from baseline of 4,936 lbs during 1989-1991) (San Francisco Bay Board 1992a,b; 1993). Proposed load reductions were achieved in 1998 and since then, the combined Se load from the refiners has remained at approximately 1,200 pounds (lbs)/year. The target of 1,234 lbs/year was a balance between ecological, technological, and economic considerations. (p. 7)

- Daily water-column Se concentrations in effluents were as elevated as 300 µg/L before 1998, but allowed daily maximum effluent limits now are within the range of 34-50 µg/L. (p. 7)

- Regulation of Se for the agricultural community of the Grassland Drainage Area is occurring through the Grassland Bypass Project. The project was initiated in 1996 and is for use of the San Luis Drain and the tributaries of the San Joaquin River for discharge of agricultural drainage from approximately 100,000 acres of land [U.S. Bureau of Reclamation (USBR), 1995; 2001]. Amount of agricultural Se load discharged to the Bay-Delta depends on the amount of San Joaquin River flow that is allowed to enter the Bay-Delta and how much is recycled back to the south (Presser and Luoma, 2006). (p. 7)

- Se load measured at the compliance point (i.e., the San Luis Drain at Mud Slough) was 7,096 lbs in 1998; 5,023 lbs in 2003; 4,286 lbs in 2005; 3,301 lbs in 2008; and 1,239 lbs in 2009. (p. 7)

  Response
  - So Se loads to the San Joaquin River are decreasing with corresponding decreases in Se concentrations.

- Imposition of more restrictive Se targets for the San Joaquin River is balanced by shifting a percentage of the generated annual drainage Se load to storage in groundwater aquifers and lands designated for disposal (San Francisco Estuary Institute, 2004-2005). For example, drainage control activities resulted in storage of 4,200 lbs Se within the Grassland Drainage Area in 2005. For proposed targets from 2009-2019, wetter years allow greater discharge (e.g., 4,480 lbs Se/year during 2009-2014) than drier years. Proposed targets continue to ramp down in the coming years with ultimate goals ranging from 150-600 lbs/year by 2019. The long-term ecological consequences of such a shift in environmental compartments and increased storage of Se within the existing Se reservoir in the San Joaquin Valley is currently under debate (Presser and Schwarzbach, 2008). (p. 7)

- Data for the Grassland Bypass Project area show Se is accumulating to levels in bird eggs of black-necked stilt, American avocet, and killdeer that far exceed threshold Se concentrations for impairment of reproduction. (p. 7)

    Response
    - Mitigation measures have been taken to minimize exposure to wildlife within the Grassland Bypass Project reuse area. Alternate mitigation is also provided.

- Few data are available to quantify a San Joaquin River end-member Se concentration at the head of the estuary. Dissolved Se concentrations for the San Joaquin River averaged 0.71 µg/L (range 0.40-1.07 µg/L) at Vernalis during wet year and above normal conditions in 1998-1999 (Cutter and Cutter, 2004). (p. 8)

- Discharge of Se to the Sacramento River is unregulated. Again, few data are available to quantify a Sacramento end-member Se concentration at the head of the estuary. Dissolved Se concentrations in the Sacramento River averaged 0.07 µg/L (range 0.05-0.11 µg/L) at Freeport during wet year and above normal conditions in 1998-1999 (Cutter and Cutter, 2004). Other unregulated sources of Se include 1) effluents from wastewater treatment plants and industries other than refineries; and 2) discharges from watersheds that drain directly into the estuary. (p. 8)

- Parameters critical in determining the balance of water and Se inputs for the Bay-Delta are:
    - total river (Sacramento River and San Joaquin River) inflow;
    - water diversions or exports (i.e., pumping at Tracy and Clifton Court Forebay south to the Delta-Mendota Canal and the California Aqueduct);
    - proportion of the San Joaquin River directly recycled south before entering the estuary; and
    - total outflow of the estuary to the Pacific Ocean or Net Delta Outflow Index (NDOI). (p. 8)

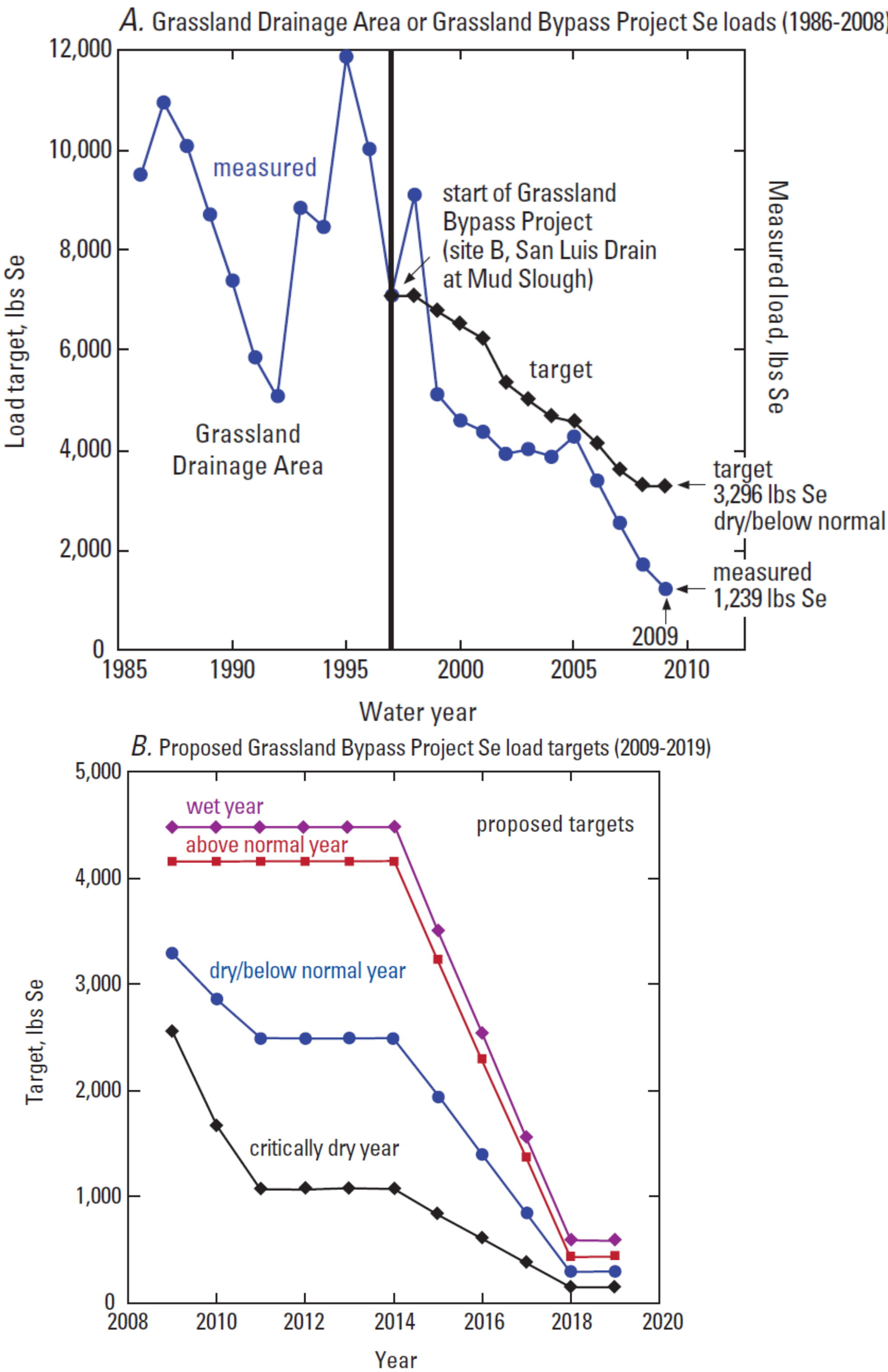


Figure 4. Grassland Bypass Project selenium loads (1997-2009) (*A*) and proposed selenium load targets (2009-2019) (*B*).

Response

- The 2010 normal target for Se was 4,162 lbs and measured 1,555. The 2011 wet year target was 4,480 lbs Se and measured 1,972 lbs Se.

- The range of suspended particulate Se concentrations (0.15-2.2 µg/g dw) for all Bay-Delta transects is not as narrowly defined as that for dissolved Se (Figure 17; Table 8). The patterns of particulate enrichment vary with specified flow condition (e.g., April, 1999; November, 1999). (p. 20)

- Observed *C. amurensis* Se concentrations compare well with predicted Se concentrations using the biodynamic methodology described. (p. 24)

Response

- Selenium concentrations in Suisun Bay scoter rose to about 11 ppm in 1989 and 7 ppm in 1990 after the clam became established, but dropped to about 4 ppm in 2002 as discharge controls became effective (Pers. Comm., T. Mongan, 2012).

- Using existing Se concentrations in seaward white sturgeon, landward white sturgeon, and largemouth bass in the Delta (Stewart et al., 2004; Foe, 2010) as the starting points for modeling, predicted prey, suspended particulate material, and dissolved Se concentrations are comparable to the range of observed conditions and most are within the range of observed Se concentrations (Tables 14-16). (p. 25)

- Species, modeled tissue guidelines, and associated ECs include:
  - adult female white sturgeon (whole-body) at EC10 and 05 (8.1 and 7.0 µg/g dw);
  - generic fish (whole-body) (5.0 µg/g dw);
  - juvenile white sturgeon (diet) EC10 and 05 (1.6 and 0.95 µg/g dw);
  - scoter or scaup (egg) at EC10, 05, and 0 (7.7, 5.9, 2.8 µg/g dw);
  - scoter or scaup (diet) at EC10, 05, and 0 (5.3, 4.4, 2.3 µg/g dw);
  - generic bird (egg) (same as above for EC10 egg of 7.7 µg/g dw);
  - juvenile salmon (whole-body) at EC10, 05 and 0 (1.8, 1.5, 1.0 µg/g dw); and
  - juvenile salmon (diet) at EC10, 05, and 0 (2.7, 2.2, 1.5 µg/g dw). (p. 25)

- For the Bay-Delta, combining modeling with knowledge of fine structure estuary processes is important for reducing uncertainty and fortifying a mechanistic basis for modeling applications and predictions in the future. (p. 29)

- A site-specific methodology for development of Se criteria for the Bay-Delta includes the following steps:
  - identification of predators at risk and their critical life stages;
  - development of conceptual food-web models for predators at risk that include dietary preferences (i.e., percentages of species of invertebrate consumed);
  - development of seasonal-cycle and habitat-use diagrams for prey and predators at risk;
  - derivation of tissue guidelines for species at risk specific to exposure route, effect endpoint, and magnitude of effect (EC0, EC05, and EC10);
  - analysis of spatially and temporally matched datasets for dissolved and suspended particulate material Se concentrations across the salinity gradient;
  - derivation of salinity-specific or location-specific Kds;

- derivation of site-specific $TTF_{C.\ amurensis}$;
- selection or development of $TTF_{fish}$, $TTF_{bird}$, and TTFs for other invertebrates;
- validation of modeling through comparison of predictions to observed Se concentrations;
- development of exposure scenarios specific to location and season or residence time; and
- prediction of allowable dissolved, suspended particulate material, and prey Se concentrations. (p.32)

Response

- We agree that much additional information regarding the complex Bay-Delta estuary ecosystem is necessary.