Results from Modeling of Se Bioaccumulation Potential in Proposed Species Conservation Habitats of the Salton Sea

Report to the Department of Water Resources
UCR Task 4

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February 9, 2011

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SUMMARY

Due to changes in water allocations from the Colorado River, freshwater inflows to the Salton Sea are declining and will result in a decrease of the Sea's size and an increase in salinity. These changes will have detrimental effects on avian species which currently utilize the Sea as a food source. To compensate for the expect decrease in avian habitat, the California Department of Water Resources (DWR) and Department of Fish and Game (DFG) have proposed the construction of Species Conservation Habitat (SCH) that will utilize freshwater inputs from the Whitewater, Alamo and/or New Rivers and water from the Sea. While the SCH ponds will provide needed resources for avian species, the use of increasing amounts of river water to maintain target salinity levels in the SCH ponds will expose birds to risk from Se toxicity. In order to quantify the degree of Se ecorisk within the SCH project, this report used the progressive modeling approach of Presser and Luoma (2010) to predict egg Se levels in invertivore and piscivore birds feeding in SCH ponds. Data used to parameterize the models were drawn from a growing dataset of Se measurements for biota in the Salton Sea region and included recently published results from the saline habitat ponds operated by the U.S. Bureau of Reclamation and U.S. Geological Survey at the south end of the Salton Sea.

Using expected water quality conditions, the progressive models predict that eggs of invertebrate consuming birds utilizing the SCH ponds will have Se levels of between 6.0 to 11.6 µg/g dry weight (DW). For piscivore bird species, egg Se levels are predicted to be slightly higher, 6.5 to 12.7 µg/g DW. Using more pessimistic scenarios of water quality and higher bioaccumulation rates for Se, modeled egg Se levels ranged from 9.4 to 23.1 µg/g DW for all birds. A worst case scenario in which only river water was used to supply the SCH ponds yielded egg Se levels of 29.1 to 31.8 µg/g. Recent work on thresholds for Se effects in birds, suggests that mild reproductive impairment will occur at 8 µg/g DW and will become significant above 12 µg/g DW. Teratogenic effects will begin at 20 µg/g DW and become elevated above 35 µg/g DW. Coupling these Se thresholds with the model results suggests that, under expected conditions in the SCH ponds, feeding birds will experience a low to moderate risk of reproductive impairment, and a low chance of teratogenic effects from Se exposure from the foodweb. Under more pessimistic scenarios, birds feeding in the SCH ponds will experience reproductive impairment and have a low to moderate risk of teratogenicity.

Several key areas for further research were identified. The effect of water residence on Se speciation, Se partitioning coefficients, trophic transfer factors and sediment Se levels is poorly understood, yet critical to the design and maintenance of SCH project. This study identified large variability in the rate of Se partitioning (K_d) between dissolved and particulate forms and suggests that the underlying speciation of Se played a significant role in K_d variation. Substantial uncertainty was introduced into the models from incomplete understanding of aquatic foodwebs in and around the Salton Sea. This shortcoming was especially acute for modeling of Se transfer between fish and avian piscivores.

1. Problem Formulation

1.1 The Species Conservation Habitat Plan

Owing to changes in the allocation of the Colorado River, less water will be available for agricultural uses in the Imperial and Coachella Valleys in the near future. As agricultural water usage declines, so too will freshwater inflows to the Salton Sea. As freshwater inputs decline the Sea will shrink in area, exposing large areas of seabed ("playa") and increasing particulate matter load to the atmosphere thereby reducing air quality. As the Sea shrinks, water salinity will increase, changing a predominantly marine ecosystem, supporting invertebrates, fish and birds, into a hypersaline ecosystem, similar to the Great Salt Lake, dominated by microbes and invertebrates (e.g. brine shrimp, brine flies) with reduced value to some migratory birds. The California Department of Water Resources (DWR) and Department of Fish and Game (DFG) have proposed the construction of Species Conservation Habitat (SCH) that will utilize freshwater inputs from the Whitewater, Alamo and/or New Rivers and water from the Sea. The SCH ponds will be used to evaluate various environmental, biological, and technical issues associated with development of larger complexes of shallow saline habitat on the exposed sea bed as envisioned in the 2007 Programmatic Environmental Impact Report (PEIR) (DWR and DFG 2007ab). In the short-term, the SCH project would also provide habitat for species dependent on the Salton Sea ecosystem. Salinity is currently 52 ppt and could approach 60 ppt as early as 2018. Chironomids, brine flies, corixids and brine shrimp will likely persist, supplying food to wading birds and eared grebes, until the salinity exceeds about 200 ppt (parts per thousands), which could occur by 2038.

As currently envisioned, the SCH Project would be composed of a series of interconnected shallow ponds, 50 to 250 hectares (ha) in area, constructed on exposed or soon-to-be exposed playa of the Salton Sea. The Project size at total build-out is currently expected to be approximately 2,400 acres. The Project's ponds would be created as the Sea recedes by constructing berms using material excavated from the sea bed. Rivers, which have better water quality than agricultural drain water (Saiki *et al.,* 2010), would provide the primary source of water for the ponds. Preliminary evaluations identified three potential siting areas for pond construction near the river mouths: Alamo River and New River at the south end of the Salton Sea, and the Whitewater River at the north end (Figure 1). The SCH ponds would have varying salinity, but will most likely be in the range of 20 to 35 ppt. Depth of water in the SCH ponds will be less than 2 meters and residence times being considered range from 4-32 weeks (Ramona Swenson, Cardno ENTRIX, personal communication). Initial results from physico-chemical modeling suggest that, when water-column stratification occurs, anoxia will occur in bottom waters, but adequate dissolved oxygen (>4ppm) will still be found in waters near the surface (M. Anderson, unpublished data). Water temperatures in the shallow SCHs will approach 5°C during the winter and 30+°C in the summer and these extremes are at or

beyond the limits of tolerance for tilapia living in saline waters. These are the initial physical conditions expected for the SCH ponds and the ones we used in developing the Se conceptual models for the SCH ponds.

1.2 Selenium Risk

Because Se behaves as an analog to sulfur in the synthesis of amino acids and other metabolic processes, high levels of Se in vertebrate diet are associated with reproductive failure and toxicity (Ohlendorf *et al.,* 1986; Ohlendorf *et al.,* 1990; Skorupa and Ohlendorf 1991). Se toxicity remains an abiding concern for resident and migratory birds that utilize the Salton Sea and nearby ecosystems (Setmire *et al.,* 1993; Bennett 1998; Bruehler and de Peyster 1999; Roberts and Berg 2000; DWR, DFG 2007b; Roy *et al.,* 2006; Armbruster 2007; Moreau *et al.,* 2007; Henny *et al.,* 2008; Johnson *et al.,* 2009; Miles *et al.,* 2009; Saiki *et al.,* 2010). Several of the large-scale restoration alternatives proposed in the 2007 PEIR involve the creation of saline habitat complexes at the southern end of the Sea. The use of agricultural drainage and river water to maintain marine salinity levels in these habitats has come under criticism on the basis of Se risk to migratory birds (Cohen 2005). At present, selenium is efficiently, and some might say safely, sequestered in organic sediments of the Sea under low redox conditions (Setmire *et al.,* 1993; Vogl and Henry 2002). However, the SCH ponds are likely to be well-mixed owing to their shallow depths; sediments along the pond margins will be exposed to frequent wave action and wetting and drying cycles. Thus sediments in the SCH ponds could be exposed to higher oxygen concentrations which could decrease selenium sequestration and potentially increase selenium mobility to the foodweb relative to the current Sea (Byron and Ohlendorf 2007). Furthermore, the relatively short residence time of water in the SCH ponds suggests there will be substantial external loading of Se from river sources, which have higher dissolved Se levels than the Sea (Table 1) (Roy *et al.,* 2006). Higher Se loading coupled with the propensity for Se to bioaccumulate within aquatic foodwebs raises the possibility of moderate to high Se risk to breeding birds utilizing the SCH ponds.

The main objective of this report is to present results from modeling of Se bioaccumulation within foodwebs of the proposed SCH ponds. Our goal was to predict the selenium levels in water and sediments of the SCH ponds and the range of concentrations of selenium in the tissues of fish and birds utilizing the SCH habitats. Owing to the complexity of Se biogeochemistry, we adopted the progressive modeling approach of Theresa Presser and Samuel Luoma to simulate transformation of dissolved Se into particulate organic matter and Se bioaccumulation rates among trophic levels (Presser and Luoma 2009; Presser and Luoma 2010). These models are progressive in structure since they simulate and track the movement of Se as it progresses from dissolved forms into particulate matter and through the food chain. Progressive modeling is consistent with the consensus that foodweb exposure is the principal Se exposure

pathway for higher organisms like fish and migratory birds (Seiler *et al.,* 2003; Hamilton 2004). Ours is one of the first studies to model Se bioaccumulation at the Salton Sea using this relatively new approach and our models used partitioning coefficients and trophic transfer factors developed from site-specific data that have been published during the past 5 years. We compared the modeled Se levels in water, sediment, fish and birds to current conditions found in and near the Salton Sea and to toxicity reference values proposed by EPA and others. These comparisons formed the basis of our predictions of Se hazard posed by construction of SCH ponds. Artificial ponds have been constructed by the US Bureau of Reclamation and the US Geological Survey (USGS) and recent studies on Se ecorisks in these ponds (Miles *et al.*, 2009) are highly relevant to the proposed SCH project. However, the fact that no SCH ponds have been built adds complexity to our risk assessment because there is substantial uncertainty regarding the ultimate water chemistry, Se speciation (i.e., the relative abundance of selenate, selenite and organic-Se), and exact foodwebs in the SCH ponds. Thus, the results presented in this report should be viewed as best estimates of Se behavior in the SCH. Further research and monitoring must be conducted throughout planning, construction and operation of the SCH ponds within a Se adaptive management framework.

An earlier draft of this report was presented at the Salton Sea Species Conservation Habitat Project-Selenium Management Strategies Workshop in Ontario CA on September 21, 2010. Comments received during the meeting as well as review comments received from D. Barnum (USGS), H. Ohlendorf (CH2M Hill) and R. Swenson (Cardno-ENTRIX) were incorporated into this final report.

1.3 SCH Conceptual Model Formulation

Model formulation began with the creation of an EndNote bibliography (including URLs and pdfs) containing relevant resource agency reports, journal publications and web content on Se biogeochemistry and ecological risks, foodwebs of the Salton Sea and nearby aquatic systems and site specific data on Se concentrations in various environmental media and organisms from the Salton Sea region. Using this knowledge-base, and initial physical conditions expected in the SCH ponds, we then developed a conceptual model for Se in the SCH ponds (Figure 2).

The SCH Se conceptual model simulates the mixing of river and Sea water to attain a specified salinity level and assumes that Se mixing is conservative. Next, the model transforms dissolved Se into particulate matter using a partitioning coefficient (K_d value ;[Presser and Luoma 2010]); particulate Se pools included sediments and organic detritus (including associated microbial biomass) and algae and phytoplankton. We conceptualize the particulate Se pool to be the 1st level of the foodweb. We initially intended to use site-specific data on Se speciation in water to refine the partitioning coefficients between dissolved and particulate Se, but there are almost no data from the Salton Sea to do such

an analysis. Understanding of Se speciation and biogeochemical factors affecting it are a high research priority (see Section 4.2 of this report).

Once Se becomes bound to organic particulate matter it is consumed by invertebrates and the bioaccumulation rate is estimated using a trophic transfer factor ($TTF_{Level\ 1\ to\ 2}$) [Presser and Luoma 2010]) derived from field measurements, Invertebrates (chiefly benthic invertebrate such as pileworms, and chironomids and nektonic invertebrates such as corixids) represent the 2nd level of the foodweb and are in turn preyed upon by fish (tilapia, mosquitofish and sailfin mollies) or invertebrate-consuming birds (Black-necked stilts, avocets and other wading birds). We recognize that zooplankton will occur in the SCH ponds and may be preyed upon by fish, but there are very few data on Se concentrations in zooplankton in the Salton Sea region, so we were forced to limit the model to benthic invertebrates and corixids. Se biomagnification is again modeled using a TTF function ($TTF_{Level\ 2\ to\ 3}$). Predators of invertebrates, for example, fish and wading birds, represent the 3rd level of the foodweb. We recognize that certain fish and bird species may purposely or indirectly consume particulate organic matter while feeding on benthic invertebrates, but for the conceptual model we have had to simplify the foodweb structure since detailed knowledge of food sources is lacking for fish and birds at the Salton Sea. Understanding of food web pathways at the Salton Sea and in the SCH ponds is a high research priority (see Section 4.2 of this report).

The final level of the conceptual model represents predation of fish by piscivorous birds such as the Caspian tern and black skimmer. Se bioaccumulation between fish and birds is then modeled using a TTF function ($TTF_{Level\ 3\ to\ 4}$). Our assessment end-point for all birds was reproduction, since reproductive effects are the most sensitive indicator of Se toxicosis (Ohlendorf and Heinz 2011) and bird reproduction is one of the primary motivations for constructing the SCH ponds. The metric we used to assess the reproduction endpoint was the Se concentration of bird eggs (µg/g dry weight (DW)).

2. EXPOSURE ASSESSMENT

Using data and models generated during Problem Formulation, we estimated selenium exposure in all four levels of the foodweb using the progressive modeling approach of Presser and Luoma (2010) and model parameters derived from field data. In the following section we will describe how K_d and TTF values were computed, the data sources we relied on for these computations, and problems encountered in developing the model parameters. While the Presser and Luoma modeling approach is relatively simple in concept, selection of model coefficients and factors is extremely difficult using field data. Accurate K_d and TTF values are only produced under equilibrium conditions, which do not often occur in natural ecosystems. Presser and Luoma (2010) stress the need for site-specific data on K_d and TTF values to overcome some of these problems, but it is still likely that many of the K_d and TTF values near the upper and lower bounds of the

data set are spurious owing to non-equilibria or misconceptions regarding food sources for consumers and predators. Thus, we have restricted our data analyses to studies within aquatic ecosystems in and near the Salton Sea. Still, selection of the final values used in the models is subjective and other scientists could use different methods to select different K_d and TTF values which could lead to substantially different estimates of Se risk in the SCH ponds. We anticipate refining the models over the next few months as new data become available and in response to suggestions from DWR, DFG and USGS. In Section 2.8 of this report we discuss the uncertainty and bias in the model predictions and present results from model validation using data collected by Miles *et al.*, (2009).

2.1 Water Column Se Concentrations in the SCH Ponds

Using data from Reclamation's water quality monitoring programs, the 2007 PEIR and recent published USGS reports (Table 1) we modeled salinity and Se concentrations as a two-component system (Table 2) with inputs from the Salton Sea and river water to answer the question: *What concentration of total dissolved Se can we expect in the SCH ponds*? Note: we explicitly assumed that salinity levels in the SCH ponds will be attained by mixing of Sea and river water rather than through evapo-concentration. Evapo-concentration of river water to a salinity of 20 to 35 ppt would require longer water residence-times and could potentially result in different (higher or lower) dissolved Se levels than those where 20 to 35 ppt salinity is produced by mixing of Sea water with its relatively low dissolved Se levels. However, some combination of evapo-concentration and mixing could be used to reach the target salinity levels and this approach could be advantageous in terms of cost and in reducing Se loading rates to the SCH ponds.

It should also be noted that our consideration of salinity in the models in no way addresses the issue of whether salinity, in and of itself, affects Se risk. Instead salinity targets were suggested to us by DWR and Cardno-ENTRIX and were used in mixing models to estimate the initial dissolved Se concentrations in the ponds; all subsequent predictions of Se concentrations in biota derive solely from values of partitioning coefficients and TTFs used in the models. In Sections 2.2 and 2.3 we address the issue of salinity and ecorisk in more detail and discuss the recent findings from Miles *et al.*, (2009).

For SCH ponds proposed at the outlet of the Alamo River we used water quality data from quarterly sampling conducted between 2004-2008 by the U. S. Bureau of Reclamation (Chris Holdren, USBR, unpublished data) and data from USGS (Miles *et al.*, 2009). For SCH ponds proposed at the New River we used data from USBR and the 2007 PEIR. Target salinity levels of 20 and 35 ppt were suggested by DWR and Cardno-ENTRIX staff. The mixing models yielded linear equations (Figure 3) that we incorporated into our spreadsheet Se model. At 20 ppt salinity, mean and 95th percentile dissolved Se concentrations will be 4.0 and 4.9 µg/L in the Alamo River SCHs and 2.6

and 2.8 µg/L in the New River SCHs (Table 2). At 35 ppt salinity, mean and 95th percentile dissolved Se levels are lower owing to a greater proportion of Sea water: 2.8 and 3.3 µg/L in the Alamo River SCHs and 2.05 and 2.2 µg/L in the New River SCHs.

2.2 Derivation of Partitioning Coefficients – K_d

Two modeling approaches were taken in this report. In one approach we computed values for K_d and TTF using the entire set of available data shown in Tables 3 through 8. We henceforth refer to these models as **General Models**. In the second approach, we used data from Miles *et al.*, (2009) to compute values for K_d and TTF (Appendix Table 1) in order to simulate Se dynamics in experimental saline habitats which are similar in design to the proposed SCH ponds. We refer to these models as **USBR/USGS SHP Models**. For both types of models, simulations of Se behavior and bioaccumulation within foodwebs were constructed in an Excel spreadsheet to predict Se concentrations in fish tissues and bird eggs.

The critical, initial step of Se bioaccumulation lies in the conversion of dissolved Se into organic Se-containing materials such as organic components of the sediment and detritus (including their associated microbial biomass), and algae and phytoplankton. This conversion process involves both geochemical and biochemical processes, including microbial Se metabolism, which are not easy to simulate with mechanistic biogeochemical models. Hence, a more empirical approach is necessary to describe the aggregation of these processes in the SCH ponds. Presser and Luoma propose a distribution coefficient of the form:

$$K_d = \frac{\text{Se concentration in particulate } (\mu g\ kg^{-1}\ DW)}{\text{Se concentration in water } (\mu g\ L^{-1})}$$

and note that values of K_d are strongly influenced by Se speciation (DW = dry weight). For example, within the San Diego Creek Watershed and downstream Newport Bay, mean K_d values varied from 136 to 42,715; lower K_ds occurred where selenate was the main Se species and the highest K_ds occurred where organic-Se and selenite were the dominant form of Se. Table 3 summarizes the database of K_d values reported in site-specific studies or values that we computed using published values on paired water:particulate Se concentration data.

Raw data were available in table format in most of the reports we referenced or in figures contained therein. To capture data from figures we used an on-screen digitizing program. In Table 3 we describe the type of particle matter used in the computation. We initially hoped to derive media-specific K_d values and include an additional trophic level in the conceptual model: algal/phytoplankton decomposition into organic detritus. However, we lacked enough data to do this and in any case there does not appear to be any

systematic difference in K_d values among the media examined, with perhaps one exception: particulate organic detritus, measured by Saiki *et al.*, (2010), had relatively high partitioning coefficients compared to sediment and algae. Overall, mean and median K_d values ranged from about 100 in the Salton Sea to over 1000 in the USGS saline habitat ponds (Table 3). The 75th percentile K_d reached 1894 in saline habitat pond 3 and, overall, this pond had the highest partitioning coefficients measured for the Salton Sea region.

We examined the relationship between K_d and water salinity, hoping to use this information to refine the Se models, however, there was no significant correlation detectable in Figure 4, although we would note that data from many different types of habitats are lumped together in this figure. Aggregation of all the data yielded a skewed distribution (Figure 5) with a weighted mean of 456 ± 350 (sd). In Table 3 we computed grand averages of the mean, median and 75th percentile K_d values, without weighting based on sample size (*n*), which were then used in the Se models. Because the values for *n* in these studies varied from 20 to 93, using a weighted average, median or 75th percentile would have emphasized some studies more than others. For example, K_d data from the USBR/USGS SHP study (Miles *et al.,* 2009) had fewer samples ($n=20$) compared to those from the New River wetlands at Brawley (n = 39) and Imperial (n = 93) (Roy *et al.,* 2006), and if we had used weighting by sample size in the computation of the model K_d values we would have deemphasized results from the saline habitat ponds that are perhaps the closest analogue for the SCH ponds. In developing the K_d parameters in the General Models (see Section 2.6), we sought to give equal weight to all of the studies since we could not develop a rationale for emphasizing one site-specific study over another. However, it is our opinion that results from the USBR/USGS SHP study are particularly useful in the current risk assessment since these are the first artificial saline habitats to be built at the Salton Sea. While the physical dimensions, salinity levels and foodwebs in these ponds may be different from those ultimately attained in the SCH project, one could argue that Se dynamics in the SHP and SCH ponds could be very similar, thus in the effects assessment we created model scenarios that used values for K_d and TTFs derived from the SHP project directly (i.e., the USBR/USGS SHP Models; see Section 2.6).

2.3 Derivation of $TTF_{Level\ 1\ to\ 2}$

TTF values are parameters computed as the ratio of Se in a consumer or predator to Se in food or prey. For example:

$$TTF_{Level\ 1\ to\ 2} = \frac{\text{Se concentration in Level 2 consumer } (\mu g\ g^{-1}\ DW)}{\text{Se concentration in Level 1 food } (\mu g\ g^{-1}\ DW)}$$

For details on the concept and derivation of TTF values please see Presser and Luoma (2010). Values of $TTF_{Level\ 1\ to\ 2}$ were developed for the transfer of Se from particulate matter (trophic level 1) into invertebrate consumers (trophic level 2) using published studies from the Salton Sea region (Setmire *et al.,* 1993; DWR,DFG 2007a; Roy *et al.,* 2006; Johnson *et al.,* 2009; Miles *et al.,* 2009; Saiki *et al.,* 2010). We had initially envisioned deriving species-specific and media-specific $TTF_{Level\ 1\ to\ 2}$ values to use in the models. Despite the substantial increase in site-specific data in the past 5 years, there are still too few data to justify this greater detail in the progressive models. For example, while almost all studies had paired invertebrate:sediment data, very few studies included algae and only Saiki *et al.*, (2010) included organic detritus and phytoplankton. In addition, we examined whether salinity was correlated with $TTF_{Level\ 1\ to\ 2}$, as with K_d values, and there was no statistically significant relationship in the largest available dataset (Figure 6: M. Saiki, USGS personal communication). Therefore, we view the $TTF_{Level\ 1\ to\ 2}$ values as describing the general rate of bioaccumulation of Se when any invertebrate consumes non-living or living particulate matter containing Se.

Mean, median and 75th percentile $TTF_{Level\ 1\ to\ 2}$ values ranged from 1.19 to 6.34, 1.09 to 4.84 and 1.36 to 6.08, respectively (Table 4). Where we used data from Roy *et al.*, 2006 and Setmire 1993, only mean values are presented since these references contained only summary data. As with the K_d values, we computed a grand average of the mean, median and 75th percentile $TTF_{Level\ 1\ to\ 2}$ values in an unweighted fashion to produce TTF factors for the models: mean =3.11, median = 2.75, 75th percentile = 3.76 (see section 2.2 for justification using this unweighted approach). In the General Models we used the median value for $TTF_{Level\ 1\ to\ 2}$, 2.75 (Table 4). In the USBR/USGS SHP Se Models we used $TTF_{Level\ 1\ to\ 2}$ values directly from three of the four SHP ponds - Pond 1: 3.17; Pond 2: 4.26; Pond 3: 1.78 (Table 4).

TTF values were also computed for Se transfer from particulate matter to fish (i.e., $TTF_{Level\ 1\ to\ 3}$; Table 5). However, as this transformation was not included in the SCH Conceptual Model (Figure 2), $TTF_{Level\ 1\ to\ 3}$ values were not used in the Se models.

2.4 Derivation of $TTF_{Level\ 2\ to\ 3}$

$TTF_{Level\ 2\ to\ 3}$ values capture the dynamics of Se transfer between invertebrate prey and fish or bird predators :

$$TTF_{Level\ 2\ to\ 3} = \frac{\text{Se concentration in Level 3 predator } (\mu g\ g^{-1}\ DW)}{\text{Se concentration in Level 2 invertebrate prey } (\mu g\ g^{-1}\ DW)}$$

Values of $TTF_{Level\ 2\ to\ 3}$ were developed for the transfer of Se from invertebrate consumers (trophic level 2) into predatory fish and the eggs of Black-necked stilt (trophic level 3) using published studies from the Salton Sea region (Setmire *et al.,* 1993; DWR,

DFG 2007a; Roy *et al.,* 2006; Johnson *et al.,* 2009; Miles *et al.,* 2009; Saiki *et al.,* 2010). Mean, median and 75th percentile $TTF_{Level\ 2\ to\ 3}$ values ranged from 1.14 to 2.59, 0.97 to 2.4 and 1.31 to 3.44, respectively (Table 6). Where we used data from Roy *et al.*, (2006) and Setmire (1993), only mean values are presented since these reports contained only summary data.

We deemed the available data sufficient to produce separate TTF values for fish tissues and Black-necked stilt eggs. As with the K_d values, we computed grand averages of the mean, median and 75th percentile $TTF_{Level\ 2\ to\ 3}$ values in an unweighted fashion to produce TTF factors for the models. For fish we computed: mean = 1.31, median = 0.97 (*n=1*), 75th percentile = 1.31 (*n=1*). For bird eggs we computed higher values: mean = 1.81, median = 1.80, 75th percentile = 2.28. In the General Models containing fish we used the average value for $TTF_{Level\ 2\ to\ 3}$, 1.31, rather than the median since the median value was based on a *n* of 1 (i.e., the median from a single study; Table 6). In the General Models containing invertebrate-consuming birds we used the median value for $TTF_{Level\ 2\ to\ 3}$, 1.80.

In the USBR/USGS SHP Models for birds we used $TTF_{Level\ 2\text{-}3}$ values directly from three of the four SHP ponds - Pond 1: 1.17, Pond 2: 1.18, Pond 3: 1.56 (Table 6). Since no fish Se concentrations were reported by Miles *et al.*, 2009, we used the average value for $TTF_{Level\ 2\ to\ 3}$ for fish, 1.31 (Table 6). Note: In an ongoing study at UCR we are measuring Se content of fish captured when the SHP experiment was terminated in 2010. Once these data are complete we can compute $TTF_{Level\ 2\ to\ 3}$ for fish in the SHP and revise the USBR/USGS SHP Se models appropriately.

TTF values were also computed for Se transfer from invertebrate consumers to coot eggs which are believed to have an omnivorous diet of mostly plants, but also including small fish, snails and insects (i.e., $TTF_{Level\ 2\ to\ 4}$; Table 7). However, as this transformation was not included in the SCH Conceptual Model (Figure 2), $TTF_{Level\ 2\ to\ 4}$ values were not used in the Se models. Furthermore, the coot TTF factors were derived from summary data for Corixidae rather than on paired data and several avian ecologists at the 9/21/2010 Selenium Management Strategies Workshop were skeptical that invertebrates make up a significant portion of coot diets at the Salton Sea.

2.5 Derivation of $TTF_{Level\ 3\ to\ 4}$

$TTF_{Level\ 3\ to\ 4}$ values should capture the dynamics of Se transfer between fish prey and bird predators such as terns and skimmers:

$$TTF_{Level\ 3\ to\ 4} = \frac{\text{Se concentration in Level 4 bird predator } (\mu g\ g^{-1}\ DW)}{\text{Se concentration in Level 3 fish prey } (\mu g\ g^{-1}\ DW)}$$

The only value for $TTF_{Level\ 3\ to\ 4}$ we could compute, based on published data from the Salton Sea region, was for the transfer of Se from Mosquitofish (trophic level 3) into the eggs of coots (trophic level 4) (Roy *et al.,* 2006; Johnson *et al.,* 2009). However, while an omnivore, it is unlikely that coot diets contain a large supplement of fish, so we do not believe that the values in Table 8 are valid. Presser and Luoma (2010) encountered similar difficulty in deriving $TTF_{Level\ 3\ to\ 4}$ values from field data owing to a lack of published observations. The $TTF_{Level\ 3\ to\ 4}$ value for mallard eggs (1.8) used by Presser and Luoma (2009 and 2010) is based on laboratory feeding studies of Ohlendorf (2003) (Table 9). In the literature, Smith *et al.*, (1988) investigated Se transfer to eggs of black-crowned night-herons and observed that birds fed a 10 mg Se/kg diet (9% moisture, so 11 mg/kg dry-weight basis) laid eggs with 3.3 mg Se/kg wet-weight basis (80% moisture, so 16.5 mg Se/kg dry weight), which results in a $TTF_{Level\ 3\ to\ 4}$ value of 1.5. Because herons are commonly found at the Salton Sea and provide a better analogue for other Salton Sea species such as terns and skimmers, we decided to use a value of 1.5 for $TTF_{Level\ 3\ to\ 4}$ in all of our Se models. Overall, we believe that Se transfer between fish and birds is the weakest link in our Se models, but given time and data constraints, we could not develop a generalized dosage-based exposure model for piscivores at the Salton Sea.

2.6 The Se Models

General Models - Parameters used in the General Models (i.e., General K_ds and TTFs) were computed from all available studies in and around the Salton Sea. Given significant differences in dissolved Se concentrations, separate General Models were made for SCH ponds utilizing Alamo River and New River water. Per suggestions from DWR and Cardno-ENTRIX we ran model simulations under two Sea:river mixing scenarios: 20 ppt target salinity and 35 ppt target salinity (see Table 2). Separate General Models were constructed for foodwebs containing invertebrate-consuming birds and foodwebs containing fish-consuming birds (Figure 1).

In addition to running the models in a "forward" direction (Appendix Tables 2-9) to produce estimates of Se concentrations in fish and bird eggs starting from initial Se concentrations in water, we also ran "inverse" models wherein we set the bird egg Se level to 6, 8 and 12 µg/g DW toxicity reference and ran the model backwards to compute the required dissolved Se concentration and ultimately the mixture of Sea and river water necessary to produce the required Se concentration in the bird eggs (Appendix Tables 10-11). The toxicity reference values used in the inverse model runs are estimated thresholds for reduced egg viability of birds at the Salton Sea and are based on data contained in Tables 10 and 11 and Ohlendorf and Heinz (2011). These inverse model runs help answer the question: *"How much river water can be used in the SCH ponds before bird embryos exhibit reduced egg viability?"* Because the dissolved Se concentrations in the Alamo and New rivers are substantially higher than in the Sea, all

things being equal, the Se risk increases with decreasing SCH salinity because more river water is required to reach the target salinity.

The initial step of the General Model takes the salinity desired in an SCH pond and computes the required proportions of river and Sea water necessary to produce the target salinity (the model assumes salinity is 52 ppt in the Sea and 2 ppt in the rivers), and then estimates the resulting dissolved Se level using the conservative mixing equations shown in Figure 3. The model then multiplies the dissolved Se level by the selected General K_d value and produces an estimate of Se concentrations in particulate organic matter. Next, General TTF factors are used, in series, to simulate the bioaccumulation of Se in each of the two different foodwebs described in Figure 2:

1. **Water→ Trophic Level 1 → Trophic Level 2 → Invertebrate-consuming Bird**

   and

2. **Water→ Trophic Level 1 → Trophic Level 2 → Trophic Level 3 (Fish) → Bird Piscivore**

Values for Se are computed at each step of the model.

Three different types of water quality were simulated for General Model runs:

- **Simulation 1**: Expected Water Quality: This scenario utilizes median values for K_d and TTFs and the median water quality parameters shown in Table 2.
- **Simulation 2**: Higher Risk Water Quality: This scenario utilizes median values for TTFs, the 75th percentile value for K_d and the 95th percentile values for dissolved Se shown in Table 2.
- **Simulation 3**: Future Scenario/River Only - 10 µg/L Rivers: This scenario simulates conditions in the future after the Salton Sea has reached excessively high salinity and is no longer used to supply SCH ponds with water[1]. In this hypothetical future scenario, the ponds would instead be supplied only by river water which has a Se_{total} concentration up to 10 µg/L. Median K_d values from Simulation 1 were used in this future scenario.

[1] Salinity in the Salton Sea is projected to reach 250 ppt by the year 2068 (Appendix H-2, DWR and DFG 2007). At that point, inflow for the SCH ponds would be 13 percent sea water to achieve 35 ppt (Se concentration 8.9 µg/L), or 3 percent sea water to achieve 26 ppt (9.0 µg/L). Simulation 3, therefore presents a worst case scenario of all-river water.

Overall, we chose to not use the mean and 75th percentile values for TTFs in these models, and instead opted for median values wherever possible. The single exception was in the General Models including fish where we used the average value for $TTF_{Level\ 2\ to\ 3}$,

1.31, rather than the median since the median value was based on a single study (Table 6).

We reason that the median TTF values best capture the true, equilibrium TTF. Mean TTF values are more likely to be affected by outliers than the median value. We speculate that TTF values well above or well below the median are most likely the result of data artifacts rather than increases or decreases in bioaccumulation potential resulting from changing Se speciation or varying organism biochemistry. On the other hand, the site-specific data suggest to us that there are real differences in K_d in the Salton Sea region and these differences most likely derive from varying Se speciation. Therefore, choosing a 75th percentile K_d value seems justifiable from a risk perspective. Similarly, choosing the 95th percentile value for dissolved Se in Simulation 2 seems prudent given that reduced river flows in the next decade will likely increase dissolved Se concentrations in both the Alamo and New rivers. Future scenarios as modeled in the Salton Sea Programmatic EIR (75 years) are not expected to exceed 10 µg/L in the New and Alamo rivers (DFG and DWR 2007a). To better understand this future "worst case scenario" we also included Simulation 3 in the revised report.

USBR/USGS SHP Models – Parameters used in the USBR/USGS SHP Models were derived from Pond 1, Pond 2 and Pond 3 data reported in Miles *et al.*, (2009) with two exceptions. Firstly, in the foodwebs containing fish-consuming birds we used $TTF_{Level\ 2\ to\ 3}$ and $TTF_{Level\ 3\ to\ 4}$ values from the General Models since we could not derive these TTF parameters from published data in Miles *et al.*, (2009). Secondly, we chose not to evaluate Se ecorisk using data from Pond 4 since this hypersaline pond was a terminal basin (average salinity from 2006-2008 was 265 ppt) with inflow derived from Ponds 1 through 3. In our opinion, the physico-chemical conditions in Pond 4 have limited relevance to simulations of SCH ponds with residence time of <32 weeks and salinity < 52 ppt.

Given significant differences in dissolved Se concentrations, separate USBR/USGS SHP Models were made for SCH ponds utilizing Alamo River and New River water. We used the average salinity levels from 2006-2008 in Ponds 1 through 3 to set the initial salinity, and hence, the required mixture of Sea and river water in the models (Pond 1: 13 ppt, Pond 2: 24.9 ppt and Pond 3: 47.6 ppt). To estimate the Se_{total} resulting from the required mixture of Sea and river water we used the "Mean Condition" equations shown in Figure 3. Separate USBR/USGS SHP Models were constructed for eggs of invertebrate-consuming and fish-consuming birds (Figure 1):

1. **Water→ Trophic Level 1 → Trophic Level 2 → Invertebrate-consuming Bird**

   and

2. **Water→ Trophic Level 1 → Trophic Level 2 → Trophic Level 3 (Fish) → Bird Piscivore**

In the USBR/USGS SHP Models, we chose to use the median values for K_ds, and $TTF_{Level\ 1\ to\ 2}$ values computed, individually, from Ponds 1, 2 and 3. All parameters used in the USBR/USGS SHP Models are summarized in Appendix Table 1 along with the true mean Se_{total} and water residence time from Ponds 1-3 during 2006-2008 (Miles *et al.*, 2009 and B. Barry & M. Anderson unpublished data). Inverse simulations were conducted using the USBR/USGS SHP Models for invertebrate-consuming bird only (Appendix Table 12) since we lacked SHP-specific parameters for foodwebs containing fish-consuming birds. USBR/USGS SHP Model results are contained in Appendix Tables 13-16. Models were also run for Pond 4, but only in the context of evaluating the accuracy of the progressive modeling approach (see Section 2.8).

2.7 Modeled Se Exposures and Relationship to Effects Thresholds

Output from all modeling runs is summarized in Appendix Tables 2-11 and Appendix Tables 13-16. The tables contain a description of the location of the SCH, the target salinity (20 to 35 ppt) and the foodweb end-point modeled (eggs of invertivore or piscivore). The results from each of the simulations are shown on individual rows. At the top of the table and within the simulation rows we have included the values for K_d and TTFs used in each step of the simulation. The overall results of the models are presented in Figure **7**a&b (in the figures the error bars denote the upper and lower 95% confidence interval for the computed values).

In assessing Se risk, we used effects thresholds proposed by Ohlendorf and Heinz (2011) that describe risks for reproductive impairment and teratogenicity of avian species (Table 13).

2.7.1 General Model Results

Overall, our models suggest that, owing to higher dissolved Se levels in the Alamo River water relative to the New River, fish and bird eggs in SCH ponds utilizing Alamo River water will have about 50% higher Se concentration than with same salinity in SCH ponds utilizing New River water (Tables 14 and 15). Similarly, risk increases as salinity decreases, with about 25-30% higher Se concentrations predicted at a salinity of 20 ppt relative to 35 ppt. Recall that higher risk at lower salinity is simply the outcome of greater water contributions of river water (higher Se_{total} concentrations) to reach lower salinity mixtures in the SCH ponds.

Using expected water quality and median K_d values (Simulation 1), the only modeling scenarios that produced egg Se concentrations below the 6 µg/g effects level were SCH ponds supplied by the New River when salinity was 35 ppt (Table 14). Less than 8 µg/g

DW was predicted, under Simulation 1, for invertebrate consuming birds in New River SCH ponds at 20 ppt salinity and in fish consuming birds in New River SCH ponds at 35 ppt salinity (Tables 14 and 15). For Alamo River SCH ponds modeled under Simulation 1, we predicted egg Se concentrations of 8.1 to 12.7 depending on salinity and bird type.

Modeling results from Simulation 2 (higher dissolved Se_{total} and higher efficiency of transformation of dissolved Se into the particulate foodweb) predicted egg Se concentrations that were 57-59% higher than in Simulation 1 for New River SCH ponds and 75-82% higher egg Se concentrations in Alamo River SCH ponds than in Simulation 1 (Tables14 and 15). Under future, "worst case" water quality conditions (Simulation 3), the models estimated egg Se concentrations of 29.1 µg/g DW and 31.8 µg/g DW for invertebrate-consuming and fish-consuming birds, respectively. Selenium concentration estimates in Simulation 3 suggest that reproductive effects would occur across a range of avian species and some species would experience teratogenic effects from Se.

2.7.2 USBR/USGS SHP Model Results

Readers of this report should note that results from the progressive models that we ran for the USBR/USGS SHP experiment are more complicated to interpret than those for the General Models; please read the following section carefully. The USBR/USGS SHP Models make use of K_d and TTF values computed directly from Ponds 1-3. Thus the parameters can be thought of as pond-specific. In parameterizing the models we set the initial salinity to the mean salinity level measured for each of the ponds during 2006-2008 (i.e., 13.0, 24.9 and 47.6 ppt respectively for Ponds 1-3; Appendix Table 1). Simply put, we used an initial salinity value in the model that was equal to the salinity regime under which the K_d and TTF values were produced. Next, we mixed the Salton Sea and river water to create the target salinity in the models (13.0, 24.9 and 47.6 ppt respectively for Pond 1-3 simulations) which set the initial Se_{total} concentration in the models (see mean condition equations in Figure 3). For example, to create 13 ppt salinity in the Pond 1 scenario we added in a greater proportion of river water compared to the Pond 3 scenario (47.6 ppt salinity). Since river water has higher Se_{total} concentrations than the Salton Sea, the simulated Pond 1 has higher Se_{total} concentration than simulated Pond 3. In reality, Se_{total} concentrations in Ponds 1-3 were somewhat different than in the simulations (e.g., compare Se_{total} values in the third and seventh columns of Appendix Table 1).

We speculate that the USBR/USGS SHP Models, to some extent, incorporate the effects of salinity on Se ecorisk. For example, Pond 1 simulations predict the bioaccumulation of Se at 13 ppt salinity using K_d and TTF values that were measured in a saline pond with mean salinity of 13 ppt between 2006-2008 (Miles *et al.*, 2009). In contrast, the K_d and TTF values in the General Model are derived from habitats with widely varying salinity,

hence they cannot provide information on the relationship between Se ecorisk and salinity as well as the USBR/USGS SHP Models.

Readers should note that the USBR/USGS SHP Models predict higher mean Se concentrations in eggs of invertebrate-consuming bird in Ponds 1 and 2 than were measured in the field (Tables 16 and 17 - no data are available for fish-consuming birds in the USBR/USGS SHP project) . This difference between modeled and measured egg Se primarily arises because the initial Se_{total} concentrations in the Pond 1 and Pond 2 models were higher than the mean Se_{total} concentrations measured in the field (columns 3 and 7 in Appendix Table 1). This situation occurred because, when we used the Mean Condition equations shown in Figure 3 to estimate the initial Se_{total} concentrations, higher concentrations were computed than were actually measured in the SHPs. Small differences in initial Se_{total} concentrations were magnified as Se moved through the simulated foodwebs, resulting in substantial differences in modeled egg Se levels relative to actual eggs.

One explanation for lower Se_{total} concentrations in the SHP ponds was that evapoconcentration was used to attain higher salinity levels in ponds downstream from Pond 1 rather than mixing of high salinity Salton Sea water and low salinity river water. While salinity acted conservatively under evapoconcentration in the SHP ponds (mean Pond 1-4 salinities were 13.0, 24.9, 47.6, 265 ppt, respectively), dissolved Se levels did not behave conservatively (mean Pond 1-4 Se_{total} concentrations were 2.7, 1.7, 2.0, 3.8 µg/L, respectively). In the mixing equations shown in Figure 3, Se_{total} concentrations are assumed to mix conservatively, hence our USBR/USGS SHP Models had higher initial dissolved Se concentrations. In Section 2.8 we discuss the results of USBR/USGS SHP Model runs where we used actual Se_{total} concentrations in the SHP ponds.

Overall, egg Se concentrations were lowest under Pond 3 conditions: 5.4 to 6.2 µg/g DW in invertebrate-consuming birds and 7.8 to 7.8 µg/g DW in fish-consuming birds (Tables 16 and 17). In the case of invertebrate-consuming birds, lower egg Se under Pond 3 conditions arose solely from lower initial Se_{total} concentrations and not because of lower K_d and TTF factors relative to Ponds 1 and 2. In the case of fish-consuming birds, lower egg Se under Pond 3 conditions arose from both lower initial Se_{total} concentrations and lower foodweb bioaccumulation. However, we would note that we did not use pond-specific values for $TTF_{\text{Level 2 to 3}}$ and $TTF_{\text{Level 3 to 4}}$ in Table 16 because they were unavailable. We are currently determining Se concentrations in fish from the USBR/USGS SHP project and will soon be able to compute pond-specific values for $TTF_{\text{Level 2 to 3}}$ which will improve the models for fish-consuming birds.

Our modeling results show very similar egg Se concentrations in Pond 1 and Pond 2 simulations for both invertebrate-consuming and fish-consuming birds (Tables 16 and 17). For foodwebs containing invertebrate-consuming birds, lower initial Se_{total}

concentrations and lower K_d in the more saline Pond 2 were balanced by higher $TTF_{Level\ 2\ to\ 3}$ (Pond 2: 4.26) relative to Pond 1 (3.17). As in the General Models, egg Se concentrations in SCH ponds supplied by the New River were lower than in Alamo River SCH ponds; this dichotomy was greatest under the low salinity, Pond 1 simulations.

The USBR/USGS SHP modeling results provide some insights into the role of salinity and residence time on Se ecorisk. For example, K_d and Se_{total} concentrations computed for the SHP ponds do not show any systematic relationship with salinity or cumulative residence time (Appendix Table 1). The highest K_d values were measured for Pond 3, but the lowest K_ds occurred in Pond 4. While Pond 4 had the highest Se_{total} concentrations in the SHP study, assuming conservative behavior of Se during evapoconcentration, one would anticipate a much higher Se_{total} concentration value in Pond 4: 54.8 µg/L. However we know from literature that mechanisms controlling the fate of trace elements like Se in ponds are complex and are strongly influenced by physiographic locations (Madramootoo *et al.*, 1997), that can consequently lead to variable responses in an evapoconcentration scenario (Ong *et al.*, 1995). Obviously, strong Se sinks existed in all of the SHP ponds, which limited the accumulation of Se in the water column and even in the sediments of the ponds (Figure 8). Thus, lower salinity and longer residence time do not appear to increase Se ecorisk through processes operating on the microbial foodweb.

Trophic transfer factors between particulate organic matter and invertebrate consumers ($TTF_{Level\ 1\ to\ 2}$) measured in Ponds 1 and 2 were high relative to other Salton Sea habitats and higher than in Pond 3 and Pond 4. Thus, one could speculate that as salinity and residence time increased, $TTF_{Level\ 1\ to\ 2}$ rates declined suggesting lower Se ecorisk. One could speculate that the form of Se in the organic matter in Ponds 3 and 4 was less labile than in Ponds 1 and 2, but there are no data to support this speculation since Se speciation was not routinely measured in sediments or invertebrates. Also, separating the effects of salinity and residence time are impossible given the experimental design used in the USBR/USGS SHP project.

Examining the $TTF_{Level\ 2\ to\ 3}$ values for Black-necked stilts in the SHP ponds reveals a pattern of increasing bioaccumulation with increasing salinity and residence time. However, this pattern may be coincidental since, Black-necked stilts were observed to feed across all of the ponds and in areas outside the SHP ponds (Miles *et al.*, 2009) and therefore, much of their salinity exposure came from outside the SHP ponds.

Taken in total, the results from the USBR/USGS SHP experiment suggest that: a) dissolved Se will not act conservatively in a saline pond undergoing evapoconcentration, b) Se bioaccumulation occurring at the level of the microbial foodweb does not seem to be affected by the range of salinities (13-265 ppt) and residence times (9 days to 1-2 years) experienced in the SHP ponds, and c) Se bioaccumulation in invertebrate consumers in constructed saline ponds appears to be higher than in agricultural drains and

freshwater wetlands and the rate of this bioaccumulation process declines as salinity and/or residence time of constructed ponds increases.

2.7.3 Inverse Modeling Results

Results from the inverse modeling runs provide useful information for establishing salinity levels in the proposed SCH ponds and are summarized in Table 18 (invertebrate consuming birds shown; for fish consuming birds please see Appendix Tables 10b and 11b).

Under expected water quality conditions, the General Models predict that New and Alamo River SCH ponds would have to be kept above 35 ppt and 44 ppt (Table 18), respectively, to keep eggs of invertebrate-consuming birds below 6 µg Se/g DW and above 48 to 50 ppt to provide similar protection to eggs of fish consuming birds (Appendix Tables 10b and 11b). Under higher risk water quality scenarios, bird eggs with < 6 µg Se/g DW are unattainable. Overall, the inverse modeling results from the expected water quality conditions in the General Models agree reasonably well with the results from the USBR/USGS SHP models. For example, all four models suggest that <12 µg Se/g DW can be achieved in eggs of invertebrate-consuming birds when New River SCH ponds are supplied only river water. Interestingly, inverse modeling results for Ponds 2 and 3 were almost identical (Appendix Tables 12 a and b).

2.8 Uncertainty Analysis

The key source of uncertainty in the progressive models stems from random and systematic errors in model parameters. All of the initial water quality conditions used in the models as well as the average and median values for K_d and TTF used in the model scenarios have associated error. In development of the K_d and TTF parameters, we have assumed that the field measurements approximate equilibrium values between Se in food and consumers. However, this is not always the case and we believe that K_ds and TTFs at the extremes of the range are likely erroneous and introduce random error to the model. To overcome this problem, we used median values of K_d and TTF, whenever possible, to compute the parameters used in the model, figuring that random errors will be more likely to cancel out, reducing the chances for bias in the model results. In addition we have made assumptions regarding the trophic structure of the SCH ponds that are not based upon rigorous foodweb analysis using stable isotopes. The lack of data for individual food web taxa forced us to lump organisms together into generic trophic levels for the models. Thus, lack of knowledge of foodwebs and non-specificity of the model parameters likely introduced systematic error into the model results.

Overall, most of the TTF data for the Salton Sea (Tables 4-6) agree well with TTF values derived from other locations (Table 9; Presser and Luoma 2010 contains an even larger summary of TTF values for other sites). However, the mean $TTF_{Level\ 3\ to\ 4}$ value of 0.85 at

the Salton Sea shown in Table 8 does not agree very well with the results from the mallard feeding study of Ohlendorf 2003 nor the heron study of Smith et al., (1988). We speculate that a $TTF_{Level\ 3\ to\ 4}$ value of 1.8 is too high for the SCH ponds, because, mallards may be a particularly sensitive species to Se toxicosis (Ohlendorf and Heinz 2011). Furthermore, mallards are omnivorous, feeding mainly on plants and invertebrates with little contribution from fish in their diets, in contrast to birds like cormorants, terns and skimmers which feed almost exclusively on fish. It is generally assumed that Se in plants presents a greater bioconcentration potential than Se in fish (Heinz *et al.*, 1989), thus piscivorous bird species utilizing the Salton Sea, owing to their predominantly fish diet, likely have a lower Se risk than mallards. Our choice of a value of 1.5 for $TTF_{Level\ 3\ to\ 4}$ is likely a more accurate estimate of the trophic transfer rate of Se from fish to birds in the SCH ponds. Overall, understanding of Se bioaccumulation in fish-eating birds is a major knowledge gap at the Salton Sea and introduces substantial error in the SCH Se models.

Since the progressive models used in this study are a series of sequential mathematical expressions, individual component errors are compounding. To understand the uncertainty introduced in estimated Se concentrations in fish tissues and bird eggs from mathematical computation, we used standard propagation of error techniques to provide error bounds around General Model output from the 3 scenarios. To do this we estimated the relative standard errors for the grand average values of K_d and TTFs, and then used the error propagation equation for multiplication to compute a relative standard error for fish tissue and bird eggs. We assumed normal distribution and then computed a 95% confidence interval (CI) bounded by ± 2 standard errors. Tables containing model results and figures summarizing these results include the 95% CI for the modeled parameters. Similar analyses were not conducted for the USBR/USGS SHP Models but we expect that the 95% CIs are smaller since there was less variance in the estimates of mean K_ds and TTFs for the SHP ponds.

To provide a more robust test of the progressive models, we compared USBR/USGS SHP Model predictions for Black-necked stilt egg Se to observed egg Se levels in Ponds 1-4 and three index sites from Miles *et al.*, (2009): Morton Bay, Freshwater Marsh and D-Pond 2 (Miles *et al.*, 2009). In the validation procedure, average annual Se_{total} concentrations measured in each of three years, 2006, 2007 and 2008, and at each of the seven sites, were used as the initial dissolved Se levels. Next we used the previously described models for Ponds 1 through 3, along with models parameterized with median values of K_d and TTFs for Pond 4, Morton Bay, Freshwater Marsh and D-Pond2. Thus, there were seven site-specific models of Se bioaccumulation that we drove using seven site-specific dissolved Se concentrations to predict Se concentrations in eggs of Black-necked stilts.

Modeled and measured values are shown in Table 19; ND indicates sites and years where no measured egg Se concentrations were available. The linear equation describing the relationship between modeled (y) and measured (x) Se concentrations was $y = 0.92x + 0.86$ with $R^2 = 0.54$ (Figure 9). Because the slope of the equation was less than 1, we believe that the models tended to slightly underestimate the Se bioaccumulation potential in the SHP ponds and index sites. The coefficient of determination, 0.54, indicates that the models explain most of the variability in egg Se concentrations in the ponds and index sites. Presser and Luoma (2010) conducted similar validation exercises for Se concentrations in invertebrates and fish using field data from several dozen studies and observed better agreement between modeled and measured values (R^2= 0.92 for invertebrates and 0.89 for fish). The relatively lower accuracy of the progressive models in our study can be attributed to a relatively narrow range of egg Se concentrations that we modeled (~2 to 9 µg/g DW measured) compared to the large range of values modeled by Presser and Luoma (~1 to180 µg/g DW for invertebrates and ~1 to 70 µg/g DW for fish).

3. Risk Characterization

Below the model-output portions of the Appendix Tables 2-11 and 13-16, we show the results of three types of risk characterization. On the left side, we present hazard quotients computed for the Se levels in water, sediment and bird eggs estimated for each of the three simulations. We did not include a hazard quotient for invertebrates, because we could not find a widely accepted toxicity reference value for invertebrates (Debruyn and Chapman 2007). The hazard quotient section contains the toxicity reference values used (2 µg/L, 1 µg/g DW, 4 µg/g and 6 µg/g DW for water, sediment, fish tissues and bird eggs, respectively) and a description of the hazard anticipated. While we conceptualized trophic level 1 as particulate matter, we interpreted it as sediment in the risk characterization. Hazard quotients are summarized graphically in Figure 10a&b, upper panel; the inset panel shows the expected Se hazard for different ranges of values. Note: In this figure we averaged the quotients across the scenarios for a given river and salinity to simplify presentation of the results.

To the right of the hazard quotient table in Appendix Tables 2-11 and 12-15, we present results from the Protocol System proposed by Lemly (1995). In the protocol scoring system, each individual component of an ecosystem (water, sediment, macroinvertebrate, fish and birds) is assigned an individual Se risk score which, when combined with the other individual scores, yields an overall hazard characterization for a specific site. In general, the Protocol System produces higher risk estimates than the hazard quotient technique (Lemly 1996). In the case of the invertivore foodweb models, which do not contain fish, we computed the total system score using only water, sediment, macroinvertebrates and bird eggs and used the reduced scoring thresholds recommended by Lemly (1996). Protocol scores are summarized graphically in Figure 10a&b, lower

panel; the inset panel shows the expected Se hazard for different scores depending on the type of foodweb. In this figure we also averaged the quotients across the scenarios for a given river and salinity to simplify presentation of the results.

The final risk characterization metric we used was based on comparisons of Se concentrations from the model simulations to Se concentrations currently measured at the Salton Sea. Table 12 and Figures 11-13 provide a summary of data used to compute a grand mean for Se concentrations in foodweb components of the Salton Sea region from published studies. The modeled Se concentrations are divided by the grand means to produce a ratio of modeled Se exposure:current Se exposure for invertebrates, fish and bird eggs. The exposure ratios are summarized graphically in Figure 14 and we averaged the ratios across the scenarios for a given river and salinity to simplify presentation of the results. This analysis was done to provide an estimate of the Se exposure in the SCH ponds relative to the current Se exposure at the Sea. We have not attempted to identify any qualitative thresholds for this ratio, nor do we mean to imply that a ratio of 2, for example, indicates that Se risks in the SCH ponds are double current Se risk at the Salton Sea. In many cases, Se levels in foodweb components in and near the Salton Sea already exceed toxicity thresholds and there is evidence that breeding birds are currently experiencing mild reproductive failure caused by Se (see Tables 10 and 11). In a sense, this final risk characterization procedure attempts to answer the question: "*How much worse will the Se exposure be in the SCH ponds relative to current conditions at the Salton Sea?*"

Overall, application of the hazard quotient approach produces moderate Se hazard for all ecosystem components in both the Alamo River and New River SCH ponds (Figures 10 a&b, upper panels). For all sites and salinities, the quotients for sediments were higher than for other media. The Protocol System predicts moderate-to-high Se hazard for invertivore foodwebs and high Se hazard for piscivore foodwebs in SCH ponds constructed on the New River at both salinity levels (Figures 10 a&b, lower panels). The Protocol scores for the Alamo River suggest high hazard from Se. Comparisons of modeled Se exposure to current Se exposure show that Se concentrations in invertebrates, fish and bird eggs could be 2-3 times greater in organisms inhabiting 20 ppt ponds supplied by the Alamo River than what is found under current conditions in and near the Salton Sea (Figure 14). At SCH ponds supplied by the New River, future Se concentrations in fish Se levels would be generally similar to current conditions if salinity was held at or above 35 ppt and the ponds do not experience the higher water quality risk described for Simulation 2. For both Alamo and New River SCH ponds, modeled Se exposures for eggs of fish-consuming birds are the most elevated relative to current conditions.

Using recently developed criteria for Se effects in birds (Table 13), the model results suggest that birds may experience mild reproductive impairment under expected water

quality conditions (egg Se of about 6-12 µg/g DW) with little chance for teratogenic effects. Under more pessimistic water quality and bioaccumulation scenarios, egg Se levels rise to a level (20-35 µg/g DW) that suggests a moderate to high risk for reproductive impairment and low to moderate risk for teratogenesis.

4. RECOMMENDATIONS

4.1 Recommendations for SCH Design

Our modeling results yield several findings in regards to SCH design and operation. First the Se risk in SCH ponds constructed with Alamo River water will likely be substantially higher than in ponds utilizing New River water. Risk characterization indices suggest there will be moderate to high risk for reduced egg viability in Black-necked stilts in Alamo River SCH ponds and that the risks will be substantially elevated above current risk levels. Thus, we recommend that initial SCH construction take place near the inlet to the New River and that the specific locations chosen should make use of recent sediment Se maps prepared by Amrhein (2010) to avoid hotspots of sediment Se. Once the New River SCH ponds have been operated and Se behavior is better understood, a decision to construct SCH ponds using Alamo River could be made.

Second, inverse modeling suggests that higher salinity levels result in lower risk from Se under our modeling assumptions. Salinity of 35 ppt is recommended to produce low risk of reproductive effects (< 6 µg/g DW). If low to moderate levels of reproductive effect are deemed acceptable, than salinity levels closer to 20 ppt are adequate for New River SCH ponds. In making these recommendations, we assume that water residence time in the SCH pond will be <32 weeks and that target salinity levels (20 and 35 ppt) will be reached primarily by mixing Sea water with river water. Se concentrations in the Sea are lower than in the rivers and SCH salinity levels near the current condition in the Sea will produce the lowest dissolved Se concentrations in the SCH ponds. Some evapoconcentration of water will occur with residence times near 32 weeks and we believe that the data from Miles *et al.*, (2009) and our models suggest that residence times on the order of months will not appreciably increase Se risk in the SCH ponds.

While longer residence time could favor the conversion of selenate into more bioavailable forms of dissolved Se, constructed fresh and saline wetlands at the Salton Sea appear to develop Se removal pathways within the first 1-2 years after construction. At the Brawley and Imperial wetlands, appreciable amounts of Se were sequestered or volatilized from the wetlands while sediment Se concentrations either declined through time (Brawley wetlands) or remained more or less constant (Figure 8, upper panel). At the USGS SHPs, sediment Se concentrations initially increased, then plateaued and then began to decline, despite long water residence time and high Se loading rates (Figure 8, lower panel). Thus, longer residence time could lower the external Se loading rate to the

ponds which could be advantageous from a Se risk perspective. However, it is very difficult to test this conjecture without more field research or conducting comparisons of Se dynamics in paired SCH ponds after construction. Overall, the influence of residence on Se ecorisk is a high priority research area.

4.2 Data Gaps for Se Risk at the Salton Sea, circa 2004, and Recent Progress

Before presenting recommendations for future research and monitoring work, we will briefly examine the progress that has been made during the last half-decade in understanding Se risk in the Salton Sea region. Prior to preparation of the Salton Sea PEIR (DWR and DFG 2007), an analysis was conducted to identify gaps in knowledge regarding Se hazards at the Sea and in future ecosystem restoration scenarios. It is informative to revisit these data gaps and assess to what extent recent studies have filled them. There are seven data gaps with relevance to Se risk in the proposed SCH project presented in a report drafted by DWR titled: "Final Report on Selenium at the Salton Sea and Summary of Data Gaps" (DWR 2005). In the list below we present these data gaps, their reasoning and a description of recent studies that addressed these gaps and whether, in our opinion, the gaps still exist in the context of the SCH project.

1. ***"Inadequate spatial characterization of selenium in Salton Sea sediment"***
    a. Reasoning: *"The distribution of selenium concentrations in sediments in different areas of the Salton Sea will be critical for predicting the selenium effects of different ecosystem management alternatives. In particular, adequate characterization of near-shore sediments will be required to predict conditions in exposed sediments when water elevations are lowered."*
    b. Recent work: Several hundred sediment samples analyzed by DWR, DFG, USGS and others from the Salton Sea were reviewed in the Salton Sea PEIR. Amrhein (2010) conducted sediment sampling at the mouths of the Alamo and New Rivers in areas targeted for SCH construction.
    c. Still a data gap? No. There are sufficient data on sediment Se concentrations at the Salton Sea for the proposed SCH.
2. ***"Selenium release and bioavailability characterization of Salton Sea sediments"***
    a. Reasoning: *"It was recognized that selenium may be re-mobilized in exposed or irrigated sediments but the magnitude of this problem has not been established. In addition, the bioavailability and toxicity of selenium in sediments will be critical for predicting the selenium effects of different ecosystem management alternatives."*
    b. Recent work: Byron and Ohlendorf (2007) suggest that Se will be sequestered in sediments under future highly saline conditions, but can be released under lower salinity and higher oxygen concentrations relative to current conditions.

c. Still a data gap? Yes. While Byron and Ohlendorf (2007) provide information on Se dynamics in nascent sediments, high loading rates of river water in the SCH ponds suggest that Se dynamics of riverine organic matter must be better understood. Sediments within the Sea are only one form of potentially bioavailable Se in the SCH. Through time, sediments in the SCH ponds will derive more and more from other, potentially more labile, forms of riverine particulate organic matter and autochthonous organic matter. Saiki *et al.*, (2010) conducted the first study at the Salton Sea to measure Se in particulate organic detritus and phytoplankton in agricultural drains supplying water to the Sea. More research is needed.

3. *"Further characterization of selenium in Salton Sea biota"*
   a. Reasoning: *"Selenium concentrations in some critical food items have not been adequately characterized. In particular, there are insufficient data for selenium concentrations in benthic and aquatic invertebrates and smaller fish that may represent important exposure pathways for other ecological receptors."*
   b. Recent work: Since the publication of the Salton Sea PEIR, the site-specific database on Se concentrations in benthic and aquatic invertebrates and small fish has undergone huge growth. Recent publications include Roy *et al.*, (2006), Miles *et al.*, (2009) and Saiki *et al.*, (2010).
   c. Still a data gap? Yes. While much more is known about the current concentrations of Se in biota of the Salton Sea region, the dataset is not yet large enough to develop species-specific trophic transfer factors necessary for more robust modeling. In our current modeling analysis we were forced to lump various invertebrate taxa into a generalized trophic levels 1 and 2, owing to insufficient data.
4. "*Refine the conceptual site models and food webs*"
   a. Reasoning: "The graphical depiction of food webs and feeding relationships provided by Setmire *et al.*, (1993) is not sufficient for modeling the pathways for selenium transfer and bioaccumulation. More refined conceptual site models and food web information are needed for the various components of the Salton Sea ecosystem, including terrestrial environments. This information will be used to confirm the adequacy of biota sampling, to determine the viability of selenium exposure pathways, and to model bioaccumulation of selenium in various trophic or feeding layers."
   b. Recent work: We could identify no recently published studies that addressed this data gap, hence we proposed to DWR to conduct a stable isotope analysis of Salton Sea foodwebs as part of our original SCH Se risk analysis. However, due to time constraints, this work has been

postponed. Saiki and collaborators are currently conducting stable isotope analysis of biota collected from rivers and agricultural drains and these new data will be of great value in refining the foodweb conceptual models for the SCH ponds.

c. Still a data gap? Yes. For the progressive modeling approach of Presser and Luoma to work, one must fully understand the trophic relationships within the foodweb to be modeled. While ongoing work by Saiki and collaborators utilizing stable isotopes will yield critical insights into the dynamics of the first three trophic levels (primary producers, primary consumers and fish), very little is known about the site-specific feeding behavior of invertebrate-consuming and fish-consuming birds. Furthermore, in our modeling analysis, TTF values between invertebrates and birds could not be developed for species other than Black-necked stilts and the TTF value between fish and avian piscivores was an educated guess. This uncertainty extends to a general lack of knowledge about the resource consumption patterns of migratory birds and how much of their Se load results from time spent at the Salton Sea in relationship to other habitats. Miles *et al.*, (2009), provide insights into local resource consumption patterns for newly hatched Black-necked stilts, but this work needs to be expanded in spatial scale for other migratory birds expected to utilize the SCH ponds.

5. "*Identify and develop tools for predicting selenium concentrations and effects*"
   a. Reasoning: "*A quantifiable method for estimating changes in selenium conditions will allow managers to give a consistent weighting for this factor under various management practices and ecosystem management alternatives. Coordinate with Theresa Presser/USGS to determine the applicability of existing selenium prediction models (Luoma and Presser, 2000) to the Salton Sea project.*"
   b. Recent work: The PEIR contains quantitative estimates of Se concentrations in media and biota under varying restoration alternatives. Our modeling analysis is an initial attempt to use the greatly expanded database of site-specific Se data for the Salton Sea region to predict Se concentrations in target avian species under SCH scenarios. Ours is the first application of the progressive modeling approach of Presser and Luoma to assess Se risk at the Salton Sea.
   c. Still a data gap? Yes. The modeling approach of Presser and Luoma likely provides the best tool for predicting changes in Se conditions under varying management scenarios, but more work is needed to refine the models. These refinements must address gaps in knowledge about food web structure, patterns of resource consumption by birds, and

uncertainties in Se partitioning between water and organic detritus. Additionally, the fate of Se in the SCH ponds is poorly understood. While recent studies in constructed freshwater and saline wetlands suggest Se removal mechanisms may exist (e.g., putative gaseous Se losses in the Brawley and Imperial wetlands and the USGS SHPs) it is difficult to assess how changes in SCH residence and Se loading rates will interact and impact Se partitioning and bioaccumulation.

6. *"Develop an electronic data set to integrate results for abiotic and biotic media in the Salton Sea ecosystem"*
    a. Reasoning: *"An electronic data set will be required for modeling associated with ecological and human health risk characterizations. It is critical that this data set be completed with the results from previous sampling, as well as upcoming analyses (such as those for sediments and bioassays). The data should also be coded by location type to avoid mixing data for areas with different selenium levels and exposure pathways."*
    b. Recent work: The PEIR contains extensive data tables for Se concentrations in abiotic and biotic media. Recent publications on Se concentration present most of the data in tabular form. However, some of the data that are available is in the form of average values rather than raw data. In other cases, data are displayed in figures, which complicates data analysis. As part of this report we compiled an EndNote library of almost 200 publications including URLs and pdf files and have created Excel spreadsheets summarizing raw Se data from recent reports on the Salton Sea.
    c. Still a data gap? Yes. To our knowledge there is no centralized, searchable database for Se in the Salton Sea region.
7. *"Need for Telemetry and Dietary Studies"*
    a. Reasoning: *"It may be important to better understand where and how the (Se) exposure is occurring under current conditions. While site-specific selenium data are available for bird and fish species, information regarding locations of uptake for wide-ranging species is lacking because movement (telemetry) studies have not been conducted and dietary (i.e., gut content) information is limited."*
    b. Recent work: Miles *et al.*, (2009) studied the local resource use of newly hatched Black-necked Stilt.
    c. Still a data gap: Yes. To our knowledge there are no published studies on the migratory patterns of adults birds utilizing the Salton Sea.

4.3 Research and Monitoring Recommendations

Based on our evaluation of recent progress in understanding of Se risk at the Salton Sea and shortcomings of the current progressive modeling study we are recommending priority areas for research. Studies based on these recommendations should be immediately begun so that results can be used in the design of the SCH habitats.

1. The effect of water residence time on Se ecorisk is highly relevant to the SCH project. We speculate, that maintaining target salinity levels solely through mixing of Sea and river water will require substantially more energy and cost more than maintaining salinity through a combination of pumping and evapoconcentration. At the SHP Workshop in Ontario CA on September 21, 2010, attendees discussed the effects of residence time on Se ecorisk. No clear consensus emerged from the discussion and it was noted that there was very little data to back up any conclusions regarding the influence of residence time on Se speciation, Se partitioning and sediment Se concentrations. Data discussed in this ecorisk assessment suggest that, after an initial mobilization of Se from flooded soils, Se removal processes became sufficiently large to cause a decrease in sediment Se in constructed wetland habitats (Figure 8), but the processes involved are not well understood.

   We propose that a study be initiated to identify and quantify Se removal processes in water bodies with varying residence time within the Imperial Valley. We have identified several bodies of water along the Alamo and New Rivers (see below) where water spends weeks to months in an impoundment. The morphometry of these water bodies are known and there are records of water pumping that allow for estimation of water residence time (J. Crayon, DFG, personal communication). Thus, these impoundments provide a gradient of water residence time that can be used to study the influence of residence time on Se speciation, Se partitioning, trophic transfer factors, aquatic foodwebs and sediment Se concentrations:

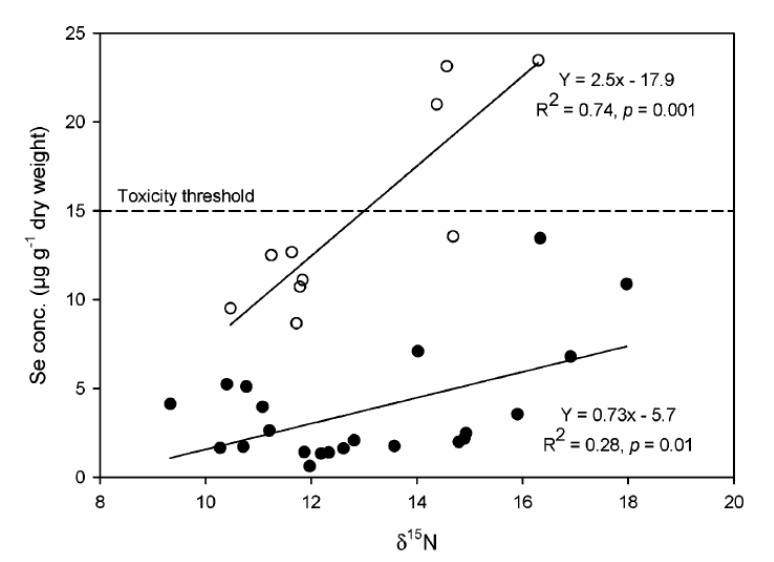
River	Water Body	UTM Easting UTM North
Alamo River	Ramer Lake	638755.19 E , 3661017.34 N
	Finney Lake	639832.83 E, 3659156.36 N
	Wiest Lake	641026.86 E, 3656974.81 N
	Gieselmann Lake	642344.16 E, 3654782.52 N
New River	Fig Lagoon	621771.01 E, 3626125.94 N
	Sunbeam Lake	623166.22 E, 3627913.09 N
	New River Wetlands	627101.61 E, 3638754.06 N

2. The partitioning coefficients between dissolved Se and particulate organic matter from recent studies in and around the Salton Sea suggest that Se speciation may significantly affect this initial, critical step in Se bioaccumulation. Very few measurements of Se speciation have been made in aquatic habitats in and around the Salton Sea and no studies have considered how Se speciation affects K_d values in the region. We recommend that periodic measurements of Se speciation be conducted in constructed wetlands, water impoundments, agricultural drains and rivers draining into the Salton Sea for a period of 1 year to examine how Se speciation varies across space and time. Samples of particulate organic matter, including sediment, organic detritus and phytoplankton should be co-collected in order to develop a robust dataset on media-specific K_d values and to examine how the K_d values vary as a function of Se speciation. Results from this study will greatly improve understanding and modeling of Se behavior in the SCH ponds. Once the SCH habitats are in operation we recommend that Se speciation measurements be included in routine monitoring protocols. While the Se speciation measurements are expensive, they are critical to understanding the dynamics of Se bioaccumulation.

3. Stable isotope techniques should be employed to fill critical data gaps with respect to foodweb structure and bioaccumulation rates of Se. All models simulating Se bioaccumulation within foodwebs are hampered by lack of knowledge regarding the exact structure of the foodwebs and the feeding behavior of consumers and predators. For example, in our models we could not estimate how much of the Se exposure in Black-necked stilts comes from their invertebrate food directly or through incidental ingestion of sediment or particulate organic detritus (either contained within the gut of the invertebrate prey or swallowed by the birds during feeding). Carbon, nitrogen and hydrogen isotope measurements will provide important insights into this question. Similar uncertainty exists in regards to Se exposure in the diets of fish, including tilapia. We recommend that periodic measurements of stable isotopes ($\delta^{13}C$, $\delta^{15}N$, and $\delta^{2}H$) and Se composition of foodweb components be conducted in constructed wetlands, water impoundments, agricultural drains and rivers draining into the Salton Sea for a period of 1 year.

   Isotope measurements can be used with Se concentrations in an alternative modeling approach that is complementary to the Presser and Luoma (2010) progressive modeling method. Nitrogen stable isotope measurements along with Se measurements have been used to examine the bioaccumulation rate of Se in foodwebs of the Sacramento Delta (Stewart *et al.,* 2004). This inset figure is from Stewart *et al.*, (2004) and illustrates the general approach. Nitrogen isotopes describe the relative trophic position of organisms within the foodweb; in the figure

$\delta^{15}N$ values span about 9 permil, and assuming a fractionation rate of 3.4 permil per trophic level, the x-axis depicts approximately 3 levels of the foodweb. The positive relationship between $\delta^{15}N$ and Se concentrations in the organisms is a clear indication of foodweb bioaccumulation of Se. The slope of the regression lines describe the rate of Se bioaccumulation and can be extrapolated to higher trophic levels, such as birds. In the figure, the upper line describes the bioaccumulation dynamics of Se in a predominantly clam-based foodweb and the lower line describes the dynamics in a crustacean-based foodweb. With these types of data, Se:isotope models can be developed that can quantitatively estimate the rate of Se bioaccumulation in prospective foodwebs of the SCH and provide improved estimates of egg Se concentration for piscivores.



4. Trophic transfer factors between fish and piscivorous birds are a major data gap for the Salton Sea. Laboratory feeding studies are one possible solution, but it would be preferable to use site-specific data for breeding birds at the Salton Sea. One of the most common piscivores to breed at the Salton Sea is the Double-crested Cormorant (*Phalacrocorax auritus*). Cormorants are likely to be one of the major beneficiaries of the SCH project making them an ideal species for which to develop a trophic transfer factor to be used in progressive modeling of the SCH project.

5. TABLES

Table 1. Summary of total dissolved Se concentrations in the n the Salton Sea, Alamo River, and New River from recent monitoring and measurements.

Site	Data Source	Mean (µg/L)	Upper 95% limit (µg/L)
Salton Sea	PEIR 2007	0.82	1.0
Salton Sea	US Bureau of Reclamation 2004-2008	1.4	-
Alamo River	PEIR 2007	4.6	6.5
Alamo River	US Bureau of Reclamation 2004-2008	5.4	-
Alamo River	Miles *et al.*, 2009 2006-2008	5.6	6.8
Alamo River	Amrhein 2010 (May and June)	4.1	
New River	PEIR 2007	2.4	3.5
New River	US Bureau of Reclamation 2004-2008	3.3	-
New River	Amrhein 2010 (May and June)	1.8	

Table 2. Predicted total dissolved selenium concentrations in SCHs created with mixtures of water from the Alamo River, New River and Salton Sea. Salinity in the Salton Sea was assumed to be 52 g/L based on recent US Bureau of Reclamation monitoring data.

Source of Freshwater Used in SCH	**Salinity Target (g/L)**	**Fraction River Water to Fraction Sea Water**	**Predicted Average Total Dissolved Se (µg/L)**	**Predicted 95th Percentile Total Dissolved Se (µg/L)**	**Data Sources**
Alamo River	20	0.64:0.36	4.0	4.9	US Bureau of Reclamation & Miles *et al.*, 2009
	35	0.34:0.66	2.8	3.3	US Bureau of Reclamation & Miles *et al.*, 2009
New River	20	0.64:0.36	2.6	2.8	US Bureau of Reclamation & DWR, DFG 2007
	35	0.34:0.66	2.05	2.2	US Bureau of Reclamation & DWR, DFG 2007

Computations assume a river salinity concentration of 2 g/L and Sea salinity concentration of 52 g/L (US Bureau of Reclamation monitoring data).

Table 3. Summary of site-specific partitioning coefficients (K_d) between total dissolved Se in water and various aquatic media for the Salton Sea region. K_d values were computed according to Presser and Luoma (2010).

Study	Media	Mean Partitioning Coefficient (K_d)	Median (K_d)	75th Percentile (K_d)	Number of Data Points
Saiki *et al.*, 2010 (extensive sites)	Sediment:Water	317	263	413	29
	Particulate Organic Detritus:Water	1188	1068	1373	41
Saiki *et al.*, 2010 (intensive sites)	Sediment:Water	343	298	462	42
	Particulate Organic Detritus:Water	1179	1053	1383	42
	Algae:Water	604	366	684	42
Miles *et al.*, 2009 (Sediment:Water)	Saline Habitat Pond 1	739	773	964	20
	Saline Habitat Pond 2	867	689	1298	20
	Saline Habitat Pond 3	1364	1247	1894	20
	Saline Habitat Pond 4	578	600	752	20
	Salton Sea Sites	100	101	110	20
	Alamo River	818	676	1213	20
	Freshwater Marsh	764	692	1081	20
	D-Pond	629	538	775	20
Roy *et al.*, 2006 (Sediment:Water)	Brawley Wetlands	195	167	297	39
	Imperial Wetlands	352	283	460	93
Grand Average of All Studies		**669**	**588**	**877**	

Table 4. Summary of site-specific trophic transfer factors between trophic Level 1 (sediment, detritus or primary producer) and Level 2 (invertebrate consumer) for the Salton Sea region. TTF values were computed according to Presser and Luoma 2010.

Trophic Level Transfer (Organisms)	**Study**	**Trophic Transfer Factor (TTF)**			**Number of Data Points**	**Notes**
		Mean	**Median**	**75th Percentile**		
1 to 2 (Chironomid:Sediment)	Saiki *et al.*, 2010 (intensive sites)	6.34	4.51	6.08	41	*Note: There are two high outliers with TTFs of 33.2 and 40.0*
1 to 2 (Chironomid:Detritus)	Saiki *et al.*, 2010 (intensive sites)	1.46	1.09	1.88	41	
1 to 2 (Chironomid:Algae)	Saiki *et al.*, 2010 (intensive sites)	4.56	2.64	3.85	41	*Note: There is one high outlier with TTF of 49.9*
1 to 2 (Chironomid:Phytoplankton)	Saiki *et al.*, 2010 (intensive sites)	4.08	2.33	3.67	41	
1 to 2 (Chironomid:Sediment)	Miles *et al.*, 2009 (Saline Habitat 1)	3.30	3.17	5.10	5	
1 to 2 (Invertebrate Mix:Sediment)	Miles *et al.*, 2009 (Saline Habitat 2)	4.35	4.26	6.67	5	
1 to 2 (Corixidae:Sediment)	Miles *et al.*, 2009 (Saline Habitat 3)	2.11	1.78	2.97	5	
1 to 2 (Corixidae:Sediment)	Miles *et al.*, 2009 (Saline Habitat 4)	1.34	1.10	1.79	5	
1 to 2 (Corixidae:Sediment)	Miles *et al.*, 2009 (Salton Sea)	4.99	4.73	5.80	5	
1 to 2 (Invertebrate Mix:Sediment)	Miles *et al.*, 2009 (Freshwater Marsh)	1.19	1.21	1.36	5	
1 to 2 (Chironomid:Sediment)	Miles *et al.*, 2009 (D-Pond)	3.05	2.91	4.26	5	

Trophic Level Transfer (Organisms)	Study	Trophic Transfer Factor (TTF)			Number of Data Points	Notes
		Mean	Median	75th Percentile		
1 to 2 (Corixidae:Sediment)	DWR, DFG (PEIR 2007), Attachment F	1.32	1.11	1.71	22	
1 to 2 (Pileworm:Sediment)	DWR, DFG (PEIR 2007) Attachment F	4.84	4.84	NA	2	
1 to 2 (Pileworm:Algae)	Setmire *et al.*, 1993 (Salton Sea)	3.20	NA	NA	NA	*Computed using mean values reported in Table 8 from Setmire et al., 1993 (1988-1990)*
1 to 2 (Corixidae:Algae)	Setmire *et al.*, 1993 (Salton Sea)	2.17	NA	NA	NA	*Computed using mean values reported in Table 8 from Setmire et al., 1993 (1988-1990)*
1 to 2 (Corixidae:Sediment)	Roy *et al.*, 2006 and Johnson *et al.*, 2009 Brawley Wetland	2.39	NA	NA	9	*Only summary statistics were available for biota, hence only mean TTF factor could be computed*
1 to 2 (Corixidae:Sediment)	Roy *et al.*, 2006 and Johnson *et al.*, 2009 Imperial Wetland	2.21	NA	NA	6	*Only summary statistics were available for biota, hence only mean TTF factor could be computed*
Level 1 to Level 2	**Grand Average of all Studies**	**3.11**	**2.75**	**3.76**		***All studies were weighted equally in the summary statistics***

Table 5. Summary of site-specific trophic transfer factors between trophic Level 1 (sediment or detritus) and Level 3 (fish) for the Salton Sea region. TTF values were computed according to Presser and Luoma 2010.

Trophic Level Transfer (Organisms)	**Study**	**Trophic Transfer Factor (TTF)**			**Number of Data Points**	**Notes**
		Mean	**Median**	**75th Percentile**		
1 to 3 (Mosquitofish:Detritus)	Saiki *et al.*, 2010 (intensive sites)	1.40	1.14	1.82	41	
1 to 3 (Sailfin Molly:Detritus)	Saiki *et al.*, 2010 (intensive sites)	1.39	1.23	1.68	42	
1 to 3 (Tilapia:Sediment)	DWR, DFG (PEIR 2007) Attachment F	5.63	4.82	5.58	15	
1 to 3 (Mosquitofish:Sediment)	Roy *et al.*, 2006 and Johnson *et al.*, 2009 Brawley Wetland	3.13	NA	NA	6	*Only summary statistics were available for biota, hence only mean TTF factor could be computed*
1 to 3 (Mosquitofish:Sediment)	Roy *et al.*, 2006 and Johnson *et al.*, 2009 Imperial Wetland	3.09	NA	NA	9	*Only summary statistics were available for biota, hence only mean TTF factor could be computed*
Level 1 to Level 3	**Grand Average of all Studies**	2.93	2.40	3.03		***All studies were weighted equally in the summary statistics***

Table 6. Summary of site-specific trophic transfer factors between trophic Level 2 (invertebrate consumer) and Level 3 (fish or invertebrate-consuming bird) for the Salton Sea region. TTF values were computed according to Presser and Luoma (2010).

Trophic Level Transfer (Organisms)	**Study**	**Trophic Transfer Factor (TTF)**			**Number of Data Points**	**Notes**
		Mean	**Median**	**75th Percentile**		
2 to 3 (BN Stilt Chironomid)	Miles *et al.*, 2009 (Saline Habitat 1)	1.25	1.17	1.67	3	
2 to 3 (BN Stilt:Invertebrate Mix)	Miles *et al.*, 2009 (Saline Habitat 2)	1.23	1.18	1.45	3	
2 to 3 (BN Stilt:Corixidae)	Miles *et al.*, 2009 (Saline Habitat 3)	1.56	1.56	NA	2	*Cannot compute 75th percentile from only two measurements*
2 to 3 (BN Stilt:Corixidae)	Miles *et al.*, 2009 (Saline Habitat 4)	2.02	2.02	NA	2	*Cannot compute 75th percentile from only two measurements*
2 to 3 (BN Stilt:Corixidae)	Miles *et al.*, 2009 (Morton Bay)	2.00	2.00	NA	2	*Cannot compute 75th percentile from only two measurements*
2 to 3 (BN Stilt:Invertebrate Mix)	Miles *et al.*, 2009 (Freshwater Marsh)	2.59	2.29	3.44	3	
2 to 3 (BN Stilt:Chironomid)	Miles *et al.*, 2009 (D-Pond)	2.15	2.40	2.55	3	
2 to 3 (BN Stilt:Corixidae)	Setmire *et al.*, 1993 (Salton Sea)	2.05	NA	NA	NA	*Computed using mean values reported in Tables 8&9 from Setmire et al., 1993 (1988-1990)*
2 to 3 (BN Stilt:Pileworm)	Setmire *et al.*, 1993 (Salton Sea)	1.39	NA	NA	NA	*Computed using mean values reported in Tables 8&9 from Setmire et al., 1993 (1988-1990)*

2 to 3 (Mosquitofish:Chironomid)	Saiki *et al.*, 2010 (intensive sites)	~~1.16~~	~~1.08~~	~~1.50~~	~~40~~	*These data were not used in the computation of TTF since recent isotope foodweb analyses do not support this Se transfer route (M. Saiki USGS personal communication 8/26/2010)*
2 to 3 (Sailfin Molly:Chironomid)	Saiki *et al.*, 2010 (intensive sites)	1.14	0.97	1.31	41	
2 to 3 (Tilapia:Corixidae)	Roy *et al.*, 2006 and Johnson *et al.*, 2009 Brawley Wetland	1.41	NA	NA	6	*Only summary statistics were available for biota, hence only mean TTF factor could be computed*
2 to 3 (Mosquitofish:Corixidae)	Roy *et al.*, 2006 and Johnson *et al.*, 2009 Brawley Wetland	1.31	NA	NA	9	*Only summary statistics were available for biota, hence only mean TTF factor could be computed*
2 to 3 (Mosquitofish:Corixidae)	Roy *et al.*, 2006 and Johnson *et al.*, 2009 Imperial Wetland	1.40	NA	NA	6	*Only summary statistics were available for biota, hence only mean TTF factor could be computed*
Level 2 to Level 3	**Grand Average of all Fish Studies**	**1.31**	**0.97**	**1.31**		***All studies were weighted equally in the summary statistics***
Level 2 to Level 3	**Grand Average of all Bird Studies**	**1.81**	**1.80**	**2.28**		***All studies were weighted equally in the summary statistics***

Table 7. Summary of site-specific trophic transfer factors between trophic Level 2 (invertebrate consumer) and Level 4 (omnivorous bird) for the Salton Sea region. TTF values were computed according to Presser and Luoma (2010). Note: These data were not used in the progressive models.

Trophic Level Transfer (Organisms)	**Study**	**Trophic Transfer Factor (TTF)**			**Number of Data Points**	**Notes**
		Mean	**Median**	**75th Percentile**		
2 to 4 (Coot:Corixidae)	Roy *et al.*, 2006 and Johnson *et al.*, 2009 Brawley Wetland	1.28	NA	NA	9	*Only summary statistics were available for biota, hence only mean TTF factor could be computed*
2 to 4 (Coot:Corixidae)	Roy *et al.*, 2006 and Johnson *et al.*, 2009 Imperial Wetland	1.02	NA	NA	6	*Only summary statistics were available for biota, hence only mean TTF factor could be computed*
Level 2 to Level 4	**Grand Average of all Studies**	**1.15**	NA	NA		***All studies were weighted equally in the summary statistics***

Table 8. Summary of site-specific trophic transfer factors between trophic Level 3 (fish) and Level 4 (omnivorous bird) for the Salton Sea region. TTF values were computed according to Presser and Luoma (2010). Note: These data were not used in the progressive models.

Trophic Level Transfer (Organisms)	**Study**	**Trophic Transfer Factor (TTF)**			**Number of Data Points**	**Notes**
		Mean	**Median**	**75th Percentile**		
3 to 4 (Coot:Mosquitofish)	Roy *et al.*, 2006 and Johnson *et al.*, 2009 Brawley Wetland	0.98	NA	NA	6	*Only summary statistics were available for biota, hence only mean TTF factor could be computed*
3 to 4 (Coot:Mosquitofish)	Roy *et al.*, 2006 and Johnson *et al.*, 2009 Imperial Wetland	0.73	NA	NA	6	*Only summary statistics were available for biota, hence only mean TTF factor could be computed*
Level 3 to Level 4	**Grand Average of all Studies**	**0.85**	NA	NA		***All studies were weighted equally in the summary statistics***

Table 9. Trophic transfer factors (TTF) reported by Presser and Luoma (2009) for the San Diego Creek Watershed, Newport Bay and published studies cited therein.

Trophic Levels	**Study**	**Mean Field TTF Derived from Field Data**
1 to 2 (Chironomid:Unspecified Food Source)	Birkner 1978; Saiki *et al.*, 1993 as cited in Presser and Luoma 2009	2.70
1 to 2 (Corixidae:Unspecified Food Source)	Birkner 1978 as cited in Presser and Luoma 2009	2.14
1 to 2 (Chironomid:Organic Detritus)	Presser and Luoma 2009 (San Diego Creek mean value)	2.40
1 to 2 (Corixidae:Organic Detritus)	Presser and Luoma 2009 (San Diego Creek mean value)	3.60
2 to 3 (Mosquitofish: Invertebrate)	Saiki *et al.*, 1993 as cited in Presser and Luoma 2009	1.20
2 to 3 (Mosquitofish: Average Invertebrate)	Presser and Luoma 2009	1.90 Lower PCW 2.60 Lower SDC 1.10 IRWD 1.20 UCI
3 to 4 (Mallard Laboratory Feeding Study)	Ohlendorf 2003 as cited in Presser and Luoma 2009	1.8 @ 3.6 µg/g Se in Diet 2.55 @ 4.9 µg/g Se in Diet 2.9 @ 5.7 µg/g Se in Diet

Table 10. Summary of selected thresholds for negative reproductive effects and observed toxicity of Se in birds.

Egg Se Concentration	**Type of Threshold**	**Species**	**Source**
6 µg/g dw	EC_{03} for egg viability, Hatchability	Black-necked stilt	Skorupa 1998, NIWQP 1998
10 µg/g dw	Reproductive impairment	Mallards	Heinz 1996
16 µg/g dw	MES EC_{10} for chick mortality	Mallards	Fairbrother *et al.*, 1999
12-14 µg/g dw	MES EC_{10} for effects	Mallards	Adams *et al.*, 2003
8 µg/g dw	Toxicity threshold	Aquatic birds	Henderson *et al.*, 1995 from Hamilton 2004
8 µg/g dw	Toxicity threshold	Aquatic birds	Stephens *et al.*, 1997 from Hamilton 2004
22 µg/g dw	MES effect threshold	Red-winged blackbirds	Harding 2008
8 µg/g dw	Toxicity threshold	Aquatic birds	Bureau of Reclamation 1993 in Bennett 1998

Table 11. Summary of egg Se concentrations and observed effects in birds nesting near the Salton Sea.

Mean Egg Se (µg/g dw) and Ranges of Observed Concentrations	Year & Location	Species	Effects Documented	Source
5.7 (5.45-6.99)	2008, USGS Ponds	Black-necked Stilt	Averaging across years, 47% of eggs from USGS Ponds and 39% from Freshwater Marsh/Morton Bay exceeded the 6 ppm dw threshold, 33% of eggs w/ embryos able to be examined had malpositioned embryos, 2 had potentially deformed embryos	Miles *et al.*, 2009
4.8 (4.42-5.26)	2008, Ref. Sites			
5.6 (4.52-6.18)	2007, USGS Ponds			
5.3 (2.18-6.11)	2007, Ref. Sites			
8.0 (7.85-9.09)	2006, USGS Ponds			
4.9 (3.62-7.05)	2006, Ref. Sites			
5.54 (1.91-11.87)	2006 and 2007, USGS Ponds	Black-necked Stilt	20.6% nests w/ at least one fail-to-hatch egg	Anderson 2008
5.1 (1.91-11.87)			Nests with 100% egg hatch	
7.56 (5.24-11.62)			Nests with at least one fail-to hatch egg	
4.91 (2.18-9.86)	2006 and 2007, MB, FWS, FWM		Not evaluated	
1.77 (<1.1-5.03)	2004, Whitewater River Delta	Black-crowned Night-Heron	Not evaluated	Henny *et al.*, 2008
3.02 (<1.1-4.90)		Great Egret		
6.16 (3.29-8.53)	2004, Davis Road	Black-necked Stilt		
9.27 (8.13-10.89)		American Avocet		

Mean Egg Se (µg/g dw) and Ranges of Observed Concentrations	Year & Location	Species	Effects Documented	Source
3.95 (2.7-4.6)	2003, Brawley Wetlands	American Coot	No evidence of impaired reproduction or teratogenesis	Skorupa in Roy *et al.*, 2006
4.00 (2.7-5.0)	2003, Imperial Wetlands			Skorupa in Roy *et al.*, 2006
4.97 (3.51-8.32)	1993, Salton Sea	Snowy Egret	29% of embryos examined had malformations, but none of these were attributed to Se	Bennett 1998
7.14 (6.1-9.9)		Great Egret		
5.82 (3.67-8.96)		Black-necked Stilt	4.5% reproductive depression due to Se	
6.90 (3.74-14.2)	1992, Salton Sea	Black-necked Stilt	1 w/ throat hemorrhaging, not attributed to Se	
6.01 (4.61-7.19)	1993, Johnson Drain area	Black Skimmer	No measureable impairment found that could be attributed to Se, but intensive nest monitoring was not part of the study	Roberts and Berg 2000
6.78 (5.10-8.17)	1993, Mullet Island			
6.35 (3.59-8.92)	1993, Obsidian Butte			
4.47 (3.25-8.03)	1993, Morton Bay			
2.60 (1.40-3.81)	1993, Mullet Island	Caspian Tern		
6.18 (3.30-7.85)	1992, Whitewater River Delta	Black-crowned Night-Heron		
4.95 (3.45-6.17)	1992, Mallard Rd., Wister Unit, IWA	Great Egret		
5.87 (5.71-6.24)	1992, Salton Sea	Black Skimmer		
3.62 (3.29-4.28)	1992, Finney Lake, IWA	White-faced Ibis		
5.27 (4.6-6.5)	1991, Whitewater River Delta/ Johnson Drain	Black-crowned Night-Heron	Unknown	Audet *et al.*, 1997 (from Henny *et al.*, 2008)
3.93 (3.9-4.0)		Snowy Egret		

Mean Egg Se (µg/g dw) and Ranges of Observed Concentrations	Year & Location	Species	Effects Documented	Source
4.65 (2.2-8.2)	1991, Salton Sea	Black Skimmer		
3.86 (2.8-5)		Great Blue Heron		Audet *et al.*, 1997 (from Henny *et al.*, 2008)
4.77 (3.5-7.1)		Great Egret		
4.30 (1.60-35.0)	1988-1990, Salton Sea	Black-necked Stilt	Unknown	Setmire *et al.*, 1993 (from Henny *et al.*, 2008)
4.4 (3.7-5.6)	1985, Salton Sea	Black-crowned Night-Heron	Not evaluated	Ohlendorf and Marois 1990 (dw values from Bennett 1998)
2.6 (2.2-3.3)		Great Egret		
5.88 (4.92-7.49)		Black-crowned Night-Heron		Ohlendorf and Marois 1990 (dw values from Henny *et al.*, 2008)
3.53 (2.97-4.51)		Great Egret		

Table 12. Summary of median and 75th percentile values for invertebrates, fish (tissue) and bird eggs in and near the Salton Sea reported in published studies. SHP = saline habitat ponds, SS = Salton Sea, FM = freshwater marsh, D-Pond = control wetland that receives water only from the Colorado River.

Organism Type	**Statistic**	**Saiki *et al.*, 2010**	**Miles *et al.*, 2009**	**Henny *et al.*, 2008**	**Moreau *et al.*, 2007**	**Roy *et al.*, 2006**	**PEIR 2005**	**Roberts 2000**	**Bennett 1998**	**Setmire 1993 (Means)**
Invertebrates	**Median**	5.9	4.6 SHP 3.0 SS 2.6 FM 1.4 D-Pond			3.6	2.4			2.6
	75th %	8.4	5.6 SHP 3.3 SS 2.8 FM 2.15 D-Pond			4.4	2.7			
Fish (tissue)	**Median**	5.6	-		9.9	4.2	10.5		5.1	7.0
	75th %	12.0	-		11.4	5.0	11.0		5.6	
Bird Eggs	**Median**	-	5.9 SHP 5.4 SS 6.1 FM 3.6 D-Pond	5.3		4.2	-	5.9	6.2	4.3
	75th %	-	7.2 SHP SS 7.1 FM 4.4 D-Pond	6.4		4.7	-	6.3	7.1	

Table 13. Threshold for potential Se effects in birds as proposed by Ohlendorf and Heinz (2011)

Table A. Thresholds for potential Se effects in birds

Effect	**Se concentration in eggs** (ppm or µg/L)	**Probability of effect**	**Source**
Background level	<3.0 mean, <5.0 individual eggs	Concentrations may be higher in some marine birds	Ohlendorf and Heinz 2011
Reproductive impairment (reduced hatching success)	6.0 ppm	Toxicity threshold (typically used)	Hamilton 2004
	<8.0 ppm 8 - 12 ppm	Low probability for reduced egg hatchability, including effects in sensitive species	Ohlendorf and Heinz 2011
	> 12	Elevated probability for reduced egg hatchability in sensitive and moderately sensitive species	Ohlendorf and Heinz 2011
Teratogenicity	<20	Low probability for teratogenic effects in most species. Threshold for statistically discernable incidence in sensitive species such as mallard	Ohlendorf and Heinz 2011
	20-35	Elevated probability for teratogenic effects in sensitive species such as mallard	interpolated from Ohlendorf and Heinz 2011
	>35	Probability for teratogenic effects in species of "average sensitivity" such as black-necked stilt	Ohlendorf and Heinz 2011

Table 14. General Model output for invertebrate-consuming birds under 2 mixing regimes (20 and 35 ppt salinity) and three water quality scenarios.

Modeled Egg Se Concentrations (µg/g DW): Invertebrate-Consuming Birds				
≤6 (µg/g DW) 6 to ≤8 (µg/g DW 8 to ≤12 (µg/g DW) 12 to ≤ 20 (µg/g DW) >20 (µg/g DW)		***General Model Scenarios***		
River Source	**Salinity**	**Simulation 1:** Expected WQ Scenario with Median TTFs	**Simulation 2:** 95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	**Simulation 3:** Future Scenario 10 µg/L Rivers Median K_d
New River	**20 ppt**	**7.6**	**12.1**	
	35 ppt	**6.0**	**9.4**	
				29.1
Alamo River	**20 ppt**	**11.6**	**21.2**	
	35 ppt	**8.1**	**14.3**	

Table 15. General Model output for fish-consuming birds under 2 mixing regimes (20 and 35 ppt salinity) and three water quality scenarios.

Modeled Egg Se Concentrations (µg/g DW): Fish-Consuming Birds				
=6 (µg/g DW) 6 to =8 (µg/g DW 8 to =12 (µg/g DW) 12 to = 20 (µg/g DW) >20 (µg/g DW)		***General Model Scenarios***		
River Source	**Salinity**	**Simulation 1:** Expected WQ Scenario with Median TTFs	**Simulation 2:** 95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	**Simulation 3:** Future Scenario 10 µg/L Rivers Median K_d
New River	**20 ppt**	**8.3**	**13.2**	
	35 ppt	**6.5**	**10.3**	
				31.8
Alamo River	**20 ppt**	**12.7**	**23.1**	
	35 ppt	**8.9**	**15.6**	

Table 16. USBR/USGS SHP Model output for invertebrate-consuming birds under three scenarios. Note that salinity, and hence required mixtures of Salton Sea and river water, are different for each of the three simulations.

Modeled Egg Se Concentrations (µg/g DW): Invertebrate-Consuming Birds			
≤6 (µg/g DW) 6 to ≤8 (µg/g DW 8 to ≤12 (µg/g DW) 12 to ≤ 20 (µg/g DW) >20 (µg/g DW)	***USBR/USGS SHP Model Scenarios***		
River Source	**Pond 1 Simulation: 13 ppt Salinity** Expected WQ Scenario with Median TTFs	**Pond 2 Simulation: 24.9 ppt Salinity** Expected WQ Scenario with Median TTFs	**Pond 3 Simulation: 47.6 ppt Salinity** Expected WQ Scenario with Median TTFs
New River	**8.3**	**8.4**	**5.4**
Alamo River	**13.1**	**12.5**	**6.2**

Table 17. USBR/USGS SHP Model output for fish-consuming birds under three scenarios. Note that salinity, and hence required mixtures of Salton Sea and river water, are different for each of the three simulations.

Modeled Egg Se Concentrations (µg/g DW): Fish-Consuming Birds			
=6 (µg/g DW) 6 to =8 (µg/g DW 8 to =12 (µg/g DW) 12 to = 20 (µg/g DW) >20 (µg/g DW)	***USBR/USGS SHP Model Scenarios***		
River Source	**Pond 1 Simulation: 13 ppt Salinity** Expected WQ Scenario with	**Pond 2 Simulation: 24.9 ppt Salinity** Expected WQ Scenario with Median TTFs	**Pond 3 Simulation: 47.6 ppt Salinity** Expected WQ Scenario with
New River	**13.9**	**14.0**	**6.8**
Alamo River	**22.0**	**20.8**	**7.8**

Table 18. Results from inverse models used to predict blends of river and Salton Sea water required to achieve target egg Se levels for invertebrate consuming birds.

River source	**Salinity (ppt) necessary for Se in eggs ≤ 6 ppm**				
	Median WQ Scenario with Median K_d	95th Percentile WQ Scenario with 75th Percentile K_d	USBR/USGS Pond 1 Scenario	USBR/USGS Pond 2 Scenario	USBR/USGS Pond 3 Scenario
New River	35	unattainable	34	43	43
Alamo River	44	unattainable	44	48	48

River source	**Salinity (ppt) necessary for Se in eggs ≤ 8 ppm**				
	Median WQ Scenario with Median K_d	95th Percentile WQ Scenario with 75th Percentile K_d	USBR/USGS Pond 1 Scenario	USBR/USGS Pond 2 Scenario	USBR/USGS Pond 3 Scenario
New River	17	43	15	28	28
Alamo River	36	49	35	41	41

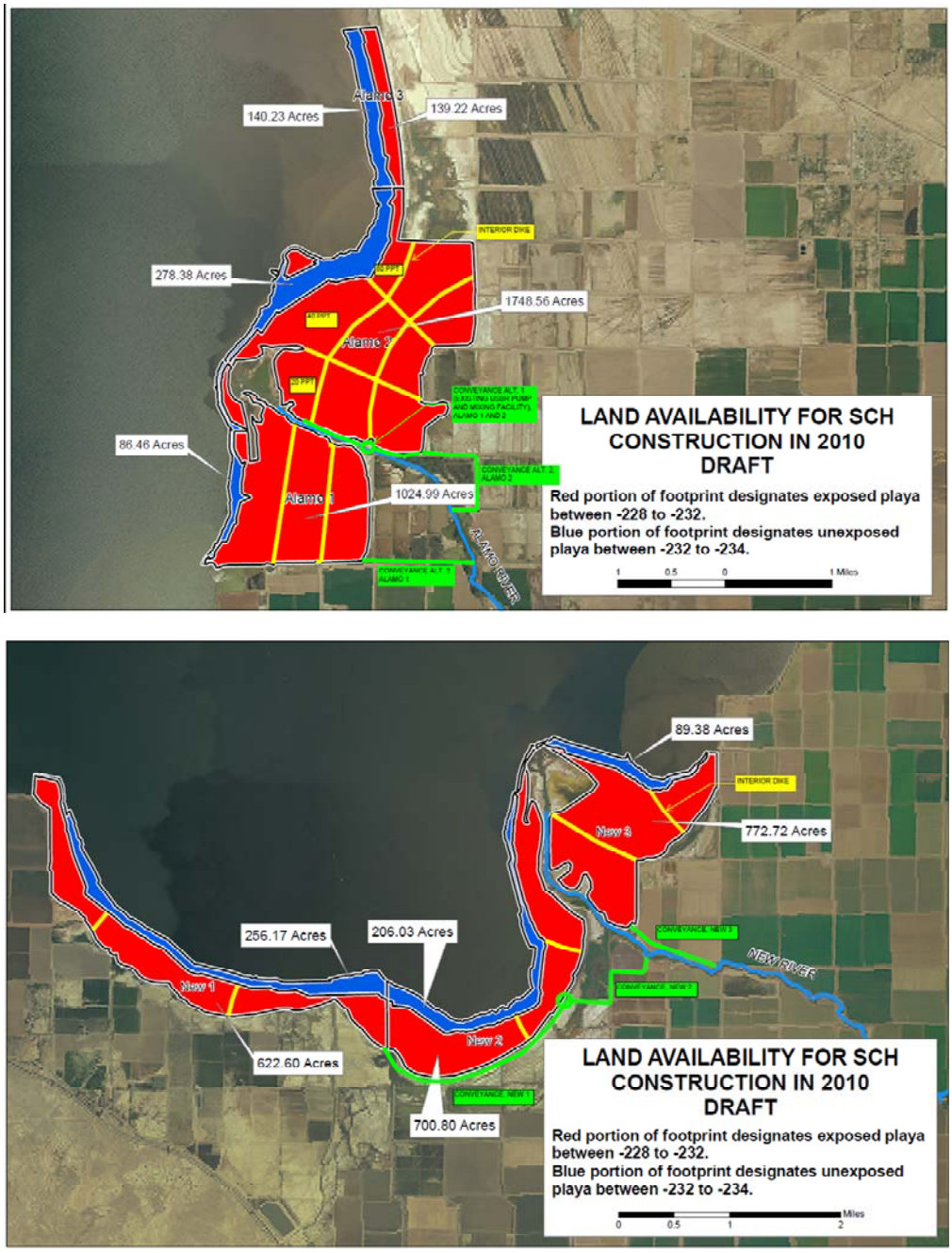
River source	**Salinity (ppt) necessary for Se in eggs ≤ 12 ppm**				
	Median WQ Scenario with Median K_d	95th Percentile WQ Scenario with 75th Percentile K_d	USBR/USGS Pond 1 Scenario	USBR/USGS Pond 2 Scenario	USBR/USGS Pond 3 Scenario
New River	all river ok	21	all river ok	all river ok	all river ok
Alamo River	18	40	18	27	27

Table 19. Modeled and measured egg Se concentrations at experimental ponds and index sites reported in Miles *et al.*, 2009.

Modeled BN Stilt Egg Selenium (µg/g DW)							
Year	**Pond 1**	**Pond 2**	**Pond 3**	**Pond 4**	**Morton Bay**	**Freshwater Marsh**	**D-Pond/Hazard**
2006	11.18	8.31	9.35	5.07	6.83	5.79	3.76
2007	5.59	4.85	6.75	4.27	5.41	7.07	3.13
2008	8.03	5.89	5.71	5.93	5.51	7.88	4.18
Actual BN Stilt Egg Selenium (µg/g DW)							
Year	**Pond 1**	**Pond 2**	**Pond 3**	**Pond 4**	**Morton Bay**	**Freshwater Marsh**	**D-Pond/Hazard**
2006	7.85	9.09	ND	ND	ND	7.05	3.62
2007	6.18	5.45	6.06	4.52	5.41	6.11	2.18
2008	5.45	5.73	6.99	5.46	ND	5.26	4.42

6. FIGURES

Figure 1. Concept diagram for Species Conservation Habitats constructed at the outlets to the Alamo River (top panel) and New River (bottom panel).



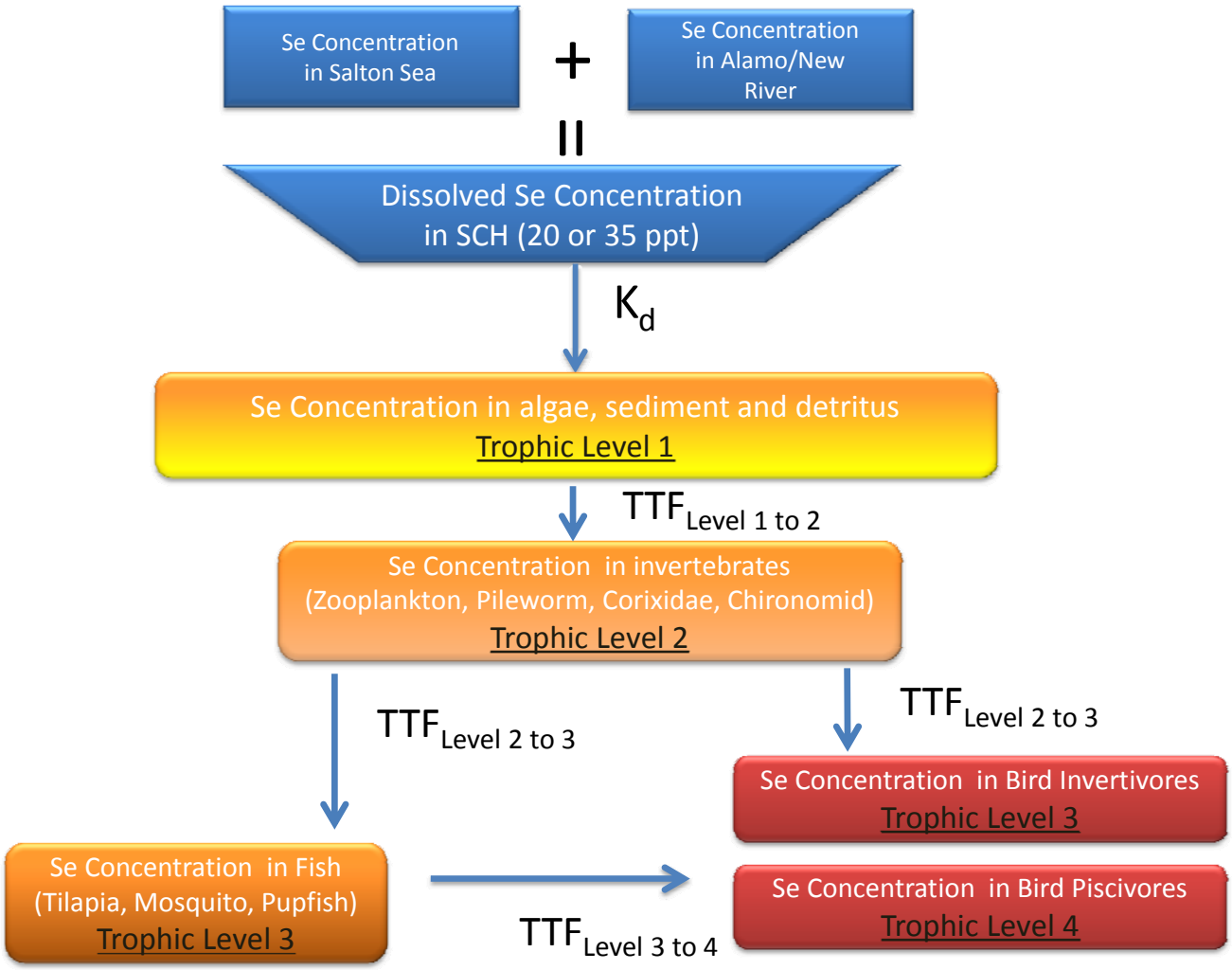
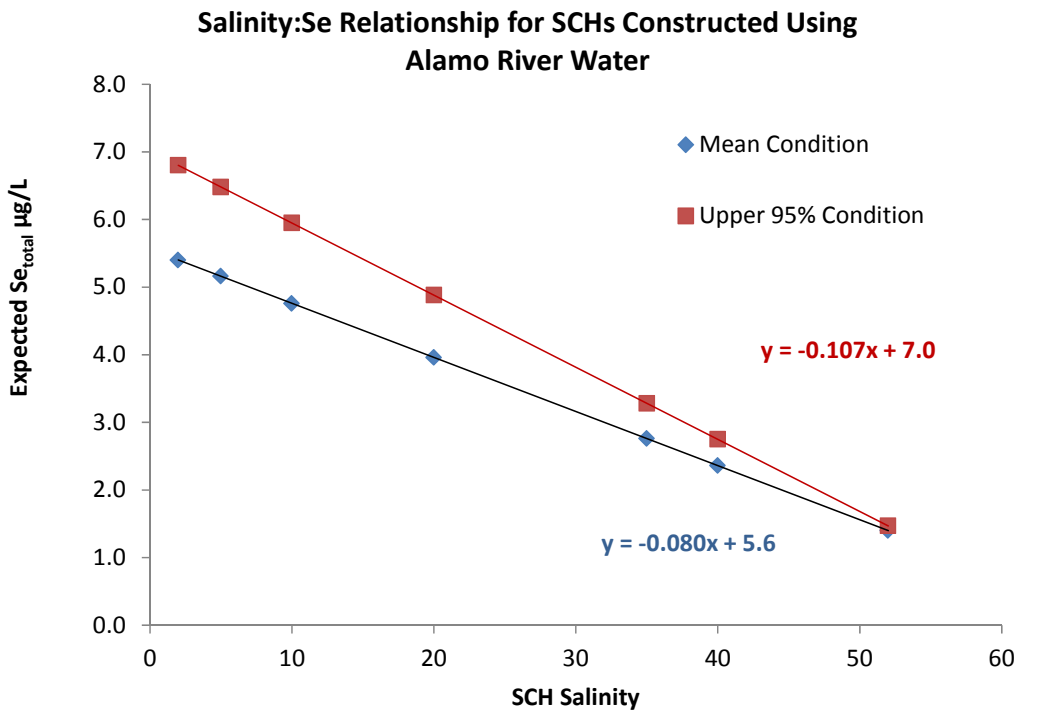


Figure 2. Conceptual model of Se transformations within the proposed SCH projects. Two foodwebs are envisioned based on feeding behavior of birds:
1) water → Trophic Level 1 → Trophic Level 2 → Bird Invertivores and
2) water → Trophic Level 1 → Trophic Level 2 → Trophic Level 3 (Fish) → Bird Piscivores



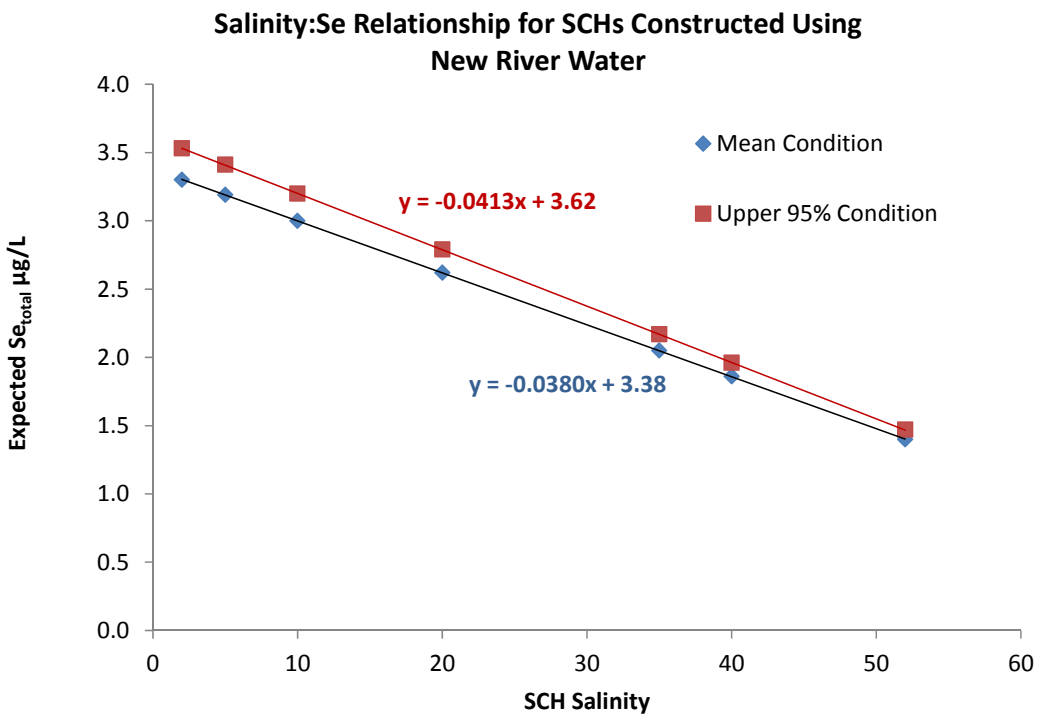


Figure 3. Predicted total Se predicted from conservative mixing of Salton Sea and a) Alamo River and b) New River water. See text for description of assumptions and data sources.

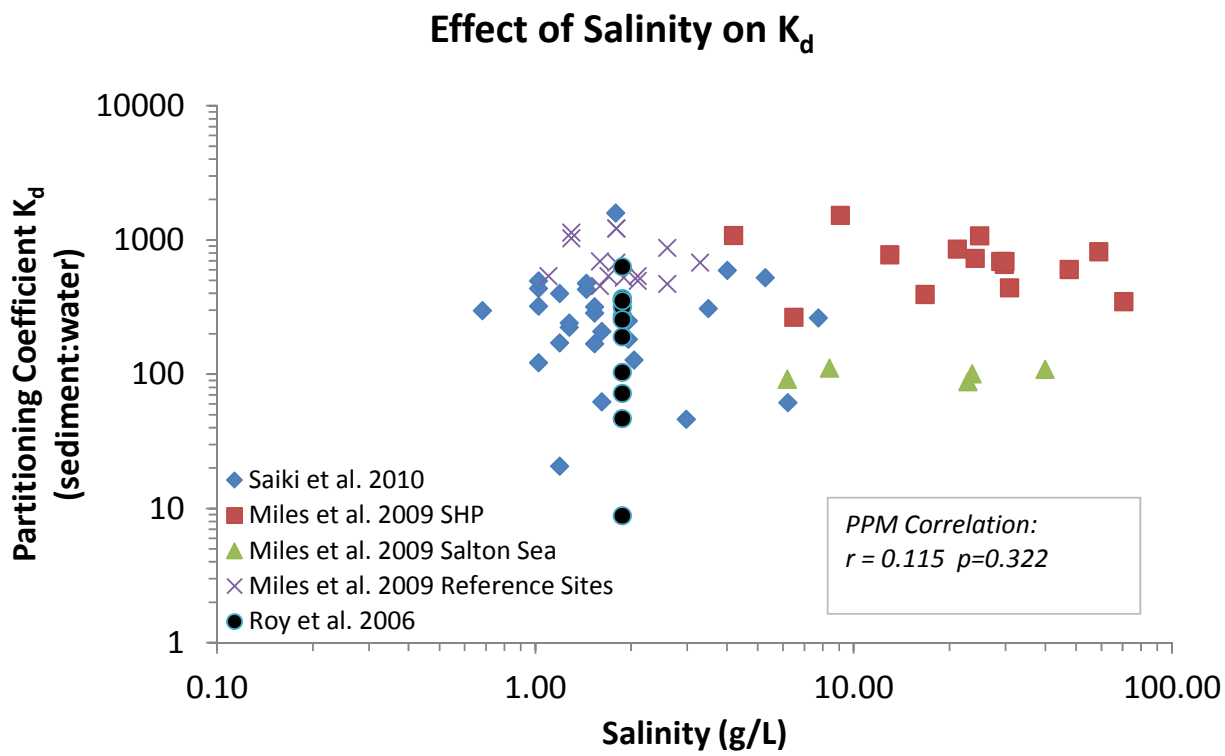
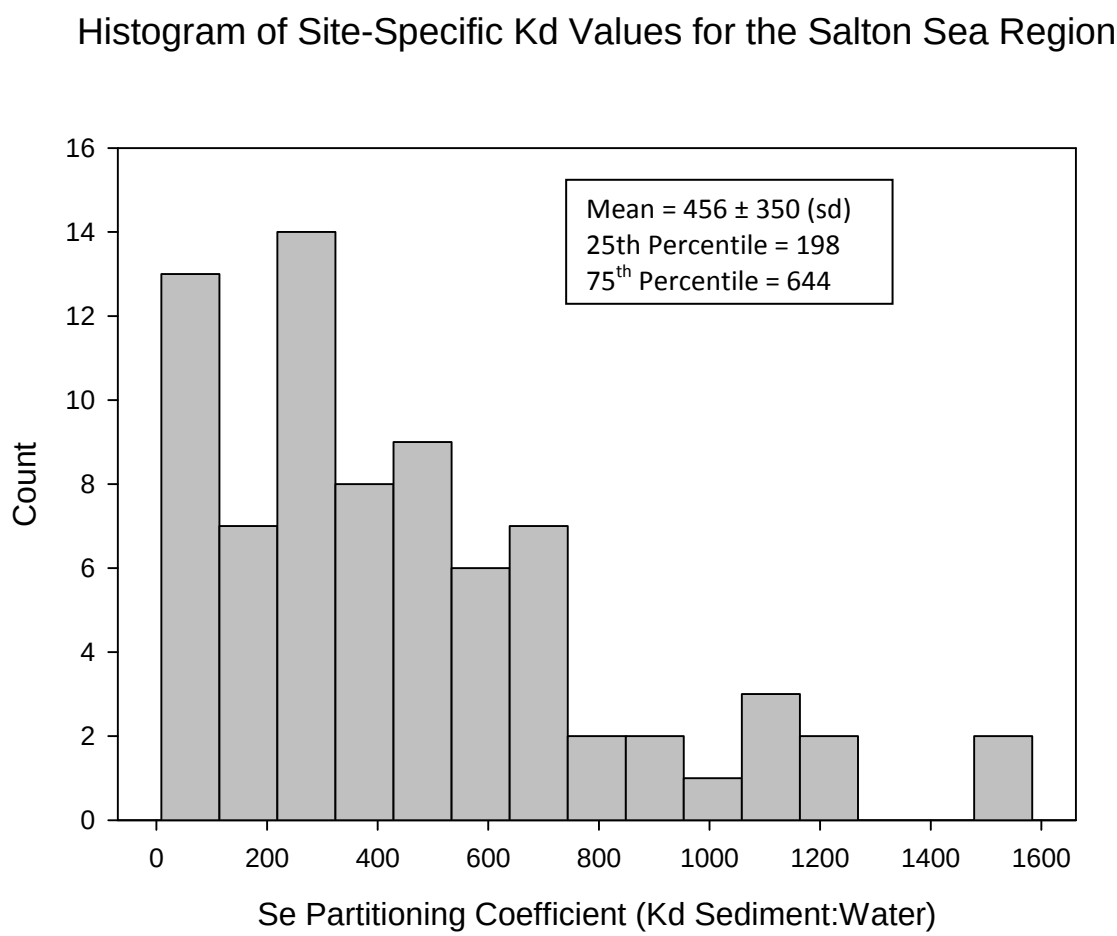


Figure 4. Relationship between salinity and Se partitioning coefficients (K_d) between sediment and water. Data from Saiki et al (2010), are the averages for salinity and K_d from 29 agricultural drains. No detailed data on salinity were available for the New River Demonstration Wetlands (Roy *et al.*, 2006) so we used the average of the highest and lowest values reported, 1.88 g/L (range = 1.38 to 2.39 g/L) to plot the data and for the correlation analysis. Each data point from Roy *et al.*, represents the average sediments Se level for multiple locations within the Brawley and Imperial wetlands sampled on a single day divided by the Se level in the outlet to the wetland. Pearson product moment correlation statistics are presented



Based on data from Saiki et al., (2010), Miles et al., (2009) and Roy et al., (2006)

Figure 5. Frequency distribution of site-specific partitioning coefficients (K_d) in the Salton Sea Region. K_d values are for the partitioning of Se between sediment and water.

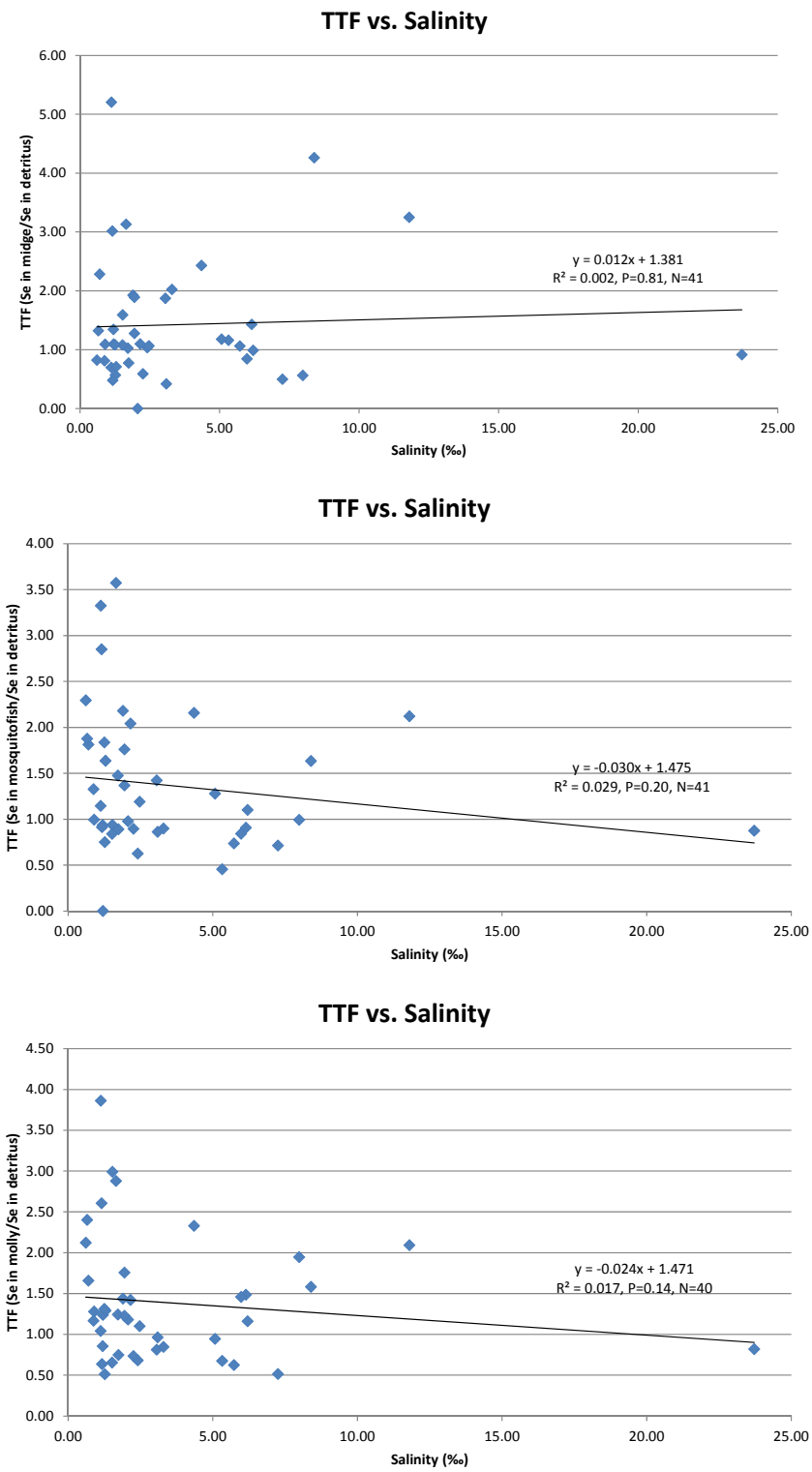


Figure 6. Relationship between salinity and site-specific trophic transfer factors between consumers and organic detritus in the Salton Sea region (personal communication M. Saiki USGS)

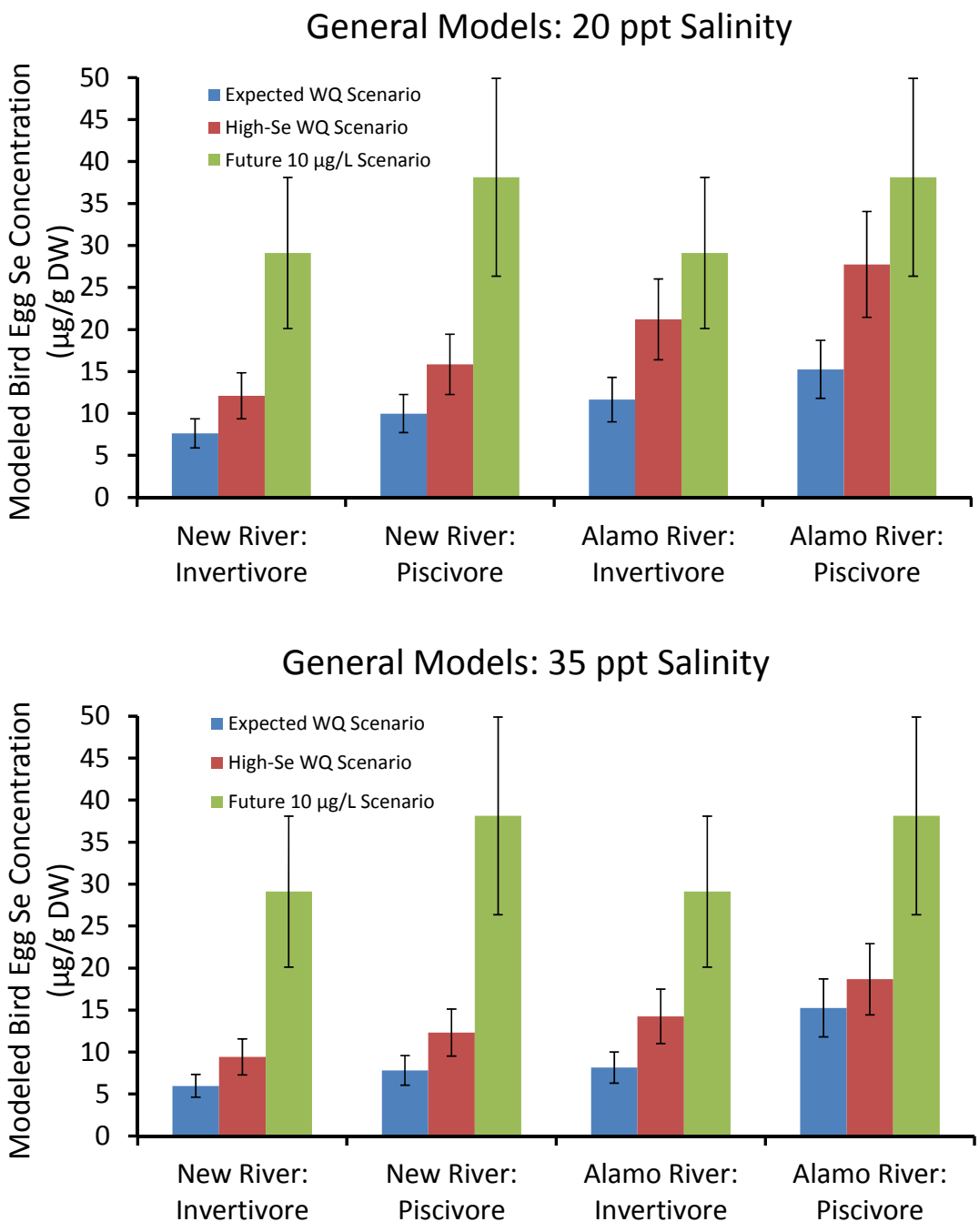


Figure 7a. Summary of bird egg Se concentrations predicted from General Models of the proposed SCH ponds constructed using variable mixtures of the Salton Sea, Alamo River and New River to attain 20 ppt and 35 ppt salinity. Also shown are results from modeling of a future scenario where only river water is used in the SCH ponds and Se_{total} concentration = 10 µg/L. Model parameters were computed from published data on water, sediment and biota Se concentrations within the Salton Sea region.

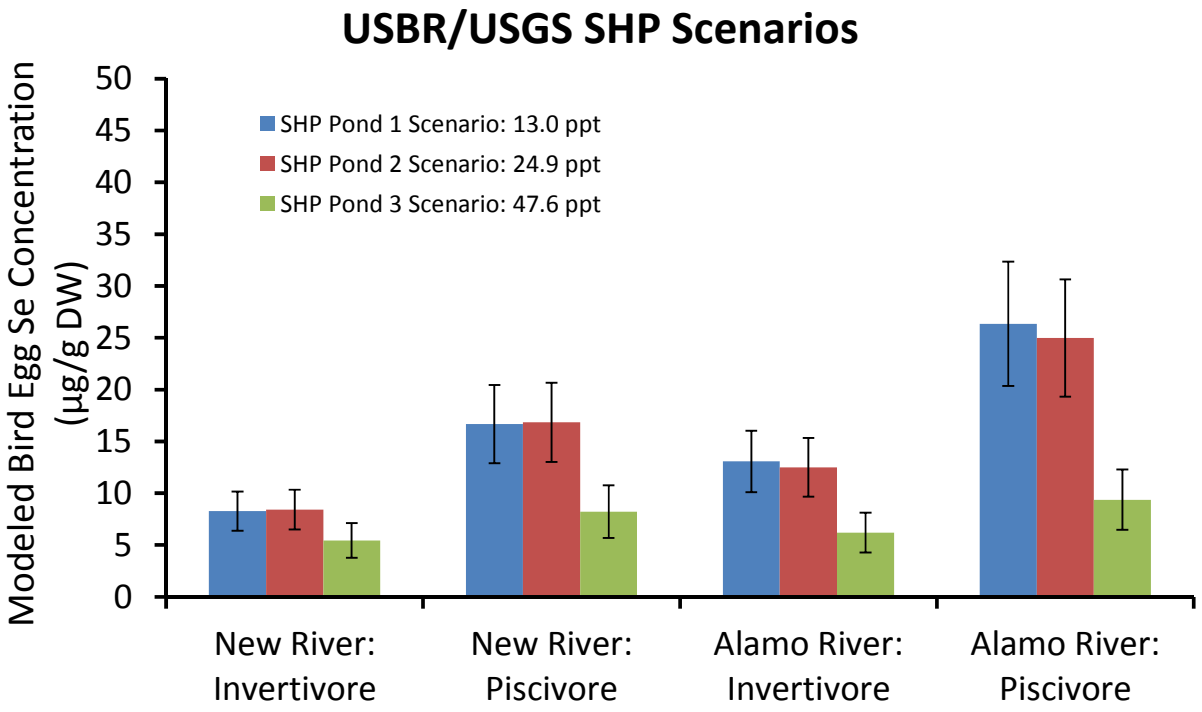
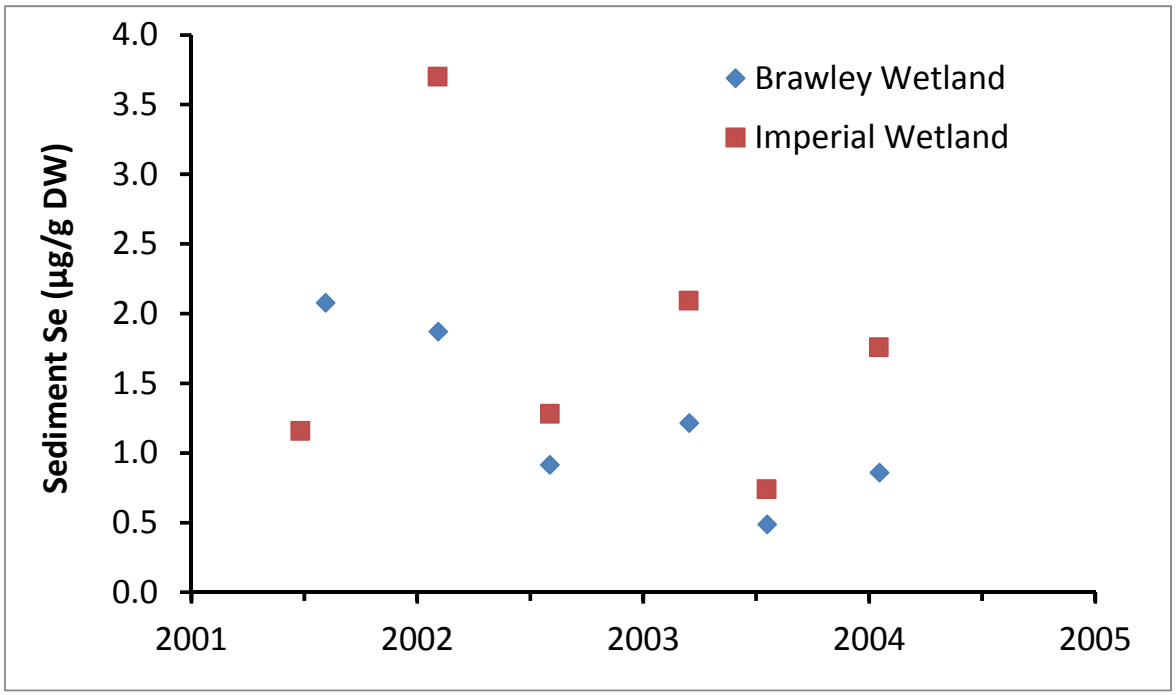


Figure 7b. Summary of bird egg Se concentrations predicted from modeling of the proposed SCH ponds constructed using variable mixtures of the Salton Sea, Alamo River and New River to attain 13 ppt, 24.0 ppt and 47.6 ppt salinity (Pond 1, Pond 2, Pond 3 scenarios, respectively). In these simulations, parameters were derived directly ponds 1, 2 and 3 of the US Bureau of Reclamation/USGS Saline Habitat Pond (SHP) experiment.



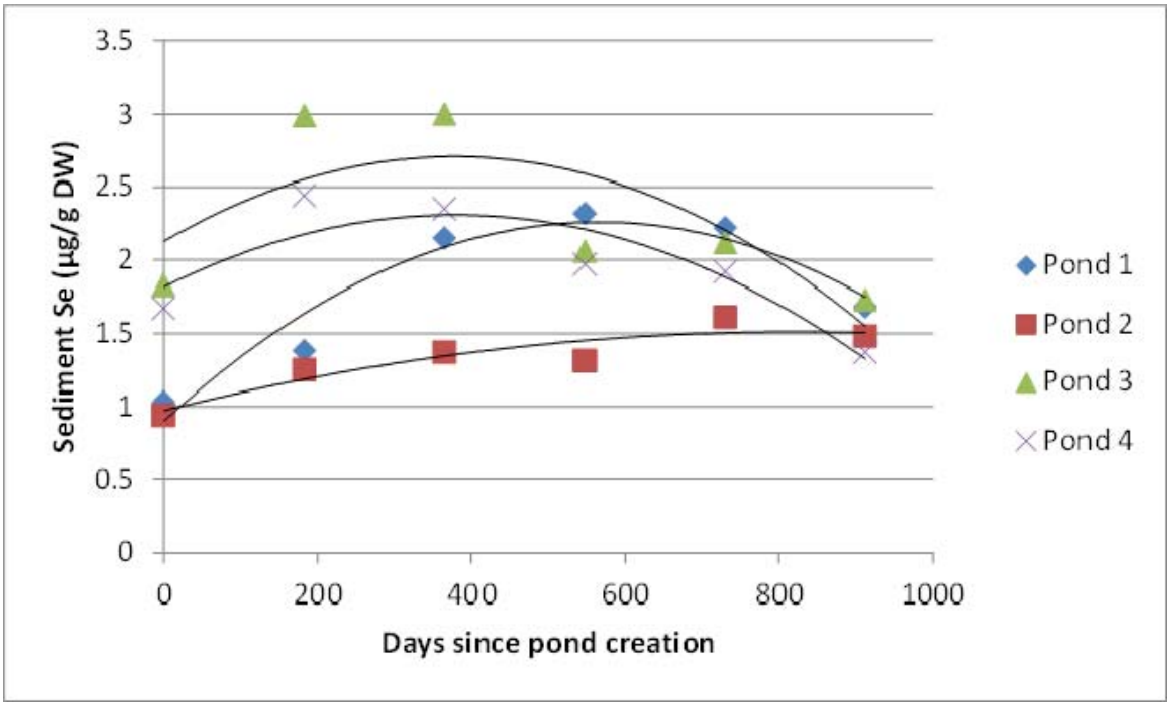


Figure 8. Time series of average sediment Se concentrations in constructed freshwater wetlands and USGS Saline Habitat Ponds and (data are from Roy *et al.*, 2006 and Miles *et al.*, 2009).

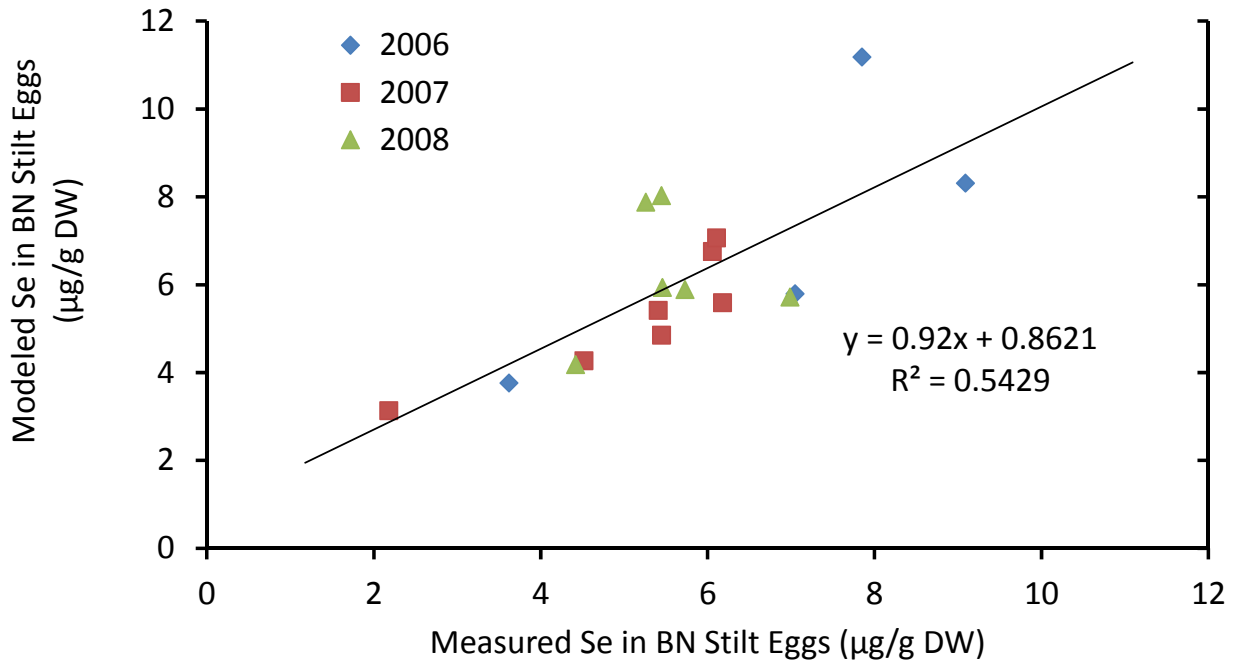
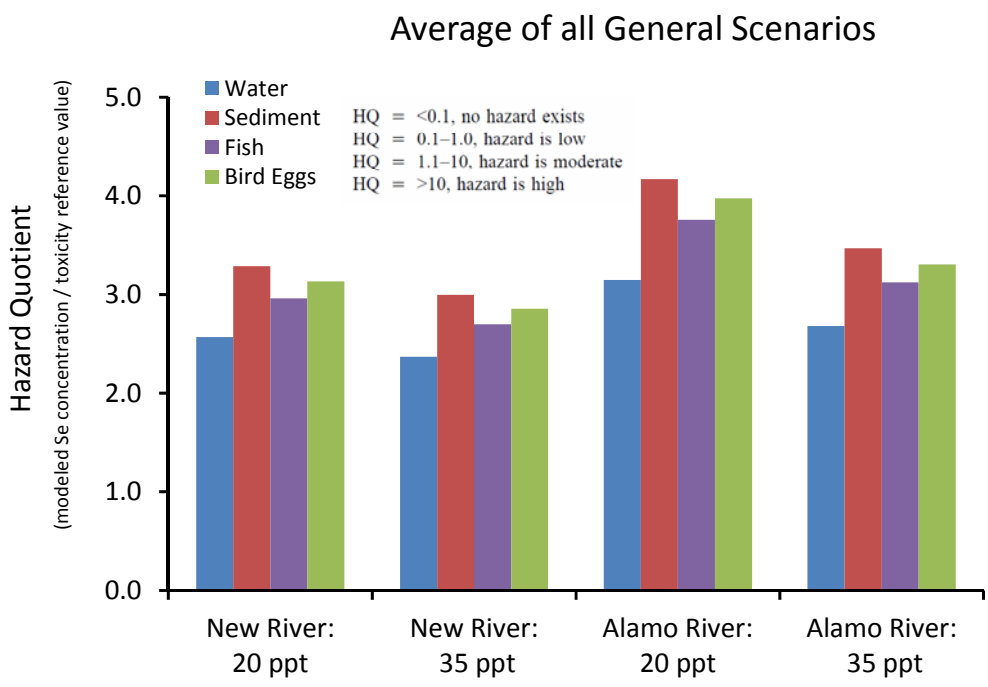


Figure 9. Validation of Se bioaccumulation models parameterized using data from the SHP ponds 1-4 and index sites (Morton Bay, Freshwater Marsh and D-Pond2) reported in Miles *et al.*, (2009). Average annual Se_{total} concentrations measured in each of three years: 2006, 2007 and 2008, were used with 2006-2008 median values for K_d and TTFs to predict Se concentrations in Black-necked stilt eggs.



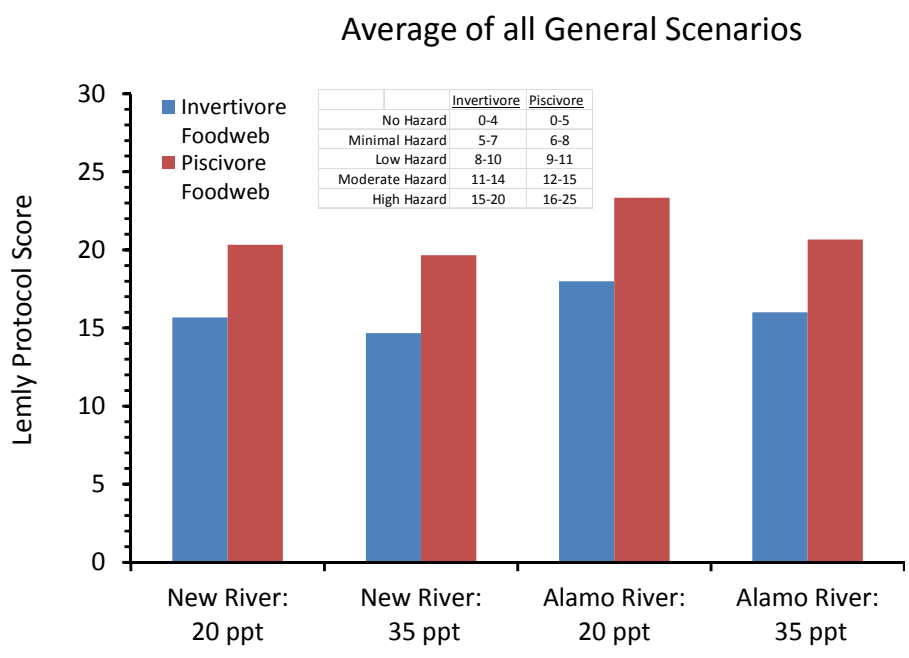
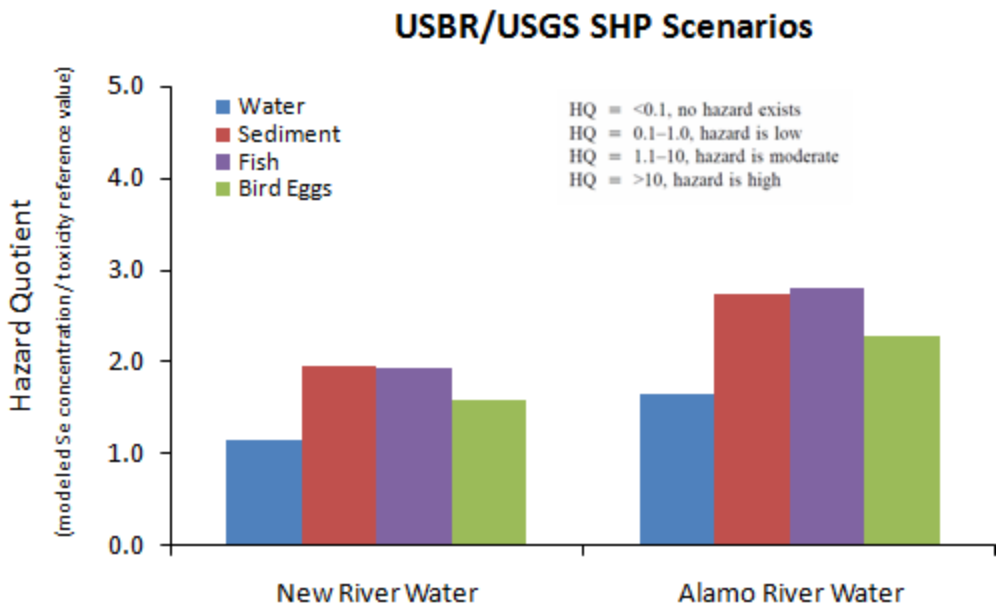
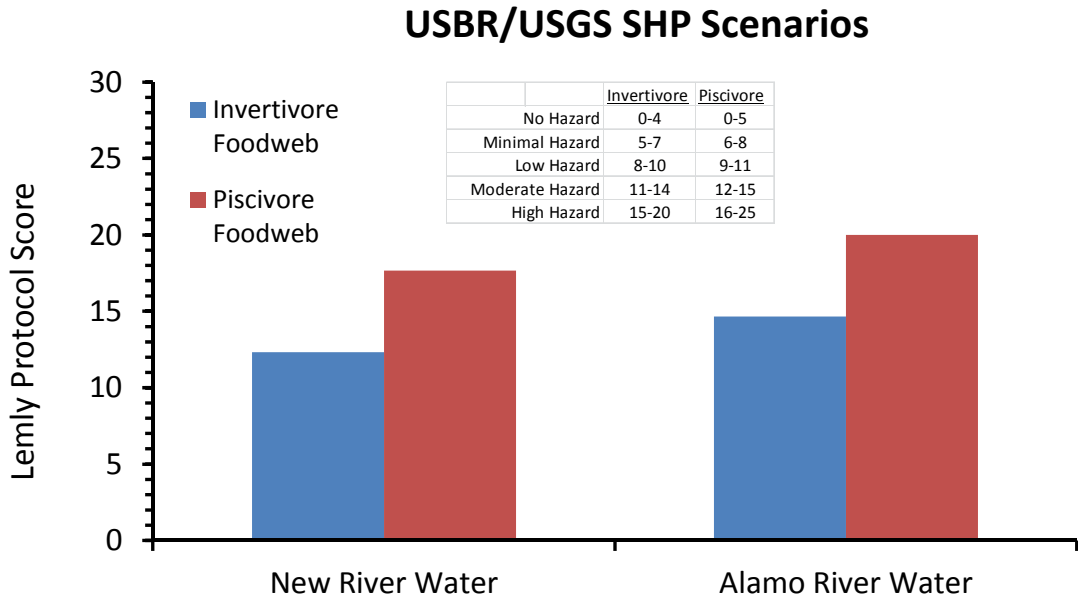


Figure 10a. Summary of Se hazards estimated using results from the general Se models and the hazard quotient method and Lemly Protocol method (Lemly 1996). Inset panels show qualitative interpretation of values in terms of Se hazard. See text for toxicity reference values used.





	Invertivore	Piscivore
No Hazard	0-4	0-5
Minimal Hazard	5-7	6-8
Low Hazard	8-10	9-11
Moderate Hazard	11-14	12-15
High Hazard	15-20	16-25

Figure 10b. Summary of Se hazards estimated using results from the USBR/USGS SHP Se models and the hazard quotient method and Lemly Protocol method (Lemly 1996). Inset panels show qualitative interpretation of values in terms of Se hazard. See text for toxicity reference values used.

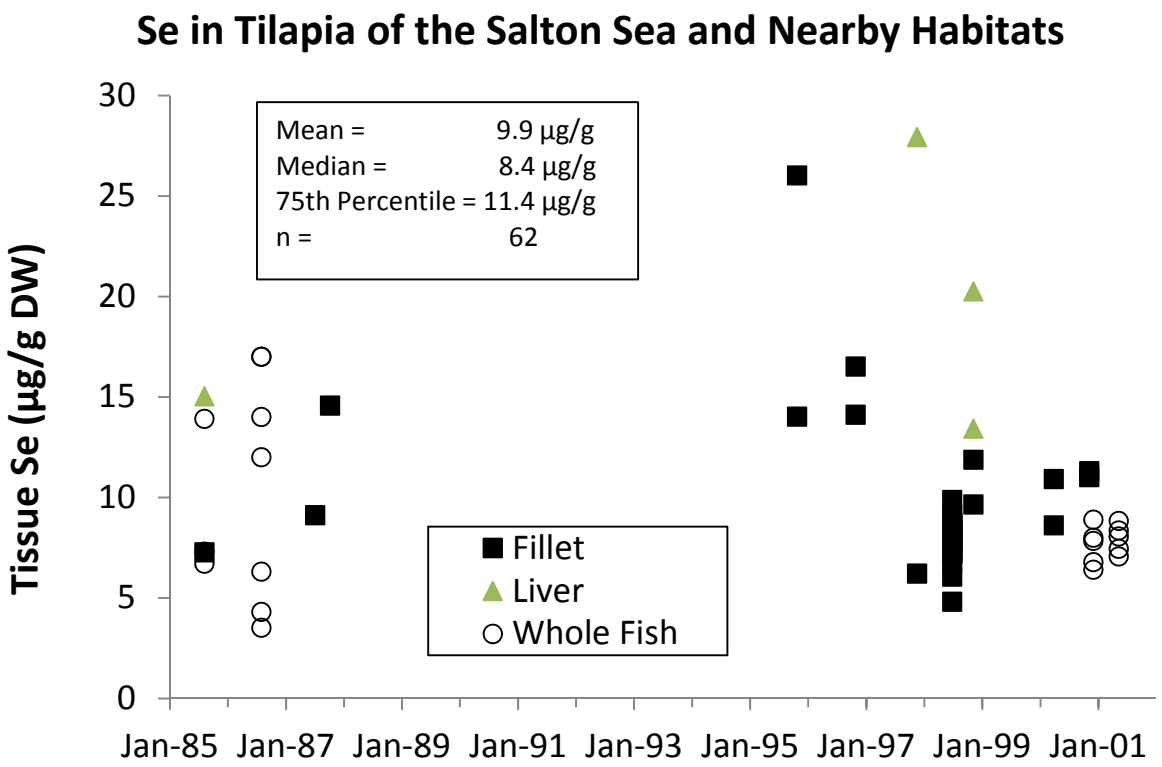


Figure 11. Se concentrations in tilapia from 1985 through 2001. Data are from Moreau *et al.*, (2007).

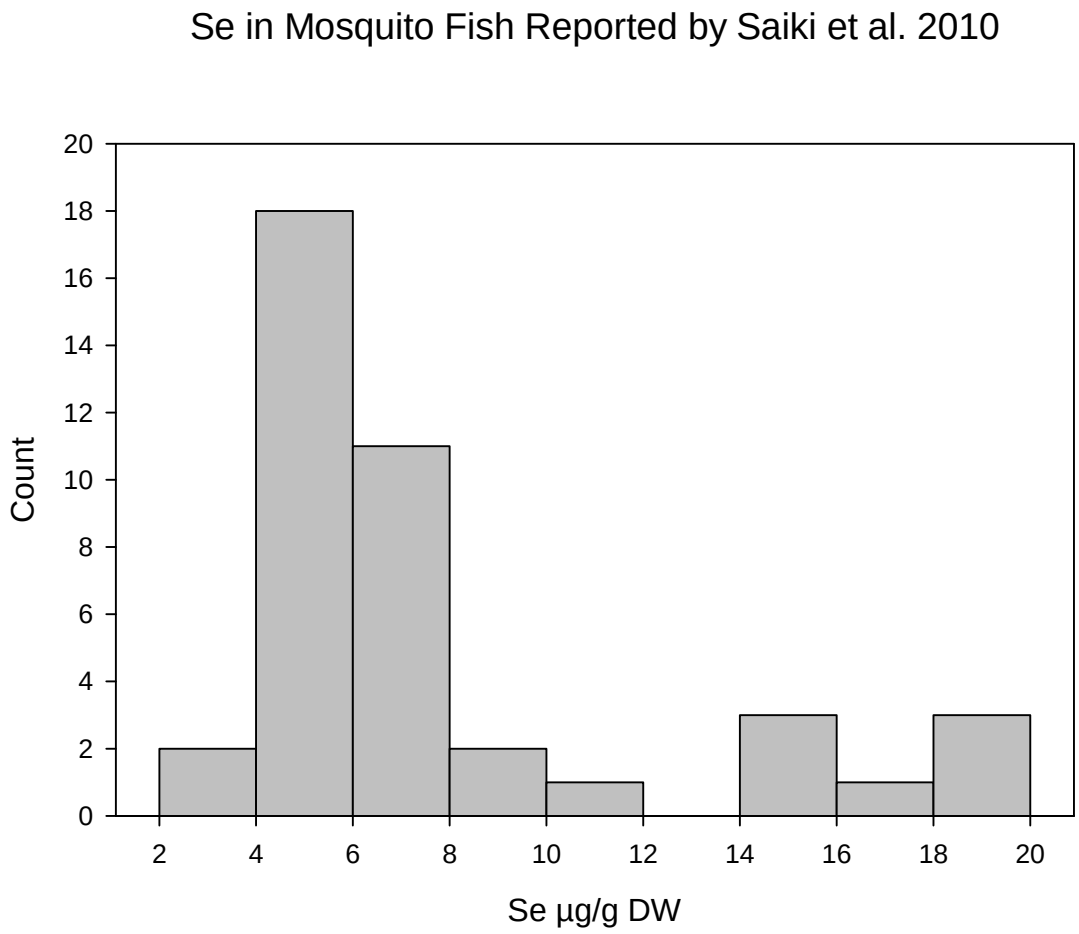


Figure 12. Se concentrations in mosquitofish collected in agricultural drains of the Imperial Valley from 2005-2009 by Saiki *et al.*, (2010).

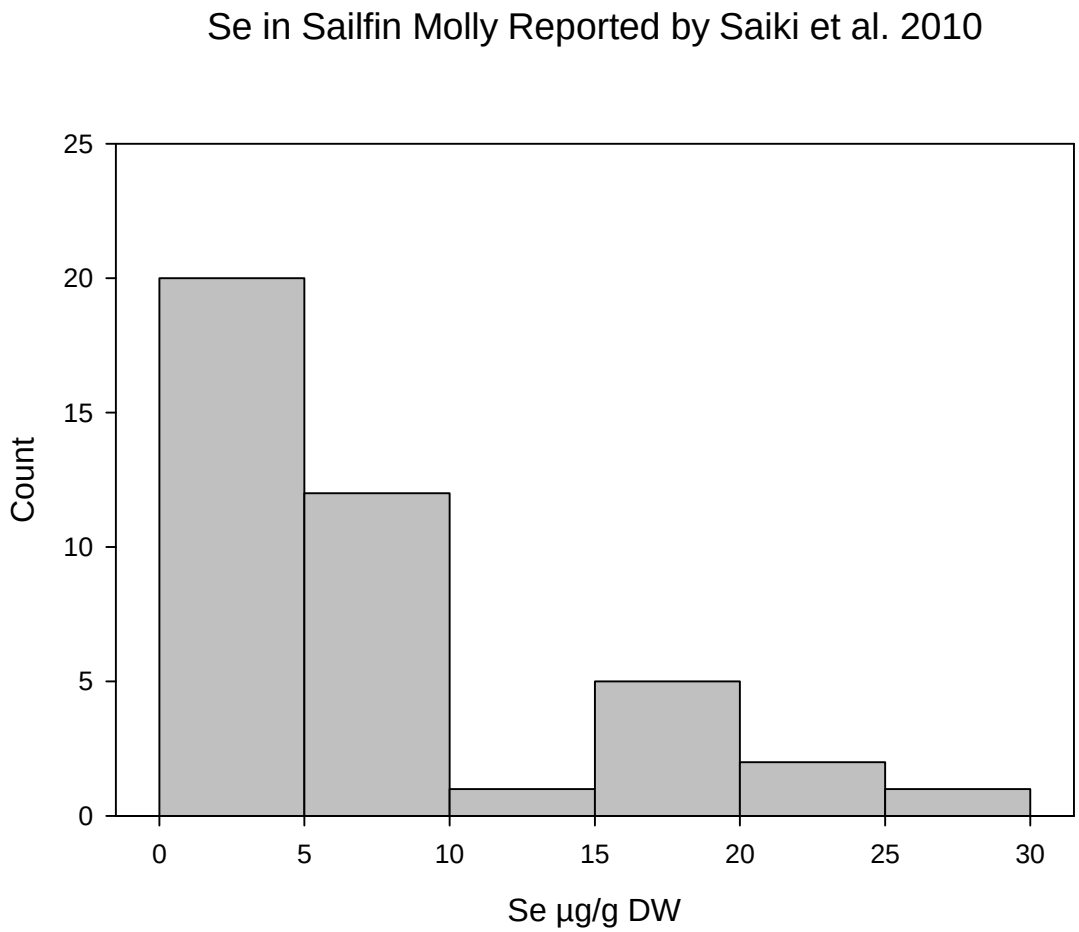
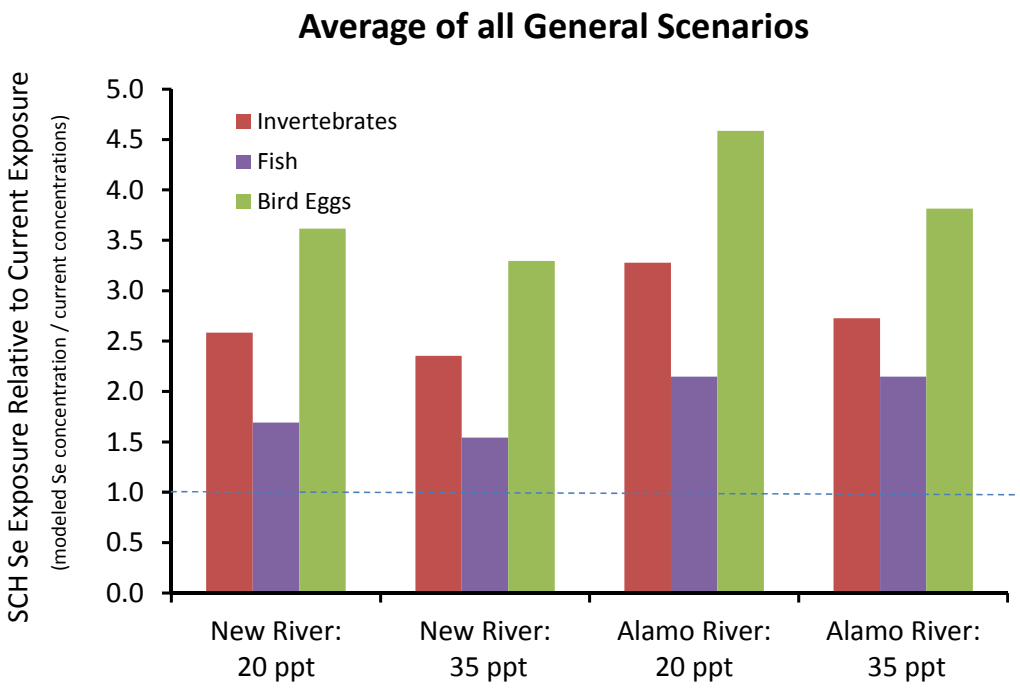


Figure 13. Se concentrations in sailfin molly collected in agricultural drains of the Imperial Valley from 2005-2009 by Saiki *et al.*, (2010).



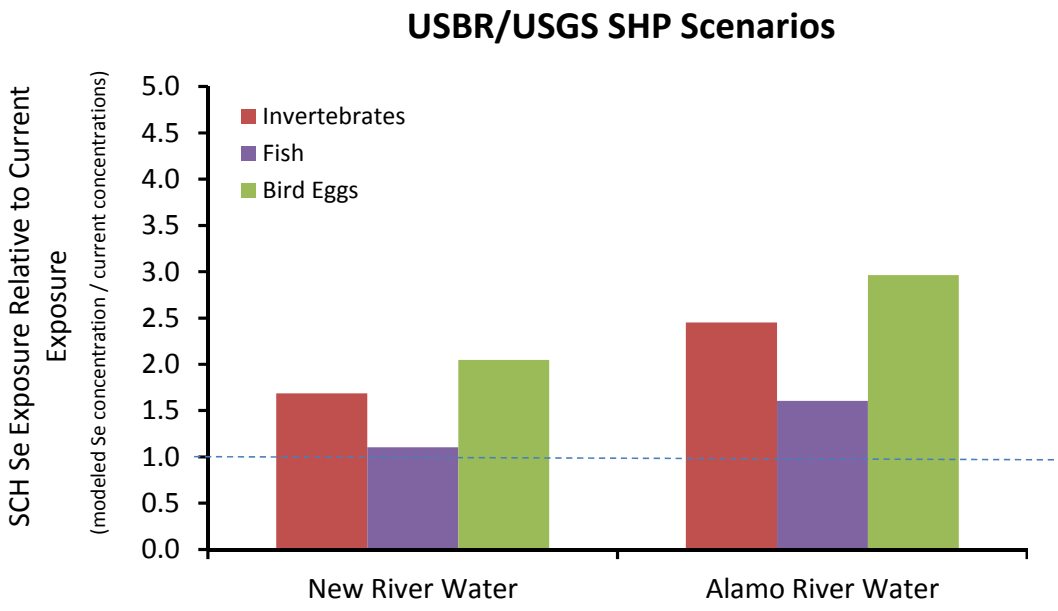


Figure 14. Summary of Se exposure in the SCH ponds relative to current Se exposure at the Salton Sea based on: General Models of Se bioaccumulation (upper panel) and SHP models (lower panel). Values of 1 indicate that modeled Se concentrations in invertebrates, fish tissues and bird eggs in the SCH are identical to current average concentrations in these organisms.

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APPENDIX

Table 1. Summary of model parameters used in Saline Habitat Ponds 1, 2 and 3 simulations of egg Se in invertebrate consuming birds. Also shown are estimates of average salinity and water residence time for these three SHP ponds derived from data in Miles *et al.*, (2009) and unpublished data from B. Barry and M. Anderson (UC Riverside). Since the SHP was a connected, flow-through experiment (Pond 1 drainage fed Pond 2; Pond 2 drainage fed Pond 3; Pond 3 drainage fed Pond 4), cumulative pond residence times include time spent in upstream ponds.

	Initial Salinity Level in Model (ppt)	**Se_{total} Resulting from Initial Salinity (New River/Alamo River Supply)**	**K_d Value in Model**	**$TTF_{1\ to\ 2}$ Value in Model**	**$TTF_{2\ to\ 3}$ Value in Model**	**Actual Dissolved Total Se in SHP (µg/L) (2006-2008 mean)**	**Actual Cumulative Pond Residence Time (days) (2006-2008 mean)**
SHP Pond 1	13.0	2.89/4.56	773	3.17	1.17	2.7	9.9
SHP Pond 2	24.9	2.43/3.61	689	4.26	1.18	1.7	36.3
SHP Pond 3	47.6	1.57/1.79	1247	1.78	1.56	2.0	70.2
Data Not Included in Models							
SHP Pond 4			600	1.10	2.02	3.8	Terminal Basin* (Mean Salinity 2006-2008 = 265 ppt)

**On occasion, water from Pond 4 was pumped into Pond 1 to increase Pond 1 salinity (B. Barry personal communication 11/14/2010).*

Se Bioaccumulation Modeling for the SCH Project

Table 2. Modeling output for simulations of Se levels in eggs of invertebrate consuming birds in an SCH supplied by the New River. In this simulation, New River and Salton Sea water were blended to produce 20 g/L salinity in simulations 1 and 2; simulation 3 had a set Se_{total} concentration of 10 µg/L. Modeling parameters are shown and were developed from a review of site specific data from the Salton Sea area.

New River 20 ppt Salinity Invertebrate Consuming Birds		**Model Parameters**			**Median Expected Case**	**95th and 75th Percentile Case**	**Future Scenario (10 µg/L) Rivers**				
				Kd	588	877	588				
Food Web Structure				$TTF_{1 \text{ to } 2}$	2.75	2.75	2.75				
Water→ Level 1 → Level 2 → Invertebrate Consuming Bird				$TTF_{2 \text{ to } 3}$	1.80	1.80	1.80				
										Bird Egg	
Simulation Number	**Simulation Conditions**	**SCH Salinity (ppt)**	**SCH Se_{total} (µg/L)**	**K_d**	**Se in Level 1 of Food Web (µg/g DW)**	**TTF Level 1 to Level 2**	**Se in Level 2 of Food Web (µg/g DW)**	**TTF Level 2 to Level 3**	**Se in Bird Egg (µg/g DW)**	***Lower 95% Confidence Limit***	***Upper 95% Confidence Limit***
1	Expected WQ Scenario with Median TTFs	20	2.62	588	**1.5**	2.75	**4.2**	1.80	**7.6**	***4.2***	***11.1***
2	95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	20	2.79	877	**2.4**	2.75	**6.7**	1.80	**12.1**	***6.6***	***17.6***
3	Future Scenario (10 µg/L) Rivers	NA	10.00	588	**5.9**	2.75	**16.2**	1.8	**29.1**	***11.1***	***47.1***

Risk Assessment For Simulation 1 (Median)

		TRV	**Hazard Quotient**	**Hazard Description**
Relative to Low Toxicity Reference Values	Water	2	1.31	Hazard is Moderate
	Sediment	1	1.54	Hazard is Moderate
	Bird Eggs	6	1.27	Hazard is Moderate

Protocol Scoring for For Simulation 1 (Median)

Hazard Profile for:	**Se Value**	**Score**	**Total Score for Ecosystem**	**Overall Hazard Characterization**
Water	2.6	3	12.0	**Moderate**
Sediment	1.5	2		
Macroinvert.	4.2	4		
Bird (eggs)	7.6	3		

Simulation 1 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	**Grand Mean**	**Ratio**
Macroinvert.	4.2	3.5	1.21
Bird (eggs)	7.6	5.2	1.47

Risk Assessment For Simulation 2 (75th and 95th %)

		TRV	**Hazard Quotient**	**Hazard Description**
Relative to Low Toxicity Reference Values	Water	2	1.39	Hazard is Moderate
	Sediment	1	2.44	Hazard is Moderate
	Bird Eggs	6	2.02	Hazard is Moderate

Protocol Scoring for For Simulation 2 (75th and 95th %)

Hazard Profile for:	**Se Value**	**Score**	**Total Score for Ecosystem**	**Overall Hazard Characterization**
Water	2.8	3	15.0	**High**
Sediment	2.4	3		
Macroinvert.	6.7	5		
Bird (eggs)	12.1	4		

Simulation 2 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	**Grand Mean**	**Ratio**
Macroinvert.	6.7	3.5	1.92
Bird (eggs)	12.1	5.2	2.33

Risk Assessment For Simulation 3 (Future 10 µg/L))

		TRV	**Hazard Quotient**	**Hazard Description**
Relative to Low Toxicity Reference Values	Water	2	5.00	Hazard is Moderate
	Sediment	1	5.88	Hazard is Moderate
	Bird Eggs	6	4.85	Hazard is Moderate

Protocol Scoring for For Simulation 3 (Future 10 µg/L)

Hazard Profile for:	**Se Value**	**Score**	**Total Score for Ecosystem**	**Overall Hazard Characterization**
Water	10.0	5	20.0	**High**
Sediment	5.9	5		
Macroinvert.	16.2	5		
Bird (eggs)	29.1	5		

Simulation 3 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	**Grand Mean**	**Ratio**
Macroinvert.	16.2	3.5	4.62
Bird (eggs)	29.1	5.2	5.60

Se Bioaccumulation Modeling for the SCH Project

Table 3. Modeling output for simulations of Se levels in eggs of invertebrate consuming birds in an SCH supplied by the New River. In this simulation, New River and Salton Sea water were blended to produce 35 g/L salinity in simulations 1 and 2; simulation 3 had a set Se_{total} concentration of 10 µg/L. Modeling parameters are shown and were developed from a review of site specific data from the Salton Sea area.

New River 35 ppt Salinity Invertebrate Consuming Birds		Model Parameters			Median Expected Case	95th and 75th Percentile Case	Future Scenario (10 µg/L) Rivers				
				Kd	588	877	588				
Food Web Structure				$TTF_{1 \text{ to } 2}$	2.75	2.75	2.75				
Water→ Level 1 → Level 2 → Invertebrate Consuming Bird				$TTF_{2 \text{ to } 3}$	1.80	1.80	1.80				
										Bird Egg	
Simulation Number	**Simulation Conditions**	**SCH Salinity (ppt)**	**SCH Se_{total} (µg/L)**	**K_d**	**Se in Level 1 of Food Web (µg/g DW)**	**TTF Level 1 to Level 2**	**Se in Level 2 of Food Web (µg/g DW)**	**TTF Level 2 to Level 3**	**Se in Bird Egg (µg/g DW)**	***Lower 95% Confidence Limit***	***Upper 95% Confidence Limit***
1	Expected WQ Scenario with Median TTFs	35	2.05	588	**1.2**	2.75	**3.3**	1.80	**6.0**	***3.3***	***8.7***
2	95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	35	2.17	877	**1.9**	2.75	**5.2**	1.80	**9.4**	***5.1***	***13.7***
3	Future Scenario (10 µg/L) Rivers	NA	10.00	588	**5.9**	2.75	**16.2**	1.8	**29.1**	***11.1***	***47.1***

Risk Assessment For Simulation 1 (Median)

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	1.02	Hazard is Moderate
	Sediment	1	1.20	Hazard is Moderate
	Bird Eggs	6	0.99	Hazard is Low

Protocol Scoring for For Simulation 1 (Median)

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	2.0	3	11.0	Moderate
Sediment	1.2	2		
Macroinvert.	3.3	3		
Bird (eggs)	6.0	3		

Simulation 1 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	3.3	3.5	0.95
Bird (eggs)	6.0	5.2	1.15

Risk Assessment For Simulation 2 (75th and 95th %)

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	1.08	Hazard is Moderate
	Sediment	1	1.90	Hazard is Moderate
	Bird Eggs	6	1.57	Hazard is Moderate

Protocol Scoring for For Simulation 2 (75th and 95th %)

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	2.2	3	13.0	Moderate
Sediment	1.9	2		
Macroinvert.	5.2	5		
Bird (eggs)	9.4	3		

Simulation 2 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	5.2	3.5	1.49
Bird (eggs)	9.4	5.2	1.81

Risk Assessment For Simulation 3 (Future 10 µg/L))

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	5.00	Hazard is Moderate
	Sediment	1	5.88	Hazard is Moderate
	Bird Eggs	6	4.85	Hazard is Moderate

Protocol Scoring for For Simulation 3 (Future 10 µg/L)

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	10.0	5	20.0	High
Sediment	5.9	5		
Macroinvert.	16.2	5		
Bird (eggs)	29.1	5		

Simulation 3 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	16.2	3.5	4.62
Bird (eggs)	29.1	5.2	5.60

Table 4. Modeling output for simulations of Se levels in eggs of fish consuming birds in an SCH supplied by the New River. In this simulation, New River and Salton Sea water were blended to produce 20 g/L salinity in simulations 1 and 2; simulation 3 had a set Se_{total} concentration of 10 µg/L. Modeling parameters are shown and were developed from a review of site specific data from the Salton Sea area.

New River 20 ppt Salinity Fish Consuming Birds		Model Parameters			Median Expected Case	95th and 75th Percentile Case	Future Scenario (10 µg/L) Rivers				
				Kd	588	877	588				
Food Web Structure				$TTF_{1 \text{ to } 2}$	2.75	2.75	2.75				
Water? Level 1 ? Level 2 ? Level 3 (Fish) ? Bird Piscivore				$TTF_{2 \text{ to } 3}$	1.31	1.31	1.31				
				$TTF_{3 \text{ to } 4}$	1.5	1.5	1.5		*Fish*		
Simulation Number	**Simulation Conditions**	**SCH Salinity (ppt)**	**SCH Se_{total} (µg/L)**	**K_d**	**Se in Level 1 of Food Web (µg/g DW)**	**TTF Level 1 to Level 2**	**Se in Level 2 of Food Web (µg/g DW)**	**TTF Level 2 to Level 3**	**Se in Level 3 of Food Web (µg/g DW)**	**TTF Level 3 to Piscivore**	**Se in Bird Egg (µg/g DW)**
1	Expected WQ Scenario with Median TTFs	20	2.62	588	**1.5**	2.75	**4.2**	1.31	**5.5**	1.5	**8.3**
2	95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	20	2.79	877	**2.4**	2.75	**6.7**	1.31	**8.8**	1.5	**13.2**
3	Future Scenario (10 µg/L) Rivers	NA	10.00	588	**5.9**	2.75	**16.2**	1.31	**21.2**	1.5	**31.8**

Risk Assessment For Simulation 1 (Median)

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	1.31	Hazard is Moderate
	Sediment	1	1.54	Hazard is Moderate
	Fish (Whole)	4	1.39	Hazard is Moderate
	Bird Eggs	6	1.39	Hazard is Moderate

Protocol Scoring for For Simulation 1 (Median)

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	2.6	3	16.0	High
Sediment	1.5	2		
Macroinvert.	4.2	4		
Fish (whole)	5.5	4		
Bird (eggs)	8.3	3		

Simulation 1 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	4.2	3.5	1.21
Fish (whole)	5.5	7.0	0.79
Bird (eggs)	8.3	5.2	1.60

Risk Assessment For Simulation 2 (75th and 95th %)

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	1.39	Hazard is Moderate
	Sediment	1	2.44	Hazard is Moderate
	Fish (Whole)	4	2.20	Hazard is Moderate
	Bird Eggs	6	2.20	Hazard is Moderate

Protocol Scoring for For Simulation 2 (75th and 95th %)

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	2.8	3	20.0	High
Sediment	2.4	3		
Macroinvert.	6.7	5		
Fish (whole)	8.8	5		
Bird (eggs)	13.2	4		

Simulation 2 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	6.7	3.5	1.92
Fish (whole)	8.8	7.0	1.26
Bird (eggs)	13.2	5.2	2.54

Risk Assessment For Simulation 3 (Future 10 µg/L))

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	5.00	Hazard is Moderate
	Sediment	1	5.88	Hazard is Moderate
	Fish (Whole)	4	5.30	Hazard is Moderate
	Bird Eggs	6	5.30	Hazard is Moderate

Protocol Scoring for For Simulation 3 (Future 10 µg/L)

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	10.0	5	25.0	High
Sediment	5.9	5		
Macroinvert.	16.2	5		
Fish (whole)	21.2	5		
Bird (eggs)	31.8	5		

Simulation 3 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	16.2	3.5	4.62
Fish (whole)	21.2	7.0	3.03
Bird (eggs)	31.8	5.2	6.11

Se Bioaccumulation Modeling for the SCH Project

Table 5. Modeling output for simulations of Se levels in eggs of fish consuming birds in an SCH supplied by the New River. In this simulation, New River and Salton Sea water were blended to produce 35 g/L salinity in simulations 1 and 2; simulation 3 had a set Se_{total} concentration of 10 µg/L. Modeling parameters are shown and were developed from a review of site specific data from the Salton Sea area.

New River 35 ppt Salinity Fish Consuming Birds		Model Parameters			Median Expected Case	95th and 75th Percentile Case	Future Scenario (10 µg/L) Rivers				
				Kd	588	877	588				
Food Web Structure				$TTF_{1 \text{ to } 2}$	2.75	2.75	2.75				
Water? Level 1 ? Level 2 ? Level 3 (Fish) ? Bird Piscivore				$TTF_{2 \text{ to } 3}$	1.31	1.31	1.31				
				$TTF_{3 \text{ to } 4}$	1.5	1.5	1.5		*Fish*		
Simulation Number	**Simulation Conditions**	**SCH Salinity (ppt)**	**SCH Se_{total} (µg/L)**	**K_d**	**Se in Level 1 of Food Web (µg/g DW)**	**TTF Level 1 to Level 2**	**Se in Level 2 of Food Web (µg/g DW)**	**TTF Level 2 to Level 3**	**Se in Level 3 of Food Web (µg/g DW)**	**TTF Level 3 to Piscivore**	**Se in Bird Egg (µg/g DW)**
1	Expected WQ Scenario with Median TTFs	35	2.05	588	**1.2**	2.75	**3.3**	1.31	**4.3**	1.5	**6.5**
2	95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	35	2.17	877	**1.9**	2.75	**5.2**	1.31	**6.9**	1.5	**10.3**
3	Future Scenario (10 µg/L) Rivers	NA	10.00	588	**5.9**	2.75	**16.2**	1.31	**21.2**	1.5	**31.8**

Risk Assessment For Simulation 1 (Median)

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	1.02	Hazard is Moderate
	Sediment	1	1.20	Hazard is Moderate
	Fish (Whole)	4	1.09	Hazard is Moderate
	Bird Eggs	6	1.09	Hazard is Moderate

Protocol Scoring for For Simulation 1 (Median)

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	2.0	3	15.0	Moderate
Sediment	1.2	2		
Macroinvert.	3.3	3		
Fish (whole)	4.3	4		
Bird (eggs)	6.5	3		

Simulation 1 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	3.3	3.5	0.95
Fish (whole)	4.3	7.0	0.62
Bird (eggs)	6.5	5.2	1.25

Risk Assessment For Simulation 2 (75th and 95th %)

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	1.08	Hazard is Moderate
	Sediment	1	1.90	Hazard is Moderate
	Fish (Whole)	4	1.71	Hazard is Moderate
	Bird Eggs	6	1.71	Hazard is Moderate

Protocol Scoring for For Simulation 2 (75th and 95th %)

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	2.2	3	18.0	High
Sediment	1.9	2		
Macroinvert.	5.2	5		
Fish (whole)	6.9	5		
Bird (eggs)	10.3	3		

Simulation 2 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	5.2	3.5	1.49
Fish (whole)	6.9	7.0	0.98
Bird (eggs)	10.3	5.2	1.98

Risk Assessment For Simulation 3 (Future 10 µg/L))

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	5.00	Hazard is Moderate
	Sediment	1	5.88	Hazard is Moderate
	Fish (Whole)	4	5.30	Hazard is Moderate
	Bird Eggs	6	5.30	Hazard is Moderate

Protocol Scoring for For Simulation 3 (Future 10 µg/L)

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	10.0	5	25.0	High
Sediment	5.9	5		
Macroinvert.	16.2	5		
Fish (whole)	21.2	5		
Bird (eggs)	31.8	5		

Simulation 3 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	16.2	3.5	4.62
Fish (whole)	21.2	7.0	3.03
Bird (eggs)	31.8	5.2	6.11

Se Bioaccumulation Modeling for the SCH Project

Table 6. Modeling output for simulations of Se levels in eggs of invertebrate consuming birds in an SCH supplied by the Alamo River. In this simulation, Alamo River and Salton Sea water were blended to produce 20 g/L salinity in simulations 1 and 2; simulation 3 had a set Se_{total} concentration of 10 µg/L. Modeling parameters are shown and were developed from a review of site specific data from the Salton Sea area.

Alamo River 20 ppt Salinity Invertebrate Consuming Birds		**Model Parameters**			**Median Expected Case**	**95th and 75th Percentile Case**	**Future Scenario (10 µg/L) Rivers**				
				Kd	588	877	588				
Food Web Structure				$TTF_{1 \text{ to } 2}$	2.75	2.75	2.75				
Water→ Level 1 → Level 2 →	Invertebrate Consuming Bird			$TTF_{2 \text{ to } 3}$	1.80	1.80	1.80				
										Bird Egg	
Simulation Number	**Simulation Conditions**	**SCH Salinity (ppt)**	**SCH Se_{total} (µg/L)**	**K_d**	**Se in Level 1 of Food Web (µg/g DW)**	**TTF Level 1 to Level 2**	**Se in Level 2 of Food Web (µg/g DW)**	**TTF Level 2 to Level 3**	**Se in Bird Egg (µg/g DW)**	***Lower 95% Confidence Limit***	***Upper 95% Confidence Limit***
1	Expected WQ Scenario with Median TTFs	20	4.00	588	**2.4**	2.75	**6.5**	1.80	**11.6**	***6.4***	***16.9***
2	95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	20	4.88	877	**4.3**	2.75	**11.8**	1.80	**21.2**	***11.6***	***30.8***
3	Future Scenario (10 µg/L) Rivers	NA	10.00	588	**5.9**	2.75	**16.2**	1.8	**29.1**	***11.1***	***47.1***

Risk Assessment For Simulation 1 (Median)

		TRV	**Hazard Quotient**	**Hazard Description**
Relative to Low Toxicity Reference Values	Water	2	2.00	Hazard is Moderate
	Sediment	1	2.35	Hazard is Moderate
	Bird Eggs	6	1.94	Hazard is Moderate

Protocol Scoring for For Simulation 1 (Median)

Hazard Profile for:	**Se Value**	**Score**	**Total Score for Ecosystem**	**Overall Hazard Characterization**
Water	4.0	4	15.0	**High**
Sediment	2.4	3		
Macroinvert.	6.5	5		
Bird (eggs)	11.6	3		

Simulation 1 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	**Grand Mean**	**Ratio**
Macroinvert.	6.5	3.5	1.85
Bird (eggs)	11.6	5.2	2.24

Risk Assessment For Simulation 2 (75th and 95th %)

		TRV	**Hazard Quotient**	**Hazard Description**
Relative to Low Toxicity Reference Values	Water	2	2.44	Hazard is Moderate
	Sediment	1	4.28	Hazard is Moderate
	Bird Eggs	6	3.53	Hazard is Moderate

Protocol Scoring for For Simulation 2 (75th and 95th %)

Hazard Profile for:	**Se Value**	**Score**	**Total Score for Ecosystem**	**Overall Hazard Characterization**
Water	4.9	4	19.0	**High**
Sediment	4.3	5		
Macroinvert.	11.8	5		
Bird (eggs)	21.2	5		

Simulation 2 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	**Grand Mean**	**Ratio**
Macroinvert.	11.8	3.5	3.36
Bird (eggs)	21.2	5.2	4.08

Risk Assessment For Simulation 3 (Future 10 µg/L))

		TRV	**Hazard Quotient**	**Hazard Description**
Relative to Low Toxicity Reference Values	Water	2	5.00	Hazard is Moderate
	Sediment	1	5.88	Hazard is Moderate
	Bird Eggs	6	4.85	Hazard is Moderate

Protocol Scoring for For Simulation 3 (Future 10 µg/L)

Hazard Profile for:	**Se Value**	**Score**	**Total Score for Ecosystem**	**Overall Hazard Characterization**
Water	10.0	5	20.0	**High**
Sediment	5.9	5		
Macroinvert.	16.2	5		
Bird (eggs)	29.1	5		

Simulation 3 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	**Grand Mean**	**Ratio**
Macroinvert.	16.2	3.5	4.62
Bird (eggs)	29.1	5.2	5.60

Se Bioaccumulation Modeling for the SCH Project

Table 7.Modeling output for simulations of Se levels in eggs of invertebrate consuming birds in an SCH supplied by the Alamo River. In this simulation, Alamo River and Salton Sea water were blended to produce 35 g/L salinity in simulations 1 and 2; simulation 3 had a set Se_{total} concentration of 10 µg/L. Modeling parameters are shown and were developed from a review of site specific data from the Salton Sea area.

Alamo River 35 ppt Salinity Invertebrate Consuming Birds		Model Parameters			Median Expected Case	95th and 75th Percentile Case	Future Scenario (10 µg/L) Rivers				
				Kd	588	877	588				
Food Web Structure				$TTF_{1 \text{ to } 2}$	2.75	2.75	2.75				
Water→ Level 1 → Level 2 →	Invertebrate Consuming Bird			$TTF_{2 \text{ to } 3}$	1.80	1.80	1.80				
										Bird Egg	
Simulation Number	**Simulation Conditions**	**SCH Salinity (ppt)**	**SCH Se_{total} (µg/L)**	**K_d**	**Se in Level 1 of Food Web (µg/g DW)**	**TTF Level 1 to Level 2**	**Se in Level 2 of Food Web (µg/g DW)**	**TTF Level 2 to Level 3**	**Se in Bird Egg (µg/g DW)**	***Lower 95% Confidence Limit***	***Upper 95% Confidence Limit***
1	Expected WQ Scenario with Median TTFs	35	2.80	588	**1.6**	2.75	**4.5**	1.80	**8.1**	***4.4***	***11.8***
2	95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	35	3.28	877	**2.9**	2.75	**7.9**	1.80	**14.3**	***7.8***	***20.7***
3	Future Scenario (10 µg/L) Rivers	NA	10.00	588	**5.9**	2.75	**16.2**	1.8	**29.1**	***11.1***	***47.1***

Risk Assessment For Simulation 1 (Median)

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	1.40	Hazard is Moderate
	Sediment	1	1.65	Hazard is Moderate
	Bird Eggs	6	1.36	Hazard is Moderate

Protocol Scoring for For Simulation 1 (Median)

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	2.8	3	12.0	Moderate
Sediment	1.6	2		
Macroinvert.	4.5	4		
Bird (eggs)	8.1	3		

Simulation 1 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	4.5	3.5	1.29
Bird (eggs)	8.1	5.2	1.57

Risk Assessment For Simulation 2 (75th and 95th %)

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	1.64	Hazard is Moderate
	Sediment	1	2.88	Hazard is Moderate
	Bird Eggs	6	2.38	Hazard is Moderate

Protocol Scoring for For Simulation 2 (75th and 95th %)

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	3.3	4	16.0	High
Sediment	2.9	3		
Macroinvert.	7.9	5		
Bird (eggs)	14.3	4		

Simulation 2 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	7.9	3.5	2.26
Bird (eggs)	14.3	5.2	2.74

Risk Assessment For Simulation 3 (Future 10 µg/L))

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	5.00	Hazard is Moderate
	Sediment	1	5.88	Hazard is Moderate
	Bird Eggs	6	4.85	Hazard is Moderate

Protocol Scoring for For Simulation 3 (Future 10 µg/L)

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	10.0	5	20.0	High
Sediment	5.9	5		
Macroinvert.	16.2	5		
Bird (eggs)	29.1	5		

Simulation 3 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	16.2	3.5	4.62
Bird (eggs)	29.1	5.2	5.60

Se Bioaccumulation Modeling for the SCH Project

Table 8. Modeling output for simulations of Se levels in eggs of fish consuming birds in an SCH supplied by the Alamo River. In this simulation, Alamo River and Salton Sea water were blended to produce 20 g/L salinity in simulations 1 and 2; simulation 3 had a set Se_{total} concentration of 10 µg/L. Modeling parameters are shown and were developed from a review of site specific data from the Salton Sea area.

Alamo River 20 ppt Salinity Fish Consuming Birds		Model Parameters			Median Expected Case	95th and 75th Percentile Case	Future Scenario (10 µg/L) Rivers			
				Kd	588	877	588			
Food Web Structure				$TTF_{1 \text{ to } 2}$	2.75	2.75	2.75			
Water? Level 1 ? Level 2 ? Level 3 (Fish) ? Bird Piscivore				$TTF_{2 \text{ to } 3}$	1.31	1.31	1.31			
				$TTF_{3 \text{ to } 4}$	1.5	1.5	1.5		*Fish*	
Simulation Number	**Simulation Conditions**	**SCH Salinity (ppt)**	**SCH Se_{total} (µg/L)**	**K_d**	**Se in Level 1 of Food Web (µg/g DW)**	**TTF Level 1 to Level 2**	**Se in Level 2 of Food Web (µg/g DW)**	**TTF Level 2 to Level 3**	**Se in Level 3 of Food Web (µg/g DW)**	**TTF Level 3 to Piscivore**
1	Expected WQ Scenario with Median TTFs	20	4.00	588	**2.4**	2.75	**6.5**	1.31	**8.5**	1.5
2	95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	20	4.88	877	**4.3**	2.75	**11.8**	1.31	**15.4**	1.5
3	Future Scenario (10 µg/L) Rivers	NA	10.00	588	**5.9**	2.75	**16.2**	1.31	**21.2**	1.5

Risk Assessment For Simulation 1 (Median)

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	2.00	Hazard is Moderate
	Sediment	1	2.35	Hazard is Moderate
	Fish (Whole)	4	2.12	Hazard is Moderate
	Bird Eggs	6	2.12	Hazard is Moderate

Protocol Scoring for For Simulation 1 (Median)

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	4.0	4	21.0	High
Sediment	2.4	3		
Macroinvert.	6.5	5		
Fish (whole)	8.5	5		
Bird (eggs)	12.7	4		

Simulation 1 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	6.5	3.5	1.85
Fish (whole)	8.5	7.0	1.21
Bird (eggs)	12.7	5.2	2.44

Risk Assessment For Simulation 2 (75th and 95th %)

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	2.44	Hazard is Moderate
	Sediment	1	4.28	Hazard is Moderate
	Fish (Whole)	4	3.86	Hazard is Moderate
	Bird Eggs	6	3.86	Hazard is Moderate

Protocol Scoring for For Simulation 2 (75th and 95th %)

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	4.9	4	24.0	High
Sediment	4.3	5		
Macroinvert.	11.8	5		
Fish (whole)	15.4	5		
Bird (eggs)	23.1	5		

Simulation 2 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	11.8	3.5	3.36
Fish (whole)	15.4	7.0	2.20
Bird (eggs)	23.1	5.2	4.45

Risk Assessment For Simulation 3 (Future 10 µg/L))

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	5.00	Hazard is Moderate
	Sediment	1	5.88	Hazard is Moderate
	Fish (Whole)	4	5.30	Hazard is Moderate
	Bird Eggs	6	5.30	Hazard is Moderate

Protocol Scoring for For Simulation 3 (Future 10 µg/L)

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	10.0	5	25.0	High
Sediment	5.9	5		
Macroinvert.	16.2	5		
Fish (whole)	21.2	5		
Bird (eggs)	31.8	5		

Simulation 3 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	16.2	3.5	4.62
Fish (whole)	21.2	7.0	3.03
Bird (eggs)	31.8	5.2	6.11

Table 9. Modeling output for simulations of Se levels in eggs of fish consuming birds in an SCH supplied by the Alamo River. In this simulation, Alamo River and Salton Sea water were blended to produce 35 g/L salinity in simulations 1 and 2; simulation 3 had a set Se_{total} concentration of 10 µg/L. Modeling parameters are shown and were developed from a review of site specific data from the Salton Sea area.

Alamo River 35 ppt Salinity Fish Consuming Birds		Model Parameters			Median Expected Case	95th and 75th Percentile Case	Future Scenario (10 µg/L) Rivers				
				Kd	588	877	588				
Food Web Structure				$TTF_{1 \text{ to } 2}$	2.75	2.75	2.75				
Water? Level 1 ? Level 2 ? Level 3 (Fish) ? Bird Piscivore				$TTF_{2 \text{ to } 3}$	1.31	1.31	1.31				
				$TTF_{3 \text{ to } 4}$	1.5	1.5	1.5		*Fish*		
Simulation Number	**Simulation Conditions**	**SCH Salinity (ppt)**	**SCH Se_{total} (µg/L)**	**K_d**	**Se in Level 1 of Food Web (µg/g DW)**	**TTF Level 1 to Level 2**	**Se in Level 2 of Food Web (µg/g DW)**	**TTF Level 2 to Level 3**	**Se in Level 3 of Food Web (µg/g DW)**	**TTF Level 3 to Piscivore**	**Se in Bird Egg (µg/g DW)**
1	Expected WQ Scenario with Median TTFs	35	2.80	588	**1.6**	2.75	**4.5**	1.31	**5.9**	1.5	**8.9**
2	95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	35	3.28	877	**2.9**	2.75	**7.9**	1.31	**10.4**	1.5	**15.6**
3	Future Scenario (10 µg/L) Rivers	NA	10.00	588	**5.9**	2.75	**16.2**	1.31	**21.2**	1.5	**31.8**

Risk Assessment For Simulation 1 (Median)

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	1.40	Hazard is Moderate
	Sediment	1	1.65	Hazard is Moderate
	Fish (Whole)	4	1.48	Hazard is Moderate
	Bird Eggs	6	1.48	Hazard is Moderate

Protocol Scoring for For Simulation 1 (Median)

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	2.8	3	16.0	High
Sediment	1.6	2		
Macroinvert.	4.5	4		
Fish (whole)	5.9	4		
Bird (eggs)	8.9	3		

Simulation 1 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	4.5	3.5	1.29
Fish (whole)	5.9	7.0	0.85
Bird (eggs)	8.9	5.2	1.71

Risk Assessment For Simulation 2 (75th and 95th %)

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	1.64	Hazard is Moderate
	Sediment	1	2.88	Hazard is Moderate
	Fish (Whole)	4	2.59	Hazard is Moderate
	Bird Eggs	6	2.59	Hazard is Moderate

Protocol Scoring for For Simulation 2 (75th and 95th %)

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	3.3	4	21.0	High
Sediment	2.9	3		
Macroinvert.	7.9	5		
Fish (whole)	10.4	5		
Bird (eggs)	15.6	4		

Simulation 2 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	7.9	3.5	2.26
Fish (whole)	10.4	7.0	1.48
Bird (eggs)	15.6	5.2	2.99

Risk Assessment For Simulation 3 (Future 10 µg/L))

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	5.00	Hazard is Moderate
	Sediment	1	5.88	Hazard is Moderate
	Fish (Whole)	4	5.30	Hazard is Moderate
	Bird Eggs	6	5.30	Hazard is Moderate

Protocol Scoring for For Simulation 3 (Future 10 µg/L)

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	10.0	5	25.0	High
Sediment	5.9	5		
Macroinvert.	16.2	5		
Fish (whole)	21.2	5		
Bird (eggs)	31.8	5		

Simulation 3 Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	16.2	3.5	4.62
Fish (whole)	21.2	7.0	3.03
Bird (eggs)	31.8	5.2	6.11

Table 10a. Inverse modeling output for simulations of required salinity levels to produce bird eggs with <6, <8 and <12 µg/g Se DW in an SCH supplied by the Alamo River. Note: unattainable values denote situations where, even if only Salton Sea water were used in the SCH, the target bird egg Se value could not be attained.

Alamo River Inverse Model Invertebrate Consuming Birds		**Model Parameters**			**Median Expected Case**	**95th and 75th Percentile Case**			
Salinity requirement to protect bird reproduction				Kd	588	877			
				$TTF_{1 \text{ to } 2}$	2.75	2.75			
Food Web Structure				$TTF_{2 \text{ to } 3}$	1.80	1.80			
Water ← Level 1 ← Level 2 ← Invertebrate Consuming Bird									
Simulation Number	**Simulation Conditions**	**Required SCH Salinity (ppt)**	**Required SCH Se_{total} (µg/L)**	**K_d**	**Se in Level 1 of Food Web (µg/g DW)**	**TTF Level 1 to Level 2**	**Se in Level 2 of Food Web (µg/g DW)**	**TTF Level 2 to Level 3**	**Se in Bird Egg (µg/g DW)**
1	Expected WQ Scenario with Median TTFs	**44**	2.06	588	1.2	2.75	3.3	1.80	**6.0**
									←
2	95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	**unattainable**	1.38	877	1.2	2.75	3.3	1.80	**6.0**
									←
3	Expected WQ Scenario with Median TTFs	**36**	2.75	588	1.6	2.75	4.4	1.80	**8.0**
									←
4	95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	**49**	1.84	877	1.6	2.75	4.4	1.80	**8.0**
									←
5	Expected WQ Scenario with Median TTFs	**18**	4.12	588	2.4	2.75	6.7	1.80	**12.0**
									←
6	95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	**40**	2.76	877	2.4	2.75	6.7	1.80	**12.0**
									←

Table 10b. Inverse modeling output for simulations of required salinity levels to produce bird eggs with <6, <8 and <12 µg/g Se DW in an SCH supplied by the Alamo River. Note: unattainable values denote situations where, even if only Salton Sea water were used in the SCH, the target bird egg Se value could not be attained.

Alamo River Inverse Model Fish Consuming Birds		**Model Parameters**			**Median Expected Case**	**95th and 75th Percentile Case**	**Saline Habitat Pond 3 Scenario**				
Salinity requirement to protect bird reproduction				Kd	588	877	1247				
				$TTF_{1 \text{ to } 2}$	2.75	2.75	1.78				
Food Web Structure				$TTF_{2 \text{ to } 3}$	1.31	1.31	1.31				
Water? Level 1 ? Level 2 ? Level 3 (Fish) ? Bird Piscivore				$TTF_{3 \text{ to } 4}$	1.5	1.5	1.5				
Simulation Number	**Simulation Conditions**	**Required SCH Salinity (ppt)**	**Required SCH Se_{total} (µg/L)**	**K_d**	**Se in Level 1 of Food Web (µg/g DW)**	**TTF Level 1 to Level 2**	**Se in Level 2 of Food Web (µg/g DW)**	**TTF Level 2 to Level 3**	**Se in Level 3 of Food Web (µg/g DW)**	**TTF Level 3 to Piscivore**	**Se in Bird Egg (µg/g DW)**
1	Expected WQ Scenario with Median TTFs	**46**	1.89	588	1.1	2.75	3.1	1.31	4.0	1.5	**6.0**
											?
2	95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	**54**	1.27	877	1.1	2.75	3.1	1.31	4.0	1.5	**6.0**
											?
3	Expected WQ Scenario with Median TTFs	**39**	2.52	588	1.5	2.75	4.1	1.31	5.3	1.5	**8.0**
											?
4	95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	**50**	1.69	877	1.5	2.75	4.1	1.31	5.3	1.5	**8.0**
											?
5	Expected WQ Scenario with Median TTFs	**23**	3.78	588	2.2	2.75	6.1	1.31	8.0	1.5	**12.0**
											?
6	95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	**42**	2.53	877	2.2	2.75	6.1	1.31	8.0	1.5	**12.0**
											?

Se Bioaccumulation Modeling for the SCH Project

Table 11a. Inverse modeling output for simulations of required salinity levels to produce bird eggs with <6, <8 and <12 µg/g Se DW in an SCH supplied by the New River. Note: unattainable values denote situations where, even if only Salton Sea water were used in the SCH, the target bird egg Se value could not be attained. In simulation 5, the bird egg Se levels could be attained using only New River water in the SCH.

New River Inverse Model Invertebrate Consuming Birds		**Model Parameters**			**Median Expected Case**	**95th and 75th Percentile Case**	**Saline Habitat Pond 3 Scenario**		
Salinity requirement to protect bird reproduction				Kd	588	877	1247		
				$TTF_{1 \text{ to } 2}$	2.75	2.75	1.78		
Food Web Structure				$TTF_{2 \text{ to } 3}$	1.80	1.80	1.56		
Water ← Level 1 ← Level 2 ← Invertebrate Consuming Bird									
Simulation Number	**Simulation Conditions**	**Required SCH Salinity (ppt)**	**Required SCH Se_{total} (µg/L)**	**K_d**	**Se in Level 1 of Food Web (µg/g DW)**	**TTF Level 1 to Level 2**	**Se in Level 2 of Food Web (µg/g DW)**	**TTF Level 2 to Level 3**	**Se in Bird Egg (µg/g DW)**
1	Expected WQ Scenario with Median TTFs	**35**	2.06	588	1.2	2.75	3.3	1.80	**6.0**
									←
2	95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	**unattainable**	1.38	877	1.2	2.75	3.3	1.80	**6.0**
									←
3	Expected WQ Scenario with Median TTFs	**17**	2.75	588	1.6	2.75	4.4	1.80	**8.0**
									←
4	95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	**43**	1.84	877	1.6	2.75	4.4	1.80	**8.0**
									←
5	Expected WQ Scenario with Median TTFs	**all river OK**	4.12	588	2.4	2.75	6.7	1.80	**12.0**
									←
6	95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	**21**	2.76	877	2.4	2.75	6.7	1.80	**12.0**
									←

Table 11b. Inverse modeling output for simulations of required salinity levels to produce bird eggs with <6, <8 and <12 µg/g Se DW in an SCH supplied by the New River. Note: unattainable values denote situations where, even if only Salton Sea water were used in the SCH, the target bird egg Se value could not be attained.

New River Inverse Model Fish Consuming Birds		**Model Parameters**			**Median Expected Case**	**95th and 75th Percentile Case**	**Saline Habitat Pond 3 Scenario**				
Salinity requirement to protect bird reproduction				Kd	588	877	1247				
				$TTF_{1 \text{ to } 2}$	2.75	2.75	1.78				
Food Web Structure				$TTF_{2 \text{ to } 3}$	1.31	1.31	1.31				
Water? Level 1 ? Level 2 ? Level 3 (Fish) ? Bird Piscivore				$TTF_{3 \text{ to } 4}$	1.5	1.5	1.5				
Simulation Number	**Simulation Conditions**	**Required SCH Salinity (ppt)**	**Required SCH Se_{total} (µg/L)**	**K_d**	**Se in Level 1 of Food Web (µg/g DW)**	**TTF Level 1 to Level 2**	**Se in Level 2 of Food Web (µg/g DW)**	**TTF Level 2 to Level 3**	**Se in Level 3 of Food Web (µg/g DW)**	**TTF Level 3 to Piscivore**	**Se in Bird Egg (µg/g DW)**
1	Expected WQ Scenario with Median TTFs	**39**	1.89	588	1.1	2.75	3.1	1.31	4.0	1.5	**6.0**
											?
2	95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	**57**	1.27	877	1.1	2.75	3.1	1.31	4.0	1.5	**6.0**
											?
3	Expected WQ Scenario with Median TTFs	**23**	2.52	588	1.5	2.75	4.1	1.31	5.3	1.5	**8.0**
											?
4	95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	**47**	1.69	877	1.5	2.75	4.1	1.31	5.3	1.5	**8.0**
											?
5	Expected WQ Scenario with Median TTFs	**-10**	3.78	588	2.2	2.75	6.1	1.31	8.0	1.5	**12.0**
											?
6	95th Percentile WQ Scenario with 75th Percentile Kd and Median TTFs	**26**	2.53	877	2.2	2.75	6.1	1.31	8.0	1.5	**12.0**
											?

Table 12a. Inverse modeling using USBR/USGS SHP Models to predict required salinity levels to produce bird eggs with <6, <8 and <12 µg/g Se DW in an SCH supplied by the New River.

New River SHP Inverse Model Invertebrate Consuming Birds		**Model Parameters**			**Pond 1**	**Pond 2**	**Pond 3**		
Salinity requirement to protect bird reproduction				Kd	773	689	1247		
				$TTF_{1 \text{ to } 2}$	3.17	4.26	1.78		
Food Web Structure				$TTF_{2 \text{ to } 3}$	1.17	1.18	1.56		
Water ← Level 1 ← Level 2 ← Invertebrate Consuming Bird									
Simulation Number	**Simulation Conditions**	**Required SCH Salinity (ppt)**	**Required SCH Se_{total} (µg/L)**	**K_d**	**Se in Level 1 of Food Web (µg/g DW)**	**TTF Level 1 to Level 2**	**Se in Level 2 of Food Web (µg/g DW)**	**TTF Level 2 to Level 3**	**Se in Bird Egg (µg/g DW)**
1	Pond 1 and Mean Condition Equation in Figure 3	**34**	2.09	773	1.6	3.17	5.1	1.17	**6.0**
									←
2	Pond 2 and Mean Condition Equation in Figure 3	**43**	1.73	689	1.2	4.26	5.1	1.18	**6.0**
									←
3	Pond 3 and Mean Condition Equation in Figure 3	**43**	1.73	1247	2.2	1.78	3.8	1.56	**6.0**
									←
4	Pond 1 and Mean Condition Equation in Figure 3	**15**	2.79	773	2.2	3.17	6.8	1.17	**8.0**
									←
5	Pond 2 and Mean Condition Equation in Figure 3	**28**	2.31	689	1.6	4.26	6.8	1.18	**8.0**
									←
6	Pond 3 and Mean Condition Equation in Figure 3	**28**	2.31	1247	2.9	1.78	5.1	1.56	**8.0**
									←
7	Pond 1 and Mean Condition Equation in Figure 3	**all river ok**	4.19	773	3.2	3.17	10.3	1.17	**12.0**
									←
8	Pond 2 and Mean Condition Equation in Figure 3	**all river ok**	3.46	689	2.4	4.26	10.2	1.18	**12.0**
									←
9	Pond 3 and Mean Condition Equation in Figure 3	**all river ok**	3.47	1247	4.3	1.78	7.7	1.56	**12.0**

Table 12b. Inverse modeling using USBR/USGS SHP Models to predict required salinity levels to produce bird eggs with <6, <8 and <12 µg/g Se DW in an SCH supplied by the Alamo River.

Alamo River SHP Inverse Model Invertebrate Consuming Birds		**Model Parameters**			**Pond 1**	**Pond 2**	**Pond 3**		
Salinity requirement to protect bird reproduction				Kd	773	689	1247		
				$TTF_{1 \text{ to } 2}$	3.17	4.26	1.78		
Food Web Structure				$TTF_{2 \text{ to } 3}$	1.17	1.18	1.56		
Water ← Level 1 ← Level 2 ←	Invertebrate Consuming Bird								
Simulation Number	**Simulation Conditions**	**Required SCH Salinity (ppt)**	**Required SCH Se_{total} (µg/L)**	**K_d**	**Se in Level 1 of Food Web (µg/g DW)**	**TTF Level 1 to Level 2**	**Se in Level 2 of Food Web (µg/g DW)**	**TTF Level 2 to Level 3**	**Se in Bird Egg (µg/g DW)**
1	Pond 1 and Mean Condition Equation in Figure 3	**44**	2.09	773	1.6	3.17	5.1	1.17	**6.0**
									←
2	Pond 2 and Mean Condition Equation in Figure 3	**48**	1.73	689	1.2	4.26	5.1	1.18	**6.0**
									←
3	Pond 3 and Mean Condition Equation in Figure 3	**48**	1.73	1247	2.2	1.78	3.8	1.56	**6.0**
									←
4	Pond 1 and Mean Condition Equation in Figure 3	**35**	2.79	773	2.2	3.17	6.8	1.17	**8.0**
									←
5	Pond 2 and Mean Condition Equation in Figure 3	**41**	2.31	689	1.6	4.26	6.8	1.18	**8.0**
									←
6	Pond 3 and Mean Condition Equation in Figure 3	**41**	2.31	1247	2.9	1.78	5.1	1.56	**8.0**
									←
7	Pond 1 and Mean Condition Equation in Figure 3	**18**	4.19	773	3.2	3.17	10.3	1.17	**12.0**
									←
8	Pond 2 and Mean Condition Equation in Figure 3	**27**	3.46	689	2.4	4.26	10.2	1.18	**12.0**
									←
9	Pond 3 and Mean Condition Equation in Figure 3	**27**	3.47	1247	4.3	1.78	7.7	1.56	**12.0**
									←

Se Bioaccumulation Modeling for the SCH Project

Table 13. Modeling output for simulations of Se levels in eggs of invertebrate consuming birds in an SCH supplied by the New River. In this simulation, parameters were derived directly from 3 of the 4 US Bureau of Reclamation/USGS Saline Habitat Ponds (SHP). Initial starting salinity levels were set to equal average salinity measured in the respective SHP ponds from 2006-2008 (Miles *et al.*, 2009). Initial Se_{total} values were estimated by blending of Alamo River and Salton Sea water to produce initial salinity values.

New River Invertebrate Consuming Birds		**Model Parameters**			**SHP Pond 1**	**SHP Pond 2**	**SHP Pond 3**				
				Kd	773	689	1247				
Food Web Structure				$TTF_{1 \text{ to } 2}$	3.17	4.26	1.78				
Water→ Level 1 → Level 2 → Invertebrate Consuming Bird				$TTF_{2 \text{ to } 3}$	1.17	1.18	1.56				
										Bird Egg	
Simulation Number	**Simulation Conditions**	**SCH Salinity (ppt)**	**SCH Se_{total} (µg/L)**	**K_d**	**Se in Level 1 of Food Web (µg/g DW)**	**TTF Level 1 to Level 2**	**Se in Level 2 of Food Web (µg/g DW)**	**TTF Level 2 to Level 3**	**Se in Bird Egg (µg/g DW)**	***Lower 95% Confidence Limit***	***Upper 95% Confidence Limit***
1	**SHP Pond 1 Scenario**	13.0	2.89	773	**2.2**	3.17	**7.1**	1.17	**8.3**	***4.5***	***12.0***
2	**SHP Pond 2 Scenario**	24.9	2.43	689	**1.7**	4.26	**7.1**	1.18	**8.4**	***4.6***	***12.3***
3	**SHP Pond 3 Scenario**	47.6	1.57	1247	**2.0**	1.78	**3.5**	1.56	**5.4**	***2.1***	***8.8***

Risk Assessment For Pond 1 Simulation

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	1.44	Hazard is Moderate
	Sediment	1	2.23	Hazard is Moderate
	Bird Eggs	6	1.38	Hazard is Moderate

Protocol Scoring for For Pond 1 Simulation

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	2.9	3	14.0	Moderate
Sediment	2.2	3		
Macroinvert.	7.1	5		
Bird (eggs)	8.3	3		

Pond 1 Simulation Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	7.1	3.5	2.02
Bird (eggs)	8.3	5.2	1.59

Risk Assessment For Pond 2 Simulation

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	1.22	Hazard is Moderate
	Sediment	1	1.68	Hazard is Moderate
	Bird Eggs	6	1.40	Hazard is Moderate

Protocol Scoring for For Pond 2 Simulation

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	2.4	3	13.0	Moderate
Sediment	1.7	2		
Macroinvert.	7.1	5		
Bird (eggs)	8.4	3		

Pond 2 Simulation Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	7.1	3.5	2.04
Bird (eggs)	8.4	5.2	1.62

Risk Assessment For Pond 3 Simulation

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	0.79	Hazard is Low
	Sediment	1	1.96	Hazard is Moderate
	Bird Eggs	6	0.91	Hazard is Low

Protocol Scoring for For Pond 3 Simulation

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	1.6	2	10.0	Low
Sediment	2.0	2		
Macroinvert.	3.5	3		
Bird (eggs)	5.4	3		

Pond 3 Simulation Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	3.5	3.5	1.00
Bird (eggs)	5.4	5.2	1.05

Table 14. Modeling output for simulations of Se levels in eggs of fish consuming birds in an SCH supplied by the New River. In this simulation, parameters were derived directly from 3 of the 4 US Bureau of Reclamation/USGS Saline Habitat Ponds (SHP). Initial starting salinity levels were set to equal average salinity measured in the respective SHP ponds from 2006-2008 (Miles *et al.*, 2009). Initial Se_{total} values were estimated by blending of Alamo River and Salton Sea water to produce initial salinity values.

New River Fish Consuming Birds		Model Parameters	SHP Pond 1	SHP Pond 2	SHP Pond 3
		Kd	773	689	1247
Food Web Structure		$TTF_{1 \text{ to } 2}$	3.17	4.26	1.78
Water? Level 1 ? Level 2 ? Level 3 (Fish) ? Bird Piscivore		$TTF_{2 \text{ to } 3}$	1.31	1.31	1.31
		$TTF_{3 \text{ to } 4}$	1.5	1.5	1.5

Simulation Number	Simulation Conditions	SCH Salinity (ppt)	SCH Se_{total} (µg/L)	K_d	Se in Level 1 of Food Web (µg/g DW)	TTF Level 1 to Level 2	Se in Level 2 of Food Web (µg/g DW)	TTF Level 2 to Level 3	*Fish* Se in Level 3 of Food Web (µg/g DW)	TTF Level 3 to Piscivore	Se in Bird Egg (µg/g DW)
1	**SHP Pond 1 Scenario**	13	2.89	773	**2.2**	3.17	**7.1**	1.31	**9.3**	1.5	**13.9**
2	**SHP Pond 2 Scenario**	24.9	2.43	689	**1.7**	4.26	**7.1**	1.31	**9.4**	1.5	**14.0**
3	**SHP Pond 3 Scenario**	47.6	1.57	1247	**2.0**	1.78	**3.5**	1.31	**4.6**	1.5	**6.8**

Risk Assessment For Pond 1 Simulation

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	1.44	Hazard is Moderate
	Sediment	1	2.23	Hazard is Moderate
	Fish (Whole)	4	2.32	Hazard is Moderate
	Bird Eggs	6	2.32	Hazard is Moderate

Protocol Scoring for For Pond 1 Simulation

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	2.9	3	20.0	High
Sediment	2.2	3		
Macroinvert.	7.1	5		
Fish (whole)	9.3	5		
Bird (eggs)	13.9	4		

Pond 1 Simulation Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	7.1	3.5	2.02
Fish (whole)	9.3	7.0	1.32
Bird (eggs)	13.9	5.2	2.67

Risk Assessment For Pond 2 Simulation

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	1.22	Hazard is Moderate
	Sediment	1	1.68	Hazard is Moderate
	Fish (Whole)	4	2.34	Hazard is Moderate
	Bird Eggs	6	2.34	Hazard is Moderate

Protocol Scoring for For Pond 2 Simulation

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	2.4	3	19.0	High
Sediment	1.7	2		
Macroinvert.	7.1	5		
Fish (whole)	9.4	5		
Bird (eggs)	14.0	4		

Pond 2 Simulation Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	7.1	3.5	2.04
Fish (whole)	9.4	7.0	1.34
Bird (eggs)	14.0	5.2	2.70

Risk Assessment For Pond 3 Simulation

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	0.79	Hazard is Low
	Sediment	1	1.96	Hazard is Moderate
	Fish (Whole)	4	1.14	Hazard is Moderate
	Bird Eggs	6	1.14	Hazard is Moderate

Protocol Scoring for For Pond 3 Simulation

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	1.6	2	14.0	Moderate
Sediment	2.0	2		
Macroinvert.	3.5	3		
Fish (whole)	4.6	4		
Bird (eggs)	6.8	3		

Pond 3 Simulation Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	3.5	3.5	1.00
Fish (whole)	4.6	7.0	0.65
Bird (eggs)	6.8	5.2	1.32

Se Bioaccumulation Modeling for the SCH Project

Table 15. Modeling output for simulations of Se levels in eggs of invertebrate consuming birds in an SCH supplied by the Alamo River. In this simulation, parameters were derived directly from 3 of the 4 US Bureau of Reclamation/USGS Saline Habitat Ponds (SHP). Initial starting salinity levels were set to equal average salinity measured in the respective SHP ponds from 2006-2008 (Miles *et al.*, 2009). Initial Se_{total} values were estimated by blending of Alamo River and Salton Sea water to produce initial salinity values.

Alamo River Invertebrate Consuming Birds		**Model Parameters**			**SHP Pond 1**	**SHP Pond 2**	**SHP Pond 3**				
				Kd	773	689	1247				
Food Web Structure				$TTF_{1 \text{ to } 2}$	3.17	4.26	1.78				
Water→ Level 1 → Level 2 →	Invertebrate Consuming Bird			$TTF_{2 \text{ to } 3}$	1.17	1.18	1.56				
										Bird Egg	
Simulation Number	**Simulation Conditions**	**SCH Salinity (ppt)**	**SCH Se_{total} (µg/L)**	**K_d**	**Se in Level 1 of Food Web (µg/g DW)**	**TTF Level 1 to Level 2**	**Se in Level 2 of Food Web (µg/g DW)**	**TTF Level 2 to Level 3**	**Se in Bird Egg (µg/g DW)**	***Lower 95% Confidence Limit***	***Upper 95% Confidence Limit***
1	**SHP Pond 1 Scenario**	13	4.56	773	**3.5**	3.17	**11.2**	1.17	**13.1**	***7.1***	***19.0***
2	**SHP Pond 2 Scenario**	24.9	3.61	689	**2.5**	4.26	**10.6**	1.18	**12.5**	***6.8***	***18.2***
3	**SHP Pond 3 Scenario**	47.6	1.79	1247	**2.2**	1.78	**4.0**	1.56	**6.2**	***2.4***	***10.0***

Risk Assessment For Pond 1 Simulation

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	2.28	Hazard is Moderate
	Sediment	1	3.52	Hazard is Moderate
	Bird Eggs	6	2.18	Hazard is Moderate

Protocol Scoring for For Pond 1 Simulation

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	4.6	4	17.0	High
Sediment	3.5	4		
Macroinvert.	11.2	5		
Bird (eggs)	13.1	4		

Pond 1 Simulation Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	11.2	3.5	3.19
Bird (eggs)	13.1	5.2	2.51

Risk Assessment For Pond 2 Simulation

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	1.80	Hazard is Moderate
	Sediment	1	2.49	Hazard is Moderate
	Bird Eggs	6	2.08	Hazard is Moderate

Protocol Scoring for For Pond 2 Simulation

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	3.6	4	16.0	High
Sediment	2.5	3		
Macroinvert.	10.6	5		
Bird (eggs)	12.5	4		

Pond 2 Simulation Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	10.6	3.5	3.03
Bird (eggs)	12.5	5.2	2.40

Risk Assessment For Pond 3 Simulation

		TRV	Hazard Quotient	Hazard Description
Relative to Low Toxicity Reference Values	Water	2	0.90	Hazard is Low
	Sediment	1	2.23	Hazard is Moderate
	Bird Eggs	6	1.03	Hazard is Moderate

Protocol Scoring for For Pond 3 Simulation

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	1.8	2	11.0	Moderate
Sediment	2.2	3		
Macroinvert.	4.0	3		
Bird (eggs)	6.2	3		

Pond 3 Simulation Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	4.0	3.5	1.14
Bird (eggs)	6.2	5.2	1.19

Se Bioaccumulation Modeling for the SCH Project

Table 16. Modeling output for simulations of Se levels in eggs of fish consuming birds in an SCH supplied by the Alamo River. In this simulation, parameters were derived directly from 3 of the 4 US Bureau of Reclamation/USGS Saline Habitat Ponds (SHP). Initial starting salinity levels were set to equal average salinity measured in the respective SHP ponds from 2006-2008 (Miles *et al.*, 2009). Initial Se_{total} values were estimated by blending of Alamo River and Salton Sea water to produce initial salinity values.

Alamo River Fish Consuming Birds		Model Parameters			SHP Pond 1	SHP Pond 2	SHP Pond 3			
				Kd	773	689	1247			
Food Web Structure				$TTF_{1 \text{ to } 2}$	3.17	4.26	1.78			
Water? Level 1 ? Level 2 ? Level 3 (Fish) ? Bird Piscivore				$TTF_{2 \text{ to } 3}$	1.31	1.31	1.31			
				$TTF_{3 \text{ to } 4}$	1.5	1.5	1.5		*Fish*	
Simulation Number	Simulation Conditions	SCH Salinity (ppt)	SCH Se_{total} (µg/L)	K_d	Se in Level 1 of Food Web (µg/g DW)	TTF Level 1 to Level 2	Se in Level 2 of Food Web (µg/g DW)	TTF Level 2 to Level 3	Se in Level 3 of Food Web (µg/g DW)	TTF Level 3 to Piscivore
1	SHP Pond 1 Scenario	13	4.56	773	**3.5**	3.17	**11.2**	1.31	**14.6**	1.5
2	SHP Pond 2 Scenario	24.9	3.61	689	**2.5**	4.26	**10.6**	1.31	**13.9**	1.5
3	SHP Pond 3 Scenario	47.6	1.79	1247	**2.2**	1.78	**4.0**	1.31	**5.2**	1.5

Risk Assessment For Pond 1 Simulation

Relative to Low Toxicity Reference Values		TRV	Hazard Quotient	Hazard Description
	Water	2	2.28	Hazard is Moderate
	Sediment	1	3.52	Hazard is Moderate
	Fish (Whole)	4	3.66	Hazard is Moderate
	Bird Eggs	6	3.66	Hazard is Moderate

Protocol Scoring for For Pond 1 Simulation

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	4.6	4	23.0	High
Sediment	3.5	4		
Macroinvert.	11.2	5		
Fish (whole)	14.6	5		
Bird (eggs)	22.0	5		

Pond 1 Simulation Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	11.2	3.5	3.19
Fish (whole)	14.6	7.0	2.09
Bird (eggs)	22.0	5.2	4.22

Risk Assessment For Pond 2 Simulation

Relative to Low Toxicity Reference Values		TRV	Hazard Quotient	Hazard Description
	Water	2	1.80	Hazard is Moderate
	Sediment	1	2.49	Hazard is Moderate
	Fish (Whole)	4	3.47	Hazard is Moderate
	Bird Eggs	6	3.47	Hazard is Moderate

Protocol Scoring for For Pond 2 Simulation

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	3.6	4	22.0	High
Sediment	2.5	3		
Macroinvert.	10.6	5		
Fish (whole)	13.9	5		
Bird (eggs)	20.8	5		

Pond 2 Simulation Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	10.6	3.5	3.03
Fish (whole)	13.9	7.0	1.98
Bird (eggs)	20.8	5.2	4.00

Risk Assessment For Pond 3 Simulation

Relative to Low Toxicity Reference Values		TRV	Hazard Quotient	Hazard Description
	Water	2	0.90	Hazard is Low
	Sediment	1	2.23	Hazard is Moderate
	Fish (Whole)	4	1.30	Hazard is Moderate
	Bird Eggs	6	1.30	Hazard is Moderate

Protocol Scoring for For Pond 3 Simulation

Hazard Profile for:	Se Value	Score	Total Score for Ecosystem	Overall Hazard Characterization
Water	1.8	2	15.0	Moderate
Sediment	2.2	3		
Macroinvert.	4.0	3		
Fish (whole)	5.2	4		
Bird (eggs)	7.8	3		

Pond 3 Simulation Relative to Grand Means for Organisms Collected in and Near the Salton Sea

	Se Value	Grand Mean	Ratio
Macroinvert.	4.0	3.5	1.14
Fish (whole)	5.2	7.0	0.74
Bird (eggs)	7.8	5.2	1.50