Appendix A: The memoranda prepared by ENTRIX and presented in this appendix are working review drafts which were not edited or finalized by the Trustees.

Appendix A-3:

- **A-3a**, “Risk Assessment Approach for HEA”
- **A-3b** “Preliminary Hazard Quotient Risk Estimations to Wildlife for Castro Cove”

Original Author(s): ENTRIX

Distributed to the injury subcommittee in the cooperative NRDA process.

Trustee Comments: The “Risk Assessment Approach for HEA” memorandum contains the methodology used, while the “Preliminary Hazard Quotient Risk Estimations to Wildlife for Castro Cove” memorandum contains the results from applying the methodology to the data from Castro Cove.

E N T R I X

MEMORANDUM

DRAFT

ENTRIX, Inc.
148 Rogers St.
Olympia, WA 98512
(360) 352-3225

Date: February 22, 2006

Re: Risk Assessment Approach for HEA

Project No. **3054545**

PURPOSE

This memorandum outlines a methodology to estimate exposures and potential risks to selected ecological receptors that may use the Castro Cove area presently or that may have used it at some other time since 1980, thus encompassing the full period under consideration for the Castro Cove NRDA.

The Trustees requested this estimation of risk for use by the Trustees and CVX in the consideration of service losses and other elements of the injury and damage assessment process. In particular, Chevron and the Trustees want to determine if the potential risks and thus the potential for injury to selected species of fish, birds and mammals from bioaccumulation of chemicals of potential concern (COPCs) are substantial enough to warrant developing a more quantitative estimate of service losses than provided through use of the habitat equivalency approach for mudflats.

This memo does not provide exposure doses for relevant receptors, which will first require agreement with the Trustees on input parameters needed to estimate exposure.

BACKGROUND

Chevron discharged processed wastewater into Castro Cove (San Pablo Bay, CA) through two locations over several decades in the middle part of the last century. Several investigations have already been performed to examine the conditions at the site, gauge the level of contamination, and frame the options for remediation. A Tier 1 assessment examined sediment concentrations at

13 locations and identified hot spots requiring further investigation at two locations (Dames and Moore 1999). Further analysis of sediment toxicity was conducted focusing on these sites in a Tier II investigation published in 2002 (URS 2002a). In the Tier II investigations three areas were examined: (1) Castro Creek channel, (2) Castro Cove Mudflat, and (3) Salt Marsh area. Further investigations of lead contamination were also performed in sediments near Skeet Hill, a former shotgun practice range (URS 2002b). To date, there has been no predictive modeling of exposure to COPCs exceeding sediment quality criteria for representative ecological receptors that may use the area for all or some portion of their life history. The requested assessments will evaluate potential exposure pathways relevant to the potential for injury and loss of services from the exposures to COPCs.

APPROACH

The approach proposed for conducting the ecological risk assessment is consistent with the State of California's 'Guidance for Ecological Risk Assessment at Hazardous Waste Sites and Permitted Facilities' (Cal EPA 1996). This guidance is relatively consistent with federal guidance for conducting ecological risk assessments (USEPA 1996) at all types of sites potentially contaminated with COPCs, whether or not defined as hazardous waste sites. Specifically, as stated in the guidance, the principles described are generally applicable to "the assessment of risk to biota whenever the Department requires corrective action pursuant to Health and Safety Code 25187 or 25200.10."

Briefly, the approach involves: (1) identification of COPCs, (2) identification of ecological receptors of potential concern, (3) identification of habitats and biological communities of concern, (4) selection of toxicity reference values (TRV), (4) identification of exposure parameters and appropriate uptake equations, (5) prediction of estimated exposure to COPCS, and (6) comparison of estimated exposure to recognized toxicological hazards associated with the COPCs to ascertain risks. Each of these steps are discussed below

[1] Identification of Contaminants of Potential Concern

The following COPCs are those identified in the URS Tier I and II risk assessment reports that exceeded the Effects Range Low (ERL—defined in more detail below) in at least one sediment sample.

- Mercury
- Arsenic
- PAH (select high and low molecular weight congeners)
- Lead (Skeet Hill, lead shot only)
- Chlordane

Based on a preliminary interpretation of the results from past studies, it was determined that of all COPC's, total sediment mercury exhibited the greatest exceedance of sediment criteria in almost all samples collected in the cove and salt marsh areas. Thus, with the exception of the creek channel, the area of concern for contamination and potential uptake can be bounded by the mercury samples in these areas. Although the delineation for clean-up purposes can be bounded by the mercury footprint, the Trustees have also requested estimates of risks to higher trophic levels from the other contaminants that exceeded sediment benchmarks, and those risks will also be considered to the extent practical from the existing data.

[2] Identification of Ecological Receptors of Potential Concern

Table 1 (appended below) lists ecological receptors potentially exposed to contaminants of concern in the Castro Cove area, as identified from past studies done on benthic communities, wildlife, and fisheries in or near the site vicinity (CH2M Hill 1982, URS 2002a,b). Figure 1 (appended below) depicts a draft conceptual site model that charts exposure pathways for a 'short list' of the ecological receptors identified in Table 1. Doses will be estimated only for those biota classes for which complete exposure pathways are possible, and for which site data conservatively suggest that risk from that exposure could be significant. Toxicity information on surrogate species may be used to characterize toxicological risks to ecological receptors of concern, if toxicity or life history data for the proposed receptors are insufficient to characterize exposure and risk. The fundamental assumption of this approach is that if negligible risk from the estimated exposure is determined for the surrogate species, it will be assumed that the entire guild of species in which the site-specific species belongs will be protected.

[3] Identification of Communities and Habitats of Potential Concern

Consistent with the previously summarized data, the areas identified with levels of contamination of potential concern include: (1) the Castro Cove mudflat (incl. the 20-acre area of concern), (2) the salt marsh area, (3) lead shot depositional area from the former Skeet Hill firing range (a 10-acre portion of the mudflat), and (4) the lower Castro Cove Creek Channel. Exposure assessments will provide estimates of the amount of time the identified ecological receptors could or would spend in each of these areas, proportional to the total area of Castro Cove and to the receptor's home range.

[4] Selection of Toxicity Reference Values for Hazard and Risk Assessment

Ingestion-based toxicity reference values (TRVs) that will be considered to gauge risks to ecological receptors in Castro Cove were derived primarily from Navy/U.S. EPA sites around San Francisco Bay (Appended Table 2). These Navy/EPA TRVs were developed on a consensus basis between the U.S. Navy and the EPA's Biological Technical Advisory Group (BTAG) (*see* PRC Environmental Management 1997 for source documentation). No uncertainty factors were applied to account for interspecies or intraspecies sensitivity in developing the BTAG TRVs. Chemicals for which only lowest-adverse-effect-levels (LOAELS) were available had uncertainty factors of up to 10 applied to adjust to a no-observed-adverse-effect-level (NOAEL). Chemicals for which only subchronic exposure studies were conducted had uncertainly factors of 10 applied to adjust to a chronic value. The TRV values appended in Table 1 reflect these BTAG values for the low TRVs. The U.S Fish and Wildlife Service also considers these values protective of ecological receptors that could be chronically exposed to the COPCs.

<u>Sediments</u>

Sediment criteria proposed for use in this risk assessment are based on identified impacts to benthic invertebrates from controlled lab studies and co-located sediment and biota data sets from the field (Long et al. 1995). These values will be the same as those used in the initial screening described in the URS reports (URS 2002a,b). Briefly, these metrics include the low range ecological effects (ERL) and the median range for ecological effects (ERM). The ERL is defined as the sediment concentration above which adverse effects on sensitive species or life stages may occur. The ERL values were obtained from matching numerous co-located chemical and biological data sets from both field and lab studies. The ERL, as originally proposed by Long et al. (1995), is ultimately calculated from the 10^{th} percentile of the effect data set. The ERM corresponds to the 50^{th} percentile of the same effect data set, and is thought to correspond to a value above which adverse effects are always or frequently observed. Table 3 (appended below) provides the sediment benchmarks for the COPCs identified for the Castro Cove site.

Accumulation Factors

No tissue residue data have been collected from marine worms or other biological matrices in the habitats of concern in Castro Cove. Thus, bioaccumulation factors developed for appropriate reference areas in the Bay region will be used to estimate tissue residue concentrations in food sources (prey items) that could be consumed by the ecological receptors of concern. Lipid-normalized tissue data co-located with sediment organic carbon data are not available from the region to calculate a Biota-Sediment Accumulation Factor (BSAF) that could be applied to the Castro Cove area. However, sufficient data are available to calculate a bioaccumulation factor (BAF)—the ratio of tissue residue of a COPC to the concentration of that COPC in the environmental media (e.g., sediment, soil, etc.). The Trustees have provided BAFs from reference stations that can be used in the exposure calculations (appended Table 4).

Receptor-Specific Trophic Transfer Factors

Dry weight Trophic Transfer Factors (TTFs) for the short list of ecological receptors of potential concern will be used to improve the accuracy of exposure dose estimates, where such data are available. For example, TTF data are available for the clapper rail and salt marsh harvest mouse, from sampling of mussels, crabs, and worms, and co-located sediment samples collected from an adjacent coastal salt marsh by the U.S. Army. are to be considered for modeling exposure point concentrations. Tables 5, 6 and 7 (appended below) summarize these parameters for arsenic, mercury, and chlordane, respectively.

[5] Identification of Exposure Parameters and Equations Used for Estimating Exposure Doses to Ecological Receptors of Potential Concern

The exposure parameters and guild species used in this assessment are summarized in Table 1. The values for body weight, dietary preference, ingestion rates, and other parameters of relevance necessary to extrapolate doses of COPC's from the Castro Cove site were primarily from studies of each species in the San Francisco Bay area, the Wildlife Exposure Handbook (US EPA 1993) and the Birds of North America web-site (Birds of North America 2006). However, it should be recognized that additional data sources are being explored to identify values for missing parameters. Table 5 provides exposure parameters that may be used to estimate site exposure and characterize risk for the short list of ecological receptors of concern from the data acquired to date.

Although more detailed equations have been identified, the principal dosage calculation will consider daily intake of COCs by each of the complete pathways with the general equation, [I].

[I] Daily intake = CM * CR * FI * AF * BW

Where,

CM = Concentration of contaminant in exposure media of concern.

CR = Contact Rate—The estimate of the quantity of the medium consumed per day.

FI = Fractional Intake—The fraction of time spent in contact with the contaminated media (e.g., the proportion of the total diet obtained from the site, as extrapolated from information such as home range data on the species, or empirical findings).

AF = Absorption Fraction—The amount of contaminant contacted (e.g., consumed) that is actually assimilated into tissue to assert a potentially toxic effect.

Recognizing that the exposure mediium for some of the receptors is assumed to be sediment, it will be necessary to identify how much sediment is taken into the diet directly [II].

[II] Sediment ingestion rate (g sediment, dw/day = (% sediment in the diet)*(food ingestion rate, g/day)

Further, where a surrogate species is used to extrapolate dose to a receptor of relevance to Castro Cove, equation [III] may be applied.

[III] $\text{Dose}_{\text{receptor}} = \text{Dose}_{\text{test organism}} (\text{BW}_{\text{test organism}}/\text{BW}_{\text{receptor}})^{1/3}$

Where,

BW = receptor body weight (kg).

[6] Predictive Assessment of Risk from COPC Exposure

Potential risks will be characterized from an analysis of the anticipated exposure relative to the toxicity reference value, through the calculation of hazard quotients [IV]. The general form of the hazard quotient (HQ) equation for chronic exposure (Carlisle *et al.*. 1996) is modified below assuming an exposure frequency of 365 days per year and a lifetime exposure duration.

[IV] $$HazardQuotient = (1/TRV) \times Cs \times \frac{[IR \times CF \times EF \times ED]}{[BW \times AT \times 365 day / year]}$$

Where-

AT = averaging time, 365 days/year
TRV = toxicity reference value, mg/kg-BW-day
Cs = concentration of chemical in sediment, mg/kg
IR = Ingestion rate (food or sediment) mg/day on a dry weight basis
CF = conversion factor to convert mg sediment to kg sediment, 10^{-6}
EF = exposure frequency, assumed to be 365 days/year
ED = exposure duration, assumed to be lifetime of the animal
BW = body weight of animal (kg)
AT = averaging time of exposure, assumed to be the lifetime of the animal

Where source data for input parameters are not available, the HQ will be calculated from the following equation:

$$HQ_1 = EPC/TRV_{low}$$

$$HQ_2 = EPC/TRV_{high}$$

Where: EPC = Exposure Point Concentration

The TRV, in this case, may be reflective of tissue-specific toxicity metrics, as obtained from literature sources (e.g., Beyer et al. 1996), and the EPC would reflect the tissue-residue expected following the application of bioaccumulation factors.

The relationship between service loss calculations for the NRDA and risks characterized from the above analyses would be subsequently explored in discussions with the Trustees.

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Table 1. Ecological Receptors with Possible Use of Castro Cove Areas of Concern

Mammals	Birds	Fish	Benthic Invertebrates
Salt Marsh Mouse	Greater Scaup	Starry flounder	Coelenterata: *Metridium senile*
Norway rat	Mallard Duck	English sole	Polychaeta: *Capitella capitata* *Etione lighti* *Nephtys caecoides* *Neanthes succinea* *Polydora ligna* *Streb. benedicti*
	Avocet	Speckled Sanddab	
	Long Billed Curlew	Staghorn Sculpin	Arthropoda: *A. confervicolus* *Balanus glandula* *B. improvisus* *Hemigrapsus oregonensis* *Pagurus hirsutiusculus* *Traskorchestia traskiana* *Cancer magister*
	Willett	Yellowfin goby	Mollusca: *Clinocoardium nuttalli* *Gemma gemma* *Modiolus demissus* *Macoma nasuta* *Mya arenaria* *Mytilus edulis* *Nassarius obsoletus* *Tapes semidecussata* *Myosotella myosotis* *Mya californica*
	Marbled Godwit	Plain midshipman	
	Dowitcher	Perch	
	Black headed Stilt	Anchovy	
	Ruddy Duck	Striped bass	
	Canvassback Duck	Steelhead trout	
	Osprey		
	Brown Pelican		

Table 2. Toxicity Reference Values Proposed for Castro Cove Ecological Risk Assessment (mg/kg body wt./day)

Ecological Receptor Guild or Species	Hg NOAEL	Hg Low TRV	Lead (Acetate form only)	Arsenic	Chlordane
Lg. Mammal	0.027	0.027	0.0015	0.32	0.0014
Sm. Mammal	0.16	0.25	0.0015	0.32	0.0014
Avian		0.039	0.014	5.5	

Table 3. Dry Weight Sediment Benchmarks for Castro Cove COPCs (ug /kg).

Chemical	**Sediment Benchmark (ug/kg)**	**Reference**
Benz(a)anthracene	261/1,600	Long et al. 1995
Benzo(a)pyrene	430/1,600	Long et al. 1995
Benzo(b)fluoranthene	3,600	US EPA 1993
Benzo(g),h,I)perylene	720	US EPA 1993
Chrysene	384/2,800	Long et al. 1995
Dibenz(a,h)anthracene	63.4/260	Long et al. 1995
Indeno(1,2,3-cd)pyrene	690	US EPA 1993
Pyrene	665/2,600	Long et al. 1995
Chlordane	7	Persaud et al. 1992
Arsenic	8,200/70,000	Long et al. 1995
Mercury	150/710	Long et al. 1995

Table 4. Bioaccumulation values for mercury, arsenic and lead, obtained from co-located sediment/biota reference stations in the San Francisco Bay Area.

Arsenic			***Mercury***			***Lead***		
	Average	Standard Deviation		Average	Standard Deviation		Average	Standard Deviation
All Sites	0.995138	0.560758	All Sites	1.65648	2.093551	All Sites	0.033876	0.032381
Petaluma River	0.89455	0.596417	Petaluma River	1.003958	0.520089	Petaluma River	0.049414	0.046629
San Pablo Bay	0.579885	0.21228	San Pablo Bay	0.770819	0.396981	San Pablo Bay	0.03064	0.015787
Pinole Point	0.823251	0.352256	Pinole Point	1.043019	1.160563	Pinole Point	0.055417	0.0492
Davis Point	1.03771	0.233945	Davis Point	2.054351	1.692403	Davis Point	0.017867	0.013682
T-0	1.281965	0.663606	T-0	2.139226	3.15900	T-0	0.016284	0.008878
			Mare Island	0.187				

Table 5. Arsenic low and high TRV values and trophic transfer factors for clapper rail and harvest mice

Values for Arsenic	*Clapper Rail*	*Harvest Mice*
TRV (mg/kg BW-day)	Low - 5.5; High - 22.01 [a]	Low -0.32; High - 4.7 [a]
TTF – Range (Minimum - Maximum) [sample size] (mg/kg biota dry wt) ÷ (mg/kg sediment dry wt)	Mussel : 0.13 – 0.45 [3] [b] Crab : 0.19 – 0.45 [3] Worm : 0.41 – 0.95 [3]	Pickleweed : 0.0256 – 0.464 [3] [c]
TTF – Mid (mg/kg biota dry wt) ÷ (mg/kg sediment dry wt)	Mussel : 0.269 (mean) Crab : 0.272 (mean) Worm : 0.620 (mean)	Pickleweed : 0.189 (mean)
Low TRV Sediment Values (mg/kg sediment, dry wt)	With Max TTF : 66.1 With Mid TTF : 93.0 With Min TTF : 126	With Max TTF : 2.53 With Mid TTF : 5.84 With Min TTF : 25.9
High TRV Sediment Value (mg/kg sediment, dry wt)	With Max TTF : 265 With Mid TTF : 372 With Min TTF : 505	With Max TTF : 37.2 With Mid TTF : 85.8 With Min TTF : 380
Hamilton Army Airfield ROD/RAP Action Goals (mg/kg sediment, dry wt)	Inboard - 16.7 Coastal Salt Marsh - 23	

[a] Value used from (PRC Environmental Management, 1997) and agreed upon by Navy and BTAG.
[b] Based on co-located sediment, mussel, crab, and worm samples collected by US Army at Hamilton in 1995 (Woodward-Clyde, 1995).
[c] Based on co-located sediment and pickleweed samples collected by US Army at Hamilton in 1995 (Woodward-Clyde, 1995).

Table 6. Mercury low and high TRV values and trophic transfer factors for clapper rail and harvest mice

Values for Mercury	*Clapper Rail*	*Harvest Mouse*
TRV (mg/kg BW-day)	Low - 0.0078 - 0.015 [a] High - 0.18 [b]	Low - 0.25; High - 4 [b]
TTF – Range (Minimum - Maximum) [sample size] (mg/kg biota dry wt) ÷ (mg/kg sediment dry wt)	Mussel : 0.09 – 0.195 [3] [c] Crab : 0.247 – 0.289 [3] Worm : 0.202 – 0.244 [3]	Pickleweed : 0.0005 – 0.0092 [3] [d]
TTF – Mid (mg/kg biota dry wt) ÷ (mg/kg sediment dry wt)	Mussel : 0.143 (mean) Crab : 0.271 (mean) Worm : 0.218 (mean)	Pickleweed : 0.0043 (mean)
Low TRV Sediment Values (mg/kg sediment, dry wt)	With Max TTF : 0.18 – 0.34 With Mid TTF : 0.19 – 0.37 With Min TTF : 0.21 – 0.40	With Max TTF : 30.9 With Mid TTF : 36.6 With Min TTF : 42.7
High TRV Sediment Value (mg/kg sediment, dry wt)	With Max TTF : 4.08 With Mid TTF : 4.41 With Min TTF : 4.79	With Max TTF : 494 With Mid TTF : 585 With Min TTF : 684
Hamilton Army Airfield ROD/RAP Action Goals (mg/kg sediment, dry wt)	Inboard - 0.43 Coastal Salt Marsh - 0.58	

[a] Value used from (PRC Environmental Management, 1997) and agreed upon by Navy and BTAG.
[b] Revised low TRV for mammals (Anderson, 2002).

[c] Based on co-located sediment, mussel, crab, and worm samples collected by US Army at Hamilton in 1995 (Woodward-Clyde, 1995).

[d] Based on co-located sediment and pickleweed samples collected by US Army at Hamilton in 1995 (Woodward-Clyde, 1995).

Table 7. Trophic Transfer Factors and Toxicity Reference Values for Chlordane

Values for Total Chlordanes	*Clapper Rail*	*Harvest Mouse*
TRV (mg/kg BW-day)	Low - 0.0014 [a] No high TRV available	No TRVs available
TTF - Range (Minimum - Maximum) [sample size] (mg/kg biota dry wt) ÷ (mg/kg sediment dry wt)	Mussel : 1.47 - 103.6 [11] [b]	
TTF - Mid (mg/kg biota dry wt) ÷ (mg/kg sediment dry wt)	Mussel : 16.37 (geometric mean)	
Low TRV Sediment Values (mg/kg sediment, dry wt)	With Max TTF : 0.0001 With Mid TTF : 0.0008 With Min TTF : 0.0081	
High TRV Sediment Value (mg/kg sediment, dry wt)	NA	
Hamilton Army Airfield ROD/RAP Action Goals (mg/kg sediment, dry wt)	Coastal Salt Marsh and Inboard - 0.0048	

[a] Value used from the Service's chlordane TRV (unpublished) based on (National Research Council of Canada (NRRC), 1975).

[b] Based on co-located sediment and mussel samples collected by the Service in 1998 (unpublished results).

Table 8: Preliminary Biological Parameters for Calculating Exposure to Select Ecological Receptors

Species	Adult Body Weight (g)	Daily Food Intake (g)	Daily Water Intake (ml)	Home Range (km^2)	Est. Portion of Diet from Site	Surface Area (cm^2)	Diet Preference	Relevant Life History Characteristics Relevant to Exposure
Avocet	B: 313	54		No data available		F: 43 M: 47	Aquatic insects, marine worms, small fishes, small crustaceans and mollusks; occasionally seeds and grasses. Long, thin upturned bill used to filter zooplankton	Breeds in shallow, brackish waters and marshes in April-June; Have long, thin upturned bill; Feeds in shallow water (< 25cm)
Willet	B: 265	45		B: 0.26		F: 33 M: 41	Aquatic insects, marine worms, small fishes, small crustaceans and mollusks; occasionally seeds and grasses. Thick, long bill used to peck, probe and plow to capture food; this occurs at 7 cm water depth of wave outwash, and prey is found within 5 cm of surface	Breeds in April-June along edge of salt marshes in spartina, in sand-dune areas utilizing beachgrass, in pond margins and raised ground near water . Inhabits eelgrass beds, muddy to sandy bottoms, and the low intertidal zone.
Dungeness Crab	B: 79			F: 3.4 (size dependent)		F: 9 M: 15	Aquatic insects, clams, fish, starfish, worms, squid, snails, and eggs from fish or crabs	Mate from May-June; Hatching between January-March Inhabits eel-grass beds, muddy to sandy bottoms, and the low intertidal zone

Table 8: Preliminary Biological Parameters for Calculating Exposure to Select Ecological Receptors								
Species	**Adult Body Weight (g)**	**Daily Food Intake (g)**	**Daily Water Intake (ml)**	**Home Range (km^2)**	**Est. Portion of Diet from Site**	**Surface Area (cm^2)**	**Diet Preference**	**Relevant Life History Characteristics Relevant to Exposure**
Marsh Wren	B: 11.25	8	3	No data		F: 45 M: 48	Insects, spiders, mollusks, and crustaceans	Breed in April; hatch in May; Migration in fall and spring; likely to be found within coastal marsh habitat where *Spartina* is abundant
Salt Marsh Harvest Mouse	B:21	9 (lactating)	7	F: .025 M: 023		F: 86 M: 91	Mixture of nuts, seeds, and insects	Breed several times during the year
Mallard Duck	F: 1,043 M: 1,225	250	F: 0.042 M: 0.055	F: 0.42 M: 0.48		F: 1,030 M: 1,148	A surface feeding "puddle" duck, feeds on an omnivorous diet. Dietary patterns vary with season. In winter, mallards feed mostly on seed mast, and to a lesser extent invertebrates. In the migratory and breeding seasons, high protein and fat diets are consumed, with more invertebrate biomass .	Affinity to marsh and wetland habitats in fresh and brackish water conditions.
Scaup	F: 770 M: 860	50	F: 0.064 M: 0.062	F: 0.34 M: 0.36		F: 842 M: 906	Juveniles ate entirely animal matter in NW territories study; 61% animal matter in Louisiana study,	Pacific Flyway spring migration from March—April; fall migration from September-mid-October.

Figure 1: Conceptual Exposure Pathways for a Short List of Species For Which Exposure Modeling Will be Attempted

Contaminant Of Concern	Ecological Receptor Exposure Route	Potential Estuarine Receptors in the Affected Envir						
		Flat Fish	Clapper Rail	Willett	Benthic Infauna (Macoma)	Benthic Epifauna (D. Crab)	Avocet	Salt M
Hg	Direct Sediment Ingestion	●	■	■	■	■	■	
	Bioaccumulation from diet or sediment	■	■	■	■	■	■	
	Bioconcentration from water	■	□	□	●	●	□	
	Drinking dissolved COPC	■	●	●	□	■	●	
PAH (select congeners)	Direct Sediment Ingestion	●	■	■	■	■	■	
	Bioaccumulation from diet or s	■	■	■	■	■	■	
	Bioconcentration from water	■	□	□	●	●	□	
	Drinking dissolved COPC	■	●	●	□	■	●	
Arsenic	Direct Sediment Ingestion	■	■	■	■	■	■	
	Exposure via Bioaccumulation	■	■	■	■	■	■	
	Bioconcentration from water	■	□	□	●	●	□	
	Drinking dissolved COPC	●	●	●	□	■	●	
Lead Shot	Direct Sediment Ingestion	●	■	■	□	□	■	
	Exposure via Bioaccumulation	□	□	□	□	□	□	
	Bioconcentration from water	□	□	□	□	□	□	
	Drinking water (dissolved COC)	□	□	□	□	□	□	

■ Complete pathway
□ Incomplete pathway or not applicable
● Potentially complete, but likely insignificant

ENTRIX

MEMORANDUM

WORKING REVIEW DRAFT

ENTRIX, Inc.
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Olympia, WA 98512
(360) 352-3225

Date: March 20, 2006

Re: **Preliminary Hazard Quotient Risk Estimations to Wildlife for Castro Cove**

Project No. **3054545**

Approach

Dosage estimates for mercury were developed for select ecological receptors known to use the salt marsh and mud flat areas of Castro Cove using equation [1].

[!] Dose = (Suf(IR[food]*C[food]) + (IR[water]*C[water]) + (IR[sed]*C[sed]*AE))/BW

Where:

(1) SUF = Site Use Factor of Habitat Area (percent)

(2) IR = consumption (i.e., intake) rate of [media]

(3) C = consumption of contaminant in [media]

(4) AE = assimilation efficienfy of benthos-derived contaminant from sediments

(5) BW = Body Weight

[2] Concentration of Containminant in Food (C) = ((% invertebrates in diet (BAF[inverts]*C[sed] + (% vegetation in diet (BAF[veg]*C[sed]))(percent of food contaminated)

Where:
(1) BAF = bioaccumulation factor (i.e., biota tissue concentration/sediment concentration)

Dosage was calculated considering the mean, maximum and upper 95% confidence values (95 UCL) above the mean for the sediment data derived from these areas. Hazard quotients presented in this memo reflect the 95 UCL only. Input parameters were primarily derived from the wildlife exposures handbook (EPA 1993), or from Sample et al (1997). Allometric conversions of food and water intake were developed from body weight (BW), where these parameters were not already presented in the previously mentioned references.

Conservative assumptions implicit to this modeling included:
- Presumed site use of 100 percent
- Presumed 100 percent assimilation efficiency of mercury with any sediment consumed (i.e., 100% bioavailable)
- Presumed that 100% of food consumed was contaminated

The toxicity reference values used in the calculation of hazard quotient are summarized below in Table 1. These values have been adopted by the BTAG for the bay area.

Table 1. Mercury Toxicity Reference Values Used for Hazard Quotient Estimations

Species Guild	Model Species/ Habitat	Low Dose TRV (mg/kg BW/day)	Toxicological Endpoint	High Dose TRV (mg/kg BW/day)	Toxicological Endpoint
Sm Mammal	Harvest Mouse/ Salt Marsh	0.25	reproductive and developmental effects in rats (EPA 1995)	4	reproductive and developmental effects in rats (EPA 1995)
Avian	Clapper Rail/ Salt Marsh	0.039	chronic reproductive effects in mallards (EPA 1995)	0.18	mortality and neurological impairment in mallards (EPA 1995)
Shorebird	Willet/ Mudflat	0.039	chronic reproductive effects in mallards (EPA 1995)	0.18	mortality and neurological impairment in mallards (EPA 1995)

Results

Dosage varied substantially based on the use of different bioaccumulation factors for mercury derived from a variety of sediment studies in the bay area in past studies (Table 2). Hazard quotients summarized in Table 3 below reflect the 'worst' and 'best' case scenarios, wherein for the former, we used the average BAF from SFEI data provided by the Trustees (i.e., BAF = 1.66), and in the latter we used the BAF estimate from Mare Island (BAF = 0.187) adopted by BTAG.

Table 2. BAF Values from Co-located Sediment and Biota Samples in the Bay Area

Hunters Point Reference Data Set						
SubLocation	**Min**	**Max**	**Sublocation Average BAF**	**St. Dev**	***n***	**Species**
Alameda Buoy	NA	NA	0.333	NA	1	*Macoma nasuta*
Alcatraz Environs	NA	NA	4.563	NA	1	*Macoma nasuta*
Bay Farm Borrow Pit	NA	NA	0.360	NA	1	*Macoma nasuta*
Eastern Wetland Area	0.365942	2.091584	1.234	0.740	8	*Macoma nasuta*
India Basin Area I	0.341176	0.59761	0.439	0.095	6	*Macoma nasuta*
Oil Reclamation Area	0.184385	0.465347	0.310	0.091	6	*Macoma nasuta*
Paradise Cove			0.381	NA	1	*Macoma nasuta*
Point Avisadero Area	0.106292	2.675497	0.622	0.665	16	*Macoma nasuta*
Red Rock			1.816	NA	1	*Macoma nasuta*
South Basin Area X	0.106122	0.775862	2.385	0.133	23	*Macoma nasuta*
	Average of All Sites for Hunter's Pt Data Source		0.582	0.747		*Macoma nasuta*
SFEI Reference Data						
Petaluma River	0.332865	2.186047	1.004	0.520	10	*Crassostrea gigas, Mytilus edulis*
San Pablo Bay	0.273689	1.413613	0.771	0.397	14	*Crassostrea gigas*
Pinole Point	0.891753	1.2891	1.043	1.161	4	*Crassostrea gigas, Mytilus edulis*
Davis Point	0.599318	5.439189	2.054	1.692	10	*Crassostrea gigas, Mytilus edulis*
T-0	0.40201	13.03085	2.139	3.159	22	*Crassostrea gigas, Mytilus edulis, Corbicula fluminea*
	Average of All Sites for SFEI Data Source		1.656	2.094		*Crassostrea gigas, Mytilus edulis, Corbicula fluminea*
Mare Island *	Mare Island		0.187		?	*Macoma nasuta*

***BAF value presented by BTAG, full data set not reviewed so *n* is unknown.**

Table 3. Dose and Hazard Quotient Estimations in Castro Cove to Select Ecological Receptors, based on the Upper 95% Sediment Concentrations

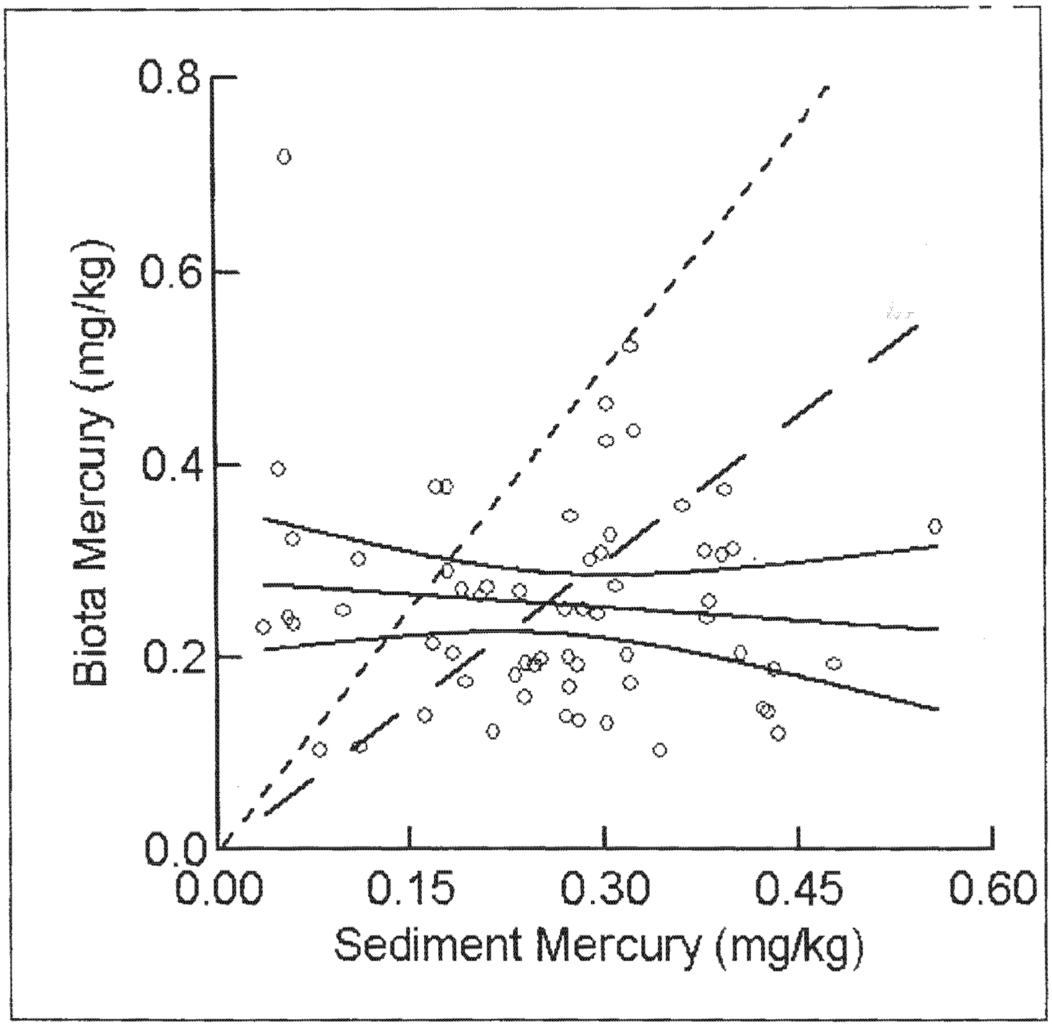
Species/Location/ Sediment	Predicted Hg Dose w/SFEI BAF of 1.66	Predicted Dose with Hg w/ BAF of 0.187 (Mare Island)	HQ* with SFEI BAF of 1.67 Low TRV	HighTRV	HQ with Mare Island BAF of 0.19 Low TRV	High TRV
Clapper Rail/Salt Marsh/Surface	0.1090 mg/kg/day	0.0217 mg/kg/day	2.79	0.61	0.56	0.12
Harvest Mouse/Salt Marsh/Surface**	0.2457	0.0305	0.983	0.061	0.124	.008
Willet/Mud Flat/ Surface	0.1903	0.0413	4.91	1.06	1.06	0.23
Scaup/Mud Flat /Surface	0.1739	0.0250	4.49	0.97	0.64	0.14

*HQ: Hazard Quotient = Predicted Dose/Toxicity Reference Value (TRV). TRVs presented in Table 1.
**A highly conservative BAF of 1.66 was also assumed for the harvest mouse vegetation, as 100% of diet is vegetable matter.

Table 3 reflects the spread in the results that have been observed. As observed in Table 3, hazard quotients exceeded '1' for the low TRV for the scaup, willet, and clapper rail, indicating possible risk to higher trophic levels in all modeling scenarios using a BAF of 1.66 (the average of all SFEI reference stations). Only the willet exposure scenario exceeded an HQ of '1' when the BAF from the Mare Island study was used.

Further discussion on the appropriate BAF value to use is required before more modeling should be conducted. To this end, BAF data plotted against the co-located sediment data from the bay area did not reflect any significant correlation between sediment and tissue mercury (Figure 1). The lack of any significant regression between sediment mercury and tissue concentration would support the use of a BAF value substantially below the 1.66 value derived from the average of the SFEI data (and consequently, lower hazards). However, it is unlikely that the Mare Island BAF value 0.187 is also representative.

Figure 1: Scatter Plot of Biota Mercury to Sediment Mercury in San Francisco Bay Samples*



*Short dashed line represents modeled relationship between sediment mercury and tissue mercury if BAF was 1.66. Long dashed line represents the same relationship if BAF = 1. Solid line represents best fit line from the observed data, with 95% confidence limits applied.