## Age Estimates and Pollutant

## Concentrations of Sediment

## Cores from San Francisco Bay

## and Wetlands

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## ExECUTIVE SummARy

This report present the findings from a study of sediment cores from San Francisco Bay subtidal locations and wetlands collected in 2006 . The objectives of this study were to determine ages and pollutant chemical concentrations of various layers in these cores, in order to provide information on San Francisco Bay sediment mixing processes and pollutant loading histories in support of ongoing efforts to forecast the recovery of this ecosystem from legacy contamination. Cores were collected at 11 subtidal sites, distributed throughout the Bay at locations where surface samples are collected annually for the Regional Monitoring Program's Status and Trends monitoring. The sites were not selected for any special characteristics of sedimentation, and were intended to begin building a representative understanding of pollutant distributions in different regions of the Bay.

Cores were also collected from six wetlands, five along the margin of the Bay, and one in a wetland adjoining an upstream but still tidally influenced portion of Alviso Slough. These sites were deterministically selected to sample marsh areas which could capture a history of sedimentation and pollutant loading over the past century or longer. The Alviso Slough location was selected with the intent of capturing a record of loading from the Guadalupe River, downstream of the New Almaden Mining District, historically the largest mercury mining district in North America.

Depths of the cores collected ranged between 1-2 m, with the intent of capturing sediments from the past century or longer. In some of the Lower South Bay sites, that depth covered a shorter time period, due to rapid subsidence from extensive groundwater withdrawal, with consequent rapid sediment accretion. Cores were sectioned and subsampled for various analyses: radioisotopes commonly used for core age determination; pollutant trace elements, with a focus on those routinely reported by the Regional Monitoring Program (RMP); organic pollutants, including legacy compounds which have since been banned in the United States (polychlorinated biphenyls (PCBs) and organochlorine pesticides) as well as newer ones (PBDEs) with continued production and use.

Ages of core sections were estimated for subtidal Bay cores by two methods: a modeling method using bathymetric histories of the sampled locations, and radioisotope tracers, ${ }^{137} \mathrm{Cs}$ to determine sedimentation since the period of atmospheric testing of atomic bombs, and ${ }^{210} \mathrm{~Pb}$ (halflife 22 years) to determine average sedimentation since the mid-1900s. For the wetland cores, only the radioisotope method was possible. In general, the age estimates by the two methods agreed qualitatively. Sites in the North Bay were generally erosional, with older sediments from the 1800s near the surface mixed in with very recent sediments. In Central and South Bay, sedimentation was fairly neutral, with little accretion or erosion since the mid-1900s. Only Lower South Bay had consistent accretion since the mid-1900s. Most wetland sites appeared consistently depositional through the sampled period.

The wetland cores, being primarily depositional areas, showed patterns of pollutant concentrations suggestive of the expected histories of their use or discharge nationally and locally. Concentrations were highest in wetlands near known past sources and have shown great changes in response to bans (e.g., PCBs and DDTs), reduced discharges (e.g., copper and mercury), or increases in use (PBDEs). One less- but not unexpected result was the finding of mercury in the Central Bay (Oakland) wetland core at concentrations as high as those from Lower South Bay, indicating the importance of urban industrial and not just mining sources to local and regional mercury pollution. There is uncertainty in the timing and magnitude of peaks for different contaminants arising from multiple factors such as the uncertainty in radiodating, the resolution (thickness) of the sections analyzed, gaps between the sections analyzed, and variations in sediment and contaminant loading rates. Nonetheless, the wetland cores are qualitatively consistent with expected patterns of historical use and loading; contaminants do not appear significantly before their known periods of widespread use, although there may be lags in responses to peaks in loads or declines following control actions, varying with localized environmental processes

In contrast, the Bay cores showed much flatter profiles, with pollutant concentrations at depth similar to current surface sediment concentrations, no or low peaks, and small gradual increases from pre-industrial background concentration. This fits expectations of lateral dilution and dispersion (seen in the similarity of surface sediment pollutant concentrations among sites in much of the Bay) as well as vertical mixing of sediments from resuspension and bioturbation. That nearly all the subtidal Bay sites showed relatively deep mixing also reduces concerns that much of the Bay contains buried pockets of more highly contaminated sediments; although there may be some subsurface reservoirs of pollutants, they appear less widespread than once feared. The unfortunate corollary of this mixing however is that these dispersed contaminants will continue to affect the ecosystem long after new inputs have ceased, until they have been diluted to below levels of concern or buried beyond the reach of resuspension processes and burrowing benthic organisms.

The results of this study have advanced our understanding of sediment pollutant processes in the Bay. These data can be used to populate mechanistic or empirical models of pollutant distributions (e.g., as initial state) or to calibrate or validate mechanistic models (e.g., as intermediate or final state). Although these sites were not deterministically selected and thus can start on building a representative characterization of the Bay, the small dataset available (e.g., in contrast to over 40 sediment sites sampled annually by the RMP) makes for large uncertainty in extrapolating to other areas in the Bay.

Nevertheless, this work provides a good basis for future efforts by reaffirming as well as refuting some past assumptions, allowing the development of more robust conceptual and numerical models. Our understanding of Bay sediment processes for such models would benefit from continued coring work, both in building a generally more representative dataset to reduce the uncertainties in extrapolation, and in characterizing specific areas or habitats of interest such as nearshore mudflats, or zones around pollutant sources or biological communities of interest. Additional coring work should proceed in a more distributed manner to reduce the demands placed on RMP analytical labs by the large number of samples that are generated by sectioning cores as well as allowing the analysis of shorter-lived isotopes ( ${ }^{234} \mathrm{Th}$ and ${ }^{7} \mathrm{Be}$ ), which were not measurable in these samples due to their rapid decay and time elapsed between collection and analysis. It is recommended that for future work, a few cores be taken from a different region each year toward building representative understanding, with additional cores taken as needed for special studies or developing new conceptual or numerical models requiring information on localized sediment history and process.

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## I. INTRODUCTION

## BACKGROUND

Although current models can draw upon a large pool of data available for characterizing surface sediment concentrations in San Francisco Bay (RMP, NOAA/EMAP), a multi-box numerical model constructed to simulate the long-term fate of PCBs in the Bay (Oram and Davis 2008) revealed the sensitivity of any projections to the inventory of pollutants already present in sediments. The lack of data on pollutant distributions in deeper sediments for most areas of the Bay thus represents a major uncertainty for predicting future pollutant concentrations.
The existing data set for that modeling effort included detailed analysis of two cores taken in 1990 by the USGS from depositional locations in the Bay (Fuller et al. 1999; Hornberger et al. 1999; Venkatesan et al. 1999), with limited data on selected pollutants for a number of other sites. A wetland core in a depositional area has been analyzed in the South Bay for mercury (Conaway et al. 2004). There also have been pollutant core data collected for specific contaminated sites for various cleanup projects (e.g., Hunter's Point), but those sites are not expected to be representative of the Bay in general and thus are of limited utility for extrapolating to Estuary-scale processes. Pollutant concentrations also are measured in cores taken for dredging projects, but samples are generally composited, so changes in concentration with depth and information on deposition history and other sediment processes are lost as a result.
The RMP, in collaboration with the Clean Estuary Partnership (CEP) therefore undertook an effort to collect additional cores widely distributed in the SF Bay in order to better characterize pollutant (mercury and PCB) distributions in deeper sediments. Funding for additional chemical analyses was provided by the Copper Development Association (for copper) and Tetra Tech (for selenium). The study was designed and conducted under guidance from the RMP Contaminant Fate Workgroup. Project budget limits precluded obtaining a sufficient number of sites to achieve a statistically robust "representative" sampling of the Bay; a statistically based design derived from surface sediment pollutant data resulted in 47 sites for RMP annual status and trends monitoring (Lowe et al. 2004). Nowhere near that number of cores that could be collected and analyzed within the budget, so a hybrid sampling plan was devised, with some deterministic sites selected to verify or refine key model assumptions or predictions, and the remainder of sites distributed geographically in segments, which have differing sedimentation regimes (i.e., depositional versus erosional), to improve the general characterization of pollutants in deeper sediments of the Bay. This hybrid approach builds anecdotal but still useful understanding of past and current environmental processes in the short term, while moving towards a more statistically robust characterization of the ecosystem for the future.

## ObJECTIVES

The primary objectives for collection and analyses of sediment cores are described below.
1: Provide a more comprehensive characterization of contamination with depth that can be used to assess future changes.

After decades of accumulating sediment as a result of hydraulic gold mining and other activities in surrounding watersheds, many areas of the Bay transitioned into an erosional regime in the latter part of the $20^{\text {th }}$ century (Jaffe et al. 1998; Cappiella et al. 1999; Foxgrover et al. 2004). The limited data from USGS cores (Fuller et al. 1999; Hornberger et al. 1999; Venkatesan et al. 1999) documented higher concentrations of pollutants at depth in sediments that may be exposed by erosion. This stock of buried contamination was seen as a possible "source" of pollutants to biota in the future, as described in the TMDL for Mercury in San Francisco Bay (Johnson and Looker 2003). However, the depositional pollutant profiles found by USGS researchers are atypical for the Bay, even for the segments from which they were taken (San Pablo and Central Bay), which have shown mostly neutral or erosional sedimentation trends in recent decades. Because neutral or erosional sedimentation has
occurred during the period of maximum loads for many contaminants (e.g., PCBs), large distinct maxima in subsurface pollutant concentrations are unlikely in most of the Bay; even for the cited USGS work, screening level analyses of a handful of other cores collected showed no distinct profiles and were not further analyzed. A majority of cores in the present study were therefore allocated to spatially distributed sites to generally characterize pollutant concentrations.

2: Verify the historic loading of contaminants to the Bay and how those loads have changed in the last several decades

The PCB multi-box model relied on historical estimates of production and use (Breivik et al. 2002), scaled proportionally with population data to generate estimated historical loads for watersheds. While providing a useful starting point, large uncertainties arise from the use of global data to estimate local pollutant sources and transport. Those uncertainties could perhaps explain a portion of the difference between model predictions of pollutant distribution and ambient measurements (overpredicting South Bay concentrations, under-predicting North Bay concentrations). The model predictions could be improved by adjusting historic loads in model boxes to better fit available data (e.g., surface contaminant concentrations), but whether and to what degree such adjustments are justified is unknown.

Cores near point and non-point sources could provide evidence whether historical loading estimates used in models would be reasonable. Cores were therefore also sought from depositional locations in each segment of the Bay. Although there are deep-water depositional locations, sediments in deeper Bay cores would likely integrate in-Bay sediments carried and mixed from a wide area, muting any signal of local changes in loading. Cores from selected wetlands along the margins of an estuary segment would represent material transported from adjacent tributaries, combined with nearby Bay sediments reworked by wind, wave, and tidal action. The relative contribution of tributary loads compared to reworked Bay sediments within any particular wetland location is not easily resolved, but the local signal almost certainly would be larger than for deep-water sediment locations in the Bay. Wetlands further upland in areas of less or no tidal influence might also provide a record of historical changes in pollutant loads for specific watersheds, with little to no influence of mixed Bay sediments.

## \#3: Provide data for parameterization and evaluation of forecast models

Data from cores collected to meet the previous objectives can also be used to parameterize models and evaluate their performance. Characterization of the distribution of pollutants with depth throughout the Bay provides data to compare with model hindcasts and/or to use as initial conditions for model forecasts. Pollutant concentrations in cores from erosional areas can be combined with projected erosion rates to estimate future pollutant fluxes from Bay sediments. Information from Bay and watershed wetland depositional cores provides evidence for trends in past loads, to verify or refine estimates derived from historical emissions and production data. Depositional cores, particularly near watersheds of interest, also provide evidence of recent trends in loads that can be used to project future loads. Depositional sites can be recognized as those with relatively high accumulation rates that have reasonable concordance for chronologies based on ${ }^{210} \mathrm{~Pb}$ and ${ }^{137} \mathrm{Cs}$ profiles, illustrated in later discussion. These sites are also expected to show accumulation both from bathymetric changes and radioisotope profiles.

## II. SITE SELECTION AND CORE COLLECTION FROM SAN FRANCISCO BAY AND WETLANDS

## Site Selection

Although this coring study was planned initially to address multi-box model needs, the RMP CFWG encouraged consideration of the field sampling independent of any particular model. Subtidal sites were selected to begin "representative" coverage of the Bay, chosen from among those randomized locations sampled for RMP Status and Trends monitoring, with most being sites scheduled for annual or less frequent revisits. Two sites were selected for each Bay segment, except Central Bay, which was allocated a third site due to its large area.

Wetland sites were selected from locations expected to be continuously hydrologically connected over at least the last century or longer. Although wetlands have been greatly reduced from their historical extent, pockets of older marsh were found, allowing allocation of one wetland sampling site to each Bay segment. Given the interest in the impact of mercury mining, one site was also chosen in Alviso Slough to try and capture indications of loading from of the New Almaden mining district. Sites were chosen in consultation with Beth Watson (Dept. of Geography, UC Berkeley) and the SFEI Historical Ecology Program.

## Core Collection And Handling

## Equipment preparation

Sample handling tools were pre-cleaned in the laboratory by AMS. Tools were cleaned in the field between samples after contact with sediment. Cleaning followed standard procedures used in the RMP: brushing with a detergent solution, then rinses in deionized water, $1 \%$ reagent grade hydrochloric acid, and finally reagent grade methanol. Polycarbonate core liners used for Bay core collection were steam cleaned and capped for transport to the sampling vessel by Weston Solutions. For wetland cores, butyrate core liners for the Livingston corer were cleaned using standard RMP procedures described above, capped, then placed into plastic sleeves, and transported to the field by AMS. Polypropylene box containers used for bulk wetland box cores were rinsed with site water prior to use.

## Bay core collection and handling

Bay cores were collected from the R/V Questuary operated by the Romberg Tiburon Center for Environmental Studies (San Francisco State University), with a sampling crew comprised of staff from Weston Solutions, AMS, and SFEI. When possible, three-point anchoring at the sampling site (one anchor from the bow and two from the stern) was employed to minimize boat movement while coring. This reduced the probability of failed collection attempts and/or damage to coring equipment (versus using bow anchors only). This also helped insure that duplicate cores were collected as closely together as possible, minimizing spatial variability of sampled sediments. A ship's log and field notes/data sheets were completed for each site, and included at a minimum: date, collection time, crew names, site coordinates, water depth, core measurements (e.g., total length, barrel penetration), and general core description (color, consolidation, odors, etc.).

Core liners were rinsed with site water prior to collection. Vibracoring equipment was then used to collect two 3.5 -inch diameter cores (one for analysis, one for archive) at each site. Vibracoring disturbed upper sediment layer stratigraphy, so the crew also collected a 3 -inch diameter push core ( $15-30 \mathrm{~cm}$ length) at each site except LSB002S, which was too deep for push coring. The push core provided a relatively undisturbed sample of near surface sediments for analysis of contaminants and possible ${ }^{234} \mathrm{Th}$ radiodating, although the latter would only be usable with very rapid sample processing, which was not achieved for most samples for this study.

Suspended sediments were seen in the overlying water of vibracores brought on deck, so the sampling crew allowed most of the suspended sediment to settle for several minutes, then drilled holes in the liner just above the sediment surface to drain water and residual suspended sediment, exposing the more consolidated sediment surface. The top of the liner was cut off with a cleaned hacksaw near the sediment surface, and then the cores were capped, sealed with tape, and labeled. The cores were kept vertical as much as possible until frozen, to avoid shifting of sediment layers. Sample handling was done with clean nitrile gloves.

In the May sampling event, cores were cut into two to three sections with a clean hacksaw and recapped, then stored on deck in a closed 55-gallon drum containing dry ice to freeze the cores. This approach was abandoned in July sampling, because the dry ice did was not effectively freezing the cores, and field sectioning could introduce sample contamination, disturbance, or loss of portions of the core (e.g. semi-consolidated sediments oozing out from the liner during sectioning). In July, intact cores were stored upright on deck at ambient temperature. On return to shore, sampling personnel transferred the cores (kept vertical) to a freezer truck operating continuously to freeze the cores. On the last cruise day, all cores were transported by AMS to freezers for storage.

## Wetland Core Collection and Handling

For wetland sites, personnel and equipment were driven to the nearest point accessible by car or boat, and then hiked to collection sites. Cores were collected by AMS and Beth Watson with assistance of SFEI staff using a Livingston corer ( 5 cm diameter, 85 cm length). To obtain samples for the full target depth range (surface to $\sim 150-200 \mathrm{~cm}$ in wetlands) separate cores were collected at multiple intervals at each site. After collection, the core liners containing samples were removed from the Livingstone corer, trimmed with a box knife, then capped, taped shut, and labeled. At each depth interval, triplicate adjacent cores were collected at each site to obtain sufficient sediment volume for radiodating and chemical analyses. Because Livingstone coring is not suitable for thickly rooted wetland surface sediments, personnel collected box cores with a shovel for the top 30 cm of sediment. Box cores were placed into clean polypropylene boxes, capped and taped closed. Collected cores were transported on ice in coolers to AMS for freezer storage at $-10^{\circ} \mathrm{C}$. Field notes were completed for each site, and included at a minimum: date, collection times, names of sampling personnel, site coordinates, and core depth ranges and descriptions.

## Core Processing

Cores were sectioned while still frozen into 2.5 cm intervals for later processing. Bay vibracores and wetland Livingston cores were sectioned in their liners, whereas wetland box cores were sectioned after being removed from their containers. Vibracores, Livingston cores, and box cores were all sectioned with a radial saw. Push cores were cut into intervals with a cleaned serrated knife by extruding them after partial thawing. Clean nitrile gloves were used for all handling of core intervals, and between cores, the saw blade or knife was cleaned as described above. After sectioning, core intervals were placed into clean, reclosable 4 mil polyethylene bags and labeled. Sections from the three replicate Livingston cores were consolidated by depth interval into the same bag. All intervals from a given core then were placed inside a larger bag labeled with the core ID, collection date and time, and depth intervals contained, and returned to freezer storage at $-10^{\circ} \mathrm{C}$.

Before core sections were shipped to laboratories for analysis, they were processed to remove any external contamination that might have adhered during collection or handling (e.g., sediments from other depth intervals smearing along the core liner during core penetration, or contact with saw blades and liner material). Sectioned core intervals were allowed to thaw partially on aluminum foil to make it easier to cut and scrape them. Then, all surfaces of each interval were scraped off to a depth of approximately 1-5 mm, using a cleaned serrated knife, and the scrapings were discarded. The remaining "clean" material was cut into portions for each laboratory analysis. Each portion was weighed in a clean glass jar, then capped and shipped per laboratory requirements (e.g., on wet or dry ice), with itemized chain-of-custody forms. Clean nitrile gloves were used for all handling of core
intervals. Unused portions of each interval were wrapped in aluminum foil and returned to the appropriate bag for freezing. Further portions of sediment taken from those intervals were first scraped again, although less deeply.

## III. CORE LAYER AGES MODELED FROM BATHYMETRIC HISTORY

## Core Reconstructions

Profiles of sediment age, referred to here as core reconstructions, were calculated based on the temporal sequence of bathymetric changes in the San Francisco Estuary between 1856 and 1990 (Jaffe et al. 1998; Cappiella et al. 1999; Foxgrover et al. 2004; Jaffe et al. 2007; Fregoso et al. 2008). The CoreProfile.aml of the GIS Bathychronology model (Higgins et al. 2005) automates the reconstruction procedure and allows for a rapid and easily repeatable analysis. The model assumes that changes in bathymetry result from sediment dynamics in the Bay. The influence of sea level rise is negated by bringing all grids to a common vertical datum. The model assumes that this correction has been applied. Therefore, a decrease in water depth between surveys is interpreted as a depositional horizon and an increase in water depth between surveys is interpreted as erosion that has removed previously deposited sediments. A tabular array of bathymetric changes is produced by querying the temporal series of bathymetric grids at a specific geographic location. Cores are reconstructed from the values in the array by tracking the sequence of deposition or erosion and adding or removing sediment from the reconstruction (Higgins et al. 2005). To account for the effect of erosion or deposition that occurred from the last bathymetric survey to core collection in 2006, the rate of change during the last bathymetric change period was linearly extrapolated and either decreased or increased the length of the reconstructed core.

## Results

Core reconstructions for study sites are summarized in Table III-1 and shown in Figures III-1 to 7. Core reconstructions were not possible at four sites SU002A, CB002S, CB006A, and SB001S, because erosion removed any deposition prior to the last survey and they were erosional during the most recent change period. Subsurface sediment at these sites is predicted to be older than the earliest survey. The complete reconstructions (Figures III-1 to 7) show how age varies with depth in the core. However, a simpler metric, the ages at the top and bottom of the reconstructed cores, are useful for understanding the general sedimentation setting at the sites (Table III-1). Cores from the sites in the lower South Bay, LSB001A and LSB002S, are predicted to have sediment from 2006, the year of core collection, at their top because of recent deposition. Erosion is predicted to have exposed sediment ranging in age from 1878 to 1954 in the remaining 5 cores. The lengths of the reconstructed cores are limited by the shallowest and deepest depths, corrected to remove the influence of sea level rise, during the surveys. For example, at LSB001A the reconstructed core is 556 cm long, which equates to the difference between the corrected depths in 1858 ( 923 cm ) and 2006 $(367 \mathrm{~cm})$. The number of layers in reconstructed cores is indicative of the sedimentation environment. A high number of layers are produced when the environment is consistently depositional (e.g., LSB001A; Figure III-6). A low number of layers are produced when erosion removed prior deposition (e.g., SPB002S; Figure III-3).

## Discussion

The ability of the core reconstruction model to predict age horizons was previously tested (Higgins et al. 2007) in cores using radioisotopes. The model's reconstructions were supported by comparisons to profiles of ${ }^{137} \mathrm{Cs}$ and excess ${ }^{210} \mathrm{~Pb}$ at 12 core sites in San Pablo Bay. The predicted depth of the 1951 sediment horizon is positively correlated to the depth of the first occurrence of ${ }^{137} \mathrm{Cs}$ at sites that have been depositional between recent surveys. Reconstructions at sites that have been erosional since the 1951 survey are supported by a lack of detectable ${ }^{137} \mathrm{Cs}$ and excess ${ }^{210} \mathrm{~Pb}$ below the upper 6-

16 cm of the core. A possible reason for detectable ${ }^{137} \mathrm{Cs}$ in the near surface sediment is that biological or physical processes mixed younger sediment downward. The model does not include this mixing. Higgins et al. (2007) also point out that, for long cores, correcting for compaction, which is not included in the model, may be necessary.
Core geochemistry was compared to age horizons produced using an earlier version (non-automated, but the same principles applied) of the core reconstruction model (Hornberger et al. 1999). They found that a discontinuity in geochemistry could be explained by sediment of intermediate age missing from the core because of erosion in the past.
Table III-1. Characteristics of reconstructed cores.

| Site | Longitude | Latitude | Length of <br> reconstructed <br> core $(\mathbf{c m})$ | Age near <br> surface | Age at <br> bottom | Number of <br> layers |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |
| SU001A | 122.04592 | 38.10253 | 81 | 1912 | 1887 | 1 |
| SPB001S | 122.38705 | 38.07200 | 93 | 1878 | 1856 | 1 |
| SPB002S | 122.34192 | 38.01605 | 59 | 1879 | 1856 | 1 |
| CB001S | 122.36190 | 37.87605 | 64 | 1943 | 1895 | 2 |
| SB002S | 122.16775 | 37.61010 | 22 | 1954 | 1931 | 1 |
| LSB001A | 122.09817 | 37.49313 | 556 | 2006 | 1858 | 6 |
| LSB002S | 122.07848 | 37.47912 | 167 | 2006 | 1931 | 4 |

## Predicted Sediment Chronology



Figure III-1. Core reconstruction at SU001A using the methodology of Higgins et al (2005).
East and North coordinates for UTM Zone 10S

Predicted Sediment Chronology


Predicted Sediment Chronology



Core spbco $-x$

Figure III-2, Figure III-3. Core reconstructions at SPB001S and SPB002S using the methodology of Higgins et al (2005).
East and North coordinates for UTM Zone 10S

## Predicted Sediment Chronology



Figure III-4. reconstruction at CB001S using the methodology of Higgins et al (2005).
East and North coordinates for UTM Zone 10S

## Predicted Sediment Chronology



Figure III-5. Core reconstruction at SB002S using the methodology of Higgins et al (2005).
East and North coordinates for UTM Zone 10S

## Predicted Sediment Chronology



Predicted Sediment Chronology



LSB002
5/21/00

Figure III-6, Figure III-7. Core reconstructions at LSB001A and LSB002S using the methodology of Higgins et al (2005).
East and North coordinates for UTM Zone 10S

## IV. CORE LAYER AGES ESTIMATED FROM RADIODATING ANALYSIS

Analyses of gamma emitting radionuclides in San Francisco Bay sediments are reported for the 11 subtidal and 6 wetland sites in this study. ${ }^{137} \mathrm{Cs}$ has penetrated to depths of 10 to $>150 \mathrm{~cm}$ at various sites. ${ }^{210} \mathrm{~Pb}$ distribution is usually consistent with the ${ }^{137} \mathrm{Cs}$ profiles, providing additional information. Simple exponential functions have been fit to the excess ${ }^{210} \mathrm{~Pb}$ results to provide estimates of the effective chronology at each site. Bioturbation has not yet been explicitly incorporated into modeling, but should affect all contaminants and tracers in a similar way. Based on ${ }^{137} \mathrm{Cs}$, calculated accumulation rates range from 0.3 to $>4 \mathrm{~cm} / \mathrm{y}$ for the different sites.

## Radiodating Method

Selected sections (generally around 10 per core) were shipped to University of Southern California (USC), where they were dried at $50^{\circ} \mathrm{C}$, ground, and placed in plastic tubes for gamma counting. Cores with significant shell material were wet sieved ( $\sim 100 \mu \mathrm{~m}$ mesh size) prior to drying, to separate the fine fraction. The coarse material was largely shells, and often amounted to half the mass of the sample. The radionuclides should be associated with the fine-grained materials, and the sieve step should ensure consistent dilution with the carbonate material. The prepared samples were gamma counted in an intrinsic Ge well detector for 1 to 4 days, depending on activity. Nuclides analyzed, along with peaks used, are in Table IV- 1.
Table IV-1. Isotopes and peak energies used for data analysis.

| Isotope | Peaks used (keV) |
| :--- | :--- |
| ${ }^{210} \mathrm{~Pb}$ | 46 |
| ${ }^{137} \mathrm{Cs}$ | 609 |
| ${ }^{234} \mathrm{Th}$ | 63 (no excess ${ }^{234} \mathrm{Th}$ detected in all samples) |
| ${ }^{228} \mathrm{Ra}$ | 338,911 (from ${ }^{228} \mathrm{Ac}$ daughter) |
| ${ }^{228} \mathrm{Th}$ | 238 (from ${ }^{224} \mathrm{Ra}$ daughter) |
| ${ }^{226} \mathrm{Ra}$ | 295,352 (from ${ }^{214} \mathrm{~Pb}$ daughter), 609 (from ${ }^{214} \mathrm{Bi}$ daughter) |
| ${ }^{40} \mathrm{~K}$ | 1461 |
| ${ }^{7} \mathrm{Be}$ | 478 (all samples below detection limit) |

## Results

Supported ${ }^{210} \mathrm{~Pb}$ activities were calculated by determining ${ }^{226} \mathrm{Ra}$ activities from its short-lived progeny ${ }^{214} \mathrm{~Pb}$ and ${ }^{214} \mathrm{Bi}$. ${ }^{222} \mathrm{Rn}$ is an intermediate in this decay chain, and sediments from 3 cores of different lithologies were analyzed to determine that about $12 \%$ of the ${ }^{222} \mathrm{Rn}$ produced is lost from the dried sediments before it decays. Consequently, we adjusted the measured activity of the ${ }^{214} \mathrm{~Pb}$ and ${ }^{214} \mathrm{Bi}$ by a factor of $1 / 0.88$ to determine ${ }^{226 R a}$. Excess ${ }^{210} \mathrm{~Pb}$ was calculated for each sample by subtracting the corrected ${ }^{226} \mathrm{Ra}$ from the measured ${ }^{210} \mathrm{~Pb}$ activity, and the excess ${ }^{210} \mathrm{~Pb}$ was corrected for decay between the time of collection and the time of analysis (averaging 1.5 years). ${ }^{137} \mathrm{Cs}$ was not decay corrected, as this correction ( $<2 \%$ ) was far less than the counting uncertainty.
Example profiles for excess ${ }^{210} \mathrm{~Pb}$ and ${ }^{137} \mathrm{Cs}$ (both on the same plot) for wetland and Bay stations are shown in Figures IV-1 and IV-2, and raw data are presented in Appendix Table A-1. The function:

$$
\begin{equation*}
A^{*}=A_{0} * \exp (-b z) \tag{eq.1}
\end{equation*}
$$

was fit to excess ${ }^{210} \mathrm{~Pb}$ profiles, where $\mathrm{A}^{*}$ is activity of excess ${ }^{210 \mathrm{~Pb}}(\mathrm{~Bq} / \mathrm{kg}), \mathrm{z}$ is depth in sediment, and $b$ is the depth attenuation coefficient. Results of these fits (Table IV-2) may be interpreted as an
estimate of the upper limit for accumulation rate by assuming input of ${ }^{210} \mathrm{~Pb}$ and sediment has been constant with time, and vertical transport is only due to burial. Given these assumptions:

$$
\mathrm{w}=\lambda / \mathrm{b}
$$

where $\mathrm{w}=$ linear accumulation rate $(\mathrm{cm} / \mathrm{y})$ and $\boldsymbol{\lambda}$ is the ${ }^{210} \mathrm{~Pb}$ decay constant $\left(0.0311 \mathrm{y}^{-1}\right)$.
Accumulation rates were also estimated from the profiles of ${ }^{137} \mathrm{Cs}$, assuming that a detectable amount of this isotope indicates the presence of some material that has been deposited since the late 1950s, when significant fallout from atmospheric testing of nuclear weapons began. At most subtidal sites, ${ }^{137} \mathrm{Cs}$ was found to depths of at least 25 cm . Sediment with detectable ${ }^{137} \mathrm{Cs}$ was assigned an effective age of 50 years. At several wetlands sites, extremely high concentrations of ${ }^{137} \mathrm{Cs}$ were present at a discrete horizon, reflecting the fallout maximum in the early 1960s, but maxima were far less distinct or not observed in subtidal cores.

Attempts to measure profiles of excess ${ }^{234} \mathrm{Th}$ and ${ }^{7} \mathrm{Be}$ were unsuccessful, despite the effort to count several near surface profiles as soon as possible (within 1-2 months of collection). This was likely due to the relatively large thickness of the top sample interval $(2.5 \mathrm{~cm})$, which reduced the ratio of water-column derived excess activity to sediment-supported activity, as well as the time elapsed between sample collection and counting.

## Discussion

A best estimate of accumulation rate was calculated from a combination of the rates derived from ${ }^{137} \mathrm{Cs}$ and ${ }^{210} \mathrm{~Pb}$ (Table IV-2). The ${ }^{137} \mathrm{Cs}$ was given more weight, as the measurement uncertainty in excess ${ }^{210} \mathrm{~Pb}$ becomes large for sediments older than 50 years. In some cases, ${ }^{137} \mathrm{Cs}$ was found to the bottom of the core, and the accumulation rate should be considered a lower limit. However, at those sites, the ${ }^{210} \mathrm{~Pb}$ profiles indicate lower accumulation rates, with an uncertainty ( $\pm 1 \sigma$ ) usually encompassing the estimate from ${ }^{137} \mathrm{Cs}$, so the lower limit from ${ }^{137} \mathrm{Cs}$ has been adopted as the best estimate.

Chronologies for the two isotopes are in relatively good agreement at 9 of the 17 sites, fair at 5 sites, and poor to very poor at 3 sites, based on comparison of the accumulation rates and uncertainties in the fits of equation 1 to the ${ }^{210} \mathrm{~Pb}$ profiles (Table IV-2). Estimated chronologies are presented in the Appendix Table A-1, based on the choices noted for accumulation rates. At some wetland sites, the ${ }^{137}$ Cs peak is large and very sharp. This is evidence that these sites may not have been strongly affected by bioturbation or other mixing processes which would have reduced and broadened the peak. Additional modeling could be used to quantitatively explore the effects of bioturbation and physical reworking on these profiles.
At sites where ${ }^{137} \mathrm{Cs}$ and ${ }^{210} \mathrm{~Pb}$ dating are not in perfect concordance, the disagreement in accumulation rates calculated from the two isotopes may reflect a non-uniform accumulation rate, temporal variation in the excess ${ }^{210} \mathrm{~Pb}$ of incoming fresh material (if sediment sources to the sample site vary with time, perhaps due to erosion of material from varying depths in soil horizons during flood periods, for example), or downward movement of Cs through solute transport. The last explanation seems less likely, based on the concordance of the two tracers at most sites.

As noted in Section III, there are a number of subtidal sites where bathymetric changes indicate no deposition or some erosion. At these sites, radioisotopes indicate low penetration of ${ }^{137} \mathrm{Cs}$ and ${ }^{210} \mathrm{~Pb}$, and it is possible that their sedimentation rates are zero or even negative. At such sites, the observed inventory of ${ }^{210} \mathrm{~Pb}$ and ${ }^{137} \mathrm{Cs}$ may result from transport of isotopes as fresh particles settle from the water column while older particles are resuspended. Simultaneous bioturbation or physical reworking would result in a downward flux and accumulation of ${ }^{210} \mathrm{~Pb},{ }^{137} \mathrm{Cs}$, and other particle-bound contaminants, even though the rate of resuspension could equal or exceed the rate of fresh particle settling. Thus, net accumulation of sediment can be negligible or negative, even though some new
material has been incorporated into sediments. At most sub-tidal sites in the Bay, bathymetric change suggests little or no accumulation, but the penetration depth of ${ }^{137} \mathrm{Cs}$ is typically 25 cm . The isotope chronology reveals the prevalence of a sediment layer containing some material from less than 50 years ago that has mixed with water column suspended matter or mixed downward through bioturbation.

Agreement of the two isotopes is particularly poor in Suisun Bay. As the excess ${ }^{210} \mathrm{~Pb}$ and ${ }^{137} \mathrm{Cs}$ are primarily bound to fine-grained material, the sandy lithology of these sediments results in isotope activities that are very low and have considerable uncertainty. The ${ }^{137} \mathrm{Cs}$ is more easily detected, and the disagreement of the chronology primarily reflects analytical uncertainty. The core from SU002A is particularly interesting, as it shows some ${ }^{137} \mathrm{Cs}$ activity more than a meter deep, with an erratic profile. The low activity and inconsistent accumulation in subtidal Suisun Bay cores fits with expectations of net erosion in the area in recent history. . The proximity of the SU002A site to the main shipping channel may be another reason, as maintenance dredging of the channel, in combination with episodic pulses of sediment supply and deposition in high flow events, could result in a patchwork of sediments of different ages going down-core. Isotope activities are higher and agreement is somewhat better in the more fine-grained Suisun wetland (Point Edith) core due to its more consistently depositional history compared to the sub-tidal site near the main channel.
San Pablo Bay subtidal cores are less variable but still somewhat patchy, whereas the wetland core (Wildcat Creek) shows good agreement in isotope profiles. Of the two subtidal sites, SPB002S is nearer the main channel and thus also more likely to be impacted by fresh sediments transported in episodic Delta flood events. Agreement is best for Central and South Bay sites, with moderate to low apparent accumulation rates.

The two LSB sites and most wetland sites appear to show more consistent net accumulation and are less influenced by bioturbation, as evident from sharper ${ }^{137} \mathrm{Cs}$ peaks. Accumulation rates appear to be highest in Lower South Bay and in wetland sites Coyote Creek and Alviso Slough, with Alviso showing ${ }^{137} \mathrm{Cs}$ activity over its entire sampled depth $(\sim 1 \mathrm{~m})$. Variability and lack of concordance in ${ }^{210} \mathrm{~Pb}$ and ${ }^{137} \mathrm{Cs}$ activity at these sites suggest variable accumulation rates, with upland soils from different time periods transported and deposited episodically. Rapid sediment accumulation, with ${ }^{137}$ Cs activity down to 80 cm and deeper in these cores are in line with historical subsidence of the region in the 1900 s due to extensive groundwater withdrawal. Patterns of sedimentation evident in radioisotope dating are thus in general agreement with regional patterns of historical sediment processes discussed in the previous chapter, influenced by local conditions (e.g. proximity to the main shipping channel and sediment discharges from the Delta for some of the North Bay sites).


Figure IV-1. Example profiles of isotopes at wetland stations.
The heavy dashed line is the best fit to the ${ }^{210} \mathrm{~Pb}$ data. Uncertainties shown are $\pm 1$ sd for activity, or the vertical thickness of the sample. Wildcat Marsh shows a distinct peak at 18 cm , probably reflecting the high fallout from atomic testing in the early 1960s. In Coyote Creek, a peak appears at about 78 cm , but it is far smaller and less distinct. The difference may reflect more dilution with by incoming sediment and greater bioturbation. Calculated accumulation rates from the two isotopes is good in Wildcat, but differs by a factor of 1.5 in Coyote Creek, perhaps due to variable accumulation


Figure IV-2. Example profiles of isotopes at subtidal Bay stations.
See Figure IV-1 for explanations of symbols used. Fits to the excess ${ }^{210} \mathrm{~Pb}$ profiles have uncertainties of $\sim 25 \%$ in depth attenuation coefficients, and the noise in the signal is likely a combination of analytical uncertainty, variability of excess ${ }^{210} \mathrm{~Pb}$ in the incoming sediment, and sometimes variation in accumulation rates. At each site, ${ }^{137} \mathrm{Cs}$ and ${ }^{210} \mathrm{~Pb}$ isotopes yield concordant estimates of sediment age. The greater penetration of isotopes at the LSB001S site indicates a greater accumulation rate there. The profile at CB001S is likely a result of isotope transport by deposition/ resuspension/ bioturbation, incorporating an inventory of relatively young particle-bound material into the upper sediments.

Table IV-2. Summary of accumulation rates.

| Site | ${ }^{137}$ Cs <br> Depth <br> (cm) | ${ }^{137} \mathrm{Cs}$ Acc rate $(\mathrm{cm} / \mathrm{y})$ | ${ }^{210} \mathrm{~Pb}$ <br> Acc rate (cm/y) |  |  | $\begin{gathered} { }^{210} \mathrm{~Pb} \\ \text { Ao* } \\ (\mathrm{Bq} / \mathrm{kg}) \end{gathered}$ |  |  | $\begin{gathered} { }^{210} \mathrm{~Pb} \\ \mathrm{~b} \\ (1 / \mathrm{cm}) \end{gathered}$ |  |  | Notes | Average Acc rate (cm/y) | Pb \& Cs age agreement |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CB001S | 24 | 0.5 | 0.5 | $\pm$ | 0.1 | 43 | $\pm$ | 7 | 0.062 | $\pm$ | 0.018 |  | 0.5 | good |
| CB002S | 25 | 0.5 | 0.7 | $\pm$ | 0.1 | 62 | $\pm$ | 5 | 0.047 | $\pm$ | 0.008 |  | 0.6 | good |
| CB006A | 26 | 0.5 | 0.9 | $\pm$ | 0.4 | 18 | $\pm$ | 4 | 0.034 | $\pm$ | 0.014 | Shell hash, sieved | 0.7 | fair |
| SB001S | 25 | 0.5 | 0.8 | $\pm$ | 0.2 | 45 | $\pm$ | 7 | 0.041 | $\pm$ | 0.012 | Shells, sieved | 0.6 | good |
| SB002S | 24 | 0.5 | 0.4 | $\pm$ | 0.1 | 49 | $\pm$ | 6 | 0.088 | $\pm$ | 0.017 |  | 0.4 | good |
| LSB001A | 63 | 1.3 | 1.5 | $\pm$ | 0.4 | 38 | $\pm$ | 5 | 0.021 | $\pm$ | 0.006 |  | 1.3 | good |
| LSB002S | >160 | $>3.2$ | 2.2 | $\pm$ | 0.5 | 34 | $\pm$ | 4 | 0.014 | $\pm$ | 0.003 | Use Cs lower limit | 3.2 | fair |
| SPB001S | 15 | 0.3 | 0.4 | $\pm$ | 0.1 | 54 | $\pm$ | 7 | 0.076 | $\pm$ | 0.017 | Some Shells, sieved | 0.34 | good |
| SPB002S | $>160$ ? | $>3.2$ | 2.6 | $\pm$ | 1.9 | 15 | $\pm$ | 4 | 0.012 | $\pm$ | 0.009 | Use Cs lower limit | 3.2 | fair |
| SU001A | 33 | 0.7 | 0.3 | $\pm$ | 0.1 | 22 | $\pm$ | 4 | 0.114 | $\pm$ | 0.041 | Iow activity | 0.5 | poor |
| SU002A | >102 | >2.0 | 0.0 | $\pm$ | 0.2 | 14 | $\pm$ | 62 | 0.8 | $\pm$ | 3.3 | Sandy, low activity Use CS lower limit | 2.0 | really poor |
| Coyote Creek (LSB) | 90 | 1.8 | 1.1 | $\pm$ | 0.2 | 39 | $\pm$ | 4 | 0.029 | $\pm$ | 0.006 |  | 1.6 | poor |
| Greco Island (SB) | 38 | 0.8 | 0.8 | $\pm$ | 0.3 | 37 | $\pm$ | 7 | 0.038 | $\pm$ | 0.012 |  | 0.8 | good |
| Pt. Edith (Su) | 13 | 0.25 | 0.1 | $\pm$ | 0.0 | 461 | $\pm$ | 542 | 0.510 | $\pm$ | 0.31 |  | 0.19 | fair |
| Damon <br> Slough (CB) | 16 | 0.32 | 0.3 | $\pm$ | 0.1 | 88 | $\pm$ | 23 | 0.117 | $\pm$ | 0.037 |  | 0.30 | good |
| Wildcat Marsh (SPB) | 30? | 0.6 | 0.5 | $\pm$ | 0.2 | 47 | $\pm$ | 11 | 0.066 | $\pm$ | 0.022 |  | 0.6 | good |
| Alviso Slough (LSB) | >100 | >2.0 | 1.4 | $\pm$ | 0.3 | 51 | $\pm$ | 6 | 0.023 | $\pm$ | 0.005 | Use Cs lower limit | 2.0 | fair |
| Cs weight $=2, \mathrm{~Pb}$ weight $=1$, unless Cs is lower limit. In this case take Cs estimate. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Uncertainties in apparent accumulation rate are approximately 20-30\% at most sites. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

## V. CONCENTRATIONS OF INORGANIC ANALYTES IN CORES

## LABORATORY ANALYSIS OF TRACE ELEMENTS

Trace elements reported (other than mercury) were analyzed by the San Francisco Public Utilities Commission (SFPUC) Southeast Laboratory. Core samples were received frozen at the laboratory and kept frozen until analysis. Samples were thawed, with a subsample taken for determination of percent moisture about one week before the sample preparation for chemical analysis. Weighed subsamples were dried overnight in a drying oven at $105^{\circ} \mathrm{C}$. Percent moisture was determined form the net change in weight. Remaining sample material was stored at $4^{\circ} \mathrm{C}$ until preparation for chemical analysis.

Based on the percent moisture, a wet subsample was measured out to provide 0.25 g (nominal weight) on a dry weight basis. The sample digestion procedure (Bureau of Mines Report 8480) was chosen to provide "true total" recovery of at least $90 \%$ for the target analytes. Samples were digested with a mixture of hydrochloric, hydrofluoric, nitric, and boric acid for approximately 7 hours, centrifuged for 15 min at $3,500 \mathrm{rpm}$ to remove residual particulate material, and diluted 10-20 times prior to ICPMS analysis.

ICPMS analysis was conducted by collision reaction cell (CRC) technology was used to minimize the various plasma and matrix based interferences. Helium was used as the carrier gas for all analyses, except for Se , for which hydrogen was used instead. The following twelve elements were quantitatively determined in each sample: $\mathrm{Ag}, \mathrm{Al}, \mathrm{As}, \mathrm{Cd}, \mathrm{Cr}, \mathrm{Cu}, \mathrm{Fe}, \mathrm{Mn}, \mathrm{Ni}, \mathrm{Pb}, \mathrm{Se}$, and Zn . Additional elements measured but not reported here were $\mathrm{Ba}, \mathrm{Be}, \mathrm{Ca}, \mathrm{Co}, \mathrm{K}, \mathrm{Mg}, \mathrm{Mo}, \mathrm{Na}, \mathrm{P}, \mathrm{Sb}, \mathrm{Sn}$, $\mathrm{Sr}, \mathrm{Ti}, \mathrm{Tl}, \mathrm{U}$, and V. These elements have not been target analytes in previous RMP Status and Trends monitoring and thus were not reported here.

Samples for sediment mercury analysis were sent to Moss Landing Marine Laboratory and stored frozen until time of analysis. Thawed sediment samples were digested by adding 4.0 mL of concentrated HCl to 1.0 g of wet sediment and swirling. Next, 1.0 mL of concentrated $\mathrm{HNO}_{3}$ was added, swirled, and samples were loosely capped and digested in a fume hood at room temperature overnight. After complete digestion, samples were diluted up to $40 \pm 0.5 \mathrm{~mL}$ with high purity deionized water (DI, 18 megaohm), capped tightly, shaken vigorously, and allowed to settle until the supernatant was clear. Total mercury ( HgT ) was measured by aqueous-phase reduction with stannous chloride solution followed by atomic absorbance detection using an automated PerkinElmer Flow Injection Mercury System (FIMS-100) with the software application AA WinLab (Heim 2003).

Conventional sediment quality parameters of moisture content, grainsize and total organic carbon (TOC) were also determined at MLML. Moisture content was determined from separate $\sim 1 \mathrm{~g}$ subsamples of thawed material taken at the same time, weighed, and oven-dried to constant weight to determine percent moisture. Calculated percent moisture was then used to derive dry weight concentration of mercury. Samples for grainsize were dispersed in de-ionized water, and subsampled with a pipette ( 2 mm diameter) while vibrating the flask to resuspend the sediment and ensure random sampling. Samples were then introduced to a Beckman-Coulter LS 13320 laser particle size analyzer attached to an aqueous module equipped with a pump and a built-in ultrasound unit. The size distributions measured ranged from $0.04 \mu \mathrm{~m}$ to 2 mm . For measurement of TOC, sediment subsamples of $\sim 1 \mathrm{~g}$ dry weight equivalent were dried in a $60^{\circ}-70^{\circ} \mathrm{C}$ convection oven to complete dryness (48-72 hrs.), then homogenized in a commercial ball-mill (SPEX Ind.) for three minutes. Small ( $5-10 \mathrm{mg}$ ) aliquots of the sample are then measured in an elemental analyzer (Control Equipment 440 Elemental Analyzer), combusting at $<800 \bullet$ C to reduce decomposition and measurement of carbonates in the samples.

## Trace element QA/QC

Samples were analyzed by SFPUC in batches of up to 20 samples. Method detection limits (MDL, determined according to 40 CFR Part 136, Appendix B, reagent water matrix.) were sufficient for quantitative results for nearly all reported elements in all samples, except Se , with $7 \%$ of results below detection (Table V-1). Each batch included a method blank, method blank spike, sample duplicate, matrix spike/duplicate, and at least two different Certified Reference Materials (CRMs, NRC MESS3 Beaufort Sea and NIST 1646a Chesapeake Bay). Target analytes were generally not detected in method blanks, or were at concentrations much lower than in field samples, except Cu , which was found in blanks at average concentrations of $4 \mathrm{mg} / \mathrm{kg}$ and reported blank corrected. Replicates were generally good, with relative percent difference or relative standard deviation (RPD/RSD) averaging $<25 \%$. Sample spike recoveries were in the target range ( $75-125 \%$ recovery) for spikes at least equal to the native concentration. Generally the recoveries of the CRMs were in the range of $85-115 \%$ of their certified values, except for analytes that were near the detection limit. A summary of results for QA/QC samples in a quantitative range (target values at least three times MDL) is presented in Table V-2.

MLML derived the mercury MDL from three times the standard deviation of nine determinations of a low mercury matrix (sand) spiked with $60 \mathrm{ng} \mathrm{Hg} \mathrm{g}-1 \mathrm{dw}$ sediment. All sediment Hg concentrations were above the laboratory MDL of $0.004 \mu \mathrm{~g} \mathrm{Hg}$ g-1 dry weight. Method blanks were included for all analytical batches, and mercury was not detected above MDL in any of the blanks. Precision on replicate analysis of field samples was good, with an average relative percent difference (RPD) for duplicate measurements of $1.9 \%$ for HgT in solids ( $\mathrm{n}=5$ pairs). Recoveries for standard reference material analyses ( $\mathrm{n}=10$, NIST 1944, with Hg of $3.4 \mu \mathrm{~g} / \mathrm{g} \mathrm{dw}$ sediment) were within the target range (100 $\pm 25 \%$ ), averaging ( $\pm$ stdev) $99 \pm 6 \%$.

## Table V-1. Summary QA/QC Results, Ancillary and Trace Element Analysis.

MDL and blank averages reported as $\mathrm{mg} / \mathrm{kg}$, except for $\%$ total nitrogen and $\%$ total organic carbon.

|  | Avg MDL | \%NDs | Avg <br> Blank | Replicate <br> RSD | MS rec <br> avg | MS rec <br> stdev | SRM rec <br> avg | SRM rec <br> stdev |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Aluminum | 100 | $0 \%$ | ND | $4 \%$ | - | - | $95 \%$ | $3 \%$ |
| Arsenic | 0.3279265 | $0 \%$ | ND | $10 \%$ | $99 \%$ | $7 \%$ | $105 \%$ | $8 \%$ |
| Cadmium | 0.0466777 | $0 \%$ | ND | $9 \%$ | $98 \%$ | $6 \%$ | $88 \%$ | $13 \%$ |
| Chromium | 0.0337857 | $0 \%$ | 0.28 | $5 \%$ | - | - | $85 \%$ | $7 \%$ |
| Copper | 0.3379787 | $0 \%$ | 0.95 | $6 \%$ | $95 \%$ | $7 \%$ | $94 \%$ | $12 \%$ |
| Iron | 100 | $0 \%$ | ND | $5 \%$ | $0 \%$ | $0 \%$ | $92 \%$ | $4 \%$ |
| Lead | 0.1336602 | $0 \%$ | ND | $6 \%$ | $101 \%$ | $6 \%$ | $98 \%$ | $7 \%$ |
| Manganese | 0.1033785 | $0 \%$ | 0.02 | $6 \%$ | - | - | $93 \%$ | $3 \%$ |
| Nickel | 0.0285988 | $0 \%$ | 0.1 | $5 \%$ | - | - | $88 \%$ | $4 \%$ |
| Selenium | 0.1969331 | $7 \%$ | ND | $7 \%$ | $98 \%$ | $5 \%$ | $100 \%$ | $14 \%$ |
| Silver | 0.0106691 | $0 \%$ | 0.04 | $24 \%$ | $104 \%$ | $7 \%$ | $119 \%$ | $24 \%$ |
| Zinc | 0.732932 | $0 \%$ | 1.12 | $4 \%$ | $104 \%$ | $8 \%$ | $94 \%$ | $7 \%$ |
| $\%$ Total Nitrogen | 0.001 | $0 \%$ | ND | $3 \%$ | - | - | $100 \%$ | $1 \%$ |
| $\%$ Total Organic Carbon | 0.02 | $0 \%$ | ND | $3 \%$ | - | - | $99 \%$ | $3 \%$ |
| Mercury | 0.004 | $0 \%$ | ND | $3 \%$ | - | - | $99 \%$ | $6 \%$ |

## Results and Discussion

Results for all reported trace elements are presented in Appendix Table B-1 and B-2 as mg/kg dry weight. The discussion herein will focus on copper, mercury, and selenium, elements of particular
concern due to concentrations near ambient water quality criteria and listed as impairing beneficial uses in San Francisco Bay.

## Copper

Copper concentrations measured in cores from wetland and Bay sites are presented in Figures V-1 and V-2, respectively. Concentrations for surface sediments in the figures represent Bay segment means of surface ( $0-5 \mathrm{~cm}$ ) samples collected by the RMP Concentrations shown are normalized to percent fine sediments, to be comparable with sieved ( $<64 \mu \mathrm{~m}$ ) results previously reported (Hornberger et al. 1999). The highest concentrations were found in cores from wetlands, with four of the six wetland cores containing sections with normalized copper concentrations over $100 \mathrm{mg} / \mathrm{kg}$. Sections in wetland cores with the highest concentrations were generally found midway between the maximum depth of ${ }^{137}$ Cs penetration (corresponding to around 1960) and the surface (2006). This pattern is in agreement with the previous results showing a 1979 maximum in surface sediment and clam tissue concentrations for a time series of samples collected from a shallow subtidal site near a wastewater treatment plant in South Bay (Hornberger et al. 2000). Discharges of copper from that plant and others have decreased dramatically since then, with corresponding decreases in surface sediment concentrations over time and in near-surface sections from sediment cores. The exceptions to the general pattern showing a decrease in copper since around 1980 were from Damon Slough in Central Bay, and Alviso Slough in Lower South Bay. The Damon Slough site is located near $(<200 \mathrm{~m})$ the edge of a major freeway in a densely urban area, fringing San Leandro Bay, a sub-embayment more enclosed that the other sites in this study. Thus we would expect more influence from local tributaries sediments and less mixed sediments from the open-water areas of Central Bay. Copper concentrations in automotive brake pad materials have increased since the 1990s (Boren 2008), which may in part explain the continued rising trend in sediment copper concentrations at that site despite decreases in wastewater loads. The wetland site along the edge of Alviso Slough is also relatively enclosed, draining an urbanized area, and thus likely to have less open water Bay sediments and more watershed influences.

In contrast, only two cores from subtidal open water sites, CB006A and SU002A, contained concentrations as high as those in wetlands (i.e. $>100 \mathrm{mg} / \mathrm{kg}$ ). For the SU002A site, many of the sections had extremely low ( $<10 \%$ ) fine sediment content, with highly variable fines content between sections, resulting in artifacts of anomalously high calculated concentrations when normalized for percent fines in some sections. Although post analysis normalization for grainsize can serve as a reasonable proxy for concentrations of sieved fractions in samples with consistent and moderate to high fines content, with low fines, small uncertainties in grainsize measurements in absolute terms (e.g. $2 \pm 1 \%$ fines) become extremely large uncertainties in relative terms (i.e. $\pm 50 \%$ for concentrations normalized with percent fines as denominator) when measured values are small.

The results from CB006A are moderately high in fines content (all measured sections $>50 \%$ fines), so the calculated normalized concentrations are more reasonable and coherent. The depth of the section with the highest concentration in that core corresponds to an age of around 20 years, in line with the expected timing of improvements in wastewater treatment and efforts in source reduction around the Bay Area. Sections for the other subtidal Bay cores were fairly uniform, and similar to surface sediment copper concentrations in RMP Status and Trends monitoring sites for the period 2002-2006. The uniform concentrations in most Bay cores are consistent with previous work in a USGS study (Hornberger et al. 1999). Although much of that work focused on reporting results from selected depositional areas, the majority of sampled sites in that study also showed uniform profiles of trace elements in screening level analysis seeking peaks in metals concentrations.


Figure V-1. Copper Concentrations in Sediments from Wetland Cores.


Figure V-2. Copper Concentrations in Sediments from Bay Cores. I missed something, why the surface samples are any different from cored samples? Separate collection effort?

## Mercury

Mercury concentrations in wetland core sediments (Figure V-3) were especially high in surprisingly recent layers, arriving over a century after the widespread and poorly-controlled use of mercury in the Sierra Nevada during the Gold Rush and the peak of mercury production in the mines of New Almaden and other mines in the Coast Range. Similar to the copper results, the highest mercury concentrations in wetlands generally were found at depths deposited around or slightly before 1960, suggesting a period of maximum mercury loading to all segments of the Bay after World War II. This peak in mercury concentrations in subsurface sediment is most pronounced in the wetland cores from Lower South Bay (Coyote Creek) and from Central Bay (Damon Slough, discharging to San Leandro Bay). The wetland cores are consistent with results of the USGS cores previously reported (Hornberger et al. 1999) which suggested that there would be areas with layers of sediment more highly contaminated with mercury and other pollutants in depositional areas.

However, for the majority of cores taken in subtidal areas of the Bay in this study, mercury concentrations were fairly uniform in sections nearer the surface and in intermediate layers. Although concentrations were lower in the deepest sections of the cores from before the Gold Rush (e.g. in Figure V-4 all SPB, CB, and SB sites), maximum concentrations in most cores contained (normalized to percent fines) less than $1 \mathrm{mg} / \mathrm{kg}$ of mercury (dry weight), similar to maximum concentrations ( 0.8 $\mathrm{mg} / \mathrm{kg}$ ) in current surface sediments measured in the RMP Status and Trends monitoring.
The uniformity of mercury concentrations in subtidal cores from open-water areas of the Bay could occur through a number of mechanisms. The mixing of suspended sediments carried in from various watersheds loading to the Bay, combined with reworking of sediments through bioturbation and wind and wave processes would tend to disperse any highly contaminated sediments both vertically and laterally. The similarity of concentrations between Bay segments, with even Lower South Bay only slightly elevated compared to other segments despite its proximity to New Almaden, supports the role of mixing in creating these fairly uniform conditions. Radioisotopes in the subtidal cores also indicate mixing, with the ${ }^{137} \mathrm{Cs}$ peak greatly flattened compared to wetland sites.

Previous work (Hornberger et al. 1999) suggested that spatial trends in peak mercury concentrations and sediment inventories reflect "a historic source in the watershed (the mines)." However, the highest mercury concentration for the Damon Slough site was similar to the highest concentration in Lower South Bay, despite being the location most distant from large mining efforts for either mercury in Lower South Bay or gold in the Sierra Nevada. Mining contaminated sediments from the New Almaden Mining District could explain the maximum of mercury seen in the Coyote Creek core, given its proximity. However, for Damon Slough, there was little documented mercury mining in the watershed, yet maximum concentrations were similar to those for wetlands downstream of North America's largest mercury mine. Long range transport from mining operations from watersheds in Lower South Bay or North Bay could also be possible but seem very unlikely, as we would expect similar layers with high concentrations for sites more intermediately proximate to those sources (e.g., in South Bay at Greco Island, or San Pablo Bay at Wildcat Marsh).

Although the Alviso Slough wetland site is in the Guadalupe River watershed, where the New Almaden Quicksilver Mine was located, maximum mercury concentrations in that core were lower than those from Damon Slough and Coyote Creek. For the Lower South Bay wetland sites, the earliest period of gold and mercury mining may not have been entirely captured in the cores. Extensive groundwater drawdown in Lower South Bay for agriculture and other uses during the 1900s caused the area around Coyote Creek and Alviso Slough to subside, around 100 cm or more just in the period 1920-1960. Cores from both sites were collected and analyzed to a depth of just over 160 cm , so a large portion of the overall length for both cores is of recent origin. A core in another study (Conaway et al. 2004) collected in 2000 from Triangle Marsh (near the Coyote Creek site) showed a maximum in mercury at a similar depth $(65 \mathrm{~cm})$, deposited between layers from World War II and 1983. In the Triangle Marsh core, mercury concentrations decreased to background
concentrations (around 0.1 ppm ) in pre- Gold Rush era sediments at 160 cm depth, concentrations similar to those in the deepest sections from other locations in this study. Mercury concentrations above this regional background concentration in the deepest sections of the current Alviso and Coyote Creek cores suggest that they capture a period starting after the onset of mining in the New Almaden District in the mid-1800s. Other cores taken in Alviso have shown mercury concentrations that are patchy, differing among locations along the length of the slough, and among cores taken from each bank and mid-channel at each location (Marvin-DiPasquale and Cox 2007), so the lack of a distinct mercury peak even in the Alviso core is not uncommon. This patchiness may be due to episodic scour or deposit in different areas during high flow conditions.

Figure V-5 shows the production volumes of the New Almaden Mine from 1847-1945 (Bailey and Everhart 1964). Maximum production occurred in the late 1800s, long before the peak in sediment concentrations found in the wetland cores in the current and Conaway et al. (2004) studies. The cause of the lag between the period of maximum mining activity and appearance of mercury in bayside wetlands is unknown. This may in part be due to a long lag time for transport of contaminated sediments from the upper watershed (where the mines were located) to the edge of the Bay. Another possibility is a brief spike in mining activity at New Almaden from the 1960s through the 1970s (Cargill et al. 1980), after which the property was acquired by Santa Clara County. This post-WWII activity was driven by high demand (Jasinski 1994) and prices for mercury (Figure V-6), with much of the production at New Almaden achieved through open cut mining, exposing and potentially mobilizing large areas of soil. Given the distance from New Almaden and a lack of similar peak in a site in between (Greco Island), the peak in mercury found in the Oakland wetland core is more likely to be a local, dominantly urban (Oakland) source for mercury contamination, as that peak corresponding to the national increase in mercury demand during the 1960s.

Based on high concentrations of mercury in areas of the Guadalupe River watershed, delayed or post- World War II transport of mercury from mining areas might still be the primary source of the peak in mercury found in wetland areas of Lower South Bay. However, with a large peak also seen in an Oakland location distant from mining, and given urbanization of much of the Bay area, local industrial urban sources may also explain a large portion of the post- World War II maximum in mercury loading, possibly even for mercury-mining impacted areas in South and Lower South Bay. Given both plausible mining and urban sources, it may be difficult to resolve the relative contributions of various sources until specific markers for each source type are measured. For example, mineral forms such as cinnabar and metacinnabar would be more indicative of mining sources, whereas mercuric oxides could indicate applications as biocides in paint and other products, and elemental mercury would suggest use in electronics and other applications requiring liquid mercury. A current special study funded by the RMP measuring the relative abundance of stable mercury isotopes in surface sediments from various areas of the Bay might also help to distinguish among various possible sources, information which may one day allow us to better identify ongoing sources and devise more effective management options.


Figure V-3. Mercury Concentrations in Sediments from Wetland Cores.


Figure V-4. Mercury Concentrations in Sediments from Bay Cores.


Figure V-5. Production of the New Almaden Mines 1847-1945 (Bailey and Everhart 1964).


Figure V-6. United States Mercury Consumption 1941-1990 (Jasinski 1994).

## Selenium

Similar to the other trace elements, selenium concentrations in core sections taken from the Bay were lower and more uniform than cores from wetlands (with exception of SU002A, which was highly variable due to artifacts of normalizing concentrations to very low percent fines). In all the wetland cores, normalized selenium concentrations were elevated relative to surface sediments in at least some of the analyzed sections. This enrichment may in part be due to biological processes on the marsh. Previous work in North SF Bay wetlands found similar patterns (Zawislanski et al. 2001), with up to two-fold higher sediment concentrations at depth compared to the sediment surface. A similar trend of increasing selenium concentration was observed in transects from subtidal mud flats to high marsh plain. Organic matter binding of selenium with subsequent diagenetic losses to surface waters may explain both trends. However, these processes are unlikely to be the exclusive cause of the over ten-fold differences in concentrations between sections found in the Suisun and San Pablo Bay wetland cores. Peak concentrations in these cores occurred in sections corresponding to ages of around 30 or 40 years, with lower concentrations before and since then. The Sacramento River is the largest source of selenium to North Bay by virtue of its higher flows despite low concentrations. Sacramento River selenium concentrations have remained fairly constant over recent decades (Cutter and Cutter 2004), but it is unknown what concentrations were prior to irrigation projects in the Central Valley. Selenium discharge from the San Joaquin River is of a similar magnitude, with much (around ten-fold) less volume but higher concentrations. Again, data on concentrations prior to development of irrigation projects are lacking. The majority of dams were constructed in the 1930s1960 s, which would coincide with the period of rising selenium concentrations, but river loads have been fairly constant in recent history and could not explain the recent decrease in selenium concentrations for sections nearer the surface for wetland cores.

One source category with well documented load decreases (at least in recent history) is petroleum refineries, all of which are located in Northern San Francisco Bay. Although refineries have been present in the region since around 1900, petroleum product demand and production volumes increased greatly during World War II period and have remained high. As a result of regulatory limits imposed in the 1990s, total selenium discharges from refineries have decreased by up to ten-fold at some refineries between 1988 and 2000, and effluents that previously were dominantly selenite are now primarily discharged as selenate (Cutter and Cutter 2004), which is accumulated less by biota. Given lower concentrations in core sections nearer the surface, and the proximity of the North Bay wetlands sites to refineries (within visual distance of both sites), changing refinery loads may explain a portion of the trends seen in the wetland cores. Another possible source is Chevron Chemical, with one recorded wastewater effluent selenium concentration of $2400 \mathrm{ug} / \mathrm{L}$ in March 1985, although nearly all other reported values 1984 to 1986 were not detected, and laboratory quality control information for that value was not available (Gunther et al. 1987).

Selenium concentrations normalized to percent fines in Bay cores were consistent and generally $<1$ $\mathrm{mg} / \mathrm{kg}$ dry weight. Bay surface sediment selenium concentrations normalized to percent fines derived from RMP Status and Trends monitoring were slightly lower, averaging $0.3 \mathrm{mg} / \mathrm{kg}$ dry weight. The lack of distinct peaks in Bay sediment cores and concentrations similar to surface sediments are in line with expectations of reduced concentrations away from sources and surface sediment mixing in open water sites, with erosion or no net sedimentation expected in most areas of North Bay. Additional reasons for higher selenium retention in wetlands versus open water sites may be organic matter adsorption and selenium reduction (Zawislanski et al. 2001), which can reduce its mobilization via soluble species. Similar to other trace element pollutants, selenium loading by erosion of highly contaminated Bay sediments does not appear to be a significant concern for the future. Although wetlands appear to have captured pockets of highly contaminated sediments, unless marsh plain vegetative growth is unable to keep up with sea level rise (turning those areas into open water mud flats), wetlands are unlikely to erode sufficiently to release their contained pollutants.


Figure V-7. Selenium Concentrations in Sediments from Wetland Cores.


Figure V-8. Selenium Concentrations in Sediments from Bay Cores.

## VI. CONCENTRATIONS OF ORGANIC ANALYTES IN CORES

## LABORATORY ANALYSIS OF ORGANIC COMPOUNDS

Frozen core sections for organic analyses were sent to the East Bay Municipality Utility District (EBMUD) laboratory and stored in the dark at $<-10^{\circ} \mathrm{C}$. Samples to be analyzed were thawed and homogenized, and a sub-sample removed for moisture determination. For PCBs samples ( 20 g wet weight) were mixed with pelletized, pre-extracted diatomaceous earth until a dry, free-flowing mixture was obtained. Samples were spiked with a labeled spiking solution and were extracted with a 1:1 (volume:volume) solution of methylene chloride and acetone using a Dionex Accelerated Solvent Extractor. Prior to cleanup, a labeled cleanup standard was spiked into the extract. The extract was then put through a drying column and concentrated. After drying and concentration, the samples were purified using gel permeation chromatography and an activated alumina column. The solvent was exchanged to hexane. Immediately prior to injection, labeled injection internal standards were added to each extract. An aliquot of the extract was injected into the gas chromatograph (GC) with an SPB-octyl capillary column (Supelco 2-4218, or equivalent). The analytes were separated by the GC and detected by a high-resolution $(\geq 10,000)$ mass spectrometer. Two exact $\mathrm{m} / \mathrm{z}$ 's were monitored for each compound throughout a pre-determined retention time window. The analytical method for organochlorine pesticides was largely identical with exception of the GC column (silicone-coated fused-silica capillary column, Restek RTX-5MS, or equivalent) and the resolution of the mass spectrometer was $\geq 8,000$. The PBDE analytical method was similar, but it did not require as large a sample ( 10 g ), the resolution of the mass spectrometer was $\geq 5,000$, and the GC was run with a $95 \%$ methyl, $4 \%$ phenyl, $1 \%$ vinyl silicone high temperature use capillary column (J\&W Scientific DB-5HT, or equivalent).

## Organic analysis QA/QC

Samples were analyzed for organic compounds by EBMUD in batches of up to 20 samples. Sample specific detection limits were determined from instrument software evaluation of baseline signal to noise ratio. Each batch included a method blank, low level spike, method blank spike, sample duplicate, matrix spike/duplicate, and reference materials where available. Target analytes were commonly measured above detection limits in method blanks, but were usually at concentrations much lower than in field samples. Compounds present at concentrations less than three times the amount found in blanks were censored. If compounds typically accounting for $30 \%$ or more of the sum in a group of analytes (e.g. PCBs, PBDEs, or DDTs) could not be reported in any given sample, no sum was reported for that group for that sample. Replicates were generally good, with relative percent difference or relative standard deviation (RPD/RSD) averaging $<35 \%$. Sample spike recoveries generally were in the target range ( $65-135 \%$ recovery), so long as the spike was at least as large as the native concentration. Generally the recoveries of the reference materials were in the range of $65-135 \%$ of the published or certified value, except for analytes that were near the detection limit. A summary of results for QA/QC samples in a quantitative range (target values at least three times MDL) is presented in Table VI-1.

## Results and discussion

Raw results from organics analyses are presented in Appendix Tables C-1, 2, and 3 for PCBs, PBDEs, and pesticides, respectively. Each of these analyte groups will be discussed separately below.

Table VI-1. Organic Analysis Summary QA/QC Results.
MDLs and blanks reported as $\mu \mathrm{g} / \mathrm{kg}$.

| Analyte | $\begin{gathered} \mathrm{Avg} \text { MDL } \\ \mu \mathrm{g} / \mathrm{kg} \end{gathered}$ | \%NDs | Avg Blank | Replicate RSD | MS rec avg | MS rec stdev | SRM rec avg | SRM rec stdev |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Aldrin | 0.0009 | 19\% | 0.00034 | 18\% | 113\% | 13\% | 0\% | 0\% |
| Chlordane, alpha- | 0.0004 | 0\% | 0.0018 | 5\% | 122\% | 28\% | 154\% | 26\% |
| Chlordane, gamma- | 0.0002 | 0\% | 0.0018 | 4\% | 103\% | 9\% | 341\% | 57\% |
| DDD ( $0, \mathrm{p}^{\prime}$ ) | 0.0018 | 1\% | 0.0013 | 5\% | 112\% | 9\% | 129\% | 23\% |
| DDD ( $\mathrm{p}, \mathrm{p}^{\prime}$ ) | 0.0006 | 0\% | 0.0013 | 6\% | 107\% | 0\% | 104\% | 14\% |
| DDE ( $0, \mathrm{p}^{\prime}$ ) | 0.0012 | 8\% | 0.00030 | 4\% | 107\% | 10\% | 104\% | 10\% |
| $\operatorname{DDE}\left(\mathrm{p}, \mathrm{p}^{\prime}\right)$ | 0.0023 | 0\% | 0.0024 | 3\% | 106\% | 0\% | 88\% | 8\% |
| DDT( $\mathrm{o}, \mathrm{p} \mathrm{p}^{\prime}$ ) | 0.0020 | 5\% | 0.0019 | 17\% | 119\% | 14\% | 0\% | 0\% |
| DDT( $\mathrm{p}, \mathrm{p}$ ) | 0.0011 | 2\% | 0.0019 | 25\% | 109\% | 23\% | 163\% | 37\% |
| Dieldrin | 0.0012 | 1\% | 0.0017 | 6\% | 105\% | 3\% | 0\% | 0\% |
| Endrin | 0.0021 | 25\% | 0.00085 | 29\% | 97\% | 10\% | 0\% | 0\% |
| HCH, alpha | 0.0007 | 3\% | 0.00071 | 7\% | 93\% | 7\% | 18\% | 12\% |
| HCH, beta | 0.0008 | 17\% | 0.00077 | 6\% | 114\% | 17\% | 0\% | 0\% |
| HCH, delta | 0.0009 | 18\% | 0.00091 | 20\% | 49\% | 24\% | 0\% | 0\% |
| HCH, gamma | 0.0007 | 6\% | 0.00061 | 8\% | 97\% | 6\% | 0\% | 0\% |
| Heptachlor | 0.0005 | 6\% | 0.00081 | 20\% | 105\% | 7\% | 0\% | 0\% |
| Heptachlor epoxide | 0.0003 | 8\% | 0.00045 | 5\% | 104\% | 4\% | 0\% | 0\% |
| Hexachlorobenzene | 0.0001 | 0\% | 0.010 | 7\% | 106\% | 6\% | 112\% | 12\% |
| Mirex | 0.0004 | 27\% | 0.00020 | 12\% | 70\% | 16\% | 0\% | 0\% |
| Nonachlor, cis- | 0.0002 | 2\% | 0.00046 | 4\% | 100\% | 18\% | 137\% | 25\% |
| Nonachlor, trans- | 0.0002 | 0\% | 0.0010 | 4\% | 108\% | 5\% | 155\% | 16\% |
| Oxychlordane | 0.0005 | 33\% | 0.00017 | 11\% | 104\% | 5\% | 0\% | 0\% |
| PBDE 007 | 0.0007 | 29\% | 0.00066 | 5\% | 103\% | 4\% | - | - |
| PBDE 008 | 0.0005 | 8\% | 0.0011 | 5\% | 105\% | 5\% | - | - |
| PBDE 010 | 0.0026 | 67\% | 0.0013 | - | 101\% | 1\% | - | - |
| PBDE 011 | 0.0005 | 0\% | ND | - | - | - | - | - |
| PBDE 012 | 0.0004 | 8\% | 0.0012 | 20\% | 103\% | 4\% | - | - |
| PBDE 013 | 0.0004 | 0\% | ND | - | - | - | - | - |
| PBDE 015 | 0.0004 | 0\% | 0.00066 | 2\% | 100\% | 1\% | - | - |
| PBDE 017 | 0.0008 | 0\% | 0.0015 | 2\% | 104\% | 1\% | - | - |
| PBDE 025 | 0.0008 | 0\% | ND | - | - | - | - | - |
| PBDE 028 | 0.0008 | 0\% | 0.0018 | 3\% | 104\% | 1\% | - | - |
| PBDE 030 | 0.0020 | 67\% | 0.00065 | - | 96\% | 1\% | - | - |
| PBDE 032 | 0.0020 | 88\% | 0.00058 | - | 103\% | 4\% | - | - |
| PBDE 033 | 0.0008 | 0\% | ND | - | - | - | - | - |
| PBDE 035 | 0.0005 | 0\% | 0.00086 | 7\% | 106\% | 1\% | - | - |
| PBDE 037 | 0.0005 | 46\% | 0.00069 | 16\% | 106\% | 1\% | - | - |
| PBDE 047 | 0.0004 | 0\% | 0.0051 | 5\% | 105\% | 5\% | - | - |
| PBDE 049 | 0.0005 | 0\% | 0.00089 | 6\% | 104\% | 1\% | - | - |
| PBDE 051 | 0.0004 | 0\% | 0.0010 | 14\% | 104\% | 1\% | - | - |
| PBDE 066 | 0.0006 | 29\% | 0.00076 | 5\% | 105\% | 4\% | - | - |
| PBDE 071 | 0.0016 | 25\% | 0.00057 | 24\% | 106\% | 8\% | - | - |
| PBDE 075 | 0.0013 | 54\% | 0.00023 | 27\% | 101\% | 5\% | - | - |
| PBDE 077 | 0.0003 | 58\% | 0.00059 | 0\% | 104\% | 1\% | - | - |
| PBDE 079 | 0.0004 | 67\% | 0.00065 | 21\% | 105\% | 4\% | - | - |
| PBDE 085 | 0.0030 | 50\% | 0.00055 | 40\% | 108\% | 8\% | - | - |
| PBDE 099 | 0.0036 | 25\% | 0.00356 | 20\% | 105\% | 9\% | - | - |
| PBDE 100 | 0.0008 | 0\% | 0.0012 | 16\% | 100\% | 1\% | - | - |
| PBDE 105 | 0.0028 | 96\% | 0.00070 | 0\% | 102\% | 5\% | - | - |
| PBDE 116 | 0.0022 | 100\% | 0.00038 | - | 101\% | 5\% | - | - |
| PBDE 119 | 0.0020 | 92\% | 0.0012 | 0\% | 101\% | 5\% | - | - |
| PBDE 120 | 0.0020 | 0\% | ND | - | - | - | - | - |
| PBDE 126 | 0.0009 | 67\% | 0.00046 | - | 100\% | 0\% | - | - |
| PBDE 128 | 0.0020 | 92\% | 0.00042 | - | 95\% | 3\% | - | - |
| PBDE 138 | 0.0017 | 58\% | 0.0011 | 34\% | 95\% | 0\% | - | - |
| PBDE 140 | 0.0016 | 42\% | 0.00082 | 33\% | 102\% | 3\% | - | - |
| PBDE 153 | 0.0012 | 50\% | 0.0010 | 28\% | 102\% | 8\% | - | - |
| PBDE 154 | 0.0015 | 25\% | 0.00093 | 26\% | 104\% | 6\% | - | - |
| PBDE 155 | 0.0017 | 29\% | 0.00079 | 23\% | 106\% | 7\% | - | - |
| PBDE 166 | 0.0017 | 0\% | ND | - | - | - | - | - |


| PBDE 181 | 0.0008 | 25\% | 0.00047 | 14\% | 98\% | 0\% | - | - |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| PBDE 183 | 0.0096 | 33\% | ND | 16\% | 105\% | 6\% | - | - |
| PBDE 190 | 0.0010 | 75\% | 0.00063 | 5\% | 95\% | 2\% | - | - |
| PBDE 196 | 0.0231 | 79\% | 0.0029 | 6\% | 91\% | 5\% | - | - |
| PBDE 197 | 0.0043 | 67\% | 0.00080 | 10\% | 96\% | 7\% | - | - |
| PBDE 203 | 0.0101 | 58\% | 0.0011 | 5\% | 108\% | 1\% | - | - |
| PBDE 204 | 0.0099 | 96\% | 0.00063 | - | 99\% | 1\% | - | - |
| PBDE 205 | 0.0078 | 100\% | 0.00060 | - | 93\% | 0\% | - | - |
| PBDE 206 | 0.0154 | 50\% | ND | 4\% | 112\% | 1\% | - | - |
| PBDE 207 | 0.0067 | 17\% | 0.0017 | 4\% | 121\% | 1\% | - | - |
| PBDE 208 | 0.0034 | 46\% | 0.00080 | 5\% | 125\% | 4\% | - | - |
| PBDE 209 | 0.0159 | 8\% | 0.016 | 3\% | 109\% | 2\% | - | - |
| PCB 008 | 0.0019 | 1\% | 0.0020 | 3\% | 104\% | 0\% | 122\% | 11\% |
| PCB 018 | 0.0004 | 0\% | 0.0017 | 7\% | 94\% | 0\% | 114\% | 10\% |
| PCB 028 | 0.0003 | 0\% | 0.0014 | 3\% | 105\% | 0\% | 132\% | 23\% |
| PCB 031 | 0.0002 | 0\% | 0.0011 | 3\% | 103\% | 0\% | 96\% | 9\% |
| PCB 033 | 0.0003 | 0\% | 0.00090 | 3\% | 107\% | 0\% | 0\% | 0\% |
| PCB 044 | 0.0003 | 0\% | 0.0017 | 4\% | 101\% | 0\% | 163\% | 20\% |
| PCB 049 | 0.0003 | 0\% | 0.00080 | 3\% | 101\% | 0\% | 100\% | 9\% |
| PCB 052 | 0.0003 | 0\% | 0.0013 | 5\% | 99\% | 0\% | 108\% | 11\% |
| PCB 056 | 0.0004 | 0\% | 0.00062 | 3\% | 115\% | 0\% | 0\% | 0\% |
| PCB 060 | 0.0004 | 10\% | 0.00051 | 5\% | 115\% | 0\% | 0\% | 0\% |
| PCB 066 | 0.0004 | 0\% | 0.00093 | 2\% | 112\% | 0\% | 108\% | 16\% |
| PCB 070 | 0.0004 | 0\% | 0.0019 | 3\% | 111\% | 0\% | 0\% | 0\% |
| PCB 074 | 0.0004 | 0\% | ND | - | - | - | - | - |
| PCB 077 | 0.0004 | 7\% | 0.00051 | 3\% | 104\% | 0\% | 0\% | 0\% |
| PCB 081 | 0.0014 | 21\% | 0.00018 | 23\% | 104\% | 0\% | 0\% | 0\% |
| PCB 087 | 0.0004 | 0\% | 0.0016 | 4\% | 101\% | 0\% | 182\% | 18\% |
| PCB 095 | 0.0004 | 0\% | 0.0011 | 4\% | 97\% | 0\% | 74\% | 8\% |
| PCB 097 | 0.0004 | 0\% | ND | - | - | - | - | - |
| PCB 099 | 0.0003 | 0\% | 0.00084 | 3\% | 99\% | 0\% | 82\% | 9\% |
| PCB 101 | 0.0003 | 0\% | 0.0015 | 3\% | 100\% | 0\% | 97\% | 8\% |
| PCB 105 | 0.0005 | 0\% | 0.00086 | 4\% | 106\% | 0\% | 107\% | 9\% |
| PCB 110 | 0.0003 | 0\% | 0.0016 | 4\% | 103\% | 0\% | 107\% | 9\% |
| PCB 114 | 0.0005 | 14\% | 0.00016 | 13\% | 105\% | 0\% | 0\% | 0\% |
| PCB 118 | 0.0005 | 1\% | 0.0015 | 3\% | 106\% | 0\% | 95\% | 10\% |
| PCB 123 | 0.0005 | 24\% | 0.00015 | 15\% | 106\% | 0\% | 0\% | 0\% |
| PCB 126 | 0.0006 | 10\% | 0.00040 | 14\% | 104\% | 0\% | 0\% | 0\% |
| PCB 128 | 0.0004 | 1\% | 0.00055 | 3\% | 118\% | 0\% | 145\% | 13\% |
| PCB 132 | 0.0004 | 0\% | 0.00076 | 4\% | 109\% | 0\% | 0\% | 0\% |
| PCB 138 | 0.0004 | 0\% | 0.0016 | 4\% | 114\% | 0\% | 123\% | 17\% |
| PCB 141 | 0.0004 | 6\% | 0.00044 | 5\% | 110\% | 0\% | 0\% | 0\% |
| PCB 149 | 0.0004 | 0\% | 0.0011 | 2\% | 107\% | 0\% | 117\% | 16\% |
| PCB 151 | 0.0001 | 0\% | 0.00062 | 2\% | 104\% | 0\% | 146\% | 18\% |
| PCB 153 | 0.0004 | 0\% | 0.0013 | 5\% | 111\% | 0\% | 96\% | 15\% |
| PCB 156 | 0.0004 | 5\% | 0.00062 | 5\% | 104\% | 0\% | 126\% | 11\% |
| PCB 157 | 0.0004 | 0\% | ND | - | - | - | - | - |
| PCB 158 | 0.0003 | 5\% | 0.00047 | 4\% | 114\% | 0\% | 0\% | 0\% |
| PCB 167 | 0.0003 | 11\% | 0.00019 | 4\% | 106\% | 0\% | 0\% | 0\% |
| PCB 169 | 0.0003 | 19\% | 0.00015 | 23\% | 101\% | 0\% | 0\% | 0\% |
| PCB 170 | 0.0004 | 2\% | 0.00049 | 4\% | 113\% | 0\% | 88\% | 12\% |
| PCB 174 | 0.0002 | 4\% | 0.00044 | 5\% | 111\% | 0\% | 0\% | 0\% |
| PCB 177 | 0.0003 | 5\% | 0.00042 | 3\% | 115\% | 0\% | 0\% | 0\% |
| PCB 180 | 0.0003 | 0\% | 0.00077 | 7\% | 112\% | 0\% | 98\% | 15\% |
| PCB 183 | 0.0002 | 7\% | 0.00043 | 5\% | 110\% | 0\% | 122\% | 19\% |
| PCB 187 | 0.0002 | 0\% | 0.00065 | 3\% | 110\% | 0\% | 116\% | 18\% |
| PCB 189 | 0.0004 | 14\% | 0.00017 | 11\% | 126\% | 0\% | 0\% | 0\% |
| PCB 193 | 0.0003 | 0\% | ND | - | - | - | - | - |
| PCB 194 | 0.0004 | 6\% | 0.00059 | 6\% | 110\% | 0\% | 118\% | 17\% |
| PCB 195 | 0.0004 | 11\% | 0.00035 | 6\% | 112\% | 0\% | 132\% | 21\% |
| PCB 201 | 0.0001 | 13\% | 0.00030 | 6\% | 102\% | 0\% | 0\% | 0\% |
| PCB 203 | 0.0002 | 10\% | 0.00036 | 7\% | 108\% | 0\% | 0\% | 0\% |

## Polychlorinated Biphenyls (PCBs)

PCBs in cores from wetlands and the Bay (Figures VI-1 and VI-2) follow patterns similar to those of the trace elements, with core sections from the Bay generally showing lower and more uniform concentrations than core sections from wetlands. Total PCBs normalized to percent fines in all Bay core sections were $<60 \mu \mathrm{~g} / \mathrm{kg}$, and concentrations in the deepest sections from cores were not detected or near detection limits $(<1 \mu \mathrm{~g} / \mathrm{kg})$. This pattern of negligible PCBs in the deepest sections of cores is consistent with the expected history of PCB loads. PCBs were first produced commercially in the late 1920s, with widespread use increasing in the succeeding decades and peaking in the 1970s (Breivik et al. 2002), followed by a major decrease after EPA enacted a phase out and ban on production and sale for most uses in 1979. For Bay cores, analyzed sections nearest the surface were usually similar to average concentrations of surface ( $0-5 \mathrm{~cm}$ ) grab samples of sediments taken in their respective segments of the Bay as part of the RMP Status and Trends monitoring. This was also the case for most wetland cores, with the exception of Damon Slough, where the near surface sections were still well above Central Bay ambient concentrations. However, even for the Damon Slough site, near surface trends in the core suggest that surface sediment concentrations may eventually drop to a range comparable to those for other surface sediments in Central Bay.

Maximum total PCBs in sediment core sections reported previously (Venkatesan et al. 1999) for depositional locations in Richardson Bay and San Pablo ranged up $30-35 \mu \mathrm{~g} / \mathrm{kg}$, compared to 1-54 $\mu \mathrm{g} / \mathrm{kg}$ total PCBs for the maximum sections reported here (average maximum of $18 \mu \mathrm{~g} / \mathrm{kg}$ ). However, it should be noted that Venkatesan reported a smaller number of congeners (20), and although the 40 congeners reported by RMP are not a complete superset of the former (e.g. Venkatesan included PCBs 77,126 , dioxin-like PCBs typically comprising $<0.1 \%$ of total PCBs, and PCBs 206, 209, heavy congeners that typically represent $\sim 1 \%$ or less of total PCBs (Frame et al. 1996) in various Aroclor mixtures), the 16 shared congeners reported by Venkatesan only account on average for $55 \%$ of RMP total PCBs. Adjusting for this difference, only one core would have a maximum concentration similarly high (LSB001S, at $30 \mu \mathrm{~g} / \mathrm{kg}$ equivalent for the sum of 16 PCBs ), with the next highest sections being from CB002S, with sums of 16 PCBs equivalent 16 and 17 $\mu \mathrm{g} / \mathrm{kg}$ at $\sim 6$ and 11 cm depths, respectively.

Thus aside from a single core in Lower South Bay, maximum PCB concentrations in subtidal cores from this study are around half those previously found by Venkatesan or lower. What may be even more important, current RMP surface sediment concentrations of total (sum of 16) PCBs typically average $\sim 4 \mu \mathrm{~g} / \mathrm{kg}$ or less for the various Bay segments, less than half the typical surface concentrations ( $\sim 12 \mu \mathrm{~g} / \mathrm{kg}$ ) found by Venkatesan around 1990. Although the cores in that work may have been more influenced by near-field sources than the segment-wide averages obtained in the RMP, it still suggests that either the highest concentrations are not widespread, and/or there have been continued reductions in PCB concentrations for sediments entering the Bay since that time.

A model of long-term PCB fate in the Bay (Davis 2004) projected that concentrations will decrease over time through a combination of factors: decreasing new loads from surrounding watersheds, combined with degradation, volatilization, and aqueous export. Congener dependent simulations with the model suggest that the greatest losses would occur for lighter congeners, with over $90 \%$ of the mass of PCB 18 in the Bay lost over 20 years, $75 \%$ of PCB 66 lost, and progressively less losses for heavier congeners. Relative masses of PCB homologs in core sections are shown in Figures VI-3 and VI-4 for sections near the surface and containing the maximum total PCBs, respectively. In wetland cores, Suisun, San Pablo, and Central Bay especially, relative concentrations of di- and triand tetra PCBs were lower than in the Bay, both for the sections near the surface and for deeper sections containing the highest PCB concentrations.

These patterns suggest differences in PCB loss processes for subtidal Bay sites versus those in wetlands. Volatilization is expected to be a greater proportion of total losses for lighter (less substituted) congeners in surface waters in the mass budget model (Davis 2004). Differential
volatilization losses may be even more important for wetlands due to a number of factors: exposure and sometimes desaturation of wetland sediments for parts of each day, higher solar irradiation and daytime temperature, and a shallow water column with greater surface area relative to volume, all would tend to increase the loss rates via volatilization. Differential losses of lighter congeners are likely to occur whether volatilized from PCBs dissolved in shallow wetland waters or directly from wetland soils; organic/air equilibrium partition coefficients (ratio of the concentration in an organic phase to the concentration in air) are typically an order of magnitude lower (i.e., a higher concentration in air for any given concentration in organic phase) for the lighter congeners (Harner and Mackay 1995). Although once buried below the saturated zone, the loss rates would decrease, wetland sediments would be exposed to these processes for several decades in most areas of the Bay due to slow rates of accretion. This pattern is absent the South and Lower South Bay wetland cores. For the Lower South Bay cores, this may in part be explained through subsidence and resulting rapid accretion of wetland sediments; sediments would be exposed on the surface for fewer years before getting buried to a depth where elevated temperatures and desaturation would no longer occur.
In addition to higher rates of volatilization, higher biological degradation rates are expected for lighter PCB congeners (Sinkkonen and Paasivirta 2000). However, this was not apparent in either the wetland or Bay core homolog patterns. Relative percentages of the hexa- and heavier PCBs generally ranged $50-70 \%$ of the total PCB mass, regardless of whether they came from core sections nearer the surface ( $\sim 10$ years of age) or those from the period of maximum PCB loads ( $\sim 25$ years prior). With mixing of surface sediments, and degradation half-lives for PCBs of multiple decades, there is perhaps not enough difference in the relative ages of different core sections to reliably see a measurable difference in congener distributions. Furthermore, as there would be few truly "new" PCB sources in the watershed since their banning, much of the PCBs newly deposited in the Bay and margins wetlands could have aged through similar patterns of degradation in the upper watershed, and thus perhaps are unlikely to show any patterns distinct from those already in deeper sediment layers in the Bay.


Figure VI-1. Total PCBs Concentrations in Sediments from Wetland Cores.




Figure VI-2. Total PCBs Concentrations in Sediments from Bay Cores.


Figure VI-3. PCB Homologs in Upper Sections (age $\sim 10$ years) of Cores.


Figure VI-4. Homologs in Most Contaminated Sections (age $\sim 25$ years) of Cores.

## Polybrominated Diphenyl Ethers (PBDEs)

PBDEs were only measured in cores from three wetlands sites (Figure VI-5) due to budget limitations. Wetland sites, being more consistently depositional and nearer likely sources, were deemed more useful for tracking historical loading trends. However, results from RMP Status \& Trends monitoring surface samples were available for comparison to provide some context of spatial distribution. Concentrations of total PBDEs (normalized to percent fines) in wetland core sections ranged up to nearly $50 \mu \mathrm{~g} / \mathrm{kg}$, with maximum concentrations a factor of two or more greater than average Bay concentrations, and maximum concentrations slightly greater than the maximum surface sediment concentrations for their respective Bay segments. Concentrations in the deepest sections were below or near detection limits, e.g., between 30-250 times below the maximum concentrations for BDE 209. This drastic rise in sediment concentrations of BDEs was also seen in cores from the Great Lakes (Zhu and Hites 2005), where there has been a 100 -fold increase in PBDEs in recent sediments from around 2000 compared to background levels from 1960, with concentrations starting to rise around 1970. The PBDE Conceptual Model/Impairment Assessment (Werme et al. 2007) did not include any local sediment trend data as long-term monitoring of PBDEs by the RMP had just started, but trends of PBDEs in the literature for various biological matrices unanimously show increases since the 1970s or slightly earlier.
Maximum concentrations were found in near surface sections of the cores for two of the three wetland sites, which would be expected given ongoing uses and continued loading of many PBDEs. California banned the use of penta- and octa- PBDE mixtures with Assembly Bill 302 (California 2003), but provisions of the bill only covered penta- and octa- mixtures, with labeling requirements after March 2005, and bans on use and sale only starting January 2008. Although the major PBDE manufacturers ceased production of penta- and octa- BDEs by the end of 2004, sale, use, and disposal of products containing these materials could and likely would have continued through the period (2005-2006) of core collection. Additionally, no action was taken on deca-BDE, so new releases of that mixture are likely ongoing.
Figure VI-6 shows the relative contributions of the various PBDE homologs, for the core sections from each site for the top (surface) and middle (deepest section quantifiable for most PBDEs) of each core. Deca-BDE was the dominant congener, accounting for 45-75\% of total PBDEs at the three sites. Most of the remaining PBDE mass was usually comprised of penta- and tetra- BDEs. The dominance of deca BDE (209) was not as pronounced as in cores from Lake Erie and Lake Michigan, where it comprised $95-99 \%$ of total PBDEs measured (Zhu and Hites 2005). That study included a subset of the PBDEs reported here. However, even reducing the sum of PBDEs in these cores to the subset of congeners reported there, BDE 209 still only accounts for around $50-75 \%$ of total PBDEs in sediment.. Another study of Great Lakes sediments reported somewhat more comparable results, with the sum of 20 BDEs (other than 209) reported as often equaling or exceeding the BDE 209 measured (Li et al. 2006). Over time, the relative contributions of BDE 209 to total PBDEs should increase, as loads and concentrations of the deca- and octa- forms decrease following the cessation of production. Within these cores, there were no consistent trends in relative abundances of homologs between deeper and shallower sections; for Point Edith and Damon, the proportion of deca increased, while for Alviso, it decreased. However, given the inventory of products currently in use containing the penta- and octa- BDEs, it may be a number of years before measurable decreases in environmental concentrations or shifts in relative abundance of any of these formulations are seen.


Figure VI-5. Total PBDEs Concentrations in Fine Sediments from Wetland Cores.


Figure VI-6. PBDE Homologs (\% of Total) in Top and Middle Sections from Wetland Cores.

## Pesticides (DDTs)

Although other organochlorine pesticides were measured and reported by the laboratory (Appendix Table C-3), many of the less abundant compounds were either not detected or were at such low levels that analytical interferences or background blank contamination could be a substantial portion of the total signal measured. This discussion will therefore focus on DDT and its degradation products, for which results were quantitative in most samples. Raw (bulk concentration) data for individual pesticide compounds are shown in Appendix Table C-3. Total DDTs (the sum of $\left.\operatorname{DDD}\left(\mathrm{o}, \mathrm{p}^{\prime}\right), \operatorname{DDE}\left(\mathrm{o}, \mathrm{p}^{\prime}\right), \operatorname{DDT}\left(\mathrm{o}, \mathrm{p}^{\prime}\right), \mathrm{DDD}\left(\mathrm{p}, \mathrm{p}^{\prime}\right), \mathrm{DDE}\left(\mathrm{p}, \mathrm{p}^{\prime}\right), \mathrm{DDT}\left(\mathrm{p}, \mathrm{p}^{\prime}\right)\right)$ normalized to percent fines in sediment cores are shown in Figures VI-7 and VI-8 for wetland and Bay cores respectively.

Concentrations differed widely among sites, with the highest concentrations found in Wildcat Marsh on San Pablo Bay. The maximum concentration in that core was over $1200 \mathrm{ug} / \mathrm{kg}$ dry weight, over an order of magnitude higher than the next most contaminated sample, found at the Damon Slough site in Central Bay (note the wider scale on the San Pablo Bay wetland graph). The maximum in DDT concentrations for Wildcat $(18.75 \mathrm{~cm})$ and Damon $(13.75 \mathrm{~cm})$ correspond to approximate ages of 30 and 40 years, respectively, approximately corresponding to the period of its banning for general use at the end of 1972 (USEPA 1972). Concentrations in cores decreased rapidly at most sites in the following period, similar to results for other pollutants, consistent with large increases (ca. World War II) and decreases (1960's) seen in other Bay cores (Venkatesan et al. 1999).
Concentrations normalized to fines in Bay cores were much lower, around $11 \mathrm{ug} / \mathrm{kg}$ dry weight or less, except for the Suisun Bay sample SU002A, which as mentioned previously had highly variable normalized concentrations as an artifact of variable and low percent fines in many of the sections. For the other Bay sites, concentrations were lower than those found in Bay cores for previous work in SF Bay (Venkatesan et al. 1999), which found concentrations ranging up to almost $60 \mathrm{ug} / \mathrm{kg}$ in sieved fine sediments.

For both Bay and wetland sites, a large majority (average $96 \%$ ) of the total mass of DDT compounds was as its metabolites, DDD or DDE (Figure VI-9), similar to the results of Venkatesan for their San Pablo Bay site. DDDs and DDEs were evenly split, comprising $46 \%$ and $49 \%$ of total DDTs on average (approximately a 1:1 ratio), also similar to the results of Venkatesan, with DDD/DDE ratios generally between 1.1 and 1.6. However, for the Richardson Bay core samples in that work, DDT ranged 14 to $62 \%$ of total DDTs, much higher than the average of the samples found here. Likewise, that work found DDD/DDE ratios 1.7 or higher in all sections from the Richardson Bay sample.

Lauritzen Channel in Richmond Inner Harbor is the location of the United Heckathorn Superfund site, where pesticides (including DDT) were formulated, packaged, and shipped from 1947 to 1966. Cleanup actions including capping of the site and dredging of Lauritzen Channel and Parr Canal took place in 1990 to 1999, although concentrations in the channel remain high even after the remedial action. The Wildcat Marsh site is the wetland location in our study nearest Richmond Harbor, although maximum concentrations in that core are nearly as high as the highest in a transect study of surface sediments from within Richmond Harbor, in which DDT concentrations dropped rapidly to below $1000 \mu \mathrm{~g} / \mathrm{kg}$ within 1 km of the United Heckathorn site (Pereira et al. 1996). This rapid dropoff in concentrations suggests that DDTs transported away from the Superfund site are a small proportion of the total, or are rapidly dispersed and diluted.

However, follow-up monitoring around the site post cleanup in 2007 has identified locations with concentrations up to nearly $90,000 \mu \mathrm{~g} / \mathrm{kg}$ total DDTs (USEPA 2009), so mid-range transport from Richmond Harbor during a period of much higher DDT loading could in part explain the maximum DDT concentrations in the Wildcat Marsh core. Additionally, sediments from Lauritzen Channel and nearby sites contain DDD/DDE ratios of up to 10:1 (Pereira et al. 1996). Although DDTs at Wildcat are not as predominantly DDD, it is one of the three sites with DDD representing over $60 \%$ of total DDTs. The nearest subtidal Bay site, CB001s, is also one of the sites containing over $60 \%$ DDD, which may represent the influence of the United Heckathorn source. Cores along a longer
transect of wetland and Bay sites moving away from Richmond Harbor would be needed to resolve whether DDTs found at Wildcat would likely have come from United Heckathorn.
Another possible source to the Wildcat marsh site is Chevron Chemical, which according to its wastewater discharge permit (March 1978) was a producer (manufacturer or formulator) of pesticides including "organochlorine compounds". It is unknown whether these compounds included DDTs, nor what DDD/DDE ratios would be from that source.


Figure VI-7. Total DDTs Concentrations Normalized to Fine Sediments from Wetland Cores.
(note different scale for SPB graph (Wildcat))


Figure VI-8. Total DDTs Concentrations Normalized to Fine Sediments from Bay Cores .


Figure VI-9. DDT Isomers (\% of Total DDTs) in Bay and Wetland Core Sections with Maximum DDTs.

## VII. CONCLUSIONS AND FUTURE WORK

Results of this coring study have been useful in refining and revising our understanding of sediment processes in subtidal San Francisco Bay and intertidal wetlands fringing its margin. Protection afforded by wetland vegetation has allowed slow but relatively undisturbed and continuous accretion of sediment with sea level rise in fringing wetlands. As a result, many of the cores taken from wetland sites have captured transient signals in the loading of one or more pollutants. Patterns of deposition often coincided with the approximate periods and locations for which maximum loads (within the uncertainty of the radiodating methods and load estimates) of these pollutants would be expected: maximum selenium in northern San Francisco Bay where refinery loads occurred; maximum copper and PCBs in Central and Lower South Bay near major urban centers (Oakland and San Jose); maximum DDTs found in San Pablo Bay, near a major DDT Superfund site; maximum PBDEs in near surface sediments, increasing over 100 -fold in recent decades; maximum mercury in Lower South Bay, near New Almaden, North America's largest mercury mine. However, in addition to the expected results, some unexpected patterns emerged: mercury concentrations at the Oakland wetland were as high as those in the wetland near the New Almaden mines; copper concentrations at the Oakland wetland also remain nearly as high as in 1980. These deviations from the expected highlight the importance of discovering and understanding local sources and processes.

In contrast, the exposed and largely unvegetated subtidal Bay sediments are continually being reworked through resuspension and bioturbation. As a result, the sharp peaks tracking historical loads seen in wetland cores were largely muted, or nonexistent in Bay cores, aside from a muted gradual increase from very deep pre-industrial sediments. This is in sharp contrast to early conceptual and numerical models of the Bay developed for projecting long-term pollutant fate, which had assumed reservoirs of highly contaminated sediments widely distributed which could worsen conditions on their re-exposure. Although in retrospect it may seem obvious that such reservoirs should not exist in the many areas of the Bay that have exposed and well-mixed sediments, the focus of existing literature on cores from primarily depositional areas required reading between the lines; i.e. that such locations were not easily found, even in an effort seeking such sites. This highlights the potential pitfalls of overextending by generalizations from past or present data, without fully understanding the potential biases built into their sampling or analytical design.
Some material from the collected cores remains, and additional analyses beyond the scope of work originally developed are planned or under consideration. Bay core sections will be analyzed for polychlorinated dibenzo-dioxins and furans, in order to improve and build upon our limited (primarily surface sediment) understanding of their distribution and environmental processes in the Bay. Expanding the scope of the samples analyzed for PBDEs may also be warranted; analyses of the remaining wetland cores can confirm whether the great increases seen at the three analyzed sites are found elsewhere in the region, and analysis of Bay cores for PBDEs which have had somewhat less time to disperse can illustrate whether the within Bay uniformity seen for many older legacy contaminants is more a function of an extended period of mixing or from rapid dispersion of a small but highly mobile fraction of total loads. Interest has also been expressed in analyzing core sections for various contaminants of emerging concern; for inquiries on historical trends in loading wetland cores are most appropriate, while questions on potential aquatic exposure or transport and fate processes are best addressed by the subtidal cores.
The 17 cores collected and analyzed in this effort, although a major addition to the data previously available, barely scratch the surface of representatively characterizing sediments in the Bay and surrounding wetlands. Whether future efforts should focus on expanding the number of stratified random samples collected to better characterize the ambient environment, concentrate on gradient or near-field characterization of known or expected sources, or some combination of both, ultimately depends on the relative priorities of obtaining these different types of information. In all these cases, information on sediment ages and contaminant profiles from cores are critical to developing an
understanding of sediment process needed to project recovery through conceptual or numerical models; the ways in which these cores differed from previous USGS core results and our conceptual models demonstrate the risks of extrapolating in the absence of localized data.
A number of sites characterized via bathymetric surveys as regions of low or negative sediment accumulation contain significant quantities of recent contaminants, often penetrating to depths of 10 to 20 cm or more, with ${ }^{210} \mathrm{~Pb}$ and ${ }^{137} \mathrm{Cs}$ profiles showing similar distributions. This suite of modern contaminants and radiotracers indicate sediments exposed to surficial environments in the past 50 years. Their penetration at sites with little or no net accumulation in that period demonstrates the magnitude and prevalence of mixing processes such as surficial sediment exchange with suspended sediments and bioturbation, which effectively transport these contaminants downward through mixture of old and young sediments into a large reservoir. Although these processes can reduce concentrations from peak loads of sediment associated contaminants, the downside is a continued lower concentration reservoir of contamination supplying the biologically active sediment zone and water column, a phenomenon illustrated in various mass budgets for Bay TMDLs with very long recovery times.
Although there are some logistical advantages (e.g., hiring sampling equipment and crew) and fewer temporal ambiguities from synoptic core sampling like in this effort, there are also logistical difficulties introduced. The number of samples generated for laboratory analysis exceeded three years' worth of samples collected under the annual RMP Status and Trends monitoring, resulting in a backlog at the analytical labs. The large number of synoptically collected samples and relatively thick surficial intervals that were analyzed also precluded the analysis of shorter lived radioisotopes in most samples, which might have elucidated near-surface bioturbation rates and surface sediment exchange processes in various locations, although the deeper bioturbation would ultimately control remobilization from the larger sediment reservoir. Future efforts should therefore consider sampling and analyzing a smaller number of sites in different regions in different years, which is easier from both a logistical and budgetary perspective, but requires long-term planning and prioritization. Although by coring different regions in different years the temporal coherence afforded by synoptic collection is lost, the interest in cores is in decadal rather than annual or intra-annual process, distributed sampling across years should be adequate. Even without information on shorter term processes provided by shorter lived isotopes, the information about sediment pollutant processes provided by the data from this study highlight the importance of getting cores tailored to the questions at hand for building conceptual and mechanistic understanding of the Bay ecosystem processes.

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Table A-1. Radioisotope dating raw data and section age estimates

| Station | Depth (cm) | $\begin{gathered} \hline \mathrm{Cs}-137 \\ \mathrm{~Bq} / \mathrm{kg} \end{gathered}$ | sig | $\begin{gathered} \hline \mathrm{Pb}-210 \\ \mathrm{~Bq} / \mathrm{kg} \end{gathered}$ | sig | $\begin{gathered} \text { Age } \\ \text { (years) } \end{gathered}$ | Acc rate cm/y | quality |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CB Damon Slough-2 | 3.75 | 6.5 | 1.2 | 53 | 11 | 12 | 0.30 | good |
| CB Damon Slough-4 | 8.75 | 15 | 2.1 | 24 | 19 | 29 |  |  |
| CB Damon Slough-6 | 13.75 | 30 | 1.9 | 8.2 | 18 | 46 |  |  |
| CB Damon Slough-8 | 18.75 | 0.4 | 2.2 | 23 | 24 | 62 |  |  |
| CB Damon Slough-10 | 23.75 | -0.3 | 0.8 | -2.0 | 8.6 | 79 |  |  |
| CB Damon Slough-12 | 28.75 | 0.0 | 0.7 | 1.5 | 7.1 | 95 |  |  |
| CB001S-P1- | 1.25 | 3.4 | 0.8 | 35 | 11 | 3 | 0.49 | good |
| CB001S-P2 | 3.75 | 3.1 | 0.8 | 51 | 11 | 8 |  |  |
| CB001S-P3 | 6.25 | 4.7 | 0.7 | 29 | 11 | 13 |  |  |
| CB001S-P4 | 8.75 | 1.8 | 0.4 | 14 | 6 | 18 |  |  |
| CB001S-P5 | 11.25 | 1.3 | 0.4 | 9 | 7 | 23 |  |  |
| CB001S-P8 | 18.75 | 2.3 | 0.5 | 8 | 7 | 38 |  |  |
| CB001S-P9 | 21.25 | 1.7 | 0.5 | 19 | 8 | 44 |  |  |
| CB001S-P11 | 26.25 | 0.2 | 0.5 | 10 | 7 | 54 |  |  |
| св001S-13 | 31.25 | 0.5 | 0.5 | 15 | 9 | 64 |  |  |
| CB001S-16 | 38.75 | -0.9 | 0.7 | 10 | 8 | 80 |  |  |
| CB001S-19 | 46.25 | 0.5 | 0.6 | 7 | 7 | 95 |  |  |
| CB001S-22 | 53.75 | 0.5 | 0.6 | 3 | 7 | 110 |  |  |
| св001S-25 | 61.25 | 0 | 0.3 | 1 | 11 | 126 |  |  |
| CB001S-28 | 68.75 | -0.4 | 0.5 | 0 | 6 | 141 |  |  |
| CB002S-P1 | 1.25 | 3.4 | 0.6 | 48 | 8 | 2 | 0.55 | good |
| CB002S-P2 | 3.75 | 4.6 | 0.5 | 47 | 8 | 7 |  |  |
| CB002S-P3 | 6.25 | 4.2 | 0.5 | 51 | 8 | 11 |  |  |
| CB002S-P4 | 8.75 | 4 | 0.7 | 48 | 9 | 16 |  |  |
| CB002S-P5 | 11.25 | 3.9 | 0.7 | 39 | 8 | 20 |  |  |
| CB002S-P7 | 16.25 | 4.6 | 0.5 | 32 | 7 | 29 |  |  |
| CB002S-10 | 23.75 | 4.4 | 0.6 | 20 | 10 | 43 |  |  |
| CB002S-13 total | 31.25 | 1 | 0.3 | 6 | 7 | 56 |  |  |
| CB002S-V1-17 | 41.25 | 0.2 | 0.5 | 9 | 7 | 74 |  |  |
| CB002S-V1-21 | 51.25 | -0.1 | 0.6 | 0 | 7 | 93 |  |  |
| CB002S-25 use | 61.25 | 0.1 | 0.5 | -4 | 8 | 111 |  |  |
| CB002S-V1-29 | 71.25 | -0.4 | 0.6 | 0 | 8 | 129 |  |  |
| CB002S-32 Net | 78.75 | 0.8 | 0.5 | 13 | 9 | 142 |  |  |
| CB002S-37 Net | 91.25 | 0.1 | 0.4 | 7 | 8 | 165 |  |  |
| CB006SA-P1 | 1.25 | 2.8 | 0.6 | 20 | 8 | 2 | 0.65 | good |
| CB006SA-P2 | 3.75 | 3.9 | 0.6 | 23 | 8 | 6 |  |  |
| CB006SA-P3 | 6.25 | 2.3 | 0.5 | 8 | 7 | 10 |  |  |
| CB006SA-P4 | 8.75 | 4.2 | 0.6 | 14 | 8 | 13 |  |  |
| CB006SA-P5 | 11.25 | 2.8 | 0.6 | 12 | 8 | 17 |  |  |
| CB006SA-P6 | 13.75 | 1.5 | 0.5 | 11 | 8 | 21 |  |  |
| CB006SA-P7 total | 16.25 | 1.5 | 0.4 | 11 | 9 | 25 |  |  |
| CB006SA-P8 | 18.75 | 0.3 | 0.4 | 2 | 6 | 29 |  |  |
| CB006SA-P10 | 23.75 | 0.7 | 0.4 | 5 | 7 | 36 |  |  |
| CB006SA-P12 | 28.75 | -0.1 | 0.8 | 11 | 11 | 44 |  |  |
| CB006SA-13 Net | 31.25 | 0.3 | 0.3 | 18 | 8 | 48 |  |  |
| CB006SA-17 Net | 41.25 | 0.9 | 0.4 | 8 | 8 | 63 |  |  |
| CB006SA-V2-21 | 51.25 | -0.4 | 0.5 | 4 | 11 | 79 |  |  |
| CB006SA-v2-25 | 61.25 | 0.1 | 0.3 | -3 | 10 | 94 |  |  |
| LSB Alviso Slough-2 | 3.75 | 5.8 | 0.6 | 45 | 7.2 | 2 | 2 | fair |
| LSB Alviso Slough-6 net | 13.75 | 5.5 | 0.4 | 31 | 5.7 | 7 |  |  |
| LSB Alviso Slough-10 net | 23.75 | 6.1 | 0.4 | 18 | 4.8 | 12 |  |  |
| LSB Alviso Slough-16 net | 38.75 | 4.9 | 0.4 | 15 | 5.0 | 19 |  |  |
| LSB Alviso Slough-24 | 58.75 | 8.1 | 0.7 | 9.2 | 5.5 | 29 |  |  |
| LSB Alviso Slough-32 net | 78.75 | 7.5 | 0.4 | 12 | 5.0 | 39 |  |  |
| LSB Alviso Slough-40 | 98.75 | 8.1 | 0.7 | 7.7 | 7.1 | 49 |  |  |
| LSB Coyote Creek-2 | 3.75 | 4.6 | 0.8 | 30 | 8.5 | 2 | 1.6 | poor |
| LSB Coyote Creek-6 | 13.75 | 6.8 | 0.8 | 24 | 7.0 | 9 |  |  |


| \|LSB Coyote Creek-16 <br> LSB Coyote Creek-24 <br> LSB Coyote Creek-32 <br> LSB Coyote Creek-40 | 38.75 58.75 78.75 98.75 | 6.1 <br> 8.0 <br> 9.4 <br> -0.1 | $\begin{aligned} & 0.7 \\ & 0.7 \\ & 0.8 \\ & 0.5 \\ & \hline \end{aligned}$ | $\begin{aligned} & 5.5 \\ & 4.7 \\ & 2.7 \\ & 5.8 \\ & \hline \end{aligned}$ | $\begin{aligned} & 6.1 \\ & 5.2 \\ & 6.3 \\ & 6.6 \\ & \hline \end{aligned}$ | $\begin{aligned} & 25 \\ & 38 \\ & 51 \\ & 63 \\ & \hline \end{aligned}$ |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| LSB001SA-P1 | 1.25 | 3.8 | 0.6 | 34 | 8 | 1 | 1.3 | good |
| LSB001SA-P2 | 3.75 | 4.5 | 0.6 | 30 | 8 | 3 |  |  |
| LSB001SA-P3 | 6.25 | 3.3 | 0.5 | 26 | 7 | 5 |  |  |
| LSB001SA-P4 | 8.75 | 4.8 | 0.7 | 37 | 9 | 7 |  |  |
| LSB001SA-P5 | 11.25 | 5 | 0.7 | 43 | 9 | 8 |  |  |
| LSB001SA-P9 | 21.25 | 5.4 | 0.7 | 36 | 9 | 16 |  |  |
| LSb001SA-13 | 31.25 | 2.3 | 0.4 | 9 | 10 | 23 |  |  |
| LSB001S-17 Net | 41.25 | 4.9 | 0.4 | 8 | 6 | 31 |  |  |
| LSB001SA-21 Net | 51.25 | 1.4 | 0.4 | 5 | 7 | 38 |  |  |
| LSB001SA-25 Net | 61.25 | 6.6 | 0.4 | 23 | 8 | 46 |  |  |
| LSB001SA-V1-29 | 71.25 | 0.6 | 0.4 | 1 | 7 | 53 |  |  |
| LSB001SA-V1-33 | 81.25 | 0.2 | 0.5 | 0 | 8 | 61 |  |  |
| LSB001SA-V1-37 | 91.25 | 0.2 | 0.5 | 8 | 6 | 68 |  |  |
| LSB001SA-41 | 101.25 | 0.9 | 0.9 | 15 | 9 | 76 |  |  |
| LSB001SA-49 | 121.25 | 0.6 | 0.6 | 12 | 7 | 91 |  |  |
| LSB001SA-58 | 143.75 | 0.1 | 1 | 3 | 8 | 108 |  |  |
| LSB002S-2 | 3.75 | 6.2 | 0.7 | 33 | 9 | 1 | 3.2 | fair |
| LSB002S-4 | 8.75 | 4.8 | 0.6 | 29 | 8 | 3 |  |  |
| LSB002S-5 | 11.25 | 4.3 | 0.7 | 17 | 11 | 4 |  |  |
| LSB002S-7 | 16.25 | 6.1 | 0.8 | 34 | 9 | 5 |  |  |
| LSB002S-10 | 23.75 | 6.5 | 0.7 | 35 | 9 | 8 |  |  |
| LSB002S-13 | 31.25 | 4.7 | 0.7 | 19 | 12 | 10 |  |  |
| LSB002S-V1-19 | 46.25 | 2.3 | 0.5 | 14 | 11 | 15 |  |  |
| LSB002S-25 | 61.25 | 0.7 | 0.4 | 19 | 11 | 20 |  |  |
| LSB002S-V1-P31 | 76.25 | 0.4 | 0.5 | 10 | 9 | 25 |  |  |
| LSB002S-37 | 91.25 | 0.7 | 0.6 | 2 | 10 | 30 |  |  |
| LSB002S-43 | 106.25 | 0.5 | 0.6 | 13 | 9 | 35 |  |  |
| LSB002S-49 | 121.25 | 0.5 | 0.8 | 6 | 11 | 40 |  |  |
| LSB002S-57 | 141.25 | 0.7 | 0.9 | 7 | 9 | 47 |  |  |
| LSB002S-64 | 158.75 | 0.9 | 0.7 | 6 | 9 | 53 |  |  |
| SB Greco Island-2 | 3.75 | 5.9 | 0.7 | 32.6 | 6.9 | 5 | 0.78 | good |
| SB Greco Island-4 | 8.75 | 4.8 | 0.6 | 24.1 | 6.3 | 11 |  |  |
| SB Greco Island-6 | 13.75 | 7.3 | 0.8 | 7.1 | 6.3 | 18 |  |  |
| SB Greco Island-8 | 18.75 | 8.3 | 0.7 | 11.3 | 6.8 | 24 |  |  |
| SB Greco Island-10 | 23.75 | 10.1 | 1 | 20.1 | 8.8 | 30 |  |  |
| SB Greco Island-12 | 28.75 | 10.4 | 0.9 | 11.7 | 7.7 | 37 |  |  |
| SB Greco Island-14 | 33.75 | 1 | 0.7 | 6 | 8.8 | 43 |  |  |
| SB Greco Island-18 | 43.75 | -0.3 | 0.6 | 9.2 | 7.1 | 56 |  |  |
| SB Greco Island-22 | 53.75 | 0.1 | 0.5 | 1.3 | 6.5 | 69 |  |  |
| SB001S-P1 | 1.25 | 3.8 | 0.6 | 31 | 8 | 2 | 0.59 | good |
| SB001S-P2 | 3.75 | 4.2 | 0.4 | 35 | 7 | 6 |  |  |
| SB001S-P3 | 6.25 | 3.8 | 0.6 | 44 | 8 | 11 |  |  |
| SB001S-P4 | 8.75 | 5.1 | 0.7 | 31 | 9 | 15 |  |  |
| SB001S-P5 | 11.25 | 5 | 0.7 | 38 | 9 | 19 |  |  |
| SB001S-P7 | 16.25 | 5.4 | 0.5 | 36 | 8 | 28 |  |  |
| SB001S-P9 | 21.25 | 2 | 0.6 | 8 | 7 | 36 |  |  |
| SB001S-P11 | 26.25 | 1.7 | 0.5 | 8 | 13 | 45 |  |  |
| SB001S-V1-13 | 31.25 | -0.3 | 0.4 | -2 | 13 | 53 |  |  |
| SB001S-V1-15 | 36.25 | -0.6 | 0.6 | 14 | 12 | 62 |  |  |
| SB001S-V1-18 | 43.75 | -0.2 | 0.5 | 11 | 12 | 75 |  |  |
| SB001S-V1-21 | 51.25 | 0.4 | 0.6 | 12 | 11 | 87 |  |  |
| SB001S-25 | 61.25 | -0.5 | 0.4 | 0 | 12 | 104 |  |  |
| SB002S-P1 | 1.25 | 3.9 | 0.8 | 36 | 10 | 3 | 0.44 | good |
| SB002S-P2 | 3.75 | 4.7 | 0.6 | 36 | 9 | 9 |  |  |
| SB002S-P3 | 6.25 | 4.8 | 0.8 | 32 | 10 | 14 |  |  |
| SB002S-P4 | 8.75 | 4.5 | 0.5 | 31 | 7 | 20 |  |  |
| SB002S-P5 | 11.25 | 3.6 | 0.9 | 20 | 11 | 26 |  |  |


| SB002S-P6 | 13.75 | 2.3 | 0.4 | 18 | 8 | 31 |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| SB002S-P7 | 16.25 | 0.8 | 0.4 | 9 | 8 | 37 |  |  |
| SB002S-P8 | 18.75 | 1.4 | 0.3 | 5 | 6 | 43 |  |  |
| SB002S-P9 | 21.25 | 0.7 | 0.5 | 11 | 7 | 49 |  |  |
| SB002S-P10 | 23.75 | 0.3 | 0.6 | -1 | 12 | 54 |  |  |
| SB002S-P11 | 26.25 | -0.3 | 0.4 | 0 | 6 | 60 |  |  |
| SB002S-13 | 31.25 | -0.3 | 0.5 | -5 | 12 | 71 |  |  |
| SB002S-17 Net | 41.25 | -0.3 | 0.4 | 13 | 7 | 94 |  |  |
| SB002S-20 | 48.75 | 0 | 0.4 | -4 | 6 | 111 |  |  |
| SB002S-25 | 61.25 | -0.4 | 0.5 | -2 | 9 | 140 |  |  |
| SPB Wildcat Marsh-2 | 3.75 | 5.6 | 0.5 | 35.7 | 5.5 | 7 | 0.56 | good |
| SPB Wildcat Marsh-4 | 8.75 | 6.5 | 1 | 18.2 | 7.3 | 16 |  |  |
| SPB Wildcat Marsh-6 | 13.75 | 13.5 | 1.3 | 8.4 | 9.5 | 25 |  |  |
| SPB Wildcat Marsh-8 | 18.75 | 75.3 | 1.7 | 18.9 | 7.1 | 34 |  |  |
| SPB Wildcat Marsh-10 | 23.75 | 10.3 | 0.7 | 9.8 | 6.8 | 43 |  |  |
| SPB Wildcat Marsh-12 | 28.75 | 3.6 | 0.6 | 4.7 | 7.1 | 52 |  |  |
| SPB001S-P1 total | 1.25 | 5 | 0.6 | 48 | 9 | 4 | 0.34 | good |
| SPB001S-2 | 3.75 | 3.5 | 0.7 | 40 | 10 | 11 |  |  |
| SPB001S-P4 | 8.75 | 3.6 | 0.6 | 30 | 8 | 26 |  |  |
| SPB001S-P7 | 16.25 | 0.2 | 0.4 | 10 | 7 | 48 |  |  |
| SPB001S-9 | 21.25 | -0.2 | 0.5 | 10 | 11 | 63 |  |  |
| SPB001S-13 | 31.25 | 0 | 0.5 | 2 | 11 | 93 |  |  |
| SPB001S-V1-P15 | 36.25 | 0.7 | 0.5 | 5 | 10 | 108 |  |  |
| SPB001S-V1-P17 | 41.25 | 0.3 | 0.5 | 12 | 8 | 123 |  |  |
| SPB001S-V1-P19 | 46.25 | -0.1 | 0.5 | 8 | 8 | 137 |  |  |
| SPB001S-V1-P22 | 53.75 | -0.1 | 0.4 | 2 | 7 | 160 |  |  |
| SPB001S-25 | 61.25 | -0.2 | 0.5 | 1 | 12 | 182 |  |  |
| SPB001S-V1-P28 | 68.75 | -0.1 | 0.6 | -4 | 7 | 204 |  |  |
| SPB001S-V1-P31 | 76.25 | 0 | 0.6 | 13 | 8 | 227 |  |  |
| SPB001S-41 | 101.25 | -0.2 | 0.4 | 6 | 9 | 301 |  |  |
| SPB001S-49 | 121.25 | -0.2 | 0.5 | 16 | 10 | 360 |  |  |
| SPB001S-61 | 151.25 | -0.4 | 0.5 | 2 | 10 | 450 |  |  |
| SPB002S-P1 | 1.25 | 2.8 | 0.6 | 33 | 8 | 0 | 3.2 | fair |
| SPB002S-P2 | 3.75 | 1.1 | 0.6 | 13 | 9 | 1 |  |  |
| SPB002S-P3 | 6.25 | 0.3 | 0.5 | 9 | 8 | 2 |  |  |
| SPB002S-P4 | 8.75 | 0.2 | 0.6 | 13 | 9 | 3 |  |  |
| SPB002S-P5 | 11.25 | 0.5 | 0.6 | 2 | 9 | 4 |  |  |
| SPB002S-P7 | 16.25 | 0.8 | 0.6 | 14 | 10 | 5 |  |  |
| SPB002S-P10 | 23.75 | 0.5 | 0.5 | 7 | 8 | 7 |  |  |
| SPB002S-13 Net | 31.25 | 0.6 | 0.3 | 13 | 7 | 10 |  |  |
| SPB002S-17 | 41.25 | -0.6 | 0.5 | 2 | 12 | 13 |  |  |
| SPB002S-25 | 61.25 | 0.1 | 0.4 | 7 | 12 | 19 |  |  |
| SPB002S-33 | 81.25 | 0.4 | 0.4 | 22 | 10 | 25 |  |  |
| SPB002S-41 | 101.25 | 0.9 | 0.5 | 4 | 9 | 32 |  |  |
| SPB002S-49 | 121.25 | 0.1 | 0.4 | 0 | 8 | 38 |  |  |
| SPB002S-61 | 151.25 | 0.5 | 0.6 | 4 | 12 | 47 |  |  |
| SU Point Edith-2 | 3.75 | 5.9 | 2.1 | 59.5 | 19.9 | 19 | 0.19 | fair |
| SU Point Edith-4 | 8.75 | 103.1 | 1.7 | 3.6 | 7.9 | 45 |  |  |
| SU Point Edith-6 | 13.75 | 1.7 | 0.5 | -7 | 5.1 | 71 |  |  |
| SU Point Edith-8 | 18.75 | 0.8 | 0.6 | -3.8 | 5.3 | 97 |  |  |
| SU Point Edith-10 | 23.75 | 0.2 | 0.6 | -11.6 | 4.9 | 123 |  |  |
| SU Point Edith-12 | 28.75 | 0.1 | 0.5 | -12.6 | 5.3 | 148 |  |  |
| SU001SA-P1 | 1.25 | 2 | 0.3 | 19 | 6 | 2 | 0.53 | poor |
| SU001SA-P4 | 8.75 | 0.1 | 0.4 | 8 | 9 | 16 |  |  |
| SU001SA-P7 | 16.25 | 0.1 | 0.3 | 5 | 8 | 31 |  |  |
| SU001SA-9 | 21.25 | 0.6 | 0.4 | 1 | 8 | 40 |  |  |
| SU001Sa-13 | 31.25 | 0.9 | 0.5 | -1 | 13 | 59 |  |  |
| SU001SA-17 | 41.25 | 0 | 0.6 | 4 | 7 | 78 |  |  |
| SU001SA-21 | 51.25 | 0.2 | 0.5 | 4 | 7 | 97 |  |  |
| SU001Sa-25 | 61.25 | -0.2 | 0.4 | 3 | 12 | 115 |  |  |
| SU001SA-33 | 81.25 | 0.4 | 0.8 | 7 | 8 | 153 |  |  |


| SUO01SA-41 | 101.25 | 0.1 | 0.5 | 3 | 7 | 191 |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| SU001SA-49 | 121.25 | 0.1 | 0.4 | -2 | 7 | 228 |  |  |
| SU002Sa-1 | 1.25 | 0.9 | 0.3 | 5 | 6 | 0 | $>2.6$ | really poor |
| SU002Sa-2 | 3.75 | 0.6 | 0.4 | 0 | 6 | 1 | use 2.6 |  |
| SU002Sa-3 | 6.25 | 0.9 | 0.4 | 3 | 6 | 2 |  |  |
| SU002Sa-4 | 8.75 | 0.6 | 0.3 | -2 | 6 | 3 |  |  |
| SU002Sa-5 | 11.25 | 0.4 | 0.3 | 1 | 5 | 4 |  |  |
| SU002SA-P7 | 16.25 | 0 | 0.3 | 4 | 9 | 6 |  |  |
| SU002Sa-P10 | 23.75 | -0.4 | 0.5 | -8 | 12 | 9 |  |  |
| SU002S-13 total | 31.25 | 2 | 0.4 | 3 | 8 | 12 |  |  |
| SU002SA-17 | 41.25 | 8 | 0.7 | 11 | 8 | 16 |  |  |
| SU002SA-21 | 51.25 | 2.7 | 0.4 | 1 | 6 | 20 |  |  |
| SU002Sa-25 | 61.25 | 0.7 | 0.5 | 0 | 10 | 24 |  |  |
| SU002SA-29 | 71.25 | 3 | 0.4 | 5 | 6 | 27 |  |  |
| SU002SA-33 | 81.25 | 5.9 | 0.6 | 1 | 8 | 31 |  |  |
| SU002SA-37 | 91.25 | 1.3 | 0.4 | 8 | 7 | 35 |  |  |
| SU002SA-41 | 101.25 | 1.7 | 0.3 | -3 | 6 | 39 |  |  |

Table B-1. Raw Data for Trace Element Analysis (except Mercury)
$\mathrm{ND}=$ analyte not detected above MDL

| Station | Depth (cm) | \% Solids | $\begin{array}{\|c} \hline \mathrm{Ag} \\ (\mathrm{mg} / \mathrm{kg}) \\ \hline \end{array}$ | $\begin{array}{\|c\|} \hline \text { Al } \\ (\mathrm{mg} / \mathrm{kg}) \\ \hline \end{array}$ | $\begin{array}{\|c\|} \hline \text { As } \\ (\mathrm{mg} / \mathrm{kg}) \end{array}$ | $\begin{array}{\|c\|} \hline \text { Cd } \\ (\mathrm{mg} / \mathrm{kg}) \\ \hline \end{array}$ | $\begin{array}{\|c\|} \hline \mathrm{Cr} \\ (\mathrm{mg} / \mathrm{kg}) \\ \hline \end{array}$ | $\begin{array}{\|c} \hline \mathrm{Cu} \\ (\mathrm{mg} / \mathrm{kg}) \\ \hline \end{array}$ | $\begin{gathered} \mathrm{Fe} \\ (\mathrm{mg} / \mathrm{kg}) \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{Mn} \\ (\mathrm{mg} / \mathrm{kg}) \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{Ni} \\ (\mathrm{mg} / \mathrm{kg}) \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{Pb} \\ (\mathrm{mg} / \mathrm{kg}) \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{Se} \\ (\mathrm{mg} / \mathrm{kg}) \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{Zn} \\ (\mathrm{mg} / \mathrm{kg}) \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CB Damon Slough | 3.75 | 20.4 | 0.366 | 61200 | 13.8 | 0.171 | 117 | 93.5 | 38500 | 1450 | 88.9 | 125 | 1.05 | 203 |
| CB Damon Slough | 8.75 | 22.9 | 0.318 | 47800 | 13.9 | 0.157 | 93.5 | 83.3 | 37400 | 1200 | 82.9 | 285 | 0.808 | 139 |
| CB Damon Slough | 13.75 | 33.9 | 0.347 | 67200 | 31.4 | 0.252 | 143 | 70.3 | 67000 | 1630 | 125 | 348 | 0.666 | 223 |
| CB Damon Slough | 18.75 | 16.5 | 0.929 | 47700 | 14.7 | 1.05 | 101 | 75.1 | 27500 | 246 | 85.8 | 217 | 0.828 | 196 |
| CB Damon Slough | 23.75 | 26.3 | 0.306 | 67500 | 20.5 | 0.538 | 140 | 66.6 | 39600 | 244 | 129 | 588 | 0.412 | 249 |
| CB Damon Slough | 28.75 | 51.3 | 0.147 | 68100 | 9.76 | 0.137 | 131 | 36.7 | 35800 | 223 | 105 | 35.8 | ND | 99.4 |
| CB Damon Slough | 38.75 | 39.6 | 0.138 | 75300 | 10.9 | 0.0792 | 148 | 37.8 | 40600 | 290 | 90 | 13.7 | 0.346 | 99.3 |
| CB Damon Slough | 48.75 | 33.1 | 0.0985 | 64100 | 11 | 0.167 | 123 | 30.5 | 36800 | 239 | 89.8 | 8.83 | 0.482 | 83.4 |
| CB Damon Slough | 58.75 | 21.7 | 0.169 | 101000 | 12.1 | 0.167 | 192 | 35.5 | 57800 | 386 | 121 | 14.3 | 0.822 | 119 |
| CB Damon Slough | 68.75 | 37.6 | 0.12 | 69600 | 8.17 | 0.205 | 133 | 31.1 | 36400 | 249 | 94.4 | 8.27 | 0.431 | 81.6 |
| CB001S | 6.25 | 54 | 0.565 | 87000 | 14.5 | 0.342 | 155 | 47.8 | 44500 | 432 | 93 | 36.2 | 0.512 | 147 |
| CB001S | 11.25 | 51.1 | 0.492 | 81100 | 14.7 | 0.362 | 142 | 51.7 | 42800 | 376 | 89.4 | 38.7 | 0.53 | 149 |
| CB001S | 21.25 | 59.5 | 0.326 | 78800 | 13.6 | 0.356 | 135 | 44.2 | 40700 | 384 | 82.2 | 29.8 | 0.379 | 129 |
| CB001S | 31.25 | 57.5 | 0.254 | 79100 | 13.2 | 0.233 | 135 | 41.8 | 39200 | 382 | 78.6 | 25.4 | 0.354 | 118 |
| CB001S | 46.25 | 63 | 0.176 | 76200 | 10.6 | 0.219 | 132 | 41.2 | 38400 | 367 | 79.8 | 20.9 | 0.275 | 100 |
| CB001S | 61.25 | 62 | 0.337 | 89200 | 14.6 | 0.281 | 148 | 42.7 | 45400 | 406 | 88.8 | 19.6 | 0.428 | 108 |
| CB001S | 68.75 | 51.4 | 0.15 | 87300 | 13.9 | 0.25 | 151 | 34.1 | 45800 | 423 | 90 | 16 | 0.35 | 98.3 |
| CB001S | 81.25 | 62.3 | 0.152 | 73000 | 10.8 | 0.244 | 128 | 26.4 | 39800 | 374 | 76.7 | 9.97 | 0.347 | 87 |
| CB001S | 101.25 | 53.1 | 0.127 | 75200 | 11.3 | 0.246 | 128 | 28.7 | 41500 | 383 | 80.4 | 10.5 | 0.374 | 110 |
| CB001S | 121.25 | 53.8 | 0.11 | 81700 | 10.6 | 0.3 | 142 | 30.9 | 45500 | 418 | 89.4 | 11.3 | 0.52 | 96.2 |
| CB002S | 6.25 | 51.2 | 0.384 | 84900 | 9.92 | 0.164 | 159 | 48.4 | 48100 | 457 | 101 | 32.1 | 0.503 | 149 |
| CB002S | 11.25 | 51.9 | 0.475 | 78300 | 10.3 | 0.178 | 152 | 45.3 | 45900 | 448 | 97.1 | 31.8 | 0.464 | 142 |
| CB002S | 23.75 | 53.1 | 0.408 | 80600 | 12.6 | 0.49 | 156 | 51.3 | 45100 | 376 | 99.4 | 34.3 | 0.563 | 138 |
| CB002S | 31.25 | 53 | 0.361 | 84200 | 15.9 | 0.304 | 157 | 46.2 | 46900 | 390 | 98.6 | 31 | 0.397 | 122 |
| CB002S | 41.25 | 51.5 | 0.174 | 79500 | 11.2 | 0.165 | 139 | 38.3 | 41300 | 358 | 85.7 | 19.5 | 0.42 | 102 |
| CB002S | 51.25 | 50.2 | 0.15 | 80900 | 11.6 | 0.22 | 132 | 33.5 | 40200 | 364 | 79.2 | 17.7 | 0.34 | 87.6 |
| CB002S | 61.25 | 50 | 0.13 | 70400 | 8.78 | 0.218 | 138 | 27.6 | 42700 | 464 | 86.5 | 11.8 | 0.343 | 94.3 |
| CB002S | 71.25 | 44.5 | 0.13 | 86000 | 12.4 | 0.27 | 143 | 25.2 | 47000 | 524 | 90.9 | 12.1 | 0.46 | 97.5 |
| CB002S | 78.75 | 47.8 | 0.232 | 78100 | 9.08 | 0.156 | 139 | 23.7 | 40600 | 543 | 82 | 10.8 | 0.269 | 92.2 |
| CB002S | 101.25 | 46.3 | 0.236 | 77500 | 9.55 | 0.171 | 145 | 28.3 | 45700 | 493 | 94.9 | 12.1 | 0.337 | 105 |
| CB006SA | 6.25 | 53.5 | 0.425 | 70300 | 8.69 | 0.481 | 123 | 40 | 36500 | 438 | 75.7 | 29.1 | 0.52 | 122 |
| CB006SA | 11.25 | 56.7 | 1.15 | 61100 | 9.36 | 1.52 | 105 | 87.5 | 31300 | 390 | 72.5 | 22.4 | 1.06 | 113 |
| CB006SA | 21.25 | 50.5 | 0.366 | 72400 | 12.3 | 0.282 | 128 | 41.2 | 40200 | 490 | 82.2 | 28.7 | 0.39 | 124 |
| CB006SA | 31.25 | 58.3 | 0.593 | 58800 | 9.95 | 0.252 | 101 | 29.3 | 30800 | 650 | 63 | 20.2 | 0.267 | 90.4 |
| CB006SA | 41.25 | 58.5 | 0.317 | 51400 | 7.1 | 0.173 | 84.8 | 24 | 26000 | 454 | 52.3 | 14.2 | 0.264 | 73.3 |
| CB006SA | 51.25 | 58.7 | 0.11 | 35200 | 6.25 | 0.22 | 63.3 | 21.9 | 19700 | 543 | 40.6 | 8.69 | ND | 46.2 |
| CB006SA | 61.25 | 61.9 | 0.118 | 51300 | 7.15 | 0.224 | 91.2 | 22.8 | 28800 | 437 | 58.4 | 7.91 | 0.376 | 66.7 |
| CB006SA | 71.25 | 55.2 | 0.12 | 74800 | 9.36 | 0.23 | 130 | 25.7 | 39900 | 472 | 78.4 | 9.89 | 0.35 | 80.3 |
| CB006SA | 81.25 | 63 | 0.127 | 58300 | 7.48 | 0.121 | 95 | 20.7 | 29200 | 405 | 58.8 | 8.16 | 0.382 | 65.4 |
| CB006SA | 101.25 | 56.5 | 0.112 | 57200 | 8.15 | 0.193 | 86.7 | 20.5 | 27500 | 399 | 55.6 | 8.4 | 0.299 | 59.9 |
| LSB Alviso Slough | 3.75 | 42.7 | 0.485 | 76400 | 7.66 | 0.242 | 153 | 45 | 48700 | 2260 | 115 | 34.8 | 1.24 | 185 |
| LSB Alviso Slough | 13.75 | 44.6 | 0.611 | 80700 | 8.61 | 0.39 | 164 | 59.8 | 48600 | 2020 | 124 | 37.9 | 1.45 | 173 |
| LSB Alviso Slough | 23.75 | 43.7 | 0.701 | 82900 | 14.5 | 0.343 | 165 | 54.8 | 64000 | 2510 | 117 | 43.2 | 0.634 | 183 |
| LSB Alviso Slough | 38.75 | 48.5 | 0.806 | 85200 | 7.99 | 0.384 | 178 | 58.1 | 51600 | 1350 | 129 | 53.4 | 0.678 | 185 |
| LSB Alviso Slough | 58.75 | 42.6 | 1.01 | 87800 | 8.29 | 0.45 | 190 | 66.8 | 49600 | 966 | 145 | 82.6 | 1.02 | 206 |
| LSB Alviso Slough | 78.75 | 42.7 | 1.43 | 84800 | 9.08 | 0.654 | 194 | 60.8 | 51200 | 1060 | 136 | 81.6 | 0.625 | 196 |
| LSB Alviso Slough | 98.75 | 46.5 | 1.44 | 81400 | 10.7 | 0.631 | 178 | 58.6 | 54400 | 1020 | 120 | 59.2 | 0.585 | 186 |
| LSB Alviso Slough | 118.75 | 40.7 | 1.07 | 92600 | 13.1 | 0.78 | 210 | 59.6 | 59000 | 983 | 159 | 65.6 | 0.765 | 192 |
| LSB Alviso Slough | 138.75 | 39.4 | 1.5 | 96600 | 13.6 | 0.572 | 215 | 65.2 | 61900 | 1290 | 155 | 60.3 | 0.818 | 203 |
| LSB Alviso Slough | 163.75 | 42.7 | 0.0446 | 72000 | 9.34 | 0.216 | 139 | 30.9 | 36800 | 419 | 91.2 | 14.4 | 0.798 | 102 |
| LSB Coyote Creek | 3.75 | 43.1 | 0.448 | 75700 | 8.75 | 0.18 | 149 | 45.4 | 46800 | 2540 | 118 | 28.6 | 0.666 | 155 |
| LSB Coyote Creek | 13.75 | 36.4 | 0.429 | 88500 | 15.1 | 0.16 | 177 | 48.8 | 61000 | 1570 | 128 | 42.5 | 0.923 | 173 |
| LSB Coyote Creek | 23.75 | 75.8 | 0.157 | 35900 | 12 | 0.0627 | 75.8 | 16.8 | 34000 | 1230 | 61.5 | 22 | 0.417 | 73.3 |
| LSB Coyote Creek | 38.75 | 21.6 | 2.42 | 186000 | 23.1 | 0.948 | 382 | 116 | 113000 | 2200 | 276 | 99.5 | 1.08 | 367 |
| LSB Coyote Creek | 58.75 | 62.7 | 0.753 | 66800 | 8.7 | 0.5 | 148 | 46.7 | 39900 | 888 | 113 | 36.5 | 0.336 | 127 |
| LSB Coyote Creek | 78.75 | 53.4 | 0.921 | 56500 | 9.47 | 0.452 | 131 | 37.2 | 38300 | 900 | 89.4 | 31.4 | 0.627 | 122 |
| LSB Coyote Creek | 98.75 | 45.2 | 0.815 | 86300 | 17.5 | 0.54 | 165 | 53.1 | 59600 | 942 | 118 | 43.8 | 0.457 | 167 |
| LSB Coyote Creek | 118.75 | 39.3 | 0.445 | 102000 | 31.5 | 0.307 | 187 | 56 | 60900 | 660 | 144 | 39 | 0.589 | 168 |
| LSB Coyote Creek | 138.75 | 51.8 | 0.306 | 88200 | 17.6 | 0.276 | 158 | 52.4 | 48700 | 451 | 108 | 36.1 | 0.466 | 149 |
| LSB Coyote Creek | 163.75 | 54.7 | 0.433 | 79300 | 36.2 | 0.917 | 144 | 54.2 | 40500 | 341 | 157 | 25.4 | 0.553 | 164 |
| LSB001SA | 11.25 | 38.5 | 0.5 | 91600 | 10.1 | 0.22 | 167 | 50.2 | 52000 | 642 | 112 | 33.6 | 0.47 | 166 |
| LSB001SA | 21.25 | 53.5 | 0.745 | 79800 | 8.56 | 0.448 | 156 | 55.5 | 46000 | 568 | 105 | 39.2 | 0.612 | 160 |
| LSB001SA | 41.25 | 54.1 | 0.824 | 78800 | 10.5 | 0.251 | 160 | 48.9 | 47300 | 596 | 106 | 37.2 | 0.371 | 152 |
| LSB001SA | 61.25 | 48.4 | 0.531 | 80400 | 12.4 | 0.281 | 151 | 45.4 | 46700 | 522 | 98.6 | 36.2 | 0.446 | 151 |
| LSB001SA | 71.25 | 50.5 | 0.562 | 82600 | 13.2 | 0.282 | 155 | 48.6 | 47800 | 519 | 103 | 37.1 | 0.539 | 153 |
| LSB001SA | 81.25 | 49.8 | 0.701 | 83200 | 14.8 | 0.457 | 156 | 50.4 | 48000 | 737 | 104 | 36.3 | 0.532 | 155 |
| LSB001SA | 91.25 | 49.3 | 0.33 | 73500 | 14.1 | 0.23 | 130 | 36.6 | 41000 | 605 | 85.5 | 29.1 | 0.4 | 117 |
| LSB001SA | 101.25 | 49.1 | 0.339 | 85000 | 15.9 | 0.178 | 155 | 46.3 | 49400 | 821 | 108 | 32.6 | 0.431 | 145 |
| LSB001SA | 121.25 | 52.9 | 0.274 | 69800 | 21.5 | 0.198 | 125 | 36.4 | 40900 | 1650 | 89.3 | 27.5 | 0.333 | 113 |
| LSB001SA | 143.75 | 52.2 | 0.365 | 83200 | 15 | 0.227 | 145 | 44.6 | 46100 | 947 | 105 | 29.8 | 0.398 | 139 |
| LSB002S | 11.25 | 46 | 0.39 | 79600 | 8.39 | 0.24 | 142 | 40 | 44900 | 1000 | 102 | 29.5 | 0.38 | 138 |
| LSB002S | 31.25 | 53.1 | 0.602 | 75500 | 8.61 | 0.263 | 146 | 43.6 | 44000 | 1060 | 109 | 30.4 | 0.44 | 150 |
| LSB002S | 46.25 | 50.6 | 0.412 | 53000 | 7.42 | 0.203 | 122 | 26.9 | 29000 | 560 | 69.4 | 16.7 | 0.248 | 82.3 |
| LSB002S | 61.25 | 62.4 | 0.25 | 57500 | 6.86 | 0.139 | 92.7 | 18.3 | 28200 | 429 | 75.7 | 9.63 | 0.259 | 66.8 |


| LSB002S | 76.25 | 65.5 | 0.14 | 53000 | 6.21 | 0.1 | 98.3 | 16.8 | 26400 | 373 | 73.7 | 8.45 | 0.288 | 59.4 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| LSB002S | 91.25 | 63 | 0.08 | 44800 | 6.07 | 0.11 | 78.2 | 14.6 | 23800 | 362 | 63.1 | 7.63 | ND | 52.1 |
| LSB002S | 106.25 | 54.4 | 0.21 | 67800 | 8.3 | 0.158 | 108 | 23.7 | 34300 | 441 | 78.9 | 10.5 | 0.421 | 80 |
| LSB002S | 121.25 | 54.8 | 0.0864 | 49700 | 6.67 | 1.01 | 81.4 | 23.1 | 25700 | 1870 | 71.4 | 10.1 | 0.14 | 57 |
| LSB002S | 141.25 | 54.8 | 0.115 | 67300 | 10.4 | 0.172 | 107 | 24.2 | 36400 | 586 | 79.3 | 10.3 | 0.433 | 78.3 |
| LSB002S | 158.75 | 67.7 | 0.109 | 48000 | 5.83 | 0.123 | 78.9 | 16.4 | 22900 | 536 | 57.4 | 7.17 | 0.178 | 53.8 |
| SB Greco Island | 3.75 | 42 | 0.335 | 70600 | 9.85 | 0.0825 | 135 | 40.5 | 42800 | 663 | 90.2 | 28.5 | 0.424 | 132 |
| SB Greco Island | 13.75 | 36.7 | 0.649 | 66300 | 17.7 | 0.441 | 132 | 44.1 | 45500 | 501 | 101 | 38.4 | 0.805 | 150 |
| SB Greco Island | 23.75 | 30.3 | 1.17 | 74900 | 8.85 | 0.403 | 156 | 58.5 | 40100 | 411 | 98.4 | 61.8 | 0.565 | 139 |
| SB Greco Island | 33.75 | 31.7 | 0.279 | 59400 | 30.6 | 0.346 | 114 | 41 | 71600 | 1850 | 85.3 | 33.4 | 0.564 | 125 |
| SB Greco Island | 43.75 | 43.5 | 0.278 | 79900 | 16.1 | 0.316 | 152 | 44.5 | 45500 | 452 | 104 | 33.5 | 0.415 | 135 |
| SB Greco Island | 53.75 | 45.4 | 0.252 | 77600 | 24.4 | 0.327 | 143 | 48.1 | 47700 | 432 | 106 | 32.4 | 0.434 | 129 |
| SB Greco Island | 63.75 | 32.9 | 0.0597 | 59500 | 7.54 | 0.0728 | 117 | 25.8 | 33300 | 292 | 74.9 | 9.7 | 0.723 | 75.2 |
| SB Greco Island | 73.75 | 35.5 | 0.184 | 79200 | 6.71 | 0.386 | 152 | 30.1 | 41400 | 331 | 99.2 | 10.1 | 0.299 | 97.1 |
| SB Greco Island | 83.75 | 37.2 | 0.0936 | 72100 | 10.8 | 0.326 | 139 | 30.6 | 46300 | 345 | 101 | 9.68 | ND | 99.1 |
| SB Greco Island | 93.75 | 35.9 | 0.0842 | 59300 | 7.08 | 0.178 | 112 | 27 | 39500 | 308 | 70.6 | 8.14 | 0.446 | 68.8 |
| SB001S | 6.25 | 49.2 | 0.238 | 65900 | 7.99 | 0.172 | 111 | 29.9 | 34000 | 520 | 70.5 | 18.9 | 0.327 | 95.8 |
| SB001S | 11.25 | 65.8 | 0.198 | 42300 | 5.01 | 0.126 | 73.6 | 23.2 | 22100 | 437 | 46.9 | 13.7 | 0.218 | 64.2 |
| SB001S | 21.25 | 52.3 | 0.142 | 59000 | 8.5 | 0.118 | 98.2 | 27.2 | 29700 | 418 | 62.3 | 14.5 | 0.29 | 74.6 |
| SB001S | 31.25 | 56.5 | 0.169 | 38300 | 6.28 | 0.108 | 71.4 | 16.7 | 22200 | 516 | 46.1 | 6.35 | 0.248 | 51 |
| SB001S | 43.75 | 48.3 | 0.115 | 62400 | 8.11 | 0.172 | 114 | 25.7 | 35800 | 545 | 76.7 | 9.69 | 0.488 | 83.1 |
| SB001S | 51.25 | 52.4 | 0.11 | 42800 | 5.63 | 0.14 | 77.2 | 17.1 | 24600 | 448 | 50.3 | 6.34 | 0.32 | 56.7 |
| SB001S | 61.25 | 46.5 | 0.159 | 71800 | 9.4 | 0.133 | 129 | 28.6 | 40600 | 537 | 86.6 | 10.7 | 0.356 | 93.2 |
| SB001S | 71.25 | 53.6 | 0.08 | 46300 | 6.28 | 0.1 | 84.6 | 16.2 | 26900 | 395 | 54.5 | 6.85 | 0.31 | 55.8 |
| SB001S | 81.25 | 46.7 | 0.133 | 65200 | 7.82 | 0.174 | 115 | 25 | 37000 | 603 | 75.4 | 9.25 | 0.455 | 84.9 |
| SB001S | 101.25 | 41.8 | 0.151 | 64600 | 6.9 | 0.246 | 114 | 34.3 | 37200 | 494 | 77.8 | 9.34 | 0.384 | 90 |
| SB002S | 6.25 | 61.2 | 0.342 | 72600 | 8.58 | 0.215 | 123 | 34.1 | 35200 | 424 | 77.3 | 25.9 | 0.338 | 109 |
| SB002S | 11.25 | 63 | 0.452 | 74800 | 10.1 | 0.393 | 131 | 42.2 | 38000 | 436 | 85.1 | 25.7 | 0.392 | 122 |
| SB002S | 21.25 | 65.8 | 0.163 | 64400 | 8.46 | 0.135 | 112 | 21.4 | 31400 | 404 | 72.9 | 10 | 0.262 | 77.1 |
| SB002S | 31.25 | 65 | 0.132 | 74800 | 8.17 | 0.146 | 131 | 20.3 | 34100 | 459 | 86.2 | 9.13 | 0.235 | 79.2 |
| SB002S | 51.25 | 72.3 | 0.07 | 66500 | 8.78 | 0.13 | 116 | 17.6 | 31800 | 405 | 86.9 | 8.58 | ND | 69.3 |
| SB002S | 61.25 | 59.4 | 0.251 | 74100 | 8.09 | 0.146 | 125 | 24.5 | 35700 | 429 | 85 | 10.1 | 0.279 | 90.5 |
| SB002S | 71.25 | 67.5 | 0.09 | 69100 | 8.27 | 0.15 | 123 | 24.7 | 38200 | 507 | 79.5 | 9.39 | 0.27 | 80.4 |
| SB002S | 81.25 | 68.6 | 0.144 | 67200 | 9.94 | 0.196 | 104 | 17.8 | 30100 | 476 | 59.1 | 8.61 | 0.232 | 65.1 |
| SB002S | 101.25 | 62.9 | 0.129 | 68800 | 9.23 | 0.205 | 113 | 22 | 33500 | 565 | 63.4 | 9.23 | 0.314 | 76.4 |
| SB002S | 121.25 | 62.3 | 0.11 | 78600 | 10.5 | 0.17 | 136 | 28.9 | 43600 | 520 | 86.7 | 10.7 | 0.32 | 89 |
| SPB Wildcat Marsh | 3.75 | 26 | 0.2 | 98600 | 26.2 | 0.215 | 179 | 66.7 | 70600 | 421 | 126 | 35.1 | 0.864 | 172 |
| SPB Wildcat Marsh | 8.75 | 34.2 | 0.18 | 63200 | 16.7 | 0.141 | 125 | 57.4 | 41100 | 302 | 89.4 | 37.8 | 1.54 | 108 |
| SPB Wildcat Marsh | 13.75 | 19.9 | 0.352 | 55900 | 26.7 | 0.177 | 148 | 91.1 | 30600 | 208 | 97.4 | 90.7 | 5.29 | 103 |
| SPB Wildcat Marsh | 18.75 | 22.9 | 0.321 | 61000 | 28.8 | 0.151 | 187 | 93.6 | 32800 | 231 | 119 | 92.1 | 6.78 | 105 |
| SPB Wildcat Marsh | 23.75 | 20.8 | 0.394 | 86200 | 45.6 | 0.312 | 172 | 83.3 | 46100 | 298 | 121 | 126 | 2.84 | 157 |
| SPB Wildcat Marsh | 28.75 | 23.2 | 0.343 | 74300 | 88.7 | 1.81 | 136 | 84.8 | 53300 | 325 | 109 | 89.6 | 1.11 | 279 |
| SPB Wildcat Marsh | 38.75 | 37.8 | 0.267 | 69500 | 27.4 | 0.427 | 118 | 49.3 | 37300 | 286 | 81.8 | 46.4 | 0.479 | 107 |
| SPB Wildcat Marsh | 48.75 | 38.9 | 0.118 | 96000 | 13 | 0.268 | 162 | 48.6 | 48500 | 441 | 101 | 20.9 | 0.624 | 103 |
| SPB Wildcat Marsh | 58.75 | 38.9 | 0.0834 | 79300 | 16.2 | 0.257 | 131 | 37.3 | 42900 | 412 | 83.9 | 12.1 | 0.588 | 85 |
| SPB Wildcat Marsh | 68.75 | 27.8 | 0.202 | 70000 | 9.91 | 0.352 | 122 | 30.5 | 40800 | 394 | 82.2 | 10.3 | 0.4 | 89.2 |
| SPB001S | 8.75 | 46.3 | 0.392 | 95200 | 23.8 | 0.344 | 147 | 66.1 | 50000 | 670 | 95.9 | 39.8 | 0.601 | 174 |
| SPB001S | 16.25 | 52.5 | 0.34 | 92700 | 17.4 | 0.294 | 138 | 54.1 | 45600 | 579 | 87 | 29 | 0.425 | 127 |
| SPB001S | 21.25 | 48.1 | 0.307 | 88400 | 18.9 | 0.289 | 148 | 58.6 | 46800 | 535 | 94.4 | 26.8 | 0.328 | 123 |
| SPB001S | 31.25 | 48.9 | 0.276 | 83600 | 18.3 | 0.185 | 142 | 56.1 | 48000 | 489 | 89.2 | 25 | 0.427 | 115 |
| SPB001S | 41.25 | 48.8 | 0.227 | 93100 | 20.5 | 0.191 | 159 | 55.5 | 48900 | 481 | 97.7 | 24 | 0.37 | 116 |
| SPB001S | 61.25 | 46.8 | 0.18 | 93200 | 19.2 | 0.0968 | 146 | 53.7 | 46400 | 446 | 81.5 | 17.7 | 0.461 | 100 |
| SPB001S | 76.25 | 45.5 | 0.185 | 91800 | 16.5 | 0.188 | 207 | 38.3 | 53600 | 914 | 104 | 17 | 0.267 | 115 |
| SPB001S | 101.25 | 54.2 | 0.146 | 83800 | 14 | 0.143 | 136 | 46.5 | 42900 | 484 | 76.8 | 14 | 0.297 | 88.3 |
| SPB001S | 121.25 | 51.5 | 0.12 | 110000 | 16.8 | 0.22 | 170 | 54.9 | 53300 | 738 | 105 | 16.8 | 0.39 | 97.6 |
| SPB001S | 151.25 | 45.5 | 0.14 | 88300 | 19.6 | 0.19 | 146 | 29.7 | 49400 | 555 | 101 | 12.3 | 0.37 | 99 |
| SPB002S | 6.25 | 42.7 | 0.234 | 94900 | 16.7 | 0.208 | 152 | 52.5 | 45800 | 684 | 87.1 | 22.9 | 0.468 | 114 |
| SPB002S | 11.25 | 47.4 | 0.199 | 98100 | 14.1 | 0.209 | 156 | 52.9 | 48700 | 833 | 89.2 | 22.4 | 0.515 | 110 |
| SPB002S | 23.75 | 54.1 | 0.226 | 85800 | 13.1 | 0.139 | 132 | 42.4 | 39900 | 504 | 74.4 | 18 | 0.402 | 88.7 |
| SPB002S | 31.25 | 55.9 | 0.26 | 92100 | 13.6 | 0.183 | 143 | 46.3 | 41500 | 481 | 78 | 19.3 | 0.392 | 94.8 |
| SPB002S | 41.25 | 57.2 | 0.16 | 87800 | 15.2 | 0.16 | 133 | 43.4 | 40900 | 520 | 71.4 | 16.2 | 0.423 | 87.4 |
| SPB002S | 61.25 | 53.1 | 0.41 | 86300 | 14.2 | 0.211 | 140 | 43.5 | 42600 | 509 | 82.2 | 14.8 | 0.365 | 86.3 |
| SPB002S | 81.25 | 49.5 | 0.174 | 91900 | 13 | 0.179 | 155 | 47.8 | 48200 | 582 | 91.2 | 15.6 | 0.427 | 99.3 |
| SPB002S | 101.25 | 53.5 | 0.1 | 84700 | 11.7 | 0.185 | 147 | 43.5 | 43700 | 554 | 85.6 | 13.8 | 0.344 | 91.6 |
| SPB002S | 121.25 | 39.5 | 0.23 | 107000 | 16.2 | 0.22 | 182 | 52.9 | 56600 | 758 | 120 | 15.3 | 0.44 | 107 |
| SPB002S | 151.25 | 42.8 | 0.14 | 86600 | 10.2 | 0.22 | 153 | 40.3 | 51300 | 650 | 113 | 12.6 | 0.38 | 109 |
| SU Point Edith | 3.75 | 17.4 | 0.314 | 31200 | 16.7 | 0.251 | 65.3 | 31.5 | 37000 | 274 | 64.3 | 39 | 2.1 | 66.5 |
| SU Point Edith | 8.75 | 26.1 | 0.708 | 47000 | 22.8 | 0.197 | 179 | 75.5 | 27400 | 175 | 80.5 | 143 | 2.57 | 78.9 |
| SU Point Edith | 13.75 | 30.7 | 0.555 | 92500 | 29.9 | 0.319 | 172 | 103 | 43100 | 290 | 105 | 160 | 1.48 | 167 |
| SU Point Edith | 18.75 | 37.9 | 0.397 | 93600 | 41 | 0.273 | 155 | 107 | 55900 | 272 | 86.2 | 65.6 | 0.769 | 143 |
| SU Point Edith | 23.75 | 44.6 | 0.381 | 102000 | 26.2 | 0.235 | 167 | 64.1 | 51400 | 270 | 90.9 | 44.6 | 0.653 | 129 |
| SU Point Edith | 28.75 | 46.3 | 0.354 | 92100 | 23 | 0.84 | 138 | 53.6 | 52200 | 229 | 70.9 | 17 | 0.445 | 104 |
| SU Point Edith | 38.75 | 48 | 0.139 | 102000 | 10.4 | 0.485 | 150 | 48.2 | 39500 | 235 | 78.2 | 16.7 | 0.452 | 95.1 |
| SU Point Edith | 48.75 | 27.1 | 0.139 | 52200 | 40.6 | 3.21 | 102 | 31.3 | 47700 | 244 | 136 | 12.5 | 0.714 | 92.7 |
| SU Point Edith | 58.75 | 26.6 | 0.168 | 55700 | 13.8 | 0.119 | 106 | 25.6 | 38700 | 315 | 74.6 | 8.25 | 0.371 | 74 |
| SU Point Edith | 68.75 | 21.5 | 0.0727 | 57300 | 12.4 | 0.249 | 110 | 26.8 | 35700 | 294 | 82.9 | 8.25 | 0.438 | 73.2 |
| SU001SA | 6.25 | 64.9 | 0.261 | 66100 | 14.6 | 0.197 | 199 | 33.2 | 45300 | 762 | 82.6 | 18.8 | 0.322 | 119 |
| SU001SA | 16.25 | 57.5 | 0.17 | 75400 | 18.6 | 0.267 | 174 | 40.1 | 46400 | 732 | 82.7 | 20.1 | 0.478 | 133 |


| SU001SA | 21.25 | 47.1 | 0.198 | 77400 | 26 | 0.31 | 151 | 50.9 | 46500 | 799 | 86.5 | 23.5 | 0.682 | 155 |
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| SU001SA | 31.25 | 51.9 | 0.211 | 74400 | 33.4 | 0.545 | 139 | 59.4 | 42600 | 683 | 82.2 | 27.5 | 0.64 | 188 |
| SU001SA | 41.25 | 50.6 | 0.252 | 74300 | 37.5 | 0.381 | 138 | 52.4 | 45300 | 530 | 82.3 | 21.7 | 0.445 | 147 |
| SU001SA | 61.25 | 47.5 | 0.232 | 90400 | 24 | 0.219 | 192 | 50 | 52000 | 824 | 106 | 19.6 | 0.342 | 123 |
| SU001SA | 81.25 | 49.2 | 0.197 | 90400 | 22.4 | 0.273 | 151 | 63.8 | 49800 | 959 | 94.8 | 24.2 | 0.47 | 121 |
| SU001SA | 101.25 | 73.5 | 0.0987 | 62400 | 7.64 | 0.0389 | 205 | 14.4 | 43000 | 707 | 82.1 | 7.59 | ND | 80.9 |
| SU001SA | 121.25 | 50.9 | 0.19 | 95100 | 18 | 0.22 | 187 | 37.3 | 47700 | 777 | 102 | 18.3 | 0.28 | 98.5 |
| SU001SA | 151.25 | 45.6 | 0.28 | 105000 | 18.7 | 0.282 | 175 | 70.2 | 55700 | 1040 | 102 | 27.9 | 0.533 | 114 |
| SU002SA | 6.25 | 64.7 | 0.108 | 79600 | 7.64 | 0.126 | 155 | 20.8 | 43100 | 755 | 98.7 | 11.6 | 0.197 | 90.5 |
| SU002SA | 11.25 | 79.4 | 0.121 | 63200 | 6.5 | 0.0931 | 140 | 14.2 | 35500 | 671 | 79.7 | 9.67 | ND | 65.7 |
| SU002SA | 23.75 | 84.8 | 0.121 | 60700 | 6.33 | 0.0966 | 182 | 15.7 | 36500 | 622 | 75.4 | 10 | ND | 70.9 |
| SU002SA | 31.25 | 60 | 0.326 | 64400 | 25 | 0.632 | 119 | 57.3 | 36400 | 588 | 82.4 | 29.7 | 0.505 | 117 |
| SU002SA | 41.25 | 69.6 | 0.117 | 67400 | 9.14 | 0.149 | 126 | 23.6 | 32900 | 438 | 92.1 | 9.73 | 0.309 | 71.3 |
| SU002SA | 61.25 | 79.1 | 0.137 | 61400 | 5.85 | 0.113 | 133 | 13.5 | 32900 | 568 | 75.3 | 9.47 | ND | 76.3 |
| SU002SA | 71.25 | 74.5 | 0.121 | 66400 | 7.77 | 0.23 | 105 | 21.1 | 33800 | 551 | 78.8 | 14 | ND | 84.3 |
| SU002SA | 81.25 | 54 | 0.453 | 83800 | 24 | 0.695 | 153 | 73 | 48600 | 1030 | 108 | 37.3 | 0.542 | 160 |
| SU002SA | 91.25 | 63.4 | 0.135 | 80400 | 11 | 0.226 | 129 | 24.7 | 40700 | 588 | 96.5 | 13.6 | ND | 95.8 |
| SU002SA | 101.25 | 54.5 | 0.205 | 73800 | 16.4 | 0.318 | 138 | 36.4 | 39600 | 632 | 92.6 | 16.6 | 0.303 | 107 |

Table B-2. Raw Data for Mercury and Sediment Quality Analysis

| StationCode | Depth | Mercury ( $\mathrm{mg} / \mathrm{kg}$ ) | \% Moisture | \% Clay < $4 \mu \mathrm{~m}$ | \% Silt 4-63 $\mu \mathrm{m}$ | $\begin{gathered} \text { \% Sand 63- } \\ 2000 \mu \mathrm{~m} \end{gathered}$ | \% Total <br> Nitrogen | \% Organic <br> Carbon (TOC) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CB Damon Slough | 3.75 | 0.533 | 73.1 | 7.4 | 49.1 | 43.6 | 0.95 | 15.33 |
| CB Damon Slough | 8.75 | 0.384 | 78.6 | 5.5 | 49.1 | 45.4 | 0.93 | 12.64 |
| CB Damon Slough | 13.75 | 0.572 | 62.5 | 13.5 | 55.7 | 30.8 | 0.39 | 5.62 |
| CB Damon Slough | 18.75 | 3.14 | 76.2 | 5.2 | 40.1 | 54.7 | 0.75 | 11.23 |
| CB Damon Slough | 23.75 | 1.44 | 64.1 | 15.4 | 51.1 | 33.5 | 0.44 | 6.34 |
| CB Damon Slough | 28.75 | 0.193 | 50.3 | 25.5 | 51.3 | 23.2 | 0.32 | 3.55 |
| CB Damon Slough | 38.75 | 0.071 | 48.7 | 18.5 | 51.2 | 30.3 | 0.28 | 2.96 |
| CB Damon Slough | 48.75 | 0.016 | 62.2 | 9.1 | 34.8 | 56 | 0.41 | 4.51 |
| CB Damon Slough | 58.75 | 0.019 | 58.6 | 8.2 | 33.1 | 58.7 | 0.4 | 3.66 |
| CB Damon Slough | 68.75 | 0.023 | 58.5 | 10.7 | 38.1 | 51.2 | 0.37 | 3.4 |
| CB001S | 6.25 | 0.312 | 40.2 | 25 | 60.8 | 14.2 | 0.1 | 1.2 |
| CB001S | 11.25 | 0.441 | 40.7 | 24.9 | 64.5 | 10.7 | 0.11 | 1.37 |
| CB001S | 21.25 | 0.347 | 39.5 | 23.7 | 53.3 | 23 | 0.08 | 1.37 |
| CB001S | 31.25 | 0.365 | 37 | 24.1 | 52.7 | 23.1 | 0.08 | 0.98 |
| CB001S | 46.25 | 0.302 | 39.2 | 23.1 | 49.6 | 27.3 | 0.08 | 0.88 |
| CB001S | 61.25 | 0.232 | 36.4 | 24.1 | 54 | 21.8 | 0.09 | 0.92 |
| CB001S | 68.75 | 0.13 | 38.5 | 22.5 | 53.3 | 24.2 | 0.11 | 1.07 |
| CB001S | 81.25 | 0.097 | 39.4 | 19.4 | 54.3 | 26.3 | 0.11 | 1.14 |
| CB001S | 101.25 | 0.045 | 38.9 | 20.9 | 56.6 | 22.5 | 0.12 | 1.37 |
| CB001S | 121.25 | 0.058 | 40.2 | 22.9 | 54.6 | 22.5 | 0.12 | 1.38 |
| CB002S | 6.25 | 0.249 | 42.8 | 23.8 | 67.7 | 8.4 | 0.13 | 1.31 |
| CB002S | 11.25 | 0.293 | 43.7 | 26.2 | 63.4 | 10.4 | 0.13 | 1.24 |
| CB002S | 23.75 | 0.434 | 49.2 | 29.1 | 64.3 | 6.6 | 0.11 | 1.15 |
| CB002S | 23.75 | 0.434 | 49.2 | 29.1 | 64.3 | 6.6 | 0.11 | 1.15 |
| CB002S | 31.25 | 0.393 | 42.9 | 27.6 | 63.5 | 8.9 | 0.11 | 1.34 |
| CB002S | 41.25 | 0.304 | 49 | 29.5 | 64.6 | 6 | 0.09 | 0.95 |
| CB002S | 51.25 | 0.246 | 42.9 | 27 | 66.1 | 6.9 | 0.1 | 1.19 |
| CB002S | 61.25 | 0.05 | 44.4 | 21.7 | 69.5 | 8.8 | 0.13 | 1.3 |
| CB002S | 71.25 | 0.044 | 48 | 24.6 | 70.3 | 5.2 | 0.13 | 1.28 |
| CB002S | 78.75 | 0.043 | 46.9 | 24.2 | 72.7 | 3.1 | 0.13 | 1.29 |
| CB002S | 78.75 | 0.043 | 46.9 | 24.2 | 72.7 | 3.1 | 0.13 | 1.29 |
| CB002S | 101.25 | 0.044 | 50.3 | 25.4 | 74.6 | 0 | 0.13 | 1.19 |
| CB006SA | 6.25 | 0.283 | 42.9 | 31.6 | 59.4 | 9 | 0.1 | 1.74 |
| CB006SA | 11.25 | 0.207 | 43.4 | 31.8 | 60 | 8.2 | 0.08 | 1.75 |
| CB006SA | 21.25 | 0.309 | 54.4 | 24.6 | 59.9 | 15.5 | 0.11 | 1.9 |
| CB006SA | 31.25 | 0.132 | 43.4 | 29.1 | 58.9 | 12 | 0.09 | 1.84 |
| CB006SA | 41.25 | 0.184 | 52.3 | 25.2 | 60.6 | 14.2 | 0.11 | 1.97 |
| CB006SA | 51.25 | 0.118 | 57.6 | 15.2 | 44.5 | 40.3 | 0.1 | 2.27 |
| CB006SA | 61.25 | 0.045 | 45.3 | 21 | 52.5 | 26.5 | 0.08 | 1.77 |
| CB006SA | 71.25 | 0.036 | 42.1 | 24.7 | 64.8 | 10.5 | 0.08 | 1.15 |
| CB006SA | 81.25 | 0.024 | 32.2 | 16.9 | 41.9 | 41.1 | 0.06 | 1.22 |
| CB006SA | 101.25 | 0.027 | 35.9 | 20.7 | 49.4 | 29.9 | 0.09 | 1.58 |
| LSB Alviso Slough | 3.75 | 0.39 | 54.7 | 24.6 | 61.1 | 14.4 | 0.34 | 3.8 |
| LSB Alviso Slough | 13.75 | 0.789 | 50.5 | 33.2 | 58.1 | 8.6 | 0.23 | 2.54 |
| LSB Alviso Slough | 23.75 | 0.482 | 51.4 | 35 | 56.7 | 8.3 | 0.19 | 2.2 |
| LSB Alviso Slough | 38.75 | 0.515 | 47.3 | 28.6 | 60.9 | 10.5 | 0.18 | 1.99 |
| LSB Alviso Slough | 58.75 | 0.769 | 52.9 | 34.5 | 61 | 4.5 | 0.18 | 1.88 |
| LSB Alviso Slough | 78.75 | 0.67 | 49.7 | 33.3 | 60.3 | 6.4 | 0.2 | 1.85 |
| LSB Alviso Slough | 98.75 | 0.628 | 50.2 | 37.8 | 61.9 | 0.3 | 0.16 | 1.49 |
| LSB Alviso Slough | 118.75 | 1 | 50.3 | 32.1 | 63.5 | 4.4 | 0.15 | 1.49 |
| LSB Alviso Slough | 138.75 | 0.864 | 50.5 | 39 | 60.9 | 0.1 | 0.15 | 1.42 |
| LSB Alviso Slough | 163.75 | 0.305 | 54.9 | 14.4 | 40.7 | 44.9 | 0.34 | 3.27 |
| LSB Coyote Creek | 3.75 | 0.329 | 49.2 | 36.8 | 54.7 | 8.4 | 0.21 | 2.28 |
| LSB Coyote Creek | 13.75 | 0.315 | 58 | 28.2 | 54.4 | 17.4 | 0.25 | 3.06 |
| LSB Coyote Creek | 23.75 | 0.478 | 59 | 29.3 | 53.6 | 17.1 | 0.23 | 2.83 |
| LSB Coyote Creek | 38.75 | 0.658 | 49.5 | 29.6 | 68.7 | 1.7 | 0.19 | 1.84 |
| LSB Coyote Creek | 58.75 | 0.469 | 50.7 | 29.9 | 69.9 | 0.2 | 0.2 | 2.12 |
| LSB Coyote Creek | 78.75 | 3.22 | 53.5 | 23.9 | 62 | 14.1 | 0.25 | 2.66 |
| LSB Coyote Creek | 98.75 | 0.719 | 52.3 | 26.6 | 60.2 | 13.1 | 0.22 | 1.95 |
| LSB Coyote Creek | 118.75 | 0.6195 | 48.4 | 33.1 | 57.3 | 9.7 | 0.21 | 2.33 |
| LSB Coyote Creek | 138.75 | 0.511 | 40.6 | 32.8 | 59 | 8.3 | 0.2 | 2.22 |
| LSB Coyote Creek | 163.75 | 0.657 | 43.3 | 35.1 | 60.2 | 4.7 | 0.17 | 1.63 |
| LSB001SA | 11.25 | 0.28 | 55.3 | 25.7 | 73.9 | 0.4 | 0.14 | 1.62 |
| LSB001SA | 21.25 | 0.302 | 40.6 | 28.3 | 60.3 | 11.3 | 0.12 | 1.55 |
| LSB001SA | 41.25 | 0.311 | 44.8 | 24.7 | 67.8 | 7.4 | 0.12 | 1.27 |
| LSB001SA | 61.25 | 0.349 | 42.4 | 25.7 | 68 | 6.4 | 0.12 | 1.33 |
| LSB001SA | 71.25 | 0.334 | 43.8 | 28.6 | 67.1 | 4.3 | 0.13 | 1.31 |
| LSB001SA | 81.25 | 0.369 | 45.4 | 27.1 | 72.4 | 0.5 | 0.13 | 1.39 |
| LSB001SA | 91.25 | 0.43 | 43.7 | 24.5 | 63.9 | 11.5 | 0.11 | 1.72 |
| LSB001SA | 101.25 | 0.409 | 44.4 | 21.3 | 66 | 12.7 | 0.13 | 1.4 |
| LSB001SA | 121.25 | 0.479 | 43.9 | 23.2 | 55.6 | 21.2 | 0.11 | 1.6 |
| LSB001SA | 143.75 | 0.383 | 42.2 | 25 | 61.9 | 13.1 | 0.15 | 1.34 |
| LSB002S | 11.25 | 0.266 | 54.8 | 26.9 | 72.5 | 0.6 | 0.14 | 1.31 |
| LSB002S | 31.25 | 0.405 | 44.2 | 29.6 | 64.9 | 5.5 | 0.15 | 1.57 |


| LSB002S | 46.25 | 0.144 | 46.9 | 23.1 | 62.5 | 14.4 | 0.13 | 1.85 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| LSB002S | 61.25 | 0.044 | 39.4 | 13.9 | 38.4 | 47.8 | 0.07 | 1.31 |
| LSB002S | 76.25 | 0.031 | 34.8 | 14.3 | 37.5 | 48.2 | 0.08 | 1.47 |
| LSB002S | 91.25 | 0.032 | 45.9 | 20.3 | 56.9 | 22.8 | 0.12 | 1.91 |
| LSB002S | 106.25 | 0.047 | 42.1 | 17.1 | 45.8 | 37.1 | 0.08 | 1.4 |
| LSB002S | 121.25 | 0.035 | 35.9 | 15.4 | 37.7 | 47 | 0.06 | 1.22 |
| LSB002S | 141.25 | 0.044 | 41 | 21.5 | 53 | 25.5 | 0.11 | 1.81 |
| LSB002S | 158.75 | 0.028 | 31.7 | 17.7 | 37.9 | 44.5 | 0.07 | 1.65 |
| SB Greco Island | 3.75 | 0.253 | 55.2 | 15.6 | 62.8 | 21.6 | 0.42 | 4.9 |
| SB Greco Island | 13.75 | 0.277 | 52.8 | 23 | 58 | 19 | 0.3 | 3.03 |
| SB Greco Island | 23.75 | 0.239 | 61.3 | 12.4 | 55.8 | 31.8 | 0.38 | 4.77 |
| SB Greco Island | 33.75 | 0.279 | 55.7 | 13.1 | 59.7 | 27.2 | 0.31 | 3.93 |
| SB Greco Island | 43.75 | 0.4 | 55.5 | 28.2 | 65.3 | 6.6 | 0.16 | 1.46 |
| SB Greco Island | 53.75 | 0.364 | 45.4 | 34.6 | 60.8 | 4.6 | 0.16 | 1.45 |
| SB Greco Island | 63.75 | 0.056 | 62.8 | 13.3 | 50 | 36.7 | 0.38 | 4.13 |
| SB Greco Island | 73.75 | 0.032 | 60.9 | 10.2 | 45.1 | 44.7 | 0.35 | 3.64 |
| SB Greco Island | 83.75 | 0.033 | 51.6 | 23.1 | 60.4 | 16.5 | 0.23 | 2.2 |
| SB Greco Island | 93.75 | 0.042 | 64.2 | 22.5 | 63.7 | 13.8 | 0.22 | 1.94 |
| SB001S | 6.25 | 0.193 | 57.1 | 21.2 | 59.6 | 19.2 | 0.12 | 1.84 |
| SB001S | 11.25 | 0.271 | 62.9 | 25 | 57.2 | 17.8 | 0.12 | 1.91 |
| SB001S | 21.25 | 0.258 | 60.5 | 27.1 | 58.7 | 14.3 | 0.14 | 1.88 |
| SB001S | 31.25 | 0.023 | 33.6 | 20 | 61.4 | 18.5 | 0.1 | 1.52 |
| SB001S | 43.75 | 0.071 | 62.3 | 26.5 | 65.1 | 8.4 | 0.18 | 2.05 |
| SB001S | 43.75 | 0.071 | 62.3 | 26.5 | 65.1 | 8.4 | 0.18 | 2.05 |
| SB001S | 51.25 | 0.041 | 59.8 | 21.8 | 67 | 11.3 | 0.11 | 1.97 |
| SB001S | 61.25 | 0.03 | 54.7 | 22 | 67.6 | 10.4 | 0.12 | 1.78 |
| SB001S | 71.25 | 0.032 | 54.3 | 18.1 | 69.3 | 12.6 | 0.1 | 1.87 |
| SB001S | 81.25 | 0.024 | 47.4 | 17.1 | 65.6 | 17.3 | 0.1 | 1.96 |
| SB001S | 101.25 | 0.031 | 56 | 25.6 | 64.1 | 10.3 | 0.11 | 2.11 |
| SB002S | 6.25 | 0.55 | 42.2 | 24.5 | 54.9 | 20.5 | 0.12 | 1.31 |
| SB002S | 11.25 | 0.221 | 38.6 | 23.9 | 53 | 23.1 | 0.1 | 1.42 |
| SB002S | 21.25 | 0.043 | 32.4 | 17.8 | 40.6 | 41.6 | 0.07 | 0.96 |
| SB002S | 31.25 | 0.033 | 31.7 | 17.7 | 45.7 | 36.6 | 0.06 | 0.91 |
| SB002S | 51.25 | 0.032 | 27.1 | 12.3 | 35.6 | 52.2 | 0.05 | 0.65 |
| SB002S | 61.25 | 0.041 | 38.8 | 22.7 | 61.1 | 16.2 | 0.08 | 0.89 |
| SB002S | 71.25 | 0.037 | 30 | 13.8 | 35 | 51.1 | 0.06 | 0.82 |
| SB002S | 81.25 | 0.039 | 34.4 | 16.8 | 52.8 | 30.4 | 0.07 | 1.16 |
| SB002S | 101.25 | 0.043 | 38.5 | 19.6 | 56.2 | 24.2 | 0.09 | 1.22 |
| SB002S | 121.25 | 0.046 | 40.6 | 20.9 | 59.8 | 19.2 | 0.1 | 1.22 |
| SPB Wildcat Marsh | 3.75 | 0.158 | 57.6 | 20.6 | 60.3 | 19.1 | 0.39 | 4.82 |
| SPB Wildcat Marsh | 8.75 | 0.282 | 66.6 | 16.2 | 58.4 | 25.4 | 0.44 | 6.34 |
| SPB Wildcat Marsh | 13.75 | 0.32 | 72.4 | 7.3 | 46.1 | 46.5 | 0.85 | 11.6 |
| SPB Wildcat Marsh | 18.75 | 0.78 | 77.3 | 6.1 | 40.2 | 53.7 | 0.81 | 10.54 |
| SPB Wildcat Marsh | 23.75 | 0.712 | 71.8 | 9.4 | 47.9 | 42.7 | 0.51 | 9.14 |
| SPB Wildcat Marsh | 28.75 | 0.361 | 65.5 | 20.6 | 53.9 | 25.5 | 0.3 | 5.18 |
| SPB Wildcat Marsh | 38.75 | 0.265 | 59.2 | 19.8 | 46.4 | 33.8 | 0.21 | 3.44 |
| SPB Wildcat Marsh | 48.75 | 0.18 | 52 | 25.2 | 53.9 | 20.9 | 0.16 | 2.47 |
| SPB Wildcat Marsh | 58.75 | 0.112 | 54.4 | 25.7 | 52 | 22.4 | 0.2 | 3.07 |
| SPB Wildcat Marsh | 68.75 | 0.035 | 70 | 14.8 | 50.8 | 34.4 | 0.32 | 5.51 |
| SPB001S | 8.75 | 0.419 | 49.3 | 25.1 | 68.3 | 6.6 | 0.11 | 1.33 |
| SPB001S | 8.75 | 0.419 | 49.3 | 25.1 | 68.3 | 6.6 | 0.11 | 1.33 |
| SPB001S | 16.25 | 0.329 | 39.5 | 26.2 | 62.8 | 11 | 0.08 | 1.14 |
| SPB001S | 21.25 | 0.342 | 39.9 | 27.2 | 62.6 | 10.2 | 0.08 | 1.05 |
| SPB001S | 31.25 | 0.327 | 43.8 | 22.3 | 64.2 | 13.5 | 0.09 | 1.2 |
| SPB001S | 41.25 | 0.327 | 45.2 | 23.3 | 68.7 | 8 | 0.07 | 0.84 |
| SPB001S | 61.25 | 0.284 | 44.5 | 30.5 | 63.7 | 5.8 | 0.05 | 0.65 |
| SPB001S | 76.25 | 0.278 | 46 | 25.6 | 66.2 | 8.2 | 0.06 | 0.68 |
| SPB001S | 101.25 | 0.274 | 44.2 | 30.9 | 64.8 | 4.3 | 0.07 | 1.01 |
| SPB001S | 121.25 | 0.297 | 44.5 | 30.4 | 60.2 | 9.4 | 0.09 | 1.14 |
| SPB001S | 151.25 | 0.048 | 46.8 | 19.2 | 71.1 | 9.7 | 0.14 | 1.43 |
| SPB002S | 6.25 | 0.3 | 46.4 | 17 | 56.5 | 26.5 | 0.06 | 1.06 |
| SPB002S | 11.25 | 0.2935 | 50.5 | 25.3 | 66.3 | 8.5 | 0.06 | 0.88 |
| SPB002S | 23.75 | 0.29 | 50.9 | 23.2 | 65.3 | 11.5 | 0.06 | 0.97 |
| SPB002S | 23.75 | 0.29 | 50.9 | 23.2 | 65.3 | 11.5 | 0.06 | 0.97 |
| SPB002S | 31.25 | 0.303 | 49.8 | 28 | 65 | 7 | 0.06 | 0.76 |
| SPB002S | 41.25 | 0.283 | 43.3 | 23.8 | 58.5 | 17.7 | 0.06 | 1.01 |
| SPB002S | 61.25 | 0.282 | 48.4 | 24 | 63.8 | 12.2 | 0.1 | 0.98 |
| SPB002S | 81.25 | 0.295 | 47.7 | 28.6 | 64.5 | 6.8 | 0.11 | 1.13 |
| SPB002S | 101.25 | 0.222 | 45.2 | 28.5 | 61.8 | 9.7 | 0.12 | 1.26 |
| SPB002S | 121.25 | 0.156 | 52.2 | 24.2 | 64.1 | 11.7 | 0.13 | 1.31 |
| SPB002S | 151.25 | 0.043 | 47.4 | 25.2 | 69.4 | 5.5 | 0.16 | 1.73 |
| SU Point Edith | 3.75 | 0.182 | 82 | 4 | 39.8 | 56.1 | 1.31 | 17.87 |
| SU Point Edith | 8.75 | 0.498 | 73.7 | 5.7 | 34.9 | 59.4 | 1.08 | 15.83 |
| SU Point Edith | 13.75 | 0.622 | 63.4 | 25 | 54 | 21 | 0.32 | 4.12 |
| SU Point Edith | 18.75 | 0.465 | 64 | 27.5 | 47.8 | 24.7 | 0.35 | 4.6 |
| SU Point Edith | 23.75 | 0.334 | 42.7 | 28.8 | 53.9 | 17.4 | 0.15 | 1.92 |
| SU Point Edith | 28.75 | 0.234 | 50.2 | 26.3 | 49.5 | 24.2 | 0.18 | 2.27 |


| ISU Point Edith | 38.75 | 0.063 | 64.3 | 17.7 | 43.4 | 38.9 | 0.29 | 3.54 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| SU Point Edith | 48.75 | 0.026 | 68.2 | 12.1 | 46.9 | 40.9 | 0.44 | 6.27 |
| SU Point Edith | 58.75 | 0.031 | 72.8 | 8.4 | 35.2 | 56.4 | 0.56 | 8.45 |
| SU Point Edith | 68.75 | 0.019 | 72.8 | 8.6 | 34 | 57.3 | 0.46 | 5.56 |
| SU001SA | 6.25 | 0.15 | 33.3 | 11.2 | 34.2 | 54.6 | 0.03 | 0.52 |
| SU001SA | 16.25 | 0.268 | 39.7 | 15.5 | 51.5 | 33.1 | 0.06 | 0.83 |
| SU001SA | 21.25 | 0.225 | 34.7 | 13.3 | 41.3 | 45.4 | 0.05 | 0.65 |
| SU001SA | 31.25 | 0.372 | 48.1 | 15.6 | 48.1 | 36.2 | 0.08 | 1.09 |
| SU001SA | 41.25 | 0.263 | 40.8 | 13.3 | 41.3 | 45.4 | 0.07 | 1.07 |
| SU001SA | 61.25 | 0.313 | 48.2 | 22.8 | 56.4 | 20.8 | 0.09 | 1.26 |
| SU001SA | 81.25 | 0.263 | 45.1 | 18.5 | 57.1 | 24.4 | 0.09 | 1.31 |
| SU001SA | 101.25 | 0.229 | 40.5 | 15.1 | 44.1 | 40.8 | 0.09 | 1.43 |
| SU001SA | 121.25 | 0.175 | 33.9 | 14.2 | 39.7 | 46.2 | 0.07 | 0.99 |
| SU001SA | 151.25 | 0.384 | 46.1 | 31.2 | 64.6 | 4.2 | 0.14 | 1.36 |
| SU002SA | 6.25 | 0.024 | 14.3 | 0.7 | 1.4 | 97.9 | 0.01 | 0.07 |
| SU002SA | 11.25 | 0.021 | 16.3 | 0.7 | 1.6 | 97.6 | 0.01 | 0.08 |
| SU002SA | 23.75 | 0.077 | 22.3 | 4.6 | 8.9 | 86.6 | 0.03 | 0.42 |
| SU002SA | 23.75 | 0.077 | 22.3 | 4.6 | 8.9 | 86.6 | 0.03 | 0.42 |
| SU002SA | 31.25 | 0.297 | 42.2 | 11.5 | 32 | 56.5 | 0.11 | 1.85 |
| SU002SA | 41.25 | 0.04 | 25.9 | 12 | 29 | 59 | 0.05 | 0.62 |
| SU002SA | 61.25 | 0.03 | 21.4 | 1 | 2.4 | 96.6 | 0.01 | 0.06 |
| SU002SA | 71.25 | 0.235 | 30.6 | 13.4 | 33 | 53.6 | 0.07 | 0.96 |
| SU002SA | 81.25 | 0.4165 | 42.2 | 18.1 | 49.6 | 32.3 | 0.13 | 1.89 |
| SU002SA | 91.25 | 0.092 | 22.5 | 5.7 | 14.7 | 79.6 | 0.03 | 0.33 |
| SU002SA | 101.25 | 0.226 | 40.6 | 7.4 | 27.3 | 65.3 | 0.07 | 1.54 |


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| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ${ }^{10.3}$ |  |  |  |  |  |  |  |  |  |  |  |  |
|  | cist | 20， |  |  |  |  |  |  |  | coicle |  |  |  |  |  |  |  |  |  |  |  | ， |  |  |  | 1895 |  |  |  |  |  |  |  |  | 5017 | 0．009 | 203 |  |  |  |  |  |
|  | ${ }^{58} 8$ |  |  |  |  |  |  |  |  |  | 0．0006 |  |  |  |  |  | ¢0．0．054 |  | － 0.00555 |  | coiosi4 |  | 0．0094 | ${ }^{0} 0.0054$ | －0．0087 |  | ${ }^{0} 0.002727$ |  |  | 2038 |  |  |  | 0．005 |  | －0， 0 |  | 20045 |  |  |  |  |
|  | ${ }_{\substack{68,75 \\ 6.25}}$ |  |  |  | ${ }_{0}^{0} 0$ |  |  |  |  |  |  |  |  |  |  |  | O．0．491 |  |  |  | －0．0484 |  | （12 |  | 第．028 |  | ） | － | ${ }_{0}^{0.543}$ | cios | 2043 | ${ }_{0}^{0.136}$ | 0.9 |  | 0．0199 | ${ }_{0}^{0.988}$ | 0.302 | $\bigcirc$ | ${ }_{0}^{0} 235$ | ${ }^{\circ}$ | 0.033 | ${ }_{0}^{0.132}$ |
|  |  |  | ${ }^{0.0992}$ |  | 0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ${ }_{\substack{0.050 \\ 0.050}}^{\substack{080}}$ |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ${ }^{\circ}$ |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  | －0， 0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | ${ }^{0} 0.084$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | ® |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | ${ }^{0.001}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0．098 |
|  |  | ${ }_{\substack{3.59 \\ 209}}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  | lot 0.121 |  | ${ }^{0} 0.1074$ | 0．11 |  | 1196 |  |  |  | ， 316 |  |  | （19 |  |  |  |  |  |  |  |  |  |  |  |  | \％ |
|  |  | ${ }_{\substack{0.337 \\ 0.15}}^{\substack{0}}$ | coiole |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0．0．077 |  |  |  |  |  |  |  |  |  |  | coin |  |  |  |  |  |  |  |  |  |  |  |
|  |  | coind |  |  |  |  |  |  |  |  |  | $\bigcirc$ |  |  |  |  |  |  |  |  |  |  |  |  |  | 20020 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  | ${ }^{0.1022}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | ${ }_{30}^{27}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | ${ }_{4}^{362}$ | －0．119 | 足．108 |  |  | ${ }^{0.142}$ | ${ }_{\substack{0.598 \\ 0.623}}^{\substack{0}}$ |  | ${ }^{0.205} 0$ |  | ${ }_{0}^{0.146}$ |  |  |  |  | － |  | 207 |  |  |  |  |  |  |  |  | 234 |  | － |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | ${ }_{23,2}^{23,2}$ | 20．028 |  | ${ }_{\text {a }}^{0.594}$ |  | 20， 0 | ${ }_{\substack{0.39 \\ 0.39}}^{0 .}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 227 |  |  |  |  |  |  |  |  |  |  |  | 1018 |
|  |  |  |  |  |  |  |  |  | ${ }^{\substack{0.3011 \\ 0.341}}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ${ }^{\text {0．0．51 }}$ |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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|  |  |  | cois |  | ${ }_{\substack{439 \\ 238}}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 迷 |  |  |  |  |  |  |  |
|  |  | 2,2 | 0．03022 |  | ${ }_{0}^{0.029}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | 1194 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | 0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | ${ }_{\substack{0,28 \\ 15}}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | ${ }^{29}$ | 0.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | \％ 72 |  | 0.03 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | ${ }_{202}^{402}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | cosios | ${ }^{0.003388}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | 0 | $\bigcirc$ |  |  |  |  |  |  |  |  | 0.019 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | 000 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | N005s |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | ${ }_{0}^{7.39}$ |  |  |  |  |  |  |  |  |  | ${ }^{0.025}$ |  | （0．028 |  |  |  |  | 员0．184 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | 0 |  |  |  |  |  |  |  |  |  | ${ }_{\text {dor }}^{0.00298}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0．0298 |  |  |  |  |  |  |  |  |  | 50774 |  |  | 00， |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | no | No |
| 边 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |



\begin{tabular}{|c|c|c|c|c|c|c|c|c|c|c|c|c|c|c|c|c|c|c|c|c|c|}
\hline StationCode \& \({ }_{\substack{\text { Depth } \\ \text { cm }}}^{\substack{\text { che }}}\) \& Sum of DDTs
\(\mu \mathrm{glkg}\) \& \[
\begin{gathered}
\mathrm{dDD}\left(0, \mathrm{p}^{\prime}\right) \\
\mathrm{\mu g} / \mathrm{kg}
\end{gathered}
\] \&  \&  \& \[
\begin{gathered}
\text { DDD(p.p') } \\
\mu g(k g)
\end{gathered}
\] \&  \&  \& \[
\begin{gathered}
\text { Sum of } \\
\text { Chlordanes } \\
\text { Lg } \mathrm{Kg}
\end{gathered}
\] \&  \& \[
\begin{aligned}
\& \text { Chlordane, } \\
\& \text { gamma. } \\
\& \text { gql/kg }
\end{aligned}
\] \& Nonachlor, cis-
\(\mu \mathrm{g} / \mathrm{Kg}\) \& Nonachlor, trans
HgKg \& \(\underbrace{\text { Hg/Kg }}_{\text {Heptachlor }}\) \& \[
\begin{gathered}
\begin{array}{c}
\text { Heptachlor } \\
\text { epoxide } \\
\text { Lggkg }
\end{array} \\
\hline
\end{gathered}
\] \& Oxychlordane \(\mu \mathrm{g} / \mathrm{Kg}\) \& \(\underset{\mu g \mathrm{Kg}}{\mathrm{Sum}}\) \& \[
\begin{gathered}
\text { HCH, alphana } \\
\mathrm{Hg} / \mathrm{Kg}
\end{gathered}
\] \&  \&  \& \[
\underset{\mathrm{Hg} / \mathrm{Kg}}{\mathrm{HCHa}}
\] \\
\hline LSB Alviso Slough \& \({ }^{3.75}\) \& 20.38 \& 0.369 \& 0.0945 \& 0.118 \& \({ }^{1.3}\) \& 2.22 \& 0.599 \& 1.26 \& \({ }^{0.324}\) \& 0 \& 0.309 \& 0.484 \& 0.00284 \& \({ }^{0.0461}\) \& 0.096 \& NRS \& 0 \& \({ }^{0.0168}\) \& \({ }^{0.0029}\) \& \({ }^{0.0088}\) \\
\hline LSB Aviso Slough \& 13.75 \& 9.67 \& 0.915 \& 0.214 \& 0.114 \& 2.83 \& 4.96 \& 0.635 \& 2.18 \& 0.719 \& Q \& 0.51 \& 0.87 \& \({ }^{0.00426}\) \& \({ }^{0.0333}\) \& \({ }^{0.0472}\) \& NRS \& Q \& \({ }^{0.0212}\) \& 0.00487 \& 0.00995 \\
\hline LSB Aviso Slough \& \({ }^{23.75}\) \& 5.62 \& \({ }^{0.625}\) \& \({ }^{0.142}\) \& \({ }^{0.0402}\) \& 1.6 \& \({ }^{2.98}\) \& 0.23 \& 1.31 \& 0.459 \& Q \& \({ }^{0.337}\) \& 0.482 \& \({ }^{0.00223}\) \& \({ }^{0.0139}\) \& \({ }^{0.0127}\) \& NRS \& Q \& \({ }^{0.0159}\) \& 0.00314 \& \({ }^{0.0126}\) \\
\hline LSB Aviso Slough \& 38.75 \& 12.1 \& 1.86 \& 0.336 \& 0.154 \& 3.42 \& 5.59 \& 0.751 \& \({ }^{5.1}\) \& 1.95 \& Q \& 1.18 \& 1.92 \& 0.00479 \& \({ }^{0.0229}\) \& \({ }^{0.0206}\) \& NRS \& Q \& \({ }^{0.0167}\) \& 0.00473 \& \({ }^{0.0262}\) \\
\hline  \& \begin{tabular}{l}
58.75 \\
78.75 \\
\hline
\end{tabular} \& 16.8
14.9 \& 1.73
1.01
1 \& \({ }_{0}^{0.506}\) \& 0.131
0.0774 \& \begin{tabular}{l}
3.98 \\
3.36 \\
\hline
\end{tabular} \& \({ }_{9.49}^{9.77}\) \& -0.649 \& 7.35
4.14 \& \begin{tabular}{l}
2.68 \\
1.39 \\
\hline 1.4
\end{tabular} \& \(\stackrel{\square}{\text { a }}\) \& \begin{tabular}{l}
2.17 \\
1.65 \\
\hline 1.12
\end{tabular} \& \begin{tabular}{l}
2.47 \\
1.08 \\
\hline
\end{tabular} \& 0.00832
0.00689 \& - 0.0165 \& 0.00961
0.00571
0.0 \& NRS
NRS \& \(\stackrel{\square}{Q}\) \& \({ }_{0}^{0.0185}\) \& \({ }_{0.0303}^{0.0157}\) \& 0,0.0254 \\
\hline LSB Aviso Slough \& -98.75 \& \({ }^{14.9}\) \& 1.89 \& \({ }_{1} 1.36\) \& \({ }_{0}^{0.101}\) \& \({ }_{10.6}\) \& 19.4 \& 0.691 \& 2.52 \& 0.89 \& \({ }^{\text {a }}\) \& 1.12 \& 0.487 \& \({ }_{0}^{0.00972}\) \& \({ }_{0} 0.00848\) \& \({ }_{0} 0.00306\) \& NRS \& Q \& \({ }_{0}^{0.0208}\) \& \({ }_{0.0446}^{0.037}\) \& \({ }_{0}^{0.0224}\) \\
\hline LSB Aviso Slough \& 118.75 \& 17.7 \& 1.02 \& 0.677 \& \({ }_{0}^{0.0708}\) \& 5.41 \& 10.1 \& 0.439 \& 1.28 \& 0.389 \& Q \& 0.684 \& 0.194 \& \({ }^{0.00527}\) \& 0.00645 \& 0.00161 \& NRS \& Q \& \({ }_{0}^{0.0172}\) \& \({ }_{0}^{0.0377}\) \& \({ }_{0}^{0.0209}\) \\
\hline LSB Aviso Slough \& 1388.75 \& 52.9 \& 3.38 \& 1.63 \& 0.343 \& 23.8 \& 22.3 \& 1.43 \& 0.687 \& 0.339 \& Q \& 0.345 \& \({ }^{0.0933}\) \& 0.0022 \& 0.00496 \& 0.00203 \& NRS \& Q \& 0.0255 \& 0.0437 \& \({ }^{0.0233}\) \\
\hline LSB Aviso Slough \& 163.75 \& 3.13 \& 0.462 \& 0.0577 \& Q \& 1.43 \& 1.15 \& 0.0279 \& 0.043 \& 0.0217 \& Q \& 0.00948 \& 0.0108 \& Q \& 0.00105 \& ND \& NRS \& Q \& 0.00751 \& 0.00502 \& 0.00491 \\
\hline CB001s \& \({ }_{6} 6.25\) \& 4.29 \& 0.523 \& 0.121 \& Q \& 2.14 \& 1.35 \& 0.155 \& 0.124 \& 0.0504 \& Q \& 0.0449 \& \({ }^{0.0275}\) \& a \& Q \& 0.000735 \& NRS \& Q \& 0.0102 \& \({ }^{0.0123}\) \& \({ }^{0.0056}\) \\
\hline CB001s \& 11.25 \& 4.49 \& 0.584 \& 0.158 \& \({ }^{0.0213}\) \& 2.34 \& 1.19 \& 0.201 \& 0.182 \& 0.0808 \& Q \& 0.0446 \& 0.027 \& . 0292 \& Q \& ND \& NRS \& Q \& 0.00465 \& 0.016 \& 0.0121 \\
\hline CB001s \& 21.25 \& 0.854 \& 0.105 \& 0.0282 \& Q \& 0.51 \& 0.179 \& 0.0319 \& 0.0158 \& 0.00713 \& Q \& 0.00451 \& 0.00411 \& Q \& Q \& ND \& NRS \& Q \& 0.00174 \& Q \& Q \\
\hline CB001s \& 31.25 \& 0.3 \& 0.0418 \& 0.0106 \& Q \& 0.16 \& \({ }^{0.0734}\) \& 0.0145 \& NRS \& 0.00348 \& Q \& 0.00123 \& Q \& Q \& Q \& ND \& NRS \& Q \& 0.000949 \& Q \& Q \\
\hline crions
croons
crols \& \({ }^{46.25}\) \& NRS \& \({ }_{0}\) \& \({ }^{0.0000911} \begin{aligned} \& 0.00519\end{aligned}\) \& Q \& Q \& 0.00263
0.00238
0 \& \({ }^{\circ}\) \& NRS \& \({ }^{\text {a }}\) \& Q \& \({ }_{0}\) \& Q \& \({ }^{\circ}\) \& \({ }^{\circ}\) \& \({ }_{\text {ND }}\) \& NRS \& \({ }^{\text {a }}\) \& -0.0017 \& \({ }^{\text {a }}\) \& \({ }^{\text {a }}\) \\
\hline cibous
ciouls \& 61.25 \& N.0276 \& \({ }_{0.00406}\) \& - 0.000519 \& \({ }_{0.004195}\) \& 0.00508 \& \({ }^{0.007745}\) \& 0.007085 \& \({ }_{0} 0.0156\) \& \({ }_{0} 0.0528\) \& \({ }^{\text {a }}\) \& 0.00131 \& 0.003425 \& 0.002113 \& 0.001545 \& \({ }^{\text {N00195 }}\) \& NRS \& Q \& ND \& ND \& 0.00251 \\
\hline \({ }^{\text {croons }}\) \& 81.25 \& 0.00779 \& - \& 0.0014 \& - \& 0.00316 \& 0.00323 \& Q \& NRS \& Q \& Q \& Q \& Q \& Q \& Q \& ND \& NRS \& Q \& \({ }^{0.00128}\) \& Q \& Q \\
\hline CB001s \& 101.25 \& NRS \& Q \& Q \& Q \& Q \& Q \& Q \& NRS \& Q \& Q \& Q \& Q \& Q \& Q \& Q \& NRS \& Q \& Q \& Q \& Q \\
\hline \({ }^{\text {croons }}\) \& \({ }^{121.25}\) \& 0.028 \& 0.00436 \& 0.0017 \& ND \& 0.00797 \& \({ }^{0.00808}\) \& 0.00586 \& \({ }^{0.0144}\) \& 0.00987 \& \({ }^{\circ}\) \& 0.00119 \& \({ }^{0.003333}\) \& ND \& ND \& \(\stackrel{\text { a }}{\text { a }}\) \& ND \& ND \& ND \& ND \& ND \\
\hline CBBo2s
CBO2S \& 6.25
11.25
18 \& \({ }_{4.3}^{4.4}\) \& \({ }_{0}^{0.497}\) \& \({ }_{0}^{0.1114}\) \& \({ }_{0}^{0.0323} 0\) \& \begin{tabular}{l}
1.85 \\
1.78 \\
\hline
\end{tabular} \& 1.75
1.71 \& 0.159
0.182 \& -0.242 \& \({ }_{0}^{0.00939}\) \& \({ }^{\text {Q }}\) \& \({ }_{0}^{0.0848}\) \& \({ }_{0}^{0.0 .0425}\) \& \({ }_{0.0}^{0} 0\) \& \({ }_{0.0117}^{0}\) \& - \(\begin{aligned} \& 0.004288 \\ \& 0.00657\end{aligned}\) \& NRS
NRS \& \({ }_{\text {Q }}\) \& \({ }_{0}^{0.0388}\) \& \({ }^{\text {a }}\) \& \({ }_{0}^{0.00101}\) \\
\hline CB002s \& 23.75 \& 1.13 \& 0.148 \& \({ }^{0.0357}\) \& 0.014 \& 0.416 \& 0.459 \& 0.0543 \& \({ }^{0.0737}\) \& \({ }^{0.0324}\) \& Q \& \({ }^{0.0221}\) \& \({ }^{0.0163}\) \& Q \& Q \& 0.0029 \& NRS \& Q \& Q \& a \& Q \\
\hline \({ }^{\text {croors }}\) \& \begin{tabular}{l}
31.25 \\
4125 \\
\hline
\end{tabular} \& \({ }^{0.751}\) \& \({ }^{0.0922}\) \& \({ }^{0.0232}\) \& \({ }^{\circ}\) \& \({ }^{0.3344}\) \& 0.22 \& 0.0311 \& NRS \& \({ }^{0.0108}\) \& a \& 0.00939 \& \({ }^{\circ}\) \& \({ }^{\circ}\) \& \({ }^{\circ}\) \& \({ }^{\circ}\) \& NRS \& \({ }^{\circ}\) \& Q \& \({ }^{\circ}\) \& \(\bigcirc\) \\
\hline (ckoors \& 41.25
51.25 \& \({ }_{0}^{0.04471}\) \& \({ }_{0.00468}\) \& \({ }_{0.00187}^{\text {Q }}\) \& \({ }^{\circ}\) \& \({ }_{0}^{0.0212}\) \& \({ }_{0}^{0.00231}\) \& \(\stackrel{0}{0.0124}\) \& N00672 \& 0.00309 \& \({ }_{Q}^{\text {a }}\) \& \({ }_{0.00126}\) \& \({ }_{0.00192}\) \& Q \& \({ }_{\square}^{\circ}\) \& \({ }_{0}^{\text {O.000447 }}\) \& NRS \& \({ }^{\text {Q }}\) \& \({ }_{Q}^{\text {a }}\) \& \({ }_{Q}^{\text {a }}\) \& \({ }_{0}^{\circ}\) \\
\hline CB002s \& 61.25 \& NRS \& Q \& Q \& Q \& , \& 0.0237 \& Q \& NRS \& Q \& Q \& - \& 0 \& a \& 0.00744 \& Q \& NRS \& Q \& \({ }^{0.0136}\) \& \({ }^{0.00973}\) \& 00853 \\
\hline CB002s \& \({ }^{71.25}\) \& NRS \& Q \& 0.000667 \& Q \& Q \& 0.00412 \& Q \& NRS \& 0.00252 \& Q \& Q \& 0.00156 \& Q \& Q \& ND \& NRS \& Q \& Q \& Q \& Q \\
\hline crions
CB022S \& \begin{tabular}{l}
78.75 \\
101.25 \\
\hline 1125
\end{tabular} \& NRS \& \({ }_{0}^{\circ}\) \& \({ }^{\circ}\) \& \({ }_{0}^{\circ}\) \& \({ }_{\square}^{\circ}\) \& \({ }_{0}^{0}\) \& \({ }_{\square}^{\circ}\) \& NRS
0.0372 \& 0.0077 \& \({ }^{\text {a }}\) \& ¢0.0772 \& \(\stackrel{0}{0.0068}\) \& \({ }_{0.00526}^{\text {Q }}\) \& O.00509 \& 0.0046
0 \& NRS
NRS \& \({ }^{\text {a }}\) \& \({ }^{\circ}\) \& \(\stackrel{Q}{Q}\) \& \(\stackrel{Q}{Q}\) \\
\hline cBoobsA \& 6.25 \& 1.3 \& 0.102 \& 0.0328 \& 0.00815 \& 0.545 \& 0.55 \& \({ }^{0.0593}\) \& 0.0602 \& 0.0204 \& Q \& 0.0171 \& \({ }^{0.0203}\) \& Q \& Q \& 0.00244 \& NRS \& Q \& 0.00629 \& Q \& Q \\
\hline CBoobsA \& \({ }^{11.25}\) \& \({ }^{0.593}\) \& \({ }^{0.0598}\) \& 0.0184 \& \({ }^{\text {a }}\) \& \({ }^{0.274}\) \& 0.209 \& \({ }^{0.0318}\) \& \({ }_{\substack{0 \\ 0.0321 \\ \text { NRS }}}\) \& \({ }^{0.00153}\) \& \({ }^{\text {a }}\) \& \({ }^{0.0078}\) \& \({ }^{0.00854}\) \& Q \& \({ }^{\circ}\) \& 0.000487 \& NRS \& \({ }^{\circ}\) \& \({ }^{\circ}\) \& \({ }^{\text {a }}\) \& \({ }^{\text {a }}\) \\
\hline CBEOOSA \& \({ }_{31.25}^{21.25}\) \& \({ }_{0}^{0.335}\) \& \({ }_{0}^{0.03311}\) \& \({ }^{0.00126}\) \& \({ }_{\text {Q }}\) \& \({ }_{0}^{0.1688}\) \& - \& \({ }^{0.00208}\) \& O. \& \({ }_{0}^{0} 0\) \& \({ }_{Q}^{\text {a }}\) \& \({ }_{0.00503}\) \& \({ }_{0.00668}\) \& \({ }_{Q}^{\text {Q }}\) \& \({ }_{Q}^{\text {Q }}\) \& \({ }_{Q}^{\text {Q }}\) \& NRS \& \({ }^{\text {a }}\) \& \({ }^{\text {a }}\) \& \({ }^{\text {a }}\) \& Q \\
\hline CBoobsa \& 41.25 \& \({ }^{0.376}\) \& \({ }^{0.0356}\) \& 0.00984 \& Q \& 0.168 \& 0.144 \& \({ }^{0.0181}\) \& \({ }^{0.0339}\) \& \({ }^{0.0158}\) \& Q \& 0.00718 \& \({ }^{0.0109}\) \& Q \& Q \& Q \& NRS \& Q \& Q \& Q \& Q \\
\hline Cboossa \& 51.25 \& \({ }^{0.0888}\) \& \({ }^{0.00893}\) \& \({ }^{0.00373}\) \& Q \& \({ }^{0.0338}\) \& \({ }^{0.0354}\) \& 0.00689 \& 0.00832 \& \({ }^{0.0034}\) \& Q \& 0.00206 \& 0.00286 \& \({ }^{\circ}\) \& \({ }^{\circ}\) \& \({ }^{\circ}\) \& NRS \& \({ }^{\circ}\) \& \({ }^{\circ}\) \& \({ }^{\circ}\) \& \({ }^{\text {a }}\) \\
\hline CBoossa \& \({ }_{71.25}\) \& NRS \& \({ }^{\circ}\) \& \({ }_{\text {a }}^{0.000854}\) \& \({ }_{0}\) \& \({ }_{0}^{0.011}\) \& \({ }_{0}^{0.00895} 0\) \& \({ }^{\circ}\) \& NRS \& \({ }_{0.0023}\) \& \({ }_{Q}^{\text {a }}\) \& \({ }_{Q}^{\text {Q }}\) \& \({ }_{Q}^{\text {Q }}\) \& \({ }_{Q}^{\text {a }}\) \& \({ }_{0}\) \& \({ }_{0}\) \& NRS \& \({ }^{\text {a }}\) \& \({ }^{\text {a }}\) \& \({ }^{\text {a }}\) \& \({ }_{0}\) \\
\hline CBoossa \& 81.25 \& NRS \& Q \& Q \& Q \& Q \& Q \& Q \& NRS \& Q \& Q \& Q \& Q \& Q \& Q \& Q \& NRS \& Q \& Q \& Q \& Q \\
\hline \({ }^{\text {CBOOOSA }}\) \&  \& NRS \& \({ }_{0}^{0}\) \& \(\stackrel{\text { Q }}{ }\) \& \({ }_{0}^{\text {Q }}\) \& \(\stackrel{\text { Q }}{19}\) \& \({ }_{528}^{\text {Q }}\) \& \(\stackrel{\text { a }}{1}\) \& NRS \& \(\stackrel{\text { Q }}{\substack{09 \\ 0}}\) \& \({ }^{\text {a }}\) \& \({ }_{0}^{0.46}\) \& \(\stackrel{\text { Q }}{0}\) \& \(\stackrel{\text { Q }}{\text { Q }}\) \& \({ }^{0.00109}\) \& \({ }^{0.000942}\) \& NRS \& \({ }^{0}\) \& \({ }_{0}^{\text {Q }}\) \&  \& \(\stackrel{\text { a }}{\stackrel{\text { a }}{\text { a }} \text { - }}\) \\
\hline LSB Coyote Creek \& \({ }_{13.75}\) \& \({ }_{5.35}\) \& \({ }_{0.443}\) \& 0.114 \& \({ }_{0}^{0.0564}\) \& 0.995 \& \({ }_{3.5}\) \& \({ }_{0} 0.244\) \& 1.78 \& \({ }_{0.437}^{0.097}\) \& \({ }^{\text {a }}\) \& \({ }_{0} .46\) \& \({ }_{0} 0.777\) \& \({ }_{0}^{0.00525}\) \& \({ }_{0}^{0.0449}\) \& \({ }_{0}^{0.0509}\) \& NRS \& \({ }^{\text {a }}\) \& \({ }_{0}^{0.0146}\) \& ND \& \({ }_{0}^{0.00984}\) \\
\hline LSB Coyote Creek \& 23.75 \& 0.0393 \& 0.00533 \& 0.00107 \& Q \& 0.0124 \& 0.0155 \& 0.00496 \& 0.012 \& 0.00532 \& Q \& 0.021 \& 0.00307 \& 0.00115 \& 0.000375 \& ND \& NRS \& Q \& 0.000778 \& 0.00164 \& 0.00107 \\
\hline LSB Coyote Creek \& \({ }^{38.75}\) \& \({ }^{0.0333}\) \& \({ }^{0.0042}\) \& \({ }^{0.0012}\) \& Q \& 0.0122 \& 0.0126 \& \({ }^{0.00311}\) \& \({ }^{0.00744}\) \& 0.00341 \& Q \& 0.000674 \& \({ }^{0.001688}\) \& \({ }^{0.00113}\) \& 0.000548 \& ND \& NRS \& Q \& ND \& ND \& \({ }^{0.00132}\) \\
\hline \({ }_{\text {L }}^{\text {LSB Coyote Creek }}\) \& \({ }_{78.75}^{58.75}\) \& NRS
5.49 \& 0.00293
0.398
0 \& \({ }_{\substack{0.00127}}^{0.0127}\) \& \({ }_{0}^{0.00812}\) \& \(\stackrel{\text { 1.12 }}{ }\) \& \(\stackrel{\text { a }}{3.06}\) \& \({ }_{0}^{0.00262} 0\) \& \({ }_{\substack{0.0127 \\ 1.24}}^{0.027}\) \& \({ }_{0}^{0.00331} 0\) \& \(\stackrel{0}{0}\) \& \({ }_{\substack{0.00171 \\ 0.304}}^{0.021}\) \& \({ }_{\substack{0.00261 \\ 0.485}}^{0.0038}\) \& \({ }_{0}^{0.000225}\) \& \({ }_{0}^{0.00393}\) \& \({ }_{0}^{0.00122}\) \& NRS
NRS \& \(\stackrel{\square}{0}\) \& \({ }_{0}^{0.00101}\) \& \({ }^{0.000163} 0\) \& \({ }^{0.00018821} 0\) \\
\hline LSB Coyote Creek \& 98.75 \& 2.88 \& 0.262 \& 0.0646 \& 0.0232 \& 0.542 \& 1.87 \& 0.123 \& 0.923 \& 0.2 \& Q \& 0.264 \& 0.399 \& \({ }^{0.00187}\) \& 0.0282 \& 0.03 \& NRS \& Q \& 0.0111 \& 0.00118 \& 0.0057 \\
\hline LSB Coyote Creek \& 118.75 \& 0.436 \& 0.0698 \& 0.0112 \& 0.00443 \& 0.176 \& 0.167 \& 0.00791 \& 0.00925 \& 0.00317 \& Q \& 0.0012 \& 0.00195 \& 0.00147 \& 0.00146 \& ND \& NRS \& Q \& 0.00512 \& 0.00282 \& 0.00142 \\
\hline LSB Coyote Creek \& 1388.75 \& NRS \& Q \& 0.000355 \& Q \& 0.00225 \& Q \& 0.00257 \& NRS \& 0 \& Q \& Q \& Q \& 0.00072 \& Q \& ND \& NRS \& Q \& \& 0.000561 \& Q \\
\hline \({ }^{\text {LSB Coyote Creek }}\) \&  \& \({ }^{0.00604}\) \& Q \& 0.000489 \& Q \& \({ }^{0.00187}\) \& \({ }^{0.003688}\) \& \({ }_{0}^{\circ}\) \& NRS \& \({ }^{0.00205}\) \& \({ }^{\text {a }}\) \& Q \& \({ }_{0}^{0.00159}\) \& \({ }^{0.000139}\) \& \({ }^{0.00139}\) \& ND \& NRS \& Q \& \({ }^{0.00096}\) \& \({ }^{0.000119}\) \& \({ }^{0.00112}\) \\
\hline \({ }_{\text {ckich }}^{\text {CB Damon Slough }}\) CB Damon Slough \& \({ }_{8.75}^{3.75}\) \& 6.388
28.6 \& 0.268
1.14
1 \& - \(\begin{aligned} \& 0.0988 \\ \& 0.488\end{aligned}\) \& 0.121
0.442 \& 0.998
2.45 \& 4.31
22.3 \& 0.581
1.83 \& 6.24
36.4 \& 0.61
9.28 \& \(\stackrel{\square}{a}\) \& 1.69
6.41 \& 3.34
17.2 \& \({ }_{0}^{0.0311}\) \& 0.148
1.67 \& 0.44
1.77 \& NRS
NRS \& \(\stackrel{Q}{Q}\) \& \({ }_{0}^{0.006677}\) \& 0.00135
0.0093 \& 0.0127
0.0268 \\
\hline CB Damon Slough \& 13.75 \& 57.1 \& 7.14 \& 1.45 \& 0.799 \& 8.24 \& 34.4 \& 5.06 \& 11.7 \& 4.81 \& Q \& 1.79 \& 4.05 \& 0.0121 \& 0.586 \& 0.417 \& NRS \& \({ }^{\circ}\) \& \({ }^{0.00155}\) \& \({ }^{0.00523}\) \& \({ }^{0.0217}\) \\
\hline CB Damon Slough \& 18.75

2375 \& \begin{tabular}{l}
24.6 <br>
${ }_{128}$ <br>
\hline

 \& 

1.41 <br>
0.0542 <br>
\hline 0.0
\end{tabular} \& ${ }^{0.481}$ \& ${ }^{0.723}$ \& 2.17

0.103 \& 14.7 \& ${ }_{0}^{5.08}$ \& ${ }^{2.08}$ \& ${ }^{0.76}$ \& ${ }^{\circ}$ \& ${ }^{0.309}$ \& ${ }^{0.707}$ \& ${ }^{0.003387}$ \& ${ }^{0.25}$ \& ${ }^{0.0 .0541}$ \& NRS \& Q \& ${ }_{0}^{0.00778}$ \& 0.00138 \& ${ }^{0.0032}$ <br>
\hline CB Damon Slough \& ${ }_{28.75}^{285}$ \& ${ }^{0.105}$ \& ${ }_{0}^{0.00586}$ \& ${ }_{0} 0.00251$ \& ${ }_{0}^{0.00645}$ \& 0.00856 \& ${ }_{0}^{0.0763}$ \& 0.00494 \& ${ }_{0}^{0.0148}$ \& 0.00601 \& ${ }^{\text {a }}$ \& ${ }^{0.00158}$ \& ${ }_{0}^{0.00475}$ \& 0.0021 \& ${ }_{0}^{0.000155}$ \& ${ }^{0.000959}$ \& NRS \& ${ }^{\text {a }}$ \& 0.0029 \& ${ }_{0}$ \& ${ }_{0.00144}$ <br>
\hline CB Damon Slough \& 38.75 \& ${ }^{0.0478}$ \& 0.00455 \& 0.00155 \& a \& 0.00876 \& 0.0184 \& 0.0145 \& 0.011 \& 0.00588 \& Q \& 0.000963 \& 0.00364 \& Q \& Q \& 0.000499 \& NRS \& Q \& Q \& Q \& 0.00153 <br>
\hline CB Damon Slough \& 48.75 \& 0.0333 \& Q \& 0.00152 \& Q \& 0.00303 \& 0.0212 \& 0.00758 \& NRS \& 0.00303 \& Q \& Q \& 0.00303 \& Q \& Q \& Q \& NRS \& Q \& ND \& ND \& Q <br>
\hline CB Damon Slough \& ${ }_{58}^{58.75}$ \& NRS \& ${ }^{\circ}$ \& ${ }^{0.000133}$ \& ${ }^{\circ}$ \& ${ }^{\circ}$ \& ${ }^{0.00663}$ \& ${ }^{0.005331}$ \& NRS \& ${ }^{\circ}$ \& ${ }^{\text {a }}$ \& ${ }^{\circ}$ \& ${ }^{\circ}$ \& ${ }^{\circ}$ \& ${ }^{\circ}$ \& ${ }^{\circ}$ \& NRS \& ${ }^{\circ}$ \& ${ }^{\text {ND }}$ \& ND \& ${ }^{\circ}$ <br>
\hline ${ }_{\text {CB Damon Slough }}^{\text {SB Greoo sland }}$ \& ${ }_{\substack{68.75 \\ 3.75}}$ \& NRS
1.4 \& O.
0.14 \& 0.0013
0.0192 \& ${ }_{0}^{0.0119}$ \& ${ }_{0.482}^{\text {Q }}$ \& ${ }_{\substack{0.00649 \\ 0.696}}^{0.023}$ \& 0.00104
0.0508 \& NRS

0.439 \& ${ }_{0}{ }^{\text {Q }} 101$ \& Q \& ${ }_{0.119}^{\text {Q }}$ \& ${ }_{0.173}^{\text {Q }}$ \& ${ }_{0}{ }^{\text {a }}$ \& | 0.0231 |
| :---: |
| 0.0 |
| 0 | \& ${ }_{0}^{0.0233}$ \& NRS

NRS \& ${ }^{\text {Q }}$ \& ${ }_{0}^{0.0013} \begin{aligned} & 0.025\end{aligned}$ \& 0.0243 \& ${ }_{0}^{0.03666}$ <br>
\hline SB Greco Island \& ${ }^{13.75}$ \& 2.5 \& 0.255 \& ${ }^{0.0623}$ \& 0.0135 \& 0.678 \& 1.43 \& ${ }^{0.0576}$ \& 1.22 \& 0.347 \& Q \& 0.344 \& 0.505 \& ${ }^{0.001964}$ \& ${ }^{0.0135}$ \& 0.00435 \& NRS \& Q \& ${ }^{0.0145}$ \& 0.00232 \& ${ }^{0.00674}$ <br>
\hline  \& 23.75
33.75 \& ${ }_{4}^{6.57}$ \& - ${ }_{0}^{0.5568}$ \& -0.175 \& ${ }^{0.02208}$ \& 1.54
1.69 \& 4.09
2.26 \& 0.09044 \& 7.58
0.432 \& ${ }_{0}^{2.239}$ \& ${ }^{\text {Q }}$ \& 1.82
0.0778 \& ${ }_{0}^{2.112}$ \& 0.00424 \& ${ }^{0.0221}$ \& 0.00943
ND \& NRS
NRS \& ${ }^{\text {Q }}$ \& ${ }_{0}^{0.002584}$ \& ${ }^{0.00129} 0$ \& - <br>
\hline SB Greco sliand \& ${ }^{43.75}$ \& ${ }^{0.0332}$ \& 0.00539 \& 0.00109 \& a \& 0.00892 \& 0.0165 \& 0.00133 \& 0.00751 \& 0.0034 \& Q \& 0.00109 \& 0.00177 \& 0.00066 \& 0.00059 \& ND \& NRS \& Q \& 0.00069 \& 0.00083 \& ND <br>
\hline SB Greco Island \& 53.75 \& NRS \& Q \& ND \& Q \& 0.00299 \& 0 \& Q \& 0.00429 \& 0.00227 \& Q \& 0.000417 \& 0.0016 \& Q \& ND \& ND \& NRS \& Q \& ND \& ND \& ND <br>
\hline SB Greco Island \& ${ }^{63.75}$ \& ${ }^{0.0278}$ \& ${ }^{0.00379}$ \& ${ }^{0.000137}$ \& Q \& 0.00757 \& ${ }^{0.00118}$ \& ${ }^{0.0032929}$ \& ${ }^{0.009633}$ \& ${ }^{0.00399}$ \& ${ }^{\circ}$ \& 0.000857 \& ${ }^{0.002477}$ \& ${ }^{0.000106}$ \& 0.000757 \& ${ }^{0.000586}$ \& NRS \& ${ }^{\circ}$ \& ND \& ND \& ${ }^{0.000103}$ <br>

\hline  \& | 7375 |
| :--- |
| 83.75 | \& ${ }_{0}^{0.0243} \begin{aligned} & 0.0168\end{aligned}$ \& 0.00249

0.00227 \& 0.000714
0.000771 \& ${ }^{0.000356}{ }_{0}^{0.0037}$ \& ${ }_{0}^{0.00026}{ }_{0}^{0.002}$ \& 0.00873
0.00456 \& 0.00433
0.00383 \& ${ }_{0}^{0.002924}$ \& - \& $\stackrel{\text { Q }}{ }$ \& ${ }^{0.0000786}$ \& ${ }^{0.002927}$ \& ${ }^{0.00191}{ }_{0.006}$ \& ${ }_{\substack{0.00167 \\ 0.00113}}^{0.0}$ \& ${ }^{0.0000657}$ \& $\stackrel{\text { NRS }}{\text { NRS }}$ \& $\stackrel{\text { Q }}{ }$ \& \& ${ }^{0.00121}$ \& ${ }^{0.000259} 0$ <br>
\hline SB Greco siland \& ${ }^{93.75}$ \& ${ }^{0.0168}$ \& 0.00234 \& 0.00101 \& 0.00361 \& 0.00182 \& 0.00515 \& 0.00284 \& 0.011 \& 0.00373 \& Q \& 0.00161 \& ${ }^{0.0027}$ \& ${ }^{0.00123}$ \& 0.00101 \& 0.000756 \& NRS \& Q \& 0.000866 \& 0.00112 \& 0.00126 <br>
\hline ${ }_{\text {LSB001sA }}$ \& 11.25
21.25 \& ${ }_{4.03}^{4.25}$ \& ${ }_{0}^{0.313}$ \& ${ }_{0}^{0.097}$ \& ${ }_{0}^{0.03399} 0$ \& 1.29
1.35 \& 2.31
2.31 \& ${ }_{0}^{0.186}$ \& - \& 0.153
0.104 \& ${ }_{Q}^{\text {Q }}$ \& ${ }_{0}^{0.077}$ \& ${ }_{0}^{0.10507}$ \& 0.002 \& ${ }_{0}^{0.00043}$ \& 0.00258
0.00162 \& NRS \& ${ }_{Q}^{\text {Q }}$ \& 0.00835
0.0137 \& ${ }_{0.06551}^{\text {Q }}$ \& (e.0645 <br>
\hline
\end{tabular}









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| :--- |





| $\left.\right\|_{\text {Su002sA }} ^{\text {SuO22SA }}$ | 6.25 | 0.329 | 0.0291 | 0.00602 | 0.00174 | 0.184 | ${ }^{0.0936}$ | 0.0148 | NRS | Q | Q | 0.00101 | Q | Q | Q | Q | NRS | Q | Q | Q | Q |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| (suoorsA | 11.25 <br> 235 <br> 275 | 0.207 | ${ }^{0.02012}$ | ${ }^{0.00375}$ | ${ }^{0.001888}$ | 0.104 0.215 7 | ${ }^{0.0651}$ | ${ }_{0}^{0.01261}$ | NRS | ${ }^{0.0003357}$ | ${ }^{\circ}$ | 0.000981 0 | ${ }^{\text {a }}$ | Q | ${ }^{\text {a }}$ | ${ }_{\text {Q }}$ | NRS NRS | ${ }^{\text {a }}$ | ${ }_{0}{ }^{\text {a }}$ | ${ }_{0}{ }^{\circ}$ | ${ }_{\text {Q }}{ }^{\text {a }}$ |
| suoorsa | 31.25 | 9.15 | ${ }_{0} 0.332$ | 0.114 | 0.00289 | 7.23 | 1.42 | 0.056 | 0.0518 | 0.0257 | Q | 0.021 | 0.00475 | Q | Q | 0.00331 | NRS | Q | 0.00245 | 0.00101 | 0.00356 |
| SU002SA | 41.25 | 0.0308 | 0.00334 | 0.0012 | ND | 0.00916 | 0.00715 | 0.00994 | NRS | 0.00334 | Q | Q | 0.00159 | Q | Q | ND | NRS | Q | ND | ND | Q |
| SU002SA | ${ }_{6}^{61.25}$ | 0.67 | ${ }^{0.0746}$ | ${ }^{0.0189}$ | ${ }^{0.003857}$ | ${ }^{0.306}$ | ${ }^{0.248}$ | ${ }^{0.0182}$ | NRS | 0.000584 | ${ }^{\circ}$ | ${ }^{0.00335}$ | Q | Q | Q | ND | NRS | ${ }^{\circ}$ | ND | ND | Q |
| SU002SA | 71.25 | 5.6 | 0.303 | ${ }^{0.182}$ | ${ }^{0.00777}$ | 3.06 | 1.98 | 0.0672 | ${ }^{0.0677}$ | ${ }^{0.0387}$ | Q | ${ }^{0.0243}$ | ${ }^{0.00474}$ | Q | Q | Q | NRS | Q | 0.00127 | 0.000869 | 0.0217 |
| SU002SA | 91.25 | 4.11 | 0.452 | 0.0967 | 0.00703 | ${ }^{2.35}$ | 1.14 | 0.0614 | 0.0545 | 0.0301 | Q | 0.0181 | 0.00627 | Q | Q | Q | NRS | Q | Q | 0.00081 | 0.00176 |
| SU002SA | 81.25 | 16.7 | 1.42 | ${ }^{0.436}$ | 0.0215 | 10.2 | 4.41 | 0.19 | 0.133 | ${ }^{0.0733}$ | Q | 0.0451 | 0.0119 | 0.00099 | ${ }^{0.00116}$ | 0.00035 | NRS | Q | ${ }^{0.00456}$ | 0.00227 | 0.00638 |
| SU002SA | ${ }^{101.25}$ | 7.16 | 1.5 | 0.131 | 0.0112 | 3.88 | 1.57 | 0.0633 | 0.151 | 0.104 | Q | ${ }^{0.0273}$ | 0.0174 | 0.000873 | 0.000978 | 0.000619 | NRS | Q | 0.00162 | 0.0003 | 0.00232 |
| - SPB Widcat Marsh | 3.75 <br> 8.85 <br> 8 | 3.92 815 | (0.408 | ${ }_{\substack{0.0873 \\ 0.185}}^{0.351}$ | ${ }^{0.0271}$ | 0.872 .21 2, | 2.36 4.24 | 0.164 <br> 0.209 | 1.84 4.13 | (0.495 | ${ }^{\text {a }}$ | 0.473 <br> 0.991 <br> 0.0 | ${ }_{1}^{0.696}$ | 0.00301 0.011 | co.0.0482 | 0.12 0.172 | NRS NRS | ${ }^{\text {a }}$ | ${ }_{\substack{0.0151 \\ 0.044}}^{0.054}$ | 0.00151 0.00366 | 0.00602 0.00916 0 |
| SPB Wididat Marsh | 8.75 <br> 13.75 <br> 185 | 8.15 <br> 32.8 | 7.07 | ${ }_{0}^{0.547}$ | ${ }_{0}^{0.0878}$ | 12.5 | ${ }^{12.1}$ | ${ }_{0} 0.45$ | 29.4 | 11.6 | ${ }^{\text {a }}$ | 7.16 | 10.1 | 0.00901 | 0.367 | 0.205 | NRS | Q | 0.36 | ${ }_{0} 0.0113$ | 0.0225 |
| SPB Widcat Marsh | 18.75 | 568 | 100 | 5.61 | 0.661 | 267 | 191 | 3.81 | 52.8 | 28.5 | Q | 9.18 | 13.9 | ${ }^{0.0181}$ | 0.992 | 0.215 | NRS | Q | 0.57 | 0.0311 | 0.109 |
| SPB Widdat Marsh | 23.75 | 280 | 64.7 | 5.47 | 0.331 | 129 | 79.1 | 1.77 | 23.4 | 13.3 | Q | 3.94 | 5.77 | 0.0122 | 0.376 | 0.0488 | NRS | Q | 0.492 | 0.0732 | 0.28 |
| SPB Widcat Marsh | 28.75 | 13.1 | 2.57 | 0.42 | 0.00856 | 4.75 | 5.27 | 0.103 | 1.18 | 0.608 | Q | 0.209 | ${ }^{0.327}$ | 0.00171 | 0.024 | 0.00856 | NRS | Q | ${ }_{0} 0.276$ | 0.0171 | . 00685 |
| \|SPB Wildcat Marsh | 38.75 | 0.111 | 0.0128 | 0.00427 | O | 0.0242 | 0.0399 | 0.0299 | 0.0228 | 0.00997 | Q | 0.00427 | 0.0057 | - | 0.00142 | 0.00142 | NRS | Q | 0.00427 | 0.00285 | Q |
| - SPB Widatat Marsh | 48.75 | NRS | Q | Q | Q | Q | ${ }^{0.0103}$ | Q | NRS | Q | Q | $\bigcirc$ | 0 | a | Q | Q | NRS | Q | 0 | 0 | Q |
| (e) $\begin{aligned} & \text { SPB Wildat Marsh } \\ & \text { SPB Wididat Marsh }\end{aligned}$ | 58.75 68.75 | NRS NRS | ${ }_{\text {Q }}$ | ${ }_{\text {Q }}$ | Q | Q | Q | ${ }^{\text {a }}$ | NRS NRS | Q | ${ }_{\text {Q }}$ | ${ }^{\circ}$ | ${ }^{\text {a }}$ | Q | ${ }_{\text {Q }}$ | ${ }_{\text {Q }}$ | NRS NRS | ${ }^{\text {Q }}$ | ${ }_{\text {Q }}$ | ${ }^{\text {a }}$ | ${ }_{\text {Q }}$ |

