Clean Estuary Partnership Project 4.26

Multi-Box Contaminant Transport Model and Multi-Year Sediment Sampling Strategy

Sampling and Analysis Plan for Sediment Cores in San Francisco Bay

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INTRODUCTION

This sampling plan for collection of sediment cores from San Francisco Bay and chemical analyses of these cores for pollutants and radiodating has been prepared pursuant to Subtasks 4.1 and 4.2 of Clean Estuary Partnership (CEP) Project 4.26 (*Multi-Box Contaminant Transport Model and Multi-Year Sediment Sampling Strategy*). Analysis of sediment cores from San Francisco Bay is a key task in Project 4.26, and the CEP has budgeted $200,000 and the Regional Monitoring Program (RMP) $100,000 for this effort.

Technical oversight/peer review for the project is being provided by the Contaminant Fate Work Group (CFWG) of the RMP, a group of local and national experts in estuarine modeling and sediment analysis. With the advice and review of the CFWG, project plans and reports are delivered to the CEP Technical Committee and the RMP Technical Review Committee for approval. Prior to conducting the sampling and analysis of sediment cores, the scope of work for Project 4.26 called for the preparation, review, and approval of this Sampling and Analysis Plan (SAP).

BACKGROUND

CEP Project 4.26 is a systematic multi-year program, building on model development efforts already underway, to construct a basic mechanistic model that will advance our understanding of contaminant behavior in the Bay and provide a new tool for water quality management. To achieve these ends, it was expected that the project would identify a field study to reduce uncertainties in the model, and then plan and conduct the field work. This (SAP) has been prepared to present (1) the rationale and objectives for the field sampling program, (2) the methods to be used and analyses to be conducted, and (3) the schedule and budget for completion of these tasks.

A conceptual draft plan was reviewed by the CFWG on March 15, 2005. The CFWG agreed that the scarcity of data on sediment processes and pollutant distributions in deeper estuarine sediments represent gaps in our knowledge that lead to large uncertainties in our ability to predict future pollutant concentrations. The existing data set includes detailed analysis of two cores taken from depositional locations in the Bay (Hornberger, Venkatesan, and Fuller, 1999), with limited data on selected pollutants for a number of other sites. Another depositional core recently has been analyzed in the South Bay for mercury (C. Conaway, UC Santa Cruz, pers. comm). There also have been pollutant core data collected for specific contaminated sites (e.g. Hunter's Point), but those sites are not expected to be representative of the Bay in general and thus are of limited usefulness for understanding Estuary-scale processes. Pollutant concentrations in cores taken for dredging projects also are measured, but samples are composited, so changes in concentration with depth and information on deposition history and sediment processes are lost.[1]

[1] Another CEP project (*Analysis of Pollutants in Sediment Cores Near Storm Water Inputs* [#4.10b]) collected pollutant cores in nearshore locations that were expected to be highly contaminated, and these cores were similarly composited. This project report is available at: http://www.cleanestuary.org/publications/files/CEP%5F4%2E10B%5Freport%2Epdf).

The CFWG also concluded that budgetary limitations would prevent Project 4.26 from achieving a statistically robust sampling program. It is costly to collect cores and then conduct chemical analyses on many sections. Given the high variability in chemical concentrations documented by the RMP in surficial sediment samples collected in the Bay during the last decade, it seems reasonable to expect similar variability in the results from cores. The CFWG consequently noted that although a few cores collected in each segment would likely not be adequately representative of the Bay, it would be a step towards improving our understanding..

Given the limited number of samples that could be collected and analyzed within the budget, the CFWG recommended a hybrid sampling plan, in which some sites are selected to verify or refine key model assumptions or predictions, with the remainder of sites distributed geographically in segments with differing sedimentation regimes (i.e., depositional v. erosional) to improve the relatively poor characterization of pollutants with depth in the sediments of the Bay. This hybrid approach builds anecdotal but 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.

Based on this recommendation, this Sampling and Analysis Plan has adopted three objectives that are used to guide the locations for the sediment cores. This Plan then describes (1) how the cores will be collected, sectioned, and chemically analyzed, (2) a data analysis approach, and (3) a budget and schedule for the work described.

SAMPLING PROGRAM OBJECTIVES

Although existing models can draw upon a large pool of data available for characterizing surface sediment concentrations in the Bay (RMP, NOAA/EMAP), as noted above there are far fewer data for characterizing pollutants at depth. Improved data are required to better quantify the pool of legacy and emerging pollutants in the Bay, verify certain model parameters, and test model results against field data.

The collection of sediment cores and analyses for pollutants and radioisotopes will be used to achieve the following three objectives: (1) provide a more comprehensive characterization of contamination with depth that can be used to assess future changes, (2) verify the historic loading of pollutants to the Bay and how those loads have changed in the last several decades, and (3) provide valuable data for parameterization and evaluation of the multi-box model.

Objective #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 the watershed, many areas of the Bay have transitioned into an erosional regime (Cappiella 1999; Foxgrover 2004; Jaffe *et al*., 1998). The limited existing data document higher concentrations of pollutants at depth in sediments that may be exposed by erosion and bioaccumulate. This stock of buried contamination is thus a possible “source” of pollutants to biota in the future, as has been described in the recently completed TMDL for Mercury in San Francisco Bay (Looker & Johnson, 2004). However, the depositional pollutant profiles found by USGS researchers (Hornberger *et al*, Venkatesan *et al*, and Fuller *et al* 1999) are likely 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. Because neutral or erosional sedimentation has occured during the period of maximum loads for many contaminants (e.g. PCBs), large distinct maxima in subsurface pollutant concetrations are unlikely in most cores (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).

The CFWG noted that obtaining data from one or two dozen additional cores, although an improvement in the current state of knowledge, would likely still not be representative of the Bay given the variability seen in surface grab samples from RMP and NOAA/EMAP. The CFWG therefore suggested the sampling plan also should further the long-term goal of representatively characterizing the Bay. If sediment cores can be taken periodically in the coming decades at sites complementary to those taken in this sampling exercise, the long-term data set generated would be valuable for generally characterizing the Bay and assessing trends.

While initial multi-box model performance has been promising, the CFWG encouraged consideration of the field sampling independent of any particular model. Future model refinements could lead to poorer performance (e.g. increasing model complexity and data needs without appreciably reducing uncertainty or even increasing uncertainty), and model sensitivities to some parameters may arise from limitations in model structure and assumptions. In that instance, the field measurements from the cores would themselves be vital technical information for use in policy development and identifying remaining information needs.

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

The present version of the multi-box model relies on national historical estimates of pollutant production and use (Breivik 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. These uncertainties could explain a significant fraction of the difference between model predictions of pollutant distribution and ambient measurements (over-predicting 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.

To address this issue, cores should be taken from locations with consistently depositional histories. The data gathered from these cores then could be used to determine if revising the historical loading estimates used in the model hindcast runs would be reasonable. Although depositional cores could be taken in either deep-water areas or wetlands, sediment cores from deep-water depositional areas are subject to various disturbances that are not easily observed prior to or after sample collection, confounding interpretation of chronology and sediment processes. Depositional sediments in deeper Bay cores will integrate sediment processes unrelated to changes in loading, because redistributed in-Bay sediments will contribute to deposited material. Cores from selected wetlands along the margins of an estuary segment will represent material transported from nearby tributaries, combined with nearby bottom sediments resuspended by wind, wave, and tidal action. The relative contribution of tributary loads compared to reworked Bay sediments within any particular wetland core is not easily resolved, but the reponse almost certainly would be larger than for deep-water sediment cores from the Bay.

Wetland areas, especially vegetated wetlands (tidal or seasonal) that are less subject to scouring and erosion than channels and banks, might also provide a record of historical changes in pollutant loads for specific watersheds. These data would be valuable for tracking the past changes in loading of PCBs and other pollutants from watersheds and in making predictions of future changes in loads. Prediction of future loads is an important input to the model for predicting future Estuary response.

Objective #3: Provide data for parameterization and evaluation of the multi-box or other models

Data from cores collected to meet the previous objectives also will be used to parameterize the model and evaluate its performance. Pollutant concentrations in cores from erosional areas combined with projected erosion rates provide estimated inputs of future pollutant loads from Bay sediments for modeling. Information from Bay and watershed wetland depositional cores provides evidence for past loads, to verify or refine estimates derived from the data of Breivik (2002). Depositional cores, particularly from watersheds, also provide evidence of recent trends in loads that can be used to project baseline loads in the future. Finally, characterization of the distribution of pollutants with depth throughout the Bay provides data to compare with model hindcasts and to use as initial conditions for model forecasts.

SAMPLING AND ANALYSIS

Sample Site Selection

In order to achieve the objectives discussed above, sites should be distributed geographically in the Bay. Sedimentation rates within the Bay are not constant within a geographic region, however, but will vary over time and in space due to factors such as climatic regime or differences in water and land management practices. Net sedimentation regime can be inferred from recent bathymetric changes where that information is available, although limitations in bathymetric resolution may not capture small scale variability in depositional history that would only become apparent after a sample is collected and analyzed (e.g. a particular core might be more eroded within a generally depositional area).

Jaffe *et al*. (1998) have documented bathymetric change over time in the Bay, and as a first approximation, bathymetric change in recent decades can be expected to continue in the near term. USGS has developed this information for Suisun, San Pablo, South, Lower South Bay, and a portion of Central Bay (south of Hunter's Point to Oakland Harbor).

Bathymetric change in northern Central Bay is likely be evaluated by USGS in the future, so all Bay segments can be targeted for coring (Figure 1).

An earlier version of this sampling plan suggested stratifying areas of Bay segments to sample on the basis of sedimentation history. However, the CFWG expressed concern that existing surface sediment data suggest small scale spatial heterogeneity in surface pollutant concentrations, which would be mirrored by heterogeneity in sediment depositional histories on a similarly small scale. The workgroup recommended avoiding only anomalous areas within the segments (e.g. maintained channels, dredge disposal piles, borrow pits) and stratifying post-analysis, without any other *a priori* expectations for the collected samples. The majority of core locations will therefore be distributed randomly among segments, with two samples collected per segment (three in Central Bay due to its larger area) to begin characterizing pollutant and sedimentation histories (Table 1). Where possible, samples will be taken from sites previously used by NOAA/EMAP or RMP so that comparable data on pollutants from nearby surface samples will be available (Table 2, Figure 2).

	General Segment Trend	Representative Bay Samples	Depositional Wetland Samples
Suisun Bay	-	2	1
San Pablo Bay	-	2	1
Central Bay	0	3	1
South Bay	0	2	1
Lower South Bay	+	2	1
Guadalupe Watershed			1
Total		11	6

Table 1: Sediment cores by Bay segment and sedimentation regime (cores are taken in each segment to begin "representative" characterization). Note that wetlands depositional sites (one for each Bay segment) are included for information on nearby watershed loading histories.

Cores from one wetland in each segment on the Bay margins (five sites) will be collected to develop a historical chronology of pollutants in Bay segments. Historical maps can be used to identify areas that have remained wetlands continuously within these general areas: near the mouth of Guadalupe River or Coyote Creek for Lower South Bay, Outer Greco Island (or the mouth of Alameda Creek as an alternate) for South Bay, in San Leandro Harbor for Central Bay, the mouth of the Petaluma River to western Mare Island for San Pablo Bay, and West Pittsburg to Mallard Island for Suisun Bay (Figures 3 and 4).

RMP/EMAP site code	***longitude***	***latitude***	***primary site***

CB001S,	-122.36210,	37.87587	*
CB002S,	-122.34735,	37.62573	*
CB006S,	-122.24800,	37.71300	*
LSB001S,	-122.09797,	37.49162	*
LSB002S,	-122.07873,	37.47918	*
LSB003S,	-122.11600,	37.49100	
LSB004S,	-122.08400,	37.49500	
SB001S,	-122.26508,	37.61203	*
SB002S,	-122.16742,	37.61015	*
SB003S,	-122.30200,	37.61700	
SB004S,	-122.21700,	37.60100	
SPB001S,	-122.38707,	38.07177	*
SPB002S,	-122.34150,	38.01613	*
SPB003S,	-122.47600,	38.02800	
SU001S,	-122.04718,	38.09937	*
SU002S,	-121.97988,	38.05900	*
SU003S,	-122.09600,	38.06600	
NOAA11-2,	-122.47336,	38.08906	
NOAA13-2,	-122.35401,	38.02746	
NOAA14-3,	-122.45309,	38.10172	
NOAA15-2,	-122.46610,	37.94434	
NOAA16-2,	-122.40185,	37.90396	
NOAA17-3,	-122.39359,	37.92162	
NOAA3-2,	-121.93314,	38.06727	
NOAA34-4,	-122.25995,	37.58001	
NOAA37-2,	-122.23858,	37.56203	
NOAA38-2,	-122.22009,	37.57398	
NOAA4-1,	-122.05270,	38.13333	
NOAA41-2,	-122.09408,	37.48041	
NOAA42-1,	-122.10141,	37.49403	
NOAA43-2,	-122.04249,	37.46048	
NOAA5-4,	-121.96451,	38.06567	

Table 2. Proposed sediment core sampling sites, including backup sites within each segment.

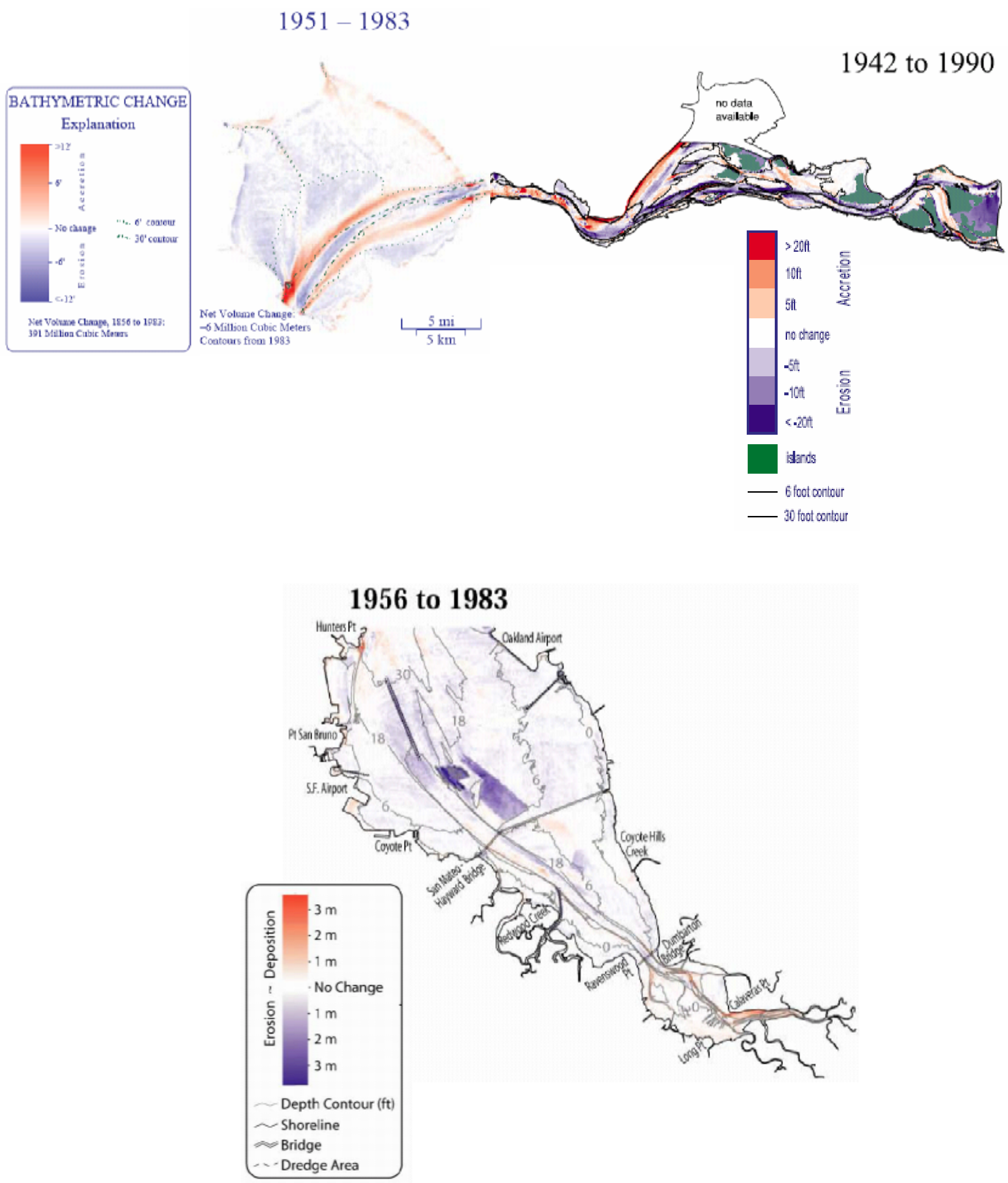

Figure 1: Areas of Deposition, Erosion, and No Net Bathymetric Change in Suisun, San Pablo, South, and Lower South Bay. From Jaffe *et al.* 1998, Capiella *et al.* 1999, and Foxgrover *et al.* 2004.

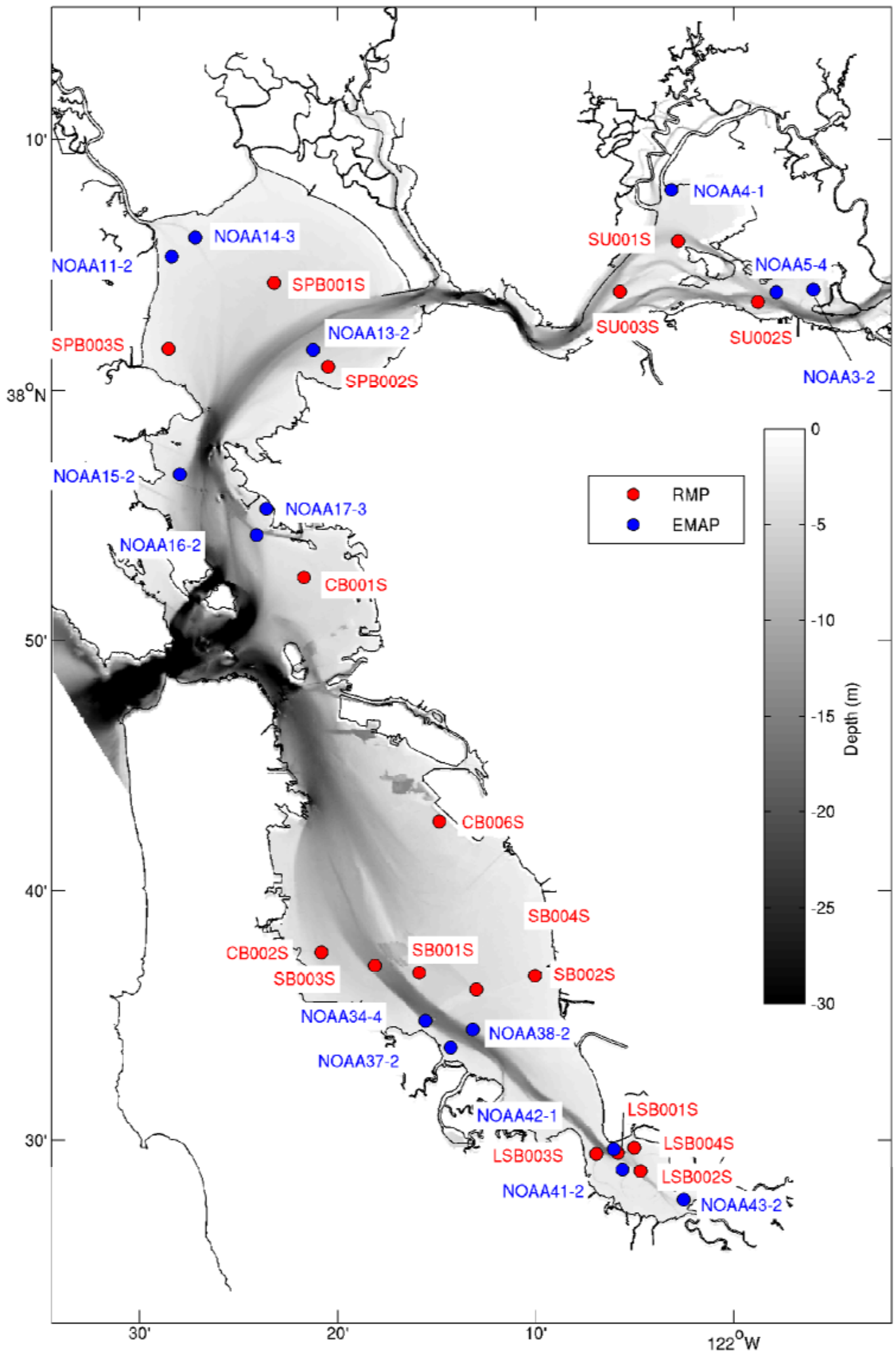

Figure 2: Surface sediment sampling sites of NOAA/EMAP and RMP for coring plan, with backup sites (Table 2 indicates primary sites in each segment)

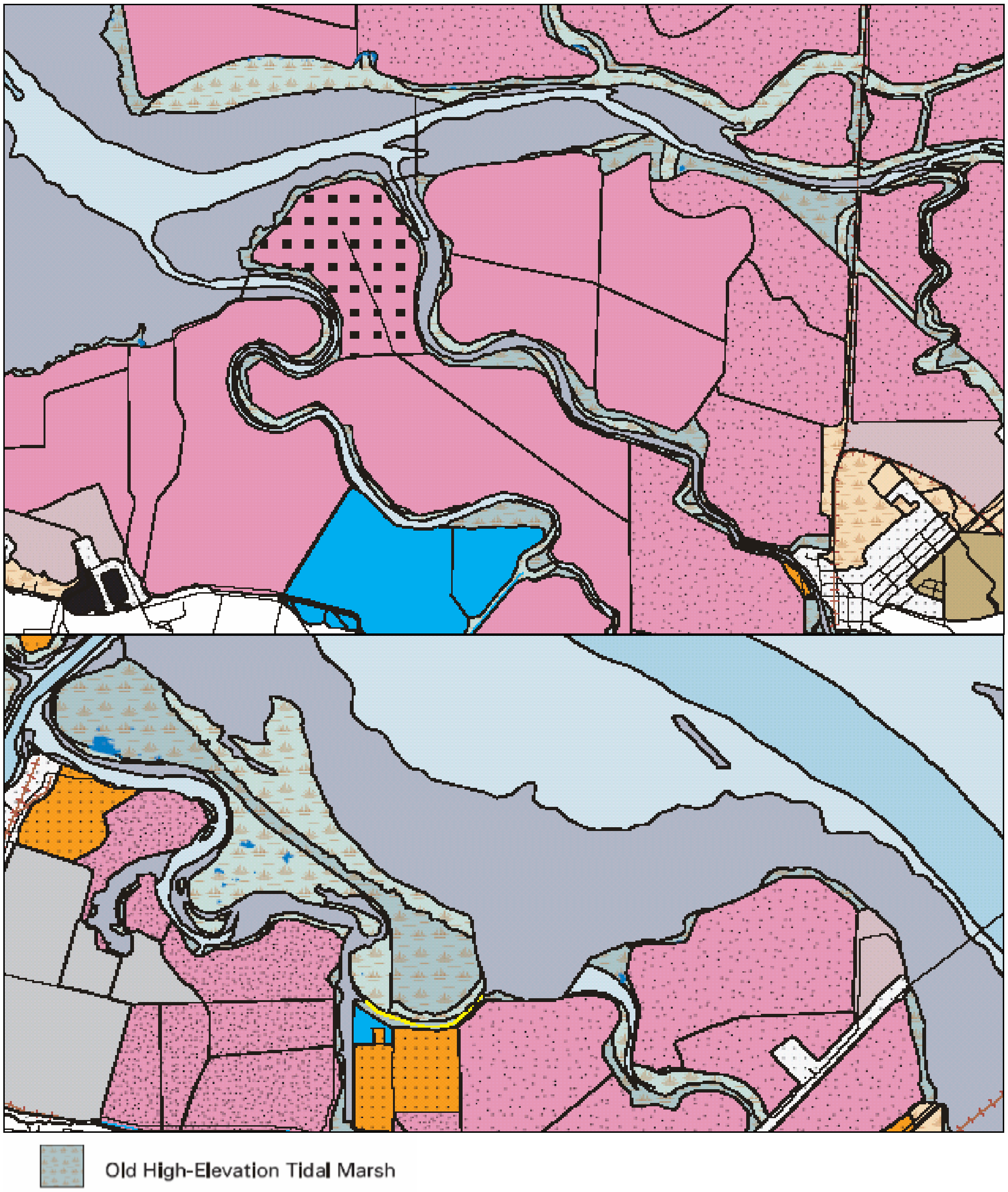

Figure 3. Potential Wetland Sampling Areas in Lower South Bay (top) and South Bay (bottom). Target sites are in old-high elevation marsh.

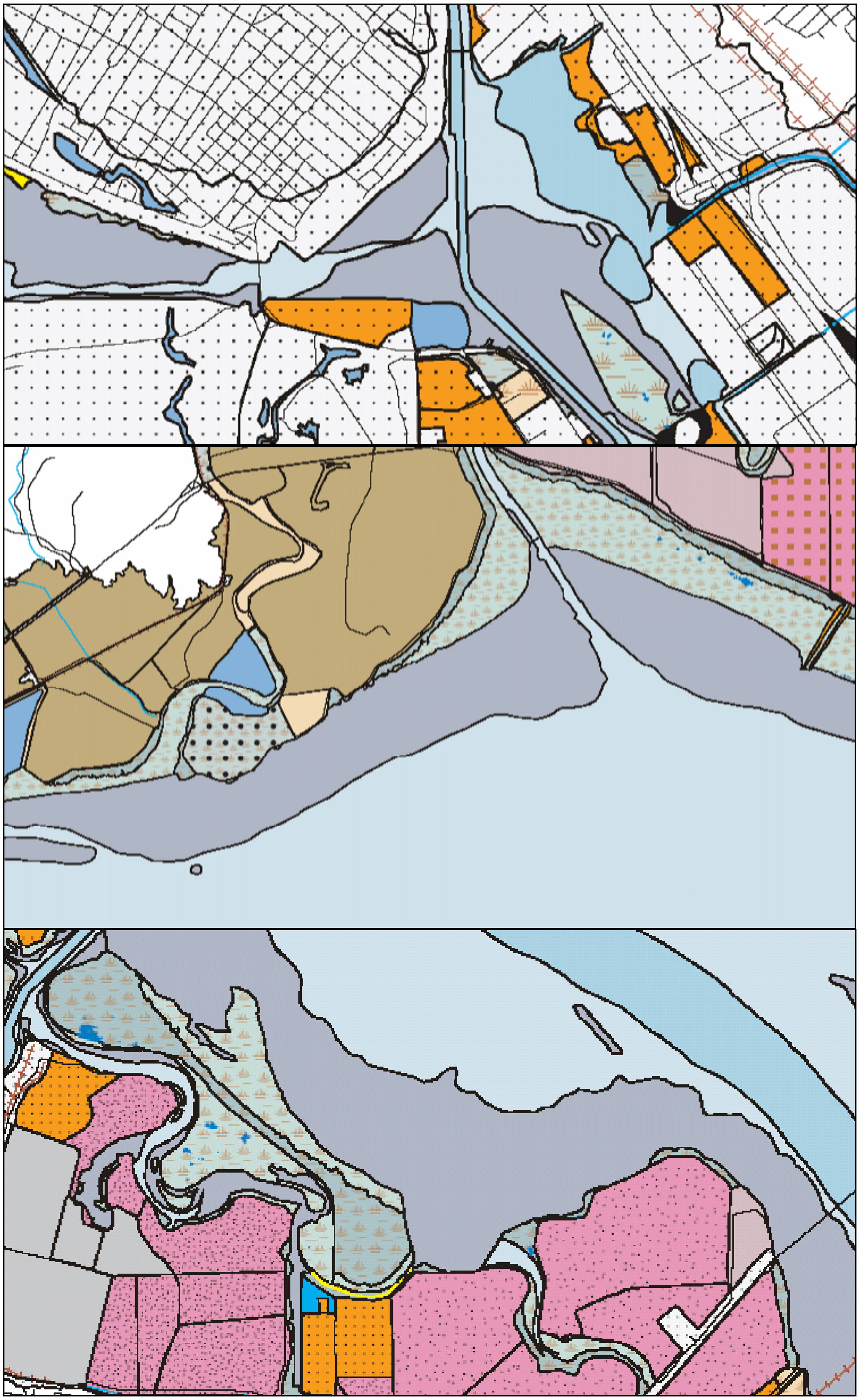

Figure 4. Potential Wetland Sampling Areas in Central (top), San Pablo (mid) and Suisun Bay (bottom). Target sites are in old-high elevation marsh.

For obtaining cores with a recent history of watershed loads, continuously existing wetland areas near the mouth of key tributaries could be used. However, these sites can be difficult to identify as many have been modified (e.g. dredging, levee construction, channel modification). This assessment of past loads is best made in a watershed where current pollutant loads are well characterized, and where historical information regarding wetlands extent is available. The Guadalupe River watershed fits these criteria, so a site at the base of that watershed will be sampled with the goal of estimating a historical trend of contaminant loads from the watershed. Small wetland areas adjacent to the channel have remained unmodified and can provide a depositional history of pollutants from the Guadalupe, although some influence of Bay sediments (larger for sample sites further downstream) may confound efforts to attribute loads to the watershed. A wetland site in the Guadalupe will be selected as far upstream as is practicable.

Core Collection

Changes in bathymetry for Bay sites within a 3-4 decade period (e.g. 1950s to 1980s by Jaffe *et al*. 1998) range up to 3-4 m, with some of the larger changes the direct result of human activities (channel deepening, borrow pits for fill material, dredge material disposal). However, a majority of the area within the Bay exhibits a change in bathymetry over this time of about 1 m. Since one aim of modeling efforts is to reconstruct and then predict the long-term fate of pollutants over periods of decades to a century, taking sediment cores up to a depth of two meters should capture a large portion of the sediment activity that occurred over that time scale for most sites.

Cores will be obtained at the 11 Bay sites using a Vibracore. Four-inch cores will be collected from Bay sites. When cores are recovered, they will be kept vertical to minimize disturbance of surficial layers until after overlying water can be siphoned off. The cores then will be cut into the maximum lengths that will fit into a large cooler, capped and frozen upright in a rack made of PVC pipe large enough to hold the core sections and dry ice. After they are frozen, cores will be transferred into standard coolers with dry ice.

Cores will be obtained at the six wetland sites (one for each Bay segment and Guadalupe River) using a manual coring device. Coring equipment will be taken to each sampling site either in a small boat or by wheeled vehicle, possibly carried a short distance (up to ~100 meters). Road access using a vehicle is preferred because of the weight of equipment that will be needed onsite. The wetland and Guadalupe River cores will be two inches in diameter and two meters long. They will be handled and processed upon recovery using the same procedures as for the Bay cores.

All cores will be kept frozen in a commercial cold storage facility until they are processed in the laboratory. Laboratory processing will consist of sectioning at the specified depth intervals to obtain sub-samples for chemical analyses (see description below). Sub-samples will be shipped frozen to the appropriate analytical laboratory for analysis. All shipping and analytical procedures will be consistent with those used by the Regional Monitoring Program. A duplicate core will be taken at each location and archived.

Sample Analysis

Core sectioning. Cores initially will be sub-sampled at large intervals (e.g. in the top half of the core) for radiodating to identify sediment layers for more detailed radiodating and subsequent pollutant analysis. If preliminary analyses suggest the top half of the core already contains the period of interest, additional sections for radiodating and pollutant analyses will include sections taken between the already measured intervals. If on the other hand, the top half covers a shorter period, the remainder of the core will be sectioned at sufficeintly spaced intervals expected to cover the whole period of interest. The detailed sectioning for each individual core will be focused on the last 60-150 years. Within this region additional sections will be taken at intervals to characterize sediment age and pollutant concentrations (1940s – present for PCBs and organochlorine pesticides, ~1850 – present for mercury, ~1970 – present for PBDEs [in some cores]). Up to 10 sections will be taken from each core for radiodating and chemical pollutant analyses. Section sizes will be a minimum of 1 cm, larger as needed depending on the quantity of material required for sufficient analytical sensitivity to measure parameters of interest (see below).

Chemical and isotope analysis. Radioisotopes will help us to determine the age of sediments at various depths within cores, allowing reconstruction of historical pollutant concentrations in sediments. A uniform pollutant depth profile might result from either mixing or constant loading over time, but the age of the sediment determined by isotopes would distinguish the two scenarios. Isotopes such as ^{137}Cs and ^{210}Pb have half-lives suitable to distinguish among sediments deposited from different decades, and erosional or mixing processes can be seen in discontinuous or uniform age profiles with depth. ^{210}Pb would be more useful for sediments extending prior to the advent of atomic bomb testing. The generally preferred (for cost, speed, and ease) method for ^{210}Pb measurement by several commercial labs (Mycore Scientific, Science Museum of Minnesota) is through separation and alpha counting of progeny isotopes (e.g., ^{210}Po). A minimum of 1g dry weight sediment for each section is generally requested for radiodating. Gamma counting (for ^{137}Cs and ^{210}Pb) allows for non-destructive measurement of radioisotope signal, and can also be done by academic or commercial research institutions (e.g. Flett Research, USC).

If the age distribution of sediments in cores is found to be fairly uniform, chemicals can be analyzed at larger intervals. In contrast, cores showing large changes in age with depth will require sectioning and analysis at smaller intervals to better resolve the distribution of pollutants. For PCBs and PBDEs, the analytical laboratory performing sediment analyses for the RMP (East Bay Municipal Utility District) requires ~10g wet weight of sediment (about 5-7g dry weight). Laboratory requirements for total mercury are about 0.6-1.0 g wet weight.

Sediment pollutant concentrations often covary with sediment quality characteristics such as TOC and the percentage of fine-grained sediments due to physical and chemical partitioning, so analysis of these parameters will be included to aid interpretation of pollutant concentrations. Optionally, if there is remaining budget (or through reduction of the number of sites or sections to be analyzed for other pollutants), PBDEs may be analyzed in a number of cores. More recently deposited sections of depositional sites to confirm estimated past loads would be the best candidate for these analyses given limited resources. Sections also can be stored frozen to analyze at a later date for many of these pollutants, as degradation and loss rates from frozen samples are negligible. Those sections could be analyzed in future years should additional funds become available.

Data Analysis

The small number of samples and likely poor statistical power are not expected to support robust statistical evaluation of differences in sediment core characteristics for different sedimentation strata and segments. However, sample results can be used for addressing the objectives of the project described above. While it is not possible to predict exactly all the analyses that will be conducted until the data are available, the following discussion is meant to provide a description of how expected results will be analyzed to achieve each objective.

Objective #1: Provide a more comprehensive characterization of contamination with depth that can be used to assess future changes.
Collecting and analyzing cores will improve the present characterization of pollutant distributions in the Bay. Sediment pollutant distribution and age profiles will serve as important elements in characterizing the current condition of the Bay to supplement past and planned surface sediment sampling. In combination with surface pollutant distributions, the core data serve as our starting point for evaluating changes, both in estimating the initial pool of pollutants, and in our understanding sediment processes (e.g., the range of mixing depths encountered, spatial differences in pollutant sources and sediment characteristics and processes). Future work will collect and analyze surface samples and ideally cores from additional sites to continue improving our understanding of the Bay through more spatially representative sampling of the system.

In addition to their use in pollutant mass balance modeling, the measurements from the cores would themselves be vital technical information for use in policy development, e.g. for estimating risks posed to deeper residing benthic organisms by pollutants distributed in sediments below the surface 5cm typically sampled.

Objective #2: Verify the historic loading of contaminants to the Bay and how those loads have changed in the last several decades.
Cores from wetlands in each segment on the Bay margins will provide historical trends of pollutants in near-shore sediments. These will be compared to deposited Bay sediments from the same time periods (i.e. core sections of similar age) where data are available to identify similarities or differences in pollutant distributions that may provide information on sources or transport processes. For example, if wetland cores have higher pollutant concentrations, it may suggest either a nearby source, or partitioning and transport processes that fractionate pollutants preferentially in materials that deposit in wetlands (uncertainty in radiodating could make such comparisons difficult.) . Grain size and TOC data will provide further information that will help identify these possible confounding factors.

Pollutant concentrations and sediment accumulation rates in surface sediments from the Guadalupe watershed core will be compared to recently measured loads to understand the current relationship between deposited wetland sediments and exported loads. For example, pollutant concentrations in the core could be biased consistently high relative to the concentrations in suspended sediments in the riverine discharge. Such a relationship, combined with the historical wetland deposits, can then be used to improve historical estimates of pollutant loading from the watershed.

Wetlands core data also will be used to verify model expectations of pollutants in transported sediments for those periods. For example, if wetland cores do not show pollutant concentrations that mirror quantitatively or qualitatively the historical expectations, then adjustments to refine the model may be warranted (e.g., introducing a time lag between use pattern changes and watershed loading signals, or reallocating historical loads among watersheds or bay segments based on differences in deposited sediments). While there is always a danger of attempting to infer too much from a limited number of cores, the additional information will represent a large improvement over the current state of knowledge. Obtaining supporting information (e.g., different periods of development in various areas around the Bay, or the presence of specific pollutant sources in some watersheds) would provide additional confidence that such model adjustments would be warranted through support by multiple lines of evidence.

Objective #3: Provide data for parameterization and evaluation of the multi-box or other models.
The information derived from analysis of the cores described above will serve also as data for inputs or as verification of various portions of the multi-box mass budget model (the data are not, however, constrained for use with any particular model). Data from erosional areas can be used in estimates of pollutants reintroduced by sediment erosion and resuspension. Data from depositional cores can serve to verify or refine historical pollutant concentrations and sedimentation rates in different areas of the Bay. The age and distribution of pollutants in individual cores can also be compared to those predicted in mass budget modeling for hindcast runs. Pollutant distributions with depth can be used to initialize the model for forecast runs, and anticipated trends in loading (extrapolated from past loads) are also important inputs to these runs.

However, care must be taken not to over-interpret or attempt to fit the multi-box model too tightly to the core data, given their limited representativeness, and given simplifications used in the modeling that would not be reflected in the ecosystem. For example, the multi-box model subdivides Estuary segments into surface boxes that run shore to shore, whereas there likely are differences and asymmetry in loading sources, sediment processes, and bathymetry from one shore to the other within each of the model boxes in the Bay. Failures of the model to fit the collected data could represent limitations of the model or of the data. Members of the CFWG have suggested a number of statistical methods (bootstrapping, data/model melding) to overcome problems of limited representativenss of collected data combined with limitations arising from model assumptions and uncertainties. These analyses can be used for reviewing and revising the existing multibox model, or for evaluating confidence in any new models employed in the future.

Although USGS cores taken in 1990 in Richardson and San Pablo bays and more recent (ca 2000) cores in both northern and southern areas of the Bay have already have provided some evidence of pollutant loading histories, with over a decade since that first effort and the limited analyses on the more recent cores (e.g. no organic pollutants measured), the new cores collected in this effort will help characterize more recent trends, particularly for emerging pollutants like PBDEs. The fewer than 20 cores to be collected in this effort are also not likely sufficiently representative of the Bay, but they would represent a major step toward developing a more detailed and accurate understanding of sediment processes and pollutant distributions, as well as for refining and verifying simplistic assumptions and extrapolations currently being used in modeling.

SCHEDULE

A timeline for the various study tasks is indicated in Table 3:

Sampling and Analysis Plan Development	March – Sept 2005
Sampling and Analysis Plan Approval	November 2005
Field sampling	Jan-Feb 2006
Initial core sectioning and radiodating.	Feb-Mar 2006
Follow-up sectioning and core dating	Mar-Apr 2006
Chemical (pollutant) analyses	May-Aug 2006
Data QC and analysis	Aug-Oct 2006
Draft technical report	November 2006
Final report	January 2007

Table 3: Estimated Project Schedule

BUDGET

The budget presented in Table 4 assumes hiring of a commercial boat for sampling. Analytical costs are estimates based upon costs from laboratories on previous projects. The sample total in the budget also assumes only 17 sites sampled: 6 wetland sites (5 bayshore + Guadalupe), and 11 in the Bay (2 each segment, 3 Central Bay).

Component	Cost	CEP Share	RMP Share
Sample Collection & Processing			
22 bay sites	$63,565	$63,565	
6 wetlands	$17,000	$17,000	
Radiochemistry			
Preliminary radiodating 210Pb (5/core, 17 sites)	$25,500		$25,500
Followup 210Pb radiodating (5/core, 17 sites)	$25,500		$25,500
Organic Chemistry			
PCBs (10/core, 17 sites)	$68,000	$68,000	
OC Pesticides (10/core, 17 sites)	$21,250	$21,250	
PBDEs (8/core, 3 sites)	$5,400	$5,400	
Inorganic Chemistry			
Mercury (10/core, 17 sites)	$18,700	$18,700	
TOC, grain size (10/core, 17 sites)	$17,000		$17,000
Reporting			
Data QC and analysis	$8,000		$8,000
Data interpretation/analysis, final & draft report preparation	$24,000		$24,000
Contingency	$6,085	$6,085	
Total	$300,000	$200,000	$100,000

Table 4: Estimated Project Budget. Analytical costs are estimated as $300/sample for 210Pb (USGS or USC); $750/sample for PCBs, PBDEs, and OC Pesticides (EBMUD); and $110/sample for mercury (Batelle). A contingency day is include in the field sampling budget.

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