Final

Current Conditions Report

University of California, Berkeley
Richmond Field Station, Richmond, California

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Prepared for
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ACRONYMS AND ABBREVIATIONS

µg/L	Microgram per liter
ACA	Ammoniacal copper arsenate
AST	Aboveground storage tank
ASTDR	Agency for Toxic Substances and Disease Registry
AWQC	Ambient water quality criteria
BAPB	Biologically active permeable barrier
Bay Trail	East Bay Regional Park District Bay Trail
BBL	Blasland, Bouck & Lee, Inc.
bgs	Below ground surface
Bio-Rad	Bio-Rad Laboratories
Cal/EPA	California Environmental Protection Agency
CCA	Chromated copper arsenate
CCCHSD	Contra Costa County Health Services Department
CDFG	California Department of Fish and Game
CDPH	California Department of Public Health
CHHSL	California human health screening level
CKD	Cement kiln dust
CNDDB	California Natural Diversity Database
COC	Chemical of concern
COPC	Chemical of potential concern
CPT	Cone penetrometer test
CSM	Conceptual site model
CSV	Cherokee Simeon Ventures I, LLC
cy	Cubic yard
DCE	Dichloroethene
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethene
DDT	Dichlorodiphenyltrichloroethane
DHS	Department of Health Services
Division	Division of Radiation Safety
DTSC	Department of Toxic Substances Control
EEHSL	Environmental Engineering and Health Sciences Laboratory
EERC	Earthquake Engineering Research Center
EES	Ensco Environmental Services, Inc.
EH&S	Environment, Health & Safety

EPA	U.S. Environmental Protection Agency
ER-M	Effects range-median
E-SSTL	Ecological site-specific target level
FAMP	Feral Animal Management Program
FPL	Forest Products Laboratory
FSAP	Field sampling and analysis plan
HEA	Habitat Enhancement Area
H-SSTL	Human health site-specific target level
ICI	Imperial Chemical Industries, P.L.C.
JSA	Job Safety Analysis
LBNL	Lawrence Berkeley National Laboratory
MCL	Maximum contaminant level
MI/DU	Multi-incremental Decision Unit
MFA	Mercury Fulminate Area
mg/kg	Milligram per kilogram
MLLW	Mean lower low water
MSRI	Math Sciences Research Institute
NAWQC	National Ambient Water Quality Criteria
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
NRLF	Northern Regional Library Facility
ORP	Oxidation-reduction potential
PAC	Powder-activated carbon
PAH	Polycyclic [or polynuclear] aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PCE	Tetrachloroethylene
PG&E	Pacific Gas and Electric Company
PHA	Public health assessment
ppm	Part per million
PRG	Preliminary remediation goal
RA	Remediation area
RAP	Remedial Action Plan

RBSL	Risk based screening levels
RFS	Richmond Field Station
RSC	Radiation Safety Committee
RSO	Radiation Safety Officer
RUA	Radiation Use Authorization
SERL	Sanitary Engineering Research Laboratory
SMP	Soils Management Plan
SPRR	Southern Pacific Railroad
SSTL	Site-specific target level
Stauffer	Stauffer Chemical Company, Inc.
Stellar	Stellar Environmental Solutions
SVOC	Semivolatile organic compound
TCE	Trichloroethylene
TCRA	Time critical removal action
Tetra Tech	Tetra Tech EM Inc.
TMDL	Total Maximum Daily Load
TOC	Total organic carbon
TPH	Total petroleum hydrocarbons
TWP	The Watershed Project
UC	University of California
UC Berkeley	University of California, Berkeley
URS	URS Corporation
USFWS	U.S. Fish and Wildlife Service
UST	Underground storage tank
VOC	Volatile organic compound
Water Board	San Francisco Bay Regional Water Quality Control Board
WRC	Western Research Center
WSMRP	Western Stege Marsh Restoration Project
WTA	Western transition area
WTL	Wood Treatment Laboratory
Zeneca	Zeneca Inc.

EXECUTIVE SUMMARY

The University of California, Berkeley's (UC Berkeley) Richmond Field Station (RFS) is an academic teaching and research facility located adjacent to the San Francisco Bay and 6 miles northwest of the UC Berkeley Central Campus that has been used primarily for large-scale engineering research since 1950. The 170-acre property consists of 96 acres of uplands used for academic institutional activities, approximately 7.5 acres of tidal salt marsh, 5.5 acres marsh edge habitat and transition area, and approximately 61 acres south of the East Bay Regional Parks District's Bay Trail (Bay Trail), known as the outboard area, and consisting of tidal mud flats, marsh, and open water. This Current Conditions Report provides a comprehensive summary of current conditions at the RFS in accordance with the Department of Toxic Substance Control's (DTSC) Order, including the 96 acres of upland and 13 acres of tidal marsh. The DTSC Order does not apply to the 61-acre outboard area.

The RFS property currently supports a range of research and resource conservation values. With more than 500,000 assignable square feet of research space, the RFS houses one of the world's largest earthquake shaking tables, sophisticated test facilities for advanced transportation research, a regional laboratory for the U.S. Environmental Protection Agency (EPA), and the 7.7-million volume Northern Regional Library Facility (which serves as an archive for lesser-used books for four northern University of California campuses).

The open areas of the RFS are also prized for their research and habitat value. The RFS contains one of the largest and best-preserved remaining areas of native coastal grasslands once prevalent throughout the San Francisco Bay Area. The adjacent stands of eucalyptus trees provide a home for wintering monarch butterflies and nesting raptors. The tidal wetlands provide additional habitat for a variety of flora and fauna, including the endangered California clapper rail, as well as an opportunity for the UC Berkeley faculty, staff, and students to use these areas for teaching and research.

In September 2002, UC Berkeley began remediation work at the RFS to clean up contamination from industrial activities that occurred prior to UC Berkeley ownership of the land. UC Berkeley has spent more than $18 million on the cleanup and restoration project to date. As one component of the project, UC Berkeley continues to enhance and restore the shoreline and tidal salt marsh habitat, known as Western Stege Marsh.

This Current Conditions Report for the RFS has been prepared on behalf of The Regents of the University of California (UC), in response to the California Environmental Protection Agency (cal/EPA), DTSC, Site Investigation and Remediation Order, Docket No. ISE-RAO 06/07-004, dated September 15, 2006 (DTSC Order; see Appendix A). This Current Conditions Report provides a comprehensive summary of current conditions at the RFS in accordance with the DTSC Order, including a site-wide summary of past activities, current site conditions based on historic sampling analytical data, and anticipated data needs to plan further studies and assess whether any additional cleanup actions for the RFS are needed.

RFS DESCRIPTION AND HISTORY

The RFS is located at 1301 South 46th Street Richmond, California, along the eastern shoreline of the Richmond Inner Harbor of the San Francisco Bay and northwest of Point Isabel (see Figure 1). It consists of the uplands developed for academic teaching and research activities, an upland remnant coastal terrace prairie, tidal salt marsh (Western Stege Marsh), and a transition zone between the upland areas and marsh. Between the late 1800s and 1948, the California Cap Company and other smaller companies, manufactured explosives on the property. In 1950, UC purchased the property from the California Cap Company. UC Berkeley initially used the RFS for research for the College of Engineering and later, other campus departments and private tenants.

Historical chemical manufacturing operations at the California Cap Company and industrial operations at neighboring properties resulted in chemicals being released or deposited onto the RFS uplands, marsh and transition areas. From 1897 to 1970, the former Stauffer Chemical Company Inc. (later Zeneca, Inc. [Zeneca]), the previous owner of the property bordering the RFS to the east (referred to in this report as the "former Zeneca site"), manufactured sulfuric acid from iron sulfide ore (pyrite) and other industrial chemicals. These production activities created residual pyrite cinder. Large quantities of cinders were deposited on the RFS prior to 1950, as well as on the former Zeneca site. Pesticides were also manufactured at the former Zeneca site until 1997. Activities at the former Kaiser Shipyard, at the southwest border of the RFS, likely resulted in the deposit of paint-related metals and hydrocarbons into Western Stege Marsh. Activities at other neighboring facilities, including Bio-Rad Laboratories, Pacific Gas and Electric Company (PG&E), Harbor Front Industries, and Liquid Gold may have historically contaminated portions of the RFS. One known UC academic research and teaching operation resulted in metals releases on a small portion of the upland RFS near the former Forest Products Laboratory (FPL) at Building 476. Runoff conveying urban pollutants from the surrounding watershed, including air-deposited pollutants, is another potential source of contaminants at the RFS.

Environmental investigations of the RFS date back to 1981, including work performed for planning of the construction of the EPA Region 9 Laboratory in 1991. In 1999, the San Francisco Bay Regional Water Quality Control Board (Water Board), another division of the Cal/EPA, identified the Western Stege Marsh as an environmentally contaminated area. Under Water Board oversight, UC Berkeley investigated the extent of pollution in Western Stege Marsh and the RFS uplands. Between 1999 and 2002, UC Berkeley's environmental consultants completed extensive investigations, including reviews of historic records and aerial photographs and collection and analysis of hundreds of environmental samples (soil, sediment, and water) that were analyzed for a wide range of chemical constituents, including mercury, arsenic, and other metals; pesticides; polychlorinated biphenyls (PCB); semivolatile organic compounds; radionuclides; and explosives.

After extensive sampling of soil, groundwater, and sediment on the RFS, UC Berkeley identified areas contaminated with mercury, as well as certain heavy metals - including arsenic, cadmium, copper, lead, selenium, and zinc - that are associated with pyrite cinders. Elevated concentrations of mercury were discovered in Western Stege Marsh and portions of the adjacent RFS uplands. UC Berkeley confirmed that most of the contamination was the result of historical

industrial manufacturing operations dating back to the late 1800s. PCBs of unknown origin were also found in the marsh. In 2001, a human health and ecological risk assessment was completed and areas of concern in the upland and marsh areas were identified for risk management through removal actions.

RFS REMEDIATION HISTORY

In 2002, UC Berkeley established an aggressive plan for cleaning up the historic contamination at the RFS under the oversight of the Water Board. All of UC Berkeley's remediation plans required and received the Water Board's approval, as well as permits and access agreements from numerous other agencies, including the U.S. Army Corps of Engineers, the Bay Conservation and Development Commission, the East Bay Regional Parks District, the U.S. Fish and Wildlife Service, and the City of Richmond. All cleanup activities have been performed under stringent health and safety protocols to ensure the protection of remediation workers, RFS employees, visitors, and the surrounding community. The project's environmental impacts were assessed through a UC-led California Environmental Quality Act review process.

UC Berkeley performed three phases of remediation from 2002 to 2004 under the oversight of the Water Board, which resulted in the excavation and removal of more than 60,000 cubic yards (cy) of contaminated soils and sediments from the RFS and the restoration of 6.5 acres of tidal salt marsh. The remediation and restoration projects at the RFS were performed in phases, in part due to the prohibition of working in the marsh during the California clapper rail breeding season (February 1 through August 31). A brief description of the three phases of remediation activities performed at RFS under the Water Board is as follows:

- Phase 1: August to December 2002. An area at the RFS (bordered by the former Zeneca site on the east and the Bay Trail to the south) that was impacted by pyrite cinders and mercury was cleaned up. The Phase 1 cleanup involved digging up and removing approximately 28,000 cy of contaminated soil and marsh sediment from RFS.

- Phase 2: August 2003 to February 2004. Approximately 31,000 cy of contaminated material was removed and taken to the former Zeneca property. The Phase 2 remediation activities also included excavation of a localized area of PCBs at the outfall of a storm drain in Meeker Slough, which is located in the western portion of Western Stege Marsh. UC Berkeley also began restoration of the portions of the marsh that were remediated during Phase 1 and 2 and backfilled with clean bay mud.

- Phase 3: September 2004 to November 2004. Approximately 3,300 cy of soil contaminated with metals and PCBs were excavated from six areas in the Upland Area and transported to State-approved off-site landfills. UC Berkeley also continued restoration of the areas cleaned up in the first two phases of work.

In October and November 2007, UC Berkeley performed a time-critical removal action (TCRA) at the former FPL Wood Treatment Laboratory (WTL) site under the oversight of DTSC to excavate 140 cy (in-situ volume) of arsenic-affected soil. The excavated soil was transported to a State-approved off-site landfill.

CURRENT ENVIRONMENTAL CONDITIONS

This Current Conditions Report presents a summary of current environmental conditions at the RFS. For purposes of this analysis, the RFS has been divided into three general areas. The Upland Area includes the institutionally-developed area bounded on the south by the Transition Area. The Transition Area is an area between the Upland Area and Western Stege Marsh where imported fill was historically placed on top of the former tidal mudflat. The Transition Area includes a feature known as "the Bulb," and the Connector Trail to the Bay Trail. Western Stege Marsh is the tidal salt marsh between the Transition Area and the Bay Trail.

Western Stege Marsh includes Meeker Slough, the primary drainage of Western Stege Marsh and the watershed in which the RFS is located. Meeker Slough is the eastern border of the nearby Marina Bay housing development and it is located on City of Richmond property. Two property boundary areas discussed in this report are the eastern boundary with the former Zeneca site along South 46th Street and the northern boundary along Meade Street and adjacent to the former PG&E maintenance yard.

In May 2005, agency jurisdictional oversight was transferred from the Water Board to the DTSC. The DTSC Order was issued and an Order issued by the Water Board was rescinded. Beginning in May 2005, Contra Costa County Health Department Officials and the California Department of Public Health (CDPH) studied potential exposures and health effects arising from the former Zeneca site and RFS. In March 2008, CDPH and the federal Agency for Toxic Substances and Disease Registry (ATSDR) released a Public Health Assessment (PHA) for the RFS. The PHA concluded that outside of the fenced former mercury fulminate plant area there is no evidence that working in Uplands Area is hazardous. The PHA states that "walking on the ground at the RFS would not expose people to contaminants at levels of health concern." The PHA also recommended that UC Berkeley complete a variety of actions, many of which have already been completed, including training workers that could be exposed to residual pyrite cinders and potentially contaminated soil during excavation activities.

Upland Area

The Phase 3 remediation activities conducted in 2004 consisted of the removal of metals-contaminated soils in five areas located in the Upland Area to assure the safety of humans and ecological receptors. In addition, soil and caulking material containing PCBs was removed in one area.

The TCRA performed in October and November 2007 in the vicinity of the former FPL WTL removed approximately 140 cy (in situ volume) of arsenic-affected soil.

The soil in the area of the former California Cap Company's mercury fulminate manufacturing plant, known as the mercury fulminate area (MFA), contains elevated concentrations of mercury, arsenic, cadmium, copper, lead, and zinc. This area is currently fenced off as a restricted access zone. UC Berkeley plans to clean up this area in the near future.

In addition to the MFA, thin layers of pyrite cinders that were historically placed as fill by the California Cap Company are found intermittently in some localized areas in the Transition and Upland Areas. These pyrite cinders typically contain elevated concentrations of arsenic, cadmium, copper, lead, nickel and zinc. Working in conjunction with DTSC, UC Berkeley has developed an interim Soils Management Plan to effectively identify and manage the pyrite cinders during RFS maintenance and research activities.

In December 2003, a slurry wall was installed along the RFS and the former Zeneca site property boundary in the southern portion of 46th Street. The slurry wall extends from approximately 3 feet below ground surface (bgs) to 23 feet bgs and is reportedly 3 feet wide and approximately 610 feet long. The slurry wall was constructed with a mixture of soil and bentonite.

Detectable concentrations of chlorinated hydrocarbons have been identified in groundwater along the RFS/former Zeneca site property boundary in the northeastern portion of the RFS near Building 476. In 2006, DTSC required additional characterization of chemicals in the shallow and intermediate groundwater zones along the property boundary between RFS and the former Zeneca site.

Transition Area

During the remediation activities performed in 2002 and 2003, the contaminated soil and sediments present in the eastern half of the Transition Area were excavated and backfilled with clean imported soils, which is the current condition. During the 2002 remediation activities, UC Berkeley also installed a biologically active permeable barrier (BAPB) wall in the Transition Area. This BAPB wall extends eastward onto the former Zeneca site. The BAPB wall was installed between ground surface and a depth of 20 feet to treat dissolved metals in groundwater that may be migrating toward the marsh. Groundwater at depths greater than 20 feet bgs may be contaminated with metals that would not be treated by the BAPB. The horizontal and vertical distribution of metals in groundwater has not been determined, but will be investigated in the upcoming field sampling workplan. A groundwater monitoring plan will be determined following characterization, and will be implemented after DTSC has reviewed and approved the plan.

The western portion of the Transition Area consists of about 5 feet of fill material placed in the area beginning in the 1960s. Beneath the fill material, elevated concentrations of arsenic and mercury had been identified in the underlying sediments of the former tidal mudflat. A layer of pyrite cinders (approximately 2 feet thick and 10 feet wide) used as bedding material for the former southern sanitary sewer line has been identified in subsurface soils in the Western Transition Area (WTA). Most of this sanitary sewer line (and associated cinder backfill material) was removed during the 2003 remediation activities. Elevated concentrations of arsenic and lead have been identified in the vicinity of this area.

A portion of the Transition Area known as “the Bulb” may have historically been used for the disposal of vegetative and miscellaneous site debris and drums into trenches at depths at or below groundwater levels. Based on an interview with a former RFS employee, DTSC’s Geologic Services Unit conducted a magnetometer survey in the Bulb area to investigate the potential presence of buried metal drums in this area. Analysis of the results of the

magnetometer survey showed a strong anomaly centered 170 feet south-southwest of the concrete pad (constructed during the 2003 remediation activities) that is located in the center of the Bulb area. DTSC's Geologic Services Unit concluded that the anomaly is some kind of large ferrous body buried at an unknown depth that warrants further investigation.

Western Stege Marsh

Contaminated vegetation, soils, and sediments present in the north-central and eastern portions of Western Stege Marsh were removed between 2002 and 2004. Contaminated materials were excavated down to the underlying clean bay mud and transported off site to State-approved landfill facilities, and the areas were backfilled with clean imported bay mud. Since the remediation activities were performed between 2002 and 2004, fine-grained sediments deposited on top of the clean backfill material have been discovered to contain slightly elevated concentrations of metals and PCBs. Results of sampling of this sediment completed since 2005 shows stable or slightly decreasing concentrations. The ATSDR March 2008 PHA concluded that these slightly elevated concentrations do not pose a public health hazard, but recommended ongoing monitoring. UC Berkeley is currently performing aggressive marsh restoration activities in the remediated portions of Western Stege Marsh.

RESTORATION

UC Berkeley is restoring the native marsh and upland environment in the recently remediated areas of the RFS through active vegetation management, including invasive weed removal and the reintroduction of native plants. Work conducted to date includes: (1) revegetation with native plants of the ecotone (the vegetated strip between the marsh and upland that provides cover for the California clapper rail during high tides) along the entire edge of the remediated Western Stege Marsh and the fill island in the south part of the marsh; (2) removal of non-native invasive plants, including non-native cordgrass and perennial pepperweed; (3) planting of native cordgrass and other native marsh plants in the remediated marsh; and (4) restoration of approximately 1 acre of upland coastal terrace prairie.

CONCEPTUAL SITE MODEL

The Current Conditions Report presents a conceptual site model (CSM) that identifies potential sources, migration pathways, fate and transport of contaminants, and exposure pathways to human and ecological receptors. The CSM concludes that on-site workers (UC Berkeley staff and researchers and workers of RFS tenants) are not likely to be exposed to chemicals in surface and subsurface soils.

DATA GAPS

The following areas of the RFS are identified as data gaps warranting additional characterization. UC Berkeley will develop a field sampling workplan which will present recommended investigations, including soil, soil gas, and groundwater sampling, to assess the potential for contamination in these areas. The sampling strategy and data quality objectives for all areas and media will be developed in concurrence with DTSC. For many of the data gaps, there is no

evidence from any source that spills occurred in these areas, however, because chemicals were used or stored in these areas, UC Berkeley proposes further investigation. UC Berkeley plans to use various sampling or screening methods to evaluate these areas.

- **Groundwater.** Additional characterization of groundwater is needed at the RFS. This includes collecting general hydrogeologic information (groundwater elevations and lithology) to generate a hydrogeologic model and groundwater quality data (chemical concentrations, total dissolved solids concentrations, metals bioavailability data, etc.). Additional characterization is needed to adequately characterize soil and groundwater conditions in the following areas:

    - Building 478 where shallow-zone groundwater containing volatile organic compounds (VOC) has been identified in the vicinity of the nearby Campus Bay Site Lot 1 removal action performed in the summer of 2008.

    - Western Transition Area, including the southern portion of the Western Storm Drain line where metals (cadmium, copper, mercury, nickel, and zinc) and PCBs may be present at elevated concentrations.

    - Shallow, Intermediate, and Deep Groundwater Zones along the RFS/former Zeneca site property boundary that is between the southern portion of the Building 478 area and the southern end of the slurry wall where metals, pesticides, and VOCs have been identified in groundwater.

    - The Biologically Active Permeable Barrier wall. The effectiveness of the portion of the BAPB wall located on the RFS property has yet to be assessed and additional information is needed to characterize the shallow and intermediate zone's groundwater quality in the vicinity of the wall.

    - Shallow, Intermediate, and Deep Groundwater Zones in various areas across RFS. Additional investigation is needed to adequately characterize groundwater zones in various areas across the RFS.

- **Sanitary Sewer Lines.** The historical and existing sanitary sewer lines may have possibly served as preferential pathways for contaminant transport at RFS and will be further investigated.

- **Bulb Area (Western Transition Area).** Anecdotal information suggests disposal of miscellaneous debris may have occurred in this area. A follow-up magnetic survey performed by DTSC's Geologic Services Unit located a magnetic anomaly indicating the potential presence of buried ferrous metal that DTSC stated "warrants further investigation".

- **Research Facilities.** Many current and historic research facilities used or stored hazardous chemicals. Although there are no indications from any other sources that spills have occurred in these areas, there has been limited or no samples collected in these areas. These areas include: the earthquake engineering facilities at Buildings 420 and 421, Buildings 102, 110, 111, 112, 113, 114, 117, 118, 121, 125, 138, 150, 151, 158, 175, 177, 197, 278, 280A, 280B, 450, 460, 470, 474, 478, 480, and 482. There have been reported spills in the vicinity of Building 120 and the RFS Corporation Yard; however, there is no site-specific data available in these two areas.

- **Above Ground Storage Tanks (AST).** The ASTs are in good condition and there have been no reports of releases from the ASTs; however, there is no site-specific data available in the vicinity of the tanks.

- **Engineering Geosciences Well Field.** The Geosciences Well Field was installed in the 1980s and has been used and continues to be used primarily for research on borehole-to-surface electrical resistivity monitoring to accurately map subsurface ground water flow. No site-specific characterization data is available for these wells.

- **Former PCB-containing Transformers Areas (including temporary storage in Building 280B):** There are currently no PCB-containing transformers at the RFS. All former PCB-containing transformers have been removed and there are no records to indicate that there were any spills or releases in any of the former transformer areas; however, no site-specific characterization data is available for Building 280B or the former transformer areas.

- **Former California Cap Company Test Pit and Dry House.** These two areas were identified as areas where explosions may have occurred during California Cap Company operations. No site-specific characterization data for explosive residues is available for these areas.

- **Former California Cap Company Tram Line.** The tram line's construction, use, how it was maintained, or if historical releases occurred along the various tram lines is not known. No site-specific characterization data exists along several sections of the former tram line.

- **U.S. Briquette Company and Pacific Cartridge Company.** These companies have been identified on historical Sanborn maps from 1912 and 1916 as operating on the property when it was owned by the California Cap Company. No site-specific characterization data exists in the areas these companies reportedly operated.

- **Western Stege Marsh.** Further information is needed to determine if the contaminant concentrations in sediments in the marsh pose a significant risk to human and ecological receptors.

1.0 INTRODUCTION AND BACKGROUND

This Current Conditions Report for the University of California, Berkeley's (UC Berkeley), Richmond Field Station (RFS) has been prepared on behalf of The Regents of the University of California (UC), in response to the California Environmental Protection Agency (Cal/EPA), Department of Toxic Substances Control (DTSC), Site Investigation and Remediation Order, Docket No. ISE-RAO 06/07-004, dated September 15, 2006 (DTSC Order; see Appendix A). This report provides a site-wide summary of past activities, current site conditions, and anticipated data needs to plan further studies and assess the need for additional cleanup actions for the RFS.

UC Berkeley has conducted numerous environmental investigations at the RFS. UC Berkeley investigated the marsh and sources of historic contamination under the oversight of the San Francisco Bay Regional Water Quality Control Board (Water Board). Three phases of remediation in the marsh and uplands were completed from 2002 to 2004, also under the oversight of the Water Board, in accordance with Site Cleanup Requirement Order No. 01-102 issued in October 2001 (Water Board 2001). In May 2005, the Cal/EPA designated DTSC as the lead environmental agency for the RFS, replacing the Water Board (which rescinded its Order in October 2005). After receiving the DTSC Order, UC Berkeley has performed a Time-Critical Removal Action (TCRA) in October and November 2007 in the vicinity of the former Forest Products Laboratory (FPL) Wood Treatment Laboratory (WTL) near Building 476 and has completed some additional soil and water investigations under the oversight of DTSC.

This Current Conditions Report is designed "to provide a comprehensive summary of current conditions at RFS," in accordance with Section 5.2.2 of the DTSC Order. The report summarizes investigations, removal, and remedial actions at RFS, provides historical information on previous uses of the RFS, and compiles data collected during previous investigations. This report also serves as a planning tool for future investigations and remediation. To meet these objectives, this report contains the following sections:

- **Section 1.0 – Introduction and Background**, discusses site description and history; compiles previous investigation and previous remediation information in one document; and summarizes existing environmental data currently available for RFS.
- **Section 2.0 – Conceptual Site Model (CSM)**, discusses sources of chemicals; assesses potentially affected media and migration pathways; evaluates the persistence and mobility of chemicals in the Upland Area, the Transition Area (including the Bulb), and the Western Stege Marsh environments; and identifies actual and potential receptors at the RFS.
- **Section 3.0 – Data Gaps for Richmond Field Station,** discusses potential data gaps and data uncertainties.
- **Section 4.0 – References**, lists the documents used to prepare this report.

Figures and tables are presented following Section 4.0 of this report. In addition, the following appendices (presented after the figures and tables) provide supporting information used to prepare this report:

- Appendix A, DTSC Order
- Appendix B, Water Board Order
- Appendix C, Photographs of the Richmond Field Station and Vicinity Properties
- Appendix D, Environmental Data Tables
- Appendix E, Technical Report – Summary of Polychlorinated Biphenyl (PCB) Results, Richmond Field Station, University of California, Berkeley, Richmond, California
- Appendix F, Magnetometer Survey
- Appendix G, Radiological Survey and Sampling Data
- Appendix H, Analytical Results of Soil Samples Representing Backfill Materials
- Appendix I, Underground Storage Tank (UST) Closure Reports and Soil Sample Analytical Results
- Appendix J, Hydrogeologic Summary Report
- Appendix K, Response to Comments
- Appendix L, Multi-Incremental/Decision Unit (MI/DU) Sampling Letters

1.1 SITE DESCRIPTION, HISTORY, AND CURRENT USES

This section provides a site description, historical information on previous site owners and uses, and information about current site uses.

1.1.1 Site Description

The RFS is located at 1301 South 46th Street Richmond, California, along the eastern shoreline of the Richmond Inner Harbor of the San Francisco Bay and northwest of Point Isabel (see Figure 1). It consists of upland areas developed for academic teaching and research activities, an upland remnant coastal terrace prairie, tidal salt marsh, and a transition zone between the upland areas and marsh. Between the late 1800s and 1948, several companies, including the California Cap Company, manufactured explosives at the RFS. In 1950, UC purchased the property from the California Cap Company. UC Berkeley initially used the RFS for research for the College of Engineering and, later, other campus departments.

In this Current Conditions Report, the RFS is discussed in terms of types of habitat because future use and potential receptors vary by the type of habitat available. Three habitat type areas have been identified: (1) the Upland Area, (2) the Transition Area, and (3) the Western Stege Marsh (see Figure 2). Current existing buildings and the RFS's site features can be seen on Figure 3. Under the Water Board Order, the RFS was formerly designated as Subunit 2 of the Meade Street Operable Unit. Subunit 2 was further divided into Subunits 2A (Upland Area and Marsh) and 2B (Upland Area and Marsh) (see Figure 4).

The 170-acre property consists of 96 acres of uplands bounded by Meade Street and Hoffman Boulevard to the north, South 46th Street to the east, the Transition Area to the south, and Meeker Slough and Regatta Boulevard to the west. The Transition Area occupies approximately 5.5 acres and is bounded to the north by the Upland Area at the location of a buried, former seawall that is believed to have been the edge of the historic mudflats and to the south by Western Stege Marsh at the 5 foot elevation upper extent of the marsh [National Geodetic Vertical Datum 29 (NGVD 29)]. The Transition Area is believed to consist entirely of artificial fill placed on historic mudflats. Western Stege Marsh occupies approximately 7.5 acres and is bounded by the Transition Area to the north, the RFS connector trail to the East Bay Regional Park District Trail (Bay Trail) and Eastern Stege Marsh to the east, the Bay Trail to the south, and Meeker Slough and Marina Bay housing development to the west (see Figure 2). Western Stege Marsh includes a small isolated area of artificial fill known as the Island that occupies 0.425 acres and is surrounded by tidal marsh (see Figure 5). RFS property includes 61 acres south of the Bay Trail, known as the outboard area, consisting of tidal mud flats, marsh, and open water. The DTSC Order does not apply to the 61-acre outboard area.

1.1.1.1 Climate

Meteorological conditions for the City of Richmond are influenced by its proximity to the central San Francisco Bay estuary, the Pacific Ocean, and the Oakland-Berkeley Hills. The prevailing winds along the south Richmond shoreline are southeasterly and southwesterly, with an average wind speed of 6 to 7 miles per hour. Due to exposure along the San Francisco Bay fringe, the area is subject to frequent wind gusts. Average annual daily temperatures for Richmond range from 50 °F in the winter to 67 °F in the summer. Average total precipitation for Richmond is 23 inches annually, with approximately 83 percent of the annual rainfall occurring between November and March.

1.1.1.2 Geology and Hydrogeology

The RFS is located at the distal end of an alluvial plain that slopes to the southwest. The Hayward Fault Zone transects the alluvial plain to the northeast, toward the Berkeley Hills. The alluvial plain consists of relatively recent Quaternary age deposits (less than 2 million years old).

The lithology of the alluvial plain is primarily consolidated to unconsolidated clay, silt, sand, and gravel, with organic-rich clay and silt bordering the San Francisco Bay. The total thickness of the deposits ranges from shallow surface deposits, where the alluvium thins against the Berkeley Hills, to a depth of approximately 300 feet (URS Corporation [URS] 2000). These deposits are

underlain by bedrock of the Mesozoic Franciscan Formation. The Franciscan Formation is a complex assemblage of serpentinite, greenstone, greywacke, chert, shale, sandstone, and schist, found on many ridges and mountains of the San Francisco Bay region (URS 2000).

Four major hydrogeologic units were defined for the RFS area as follows (Woodward-Clyde 1993):

- Artificial Fill
- Quaternary Alluvium
- Bay Sediments
- Yerba Buena Mud (Older Bay Mud)

The Artificial Fill at RFS predominantly consists of imported soils, including pyrite cinders that originated from adjacent properties, and on-site soils that were moved and re-deposited in upland areas as part of construction activities. Most of the artificial fill that was historically and recently imported to the RFS was placed in the Transition Area and in the areas excavated during Phase 3 remedial activities performed in the fall of 2004. The Transition Area formerly contained a large area of pyrite cinders that was excavated as part of remediation activities by UC Berkeley in 2002 to 2004. Excavated areas were backfilled with clean upland fill from sources outside of the RFS. The Upland Area of the RFS is a topographically flat area of an alluvial fan reflecting historic conditions (Nelson 1910). Pyrite cinders have been found in small patches around buildings. Pyrite cinders at RFS are managed according to the DTSC-approved Pyrite Cinder-containing Soils Management Plan. Imported clean upland soil was used for backfill in five areas excavated during Phase 3 of the remediation project in 2004 and one area during the 2007 FPL TCRA (see Appendix H for backfill analytical laboratory results). Two areas of mounded soil, to the north and to the west of the Environmental Protection Agency (EPA) laboratory are believed to have been native soils deposited as part of grading activities during the EPA laboratory construction. Imported fill has also been used for road base and utility backfill in the Upland Area.

The Quaternary Alluvium consists of fine- to coarse-grained sediments. The Bay Sediments consist of fine- to very fine-grained sediments, while the Yerba Buena Mud is a fine-grained unit, which behaves as a regionally extensive aquitard.

Most of the borings, temporary piezometers, and monitoring wells that have been advanced at the RFS were completed for environmental investigation near-surface and artificial fill and only extend to a depth of approximately 20 feet below ground surface (bgs). Information about the deeper site geology is limited to data collected from 25 monitoring wells installed to depths of approximately 90 to 100 feet bgs as part of a sanitary engineering research project in the 1950s and to eight wells installed by the Engineering Geosciences group in 1986 in the Engineering Geosciences Well Field.

Evaluation of the lithologic logs from the Sanitary Engineering wells indicated that water-bearing zones are present at depths between 30 and 74 feet bgs (Stellar Environmental Solutions [Stellar] 2005). Together, these data suggest that at least three water-bearing zones are present at the RFS:

- Shallow-zone groundwater, from approximately 10 to 20 feet bgs
- Intermediate-zone groundwater, from approximately 30 to 74 feet bgs
- Deeper-zone groundwater, from approximately 90 to 100 feet bgs

Evaluation of the Engineering Geosciences Well Field in 1987 identified three separate aquifer zones with hydrologic connection to the Sanitary Engineering Well Field with a westward regional hydraulic gradient (Pouch, Gregory W., 1987). The well field is discussed in further detail in Section 1.1.4.2.

In March 2000, UC Berkeley measured the depth to groundwater in 27 open borings after soil and water samples were collected. Groundwater elevations were determined and used to evaluate groundwater flow directions in shallow groundwater at RFS. UC Berkeley's environmental consultant's interpretation of the results of the March 2000 sampling event indicated that during the late winter/early spring groundwater flows to the west/southwest in the southern portion of RFS and to the west/northwest in the northern portion of the RFS (URS 2000).

In 2002, UC Berkeley installed three temporary piezometers in the southeastern portion of the RFS to further evaluate shallow groundwater elevations and flow directions, as discussed further in Section 1.2.1.6. These three piezometers were removed in February 2006, with DTSC approval and under permit and inspection by the Contra Costa County Health Services Department. UC Berkeley's environmental consultant's interpretation of the results of this evaluation indicated that groundwater flows to the southwest in the southern portion of the Upland Area of the RFS.

Based on groundwater monitoring well observations throughout the former Zeneca site, located adjacent to and east of the RFS, groundwater flow is generally south toward San Francisco Bay (LFR, Inc. 2005a, 2005b, 2005c). It should be noted that these groundwater flow directions are based on current site conditions following remediation activities that were performed at the former Zeneca site in 2002 and 2003, including the excavation and placement of stabilized pyrite cinders in the cinder placement area, installation of the slurry wall along the southern boundary between RFS and the former Zeneca site, installation of a biologically active permeable barrier (BAPB) wall, and installation of a temporary cap (HydroSeal) over the cinder placement areas.

Additional information on site-specific groundwater flow directions will be collected as part of the upcoming field sampling workplan and groundwater monitoring plan activities.

1.1.1.3 Ecology

The RFS consists of a number of distinct and varied habitats resulting from both natural and manmade activities. The northern portion of the RFS consists of numerous research facilities, with their associated out-buildings surrounded by landscaped trees and plants. The eastern and central portions of the RFS are largely developed and few natural ecological conditions exist. The western portion of the RFS includes a coastal grassland area that contains many Californian endemic species. The southern portion of the RFS is the least developed and consists of a low salt marsh, middle salt marsh, high salt marsh, and tidal wetlands. The plants observed in this area include both native and non-native species and attract a variety of special-status species birds such as the California clapper rail (*Rallus longirostris obsoletus*). Site ecology and ecological receptors at the RFS are discussed in further detail in Section 2.4.2.

1.1.1.4 Surface Water

The RFS is located in a small unnamed watershed that primarily drains the neighboring City of Richmond properties to the west and north (see Figure 6). The watershed is almost completely urbanized and consists of housing, light industry, commercial and institutional facilities, and some small parks.

Stormwater from the neighboring City of Richmond properties is conveyed through underground culverts to two open channels to the west of the RFS. An open concrete-line culvert (often referred to as Meeker Ditch) is present along the western property boundary that discharges at the southwest corner of the RFS Upland Area into Meeker Tidal Creek. Meeker Tidal Creek begins at the outfall of a culvert along Marina Bay Parkway and drains between Marina Bay and developed and undeveloped properties along Regatta Boulevard. Both the culvert and Meeker Tidal Creek are tidally influenced. Meeker Slough is on City of Richmond property to the west of Western Stege Marsh and begins at the confluence of these two drainages. Meeker Slough was historically an open tidal channel near the edge of the Upland Area. Historical changes in the tidal mudflat, including construction of breakwaters and the Southern Pacific Railroad (SPRR) spur and importation of fill for the Kaiser Shipyards, created the constrained channel that exists today.

On-site stormwater drainage is by overland flow that is conveyed on the Upland Area through a series of culverts and open swales. Two subcatchments on the RFS drain to two storm drain outlets at the edge of Western Stege Marsh, known as the Eastern Storm Drain and the Western Storm Drain. These storm drains discharge into a series of tidal salt marsh channels that drain to Meeker Slough. The Western Storm Drain line also historically acted as a City of Richmond sanitary sewer overflow pipe (see Section 1.1.5.5). The overflow was plugged with cement grout by UC Berkley in 2004 and the remaining active portion of the line now only transports on-site stormwater runoff. A third, smaller subcatchment to the west of the EPA laboratory drains discharge overland directly into Meeker Slough.

An unspecified portion of the former Stauffer Chemical Company, Inc. (Stauffer) site and later the Zeneca site, located on the eastern side of 46th Street, historically drained stormwater runoff

to the Eastern Storm Drain on the RFS through a storm drain pipe originating on South 46th Street near Building 185. Following remediation activities performed on the former Zeneca site in 2002 and 2003, only a small amount of surface runoff from the former Zeneca site, primarily the southern portion of South 46th Street, drains to the storm drain inlet near Building 185.

Seasonal wetlands are also present at RFS, mostly in the coastal terrace prairie areas located to the north and west of the EPA Laboratory, which is located in the southwestern portion of the RFS Upland Area, as shown on Figure 5.

1.1.2 Site History Overview

This section discusses the history of the RFS and provides an overview of historical ownership and site features. Subsequent sections provide further details about the California Cap Company history at the RFS (Section 1.1.3); UC research, teaching, operations history, chemical use, and storage at RFS (Section 1.1.4); and the history of off-site properties (Section 1.1.5). Aerial photographs for years 1948, 1953, 1957, 1959, 1966, 1969, 1975, 1977, 1983, 1998, 2003, 2004, 2005, and 2008 are provided in Appendix C, Photographs C-1 through C-14. The research for the following sections included but was not limited to records reviews, photograph reviews, and review of materials at the Richmond Public Library. Not all photographs discovered were included in the report due to the volume of material found. Anecdotal information that could not be substantiated was not included in this report.

1.1.2.1 Early Site History

The RFS property has been subject to numerous land alterations through its history of development, including ditching and culverting to channel storm drainage, the placement of fill onto tidal mudflats and to a lesser degree in the uplands, the construction of buildings and utilities, and the placement of structures on tidal mudflats such as a pier, breakwaters, and a railroad embankment.

Prior to settlement of the East Bay plain by the Spanish beginning in the 1772, the region was an upland treeless plain with creeks. The following is an early description of the area where the RFS is located when it was part of the town of Stege: “At Stege, there has been, as far back as anyone remembers, a gap in the marsh belt made by a small tongue of the upland which fronts the bay waters with a six to eight foot bluff” (Nelson 1910). The shoreline contained extensive tidal mudflats and limited areas of tidal marsh, making the area excellent for fishing and shellfish harvesting by Native Americans living in the region. Evidence of Native American occupancy of the region included large shell mounds, known as the Stege Shellmounds, to the west of the RFS that were removed in 1915 for the development of the Harborgate tract (Loud 1924).

The RFS was part of a land grant from the Spanish Governor of Alta, California to Francisco Maria Castro in 1823 and was part of Castro’s Rancho San Pablo. Wheat was grown on the rancho, and a grain storage warehouse was built on the RFS (at the current location of Building 102). The Rancho was subdivided and sold in the 1850s. Richard Stege raised frogs for

restaurants in San Francisco and is believed to have constructed the pier on the mudflat known as Stege Landing. In the late 1800s, portions of the property were sold and chemical and explosives industries moved into the area. Between the 1880s and 1948, the California Cap Company, manufacturer of blasting caps, shells, and explosives, and several other small companies, including the U.S. Briquette Company and the Pacific Cartridge Company, operated explosives manufacturing plants at the RFS (UC Berkeley 1973). Research has demonstrated that there is very little known information regarding activities at the RFS prior to World War II. The California Cap Company slowed operations following World War II, but no additional information is available. The locations of former California Cap Company facilities and buildings are shown on Figures 7 and 8.

In October 1950, the UC Regents purchased the California Cap Company property with the agreement that the California Cap Company would remove all hazardous materials from the property. In 1951, UC acquired the adjacent undeveloped property between Avocet Way and Regatta Boulevard in the western portion of the RFS. During the 1950s, new buildings were constructed in the northeastern portion of the RFS to accommodate research programs sponsored by UC Berkeley's College of Engineering. The research activities are discussed further in Section 1.1.4.

1.1.2.2 Formation of Western Stege Marsh

The formation of tidal wetlands in the Stege Marsh area is a relatively recent occurrence. Prior to the construction of the former SPRR grade in 1959 (currently the Bay Trail), the Stege Marsh area was open water or intertidal mudflat. Around 1959, the SPRR placed fill material along the coastline and south of the breakwater in the marsh to build a rail spur. Around the same time, likely during construction of the rail spur, a linear mound of dirt approximately 10 feet wide was placed parallel to the rail spur approximately 90 to 100 feet from the railway. This area of elevated land is known as the Island and can be seen on Figure 5. As a result of the railroad embankment, the northern and southern portions of the marsh became relatively isolated. The only opening between Western Stege Marsh and the open bay water was one bridged breach in the railroad embankment to allow flow from Meeker Slough in the western portion of the marsh. Although the spur was constructed by the SPRR, it is believed that the land belonged to the Santa Fe Railroad. The source of the fill used to build the raised rail spur is not known; however, it is assumed that because it was a small project, the source of the fill is similar to fill operations conducted by railroad companies at a regional level, which would have been a combination of local dredged material or local fill. The historic seawall provided evidence of the San Francisco Bay's historic shoreline. Establishment of the railroad grade, breakwaters, and wooden pier altered the local hydrology such that areas of sediment deposition were formed inboard and outboard of the former railroad grade. Accretion of sediment inboard of the former railroad grade formed the Stege Marsh plain and the tidal wetland area (URS 2003a).

A wooden seawall was constructed at the RFS along the northern boundary of the Richmond Inner Harbor tidal mudflat prior to UC's purchase of the property. Photographs C-15 and C-16 in Appendix C show the former seawall, and Figure 7 shows the approximate location of the former seawall. Sometime prior to 1946, a breakwater consisting of large concrete rubble was

placed on the bay side of and parallel to the seawall. The breakwater extended from an area near Meeker Slough to the former wooden pier that extended into the former tidal mudflat. This breakwater corresponds approximately to the southern edge of the area currently designated as the RFS Transition Area. The eastern-most portion of the breakwater is apparent on the 1948 aerial photograph and can be seen in its entirety on the 1957 aerial photograph (see Photographs C-1 and C-3 in Appendix C, respectively).

A wooden pier extended south from the former wooden seawall into the mudflats and Richmond Inner Harbor (see Photographs C-1 and C-3 in Appendix C). The date of origin of this structure is unknown, but may date to the late 1800s and conceivably could precede the California Cap Company's ownership of the RFS. A severely dilapidated portion of this pier currently remains on the San Francisco Bay side of the Bay Trail (see Photograph C-17 in Appendix C). This pier was reported to have been used initially for unloading barges (URS 2000). However, following the purchase of the property by the UC Regents, the pier was used for a seawater conversion research project and, by the Hydraulics Engineering Department, as an access way to a bay water pumping station located at its southern end (URS 2000). At some point, wooden barriers were placed along the pier pilings, forming a makeshift north-south barrier along the pier.

In the 1950s, fill materials from various sources and spent pyrite cinders from the former Stauffer operations were placed in the former tidal mudflat area south of the former seawall. This area is shown on Figure 9 and is located in an area which was remediated between 2002 and 2004. Sometime in the late 1950s or early 1960s, the UC Berkeley Sanitary Engineering Department constructed two research ponds (one rectangular oxidation pond and one circular digester pond) for sewage treatment research. In 1990, the circular digester pond was deepened and the excavated soil was placed on the pond's outer berm. In 1992, the circular digester pond was lined (URS 2000). Both ponds were demolished and removed in September 2002 during the Phase 1 remediation activities (see Section 1.2.2.1).

By the early 1960s, UC Berkeley filled a 2-acre area in the northwest corner of the Western Stege Marsh adjacent to Meeker Slough (URS 2000). This area is now designated as "the Bulb."

Pyrite cinders were found in the fill near the pier supports located on the inboard side of the former SPRR rail spur. In 1976, UC Berkeley replaced the portion of the pier located on the inboard side of the former SPRR rail spur with a road, using fill material containing pyrite cinders that had been deposited against the pier supports over the years (URS 2000). During the late 1970s to early 1980s, the Bay Conservation and Development Commission required that the RFS move the road to a location immediately west of the former Zeneca cinder area. The reconfigured road was constructed using cinders from the original cinder-laden road fill and additional marsh area was created. The reconfigured road was used by RFS staff to access the Bay Trail that was built on the old SPRR railroad embankment. All cinder-impacted soils and sediments in this area were removed during the remediation activities performed by UC Berkeley and Zeneca in 2002 (see Section 1.2.2). The construction of this road effectively separated tidal interaction between Western and Eastern Stege marshes.

1.1.2.3 Surrounding Sites

Several large former and existing chemical and industrial sites border the RFS property to the north, west, and east (see Figure 9). A former Pacific Gas and Electric Company (PG&E) facility was located to the north of the RFS. The former Kaiser Shipyard and the Butler Steel Products facilities were located to the southwest of the RFS in the current location of the Marina Bay housing development. Bio-Rad Laboratories (Bio-Rad) continues to be located to the west of the RFS. The adjacent property to the east of RFS (now known as Campus Bay) is the location of former chemical production operations previously owned by several entities, including Stauffer and Zeneca. This report refers to this adjacent site, formerly owned by Stauffer, Zeneca, and others (and currently owned by Cherokee Simeon Venture I, LLC [CSV]), as the former Zeneca site.

The former Zeneca site was historically used for chemical manufacturing of sulfuric acid and other chemicals by various entities, including Stauffer, from approximately 1897 through 1997. In 1996, agricultural product manufacturing ceased and the last production line was closed in 1997. CSV acquired the property on December 31, 2002 (LFR, Inc. 2007a), and is the current owner. Stauffer generated pyrite cinders as a byproduct of its sulfuric acid manufacturing operations from approximately 1919 through approximately 1970. The pyrite cinders, which contain metals, were placed in an area located in the southwestern corner of the former Zeneca site, and in the eastern portion of the Transition Area and Western Stege Marsh on RFS. The former cinder area at the former Zeneca site was remediated by Zeneca and CSV's remediation contractor in 2002 and 2003. The former Zeneca site is further discussed in Section 1.1.5.1. The cinders in the eastern portions of the Transition Area and Western Stege Marsh on RFS were removed by UC Berkeley's remediation contractor in 2002 and 2003 (see Section 1.2.2).

The former Liquid Gold Corporation site is located east of the former Zeneca site. Hoffman Marsh and Point Isabel are also located slightly farther to the east, approximately 1.5 miles from RFS. Richmond Inner Harbor, Stege Marsh, and the central San Francisco Bay border the RFS property to the south. Marina Bay, a mixed-use residential and commercial development, lies to the southwest. The Bay Trail on the former SPRR right-of-way is near the property to the south. Tidal mudflats fronting the Richmond Inner Harbor are located further south of the RFS.

1.1.3 California Cap Company History

Between the 1880s and 1948 and prior to UC ownership, the California Cap Company operated facilities on portions of the RFS property for the manufacturing of blasting caps, shells, and explosives (UC Berkeley 1973). Two small companies, the U.S. Briquette Company and the Pacific Cartridge Company, are presumed to have operated on a portion of the RFS property. Both companies are shown on the 1912 and 1916 Sanborn maps, although the U.S. Briquette Company was noted as "not in operation" as of January 1912. Neither company is listed on the 1930 Sanborn map.

By 1920, the California Cap Company was the only remaining explosives manufacturer on site. The California Cap Company plant consisted of several operations, including manufacturing

explosives (primarily mercury fulminate), shells, and blasting caps; testing explosives; and storing explosives (URS 1999). All components of the blasting caps were manufactured on site, including explosives, shells, copper containers, tin boxes, paper cartons, and insulated wire (see Appendix C, Photograph 62).

The chief constituent of the explosive used by the California Cap Company was a nitrocellulose (guncotton) base called "tonite." Manufacturing of the explosive included the production of mercury fulminate. Mercury fulminate, a whitish-gray solid with the chemical formula $Hg(ONC)_2$, is a key ingredient in blasting caps. Mercury fulminate is produced by dissolving mercury in nitric acid and adding ethyl alcohol (Denver University 2006). The former mercury fulminate facility was located in the southeastern portion of the RFS (see Figure 7). Other former facilities associated with the California Cap Company included the former Cap Company shell manufacturing areas located in the southern portion of the RFS; the blasting cap manufacturing area located in the central portion of the RFS; an explosives test pit area in the northeast portion of the RFS; and two explosive storage areas, both located southwest of the former explosives test pit area (see Figures 7 and 8; URS 1999).

According to an article published in the July 1922 edition of the Cap Company newspaper, *The Detonator*, the manufacturing plant consisted of approximately 150 buildings, including administration buildings, a shell and metal drawing unit, a wire drawing unit, the blasting cap line unit, an electric blasting cap unit, and fulminate nitrating and recovery units. A tram line, as seen on Sanborn maps and historic photographs, was present between these buildings (see Figure 7 and Appendix C, Photograph 63). It appears from the photograph that the tram line was a rail system with a horse-drawn cart moving supplies and other goods around the property. The entire Cap Company facility covered approximately 30 acres, with an additional 30 acres of trees surrounding the facility.

In October 1950, the California Cap Company property was purchased by UC with the agreement that the California Cap Company would remove all hazardous materials from the property. However, subsequent site observations and testing revealed the presence of hazardous materials on RFS. For example, several explosions reportedly occurred between 1950 and 1953 during a controlled burn for clearing. These explosions likely were associated with residual chemicals used by the California Cap Company. Previous investigations in the test pit and explosive storage area found a single detection of explosives at a concentration close to the detection limit (URS 2000).

Chemical spills and releases have occurred at the RFS from sources resulting from California Cap Company operations. The 1948 aerial photograph (see Photograph C-1, Appendix C), shows that debris from California Cap Company operations were historically dumped over the former seawall south of Building 102 (see Figure 9), and a review of other aerial photographs revealed a series of ditches and one pipe possibly drained surface water flow from the California Cap Company production areas into portions of Western Stege Marsh.

According to former UC Berkeley researchers, mercury was found under Building 125 during composting research projects in the 1950s. The source of the mercury reportedly was the former

mercury fulminate facility operated by the California Cap Company. At that time, Building 125, former California Cap Company Building 24 (see Figure 7), was located west of Building 110. The building was later moved to its current location in the maintenance area between Buildings 116 and 118. UC Berkeley has identified this area for potential future remediation to remove residual mercury-affected soil (see Section 1.2.2).

1.1.4 UC Richmond Field Station History and Current Operations

This section summarizes the historical and current operations conducted by UC Berkeley and tenants at the RFS since 1950, based on the review of historical documents and interviews.

The RFS was initially established by UC Berkeley for large-scale engineering research that required significant space and resources that were not available on UC Berkeley's central campus in downtown Berkeley. Studies more suited to an off-campus location included research on solid waste and sewage, transportation and lighting studies, and beach erosion modeling (McGauhey 1974). Research projects have been and are conducted under the supervision of professors from numerous UC Berkeley colleges and departments. Current research activities are conducted by the College of Engineering, the College of Natural Resources, Art Practice, the Center for Tissue Engineering, Earthquake Engineering, the Institute for Transportation Studies, the Center for Occupational and Environmental Health's Ergonomics Program, the Northern Regional Library Facility (NRLF), and others. The research is performed by graduate students, professors, and researchers, supplemented by support staff and technicians (UC Berkeley 2006b). In addition to UC Berkeley-related operations, the UC Regents have leased space to non-UC Berkeley tenants. Current tenants include the EPA Region 9 Laboratory; Schlumberger, Inc.; The Watershed Project (TWP); and Stratacor, Inc. In 1989, UC management estimated that 250 to 300 people worked at the RFS (Ensco Environmental Services, Inc. [EES] 1989). Current staffing remains at around 300 people.

Many of the RFS buildings historically housed (and currently house) offices, laboratories, warehouses, and workshops used to support engineering projects (UC Berkeley 2006b). Many of the buildings used by the California Cap Company were torn down when UC Berkeley purchased the RFS property, but some still remain—including two buildings that were formerly homes and several buildings used for a laboratory, offices, and storage. In a few cases, RFS moved buildings to new locations on the property (UC Berkeley 2006b). Table 1 lists the major former and current uses for the RFS buildings and former California Cap company facilities. Figures 7 and 8 show the locations of all known former and existing buildings listed in Table 1 and Table 2. Photographs of selected buildings are presented in Appendix C (see Photograph C-18).

The summary of historical academic research and teaching activities associated with the RFS is presented in the following subsections. Section 1.1.4.1 discusses the historical academic research and teaching activities conducted at RFS. Section 1.1.4.2 describes current research. Section 1.1.4.3 describes the facilities' operations. Section 1.1.4.4 describes other non-research activities (such as libraries and training centers) at RFS. Section 1.1.4.5 discusses RFS chemical and radioactive materials use.

1.1.4.1 Historical Academic Research and Teaching Activities

Historic academic research and teaching conducted at RFS has occurred in indoor and outdoor laboratories, varying from small bench-top operations to large sewage treatment ponds.

In addition, RFS has been the location of ecological research on salt marsh and upland wildlife, as well as research on contamination of the Stege Marsh. This section summarizes the major historical research endeavors at RFS.

Research activities at RFS focused on the following areas:

- Sanitary engineering research: Sanitary Engineering was one of the first departments to undertake research at RFS, performing pioneering research on sustainable technologies and addressing a variety of water and waste treatment concerns. Research projects included (1) processes to best treat liquid wastes and minimize water pollution, with waste streams ranging from sewage to acid mine drainage; (2) studies of symbiotic interactions of algae and bacteria in treatment ponds; (3) designs for natural treatment systems powered primarily by solar energy; (4) methods to reuse and recycle materials, including composting and solid waste treatment; (5) activities and technologies to promote public health; and (6) studies to assess the feasibility of subsurface injection of sewage waste effluent (UC Berkeley 1959b, 1959c, 1960, 1961, 1962, 1972, 1973, 1978, 1979, 1980).

  The sanitary engineering research projects operated facilities primarily in the southeastern quadrant of the RFS, including Buildings 100, 101, 102, 105, 106, 110, 111, 112, 113, and 127. The name of the laboratory changed over time from the Sanitary Engineering Research Laboratory (SERL) to the Sanitary Engineering and Environmental Health Research Laboratory, then to the Environmental Engineering and Health Sciences Laboratory (EEHSL). Three of these buildings (Buildings 101, 106, and 127) have since been demolished. These buildings were located in the Transition Area (see Figure 7). Building 101 and 127 were used as workshop and support buildings, and Building 106 was the pilot plant facility used for sewage treatment studies. Building 102 is a historical structure that pre-dates the California Cap Company, which was originally a grain warehouse from Vallejo Ranch (UC Berkeley 1973). EEHSL historically and currently uses a portion of this building for a wet chemistry laboratory and offices. Building 110 housed offices for EEHSL; it had been part of the California Cap Company and was moved by the UC to its current location. Building 112 includes offices, classrooms, and laboratories for engineering research projects.

  Historically, EEHSL also operated a rectangular oxidation pond and a circular digester that were located south of the buildings in the Transition Area. One of their projects involved treatment of chicken wastes, and a coop where chickens were housed was once located on site. Another project evaluated sewage treatment in space, and a space capsule was located near Building 110. Buildings 154 and 158 were also used for "Sky Lab" space station research. EEHSL used a number of smaller buildings in the southeast area for storage and support (Buildings 111, 113, 136, and 138). Building 111 was used for hazardous materials storage

(Jones and Stokes 1990). Currently, this area is used by the Center for Tissue Bioengineering.

- Earthquake and seismic engineering research: the Earthquake Engineering Resource Center (EERC) was constructed to study the effects of seismic activity on materials. A large shaker table continues to be used in the center to simulate earthquakes (Building 420 and 421).

- Solid waste management research: several studies on managing and recycling garbage were conducted at RFS. Waste and garbage recycling practices were conducted in Building 128 during the 1950s (UC Berkeley 2000b). Public garbage was brought to RFS for sorting during tests of garbage recycling processes.

- Mechanical engineering research: two key programs are robotics and materials studies. Discoveries emerging from the ongoing research in the Robotics Laboratory continue to refine the design and control of intelligent robotic systems and automated machines (Buildings 151 and 158).

- Structural engineering research: structural engineering studies were performed to assess properties and structural integrity of materials. Studies ranged from detailed stress analyses by means of photoelastic techniques to both static and dynamic tests on full-sized structural systems (Building 484).

- Fire safety research: fire safety studies were performed to assess safety and, if appropriate, provide certifications on the safety of products, including plastics, bunk beds, and airplane restrooms (Buildings 118 and 484). Fire safety research no longer takes place at RFS.

- Hydraulic and coastal engineering research: hydraulic and coastal engineering studies were performed to evaluate seawater intrusion, wave generation, and desalination projects. Tests also were performed to optimize ship hull designs (Buildings 275, 276, and 277).

- Transportation research: transportation studies were performed to evaluate technologies to reduce traffic congestion and improve road pavement durability, as well as to develop airplane landing lights (Buildings 450, 167, and 280).

- Soils and concrete research: studies were performed to evaluate the properties of soils and rocks. Small scale testing of asphalt cores performed on a concrete pad was conducted to evaluate the behavior of asphalts and asphalt mixtures (Buildings 480, 482, and 280).

- Forest products research: research was designed to evaluate products associated with wood, including wood preservatives, wood coatings, wood glues, and saw blades. Building 470 was the location of a furnace that was part of a pyrolysis gasification laboratory apparatus used to experiment on converting wood products into ethanol. (Buildings 470, 471, 472, 473, 474, 476, and 478).

- Geotechnical research: geotechnical studies were performed to evaluate soil strength in support of foundation designs, as well as development of metal detectors (Buildings 165 and 300).

- Ergonomic research: ergonomic studies were conducted to measure risk factors for chronic musculoskeletal disorders of the upper extremities and to evaluate hand tools and other engineering solutions designed to prevent these disorders (Buildings 112 and 163).

- Crash research: a crash laboratory used a counter weight system to evaluate the effectiveness of seat belts and other aspects of car crashes (Buildings 450 and 460).

- Sound research: sound studies were conducted using soundproof vaults (Building 167).

- Groundwater transport research: the Research Well Field was installed in the early 1950s by UC Berkeley as part of a project funded by the State of California Water Pollution Control Board. The project evaluated the feasibility of subsurface injection (recharge) of sewage waste effluent. A total of 25 wells (2 recharge [injection] wells and 23 observation wells) were installed in the central portion of the RFS in the water-bearing zone between approximately 90 and 100 feet bgs and were sealed off from the overlying water-bearing zones (see Figure 3). The wells were installed in three phases (Stellar 2005):

    - Summer 1951: the "Original" recharge well and 14 observation wells were installed along an east-west axis and a north-south axis. Observation wells were named by their distance (in feet) and compass heading from the "Original" recharge well (for example, 225-Southeast).
    - February 1953: the well field was expanded with four additional observation wells.
    - July 1953: the "Original" recharge well failed and the wellhead was sealed. A replacement "Final" recharge well and five additional observation wells were installed.

- Most recently, one of the recharge wells was used for localized on-site irrigation (Stellar 2005). This well field was closed through the Contra Costa County Health Services Department (CCCHSD) – Well Section in March 2006, since the wells did not serve any current or anticipated research function (Stellar 2006). The final technical specifications for closing the wells were reviewed and approved by DTSC and CCCHSD. As described in the 2006 Stellar closure report, water and soil samples were collected and analyzed for several of the longer-lived radionuclides that had been injected into the wells, with analytical results statistically less than background levels (based on the assessment of the UC Berkeley Radiation Safety Officer at that time in comparison to levels typically found regionally and state-wide). In addition, three previously undocumented wells were closed. The three wells (500-South, 10-South, and 100-North) were not located at the time of closure because they

may have been closed, paved over, or built over (Stellar 2005). Since then, well 500-South was recently located near Building 177, and destruction of this well is expected to be completed in 2009.

In addition, two groundwater wells not associated with the Research Well Field were recently identified near Building 175 (see Figure 3). UC Berkeley is currently seeking information on these wells, including their historic use and construction details. UC Berkeley plans to close the two wells located near Building 175 and well-500 South in 2009 in accordance with CCCHSD requirements.

1.1.4.2 Current Academic Research and Teaching Activities

The RFS continues to serve the UC Berkeley campus as an off-site academic teaching and research facility. With over 500,000 assignable square feet of research space, the RFS accommodates a range of space-intensive activities - including the UC Berkeley NRLF, the Asbestos Information Center, some of the world's largest earthquake shaking tables, the Geosciences Well Field, sophisticated test facilities for advanced transportation research, bioengineering tissue projects, and a robotics laboratory.

The RFS also provides a site for a variety of smaller-scale engineering research projects that are not conducted on the central UC Berkeley campus. For example, the bioengineering facilities include the following equipment: nano-indenter, atomic force microscope, inverted microscopes for studying cell migration, image capture systems, scanning electron microscope, confocal microscope, high performance liquid chromatography, a histology suite, cell and tissue culture room, and other biochemistry tools for studying protein production and gene regulation. Another example is the robotics laboratory, which houses several robots and precision positioning devices, and computational hardware for controlling and designing these devices.

Teaching facilities are available for bioengineering, civil engineering, mechanical engineering, transportation, fine arts, ergonomics, and occupational and environmental health. In addition to laboratory research, the following other library, teaching, and research functions are performed at the RFS:

Northern Regional Library Facility

The UC Berkeley NRLF is currently in use and has recently been upgraded by a major addition (UC Berkeley 2006b). The NRLF is a cooperative library storage facility, the first of its kind in California. The 98,000-square-foot main building was completed in 1982; an 84,000-square-foot stack annex was completed in 1990; and a 67,000-square-foot storage module was added in 2005. The NRLF offers high-density, low-cost housing for infrequently used library materials belonging to Northern California libraries. The NRLF houses collections from the University's Berkeley, Davis, Merced, San Francisco, and Santa Cruz campuses, and the California State Library. As of June 2005, the NRLF held over 4.7 million items (mostly books and journal volumes, but also microfilm, maps, audio discs, manuscripts, archives, and other formats

normally collected by research libraries). Staff at the NRLF receive, process, and create machine-readable records for newly deposited materials, which normally amount to about 200,000 items per year, and provide circulation and document delivery services on more than 100,000 items per year.

Asbestos Information Center

Building 161 is used as a classroom training center for lead and asbestos abatement. The University Extension program in Environmental Health Management conducts continuing education and training sessions in asbestos evaluation and remediation. Surrogate materials are used to simulate asbestos and lead (UC Berkeley 2006b).

Earthquake Resource Center

The EERC is the organized research unit of UC Berkeley that supports multidisciplinary research in earthquake engineering. Major projects include the Pacific Earthquake and Engineering Research Center, the Network for Earthquake Engineering Simulation, and the National Information Service for Earthquake Engineering. Earthquake research is carried out in the Earthquake Simulator Laboratory in Building 420 and 421, where a shaker table simulates earthquakes. Hydraulic oil is required to operate the shaker table (UC Berkeley 2006b). The EERC is the only place where an oil/water separator is present at the RFS. Earthquake research has historically been performed in Buildings 451, 453, and 454 (Jones and Stokes 1990). These buildings are currently used as offices.

Engineering Geosciences Well Field

The Engineering Geosciences Well Field is located in the eastern portion of the coastal terrace prairie located between Buildings 280 and 300 and to the south of the NRLF, as shown on Figure 3. The well field was installed in the 1980s and contains approximately 20 wells of varying depths, including two to a depth of 230 feet. The well field was initially drilled in 1986 for an experiment demonstrating the ability of borehole to surface electrical resistivity monitoring to accurately map subsurface ground water flow. For this experiment, salt water from the San Francisco Bay was pumped into one of the injection wells, resistivity measurements were taken, and the salt water was pumped out of the extraction well. A similar experiment was performed in 1987, using resistivity monitoring to create a model for tracking groundwater contaminants. There are no indications from any sources that any chemicals other than salt water were ever injected into the well field under the research project. The well field is currently used by EMI Schlumberger, Inc. EMI Schlumberger, Inc. performs equipment testing and uses the wells to calibrate their cross-well electromagnetic imaging systems. EMI Schlumberger, Inc. currently uses eight of the wells in the well field.

1.1.4.3 Facilities Operations

Since RFS was established, the College of Engineering's RFS Maintenance and Operations Department, Facilities Maintenance Division has provided direct support for the various research activities by providing and maintaining all grounds, buildings, refuse, and utilities services to RFS occupants. Numerous buildings have been and are currently used for offices and conference rooms. Buildings used mainly for offices include 159, 177, 179, 180, 190, 196, and 478. Building 445 is a conference facility and Building 160 is a gymnasium. Historically this building was also used for equipment storage (UC Berkeley 2006b).

Receiving took place in Building 194, and it is currently used for the same purpose (UC Berkeley 2006b). Building 190T serves as a police building. The UC Police Department maintains a 24 hour a day presence at RFS. UC Police Department handles all patrol, investigation, crime prevention education, emergency preparedness, and related law enforcement duties for the campus community and operates 7 days a week.

Maintenance activities included routine housecleaning, building upkeep and landscaping, and support for research activities (UC Berkeley 2006b). The RFS utilities and facilities maintenance operations are summarized in the following text.

Utilities

RFS is connected to the City of Richmond and local utilities for water, sewer, electric power, and natural gas. PG&E provides electricity to the RFS through an overhead 12-kilovolt electrical line service, with both underground and aerial power lines comprising the electrical service infrastructure. PG&E also provides natural gas service to RFS through a high-pressure gas main on South 46th Street. East Bay Municipal Utilities District serves the RFS with one 8-inch domestic water line and two 12-inch fire main lines. These lines enter the RFS from the north, west, and east sides of the property.

The Richmond Municipal Sewer District provides wastewater treatment and disposal services for the RFS. At the time that UC Regents purchased the RFS property, the sewer lines were constructed of 8-inch tile piping, with the main line running through the center of the former California Cap Company facility (see Figure 7). Prior to 1950, it is assumed that discharges to the sanitary sewer lines were routed to the San Francisco Bay. Subsequently, UC Berkeley researchers connected a 16-inch line to the Richmond interceptor sewer south of the existing seawall (UC Berkeley 1950).

Today, sewer discharge from RFS flows to the City of Richmond publicly-owned treatment works, located approximately 3 miles west on Canal Boulevard (URS 2003a). UC Berkeley has a wastewater discharge permit for the entire RFS property. Two main City of Richmond sewer lines enter the RFS property near the main access gate by Building 478 and cross the northern portion of RFS and then exit the northern boundary of the property (see Figure 3). Numerous sanitary sewer lateral lines are located across RFS that tie into the City of Richmond sewer lines, including (1) the lateral starting at the NRLF building that continues in a southerly direction to

the area south of the EPA Region 9 library, and (2) the lateral starting at Building 167 in the central portion RFS that continues south along Egret Way to the area near Building 102. This lateral connects with the new section of sanitary sewer line that was installed in the Transition Area in 2003 and continues west to the area south of the Region 9 EPA Laboratory, where it ties into the lateral from the NRLF and the City of Richmond sanitary sewer line.

Beyond the basic utilities provided at the time of purchase, UC Berkeley installed additional support at RFS as needed, such as water and sanitary sewer service for restrooms, laboratories, and research projects. During the 1950s, UC Berkeley routed a sewer line from Building 490 in the central portion of RFS directly to the former digester and oxidation ponds near Buildings 102 and 106 to provide a source for former sewage treatment projects (UC Berkeley 2000a). The northern end (to B421) of the abandoned sewer delivery line to the research digesters was later converted to a cooling water discharge line at some point in time. Although the rest of this line is still in place, the line is not active (see Figure 3). A pump station was established at the southern end of the pier that extended from the former seawall to the tidal mudflats south of the Bay Trail to pump seawater for the Hydraulics Engineering Department research laboratories in Buildings 275, 276, and 277 (Jonas & Associates, Inc. 1990a).

UC Berkeley determined that stormwater drainage at RFS was inadequate at the time of purchase (UC Berkeley 1950), and UC Berkeley upgraded the stormwater drainage in the 1950s. On-site stormwater drainage currently flows from the north to the south at RFS by way of open swales, culverts, and sheet flow into drainages. Figure 9 shows the historic sewer and storm drains as they existed at RFS prior to the first phase of remediation in September 2002. The current storm drain system consists of two main storm drain lines located on the eastern and western sides of the RFS property (see Figure 3). An underground line in the central portion of the RFS connects these two systems (Blasland, Bouck & Lee, Inc. [BBL] 2005a).

Boilers that operate on natural gas are present in Buildings 112, 158, 275, 451, 452, 454, 480, 472, 478, 480, and 484. Building 118 was the location of the former California Cap Company boiler, which ran on fuel oil. The fuel oil lines may still exist; however, UC Berkeley never operated the boiler in Building 118 (UC Berkeley 2006b). The locations of the former California Cap Company fuel oil lines are shown on Figures 7 and 8. Many of the remaining buildings at RFS use gas-fired heaters.

From the 1960s to the early 1980s, an incinerator was located near Building 120 and was used to burn office trash generated at RFS. How and where the ash was disposed of is not well documented, but it reportedly may have been disposed of in Western Stege Marsh in the area south of the Bulb (UC Berkeley 2006c). The incinerator was dismantled and sold to a scrap dealer in the early 1980s. Building 120 was converted to a storage building for the RFS Maintenance Department (UC Berkeley 2006b).

From the mid 1980s to the early 1990s, the UC Berkeley Police Department detonated suspect bombs and potentially explosive chemicals (peroxide forming chemicals such as diethyl ether and unstable nitrated compounds such as picric acid) from campus laboratories in a bunker located in the Transition Area to the south of the current EPA laboratory (see Figure 7). The

walls of the bunker were constructed of cinder blocks in rectangular shape with three walls and a concrete floor. The bunker was used sporadically, approximately once per month, until the early 1990s when the campus began using contractors to stabilize high hazard potentially explosive compounds and began detonating suspect bombs at an alternative location. The bunker was demolished some time around 1996.

Historic Waste Disposal Practices

Anecdotal information exists that limited waste disposal may have occurred in the late 1950s to late 1960s in the Bulb area of the Transition Area (UC Berkeley 2006c). The formation of the Bulb is evident in the 1957, 1959, 1966, and 1969 aerial photographs (see Appendix C, Photographs C-3 through C-6, respectively). Vegetative and miscellaneous site debris and drums may have been disposed of into trenches at depths at or below groundwater levels in the Bulb (UC Berkeley 2006c). The drums may have been from off-site sources (UC Berkeley 2006c). The Bulb was investigated during several investigations in early 2000 and late 2002 by advancing 10 Geoprobe borings to depths between 5 and 9 feet bgs. A review of the boring logs indicated that minimal wood debris was encountered in 3 of the 10 borings, at depths of approximately 3 feet bgs, but no other debris was encountered. In November 2006, staff from DTSC's Geologic Services Unit performed a magnetometer survey in the Bulb area to look for signatures of buried metal drums. Analysis of the results of the magnetometer survey showed a strong anomaly centered 170 feet south-southwest of the concrete pad that is located in the center of the Bulb (DTSC 2006). DTSC's Geologic Services Unit concluded that the anomaly is some kind of large ferrous body that is buried at an unknown depth and warrants further investigation. The results of the DTSC survey are provided in Appendix F.

Facility Maintenance

RFS is served by a facilities group that maintains the buildings, roads, and utilities, and manages the transfer of materials off site. Building 175 has historically served as the primary maintenance shop and as offices for the main RFS administrative support personnel. The open area south of Building 175 historically served as the maintenance support area, providing facilities for repairing, painting, and assembling research or other equipment (Buildings 114, 116, 117, 121, 197, and 175). Building 167 serves as a storage area for California Partners for Advanced Transit and Highways research vehicles.

The Corporation Yard is located in the southeast portion of the RFS near Building 120. RFS staff have historically used this area for two main functions: (1) a long-term storage area for large earthquake and seismic engineering research test specimens and (2) a support area for storing maintenance materials and equipment. Because of the nature and scale of the earthquake and seismic structural testing at RFS, UC Berkeley researchers are required to hold onto their test specimens for a prescribed period of time in case questions arise about their results. Once the end has been achieved, then the specimens are disassembled and recycled. Materials' storage in the area primarily consists of large concrete bins of sand, gravel, and other construction materials typically used for supporting a facility of this size. Also stored in this area is large maintenance equipment, including tractors, lawn mowers, lift equipment, and the facility trash compactor.

This area along with the Earthquake Engineering facility and Building 280A are the only places where hydraulic oil has been stored at the RFS. No documented releases have been attributed to the facility's use of this area.

At the time of purchase in 1950, UC determined that additional roads would be necessary for RFS (UC Berkeley 1950) and road upgrades were budgeted and completed. Facility maintenance continues to repair and upgrade roads as required.

Pyrite Cinders Management

Pyrite cinders have been encountered at various locations across RFS where they were historically deposited as fill material in low-lying areas or used as utility trench backfill (Tetra Tech EM Inc. [Tetra Tech] 2007b). Pyrite cinders have been found in landscaping areas around building foundations and may still be encountered around structures at the RFS. Most of the pyrite cinders at RFS have been removed during site remediation activities conducted from 2002 to 2004; however, small amounts of pyrite cinders have been identified and additional amounts may remain undiscovered in the Uplands and Transition Areas of the RFS (see Figure 10). Thus, UC Berkeley has implemented an interim Soils Management Plan (SMP) to provide protocols when workers disturb subsurface soils, such as during utility and road maintenance projects and landscaping projects in the Uplands and Transition Areas. The interim SMP provides a protocol to develop a site-specific sampling plan if excavation is required as part of a new building project. (Tetra Tech 2007b) The interim SMP was approved by DTSC. The interim SMP will be periodically updated as RFS utility and road maintenance projects are conducted and remediation work is completed under the DTSC Site Investigation and Remediation Order.

Table 3 presents the analytical results for select metals (arsenic, copper, lead, mercury, and zinc) from seven samples of upland cinder material collected in 2005 and 2006. Table 3 also provides a comparison with site-specific target levels (SSTL) developed for human health protection of a construction worker. In the Upland Area, the concentrations for these metals are all less than the human health site-specific target levels (H-SSTL) (URS 2001a). The SSTLs were developed under the auspices of the Water Board for remedial work conducted at the RFS from 2002 through 2004. DTSC has indicated that it will reevaluate these values.

1.1.4.4 Non-UC Berkeley Tenants

Non-UC Berkeley tenants at RFS include the EPA Region 9 Laboratory; EMI Schlumberger, Inc.; Stratacor, Inc.; and TWP. These non-UC Berkeley tenant activities are described below.

EPA Region 9 Laboratory. Since 1993, EPA has leased property at the RFS for its Region 9 Laboratory (designated as Building 201), which EPA built to operate as a full-service, state-of-the-art facility specializing in chemical analysis, biological analysis, and field sampling services. The Region 9 Laboratory plays a critical role in the EPA's mission of protecting human health

and the environment through the analysis of air, water, soil, and biota samples (such as bird, fish, and occasionally mammal tissue).

Other Non-UC Tenants. EMI Schlumberger, Inc.; Stratacor, Inc.; and TWP, a nonprofit organization, also lease space at RFS. EMI Schlumberger, Inc., located in Buildings 300 and 300 T1-T3, is a world leader in the development of electromagnetic systems for ground conductivity imaging. EMI Schlumberger, Inc. designs and manufactures leading edge instruments for geophysical exploration and research. EMI Schlumberger, Inc. uses no significant chemical compounds in their operations; therefore, releases are very unlikely from this tenant.

Stratacor, Inc., located in Buildings 154 and 176, is a small company providing technical support for the development of topical pharmaceuticals and cosmetic products. It assists companies with formulation of new products, analytical support, quality control, and manufacturing and process development. Stratacor uses extremely small quantities of three chemicals in an on-site machine: Permaflour, Monophase and Carbo-sorb. Its testing machine is designed to use very small quantities of these chemicals and has a built in recovery system. Stratacor reportedly recovers 97% of the materials used in the testing process. The remainder is absorbed by the test media, and any thing that might escape is exhausted out of the hood. The chemicals are stored in the manufacturers' supplied containers, and once a container of material is exhausted, it is properly manifested and transported to a licensed disposal facility (UC Berkeley 2008b). Based on their small operation, significant releases are very unlikely from Stratacor, Inc. operations.

The mission of TWP is to educate and inspire communities to protect their local watersheds. TWP has innovative programs including workshops for educators and the general public and support for creek protection groups.

1.1.4.5 RFS Chemical and Radioactive Materials Use

Historically, research studies at the RFS have been primarily in the field of engineering; thus, the use of hazardous materials was relatively insignificant compared with other academic programs that are present on UC Berkeley's central campus.

As described in historical records, chemicals historically used at the RFS include bench-scale laboratory chemicals and radioisotopes, mercury manometers, radioisotopes for tracer studies, wood treatment chemicals, gasoline, diesel fuel, hydraulic oil, herbicides for grounds maintenance, PCBs in electrical equipment, building paint and caulking, and other miscellaneous products for housekeeping and other facilities maintenance activities (UC Berkeley 2006b).

This section summarizes the history and current conditions relating to use of chemicals and radiological materials associated with academic research and teaching and facilities support operations. Information on historic releases or spills is included in this section.

Historical UC Berkeley Management of Chemicals and Radioactive Materials

Records indicate that a formal program for oversight of environmental health and safety at all UC campuses and field stations dates back to at least 1939, when the "University Regulation No. 18, Sanitary Code" (formerly "Orders of the President No. 18 Sanitary Code") appointed a Sanitarian to aid the University Physician in his responsibilities in "making recommendations to the President in all matters direct or indirect, which may affect the health and physical welfare of the students on campus, including Sanitation." In 1948, a University-wide Safety Agency was established. In 1949, the President of the University of California appointed a State-wide Advisory Committee on Radiological Safety and established the Division of Radiation Safety (Division) to provide oversight of radiological materials use at all UC campuses under the administrative supervision of the University Physician. The Division was responsible for health and safety of persons working with or otherwise exposed to ionizing radiation. In addition, the Division ensured that University property was "not rendered unusable as a result of radioactive contamination and that radioactivity released to the environment as a result of University projects remains well below accepted limits." Division activities included approving plans for use of radioisotopes, periodic surveying, and assuring the proper disposal of wastes. Records show that the Division inspected the RFS's SERL injection well experiments performed in the 1950s (UC Berkeley 1952, 1957, 2007).

Since the passage of the Atomic Energy Act of 1954, all radioisotope research at UC Berkeley became licensed by the Atomic Energy Commission. In addition, the Office of Environment, Health & Safety (EH&S) and the Radiation Safety Committee were established in 1960. In the 1980s, additional EH&S oversight committees, including the Hazardous Waste Management Committee and the Laboratory Operations and Safety Committee, were established to advise the campus on management of hazardous materials. These oversight committees have established guidelines for safety and environmental protection in campus use of hazardous and radiological materials (UC Berkeley 2007).

EH&S staff currently oversees UC Berkeley's hazardous and radiological materials management programs, including the following:

- Chemical inventory
- Hazardous waste management
- Hazardous waste minimization
- Laboratory safety inspections
- Acutely hazardous materials accidental release prevention
- Sanitary sewer pollution prevention (drain disposal guidelines)
- Underground and aboveground tank spill prevention
- Fire code inspection for storage of hazardous materials
- Radiation safety licensing and inspections

- Radiological waste management and including guidelines
- Injury and illness prevention
- Hazardous materials transportation
- Minimization of hazardous waste
- Stormwater pollution prevention

Periodic inspections of RFS hazardous materials use and storage areas are conducted by the Campus Fire Marshal and staff from the EH&S Radiation Safety, Laboratory Safety and Hazardous Materials Management programs (UC Berkeley 2007).

In addition to periodic EH&S inspections, use and storage of hazardous materials is inspected by local regulatory agencies. The following inspections currently occur:

- The Contra Costa County Hazardous Materials Program Division inspects RFS approximately annually for hazardous waste storage.
- The City of Richmond Fire Department inspects RFS approximately annually for hazardous materials storage and fire safety.
- The City of Richmond Public Works Industrial Pretreatment Program inspects the RFS approximately every 2 years for hazardous waste storage, hazardous waste manifest recordkeeping, and spill prevention control and countermeasure requirements.
- The City of Richmond collects wastewater samples a number of times per year for compliance with the Industrial Discharge Permit issued to the RFS.

Chemical Use – Academic Research and Teaching Activities

As an academic teaching and research facility, generally only small laboratory-scale (1 gallon or less) amounts of chemicals are used and stored at the RFS. A review of available records show there have been a few exceptions with larger quantities used, but currently the only laboratory research chemicals present in reportable quantities are gases, hydraulic oil, and petroleum products (UC Berkeley 2007).

Oversight for the use of chemicals at the RFS is provided by EH&S Laboratory Safety and Hazardous Materials Management staff through programs developed with guidance provided by the Laboratory Operations and Safety Committee and the Hazardous Waste Management Committee. Unwanted hazardous materials from laboratory operations are picked up directly from RFS laboratories for reuse or for off-site disposal at approved treatment, storage, and disposal facilities. UC Berkeley has prepared guidelines for proper disposal of hazardous wastes based on regulations established by the EPA and DTSC (that have been reviewed by both agencies). Disposal of chemicals into the sanitary sewer is regulated through an Industrial

Discharge Permit issued by the City of Richmond Industrial Pretreatment Program and through the Drain Disposal Guidelines developed by the Hazardous Waste Management Committee.

Current Use of Chemicals and Hazardous Materials

The current Hazardous Materials Business Plan and Chemical Inventory for the RFS lists the following chemicals in reportable quantities in use for academic teaching and research: acetylene, adhesive, argon, asphalt, boiler water treatment, carbon dioxide, diesel/gas/kerosene, helium, oil/transmission fluid, nitrogen, paint, oxygen, and propane (UC Berkeley 2008). In addition, bench-scale laboratory chemicals are present in non-reportable quantities. The 2007 Hazardous Materials Business Plan and Chemical Inventory report lists approximately 1,000 pounds average daily amounts of solid and 1,130 gallons average daily amounts of liquids on hand (UC Berkeley 2008). Wet chemistry laboratories remain in operation at Buildings 112 and 484 and are being phased out in Building 478 (UC Berkeley 2008).

Laboratory Aboveground Storage Tanks and Drums

Currently, three aboveground storage tanks (AST) are used to hold fluids for teaching and research laboratories (see Figure 3). Tank A-18-1, installed in 1996 and located at Building 280, is a 1,500-gallon double walled SuperVault^{TM} tank that contains diesel fuel for fueling the Institute for Transportation Studies' pavement research vehicles. Tank A-18-3, installed in 1969 and located at Building 421, is a 2,000-gallon single-walled steel tank that contains hydraulic oil used to operate equipment in the Earthquake Engineering Research Center. Tank A-18-4, installed in 1965 and located at Building 484, comprises two linked tanks containing a maximum of 1,000 gallons of hydraulic oil used to operate equipment in the Structural Test Laboratory (UC Berkeley 2007).

In addition to the tanks, 55-gallon drums are used for storage of petroleum products and wastes in two locations. Between 1995 and 2007 four drums of hydraulic oil, motor oil, kerosene, and waste oil have been stored in Building 280A. Five drums of hydraulic oil are currently kept in Building 421 for Earthquake Engineering Research Center equipment (UC Berkeley 2007).

Historic Chemical Use

Several buildings were identified where academic teaching and research activities involved the use of chemicals and hazardous materials (see Table 1). Historical laboratory research activities were performed in the following primary areas: SERL, later called the EEHSL, in Buildings 102, 106, 112, and 125 (since moved); FPL in Buildings 472-476, 478, 480, 486, 487, and 488; the Earthquake Engineering Research Laboratory in Buildings 420 and 421; and the Structural Materials Testing Laboratory in Building 484. Buildings 120 and 474 (FPL) were used exclusively for chemical storage, including some laboratory wastes. The FPL was mostly vacated in 2004, with most of the chemical inventory removed from FPL buildings (UC Berkeley 2006b).

None of the historic records indicate any releases to the environment from the use of laboratory chemicals inside these and other buildings. Until regulatory changes in the 1980s prohibited drain disposal, unwanted solvents and other laboratory chemicals were typically poured into drains leading to the sanitary sewer. There are no records of chemicals being buried on RFS. According to RFS staff, any chemical spills inside of laboratories are small and cleaned up by laboratory or EH&S personnel. Records indicate that the following releases of chemicals to the environment from academic teaching and research activities have occurred.

Former Forest Products Laboratory Wood Treatment Laboratory

The former FPL WTL was constructed in 1965 and operated by the College of Natural Resources as an academic teaching and research facility. The laboratory was located to the south of FPL Building 478, between Buildings 472 and 476 in the northeast portion of the RFS. Building 470 was the location of a furnace that was part of a pyrolysis gasification laboratory apparatus used to experiment on converting wood products into ethanol. Research studies relating to wood treatment with pentachlorophenol in liquefied petroleum gas and isopropyl ether cosolvents were conducted at the laboratory until 1970 or 1971. The facility then converted to treating wood with water-based chromated copper arsenate (CCA) and ammoniacal copper arsenate (ACA) compounds (Tetra Tech 2007a). The chemicals were stored in an AST at the RFS and plumbed to a treatment chamber used to conduct experiments. Beginning sometime in the 1980s, the facility was also used for fire retardant studies with nonhazardous ammonium phosphate solutions (Tetra Tech 2007a). These wood treatment and flame retardant experiments continued into the early 1990s. Some of these chemicals were reportedly released to the east and south of the WTL. In 2004, laboratory chemicals and laboratory wastes were cleaned out of the former FPL facility and transported to Clean Harbors San Jose for proper treatment and disposal.

Investigations of the WTL were performed as part of the site investigation and cleanup completed under Water Board oversight to determine the extent of contamination in this area. Remediation Area 3 was identified and excavated in September 2004 (URS 2005).

The WTL equipment was removed in 2006 (Tetra Tech 2007a). Results of additional samples collected as part of this cleanup revealed that two previously undetected minor releases of arsenic-containing wood treatment compounds had occurred on the soil under the equipment vent pipes, with arsenic concentrations in soil exceeding target cleanup levels (Tetra Tech 2007a).

In October and November 2007, UC Berkeley performed a TCRA to remove arsenic-affected soil in this area. A summary of the TCRA is presented in Section 1.2.2.4.

Building 421 Hydraulic Oil

In 1998, non-PCB hydraulic oil overflowed from a drum of oil filters stored outside of Building 421 when rain entered the drum. The oil traveled through the storm drain system to the Western

Storm Drain, where it entered Meeker Slough. An emergency response team from EH&S placed oil booms on the slough and removed the spilled material (UC Berkeley 2007).

Hazardous Materials Use – RFS Facilities' Support Activities

RFS Facilities' support activities, including utilities, have included uses of chemicals, such as gasoline for facility vehicles, diesel in ASTs for fueling emergency generators, and PCBs in electrical distribution equipment (transformers, capacitors and switches). This section presents information on the use and management of these chemicals by RFS Facilities' support activities.

Current Use of Chemicals and Hazardous Materials

The current Hazardous Materials Business Plan and Chemical Inventory for the RFS reports the following facilities' maintenance chemicals present in reportable quantities: paint, boiler water treatment, automatic transmission fluid, hydraulic oil, industrial and motor oil, and gasoline. In addition to these chemicals, small quantities of cleaning and maintenance chemicals were and are used by the maintenance staff (UC Berkeley 2006a).

Underground Storage Tanks

Currently, no known USTs are present at the RFS. Five USTs were removed between 1986 and 1997. No known leaks or releases were associated with these tanks (UC Berkeley 2007). The contents and removal dates are shown in the table below, and the former locations of these tanks are shown on Figure 3. Site records show that all USTs were removed with oversight by the CCCHSD. A case closure record is on file for UST T-57 removed in 1997 (CCCHSD 1998). The USTs removed in 1986 and 1988 likely pre-date the issuance of formal closure letters from the County (UC Berkeley 2007).

Tank Name	Volume	Material Stored	Tank Construction	Year Tank Removed
T-53	850 gallons	Diesel	Concrete	1986
T-54	850 gallons	Diesel	Concrete	1986
T-55	550 gallons	Gasoline	Single-walled steel	1988
T-56	635 gallons	Diesel	Concrete	1986
T-57	1,300 gallons	Gasoline	Single-walled fiberglass	1997

USTs T-53, T-54, and T-56 were used to store fuels to power generators. These tanks were removed in November 1986 upon approval of the CCCHSD. Soil samples collected from the tank pit below the former tanks were analyzed for diesel-range fuels with the following results: UST T-53 non detect (detection limit of 2 milligrams per kilogram [mg/kg]), UST T-54 (4.3 mg/kg), and UST T-56 (4.7 mg/kg) (UC Berkeley 2007). The locations of all confirmation samples from the removals were beneath the locations of the USTs shown on Figure 3. The analytical results and the closure reports are provided in Appendix I.

UST T-55 was removed in 1988 by the Office of the State Architect when the State tank program was under its purview. Benzene, toluene, xylene, gasoline, Stoddard solvent, paint thinner, diesel, kerosene, and motor oil were not detected in the soil samples collected from the tank excavation pit (UC Berkeley 2007).

UST T-57 was installed in 1980 and used to store gasoline for fueling RFS facility vehicles. The tank was removed on September 23, 1997, under the observation of a Contra Costa County inspector. The tank was reportedly in good physical condition (no holes), there were no signs of leaks, and soils under the tank appeared clean. Analytical results from two excavation pit bottom soil samples and one soil stockpile sample were all non detect for gasoline; benzene, toluene, ethylbenzene, and xylenes; and lead (UC Berkeley 2007).

Aboveground Storage Tanks and Drums

Currently, four ASTs are used to store fuels for RFS Facilities' operations. One tank, A-18-2, installed in 1997, is a 1,500-gallon double-walled SuperVault™ tank that stores gasoline for fueling RFS maintenance vehicles. The three remaining tanks contain diesel fuel used to power emergency generators and a fire suppression water pump. Tank A-18-5, installed in 1982, is a 120-gallon single-walled steel tank located at Building 400 and supplies fuel to the fire suppression system pressure booster engine. Tank A-18-6, installed in 2004, is a 110-gallon double walled steel belly tank attached to a diesel powered emergency electrical generator. Tank A-18-7, installed in 2005, is a 110-gallon double-walled steel belly tank attached to a diesel powered emergency electrical generator by Building 194 (UC Berkeley, 2008). In addition to the ASTs, 55-gallon drums are used to store waste petroleum products, such as waste oil. Drums are kept in Buildings 120 and 197 (UC Berkeley 2006a).

PCB Transformers

Electrical power distribution equipment currently present on the RFS contains only non-PCB dielectric fluids. The locations of all former and existing transformers are shown on Figure 3. Historically, most transformers were originally mounted to utility poles and they were later replaced with ground-level transformers on pads. Records showed that all PCB-containing electrical distribution system transformers were either removed for off-site disposal or retrofilled onsite with non-PCB oils in the late 1980s and early 1990s (UC Berkeley 2006b). During this time period, approximately 40 pieces of electrical equipment (mostly capacitors and some transformers) were temporarily placed on a concrete pad in the northern portion of Building 280B, as part of a campus-wide cleanout of PCB items. There are no records indicating that spills of PCB oils ever occurred, and former employees did not recall any leaks or spills associated with the transformers at the RFS (UC Berkeley 2006b).

Storage of Chemicals and Hazardous Materials

Buildings where chemicals and chemical wastes were stored include Buildings 106, 111, 114, 120, 125, 138, 150, 175, 280, 470, 474, and 478. These buildings were inspected in 1989, and proper procedures for storage, handling, and labeling of chemicals were observed (EES 1989).

Building 120 was used as a solvent storage shed at the time of the 1989 inspection, and approximately 20, 55-gallon drums of thinner, kerosene, and various petroleum hydrocarbon products were observed in the building (EES 1989). Spills were observed on the floor and in drip pans during the inspection and these were cleaned up at the time. Both empty and full unlabeled drums were observed at the time of the inspection. This building is currently used to store chemical wastes prior to off-site disposal, and it is regularly inspected by EH&S and Contra Costa County. Approximately 20, unlabeled 55-gallon drums were stacked three-high against a wall outside the building and most of the drums appeared to be empty (EES 1989). Another six, 55-gallon drums were found just outside Building 120 near a small area of stained soil. Several of the six drums were empty, while others contained a mixture of water and unknown product (EES 1989).

The RFS Corporation Yard in the vicinity of Building 120 was also historically used for material storage. In 1989, approximately 15 non-PCB transformers were stored there prior to off-site disposal. There are no records of leaks or spills in the RFS Corporation Yard (UC Berkeley 2007).

The northern end of Building 280B was used for staging transformers and capacitors, including some PCB-containing items in the late 1980s and 1990. It was also used by the campus Excess and Salvage Material Management Program in the late 1980s and early 1990s as a storage location for unused campus furniture and equipment mostly destined for sale. There are no records of spills in this location (UC Berkeley 2007).

Radiological Materials Use – Academic Research and Teaching Activities

Many research and instructional activities use sources of ionizing radiation as a valuable tool to extend fundamental knowledge. These activities are an important part of the University of California's contribution to the society it serves, and are critical to its mission.

The use of radiological materials and radiation-producing machines is governed by the California Radiation Control Regulations and the UC Berkeley Broad Scope Radioactive Materials License issued by the State of California Department of Public Health (CDPH) Radiological Health Branch. Approval and oversight for campus use of radiological materials is provided by the Radiation Safety Committee (RSC) and the EH&S Radiation Safety Officer (RSO). Any use of radiation and radiological material at UC Berkeley must be preauthorized in writing. The written authorization is referred to as a Radiation Use Authorization (RUA) and is fundamental to the UC Berkeley campus radiation safety program. The RSO conducts an evaluation of the radiation safety aspects of the proposed use. If additional information is required, the RSO may need to meet with the applicant to discuss the use. At the RSO's discretion, complex uses may need review by the RSC (UC Berkeley 2007).

Oversight of use, inventory and disposal of radiological materials is provided by EH&S Radiation Safety Team. The Radiation Safety Team performs periodic surveys of areas in which radiation and/or radioactive materials are used. Surveys include inspecting labels and posting, use of dosimetry and meter readings, and wipe surveys of laboratory surfaces, including bench

tops, equipment, sealed sources and floors. The frequency of the surveys is based on a number of factors, such as perceived risk and past RUA compliance. The standard frequency of surveys is quarterly. The Radiation Safety Team also responds to radiological material spills and directs cleanup and disposal of wastes from spills (UC Berkeley 2007). The EH&S Radioactive Waste Management Program is designed to protect individuals and the environment. Radiological waste from the RFS is either shipped directly off site for disposal at licensed treatment, storage, and disposal facilities or is picked up from laboratories by EH&S and transported to the Hazardous Materials Facility on the central campus in Berkeley. The materials are managed and prepared for decay on site or for off-site disposal. Each RUA details the project limit for drain disposal of aqueous liquids containing radiological materials to the sanitary sewer (UC Berkeley 2007).

Radiological Material Use at RFS

Radiological materials have been used in certain types of research at the RFS since the 1950s (UC Berkeley 2007; Stellar 2005). Currently, there are four RUAs for research at the RFS: two for sealed sources, one for a radiation-producing machine, and one for unsealed isotopes (UC Berkeley 2007). UC historical records show that researchers from the College of Engineering (EEHSL, Civil and Environmental Engineering), the School of Public Health, and the Department of Integrative Biology have used radioisotope tracers in laboratories inside buildings (UC Berkeley 2007). In general, quantities of radioisotopes used have been small, millicurie levels, according to RFS records. However, several larger sealed sources of radioactive materials have been stored at the RFS. These larger sources are used in gauges to measure moisture and density and to calibrate radiation instruments. No radiological spills outside of buildings have been reported, nor are any such spills indicated in any records (UC Berkeley 2007). Historically, the use of radioisotopes has occurred in certain laboratories in Buildings 102, 106, 110, 112, 113, 117, 150, 151, 158, 177, 280, 450, 478, and 480 (see Figure 11). In addition, Generally Licensed Materials (such as smoke detectors, tritium exit signs, and uranium salts) may have been used or continue to be present in these and other RFS buildings. Building 106 was used for studying sewage treatment processes and was demolished in 2002 under regulatory oversight, prior to the remediation activities performed in the Transition Area. Prior to removal of this building, an extensive radiological survey was performed in and around the building and is discussed in the following paragraph (UC Berkeley 2007).

Records show that there were two locations of historic use of radioisotopes for tracer experiments in the outdoor environment (UC Berkeley 1959b). In one study in an undetermined location, short-lived isotopes were used in areas secured with four foot high “antipersonnel” fences to research nutrient uptake in isopods (UC Berkeley 2008). In the other location, as noted in Section 1.1.4.1, UC Berkeley developed a research project in the early 1950s for deep-well injection and contaminant transport as part of a State of California-funded program (UC Berkeley 1954). Following completion of studies in 1953, some or all of these wells were used in studies in the 1950s and 1960s to evaluate groundwater transport. These studies used primarily short-lived radiological isotope tracers such as: cesium (Cs-134), iodine (I-131) and strontium (Sr-89); however, several long-lived isotopes of strontium (Sr-90), tritium (H3), and carbon (C-14) were also used. A 1959 record states that plans for one of the experiments included discharging water containing the radioisotopes strontium and tritium from the pumped

well 100-S into to the "surface drainage system of the Engineering Field Station" (UC Berkeley 1959a). A 1961 record similarly states that water containing tritium and strontium were planned to be discharged from the well field "into a nearby ditch… for discharge into the San Francisco Bay." (Kaufman 1961). In 2002, UC Berkeley collected groundwater samples in two of the 25 wells and 15 surface soils samples in the vicinity of the wells. Figure 11 shows the locations where samples were collected for analysis of radiological materials. On April 11, 2005, groundwater samples were collected from three of the research wells before they were closed in accordance with technical specifications reviewed and approved by CCCHSD and DTSC. The well water samples collected in 2002 and 2005 were analyzed for tritium, gross beta by liquid scintillation, and gamma spectroscopy. The results for the well water samples were all less than the minimum detectable activity, indicating no positive activity in any of the water samples analyzed. The soils samples were analyzed for cesium by gamma spectroscopy. The results showed the presence of only trace levels of Cs-137, which is consistent with expected background levels (Stellar 2006).

Additional Sampling for Radiological Materials

EH&S Radiation Safety staff have performed meter and wipe surveys of building interior surfaces as part of the routine radiation safety inspections for decades. No evidence of radiological environmental contamination being transported (by tracking or wind) has ever been identified in these surveys (UC Berkeley 2007).

In addition to the routine radiological surveys, sampling events were completed as part of the remediation activities performed in 2002 and 2003 and as part of a radiological source evaluation in 2006. Survey results for these sampling events are found on Figure 11 and in Appendix G. A summary of these results is provided below.

Sewage Treatment Experimental Ponds. As described in Section 1.1.2, two large ponds, one round and one rectangular, were used for studies on innovative methods of sewage treatment by principal investigator Dr. William Oswald. Dr. Oswald was among the first engineers to study the symbiotic interactions of algae and bacteria in treatment ponds, and to develop design methods for natural treatment systems powered primarily by solar energy. These ponds were demolished prior to the remediation activities performed in 2002 and 2003. Prior to demolition, 12 samples of soils, cinders, Bay sediment, sewage treatment pond sludge, and structural materials of the soils were collected on April 22, 2002, for analysis by gamma spectroscopy. The results showed no detected activity other than typical naturally occurring radioactive material and a few Cs-137 peaks consistent with expected background levels (based on the assessment of the UC Berkeley Radiation Safety Officer at that time in comparison to levels typically found regionally and state-wide). Sampling results are provided in Appendix G.

Building 106 Decommissioning. Building 106 was historically the location of a sewage treatment laboratory where radioisotopes were used as tracers in research. The building was demolished in summer 2002 prior to the remediation activities performed in 2002 and 2003. Due to the historic use of the radioisotopes in the building, the EH&S Radiation Safety division completed a decommissioning survey between June and July 2002. Hundreds of wipe samples

and radiation meter readings were collected from interior and exterior surfaces of Building 106. No radiation above background was detected (based on the assessment of the UC Berkeley Radiation Safety Officer at that time in comparison to levels typically found regionally and state-wide).

Phase 2 Remediation. In November 2003, during the Phase 2 of the remediation activities, samples were collected from four locations within the excavation and sent to a certified analytical laboratory for gamma spectroscopic analysis. The following locations were sampled for radionuclides: the former sanitary sewer line in the southern portion of the Transition Area (where pyrite cinders were removed and sampled); the central portion of Western Stege Marsh (in the area formerly designated as M3, under the Water Board Order); and at two locations south of the former seawall at depths of 2 and 4 feet bgs. Radionuclides were not detected at concentrations exceeding naturally occurring background levels in these samples (URS 2004). The exact locations where these samples were taken were not documented; however, all analytical sampling results are provided in Appendix G.

Bulb and Building 280 Survey. In December 2006, radiation safety staff from UC Berkeley EH&S and Lawrence Berkeley National Laboratory EH&S completed a radiation meter survey of two portions of the RFS in response to allegations by a former RFS employee that radiological materials may have been buried on the property in the late 1960s. A portion of the Bulb in the Transition Area and a portion of the coastal prairie on the east side of Building 280 were surveyed for radiation, using meters equipped with sodium iodide scintillation probes and with a EG&G brand Ortec Detective, a high-sensitivity detector with a high-purity germanium probe capable of making isotopic identifications based on the spectrum of gamma radiation emitted. No radiological activity at levels exceeding naturally occurring background levels was detected with the scintillation probes. Thorium, a naturally occurring radiological material, was found in asphalt at low levels next to Building 280 (UC Berkeley 2007). The results of the December 2006 radiological survey are provided in Appendix G.

1.1.5 Surrounding Off-Site Use History

The following discussions provide site descriptions and historical uses of off-site properties in the vicinity of RFS.

1.1.5.1 Former Zeneca Site

The former Zeneca site, an 86-acre property located at 1415 South 47th Street, is directly adjacent to the eastern boundary of the RFS (see Figure 2).

Site History

The former Zeneca site was owned and operated by the Stauffer Chemical Company from 1897 to 1985. In 1985, Stauffer became a subsidiary of Cheesborough Ponds. In 1986, Cheesborough Ponds was acquired by the UK-based firm Unilever. In 1987, Imperial Chemical Industries,

P.L.C. (ICI) purchased the former Stauffer from Unilever. In December of 1987, ICI sold Stauffer to Rhone-Polenc, Inc., but the site was among the former Stauffer assets retained by ICI. In June 1993, ICI underwent a global reorganization, through which it changed its name to Zeneca. Zeneca was formed by combining ICI's various biological science companies, and acquired title to the site under that name in 2002. Zeneca conveyed the property to CSV on December 31, 2002 (LFR, Inc. 2005c).

From 1897 through 1985, Stauffer expanded its facility by acquiring adjacent parcels already developed for chemical manufacturing operations. These parcels were occupied by Lacquer Chemical Company, Griffin Chemical Company, Michael Pelton Insecticide Company, Western Industries, Metropolitan Match, Wheeler Reynolds Stauffer, Blowski Copper Company, and Union Superphosphate. The historic business, manufacturing areas, and site feature locations on the former Zeneca site are presented on Figure 12. The Lacquer, Griffin, and Michael Pelton parcels appear to have been acquired by Stauffer by 1949. The exact dates of acquisition of the remaining parcels are unknown (LFR, Inc. 2005a).

The former Zeneca site was divided into three separate lots (see Figure 13). Lot 1 is an approximately 17-acre parcel located in the northernmost portion of the former Zeneca site. Lot 2 is an approximately 9-acre parcel located in the central portion of the former Zeneca site. Lot 3 is south of and adjacent to Lot 2 and encompasses the approximately 60 acres of the former Zeneca site property that lies adjacent to and north of the San Francisco Bay. Lot 3 is currently undeveloped except for Building B-240 and associated parking areas (see Figure 13). A paved road lies south and west of Building B-240. The remaining portion of Lot 3 consists of exposed soil surfaces or stabilized cinder material that is currently capped with Kuma Type II Hydroseal.

Lot 1 History. Stauffer began development on Lot 1 with the construction of a pilot research facility (Building 94) in the late 1950s (LFR, Inc. 2005a). Prior to the 1950s, much of Lot 1 was apparently used as a farm, a school, and for residential buildings (based on aerial photographs dated 1947-1950). Additionally, based on aerial photographs, a manufacturing facility was located near the intersection of East Montgomery and South 49th Streets between the early 1940s and 1961. In 1960, Stauffer began developing the site as an agricultural chemical research and development campus. Between 1984 and 1991, Stauffer or its successor, ICI, acquired and developed the property east of South 49th Street and north of East Montgomery Street. Based on review of aerial photographs, the southwestern-most margin of Lot 1 was within the Stauffer facility fence line (prior to the 1950s) and was used as a material stockpile and storage area for the manufacturing plant through 1970s (LFR, Inc. 2005a). Railroad spurs crossed Lot 1 beginning at least in the 1930s (based on aerial photographs) to supply materials to the chemical manufacturing plant located primarily on Lots 2 and 3 (LFR, Inc. 2005a).

Agricultural chemical research and development associated with the Western Research Center (WRC) were conducted on Lot 1 until 2001, when these activities ended (LFR, Inc. 2005a). The WRC's primary focus was to develop new agricultural chemicals for worldwide applications. The six primary departments were chemistry, environmental science, product development, research services, process technology, and biological research and development. The WRC

employed approximately 350 scientists. The WRC buildings include laboratories, greenhouses, offices, cafeteria, library, meeting rooms, storage buildings, and pilot plant facilities.

Concrete slabs or asphalt covered the ground surface across most of Lot 1 until the site was sold by Zeneca to CSV. At the time of CSV's acquisition, Lot 1 surface improvements consisted of office buildings, a cafeteria, laboratories, greenhouses, fences, parking, sidewalks, landscaping, and storage buildings (LFR, Inc. 2005a). A more detailed description of Lot 1 activities is provided in the Lot 1 Current Conditions Report prepared for CSV, Zeneca, and Bayer CropScience Inc. by LFR, Inc. (2005a).

Lots 2 and 3 History. The southern portion of the former Zeneca site (Lots 2 and 3) was owned by several entities, including Stauffer and Zeneca, and used for manufacturing various chemicals including phosphate fertilizer (1906-1971); carbon disulfide (1906-1961); sulfuric acid (1916-1970); aluminum sulfate (alum) (1923-1984); ferric sulfate (1949-1972); titanium trichloride (1954-1976); and proprietary pesticides (1960-1997) (LFR, Inc. 2005b, 2005c).

In addition, Stauffer began manufacturing and formulating agricultural chemicals in the 1950s on Lots 2 and 3. The historic business, manufacturing areas, and site feature locations on the former Zeneca site are presented on Figure 12. Since 2000, all buildings on Lot 3 have been demolished except Building B-240 (LFR, Inc. 2005b, 2005c).

In later years of site operations, five primary chemical manufacturing, reformulation, and storage areas were located on Lot 3 (LFR, Inc. 2005c). These site use areas include (1) the former pilot plant tank farm and agricultural chemical offloading area, (2) the former agricultural chemical and formulations tank farm area, (3) the former laboratory area, (4) the former Vapam production area, and (5) the former western tank farm, as shown on Figure 12. In addition, Lot 3 formerly contained a cinder fill area, an Agricultural Yard Pond ("Ag Yard Pond"), and a wastewater treatment system. The cinder fill area was capped in 1974 and further remediated in 2002, when cinders greater than 2 feet thick were excavated, neutralized with limestone, placed and compacted within Lot 3, and covered with the temporary cap (Kuma material). In 1991, the Ag Yard Pond was closed under the Water Board's authority pursuant to the Toxics Pits Cleanup Act of 1984 (LFR, Inc. 2005c). The wastewater treatment system was removed as part of the cinder remediation.

Earlier manufacturing or research facilities within Lot 3, based on historical aerial photographs, Sanborn Maps, and interviews with former employees, include former Union Super Phosphate Company (1916-1930s); the former US Phosphorus Company; super phosphate; Lacquer Chemicals (1930s); Griffin Chemicals (1930-1949); Metropolitan Match (1913-1930); pilot plants; Vapam production plant; Devrinol manufacturing area; carbon disulfide and Ordram manufacturing area; muriatic acid production; alum production; sulfuric acid production; ferric acid production; and titanium trichloride production (LFR, Inc. 2005c).

Additionally, as noted above, various support facilities were located on Lot 3, including wastewater treatment facilities (neutralization tanks, carbon columns, groundwater extraction

trench, stormwater collection and surge ponds); various chemical USTs and ASTs; railroad spurs; and truck terminal.

Several of the manufacturing areas overlapped Lot 2 and Lot 3, as shown on Figure 12. Additionally, a portion of the WRC was located on the central and eastern portion of Lot 2 and the eastern portion of Lot 3 (see Figure 12). In 1996, agricultural product manufacturing ceased and the last production line was closed in 1997. A more detailed description of Lot 2 and 3 activities is provided in the Lot 2 Current Conditions Report prepared for CSV, Zeneca, and Bayer CropScience Inc. by LFR, Inc. (2005b, 2005c).

Adjacent and south of the upland portions of Lot 3 is the Habitat Enhancement Area (HEA). The HEA comprises approximately 21 acres, which include the 10-acre Eastern Stege Marsh, the 8-acre Freshwater Lagoons, and the surrounding areas designated for habitat enhancement (LFR, Inc. 2007b).

Historical Releases in the Vicinity of the RFS

Certain surface spills originating from the former Stauffer operations reportedly migrated onto the RFS property (UC Berkeley 2001). RFS employees have reported that stormwater flowed from the western side of the former Zeneca site, onto 46th Street, and either onto the RFS property or into the storm drain inlet that is located east of RFS Building 185 along the western side of South 46th Street. This storm drain historically connected, and currently connects, to the eastern storm drain line that runs parallel to Egret Way and discharges into the eastern portion of Western Stege Marsh (UC Berkeley 2000a, 2000b). RFS employees photographed a large spill of alum mud caused by a break in a containment berm on the former Zeneca site that flowed over the southeastern corner of the RFS property near RFS Building 163 and into the marsh in 1983 (UC Berkeley 2000b; URS 2000). Photograph C-19 in Appendix C shows workers from Stauffer using a vacuum truck to pump out the spilled material from Western Stege Marsh. Several former RFS staff noted that releases of sulfuric acid to the air were not uncommon, and that Stauffer paid for painting cars at RFS because of acid releases (UC Berkeley 2006b, 2006c). The placement of spent pyrite cinders into Western Stege Marsh has also been identified as a former source of contamination on the RFS (a majority of the pyrite cinders were removed during the remediation activities performed in 2002 and 2003).

Regulatory History

Historical operations at the former Zeneca site have been regulated by various federal, state, and local agencies. Regulatory agencies historically required site owners and tenants to obtain various permits associated with operations, including hazardous waste generation, air emissions, and wastewater discharge. The Water Board was the lead agency for environmental investigations and remediation from the 1970s through 2004. During this time, the Water Board was involved in the oversight of several investigations at the former Zeneca site, primarily associated with operational issues associated with manufacturing operations. These investigations included several remedial investigations and the oversight of permitting under the National Pollutant Discharge Elimination System for wastewater discharge into San Francisco

Bay. On October 5, 2001, the Water Board issued Site Cleanup Requirements Order No. 01-101 covering the entire property then owned by Zeneca. Prior to issuance of the Water Board's Order No. 01-101, Zeneca had voluntarily completed Phase I and Phase II investigations throughout the site (LFR, Inc. 2005c).

The DTSC is currently the lead regulatory agency for the former Zeneca site. The Water Board Order for the former Zeneca site was rescinded on October 19, 2005. On February 8, 2005, the DTSC issued Site Investigation Order, Docket No. 04/05-006, to Zeneca, CSV, and Bayer CropScience Inc. for the upland portion of the site and outlined the reporting, site investigation, and maintenance tasks to be completed at the former Zeneca site. The DTSC subsequently assumed the role of lead agency for the HEA of Eastern Stege Marsh in addition to the upland areas. On September 15, 2006, the DTSC issued Site Investigation Order, Docket No. 06/07-005, to Zeneca, CSV, Bayer CropScience Inc., and the Regents of the UC for the entire former Zeneca site. A more detailed description of past and current agency oversight at the former Zeneca site is provided in the Current Conditions Reports prepared for Lots 1, 2, and 3 (LFR, Inc 2005a, 2005b, 2005c).

Summary of Remediation Activities – Lots 1, 2, and 3

Between 2001 and 2003, Zeneca and CSV performed remediation activities in Lots 1, 2, and 3 under the oversight of the Water Board. Remediation activities included:

- Excavation and off-site disposal of toluene-, benzene-, and dichlorodiphenyltrichloroethane (DDT)-affected soils.
- Excavation and off-site disposal of odor-affected soil in the area of the former Pilot Plant.
- Extraction and on-site treatment of 50,000 gallons of toluene-affected groundwater. Treated groundwater discharged to the City of Richmond sanitary sewer system.
- Stabilization and placement of cinders and alum mud excavated from the former Zeneca site. Cinders and alum mud were placed in the cinder placement area in Lot 3 located north of the BAPB wall.
- Placement of cinders and mercury-affected cinders (mercury at concentrations between 50 and 260 mg/kg) excavated from the eastern portion of Western Stege Marsh and the Transition Area. Most of the materials excavated from the RFS were stabilized on the RFS property before they were transported to and placed in the cinder placement area in Lot 3.
- In-situ groundwater treatment.
- Installation of the BAPB in the southern portion of Lot 3.

- Abandonment of monitoring wells and utilities that represent potential conduits for migration of chemicals in groundwater to Eastern Stege Marsh.

- Installation of a bentonite slurry wall along the RFS/former Zeneca site property boundary.

- Installation of a temporary cap (HydroSeal) over the cinder placement area to reduce infiltration of surface water, provide erosion control, and prevent dermal contact.

- Stormwater management, including installation of a low-flow interceptor trench and new storm drain system.

The Current Conditions Reports prepared for Lots 1, 2, and 3 by LFR, Inc. provide a more detailed descriptions of the remediation activities performed in Lots 1, 2, and 3 (LFR, Inc. 2005a, 2005b, 2005c).

CSV recently performed an excavation of soil impacted by PCBs and volatile organic compounds (VOC) in the vicinity of former Building 94 in the Lot 1 area pursuant to a removal action workplan approved by DTSC.

Summary of Remediation Activities – Habitat Enhancement Area

Remediation of the HEA was performed in three phases between mid-October 2004 and December 2005.

Phase I remediation activities included the excavation and backfilling of more than 90 percent of the proposed excavation in Eastern Stege Marsh and excavation and backfilling activities in the proposed excavation areas in the Upper Fresh Water Lagoons. These activities were completed under the regulatory oversight of both the Water Board and DTSC.

Phase II remediation activities included grading activities in Eastern Stege Marsh and the surrounding habitat areas. Phase III remediation activities included the remaining excavation in Eastern Stege Marsh, removal of the tidewater control berm in the central saltwater marsh remediation area, and final grading activities. DTSC required that the work in the Lower Fresh Water Lagoon be delayed for further study which is currently ongoing.

1.1.5.2 Bio-Rad Laboratories

The Bio-Rad site, at 3110 Regatta Boulevard is immediately west of the RFS and north of the Marina Bay housing development. Bio-Rad manufactures products for the life sciences and medical diagnostic testing markets. Chemicals associated with the manufacture of these products have been detected in soil and groundwater at the Bio-Rad site (DTSC 2006).

Bio-Rad has operated its Richmond manufacturing facility since 1957 and is still in operation today. The Bio-Rad site is approximately 5 acres and is bounded on the south by Meeker Slough and the Bay Trail, on the east by the RFS, on the west by industrial and/or commercial properties and on the north by Regatta Boulevard.

Bio-Rad submitted an assessment report to DTSC in 1997 that described a historic records search of past manufacturing activities, interviews with site employees, and soil and groundwater samples. Since then, Bio-Rad has conducted environmental investigations at the facility. In 2002, Bio-Rad and DTSC entered into a Consent Agreement to oversee future cleanup activities (DTSC 2006).

Since 1996, environmental investigations have been conducted at the Bio-Rad site to determine if past manufacturing activities had contaminated soil and groundwater. The investigations showed that soil and groundwater under and around the manufacturing buildings at the south end of the Bio-Rad site are contaminated with VOCs. The most recent available groundwater monitoring was conducted in June 2006, and the following contaminants were detected: chloroform (up to 75,000 micrograms per liter [µg/L]); methylene chloride (up to 5,000 µg/L); cis-1,2-dichloroethene (-DCE) (up to 1.3 µg/L); tetrachloroethylene (PCE) (up to 15 µg/L); trichloroethylene (TCE) (up to 4,000 µg/L); and vinyl chloride (up to 46 µg/L) (DTSC 2006).

In October 2004, seven groundwater monitoring wells were installed at the edges of the Bio-Rad site. Chloroform was reported at a high concentration in a groundwater sample from one of the wells near the facility fence line by Meeker Slough. This was the first time a sample near the fence line had shown any significant amount of chloroform. In response to this result, additional groundwater sampling was performed in January 2005 on the north and south sides of Meeker Slough and surface water samples were collected in Meeker Slough. Results of groundwater samples collected from the south side of Meeker Slough indicated that there is no contamination to the south of the Slough. These sample results confirmed that contaminants have not migrated to the south side of Meeker Slough (DTSC 2006).

In April 2005, the EPA inspected the Bio-Rad facility and found the company was not complying with requirements to control air emissions from hazardous waste, a violation of the agency's hazardous waste regulations. In December 2006, EPA assessed a $29,900 fine against Bio-Rad for hazardous waste storage violations. According to the EPA, Bio-Rad also failed to determine what kind of hazardous waste was generated, properly train its workers in managing and handling hazardous waste, have a hazardous waste spill response plan, and store hazardous waste in required containers with proper labels (EPA 2006).

In November 2006, DTSC issued a Fact Sheet to inform area residents about a groundwater and treatment pilot study (pilot study) for the Bio-Rad site. To address immediate groundwater issues, a 6-month pilot study will be conducted at the Bio-Rad site while long-term cleanup solutions are being developed. The purpose of conducting the pilot study at the Bio-Rad site is to evaluate whether a treatment system can eliminate the migration of VOCs toward Meeker Slough and at the same time reduce the concentrations of contaminants in the groundwater. The pilot study will include installing two groundwater extraction wells that will extract and treat the

contaminated groundwater. The extracted groundwater will be treated using an on-site granular activated carbon treatment system. According to DTSC, the pilot study was evaluated during the first 6-month period of operation to evaluate its effectiveness; and was then approved by DTSC. Groundwater and surface water samples will continue to be sampled quarterly to monitor VOC and chloroform concentrations and groundwater movement (DTSC 2006). Bio-Rad submitted two additional treatability study workplans (in-situ groundwater technologies and soil vapor extraction) on August 6, 2008 which evaluated additional technologies to enhance the removal of contaminants from soil and groundwater in conjunction with the existing groundwater extraction and treatment system. Bio-Rad is continuing to work with DTSC to perform additional pilot studies on their site.

1.1.5.3 Marina Bay

The Marina Bay housing development borders Western Stege Marsh to the west, across Meeker Slough (see Figure 2). The area now encompassing the Marina Bay housing development and the adjacent Richmond Marina Bay was the location of the former Kaiser Shipyard No. 2 for the construction of ships in the early 1940s during World War II (DTSC 2007). During shipbuilding activities, the area was used for the storage of shipyard supplies and disposal of debris (URS 2000). Between 1941 and 1943, this area was filled with dredge spoils and off-site fills. Additional fill was imported in the late 1970s. Prior to this time, the eastern part of this area along Meeker Slough consisted of mudflats and marsh.

After the war, the Marina Bay site was used by several industrial firms (DTSC 2007). From the 1940s to 1971, Butler Steel Products used the eastern portion of the Marina Bay site. The Butler Steel Products building was demolished in the mid-1980s. In 1982, during excavations to form a lagoon in the southeastern corner, a large amount of solidified paint material was discovered, prompting site remediation activities from 1982 to the early 1990s. Since then, the Marina Bay site has been developed into a residential area, including parks and a marina for the City of Richmond (URS 2000).

Several environmental investigations were performed at the Marina Bay site in association with the site remediation performed in the early 1990s. The primary sources of contamination were lead-based paint, metal debris, and petroleum hydrocarbons. Findings of these investigations are summarized below.

- In 1982, 225 cubic yards (cy) of solidified dark red paint material was removed in the southeastern corner of the Marina Bay site during excavations to build a lagoon. This material contained elevated concentrations of chromium, lead, and zinc (URS 2000).
- In 1988, metal-bearing soils were found with lead at a maximum concentration of 4,420 mg/kg (URS 2000).

- In 1989, elevated lead concentrations were found in association with metal debris. Also, paint-bearing soil was found adjacent to Meeker Slough containing elevated concentrations of lead (maximum of 4,100 mg/kg) and petroleum hydrocarbons (maximum concentration of 9,600 mg/kg) (URS 2000).

- In 1990, an area measuring 35 feet by 20 feet was excavated from the bank along the south side of Meeker Creek. This area contained heavy petroleum hydrocarbon contamination (motor oil at a maximum concentration of 2,800 mg/kg, and oil and grease at a maximum concentration of 1,400 mg/kg) (URS 2000).

- In 1992, the Draft Remedial Action Plan (RAP) reported chromium, lead, VOCs, semivolatile organic compounds (SVOC), polycyclic aromatic hydrocarbons (PAH) as chemicals of concern (COC) in soil, and high pH was reported in alkali pond sediments. Groundwater contained elevated total petroleum hydrocarbons (TPH) quantified as gasoline, diesel, and kerosene, as well as acetone, 1,2-DCE, and TCE (URS 2000).

Remediation activities conducted in the early 1990s at the Marina Bay site resulted in the removal of the following volume of materials adjacent to Meeker Slough and the western side of the Marsh:

- 2,500 cy of soil and metal debris
- 60 cy of paint debris
- 900 cy of soil with TPH and paint
- 90 cy of soil with TPH

1.1.5.4 Liquid Gold

The Liquid Gold property is located west of Hoffman Boulevard in Richmond, California, approximately 0.5 miles east of the RFS and adjacent to the former Zeneca site. The Liquid Gold site covers 17 acres of filled marshland adjacent to the San Francisco Bay (EPA 1983). The property is owned by the Southern Pacific Land Corporation, and was leased from 1947 to 1974 to San Pablo Oil for an asphalt manufacturing plant. The property was later leased to Liquid Gold, which used the property as an oil storage and transfer facility until 1982 (URS 2000). Oils, solvents, and tank bottoms were stored on site. Liquid Gold's property included a former asphalt facility, two tank farms, and several small structures. They are also reported to have operated as an oil recycler, purchasing used oil from generators such as service stations, and selling it for re-refining for use as fuel oil, lubricating oil, and a dust control agent (URS 2000). Previous activities at the Liquid Gold property are a potential source of contaminants in Western Stege Marsh through discharges to Baxter Creek, which was hydrologically connected to Western Stege Marsh until some time in the 1960's when Stauffer

constructed a landfill that hydrologically separated Eastern and Western Stege marshes (based on aerial photographs).

As of October 1979, facilities at Liquid Gold consisted of 27 storage tanks of various sizes and several unused deteriorating buildings remaining from the asphalt manufacturing plant. The three groups of tanks were surrounded by a dirt and gravel berm approximately 2 feet high. An additional 2-foot-high berm was located along the eastern side of the facility, approximately 135 feet from the storage tanks. A culvert, approximately 6 feet in diameter and 125 feet long, was located at the southern end of the facility. The culvert discharged into a bermed area, which was approximately 60 feet by 100 feet at its southern end. In 1979, the southwestern portion of the facility was leased to a pallet manufacturing and reconditioning company. The Department of Health Services (DHS) identified the following COCs at the property: copper, chromium, lead, nickel, zinc, PCBs, and oil. In April 1980, soil and groundwater samples were collected from two locations on the property. Analytical results of the samples indicated that soil contained phenols (28,500 and 29,000 parts per million [ppm]) and aqueous-phase phenols (6,300 and 7,300 ppm).

The investigations conducted during the 1970s at the Liquid Gold property by the California DHS and the Water Board documented releases of hazardous substances onto the ground and into ponds, sumps, and ditches. Consequently, the Liquid Gold site was listed on the California State Superfund List in January 1983. The EPA also listed the Liquid Gold site on the National Priority List (NPL) in September 1983. According to the EPA, Liquid Gold was registered with the State of California as a "waste oil pickup" business. EPA also noted that oily wastes were found on the ground, as well as liquid wastes stored in the tanks. The waste contained lead, chromium, nickel, and phenols (EPA 1983).

The DTSC has since assumed lead responsibility for overseeing environmental investigations and cleanup actions at the Liquid Gold site. Numerous groundwater monitoring wells are located on the Liquid Gold property. Groundwater samples were found to contain concentrations exceeding the Water Board-recommended levels for saltwater ecological protection for copper (maximum concentration of 29 µg/L) and mercury (maximum of 0.34 µg/L) (URS 2000). Historical soil samples collected and analyzed from the Liquid Gold property were found to have concentrations of several metals exceeding background levels developed for soils in this area: copper (maximum of 2,600 mg/kg), lead (maximum of 5,200 mg/kg), mercury (maximum of 4.8 mg/kg), and zinc (maximum of 4,900 mg/kg). Analytical results for sediment samples from the southwest drainage channel ("Transect 6") of the Liquid Gold property were found to contain elevated concentrations of the following chemicals: copper (maximum of 360 mg/kg), mercury (maximum of 4,200 mg/kg), lead (maximum of 830 mg/kg), and zinc (maximum of 940 mg/kg).

On June 21, 1993, EPA issued the Record of Decision (EPA 1993), and the Liquid Gold site was remediated in 1994 and 1995 by dredging the marsh channel, installing a vegetative cap, and monitoring groundwater. The remedial actions were completed at the Liquid Gold site under DTSC oversight. EPA and DTSC approved the completion of the remedial actions, and construction completion was achieved with the signing of EPA's Preliminary Closeout Report on September 27, 1995. In September 1996, the Liquid Gold site was removed from the NPL. Long-term monitoring and maintenance activities at the Liquid Gold site continue to be overseen by DTSC. Because the remedy selected for the Liquid Gold site resulted in hazardous materials remaining on site, site reviews are required every 5 years after implementation of the remedial action to evaluate the effectiveness of the selected remedy for protecting human health and the environment. In addition, access and deed restrictions were implemented to prevent exposure (Environmental Resources Management 2005). EPA notes in its most recent 5-year review that the potentially responsible party must investigate the boundaries of the cap and the fencing to determine they are consistent with the deed restriction.

1.1.5.5 Other Potential Off-Site Sources

Other potential off-site sources of contaminants in the vicinity of RFS and the watershed of Meeker Slough include the former PG&E facility and other light industries to the north of I-580 that may have drained to the western storm drain and other possible urban sources.

Western Storm Drain Line

Storm drainage from northern off-site properties entered RFS through underground culverts and open ditches. Prior to the construction of the City of Richmond's publicly owned treatment works in the early 1950s, sewage and industrial wastes were discharged directly to the San Francisco Bay through a system of combined sanitary sewer and storm drains. The RFS Western Storm Drain line was one of a number of wastewater and stormwater conveyance pipes located on and around the RFS. The date of construction of RFS's Western Storm Drain line is unknown. It is believed to have served as a combined sewer through the 1900s until the early 1950s, draining industrial and residential wastewater and stormwater from a portion of the City of Richmond upstream of the California Cap Company and from portions of the RFS itself. Sometime in the late 1940s or early 1950s, the City of Richmond wastewater treatment plant was constructed and historic sewers were routed to newly constructed sanitary sewer lines.

Two sanitary sewer lines were constructed in an east to west direction and perpendicular to the Western Storm Drain line (see Figure 7). On the south end of the RFS, a sanitary sewer line draining portions of the RFS, Stauffer, and other off-site properties was routed west across to the area that is now the Bio-Rad property. On the north end, a sewer line was constructed to continue conveying wastewater from the northeast corner of RFS and other off-site upstream areas west to the City of Richmond treatment plant. At that time, this section of the City of Richmond's sanitary sewer line was connected with the Western Storm Drain line; a manhole with an overflow bypass was installed so that portions of flow from the sanitary sewer line would overflow into the storm drain line during high-flow conditions. Because of this overflow line, the Western Storm Drain line historically transported stormwater, sewage, and wastewater from

industrial and residential properties upstream of the California Cap Company and flowed into the Meeker Slough (see Appendix E).

Since 1950, the Western Storm Drain line has conveyed stormwater runoff from portions of the RFS and likely has conveyed stormwater runoff from properties north of RFS, including the former PG&E yard north of the RFS property. The former PG&E yard is a possible source of the PCBs that have been historically identified in Western Stege Marsh and Meeker Slough. The PG&E yard was constructed in the mid 1950s, and based on historical photographs, the yard appears to have been used for parking vehicles and storing equipment (see Appendix C, Photograph C-9). The storage yard was located immediately north of the Western Storm Drain. PCBs have been widely used in transformers since 1929. Due to reconfiguration of the Regatta Boulevard/I-580 interchange in the 1990s, historic drainage patterns no longer exist.

UC Berkeley has connected on-site storm drain lines from the middle and lower areas of RFS, including the NRLF, to the Western Storm Drain line (see Figure 7). No connections were made to the north of Manhole No. 11 located directly east of the NRLF. The northernmost manhole (Manhole No. 9) of the Western Storm Drain line is north of the RFS property line and is covered by a eucalyptus tree (see Appendix E).

During the remediation activities performed in 2004 (see Section 1.2.2), the 430-foot portion of storm drain pipe between Manhole No. 11 and Manhole No. 9 was abandoned in place by digging down to the pipe using an excavator at each of the manholes to expose the pipe and breaking the pipes with the excavator bucket (see Figure 3). The sections of the pipes within the two potholes were backfilled with grout to seal this section and to isolate the storm drain from the sewer line. Except for a portion of Meade Street that may drain stormwater runoff into the on-site storm drain system, the storm drains from off-site properties do not drain to UC Berkeley (UC Berkeley 2007).

Southern Sanitary Sewer Line

Sanitary sewer discharges transported via the former Richmond Municipal Sewer District's sewer system that serviced the California Cap Company, RFS, the former Zeneca site, and other industrial businesses (including Liquid Gold) located to the east of RFS, and traversed the southern portion of the Transition Area, are other potential sources of historical contamination in the southern portion of RFS. Historically, this former section of the Richmond Municipal Sewer District's sewer line had the following capacity limitations: (1) the sewer line had a slight uphill east-to-west gradient, (2) the former line was located along the former shoreline at depths sometimes below groundwater level (depending on variations in groundwater elevations from tides and seasonal fluctuations), (3) excess surcharges into the sanitary line from storm-water runoff connections, and (4) reduced line capacity from rust building up in the sewer line (Jones and Stokes 1990). The Richmond Municipal Sewer District performed testing and determined that much of the groundwater infiltration into the line appeared to be originating in the portion of the sanitary line crossing the former Zeneca site (Jones and Stokes 1990). During removal of the portion of the sanitary sewer line on the RFS property in 2003, it was observed that the line was cracked in many places in the eastern portion of the Transition Area near the

boundary with Western Stege Marsh (URS 2004). This confirmed pre-excavation site investigation observations during videotaping of the line. In addition, the sanitary sewer line was bedded in pyrite cinders along the entire length of the sanitary sewer line that transversed the RFS property.

1.2 SUMMARY OF PREVIOUS INVESTIGATIONS AND REMEDIATION ACTIVITIES

This section summarizes previous investigations and remediation activities conducted through 2006 in the Upland Area, Transition Area (including the Bulb), and Western Stege Marsh of RFS.

1.2.1 Previous Investigations

Various investigations occurred at RFS between 1981 and 2006. These investigations included collecting soil, sediment, groundwater, and ecological tissue samples in the Upland Area, Transition Area, Western Stege Marsh, and Meeker Slough. Figure 14 shows soil and sediment sampling locations performed to date at RFS, including original sampling locations, confirmation sampling locations, and removed sampling locations. Figures 15, 16, and 17 provide the sampling locations for samples collected in the marsh, including the Transition Area, the central portions of the Upland Area, and the northern portions of the Upland Area, respectively.

The investigation process at the RFS has been iterative. The investigations have focused on potential source areas (see Figure 9), resulting in the identification of areas requiring further investigation. Areas that were remediated following investigation are shown on Figure 18. Table 4 lists the reports in which the results of investigations are documented. The following subsections provide a chronological summary of the various investigations that have been conducted at the RFS.

1.2.1.1 Historic Site Investigations (1981 to 1999)

The following is a summary of environmental investigations conducted at RFS prior to the 1999 Field Sampling and Investigation Plan performed under the Water Board oversight (UC Berkeley 2007):

- February 1981 – The State of California DHS collected five samples of soils. Mercury was detected in the vicinity of the former mercury fulminate production area, DDT in the marsh, and elevated zinc concentrations were identified in spent pyrite cinders present near the former Zeneca pyrite cinders in the southeastern portion of Western Stege Marsh.

- June 1982 – DHS collected 17 additional samples. Mercury and DDT were not detected in confirmatory samples collected as a follow up to the February 1981 sampling event. Lead was reported at a concentration of 985 mg/kg at one location, and elevated concentrations of copper were found.

- April 1984 – EAL Corporation collected four surface water samples as requested by the Water Board. No exceedances of maximum contaminant levels (MCL) for drinking water were identified.

- November 1988 – CH2MHill collected 18 samples. No VOCs, PCBs, or pesticides were detected. Elevated metals were found in the mercury fulminate area.

- August 1989 – EES completed an environmental assessment of the RFS. It notes the lack of vegetation in some areas, and recommended sampling be performed in the former mercury fulminate plant area.

- December 1989 – Jonas & Associates completed field sampling, including collection of 167 soil samples from the uplands and marsh areas and groundwater samples from two monitoring wells.

- June 1990 – Jonas & Associates performed sampling at the former FPL WTL near Building 478.

- Fall 1990 – Jonas & Associates performed additional sampling in Meeker Slough, near the pier, and from storm drain outfalls.

- February 1991 – Jonas & Associates and OHM Remediation Services Corporation completed a Preliminary Risk Assessment for the planning of the new EPA Region 9 laboratory.

- March 1991 – EPA accepted risk assessment results.

- June 1992 – Jonas & Associates completed additional soil sampling at the former FPL WTL near Building 478.

- July 1998 – Ecology Control Industries collected soil and groundwater samples from eight borings along the Egret Way sewer lateral after elevated zinc was found in the sanitary sewer during routine inspections by the City of Richmond. The sewer line was excavated and replaced in March 1999.

1.2.1.2 Field Sampling and Analysis Plan and Tiered Risk Evaluation

In 1999, URS prepared a field sampling and analysis plan (FSAP) and tiered risk evaluation report. The purpose of the FSAP was to develop a strategy to evaluate soil, groundwater, and sediment quality at RFS, to delineate the extent of any contamination, and evaluate potential sources. The approach was to focus on (1) meeting the Water Board's requirements, (2) determining on-site and off-site sources of contamination based on a review of site history, (3) delineating the extent of chemicals of potential concern (COPC), (4) collecting data necessary to allocate cleanup responsibility, and (5) obtaining data necessary for evaluating potential risks to human health and the environment (URS 1999).

The FSAP summarized the use of a three-phased approach to focus sampling efforts. Phase I consisted of identifying COPCs and sampling to determine the presence of COPCs. Based on the results of the phase I sampling, phase II included additional sampling to delineate COPCs, hydrogeologic characterization, and evaluations of human and ecological health risk. The FSAP proposed to conduct additional soil and groundwater sampling in the following areas: (1) former FPL; (2) former Test Pit and Explosives Storage Facility; (3) former California Cap Company Shell Manufacturing Facility; (4) former Mercury Fulminate Facility; (5) Western Stege Marsh; and (6) in various other areas—including the southern sewer line that formerly traversed the southern portion of the RFS, the storm drain line areas, and areas containing pyrite cinders. The FSAP detailed the rationale for the selection of chemicals and sampling locations under phase I of the proposed sampling activities (URS 1999).

The FSAP outlined a three-tiered risk evaluation to evaluate the potential risk to human and ecological receptors from COPCs in soil. Tier 1 of the evaluation entailed comparing COPCs with background concentrations. COPCs with concentrations exceeding background concentrations were compared with benchmarks representative of the receptor(s) potentially present within established risk-based protection zones. COPCs with concentrations exceeding both the background concentration and the benchmark were evaluated further in Tier 2 of the risk evaluation. Bioaccumulative chemicals were also evaluated further in Tier 2. This step entailed developing SSTLs to be protective of the potential exposure scenarios. SSTLs protective of human health were developed by calculating the total cumulative cancer and noncancer risk and the hazard quotient for each COPC. SSTLs protective of ecological receptors were developed to be protective of the receptors present in each risk-based protection zone.

All the results of phase I sampling conducted under the 1999 FSAP are presented in "Final Field Sampling and Analysis Results" (URS 2000). The sampling locations from the 1999 FSAP field activities that represent current conditions are shown on Figures 19 and 20, and Appendix D. Phase II field activities conducted between February and June 2000 included collection of soil and groundwater samples in the potential source areas within the upland portion of the RFS property and sediment and surface water samples within the marsh. Based on the sample results, additional samples were collected to evaluate the extent of pyrite cinders (an identified source of COPCs), to identify potential off-site sources of PCBs, and to collect tissue data for the ecological risk assessment (URS 2000).

Of the six on-site potential sources identified in the FSAP, two were identified as sources of COPCs to the marsh: the pyrite cinders (since removed during remedial activities in 2002 through 2004) and the former Mercury Fulminate Area (MFA). Of the five off-site sources evaluated, four were identified as potential contributors of COPCs to the marsh: the former Zeneca site, Liquid Gold, Marina Bay, and the former PG&E yard (URS 2000).

The analytical results for soil samples collected in the Upland Area were screened against the EPA industrial and residential preliminary remediation goals (PRG). Mercury and arsenic exceeded the industrial PRGs in the former MFA and five upland areas. Residential PRGs were exceeded in six separate areas (URS 2000).

As is typical of sites located near the San Francisco Bay, the analytical results for groundwater samples from the Upland Area were screened against 10 times the EPA Marine Ambient Water Quality Criteria (AWQC). Samples exceeding the screening criteria were found in five separate areas: (1) the RFS and former Zeneca site property boundary area, (2) the former storm drain outlet into Meeker Slough at the western portion of Western Stege Marsh (since remediated), the former southern sanitary sewer line in the Transition Area (since removed in 2003), (4) the former FPL area, (5) and the former MFA (URS 2000).

Soil and sediment samples collected in Western Stege Marsh had elevated concentrations of metals (arsenic, cadmium, copper, lead, mercury, nickel, selenium, and zinc), PCBs and pesticides, as well as areas exhibiting low pH conditions. Elevated PCBs were found directly adjacent to the western storm drain outfall and were targeted for additional characterization (URS 2000). This area, later designated marsh area M1a, was remediated in 2003.

The analytical results for surface water in Western Stege Marsh and groundwater sampled along the former RFS marsh-access road and the Bay Trail were screened against the AWQC for chronic exposure. Numerous locations exceeded the AWQC for a wide range of COPCs (URS 2000).

1.2.1.3 Additional Soil and Groundwater Investigations, Upland Portion of Transition Area

Additional soil and groundwater samples were collected in summer 2001. The sampling results and groundwater monitoring plan for the Transition Area are presented in "Results of Additional Soil and Groundwater Investigations and Groundwater Monitoring Plan, Upland Portion of Subunit 2A" (URS 2001b). The objectives of the investigation were to (1) delineate the extent of metals, affected sediment, and pyrite cinders in the Transition Area (since remediated as described in Section 1.2.2); (2) evaluate the effects of underlying groundwater; and (3) develop information necessary to complete a conceptual RAP for the Transition Area (formerly designated as Subunit 2A under the now-rescinded Water Board Order).

The investigations included the following activities: (1) excavation of 34 test pits and the collection and analysis of 11 soil samples, and (2) advancement of 23 Geoprobe borings and the collection and analysis of 49 soil samples and 31 groundwater samples. The soil samples consisted of fill material, pyrite cinders, and/or sediment samples (URS 2001b).

The report concluded that the engineered fill materials that were placed in the Transition Area (formerly designated as Subunit 2A) were not contaminated, but recommended the collection of four additional fill samples to be analyzed for metals. The soil/pyrite cinder layer and the upper 1 foot of sediment contained elevated concentrations of several metals, including arsenic, copper, mercury, and zinc. No additional sampling was recommended for these materials. However, the report recommended that the conceptual RAP being developed for the former Zeneca site also be applied to the Transition Area, where metal exceedances of the SSTLs occurred in soil, cinder, and sediment (URS 2001b).

Evaluation of the groundwater results indicated that elevated metal concentrations were associated with the pyrite cinders present in Western Stege Marsh. The report recommended that the source of VOCs detected be confirmed and the extent of the VOCs in groundwater be delineated through the installation of additional monitoring wells and quarterly groundwater monitoring for a 2-year period (URS 2001b).

1.2.1.4 Additional Soil and Groundwater Investigations, Western Stege Marsh

The results of soil and groundwater investigations conducted during summer and fall 2001 in the eastern portions of Western Stege Marsh were presented in the report titled "Results of Additional Soil and Groundwater Investigations and Surface Water Monitoring Plan, Marsh Portion of Subunit 2A" (URS 2001c).

The COCs identified during the previous investigations were arsenic, copper, lead, mercury, nickel, and zinc. To further delineate the extent of COCs within the eastern portion of Western Stege Marsh, the following additional investigations were conducted: (1) collecting one surface sample in the area between the orange pond (since remediated) and Bay Trail access road (since remediated), (2) advancing numerous hand-auger borings to a depth of 4 to 5 feet bgs for visual observation, (3) excavating a test pit to evaluate the location and thickness of fill material and pyrite cinders, and (4) collecting six soil samples and two groundwater samples from three Geoprobe borings within the Bay Trail access road (since remediated) (URS 2001c).

Analysis of the results of the additional investigations indicated that soils within the former Bay trail access road (since remediated) contained low pH conditions and elevated metal concentrations unsuitable for ecological receptors. The cinders and metals present within the access road extended from the upland portion of RFS south to the southeast corner of the Western Stege Marsh. Elevated metal concentrations and low pH conditions were also detected in the eastern portion of Western Stege Marsh (URS 2001c).

1.2.1.5 Human Health and Ecological Tiered Risk Evaluation

In 2001, URS conducted a multi-tiered risk assessment to evaluate the potential risks to human health and the environment by COPCs detected at RFS (URS 2001a). Based on the results of the risk assessment, areas were identified in the Upland Area in the Western Stege Marsh where further investigation and remediation were recommended. As part of the risk evaluation, SSTLs for human and ecological receptors were developed. These SSTLs were developed separately for both the upland area and the marsh area using a two-tiered method. In Tier 1, current soil and groundwater sampling results were compared against the Water Board's risk based screening levels (RBSL). If the results for that analyte exceeded the RBSL, a Tier 2 evaluation was performed. For the Tier 2 evaluations, potential exposures were evaluated for potential residents, office workers, maintenance workers/construction workers, recreators, and anglers. A Tier 2 health risk evaluation was performed based on DTSC, Office of Environmental Health Hazard Assessment, Water Board, and EPA agency guidance. Target carcinogenic risk and non-cancer hazard threshold were used to calculate risk-based concentrations that were assigned as the SSTL. The original SSTLs calculated in the Human Health and Ecological Tiered Risk

Assessment will be reevaluated by UC Berkeley and new site specific screening values will be determined with the concurrence of DTSC.

1.2.1.6 Additional Soil and Groundwater Investigations, Upland Areas

In September 2002, additional soil and groundwater samples were collected. The results of the additional soil and groundwater investigations performed in the RFS Upland Area are provided in "Results of Additional Soil and Groundwater Investigations, Upland Portion of Subunit 2B" (URS 2002b). The following field activities were performed during the investigations:

- Collected and analyzed soil samples to further delineate the potential areas for remediation.
- Collected cone penetrometer test (CPT) data to evaluate the stratigraphy in the area along the RFS and former Zeneca site property boundary for the design of the property boundary slurry wall.
- Collected and analyzed groundwater samples along the RFS and former Zeneca site property boundary to evaluate the potential migration of COCs onto the RFS property from the former Zeneca site.
- Installed temporary piezometers to evaluate groundwater flow direction (as shown on Figure 20).

An analysis of the soil results of these additional investigations concluded that various metals exceeded both human and ecological SSTLs developed during the 2001 Human Health and Ecological Risk Assessment at numerous areas in the Upland Area. The report recommended that additional soil samples be collected around each of these areas. Elevated concentrations of copper, nickel, and zinc were also reported in one of the groundwater samples collected along the property boundary.

1.2.1.7 Mercury Treatability Study

In 2002, UC Berkeley performed a treatability study to evaluate the reagent that would most effectively stabilize mercury-affected sediment and cinders located on the RFS property. Supplemental information on the results of the treatability study is provided in "Remedial Design Details – Addendum 2, Mercury Treatability Study Results, Subunit 2A" (URS 2002c).

Based on the results of the treatability study, the stabilization agent that resulted in acceptable pH and mercury concentrations in sediment leachates was 5 to 10 percent powder-activated carbon (PAC) by weight. Results also showed that larger doses of PAC produce marginally greater reductions, with dissolved concentrations less than 0.2 µg/L for sediment. The report concluded that the long-term stability of mercury chemically adsorbed on the PAC should be high, based on the relative stability of mercury surface complexes compared with other metals. The reduction in dissolved mercury concentrations related to dissolved organic carbon adsorption should also

be relatively stable, because the dissolved organic carbon that most readily forms complexes with mercury is also the fraction that preferentially adsorbs to PAC (URS 2002c).

The treatability study results indicated that the long-term leachability of mercury could be controlled with the addition of PAC (URS 2002c).

1.2.1.8 Remediation Project, Initial Study (California Environmental Quality Act)

In accordance with the California Environmental Quality Act, an Initial Study was completed in 2003 to determine if the RFS remediation project activities would result in any significant environmental effects or would require mitigation measures to reduce potential environmental effects.

The Initial Study recommended project-specific mitigation measures to address possible noise effects and effects to biological resources. Effects in all other areas were found to be less than significant, or were reduced by applicable mitigation measures that were included in the project to reduce potential effects to the degree feasible (URS 2003a).

1.2.1.9 Biological Assessment

The RFS Remediation Project Biological Assessment Report (BBL 2003) was prepared to address sensitive species and habitats within the Western Stege Marsh that may be affected by the proposed remediation activities planned in upland and marsh areas and the adjacent area of Meeker Slough (the project area). This report also presented a mitigation plan to minimize effects and compensate for those effects that were determined to be unavoidable (BBL 2003).

At the time of the report, negotiations among UC Berkeley and the Water Board regarding SSTLs and remediation activities within the Western Stege Marsh had not been completed. The proposed activities were to involve remediation and restoration of the project area. The project included the following elements:

- Removal actions
- Metal stabilization
- Disposal of material
- Backfill
- Management in place with monitoring

The sensitive flora and fauna species proposed for evaluation were the callippe silverspot butterfly (*Speyeria callippe callippe*), soft bird's beak (*Cordylanthus mollis mollis*), and California clapper rail (*Rallus longirostris obsoletus*). The silverspot butterfly was identified

because its host plant *Viola pedunculata* can occur on RFS, but no sightings had been noted during recent surveys. Soft bird's beak was identified because it was sighted regionally in 1993 at Point Pinole Regional Shoreline. Recent surveys have not found soft bird's beak at the RFS. California clapper rails were observed in the project area and the marsh habitat south of the project area; thus, they were considered in the biological assessment (BBL 2003).

Sensitive biological resources considered in the biological assessment report included the marsh and the California clapper rail. According to the report, potential effects on the marsh would be temporary in nature because of the mitigation requirements for the proposed activities. Long-term effects of the proposed activities on the project area were expected to be beneficial because the concentrations of a COC would be substantially decreased, the value and function of habitat would increase, and there would be a net increase in tidal wetland habitat. The California clapper rail used the project area for foraging, shelter, and potential nesting; implementation of proposed remediation and restoration activities will temporarily affect this species (BBL 2003).

The mitigation plan proposed in the biological assessment report recommended the following actions:

- Timing of the project implementation should occur outside of the clapper rail breeding season (February 1 through August 31, annually).
- Work areas should be fenced and sensitive natural communities avoided. The use of soil berms or silt curtains should be used to protect adjacent sensitive areas.
- Habitat should be created and enhanced to compensate for temporary project effects.
- Mitigation monitoring and reporting should be conducted.

1.2.1.10 Groundwater, Surface Water, and Sediment Monitoring

The groundwater and stormwater monitoring plan for the Uplands and Transition Areas and surface water and sediment monitoring plan for the eastern portion of Western Stege Marsh were initially developed when the RFS project was under the oversight of the Water Board. These activities are documented in the draft version of the "Groundwater, Surface Water, and Sediment Monitoring Plan, Subunit 2" (BBL 2004d). The western portion of Western Stege Marsh was not included in this draft plan because this area was still under investigation. The draft monitoring plan described semi-annual monitoring for up to 5 years.

The components of the Draft Surface Water and Storm Water Monitoring Plan were implemented in fall 2006. The draft plan will be revised based on comments from DTSC. Groundwater monitoring will be implemented following the implementation of the field sampling work plan.

1.2.1.11 Multi-Incremental/Decision Unit Sampling

MI/DU sampling has been performed by UC Berkeley for several projects at the RFS. This type of sampling provides a comprehensive and thorough evaluation of a specific area of exposure or decision unit and was used by UC Berkeley to assist in the evaluation of health and safety of onsite workers. MI sampling provides an accurate representation of the average concentration of target analytes over the area sampled that can be used directly to assess risk to an exposed population (of human or ecological receptors) (Hawaii State Department of Health, 2008). Within a decision unit, 30 to 50 incremental or discrete samples are collected and composited into one sample. The following areas have been sampled through the MI/DU technique:

- **Shade House and Coastal Prairie**: The objective of this sampling effort was to characterize surface soils at the Shade House and from areas within the coastal prairie area (two within the Big Meadow and one within the EPA Meadow). Soil samples were collected to evaluate soil conditions at the request of staff of TWP who planted and weeded in surface soils during TWP restoration activities in these areas. The decision unit selection was based on interviews conducted employees of TWP who were directly involved in all site activities conducted by TWP within the Shade House area and coastal prairie. Soil samples were analyzed for metals; TPH as gas, motor oil, and diesel; pesticides; PCBs; and SVOC. Sampling results were screened against the Commercial/Industrial and Residential California Human Health Screening Levels (CHHSL) ["Use of California Human Health Screening Levels (CHHSL) in Evaluation of Contaminated Properties" California Environmental Protection Agency, January 2005], and were either not detected or below the screening levels (See Appendix L) (Tetra Tech 2007d).

- **Central Field:** The objective of this sampling effort was to characterize surface soils in the Central Meadow. UC Berkeley researchers had considered the construction of a wind turbine in the Central Meadow; therefore, soil samples were collected to evaluate soil conditions which workers could be exposed to while performing construction activities. The decision unit selection was based on design sketches and the potential for workers exposure to soil. Soil samples were analyzed for metals, and all results were below the CHSSLs for commercial workers (See Appendix L) (Tetra Tech 2008e).

- **Western Transition Area (WTA):** The objective of this sampling effort was to characterize near-surface soils in the WTA. As part of the Western Stege Marsh Restoration Project (WSMRP), UC Berkeley routinely removes invasive and noxious weeds in the WTA; therefore, soil samples were collected to evaluate soil conditions that workers could be exposed to while performing the noxious weed abatement. Three decision units were selected to characterize the near surface soils in this area. The soil samples were screened against the Commercial/Industrial and Residential CHHSLs; however, where CHHSLs were not available, other screening levels, such as the Federal Region 9 EPA PRGs and the California Water Board's Environmental Screening Levels were used. All sample concentrations were less than their respective screening criteria with the exception of PCBs in two of the decision units (See Appendix L) (Tetra Tech 2008b).

- **Camp Fire Locations:** While performing site reconnaissance for the WTA sampling, two locations of surficial ash and debris were identified on the western edge of the WTA. These two areas were sampled independent of the three WTA decision units and were identified as the Western Transition Area Ash-pile areas, later referred to within the TCRA as campfire pits. Sampling results from these two areas indicated elevated levels of PCBs, and a TCRA has been approved by DTSC for the removal of material from these two areas. The TCRA was completed in October 2008 (Tetra Tech 2008b) and UC Berkeley will provide a TCRA Completion Report after the waste generated is disposed off site at an approved landfill facility.

- **Marsh Near-Surface Sediment:** The objective of this sampling effort was to characterize near-surface sediment in remediated portions of the Western Stege Marsh, as well as evaluate incidental sediment contact by marsh restoration workers exposed during planting or weeding on the marsh plane. One decision unit was identified as following the boundaries of the areas where marsh restoration activities may be performed, at depths of 0 to 3 inches bgs, which represents the sediment that workers may be exposed to while weeding, and that may be migrating in slough channels and being deposited on top of clean bay mud that was placed as backfill during the remediation activities performed between 2002 and 2004. The sediment sample was analyzed for metals; TPH as gas, motor oil, and diesel; PCBs; and SVOCs. The results were screened against the Commercial/Industrial and Residential CHHSLs, and concentrations were either less than the laboratory reporting limits or less than the screening levels (See Appendix L) (Tetra Tech 2008a).

- **Pampas Grass:** The objectives of this sampling effort were to characterize surface soil at a stand of pampas grass area immediately south of Building 201 (currently leased to the EPA) and to provide information for evaluation of potential incidental contact to soil by workers removing the pampas grass. Surface soil samples were collected near the pampas grass roots from 0 to 1 foot bgs at 15 locations. The soil sample was analyzed for metals; TPH as gas, motor oil, and diesel; pesticides; PCBs; and SVOCs. The soil samples were screened against the Commercial/Industrial and Residential CHHSLs, however, where CHHSLs were not available, other screening levels, such as the Federal Region 9 EPA PRGs and the California Water Board's Environmental Screening Levels were used. All sample results were reported at concentrations less than the laboratory reporting limits or less than their respective screening levels (See Appendix L) (Tetra Tech 2008d).

- **WTA Bay Mud:** This sampling effort was performed to collect additional data for the reconsolidated clean Bay Mud that was imported during the remedial activities performed between 2002 and 2004. The MI/DU soil sample was analyzed for PCBs and all results for this sample were less than the laboratory reporting limit.

1.2.1.12 Indoor Air Monitoring

UC Berkeley performed indoor air monitoring based on recommendations from the CDPH August 2007 Draft Public Health Assessment (PHA) for Evaluation of Exposure to Contaminants at the RFS. Indoor air monitoring was performed between October 2007 and February 2008, and consisted of eight separate 24-hour events at twelve locations. The monitoring was completed using stationary air collection equipment for indoor and outdoor locations, in accordance with the 2007 Air Quality Sampling and Analysis Plan (Tetra Tech 2007d). The PHA was finalized in March 2008 by ATSDR with equivalent recommendations. In the PHA, the CDPH commented on previous sampling events performed at RFS and recommended further evaluation of indoor air quality for formaldehyde and arsenic (CDPH 2007). Rather than limit the study to these compounds, UC Berkeley decided to perform a more comprehensive evaluation, which included the following constituents of concern, many of which are not historical chemicals of concern at RFS but may be present in soil and/or groundwater at nearby sites: arsenic, benzene, chloroform, 1,2-dichloroethane, 1,1-dichloroethylene, cis-1,2-dichloroethylene, trans-1,2-dichloroethlyene, formaldehyde, methlyene chloride, tetrachloroethylene, trichloroethylene, and vinyl chloride.

All sampling results were comparable to the ranges reported in three indoor air quality reference studies performed in California and across the country. Results from the monitoring effort supported that the indoor air conditions at the locations sampled are within levels typical of indoor air (Tetra Tech 2008f).

1.2.2 Previous Remediation Activities

Remediation activities at the RFS were performed in three phases beginning in 2002. Remediation Phases 1 through 3 were completed in 2002, 2003, and 2004, respectively (see Figure 18). The construction schedule was designed to accommodate the breeding season of the California clapper rail (February 1 to August 31), and limited the available time to work in the marsh area before winter rains could make work impracticable. Another area, in the uplands near the Former FPL WTL, underwent a TCRA in the fall 2007. Phases 1 through 3 were completed under the oversight of the Water Board, and the TCRA was completed under DTSC oversight. All remediation activities are summarized below.

1.2.2.1 Phase 1

Phase 1 activities began on September 16, 2002, and ended on December 18, 2002 (URS 2003b). This phase included excavation and stabilization of contaminated soil in the eastern portion of the Transition Area (formerly designated as Areas 1 and 4 of Subunit 2A) and sediment in the eastern portion of Western Stege Marsh (formerly designated as Areas 2 and 3 of Subunit 2A) (see Figure 18). Select photographs of Phase 1 remediation activities are provided in Photographs C-20 through C-29 in Appendix C. The Upland Area of the former Zeneca site was remediated in conjunction with remediation activities at RFS (URS 2003b). During Phase 1, cinder- and mercury-contaminated sediments were excavated to the design depths identified in the Water Board-approved Remedial Designs Detail Report, and backfilled with clean soil and

sediments (see Figure 18). Mercury-contaminated soils and sediment were stabilized with activated carbon in a lined on-site asphalt pad constructed on the RFS property before transport to the former Zeneca site. The excavated cinder-contaminated and stabilized mercury-contaminated sediments were transported to the former Zeneca site where they were mixed with 7.5 percent limestone, and placed and capped in the cinder placement area in Lot 3 at the former Zeneca site. The excavations within the Transition Area were backfilled with clean upland soil, and the excavation areas within the eastern portion of Western Stege Marsh were backfilled with clean Bay Mud. A BAPB wall was installed on the western or downgradient side of Area 1 to treat any residual metal concentrations in the Area 1 groundwater before it migrates to the marsh area. The barrier consists of marine sediment, leafy compost, and limestone. The volumes of materials excavated, stabilized, and placed in the mixed cinder placement area on the former Zeneca site during Phase 1 activities are provided in Table 5. Phase 1 remediation activities are further detailed in the Phase 1 Implementation Report (URS 2003b).

1.2.2.2 Phase 2

Phase 2 activities began on August 4, 2003, and ended in February 2004 (URS 2004). This phase included excavation and remediation in a portion of the Transition Area (formerly designated as Area 4 of Subunit 2A), the remaining eastern portions of Western Stege Marsh (formerly designated as Area 2 in Subunit 2A), and two areas in the central and western portions of Western Stege Marsh (formerly designated as Area M3 and M1a in Subunit 2B) (see Figure 18). Select photographs of Phase 2 remediation activities are provided in Photographs C-30 through C-52 in Appendix C.

The following activities were performed during Phase 2:

- Identifying, sampling, and procuring clean off-site bay mud sources for use as clean fill in backfilling remediated marsh areas.
- Constructing two on-site asphalt pads for storing, mixing, and staging excavated cinder- and mercury-affected sediments before transport and placement in the mixed cinder placement area on the former Zeneca site or disposal at approved off-site landfill facilities.
- Excavating and stockpiling clean overburden material from the Transition Area for reuse as backfill following the excavation of underlying materials.
- Excavating cinders and sediments containing mercury at concentrations less than 50 mg/kg as designated in the approved excavation plans, transporting these excavated materials to the on-site asphalt pads for stabilization with 7.5 percent limestone, and transporting the material to the mixed cinder placement area on the former Zeneca site for compaction and final placement.

- Excavating cinders and sediments that contained mercury at concentrations between 50 and 260 mg/kg as designated in the approved excavation plans. These excavated materials were transported to the on-site asphalt pads and mixed with five percent powdered activated carbon to stabilize the mercury, and then stabilized with 7.5 percent limestone for cinder-related metals. In addition, excavated saturated materials were also mixed with cement kiln dust (CKD) (before mixing with activated carbon or limestone) to dry the material so that it could be more effectively handled and transported to the former Zeneca site. Treated materials were transported to the mixed cinder placement area on the former Zeneca site for compaction and final placement.

- Excavating cinders and sediments containing mercury at concentrations greater than 260 mg/kg as designated in the approved excavation plans. These excavated materials were transported to the pads where they were mixed with a drying agent (CKD) before shipment off site to the Kettleman City Class I landfill in Kettleman City, California.

- Constructing a concrete-lined pad for storing, mixing, and staging excavated PCB-affected sediments from Area M1. The saturated PCB-affected sediments were mixed with CKD in the concrete-lined pad to solidify the material before shipment off site to the Kettleman City Class I landfill in Kettleman City, California.

- Regrading the portions of Western Stege Marsh areas remediated during Phase 1 and 2 activities to lower the elevation as part of marsh restoration.

- Backfilling and grading excavated upland and marsh areas with clean fill materials.

- Installing a new section of sanitary sewer line that was removed in the southern portion of the Transition Area during Phase 2.

- Removing invasive, non-native vegetative species, and planting native vegetative materials pursuant to the marsh restoration plan.

The volumes of material excavated, stabilized, and placed in the cinder placement area on the former Zeneca site or transported to off-site landfills during Phase 2 activities are provided in Table 6. Phase 2 remediation activities are further detailed in the Phase 2 Implementation Report (URS 2004).

The two asphalt pads and a concrete-lined pad were decontaminated at the completion of the remedial activities performed at the site between August 2003 and February 2004 by sweeping and pressure washing the surfaces. Confirmation rinsate samples were collected and analyzed for metals at the asphalt pads and for PCBs at the concrete pad. Rinsate samples were collected to evaluate potential total metals concentrations during a rainfall event. All results were non-detect and were presented in Table 10 of the Phase 2 Completion Report.

In December 2003, a slurry wall was installed along the southern portion of 46th Street. The slurry wall extends from approximately 3 feet bgs to 23 feet bgs and is reportedly 3 feet wide and approximately 610 feet long. The slurry wall was constructed with a mixture of soil and bentonite (LFR, Inc. 2005c).

1.2.2.3 Phase 3

Phase 3 began on September 20, 2004, and ended on November 24, 2004 (URS 2005). Remediation during Phase 3 consisted of excavating materials from upland RAs 1, 2, 3, 4, 5, and 6 and excavating sediment to widen an existing channel and create a new channel in the north-central portion of Western Stege Marsh (formerly designated as marsh area M3) (see Figure 18). Excavated upland areas were backfilled with imported clean fill. In addition, two potholes were excavated at two manholes (manholes no. 9 and 11) along the northern end of the western storm drain line. Soil samples were collected within and beneath the lines, the exposed ends of the lines were plugged with grout, and the potholes were backfilled with the excavated soil. A permanent fence was also installed south of asphalt pads B and C, and a 4-foot high "no climb" fence was installed at the top of the slope on the southern edge of the Western Stege Marsh along the Bay Trail. The volumes of materials excavated and transported to off-site landfills are provided in Table 7. Select photographs of Phase 3 remediation activities are provided in Photographs C-53 through C-59 in Appendix C. Phase 3 remediation activities are further detailed in the Phase 3 Implementation Report (URS 2005).

1.2.2.4 Former FPL Wood Treatment Laboratory TCRA

In October 2007, an area containing elevated concentrations of arsenic was excavated near the former FPL WTL. The proposed excavation limits and depths were determined by comparing the analytical results for samples collected in May and June 2007, with the project-specific remediation goal of 16 mg/kg (Tetra Tech 2007a). Confirmation samples were taken following the excavation. Upon receipt and review of the soil confirmation results, it was noted that one side-wall sample exceeded the remediation goal. A small area of over-excavation was then removed, and confirmation samples were taken at the new side-wall. Following this excavation, all concentrations reported in the confirmation samples were less than the remediation goal. A calculated in-situ volume of approximately 140 cys of soil was removed, and the area was backfilled using clean materials from a DTSC approved stockpile. No further remediation is planned in this area. Select photographs of FPL TCRA activities are provided in Photographs C-60 and 61 in Appendix C. The TCRA activities are further detailed in the Implementation Summary Report for a Time-Critical Removal Action at the Former Forest Products Laboratory Wood Treatment Laboratory Implementation Report (Tetra Tech 2008c).

1.2.2.5 Western Stege Marsh Restoration Project Monitoring

The Western Stege Marsh Project Monitoring Plan (BBL 2004c) defines the post-remediation monitoring activities being performed at the WSMRP site, which includes the areas remediated during Phases 1 and 2 remediation activities at the RFS (see Sections 1.2.2.1 and 1.2.2.2, respectively).

The objectives of the monitoring plan for the WSMRP are to:

- Quantitatively assess the hydrological functions within the site;
- Assess progress toward or deviation from defined project goals;
- Provide regulatory agencies with information on restoration efforts; and
- Initiate contingency measures as necessary.

The monitoring plan proposed to achieve its objectives by conducting monitoring events on a biannual basis for a period of 5 years. The details of the data collection methodology are included in the monitoring plan. The results of the monitoring will be documented in an annual report for the duration of the monitoring (BBL 2004c).

The purpose of post-remediation monitoring is to assess the results of the WSMRP and adaptively manage the WSMRP site. The project targets, as defined in the monitoring plan, are used to evaluate the progress of the project toward reference standards and/or site potential. The monitoring plan outlines the following project targets:

- Project Target 1: Restore the hydrologic complexity to the WSMRP site
- Project Target 2: Improve water quality by increasing the time water resides within the WSMRP site
- Project Target 3: Restore the low salt marsh (Pacific cordgrass), middle salt marsh (pickleweed), and the emergent native coastal scrub communities within the WSMRP site
- Project Target 4: Establish a compositionally and structurally complex ecosystem within the WSMRP site with attributes important to wildlife, specifically focused on increasing habitat functions for the California clapper rail

The monitoring plan defines a set of performance criteria, or project standards, to evaluate the success of each of the project targets. Field measurements and indictors, such as vegetation surveys, hydrological cross sections, and California clapper rail surveys, will be collected to determine if the project standards are being achieved (BBL 2004c).

Phases 1 and 2 of the remediation and restoration grading activities in Western Stege Marsh were completed in late January 2004. February 2004 is considered to be “time zero” for the restoration project; however, small-scale grading activities were conducted in fall 2004 to correct channel configuration. The monitoring program was initiated in the fall 2004 (BBL 2005c). Field indicators and measurements were collected biannually to determine if the project standards, the criteria used to guide the restoration activities toward project targets, were being achieved.

The WSMRP Year 1 Monitoring Report (BBL 2005c) assessed the results of the WSMRP and established baseline conditions for future monitoring events. Overall, the WSMRP Year 1 Monitoring Report determined that the WSMRP site is progressing toward providing the functions of a tidal marsh typical of San Francisco Bay. Project standards for Project Target 1 are being achieved: hydrology is sufficient to inundate the WSMRP site and flush sloughs at least once a day. Project Target 2 will be assessed by a separate monitoring plan that is currently under DTSC review. Future monitoring reports will include water quality data. The project standards for Project Target 3 were not yet achieved at the end of Year 1. Total acreage of pickleweed was slightly less than the project standard, and Pacific cordgrass had not begun to colonize the WSMRP site; however, the WSMRP Year 1 monitoring report estimated that the project standards for Project Target 3 would be met by Year 5. The project standards for Project Target 4 were not yet achieved at the end of Year 1. There were no sightings of the California clapper rail during the two surveys performed, and detrital material had not accumulated because of the absence of substantial vegetative cover; however, as the habitats continue to develop, the rail's use of the WSMRP site is expected to increase.

Year 2 marsh monitoring was conducted following the project standards outlined in the WSMRP Monitoring Plan (BBL 2004c). In addition, the following management recommendations suggested in the Year 1 Monitoring Report were completed: (1) three additional vegetation monitoring quadrats (C-0, D-0 and E-0) were established in the ecotone area (the vegetated strip between the marsh and upland that provides cover for the California clapper rail during high tides); (2) active planting of the desired Pacific cordgrass and removal of undesired smooth cordgrass (*Spartina alterniflora)* or subsequent hybrids (*S. alterniflora* x *S. foliosa*) was conducted to prevent these invasive species from colonizing the WSMRP site; (3) an assessment of the appropriate frequency for active trapping as part of the Feral Animal Management Program (FAMP) was completed, including a consultation with the U.S. Fish and Wildlife Service (USFWS) at Don Edwards National Wildlife Refuge; and (4) public outreach meetings about ongoing activities at the WSMRP site were continued.

Overall, the Year 2 Monitoring Report determined that the WSMRP site is progressing toward providing the functions of a tidal marsh typical of San Francisco Bay. Project Target 1 standards were mostly achieved (standards were not achieved in three of the eight cross-sections measured). The hydrology is sufficient to inundate the marsh portions of the WSMRP daily and support vegetative communities designed in the WSMRP Monitoring Plan. Project standards for Target 2 have not yet been established. Year 2 data indicated that metals concentrations in some surface water, sediment, and stormwater samples exceeded some federal and state screening criteria for the protection of aquatic life but more sampling is necessary to assess the significance of these results. Data collected in support of Project Target 2 were established as a baseline in Year 2 and these results will be combined with future monitoring to assess water quality over time. The project standards for Project Target 3 were achieved. The total acreage of Pacific cordgrass (*Spartina foliosa)* was less than the project standard, while the total acreage of pickleweed (*Salicornia virginica*) was greater than the project standard. The overall native plant cover exceeded the Year 2 standards. The Project Target 4 standards have not yet been achieved. The California clapper rail was not using the WSMRP site for nesting or foraging during protocol-level surveys, although individuals were detected near the edge of the site and are expected to use habitat as it matures.

Year 3 marsh monitoring was conducted following the project standards outlined in the WSMRP Monitoring Plan (BBL 2004c). Following the recommendations from the Year 2 Monitoring Report the following items were performed: (1) four additional vegetation monitoring quadrats (A4, A5, A6, and F0) were established in the ecotone area; (2) there continued to be plantings of Pacific cordgrass and removal of undesired smooth cordgrass (*Spartina alterniflora)* or subsequent hybrids (*S. alterniflora* x *S. foliosa*); (3) the information from the on-site tidal gauge was deemed non-crucial for determining the success of the marsh, and it was removed; (4) and the success of Project Target 3 was evaluated using the combined acreage of pickleweed and Pacific cordgrass.

Overall, the Year 3 Monitoring Report determined that the WSMRP site is progressing toward providing the functions of a tidal marsh typical of San Francisco Bay. Project Target 1 standards were mostly achieved. The hydrology is sufficient to inundate the marsh portions of the WSMRP daily and support vegetative communities designed in the WSMRP Monitoring Plan. Project standards for Target 2 have not yet been established. Year 3 data was compared with Year 2 data, and concentrations of most analytes have remained constant. As with Year 2 monitoring results, some samples exceeded federal and state screening criteria for the protection of aquatic life but more sampling is necessary to assess the significance of these results. The success of Project Target 2 will continue to be assessed as more data is collected. The project standards for Project Target 3 were achieved. The total acreage of Pacific cordgrass (*Spartina foliosa)* combined with total acreage of pickleweed (*Salicornia virginica*) was greater than the project standard. The Project Target 4 standards have not yet been achieved. The California clapper rail was not using the WSMRP site for nesting or foraging during protocol-level surveys, and there were fewer clapper rail detections in more hours of observation than during Year 2 surveys.

1.2.2.6 Management of Remediation Effects

Feral Animal Management Program

In 2004, a FAMP was implemented as a requirement of the USFWS Biological Opinion to the Nationwide Permit 38 issued to the U.S. Army Corps of Engineers in September 2003. The purpose of the program is to reduce impact of predation of the California clapper rail (*Rallus longirostris obsoletes*) by wild and feral domestic animals that may potentially prey on the rail, including domestic cats, raccoons, skunks, Norway rats, and red foxes (BBL 2004a).

The program consists of three components: (1) creation and enhancement of habitat for the California clapper rail, (2) active management of feral animals, and (3) educational outreach.

Creation and enhancement of habitat has included removal of concrete riprap that harbors predators and grading and planting of a gradually sloping ecotone between the marsh and upland to provide a refuge for the California clapper rail that offers protection from predators during high tide. The creation and enhancement of ecotone habitat for the California clapper rail has begun in the remediated areas of Western Stege Marsh and will continue if any further remediation and grading is required. Active management of feral animals has included

installation of a no-climb fence along the Bay Trail and trapping of predators in the Transition Area near the marsh edge. Educational outreach has included creation of a California Clapper Rail Conservation brochure, meetings with the local community, and establishment of a California Clapper Rail Conservation page on the RFS Environmental Website (http://rfs.berkeley.edu).

Invasive/Exotic Vegetation Management Program

In 2004, an Invasive/Exotic Management Program was implemented as a requirement of the USFWS Biological Opinion to the Nationwide Permit 38 issued by the U.S. Army Corps of Engineers in September 2003. The purpose of the program is to control the establishment of priority invasive/exotic vegetation that may reduce the quality of California clapper rail (*Rallus longirostris obsoletus*) habitat and/or reduce the cover of native vegetation in the marsh and upland restoration areas. The program consists of two components: (1) active monitoring and control of priority invasive and exotic plant species within the project area and (2) enhancement and creation of ecotone and upland habitat for the California clapper rail (BBL 2004b).

The program uses the California Invasive Plant Council system of characterizing invasive/exotic species. Invasive/exotic species were classified into three groups: Priority I, Priority II, and Priority III. Smooth cordgrass *(Spartina alterniflora)* and perennial pepperweed (*Lepidium latifolium)* were determined to be the two species of highest concern based on their historic presence in the vicinity and their potential to severely disrupt the ability of native vegetation to become established. Manual techniques have been to the primary method of removal of invasive/exotic species.

The control of invasive/exotic species began in summer of 2003 prior to the development of the program and continues to date. Monitoring of exotic vegetation removal is documented in the Marsh Monitoring Program annual reports.

In addition to removal of invasive and exotic vegetation, the Invasive/Exotic Vegetation Management Program includes the creation of a gradually sloping ecotone between high marsh and upland habitats to provide habitat for the California clapper rail during high tide. The creation and enhancement of ecotone habitat for the California clapper rail has begun in the remediated areas of Western Stege Marsh and will continue if any further remediation and grading is required.

1.3 SUMMARY OF EXISTING ENVIRONMENTAL DATA

This section identifies the chemicals currently present in soil, sediment, surface water, and groundwater at the RFS based on existing environmental data. Extensive investigations have been conducted at the RFS that have focused on known and suspected sources and their contaminants, as described in Sections 1.1 and 1.2. These investigations have included characterization of soil, sediment, surface water, and groundwater. Results of the investigations

have been used to support human health and ecological risk assessments and have led to three phases of remediation activities and a TCRA where more than 60,000 cy of contaminated soil and sediment were removed and disposed of. Data collection activities have also been conducted in accordance with the WSMRP Monitoring Plan as well as to evaluate worker exposure conditions at various locations throughout RFS.

The discussion of environmental data and current conditions presented in this section is based on (1) data collected during previous investigations in areas where remediation activities were not performed, (2) data from confirmation samples collected during the completed remediation activities between 2002 and 2007, and (3) additional environmental data collected since completion of the remediation activities. Because the purpose of this section is to describe current, existing conditions at the RFS, analytical data associated with soil and sediments that have been removed as part of the environmental restoration activities are not presented.

Environmental data for each sampling location are presented in Appendix D, Environmental Data Tables. These tables present samples by medium and location as follows:

- Soil and sediment from (1) Upland Area, (2) Transition Area, (3) Off-Site Property East Area, (4) Off-Site Property North Area, and (5) Marsh Area.
- Surface water and stormwater since phase 2 remediation
- Groundwater from (1) monitoring wells, (2) grab groundwater samples, and (3) grab groundwater samples from areas subject to Phase 1 and 2 removal actions.

Data for soil and sediment are discussed separately for three different ecological zones: (1) the RFS Upland Area, (2) the Transition Area (including the Bulb), and (3) the Western Stege Marsh. In addition, soil and sediment samples collected near the northern and eastern property boundaries of RFS are also discussed. Surface water data and groundwater data for all of RFS are discussed following the soil and sediment summaries. This section discusses discrete soil samples collected at RFS, and do not include results from MI/DU sampling events.

In 2001, a Human health and Ecological Tiered Risk Evaluation was completed for human and ecological receptors at the RFS based on chemicals identified during investigations (URS 2001a). Risk-based H-SSTLs and ecological site-specific target levels (E-SSTL) were developed for specific receptors to allow for comparison of chemical concentrations to determine if there is a potential health concern and if additional investigation, assessment, and/or remediation was necessary. These SSTLs will be reevaluated and new site specific screening values will be determined with the concurrence of DTSC.

The data for chemicals detected in soil that are presented in this section's text are compared against the H-SSTL and CHHSL for the commercial/industrial worker in the Upland Area and the Transition Area (including the Bulb) because the reasonably foreseeable future land use of the RFS is commercial/educational and open space (DTSC Order Docket No. I/SE-RAO 06-07-004 Section 5.1.2). The exposure assumptions for the commercial/industrial worker are

appropriate for academic researchers and RFS staff, as detailed in the CSM in Section 2.0. The data for arsenic, copper, and mercury presented in figures are compared against their respective background concentrations. PCB concentrations on figures are compared against the Edwards Air Force Base's ecological screening level for total PCBs. Data for chemicals detected in sediment in Western Stege Marsh are compared against ambient sediment concentrations and the National Oceanic and Atmospheric Administration (NOAA) effects range-low (ER-L) invertebrate effects screening criteria in the text and against ER-Ls in the figures. The data for groundwater are compared against MCLs or, in the case of copper and lead, regulatory action levels.

1.3.1 Summary of Current Chemicals in Soil in RFS Upland Area

Remediation activities performed in 2004 (see Figure 18) in the Upland Area of the RFS removed soil previously identified in RAs 1, 2, 3, 4, 5, and 6 where elevated concentrations of chemicals were identified. These areas were backfilled with clean soil after excavation (see Section 1.3.5 for a discussion of the extent of chemicals in the backfill material.) Another small area near the former FPL WTL was excavated and backfilled in October and November 2007. The only known remaining upland areas with elevated concentrations of chemicals in soil are near the former California Cap Company Mercury Fulminate Plant and isolated areas of pyrite cinders. This section provides an overview of the existing soil data for the Upland Area, followed by detailed discussions of chemical concentrations in soil for metals, pesticides, PCBs, SVOCs, VOCs, and radionuclides.

A query of the database of recorded analytical results reports that 552 soil samples have been collected from locations in the RFS Upland Area that were not remediated in 2004 (that is, locations that were either not in an RA boundary or that were underneath the bottom of an excavation). Samples were analyzed primarily for metals and PCBs, and on a more limited basis, for pesticides, SVOCs, VOCs, explosives, and TPH. Figure 19 shows the locations where soil samples were collected and indicates for each location the various analyte groups (metals, pesticides, PCBs, and SVOCs) for which the sample was analyzed. Figures 21 through 37 present concentration ranges for analytes at various depth intervals (0 to 1 foot bgs, 1 to 5 feet bgs, and 5 to 10 feet bgs relative to current surface elevations). Table 8 presents summary statistics for chemicals analyzed in discrete soil samples from the Upland Area. Table 9 presents summary statistics and comparisons of chemicals detected in soil in the Upland Area with SSTLs.

Soil samples were also collected in the former research well field area located in the central portion of the RFS Upland Area (see Figure 3) to determine the presence or absence of radionuclides. These sample data are discussed in Section 1.3.1.6 and are shown on Figure 11 but are not included in Tables 8 and 9. A review of the soil data for the Upland Area indicates the remediation activities successfully removed contamination previously associated with RAs 1, 2, 3, 4, 5, and 6 and the former FPL WTA area. Metals concentrations exceeding SSTLs remain in areas of the MFA. No pesticides or VOCs were detected in the limited number of soil samples analyzed for VOCs and radionuclide concentrations in soil samples were less than background levels.

1.3.1.1 Metals

A query of the database of recorded analytical results reports 476 soil samples were collected for analysis of various metals from existing (non-remediated) locations. Samples were collected at various depths, ranging from the ground surface to a depth of 20 feet bgs. Most samples were collected from the surface to a depth of 5 feet bgs.

Of the 17 metals analyzed, only arsenic and mercury were detected at concentrations that exceed the commercial-industrial H-SSTL in more than one sample and only arsenic, cadmium and mercury exceed the commercial-industrial CHSSL in more that one sample. One sample collected from the MFA in 1991 had concentrations of lead and cadmium exceeding the H-SSTL, but subsequent sampling in the vicinity of this sample did not find elevated concentrations of these metals.

Arsenic is present in the Upland Area soils with an average concentration of 4.15 mg/kg. The arsenic concentration for three depth intervals (0 to 1 feet, 1 to 5 feet, and 5 to 10 feet) are shown on Figures 21, 22, and 23, respectively, screened against the Tier 1 representative site background soil concentration of 16 mg/kg. Elevated arsenic concentrations have been detected in samples of pyrite cinder material collected in various locations in the Upland Area. Analytical results for these samples are provided in Table 3.

Copper is present in Upland Area soils at an average concentration of 104.05 mg/kg. The copper concentration for three depth intervals (0 to 1 feet, 1 to 5 feet, and 5 to 10 feet) are shown on Figures 24, 25, and 26, respectively, screened against Tier 1 the representative site background soil concentration of 69.4 mg/kg. Copper was not detected at concentrations exceeding the H-SSTL or CHSSL as shown in Table 9. The highest concentrations of copper are located in the MFA in the 1-to-5-foot-bgs depth interval.

Mercury was detected at concentrations ranging between 0.025 mg/kg and 1,100 mg/kg, with an average detected concentration of 26.68 mg/kg. The mercury concentration ranges for three depth intervals (0 to 1 feet, 1 to 5 feet, and 5 to 10 feet) are shown on Figures 27, 28, and 29, screened against the Tier 1 representative site background soil concentration of 0.4 mg/kg. Mercury was detected at concentrations exceeding the H-SSTL of 264 mg/kg in the MFA in 0-to-1-foot-bgs and 1-to-5-foot-bgs depth interval; however, no mercury concentrations exceeded the H-SSTL in soil samples collected from the 5-to-10-foot-bgs depth interval.

1.3.1.2 Pesticides

In 2000, 16 samples were collected for analysis of pesticides in the upland area. All results from these samples were below the residential PRG. Of these 16 samples, only one surface soil sample was collected in areas not subject to previously completed removal actions, as shown on Figure 33. Although no pesticides were detected in this sample, conclusions cannot be drawn from these samples because side-wide data is limited.

1.3.1.3 Polychlorinated Biphenyls

Since 1999, more than 450 soil and sediment samples collected throughout RFS have been analyzed for various PCB Aroclors, with much of the investigations focused on identifying the source of PCBs that entered the marsh through the Western Storm Drain (which was remediated as area M1a in 2003). A description of the historic sampling and a presentation of PCB analyses completed through July 2005 is presented in the July 8, 2005 BBL report titled "Summary of PCB Results Richmond Field Station, University of California, Berkeley, Richmond, California" and provided as Appendix E of this report. Additional sampling in the north property boundary area (including sampling at some additional locations) has occurred since the 2005 BBL report was completed.

Remediation activities performed at RFS in 2004 removed identified areas of PCBs in the Upland Area. A query of the database of historic analytical results reports that 115 soil samples were collected and analyzed for PCBs in the Upland Area that were not subject to remediation activities and therefore are representative of current site conditions. The concentrations of PCBs for each of the depth intervals (0 to 1 feet, 1 to 5 feet, and 5 to 10 feet) in the Upland Area is presented on Figures 34, 35, and 36, screened against the Tier 1 Edwards Air Force Base ecological screening criterion of 0.1 mg/kg. No locations exceed the H-SSTL for individual Aroclors. At one location of the fill along the western foundation of Building 155, the total PCB concentrations in two samples were 9.99 mg/kg (WPERIMETERB155COMP2) and 12.59 mg/kg (WPERIMETERB155COMP1). However, because these are composite samples, they are not included in the summary statistics table (see Table 8) and the comparison table (see Table 9) for the Upland Area. These sampling locations are shown on Figure 34, and the sampling results are included in Table D-1 of Appendix D.

1.3.1.4 Semivolatile Organic Compounds

A query of the database of recorded analytical results reports that 6 samples have been collected for analysis of SVOCs from upland areas that have not been subject to remediation activities (see Figure 37). Samples submitted for SVOC analysis were collected in two areas: the MFA and the former FPL WTL. Two SVOCs, benzo(k)fluoranthene and pentachlorophenol, were detected in one soil sample collected from the former FPL WTL. The soil associated with this sample was excavated during the FPL TCRA performed in 2007. Analytical results for other SVOC samples were less than the laboratory detection limits.

1.3.1.5 Volatile Organic Compounds

A query of the database of recorded analytical results reports that two samples were collected for analysis of VOCs from upland areas that have not been subject to remediation activities (see Figure 19). Samples submitted for VOC analysis were collected in two locations: one boring located west of Building 195 and one boring southwest of Building 120. Analytical results for all VOC samples were less than the laboratory reporting limits.

1.3.1.6 Radionuclides

Seventeen samples were collected for analysis of radionuclides associated with the former research well field area (see Section 1.1.4.5). In 2002, 15 samples at locations shown on Figure 11 were collected and analyzed for Cs-137 by gamma spectroscopy by the UC Berkeley Office of Radiation Safety (Stellar 2005). Thirteen samples were collected within the research well field area (see Figure 11); an additional two control samples were collected away from the research well field area. A review of the results indicates that the trace levels of Cs-137 detected in the research well field soil samples were statistically consistent with the levels in the control samples (Stellar 2005).

1.3.2 Summary of Current Chemicals in Soil and Sediment in RFS Transition Area

The Transition Area of the RFS is defined to the north by the former seawall that is believed to have been the physical edge of the former tidal mudflats and upland areas and to the south by the current marsh high tide line (approximately 5 feet above mean sea level). The Transition Area was created when upland fill materials were placed on top of the former tidal mudflat. Prior to placement of clean soil on top of the former tidal mudflat, portions of the tidal mudflat were subject to pollutant releases or direct placement of wastes from California Cap Company or filled with the placement of pyrite cinders. Remediation has been completed in the eastern half of the Transition Area (see Figure 18) and the area was backfilled with clean soils and sediments. Section 1.3.5 provides a discussion of the extent of chemicals in the backfill material.

The western portion of the Transition Area, including a fill feature known as the Bulb, consists of fill material from unknown sources placed onto the former tidal mudflat. This area has not been subject to remediation. In December 2002, 33 soil and sediment samples were collected at eight locations within the Bulb area (borings BLB-1 to BLB-8) to depths of approximately 6 to 8 feet bgs. Within these eight locations, surface elevations ranged from 5.0 feet (referenced to the NGVD 29) near the shoreline to 8.7 feet NGVD in the central portion of the Bulb. Elevations of the top of the sediment (that is the former tidal flat) range from approximately 0.6 to 4.9 feet NGVD. The fill at the sampled locations ranged from 2.5 to 7.5 feet thick, with an average depth of 4.6 feet in 2002. Portions of the Bulb have since been subject to regrading, including the construction of the concrete pad in 2003 for the Phase 2 remediation activities, so some elevations have changed. In December 2004, a stratigraphic analysis of the Bulb and sediment in Western Stege Marsh and Meeker Slough was completed to determine the elevation of the former tidal flat and the thickness of sediment or fill overlying the flat. The results of this survey are presented in Table 10 (BBL 2005b). Figure 38 presents an isopleth map showing the thickness of the soft sediment layer in the marsh and along the southern border of the Bulb area.

This section provides an overview of the existing soil data for the Transition Area, followed by detailed discussions of chemical concentrations in soil for metals, pesticides, and PCBs.

A query of the database of historic analytical results reports that 97 soil samples have been collected in the Transition Area, including the Bulb, in existing areas that have not been subject

to the remediation activities performed between 2002 and 2004. Soil samples were analyzed for metals, pesticides, and PCBs. Figure 19 shows the locations where soil samples were collected and indicates, for each location, the analytical groups (metals, pesticides, and PCBs) for which the sample was analyzed. Table 11 presents summary statistics for chemicals analyzed in discrete soil and sediment samples from the Transition Area (including the Bulb). Table 12 presents summary statistics and comparisons of detected chemicals against the H-SSTLs.

The highest concentration of chemicals detected in soil and sediment in the Transition Area are primarily found in subsurface samples in the sediments of the former tidal mudflat beneath the upland fill material.

1.3.2.1 Metals

A query of the database of historic analytical results reports that 96 samples were collected in the Transition Area and analyzed for metals. Only arsenic and lead exceeded their respective H-SSTLs.

Approximately 15 percent of arsenic detections exceeded the H-SSTL. The arsenic concentration for three depth intervals (0 to 1 feet, 1 to 5 feet, and 5 to 10 feet) are shown on Figures 21, 22, and 23, respectively screened against the Tier 1 representative site background soil concentration of 16 mg/kg. Most of the samples with concentrations exceeding the H-SSTL were collected at depths greater than 1 foot bgs. One shallow sample, B5MA, was collected in 1991 and its location was not surveyed. It was likely a point removed in the M3 excavation during the 2003 remediation activities, but this has not been confirmed. One sample collected at a depth of 8.27 feet bgs from BLB-8 contained lead concentrations exceeding the H-SSTL.

1.3.2.2 Pesticides

Two surface soil samples were collected in the Bulb area of the Transition Area for analysis of pesticides (in areas not subject to previously completed removal actions), as shown on Figure 33. No pesticides were detected.

1.3.2.3 Polychlorinated Biphenyls

Ten samples were collected for analysis of PCBs in the Transition Area in areas not subject to remediation activities performed between 2002 and 2004. The concentrations of PCBs are presented on Figures 34, 35, and 36, screened against the Tier 1 Edwards Air Force Base ecological screening criterion of 0.1 mg/kg. PCB concentrations exceeded the H-SSTL of 10 mg/kg in one surface soil sample collected along the southern edge of the Bulb area of the Transition Area at sample location Old Outfall 2. This sample was collected at the location of a former suspected sanitary sewer line outfall but the location of the sanitary sewer line has not been verified.

1.3.2.4 pH Values

The pH of soil and sediment in the Transition Area ranges from 4.1 (2AU-19 at 14.05 feet) to 12.1 (PC102 at 4.71 feet). The acidic conditions are found only at five locations (2AU-17, 2AU-19, 2AU-26, A4-13, PB12, and CD9) at deep intervals from 5 to 14 feet bgs. The pH results are summarized in Table 11.

1.3.3 Summary of Current Chemicals in Off-Site Property Areas to the North and East

As previously described in Section 1.1.5, RFS is bordered by other former and current industrial operations. Soil sampling has been conducted in areas near the northern and eastern property boundaries to assess potential impacts associated with these adjacent operations. This section describes the soil data for these areas and is presented below as "Off-Site Property North Area" and "Off-Site Property East Area." Figure 19 shows the sampling locations for both the Off-Site Property North Area and Off-Site Property East Area. Sample results are discussed below for each area.

1.3.3.1 Off-Site Property North Area

Soil samples were collected from the Off-Site Property North Area for PCB analysis to evaluate if historic industrial operations north of the property have impacted RFS. Aroclor-1260 was detected in 3 of 14 samples; however, none of the concentrations exceeded the H-SSTL of 10 mg/kg (see Table 13). Four samples for analysis of PCBs were also collected from concrete located at the surface in the Off-Site Property North Area (see Appendix D, Table D-3). PCBs were not detected in any of these samples.

1.3.3.2 Off-Site Property East Area

In total, eight soil and sediment samples have been historically collected from the Off-Site Property East Area at five locations and depths ranging from 0 to 6 feet bgs. All samples were analyzed for metals and pesticides (see Table 14). The areas located along the southern portion RFS and former Zeneca site boundary were part of the remediation activities performed by UC Berkeley and Zeneca in 2002. Of the soil remaining in the areas remediated in 2002, arsenic was detected in eight samples; no samples contained arsenic concentrations exceeding the H-SSTL. Copper was also detected in eight samples but did not exceed the H-SSTL. Mercury, detected in five of the eight samples, did not exceed the H-SSTL.

1.3.4 Summary of Current Chemicals in Sediment in Western Stege Marsh

As described in Section 1.2.2, remediation of the eastern portion of the Western Stege Marsh was performed in two phases in 2002 and 2003 (see Figure 18). The remediation activities in the marsh included excavation of sediments down to clean, stiff tan clay followed by backfilling with clean bay mud. As a result of the completed remediation activities, an extensive area of pollutant source material and most of the contaminated sediments present in the eastern portion of the Western Stege Marsh were removed. This section provides an overview of the existing sediment data (that is, areas not remediated) for the marsh area collected from 1991 to 2006, followed by detailed discussions of chemical concentrations in sediments for metals, pesticides, and PCBs.

Western Stege Marsh sediments have been extensively sampled. A query of the database of historic sampling results reports 267 discrete sediment samples (collected at locations in the marsh area that were not removed during the remediation activities). In 1991, 1992, and 1999, 45 sediment samples were collected at locations that were not surveyed for exact coordinates. Although site conditions may have changed since these samples were collected, these sample results are evaluated in this current conditions analysis because the locations of the sampling have not been remediated. From 2000 to 2002, 83 samples were collected from the western portion of Western Stege Marsh and Meeker Slough. In January 2003, 31 sediment samples were collected at 16 locations within the banks of Meeker Slough and from the vegetated areas west of the slough. In 2004, 63 sediment samples, 11 bulk sediment samples for bioaccumulation testing, and six crab and clam tissue samples were collected for various analyses. In December 2004, a stratigraphic analysis of the Bulb area in the Transition Area and sediment in Western Stege Marsh and Meeker Slough was also completed to determine the elevation of the former tidal mud flat and the thickness of sediment or fill overlying the flat. The results of this survey are presented in Table 10.

The sediment samples were analyzed for metals, pesticides, and PCBs. Figure 19 shows the locations where sediment samples were collected and the various analyte groups (metals, pesticides, and PCBs) for which the samples were analyzed. The summary statistics for analytical data for the marsh area sediment are presented in Table 15. Summary statistics comparing the marsh chemical concentrations with screening criteria are presented in Tables 16 through 19. Table 16 summarizes the comparison statistics for all sediment samples. Tables 17, 18, and 19 summarize the comparison statistics for samples collected from each depth interval: 0 to 0.5 foot bgs, 0.5 to 2.5 feet bgs, and 2.5 to 5.0 feet bgs, respectively.

Two screening criteria were used to evaluate sediment data from Western Stege Marsh; the ER-L values and the San Francisco Bay ambient sediment concentrations. The ER-L values are based on the biological effects database compiled by NOAA. The sediment ambient concentrations are based on sediment monitoring data for San Francisco Bay compiled by the Water Board (1998). The primary COCs identified in the human health and ecological tiered risk assessment were arsenic, copper, lead, mercury, selenium, zinc, and PCBs (URS 2001a).

Concentration ranges for chemicals detected in Western Stege Marsh are presented in numerous figures including the figures that present concentration ranges for Upland and Transition Areas samples. For the marsh area sediments, chemical concentrations for shallow sediment samples (0 to 0.5 feet bgs depth interval) are evaluated under this current conditions analysis because this interval tends to be the most biologically active and is the depth interval considered to be relevant to the marsh restoration workers during planting activities. Figures 39, 40, and 41 present the concentration ranges for metals (arsenic, copper, and mercury) in shallow sediment samples in Western Stege Marsh. Figure 33 shows the concentration ranges for total pesticides in shallow sediment samples. Figure 42 shows the concentration ranges for total PCBs in shallow sediment samples in Western Stege Marsh. Finally, Figures 43 through 46 show post-remediation shallow sediment sample data for the eastern portion of the Western Stege Marsh for arsenic, mercury, and PCBs. All depth intervals are based on the current surface elevations following completion of the remediation activities in the marsh area.

It is difficult to draw definitive conclusions as to the sediment conditions in terms of aerial and vertical distribution of chemicals because of the dynamic nature of sediments and the varied times and varied depth intervals for the sampling. However, using the entire sediment sample data set, several observations can be made as to the current presence of chemicals in marsh area sediments.

In general, surface sediments and samples from the 1-to-5-foot depth interval in the western portion of the marsh area, including Meeker Slough, exhibited concentrations of arsenic, copper, mercury, and PCBs exceeding the ER-L. ER-Ls were used as screening levels in this report at the request of DTSC until the SSTLs can be reevaluated and approved by DTSC. Pesticides are also commonly detected in samples from this area.

Chemicals that were present in sediments in the eastern portion of the Western Stege Marsh have been removed as part of the previous remediation activities. As a result, concentrations of most chemicals detected in subsurface samples (deeper than 1 foot bgs) are less than the respective metal's screening criteria, except for a few samples where arsenic and mercury concentrations exceeding the ER-L. In 2005 and 2006, surface sediment samples were collected in the remediated portions of the marsh that were backfilled with clean bay mud in 2002 and 2003. A review of these data indicates consistent detections of arsenic, copper, and mercury at concentrations exceeding their ER-L values (See Figures 39, 40, and 41). PCB concentrations are also present at concentrations exceeding the ER-L value in surface sediment samples from this area (see Figure 42).

1.3.4.1 Metals

Most metals concentrations in surface (0 to 0.5 bgs) sediment samples generally exceed the ER-L throughout the Western Stege marsh and slough channels (see Figure 39).

Figure 43 shows the concentration of arsenic and mercury from shallow sediment samples collected in 2006 and following the remediation in 2002 and 2003. Figure 44 shows 2007 and 2008 data results for the three locations sampled as part of the annual marsh monitoring

activities. The actual mechanism attributable to the elevated concentrations of arsenic, copper, and mercury in previously remediated portions of the marsh is not fully understood and warrants further investigation.

The average concentrations of arsenic and copper in surface sediment throughout the entire marsh (inclusive of the western portion and the previously remediated eastern portion) are 64.62 mg/kg and 174.41 mg/kg (see Table 16). The average concentration of mercury in surface sediment is 2.81 mg/kg (see Table 17).

The average concentrations of most metals are higher in the deeper sediments (greater than 1 foot), and the pattern is more dispersed and widespread (see Figures 22, 25, and 28). The highest subsurface sediment concentrations of arsenic, copper, and mercury were found in the samples collected within and along the bank of Meeker Slough and the tributary extending east from the main slough. Tables 18 and 19 present the average chemical concentrations of chemicals at 0.5 to 2.5 feet bgs and 2.5 to 5.0 feet bgs, respectively. The highest subsurface concentrations of arsenic, copper, and mercury were found in the samples collected from 0.5 to 2.5 feet bgs. The average concentration for these metals from samples collected at the deeper depth interval (2.5 and 5.0 feet bgs) is less than the samples collected from 0.5 to 2.5 feet bgs, but is still higher than the shallow sediment concentrations (0 to 0.5 feet bgs). In general, the pattern of higher chemical concentrations below the shallow sediment layer can indicate historic contaminant input (vs. recent inputs) and a sediment environment that is net depositional. However, further evaluation of the sediment transport mechanisms and processes is required to fully assess the relative magnitude of either of these processes at Western Stege Marsh.

1.3.4.2 Pesticides

Sediment samples from the western portion of the Western Stege Marsh and Meeker Slough were analyzed for a total of 32 discrete pesticides (as well as for total DDT and total chlordane), and 20 of these pesticides were detected in at least one sample. Not all samples were analyzed for the same individual pesticides. A list of the pesticides that were analyzed for, and the pesticides that were detected in the samples, is provided in Table 15, along with summary statistics for these pesticides. The locations where pesticides were analyzed in soil and sediment samples from Western Stege Marsh and Meeker Slough are presented on Figure 33. A review of the data provided Tables 17, 18, and 19 shows that the average concentrations of detected pesticides are highest beneath shallow sediments (greater than 0.5 bgs). Individual pesticides exceeded the ER-L value in each depth interval, with the fewest number of exceedances (one or two samples) found in the 2.5 to 5.0-foot-bgs depth interval. In 2004, five samples were collected in the marsh and analyzed for eight proprietary pesticides historically produced at the former Zeneca site. Only one compound, pebulate, was detected in one sample in the south-central portion of Western Stege Marsh (sample number SM172).

1.3.4.3 Polychlorinated Biphenyls

As previously discussed in Section 1.2.2, PCB-affected sediments were excavated at the outfall of the Western Strom Drain line in Western Stege Marsh in 2003 (see Figure 18). In portions of

the marsh that were not remediated 2002 and 2003, PCBs (measured as total Aroclors) detected in shallow sediment (0 to 0.5 bgs) exceed the marsh screening values in the western portion of the marsh, primarily along Meeker Slough and east of the Bulb area in the Transition Area. The highest concentrations of PCBs were detected along the northern portion of Meeker Slough. In addition, areas in the eastern portion of Western Stege Marsh that was remediated in 2002 and 2003 have slightly-elevated concentrations of PCBs in the near surface; as compared with ER-L values (see Figure 42). Figure 45 shows the concentration ranges of PCBs (measured as Aroclor-1248 and Aroclor-1260) in shallow sediment samples collected in 2006. Figure 46 shows this same area, displaying data collected in 2007 and 2008. As shown, PCBs are consistently not detected, or detected at low concentrations.

The vertical chemical distribution pattern for Aroclors showed a pattern similar to metals and pesticides. As shown in Tables 17, 18, and 19 , the average total Aroclor concentrations are 2.59 mg/kg in surface sediment samples (0 to 0.5 bgs); 6.26 mg/kg for shallow sediment samples (0.5 to 2.5 depth bgs); and 1.47 mg/kg from the deep sediment samples (2.5 to 5.0 bgs). The PCBs appear to occur primarily along Meeker Slough. Again, the pattern of higher chemical concentrations below the shallow surface layer can indicate historic contaminant input (vs. recent inputs) and a sediment environment that is net depositional. Further evaluation of the sediment transport mechanisms and processes is required to understand the sediment and contaminant transport mechanisms at the RFS.

1.3.4.4 pH Values

The pH of RFS marsh sediments ranges from 4.1 (SM110 at 7.66 feet) to 9.4 (SM142 at 2.5 feet). The acidic conditions (pH less than 5) are mostly found in deeper sediments in the eastern area of the marsh previously remediated at depths ranging from 4.0 to 8.0 feet bgs. The pH results are summarized in Table 15. Only four locations with pH values equal to or less than 5.0 were not removed from the RFS marsh. The remaining sediment samples collected from the marsh had pH values ranging from 6.3 to 9.4.

1.3.5 Extent of Chemicals in Backfill Soils and Sediment

As described in Section 1.2.2, three phases of remediation were completed at the RFS between September 2002 and November 2004 under the oversight of the Water Board and a TCRA was performed in the vicinity of the former FPL WTL under the oversight of DTSC (see Figure 18). Following excavation and disposal of contaminated soils and sediments, excavated areas were backfilled with clean soils or Bay mud. This section describes the analytical protocols and screening criteria used to determine if soils and sediments (marsh and upland) were acceptable for use as backfill and describes the sources of soil that were used for backfill. This section also provides information on existing soil stockpiles that may be used as backfill in future remediation phases. Analytical results of soil samples described below are found in Appendix H.

1.3.5.1 Analytical Protocols

The following are protocols that were used for collection and analyses of samples of soils imported as backfill during the first three phases of the remediation activities at RFS.

The samples were collected from a secure stockpile of material located either on site or at the source site. The samples also may have been collected in situ before the fill material was excavated. In both cases, measures were implemented to ensure that the samples collected were representative of material that will be used as backfill.

The backfill material was typically sampled at the rate of one four-point composite sample per 1,000 cy. Each composite sample was typically analyzed for a full suite of analytes, including priority pollutant metals, PCBs, pesticides, VOCs, PAHs with low detection limit requested from the laboratory, and TPH as motor oil and diesel with silica gel cleanup. Samples were also typically collected to assess geotechnical properties of the soil, including Atterberg limits, grain size distribution, bulk density, moisture content, and total organic carbon (TOC) content. The following table summarizes the analytical parameters and analytical method (URS 2002a).

Parameter	Analytical Method
Priority Pollutant Metals	EPA 6010
PCBs/Pesticides	EPA 8081/8082
VOCs	EPA 8260
SVOCs/PAHs	EPA 8270 (low detection limits)
TPH motor oil	Standard Method 8015M
TPH diesel	Standard Method 8015M
TOC	9060
Moisture Content and Bulk Density	ASTM 2937
Atterberg Limits	ASTM D4318
Grain Size	ASTM D-422

1.3.5.2 Screening Criteria

Materials brought on site for use as backfill in Western Stege Marsh were sampled and the results compared with the criteria selected from the wetland surface material screening guidelines included in the "Draft Staff Report – Beneficial Reuse of Dredged Materials: Sediment Screening and Testing Guidelines" (Water Board 2000), background metals concentrations documented in the Lawrence Berkeley National Laboratory (LBNL) "Protocol for Determining Background Concentrations of Metals in Soil at Lawrence Berkeley National Laboratory" (LBNL 1995), and the risk-based SSTL developed for the risk assessment. The lower of the LBNL concentration and H-SSTL was selected for metals when no criteria were established in the Water Board report. The criteria for organic chemicals were based on laboratory detection limits for VOCs, PAHs, pesticides, PCBs, or TPH. Low detection limits for

EPA Method 8270 were specified. If low concentrations of organic chemicals were detected in a potential borrow source, the source was considered on a case-by-case basis.

Samples were collected of the imported fill material for the Upland Area and the results were compared with criteria for metals based on the LBNL background metals concentrations. The criteria for organic chemicals were based on laboratory detection limits for VOCs, PAHs, pesticides, PCBs, or TPH. Low detection limits for the EPA Method 8270 were specified. If low concentrations of organic chemicals were detected in a potential source, the borrow source was evaluated on a case-by-case basis (URS 2002a).

1.3.5.3 Fill Sources and Analysis by Phase

Phases 1 and 2 of the remediation activities involved the excavation of marsh sediments and soils from portions of the Transition Area (see Figure 18). Phase 3 involved excavation of soil in the Upland Area in the central portion of the RFS and removal of a small volume of mercury-affected marsh sediments in the central portion of the Western Stege Marsh. The source of backfill materials used during each phase of remediation is outlined below.

Phase 1, Fall 2002

Phase 1 remediation activities included excavation of the eastern portions of Western Stege Marsh and the Transition Area (see Figure 18). The Phase 1 backfill sources and remediation activities are described in detail in Sections 3.2.3 and 3.3.4 of the Phase 1 Implementation Report (URS 2003b). The following paragraphs summarize the sources of clean backfill material used during Phase 1 and the analytical methods that were used to evaluate sources as potential clean backfill material.

Upland Fill (Uplands and Transition Areas): These areas included imported clean fill and clean overburden previously excavated from Area 1. There were three source locations for imported fill during the Phase 1 remediation activities: (1) the Port of Oakland, (2) a site in San Francisco adjacent to Golden Gate Park, and (3) the excavation for the Jean Hargrove Music Library at the UC Berkeley campus. Analytical results are presented in Appendix H, Tables H-1 through H-4. The suite of analytical methods run on the sources included metals, VOCs, PAHs, pesticides (including dichlorodiphenyldichloroethane [DDD], dichlorodiphenyldichloroethene [DDE], DDT, and chlordane), PCBs, and diesel and motor oil.

Marsh Fill: Clean Bay Mud imported from the Martinez Marina was used as fill material in areas remediated in Western Stege Marsh during Phase 1. The Martinez Marina source was sampled in accordance with the Water Board's screening guidelines for wetland surface material to ensure compliance with geotechnical and chemical criteria specified by the Water Board (Water Board 2000). Analytical results are presented in Appendix H, Tables H-5 and H-8. The Analytical methods performed on the samples included metals, VOCs, PAHs, pesticides (including DDD, DDE, DDT and chlordane), PCBs, and diesel and motor oil.

Phase 2, Fall 2003

Phase 2 remediation activities included excavation of marsh and upland sediments immediately west of areas excavated in Phase 1, as well as removal of the discrete PCB contamination at the end of the Western Storm Drain outfall (see Figure 18). The Phase 2 backfill sources and remediation activities are described in detail in Sections 3.2.4, 3.3.4, and 3.4.4 of the Phase 2 Implementation Report (URS 2004). The following paragraphs summarize the sources of clean backfill material used during Phase 2 and the analytical methods that were used to evaluate sources as potential clean backfill material.

Upland Fill (Uplands and Transition Area): Below the groundwater table, granular fill from three sources was used: (1) a Presidio source, (2) a San Francisco PG&E source, and (3) a private source in San Francisco. Above the groundwater table and granular fill, the source of backfill material consisted of soil that was excavated during construction of the new Stanley Hall on the central UC Berkeley campus. Analytical results of the samples collected to evaluate the upland fill source materials are presented in Appendix H, Tables H-9 through H-12. The analytical methods performed on the samples included metals, VOCs, PAHs, pesticides (including DDD, DDE, DDT and chlordane), PCBs, gasoline, diesel, and motor oil.

Marsh Fill: Clean Bay Mud from the Martinez Marina was also used as backfill for the areas in Western Stege Marsh remediated during Phase 2. The clean Bay Mud source material was sampled in accordance with the Water Board's screening guidelines for wetland surface material to ensure compliance with geotechnical and chemical criteria specified by the Water Board (Water Board 2000). Analytical results for the samples collected to evaluate the Martinez Marina source are presented in Appendix H, Tables H-5 through H-8. The analytical methods performed on the samples included metals, VOCs, PAHs, pesticides (including DDD, DDE, DDT and chlordane), PCBs, and diesel and motor oil.

Phase 3, Fall 2004

Phase 3 remediation activities included excavating upland areas in the central and southern portions of the RFS and removing a small volume of mercury-affected marsh sediments in the north-central portion of Western Stege Marsh (see Figure 18). The Phase 3 backfill sources and activities are described in Sections 3.2 and 3.4 of the Phase 3 Implementation Report (URS 2005). A small area of Western Stege Marsh was regraded, and the previously imported clean Martinez Marina Bay Mud was used as backfill as needed.

Upland Fill (Upland Area): Two sources of fill were used to backfill upland RAs after affected soils were excavated and transported for disposal: (1) stockpiled Stanley Hall soil excavated from the UC Berkeley central campus that was also used during Phase 2 remediation activities as described above, and (2) clean soil that had been imported during Phase 1 to create an earthen berm in the Western Stege Marsh during Phase 1 and 2 remediation activities. Analytical results for samples collected to evaluate the clean "earthen berm" soil are presented in Appendix H, Table H-13, taken from the Phase 3 Implementation Report (URS 2005). The analytical methods

performed on the samples included metals, VOCs, SVOCs, PAHs, pesticides (including DDD, DDE, DDT, and chlordane), PCBs, and hydrocarbons.

FPL WTL TCRA: Soil excavated from the Math Sciences Research Institute (MSRI) construction project on the central UC Berkeley campus and stockpiled in the area north of the Asphalt Pad B on RFS was approved by DTSC for use as clean backfill for the FPL WTL TCRA excavation performed in October and November 2007. The samples were submitted to a State-certified laboratory for analysis of metals, PAH, purgeable-range TPH, extractable-range TPH, pesticides, PCBs, SVOCs, and VOCs. Analytical results for samples collected from the MSRI soil stockpile are presented in Appendix H, Table H-14.

Existing Stockpiles Soils

In addition to the Phase 1, 2, and 3 remediation areas and the FPL WTL TCRA area that were graded to final design elevations, there is currently one area where imported soils were graded to more closely match surrounding topography, and one clean soil and one limestone stockpile are located in the area north of Asphalt Pad B. The location and source of these soils is described below.

Bay Mud Stockpile: In December 2004 and January 2005, the remaining clean Bay Mud from the Martinez Marina source that was stockpiled in the eastern portion of the Transition Area at the end of Phase 2 remediation activities was sold by UC Berkeley to CSV in January 2005 for use as backfill in the HEA of Eastern Stege Marsh. In February 2008, UC Berkeley consolidated the remaining amount of clean Bay Mud stockpile area was consolidated into a low-profile stockpile, covered with geosynthetic fabric, and covered with wood chips. This material was sampled during Phase 1 remediation activities, and the analytical results are provided in Appendix H, Tables H-5 and H-8.

Upland Fill and Limestone Stockpiles: Currently, one clean, covered soil stockpile and one clean, covered limestone stockpile are present in the area north of Asphalt Pad B.

- Small limestone pile – a small pile (roughly estimated at 200 cy) of limestone (calcium carbonate) remaining after the Phase 2 remediation activities. The pile is covered and secured with visqueen and routinely monitored as part of the stormwater inspection activities.

- West pile – approximately 750 to 1,250 cy (rough estimate) of soils that were excavated from the MSRI construction project on the central UC Berkeley campus were stockpiled in the area north of Asphalt Pad B in 2005. Samples of this soil were collected and analyzed in June 2006 and additional samples were collected in October 2007 as part of DTSC's review and approval of the soil for use as backfill for the FPL WTL TCRA excavation. The sampling report and analytical results are presented in Appendix H.

1.3.6 Extent of Chemicals in Surface Water

As part of the Groundwater, Surface Water, and Sediment Monitoring Plan, three surface water samples were collected in Western Stege Marsh and one at the Meeker Slough Bay Trail bridge near the Marina Bay Housing Development in October 2006, May 2007, and January 2008 (BBL 2004d). Also as part of the plan, five first-flush stormwater runoff samples were collected during rain events in November 2006, April 2007, and January 2008 from five locations: the Eastern Storm Drain outfall (STW105), the Western Storm Drain outfall (STW106), Meeker Culvert (STW107), Meeker Tidal Creek (STW108), and at the Meeker Slough Bay Trail bridge (STW104). The sampling locations are shown on Figure 47. Table 20 presents surface water screening criteria. Table 21 presents the summary statistics for the surface water and stormwater samples collectively. Appendix D provides a summary of the complete analytical results for the surface water and stormwater samples.

Surface water samples collected from Western Stege Marsh and Meeker Slough were nondetect for pesticides and PCBs. The three sampling events occurred at the same time as the soil sampling events in November 2006, April 2007, and January 2008. Most metals were not detected at concentrations exceeding the reported sample detection limits, although many detection limits were greater than the screening criteria. Copper concentrations exceeded the screening criterion (3.1 µg/L) in all three events. The estimated value for silver exceeded the screening criterion (0.19 µg/L) in the central marsh in 2006, and in 2007 and 2008, the detection limit for all samples was above the screening criterion. In one sample from 2007 and one sample from 2008 the zinc concentration exceeded the screening criterion (81 µg/L).

Recent stormwater samples collected from the Eastern and Western Storm Drain outfalls (sample numbers STW105 and STW106), two off-site outfalls draining to Meeker Slough (sample numbers STW107 and STW108), and from Meeker Slough at the Bay Trail (sample numbers SW104 and STW104) were nondetect for pesticides and PCBs, with the exception of one sample from the stormwater event in January 2008, which had an estimated value of 0.06 µg/L of DDT (STW 108). The concentration of copper exceeded the screening criterion in all five samples for all three events. Lead exceeded the San Francisco Basin Plan Criterion of 5.6 µg/L in one sample in the January 2008 event. Mercury exceeded the San Francisco Basin Plan Criterion of 0.025 µg/L in four samples in 2006 and three samples in 2008. Silver exceeded the surface water screening criterion of 0.19 µg/L (EPA 2002a, 2002b) in one sample collected from Meeker Slough at the Bay Trail. Zinc exceeded the surface water screening criterion of 81 µg/L (EPA 2000; Water Board 1995) in three samples collected in 2006, one in 2007, and all five samples taken in January 2008.

1.3.7 Extent of Chemicals Present in Groundwater on RFS

As described in Section 1.1.1.2, three groundwater zones (shallow, intermediate, and deep) are currently identified at RFS. Most of the groundwater data for RFS is from the shallow groundwater zone, with approximately 110 samples collected from 95 locations. The groundwater data were collected between 1985 and 2006. Four groundwater samples were collected from the intermediate zone in three locations, and three groundwater samples were

collected in the deep zone from three locations. The groundwater sampling results within the shallow, intermediate, and deep zones are summarized in the following subsections.

1.3.7.1 Extent of Chemicals in Shallow-Zone Groundwater

Shallow-zone groundwater samples were collected from approximately 95 locations at and near RFS, including the locations on the former Zeneca site property adjacent to and along the eastern property boundary with the RFS. Samples were analyzed for metals, VOCs, pesticides, and PCBs. Figure 20 shows the locations where groundwater samples discussed in this subsection were collected and the analyte group (metals, pesticides, and PCBs) for which the samples were analyzed. As illustrated on Figure 20, metals were the most frequently analyzed group. Most of the groundwater samples exhibited relatively low to nondetectable concentrations of chemicals.

Most of the groundwater samples were collected from the shallow zone as either grab groundwater samples or hydropunch/CPT samples. The data quality of grab and hydropunch/CPT groundwater samples is typically lower than groundwater samples collected from monitoring wells because there is no well filter pack to filter out particulates from the samples, and because boreholes are not typically purged until groundwater field parameters (such as pH, turbidity, and temperature) stabilize before collection of the sample. These types of groundwater samples are typically used as screening-level samples to identify appropriate locations for monitoring wells. Additional monitoring wells may be needed at RFS to collect groundwater samples of sufficient quality to be used in a risk assessment and for purposes of evaluating the need for remedial actions in groundwater at select areas in the southern portions of RFS.

Many of the shallow-zone groundwater samples were collected prior to remediation activities performed between 2002 and 2004. Samples collected prior to the remediation activities exhibited the highest concentrations of metals detected in groundwater, including locations A4-5B, A4-9B, B-2, B-7, PB12, and SM110 (see Appendix D, Table D-9). A discussion of the samples collected in areas of the remediation activities in 2002 to 2004 is not included in this subsection because these samples are not likely representative of current concentrations in groundwater. The groundwater data for each sampling location are presented in the Appendix D. The following text discusses the sample data representative of current conditions, collected within the remediated areas, but collected below the depth of the excavations, or collected since completion of the remediation activities.

Figure 20 shows the locations where all the shallow groundwater sample data were collected. As illustrated on Figure 20, the most common group analyzed for in groundwater samples were metals with only a small percentage of samples analyzed for other groups of chemicals. The second most commonly tested group was VOCs. VOC data were collected primarily from the area along the eastern boundary of RFS, at the boundary with the former Zeneca site. Groundwater with detectable concentrations of chlorinated hydrocarbons (cis-1,2-DCE; TCE; and PCE) was identified in the eastern portion of RFS adjacent to affected groundwater at the former Zeneca site. In 2006, DTSC required Zeneca and CSV to sample groundwater on the RFS side of the property to further characterize the extent of chemicals detected in groundwater samples collected along the former Zeneca site's western boundary.

Table 22 presents the summary statistics for groundwater data. This table lists all of the chemicals analyzed for in shallow groundwater samples at RFS, along with the number of samples analyzed, percentage of detections, maximum concentration detected, and other information. The analytical results for shallow groundwater for locations greater than 50 feet from the shoreline in the Upland Area and Transition Area were screened against 10 times the National Ambient Water Quality Criteria (NAWQC) (chronic saltwater). The precedent for this screening criterion was set by the Water Board in Order 98-072 (Water Board 1998) because of the predicted attenuation of constituents in groundwater. Although the shallow-zone groundwater would not be considered a source of drinking water because of its proximity to the surface, the shallow-zone groundwater results were also compared with drinking water standards (MCLs) in Table 22.

Dissolved Metals in Shallow-Zone Groundwater

Shallow groundwater samples analyzed for metals were found to have concentrations exceeding 10 times the NAWQC in a number of locations for several metals (see Figure 48). The locations are described below.

Transition Area: Concentrations of cadmium, nickel, and zinc exceeded screening criteria in the western portion of the Transition Area between the edge of the excavations performed at RA 4 and RA 6 during the Phase 3 remediation activities performed in 2004. UC Berkeley's consultant, BBL, collected one grab groundwater sample, AOC6-GW, downgradient of RA 6 in spring 2004. In this sample, mercury (at 0.92 µg/L) and nickel (at 93 µg/L) concentrations in groundwater slightly exceeded their screening criteria (0.25 µg/L and 82 µg/L, respectively). Samples collected from three locations (A4-14, CD9, and CD10) contained zinc at concentrations of 27,000 µg/L, 15,000 µg/L, and 7,300 µg/L exceeding the screening criterion of 810 µg/L. Samples from location A4-14 also contained cadmium and nickel concentrations (150 µg/L and 530 µg/L) exceeding screening criteria (85 µg/L and 88 µg/L). In addition, one Upland Area sample in this vicinity, AOC6-GW, contained nickel at a concentration of 93 µg/L that slightly exceeded the screening criterion of 88 µg/L. This area is adjacent to the northern boundary of the Transition Area. Metals concentrations in shallow groundwater at concentrations exceeding screening criteria in this area may be associated with former or current pyrite cinders or from the former California Cap Company operations in this area. Some of the shallow-zone groundwater samples were collected from or near areas that were remediated in

2002 and 2003 prior to performing the remediation activities. Therefore, samples from these areas may not represent current conditions.

In one location, A4-12, nickel and zinc were measured in historic, pre-remediation samples at concentrations exceeding 10 times the NAWQC (used for screening locations within 50 feet of the shoreline).

Transition Area, Western Storm Drain: In the Western Storm Drain area, two grab groundwater samples, SD101 and SD102, were collected by UC Berkeley's consultant URS and analyzed for priority pollutant metals and PCBs in 2000. In one sample, copper was reported at a concentration of 89 µg/L, exceeding the screening criterion of 31 µg/L, and total PCBs were reported at a concentration of 0.88 µg/L, exceeding the screening criterion of 0.30 µg/L. The two groundwater sampling locations were adjacent to the Western Storm Drain line and southwest of Building 128.

Upland Areas

RA 2, Cap Company Test Pit Area: Three grab groundwater samples were collected in this area in 2000 and prior to remediation activities performed in 2004. Two samples did not contain chemical concentrations exceeding screening criteria. One sample contained three metals at concentrations slightly exceeding their respective screening criteria: copper at 140 µg/L (compared with 31 µg/L), mercury at 0.27 µg/L (compared with 0.25 µg/L), and nickel at 450 µg/L (compared with 82 µg/L).

RA 3, Forest Products Area: Five grab groundwater samples, FP101 through FP105, were collected in this area in 2000, prior to remediation activities performed in 2004. One sample contained nickel at a concentration of 120 µg/L, which exceeded the screening criterion of 82 µg/L. One sample collected in 2004 and prior to remediation, AOC3-GW, had a reported copper concentration of 54 µg/L, which exceeded the screening criterion of 31 µg/L.

RA 4, Cap Company Shell Manufacturing Area: Three grab groundwater samples (SH101, SH102, and PC101) were collected in this area and analyzed for priority pollutant metals in 2000. Concentrations of the metals were less than their respective reporting limits. In addition, UC Berkeley's consultant BBL collected one grab groundwater sample, AOC4-GW, downgradient of RA 4 in spring 2004, prior to remediation performed in this area. In this sample, copper was reported at a concentration of 33 µg/L, which slightly exceeded the screening criterion of 31 µg/L.

MFA, Cap Company Mercury Fulminate Area: Of the 24 grab groundwater samples that have been collected since 2000, 10 samples contained mercury, with an average concentration of 1.6 µg/L and a maximum concentration of 5.9 µg/L, exceeding the screening criterion of 0.25 µg/L.

Eastern Sanitary Sewer Line: Three grab groundwater samples have been collected along the eastern sanitary sewer line in the vicinity of Buildings 112 and 102 (see Figure 45). Nickel was reported at a concentration of 150 µg/L, which slightly exceeded the screening criterion of 82 µg/L, in the sample collected from location SL103 in 2000.

Eastern Property Boundary Area

Numerous groundwater samples have been collected in the area along the eastern property boundary adjacent to the former Zeneca site. Samples from seven locations contained metals or pesticides at concentrations exceeding screening criteria, and samples from two locations (PB102 and PB16) contained metals at concentrations exceeding 10 times the screening criteria. Location PB102, which is located on the former Zeneca site property and east of RFS Building 185, contained copper at a concentration of 4,100 µg/L (compared with 31 µg/L) and zinc at a concentration of 11,000 µg/L (compared with 810 µg/L). Location PB16, which is located along the eastern property boundary and southeast of RFS Building 472, contained copper at a concentration of 990 µg/L compared with 810 µg/L). Except for location PB16, the six of the seven locations with exceedances are located on the eastern side of the bentonite slurry wall installed along the eastern property boundary by Zeneca.

Volatile Organic Compounds in Shallow-Zone Groundwater

Limited grab groundwatersampling and analysis for VOCs in groundwater (19 samples) has been performed at the RFS. Most of the grab groundwater samples analyzed for VOCs were collected along the eastern RFS property boundary and adjacent to the area of affected groundwater that has been investigated on the former Zeneca site. Most VOCs reported at concentrations less than their respective laboratory reporting limits and when detected, most of the VOCs were present at low concentrations (for example, near or less than the MCL). Exceptions to this include cis-1,2-DCE, PCE, and TCE. All concentrations of VOCs detected in groundwater samples are presented on Figure 49. A review of the analytical data indicated the following:

- The VOCs that were detected the most frequently and at the highest concentrations were cis-1,2-DCE (detected in 14 of 19 samples), PCE (detected in 10 of 19 samples), and TCE (detected in 15 of 19 samples).
- None of the VOCs were detected concentrations exceeding 10 times their respective NAWQC (see Figure 47).
- Cis-1,2-DCE was detected at a maximum concentration of 22 µg/L in the grab groundwater sample collected from location UCB-9, with five of the detections exceeding the State of California MCL of 6 µg/L.
- PCE was detected at a maximum concentration of 100 µg/L in the grab groundwater sample from location UCB-7 with five of the detections exceeding the MCL of 5 µg/L.

- TCE was detected in 16 of the 21 grab groundwater samples and 15 of these samples had concentrations exceeding the MCL of 5 µg/L, with 8 of the samples exceeding 100 µg/L. The maximum concentration (1,400 µg/L) of TCE was detected in samples from locations UCB-9 and UCB-7, in the northeast corner of the RFS near Building 476 and the Lot 1 area of the former Zeneca site.

- Vinyl chloride was detected in three grab groundwater samples collected at location PB15 (concentrations of 1.1 µg/L); at location PB14 (concentration of 0.9 µg/L); and at location UCB-3 (concentration of 0.4 µg/L). The results for samples from PB14 and PB15 exceeded the MCL of 0.5 µg/L for vinyl chloride.

Pesticides and PCBs in Shallow-Zone Groundwater

Four unfiltered samples were analyzed for pesticides and five unfiltered samples were analyzed for PCBs from the shallow-zone groundwater at RFS. Pesticides were not detected in any of the samples, and PCBs were detected in two of the samples. Aroclor-1260 was detected at a concentration of 1.3 µg/L (flagged by the analytical laboratory as an estimated value) in the sample from location SL103, while Aroclor-1248 was detected at a concentration of 0.88 µg/L in the sample from location SD101. Location SL103 is just north of the eastern edge of the area remediated in the Transition Area during 2003, while location SD101 was collected under the Western Storm Drain line in the western portion of the Transition Area and just south of the former seawall. Both of these results exceed 10 times the NAWQC for total PCBs (0.3 µg/L).

1.3.7.2 Extent of Chemicals in Intermediate-Zone Groundwater

Only four groundwater samples were collected from the intermediate-zone groundwater at RFS (approximately 30 to 74 feet bgs). These samples were collected from CPT borings by Zeneca's consultant LFR, Inc. in October 2006 (LFR, Inc. 2007a) and are identified as:

- UCB-CPT-3 GW 28'-31'
- UCB-CPT-3 GW 46'-49'
- UCB-CPT-2 GW 63'-68'
- UCB-CPT-1 GW 30'-33'

Groundwater samples collected from these borings were analyzed for VOCs, and sample UCB-CPT-3 GW 28'-31' was also analyzed for dissolved metals. Barium and thallium were the only metals detected in this sample, and thallium was detected at concentrations exceeding the MCL.

The VOC analytical data indicated only eight detections, with four less than the reporting limit of 0.5 µg/L (estimated quantities). Benzene, PCE, toluene, and p-isopropyltoluene were each detected once at concentrations of 0.8, 0.5, 0.3, and 0.3 µg/L, respectively. TCE was detected in

four of the samples, at concentrations ranging between 0.4 and 1.3 µg/L (less than the MCL of 5 µg/L). The sample collected from UCB-CPT-2 had significantly lower concentrations of TCE in the intermediate-zone (0.4 µg/L, estimated quantity) than in the corresponding shallow-zone sample (330 µg/L). Similarly, the sample from UCB-CPT-3 at 28 feet bgs exhibited TCE at 1.3 µg/L, while the sample from this CPT boring at 46 feet bgs exhibited TCE at 0.9 µg/L.

A review of these data indicates that VOCs detected in the shallow-zone groundwater have not had a significant impact on intermediate-zone groundwater.

1.3.7.3 Extent of Chemicals in Deeper-Zone Groundwater

As described in Section 1.1.1.2, UC Berkeley installed 25 wells in the 1950s in a deeper groundwater zone to depths of approximately 90 to 100 feet bgs (see the research well field shown on Figure 3). These wells were used as part of a research project to evaluate the feasibility of injecting treated wastewater into this groundwater zone. Most of these wells were decommissioned in 2006 (Stellar 2006). In April 2005, prior to their decommissioning, three of the wells were sampled and analyzed for metals, VOCs, PCBs, and radiological isotopes (tritium, gross beta radiation, and gamma-emitting radionuclides) (Stellar 2005). Analytical results from this sampling event can be found on Figure 20, and indicated the following:

- One detection of copper (870 µg/L)
- Two detections of zinc (150 and 24 µg/L)
- No detections of VOCs or PCBs
- All radiological results were below the method detection limit

The detected concentrations of copper and zinc did not exceed any of the groundwater PRGs or MCLs. As described in Section 1.1.4.1, 24 of the wells in the research well field were closed under permit by Contra Costa County (Stellar 2006). UC Berkeley plans to close the remaining one well from the research well field and several other groundwater wells that have been recently identified.

2.0 CONCEPTUAL SITE MODEL

This section presents the current CSM for the RFS. The CSM is based on the historical operations and sources for chemical releases, as described in Section 1.1, and the current environmental data, as presented in Section 1.3. The CSM describes the sources and chemical characteristics of each medium affected by past operations and releases and defines the associated migration pathways (see Section 2.1). The CSM also describes the fate and transport of chemicals present at RFS based on the affected environmental media (such as upland soils, marsh sediments, surface water, and groundwater) and the characteristics of chemicals present in the affected medium (see Section 2.2). The dynamic nature of sediments in the marsh is of particular relevance to the RFS, which is discussed in detail in Section 2.3. Finally, human and ecological exposure pathways are described using: (1) the information on chemicals found at RFS and their associated migration pathways, (2) the understanding of each chemical's fate and

transport characteristics, and (3) the current and anticipated future uses of the RFS and surrounding areas (see Section 2.4).

2.1 POTENTIAL SOURCES AND MIGRATION PATHWAYS

The following paragraphs identify potential sources and migration pathways for contaminants at RFS.

2.1.1 Potential Sources

As previously discussed in Section 1.1, the currently identified sources of chemicals released at the RFS are from past industrial operations by the California Cap Company, past manufacturing operations at the adjacent former Zeneca site, historical research-related activities at the former and now remediated FPL WTL, and possibly industrial operations from current or former neighboring properties such as the Bio-Rad Laboratories, the former PG&E facility, the former Liquid Gold facility and the former Kaiser Shipyard and other activities in the area that is now the Marina Bay housing development.

These chemical sources have affected the RFS in three primary ways: (1) direct release of chemicals to soils and sediments at the RFS, (2) transport of chemicals onto the RFS and into the marsh and slough areas via surface water overland flow, storm drain and sanitary sewer flows, and groundwater transport, and (3) possible influx of contaminants from the San Francisco Bay. Some air deposition of chemicals may have occurred from releases from adjacent properties.

The table below summarizes the historical operations that may have been the sources of chemicals detected in soils, sediment, and groundwater at the RFS based on the information provided in Section 1.0 of this Current Conditions Report. Chemicals in many of these areas were removed during remediation activities performed between 2002 and 2004, and in 2007, but historically the locations may have been sources of contaminant releases to the marsh.

Past Operations and Potential Contaminant Sources	Detected Chemicals at Potential Source	Primary Mechanism of Potential Release to RFS
Explosive Storage (RA 1)	Metals	Direct disposal or release
Test Pit (RA 2)	Metals	Direct disposal or release
Near Former FPL WTL (RA 3)	Metals and PAHs	Direct disposal or release
Near Former California Cap Company, Shell Manufacturing Area (RA 4)	Metals	Direct disposal or release
Southern End of the Western Storm Drain Line	Metals and PCBs	Overland flow and stormwater and sanitary sewers
Former Lark Drive/B277 drainage ditch (RA 6)	PCBs	Release from building materials and overland flow
Former California Cap Company, Mercury Fulminate Plant Area (MFA)	Metals	Direct disposal or release, overland flow, and stormwater and sanitary sewers

Past Operations and Potential Contaminant Sources	Detected Chemicals at Potential Source	Primary Mechanism of Potential Release to RFS
South and West of Former Blasting Cap Area (RA 5)	PCBs	Direct disposal or release
Former California Cap Company Operations, including Test Pit, Dry House, and Tram Lines	Undetermined	Possible direct disposal or release
Former U.S. Briquette Company and Pacific Cartridge Company Operations	Undetermined	Possible direct disposal or release
Geosciences Well Field	Undetermined	Possible direct disposal or release, groundwater migration
Former Transformer Storage Areas	PCBs	Possible direct disposal or release
Building 120 Area and RFS Corporation Yard	Undetermined	Possible releases
Former and Existing Sanitary Sewer Lines	Undetermined	Possible direct disposal or release, sanitary sewers
Western Stege Marsh	PCBs and Metals	Direct disposal or release, overland flow, tidal mixing, resedimentation
WTA, including the Bulb	PCBs, undetermined	Possible direct disposal or release
Current and Historic RFS Research Facilities	Undetermined	Possible direct disposal or release
Current Aboveground Storage Tanks	Petroleum	Possible direct disposal or release
Former Operations on the former Stauffer and Zeneca Site East of RFS	Metals, VOCs, PCBs, and Herbicides	Direct placement / release or overland flow
Former and Existing Industrial Operations West and North of RFS	Metals, PCBs, VOCs	Overland flow and stormwater and sanitary sewers

Figure 9 shows the locations of sources from the past industrial activities at both RFS and adjacent and nearby properties. Figure 18 show the areas that were remediated after being identified during previous investigations that focused on historical operations at the RFS. Most of these potential sources have been removed or remediated.

Metals present in soils and sediments at the RFS are associated with multiple sources, including (1) the former California Cap Company shell manufacturing, blasting cap manufacturing, and mercury fulminate production; and (2) pyrite cinders from the former Stauffer sulfuric acid manufacturing facility used as fill materials and placed in the marsh. VOCs are present in groundwater on the northeastern portion boundary of the RFS and the Lot 1 area of the former Zeneca site, but the source of these chemicals has not been determined at the time of submittal of this report.

On- and off-site stormwater drainage systems likely contributed to the transport of contaminants to the RFS upland and marsh areas. Figure 3 shows current and historical drainage channels and pipes. The configuration of the Western Storm Drain line from eastern and northern off-site properties that discharged into the marsh has changed over the years. Prior to the construction of the City of Richmond Wastewater Treatment Plant in the 1950s, the Western Storm Drain line appears to have been the primary sewer line in the area, conveying stormwater and sewage

(including industrial wastes) from an undelineated upstream area of the City of Richmond directly to the western portion of Western Stege Marsh and Meeker Slough. After the City of Richmond Wastewater Treatment Plan was constructed, the line continued to be used by the City of Richmond as a sanitary sewer overflow line until the northern portion of the line was disconnected by UC Berkeley from the City of Richmond's sanitary sewer system by UC Berkeley in 2004.

In addition, a historic sanitary sewer line traversed the former tidal mudflat area. This sanitary sewer line drained the eastern portion of the California Cap Company, and later RFS, and portions of the former Stauffer site and Harbor Front properties to the north and east of the former Stauffer site. Several manholes for this sanitary sewer line are evident in an aerial photograph from 1948, which shows the line extending through the former tidal mudflats in an east-to-west direction. The portion of the line extending from the former Stauffer site and other properties to the east was reportedly disconnected in 1991 when the City of Richmond required ICI to reroute the discharge north to the sewer serving the Harbor Front tract due to high concentrations of metals found in this line (Richmond Southeast Shoreline Area Community Advisory Group 2007). In 1998, UC Berkeley replaced the distal portion of the Egret Way lateral line when the City of Richmond determined that groundwater with elevated metals concentrations from exposure to pyrite cinders was infiltrating the line. UC Berkeley removed a large portion of the sanitary sewer line during the 2003 remediation activities and relocated and replaced the old line with a new section of sanitary sewer line that is now located further north of the former sanitary sewer line orientation (see Figure 3 and Photographs C-37 and C-49, Appendix C). As can be seen in Photograph C-37, the old sanitary sewer line was bedded in pyrite cinders along its entire length through the southern portion of the Transition Zone. During removal of the sanitary sewer line in 2003, it was observed that the line was cracked in many places in the eastern portion of the Transition Area near the boundary with Western Stege Marsh (URS 2004). This confirmed pre-excavation site investigation observations during videotaping of the line. An area of contaminated soil with a strong chemical odor was encountered immediately below the line at a location down stream and west of the tie in of the sanitary lateral line from RFS that ran along Egret Way. Because of the strong odor emanating from the contaminated soil during excavation of the sanitary sewer line, UC Berkeley collected a discrete sample of the soil (sample number B5-100303-Composite) immediately below the pipe and analyzed the sample for TPH diesel (5,000 mg/kg – chromatogram did not match laboratory standard) motor oil (nondetect), and gasoline (240 mg/kg – chromatogram did not match laboratory standard); VOCs (chlorobenzene at 140 mg/kg and 1,4-diclorobenzene at 16 mg/kg); pesticides (4,4'-DDT at 33 mg/kg); PCBs (Aroclor-1248 at 57 mg/kg); and SVOCs (1,4-dichlorobenzene at 23 mg/kg) (URS 2004). These results suggest a source was located upstream along this pipe and a contributing source of contamination in Western Stege Marsh. The contaminated soils were excavated, segregated, profiled, and transported off site as a hazardous waste to the Kettleman City Class I Landfill in Kettleman City, California.

2.1.2 Migration Pathways

A complete exposure pathway from the contaminated medium to the receptors must exist in order for exposure to humans or ecological receptors to occur. The following potential chemical migration pathways were evaluated at RFS:

- Leaching from soil to groundwater by infiltrating precipitation or as a result of fluctuating groundwater levels
- Migration from groundwater to surface water through direct discharge
- Volatilization from soil or groundwater to the atmosphere
- Wind entrainment of dust-size particles from surface soils to the atmosphere or to surface water
- Transport of soil or sediment to surface water with overland flow of stormwater
- Sediment transport within the marsh from tidal, wind, and wave action

Each of the potential migration pathways is discussed below.

The primary mechanism of migration of chemicals from soil to shallow groundwater at RFS is most likely through leaching by infiltrating precipitation. As a result of increased precipitation during the wet season (December through March), the water table is expected to be higher in the winter than during the dry season (April through November). Increased leaching of chemicals may occur during the wet season if groundwater comes into contact with chemicals in soil. The deep groundwater at the RFS is a confined system (Hunt 1954), and would not be directly affected by on-site infiltration.

Migration of chemicals from groundwater to surface waters may occur if groundwater discharges to the San Francisco Bay; however, the rate of discharge is expected to be low because of the low permeability of the predominant soils at RFS (such as Bay muds, clays, and silts). Soil erosion and subsequent transport by runoff can also transport chemicals to surface water, as discussed below.

Migration of chemicals from soil to the atmosphere through volatilization at RFS needs to be further evaluated because of the limited VOC samples collected at the site. Migration of chemicals from groundwater to the atmosphere through volatilization may occur where VOCs are present, such as in shallow groundwater in the northeastern portion of RFS and adjacent to the Lot 1 area of the former Zeneca site. Zeneca and CSV are currently working with the DTSC to further characterize the lateral extent of chemicals in groundwater along the property line between RFS and the former Zeneca site, and UC Berkley will perform additional sampling to further evaluate the presence or absence of VOCs in soil and groundwater at the RFS. A review

of indoor air monitoring performed by UC Berkeley in 2007 and 2008 concluded that VOC concentrations in buildings at RFS are typical of those found in indoor air.

Migration of chemicals from surface soil to the atmosphere through wind entrainment is unlikely in the upland areas of the RFS because most of the surface is paved or covered with vegetation. In March 2008, the federal Agency for Toxic Substances and Disease Registry (ATSDR), in conjunction with the California Department of Public Health evaluated the potential for resuspension of chemicals of concern and concluded that "none of the estimated air concentrations exceed screening values, and, thus, RFS workers or visitors to the RFS are not being exposed to contaminants at levels of health concern from walking outside at the RFS." (ATSDR 2008).

Historically, aerial photographs show a series of ditches and one pipe that possibly drained surface water flow from the California Cap Company production areas into portions of Western Stege Marsh. Currently, migration of chemicals from soil to surface water through transport of solids with overland flow is expected to be limited at most of RFS, because the flat surface topography throughout RFS inhibits transport of solids with overland flow over significant distances. However, sediment can enter the storm drains, be transported, and flushed out into Western Stege Marsh during heavy rains. Migration of chemicals within the marsh may occur as a result of the transport of sediments by tidal, wind, and wave action.

2.2 FATE AND TRANSPORT OF IDENTIFIED CHEMICALS

This section describes possible fate and transport mechanisms for chemicals detected at RFS, including descriptions of the persistence and mobility of specific chemicals known to occur in the primary source areas at RFS (for example, pyrite cinders fill areas, the former Mercury Fulminate Plant area, and PCB and metal contaminated sediments). The environmental behavior of the key chemicals provides a basis for understanding the transport pathways from the former source areas and the potential for migration from the locations where chemicals are currently detected. The primary chemicals present in RFS soils are metals and PCBs, which have relatively low mobility because of their high adsorption to soil particles. The geochemical conditions in the upland soils limit the potential for leaching and migration through shallow groundwater.

In addition to the metals present in groundwater, the following solvents have been identified in the shallow groundwater located near the RFS and former Zeneca site property line: PCE; TCE; and cis-1,2-DCE. Because they are soluble in groundwater, these solvents are more mobile than metals and can volatilize and degrade via reductive dehydrochlorination reactions under anaerobic conditions.

2.2.1 Metals

The behavior of metals in soils and sediments is influenced by the geochemical environment. The following factors determine the geochemical environment:

- pH and oxidation-reduction potential (ORP) status
- Presence of potential complexing agents in solution such as organic carbon or chloride
- Type of adsorbents present such as clays, aluminum oxides, or iron oxides and hydroxides
- Relative concentrations of other elements that can compete for sorption sites such as sulfate

The geochemical conditions present in soil or sediment determine the valence state for metals with multiple valences and the form of the metal for ORP-sensitive metals. Examples of metals with multiple valence states are copper and chromium. ORP-sensitive metals include arsenic, chromium, iron, manganese, and selenium. Another factor influencing the presence of metals is that trace metals may be substitutions for iron in pyrites. Substitution is particularly likely for arsenic which forms arsenopyrite.

In addition to these chemical processes, physical processes can also influence the fate of metals. The extent of infiltration from runoff or stormwater into the soils is influenced by soil type, slope, vegetative cover, and whether the area is paved or covered by buildings. The pH and alkalinity of the infiltrating solution relative to the soil solution or porewater in sediment can also exert an influence on leaching. Metals such as arsenic, mercury, and selenium can volatilize, depending on their species. Elemental mercury readily volatilizes, as does methylmercury.

The pH of the RFS upland soils is neutral to alkaline, which means that the leaching potential of metals is reduced for cationic metals such as copper, lead, nickel, and zinc. ORP conditions are not known, but would be expected to be oxidizing in the upper few feet of soil. These conditions favor the presence of iron oxides and hydroxides in soil, which are strong adsorbents of metals that might be present in the infiltrating water as it leaches metals from the soil solution. The metals in the former California Cap Company shell manufacturing area and explosives storage area may be part of solid fragments or shavings, rather than adsorbed onto soil particles. These particles would be subject to less leaching but could be transported by erosion. The pH of the transition soils is acidic to alkaline, with the acidic soils located at depths ranging from 5.0 to 14 feet.

The pH of the marsh sediments remaining after the remediation performed in 2002 to 2004 ranges from 4.1 (SM110 at 7.66 feet) to 9.4 (SM142 at 2.5 feet). The acidic conditions were mostly found in deeper sediments from 4 to 8 feet bgs in the marsh area that formerly contained pyrite cinders prior to the remediation activities performed in 2002 and 2003. Four sediments samples with pH values equal to or less than 5 were not removed from the marsh area. The remaining sediment samples had pH values ranging from 6.3 to 9.4 in the marsh area.

The shallower sediments removed from these areas were also primarily acidic. Acidic conditions contribute to greater migration of cationic metals such as copper, lead, nickel, and zinc because of higher solubility and less sorption. Therefore, before removal of the pyrite cinders, the acidic

conditions could have contributed to the migration of cationic metals into sediment porewater and into the tidal slough waters.

The pH values of the sediments in the marsh area, as measured between 2000 and 2006 in the western portion of Western Stege Marsh, were neutral to alkaline (6.3 to 8.1) at the surface and slightly more alkaline in deeper sediments (pH of 9.4 units in location SM142). Sediment samples collected between 2 and 8 feet bgs in the Transition Area (including the Bulb) were slightly alkaline to alkaline (pH of 7.6 to 12.1 units). A pH value of 12.1 was measured in sample PC102 collected at a depth of 4 feet bgs. This high pH is unusual for soil and can increase solubility of certain metals like chromium III.

The pH values of Meeker Slough sediments and marsh sediments adjacent to Meeker Slough ranged from 6.6 to 8.1 units at the surface and up to 9.1 at 2 feet bgs. Metals such as copper and lead are less soluble in these pH ranges; therefore, these metals are more likely to remain sorbed to the sediment in these areas.

Another important factor in the migration of contaminants in marsh sediments is the organic carbon content. Soluble organic carbon in the form of organic acids can complex with metals such as copper and mercury to keep it in solution. In contrast, organic matter in the sediment can also act as an efficient adsorbent and thus adsorbing the metals to the sediment.

The behavior of five metals (mercury, arsenic, chromium, copper, and lead) associated with the historical and current source areas at RFS is detailed below to illustrate the variable geochemical conditions present at the RFS and the effect of these conditions on the fate of the metals.

2.2.1.1 Mercury

Mercury is present in the San Francisco Bay region because of the legacy effects of 150 years of mercury mining (including the New Almaden Mining District near San Jose, which contributed mercury-bearing sediments to the South Bay, and Sierra Nevada gold mining operations, which generated large quantities of mercury-bearing sediments that were transported downstream along the Sacramento River). The Water Board has conducted investigations of mercury in the San Francisco Bay, and recently published the "Mercury in San Francisco Bay Proposed Basin Plan Amendment and Staff Report for Revised Total Maximum Daily Load (TMDL) and Proposed Mercury Water Quality Objectives" (Water Board 2006). Any mercury from the RFS is a much smaller contribution to the mercury in the San Francisco Bay when compared with the large historic mining sources identified above. There is limited interchange with the San Francisco Bay as a whole, especially under current conditions since only one channel, Meeker Slough, extends to the San Francisco Bay. Mercury is primarily transported within the marsh and sloughs by movement of suspended solids. Mercury is an especially complex metal because it has elemental and inorganic forms, in addition to the organic species methylmercury and di-methylmercury. The latter form is rare in the natural environment, although it is found occasionally in marine waters. Methylmercury is the form that is readily taken up by biota and can be a neurotoxin to humans, especially to fetuses and young children. The primary route of exposure to mercury for humans and wildlife is consumption of fish and aquatic biota.

The former California Cap Company historically used elemental or liquid mercury in the mercury fulminate area. This form of mercury can volatilize into the atmosphere from soil, sediment, or water. Under suitable conditions in an aqueous environment, such as a surface waterbody or wetland, elemental mercury can be oxidized to the Hg^{2+} form; and if appropriate conditions exist, this form can be methylated. This process does not occur in dry upland soils. Mercury fulminate is a compound produced by dissolving mercury in nitric acid and then adding a solution of 95 percent ethanol (Jonas & Associates, Inc. 1990b). A reaction takes place, resulting in formation of small brown to gray pyramid-shaped crystals [Hg-$(ONC)_2$] that contain colloidal mercury. The crystals are relatively insoluble in water. However, when dry, they are easily detonated by shock, impact, friction, sparks, or flame. Elevated concentrations of mercury have been found in soils in the former California Cap Company Mercury Fulminate Plant area; however no crystals have been encountered (see Figure 7). Figures 27 through 32 and 41 show the distribution of mercury in soils and sediments in the Upland Area Transition Area and Western Stege Marsh for different depth intervals, based on historical data. Figure 43 and 44 show the distribution of mercury in marsh sediment based on 2006 through 2008 data. The portion of the Upland Area with elevated mercury concentrations is included in MFA.

The MFA is fenced and is partly covered by Asphalt Pads B and C, which will limit direct contact. A small potential exists that some of the mercury, if present in the elemental mercury form in upland soils, could leach into the groundwater. More soluble complexes of dissolved mercury such as with chloride are not likely to form from mercury fulminate in the upland soils.

Trace amounts of mercury can also be present in pyrites, as a substitution for iron in pyrite, and in associated mercury sulfide compounds. As discussed in Section 1.1.2.2, pyrite cinders were formerly located in the eastern portion of Western Stege Marsh (see Figure 10). In addition, pyrite cinders were used as fill in other portions of the RFS including the Transition Area and Upland Area. Although pyrites (primarily iron sulfides) are relatively insoluble in a dry environment, they can be dissolved in an aqueous environment under low oxygen conditions. Dissolution of pyrites can release these trace metals such as mercury and arsenic.

If inorganic mercury as a dissolved form (Hg^{2+}) is produced from any type of source, and is present in shallow sediments or surface waters, it can be converted to methylmercury under the appropriate conditions. The mercury can be transformed by sulfate-reducing bacteria to methylmercury in low oxygen environments with sufficient organic matter in sediment porewater or in the anoxic portion of a water column. Acidic conditions promote the dissolution of pyrites and the sulfate reduction process. Examples of suitable aqueous environments for methylation include poorly mixed water bodies and wetlands. For methylation to occur, the mercury compound must first be dissolved, which is a slow process. Dissolution of sulfides is also influenced by the presence of organic acids and dissolved sulfide species. The presence of the mercury sulfide aqueous complex may be significant because it has been hypothesized that it can pass through bacterial cell membrane walls, where it can be methylated (Benoit and others 2001).

Under normal shallow wetland conditions (in the absence of chemical contamination), shallow-water wetlands can be significant producers of methylmercury because their high primary

productivity results in low oxygen conditions in sediment porewater (Tetra Tech 2006). Methylation can also occur in the upper few centimeters of sediment or the water column at the oxic-anoxic interface. In these aqueous environments, both methylation and demethylation processes are occurring at the same time, but the rates differ. Any methylmercury observed is the net of both types of processes. There are both biotic and abiotic demethylation processes, and more types of bacteria that can demethylate mercury than can methylate it (Marvin-DiPasquale and Agee 2003). In the upper 1.5 feet of the water column, methylmercury can be lost by photodegradation (Sellers and others 1996, 2001). Methylmercury can also diffuse into deeper sediment and be lost through burial. A more detailed discussion of mercury processes in sediment and wetlands is provided in the conceptual model of mercury in the San Francisco Bay (Tetra Tech 2006).

Other sources of mercury in soil and sediment include atmospheric deposition, both directly into the sloughs and indirectly onto land, which can then be washed off into the marsh (although minor due to the flat topography) or routed to the storm drain system. Runoff from off-site properties can be discharged into Western Stege Marsh via historical discharges from sanitary sewer and storm drain lines and present day discharges from storm drain lines. Incidental sources of mercury include oils or fuel from streets or parking lots, and sources from other uses of mercury in paint or industrial products (such as mercury manometers or instrumentation) that can enter storm drains.

The shallow wetland conditions that currently exist in Western Stege Marsh are an environment where methylation of mercury may occur. There are multiple historical and present sources of mercury to the marsh. Once the mercury is in the dissolved form, it can be methylated regardless of the original mercury source. UC Berkeley will collect additional sediment and surface water samples in the marsh area using the necessary ultra-clean low-level sampling and analytical methods (EPA Methods 1669/1631) to determine if any methylmercury is present.

2.2.1.2 Arsenic

As previously discussed, arsenic is present in soils and sediment on RFS potentially from the historical placement of pyrite cinders as fill material in the Upland Area, the Transition Area, and Western Stege Marsh; and ambient levels associated with regional soils. Arsenic is commonly associated with iron sulfides, such as those that were used in the production of sulfuric acid at the former Stauffer production areas. In addition, it is found in related sulfide minerals, including arsenopyrite and chalcopyrite. Arsenic can occur as adsorbed species onto clay and iron oxide minerals, a common component in soils. Arsenic is strongly adsorbed by iron and can co-precipitate when ORP conditions change from reducing to oxidizing. Three wood preservatives were used near the former FPL WTL that contained arsenic: ACA, ammoniacal copper zinc arsenate, and CCA. The form of arsenic in these compounds is As(V). Figures 21 through 23 and 39 show the distribution of arsenic in soils and sediments in the Upland Area, Transition Area, and Western Stege marsh areas by depth interval, based on current data. Figure 43 shows the distribution of arsenic in the recently remediated portions of Western Stege Marsh sediments based on 2006 data, and Figure 44 shows the distribution based on 2007 and 2008 data.

Arsenic can occur in aqueous environments as As(III) species under reducing conditions or as As(V) species under oxidizing conditions. As(V) has greater sorption, which is strongest at low pH (Leckie and others 1980). In contrast, adsorption of As(III) is strongest at pH values from 7 to 9 units (Pierce and Moore 1980). The toxicity of the two valence states is different, particularly for biota, but EPA has not set separate toxicity values for humans. Arsenic can volatilize, but temperatures need to be higher than would occur under most natural conditions.

2.2.1.3 Copper

Potential sources of copper at RFS include pyrite cinders, metal residues from former California Cap Company shell manufacturing, urban runoff, and paint disposed of at the former Kaiser Shipyard and Butler Steel Products sites or into Meeker Slough. Figures 24, 25, 26, and 40 show the distribution of copper in soils and sediment in the Upland Area and Marsh Area by depth interval, based on current data. Copper is more toxic to biota and humans, thus ecological criteria have lower concentrations. The comparisons with ecological criteria show that some copper exceedances are present in the marsh sediments (see Tables 16 through 19); however, copper concentrations were less than human health criteria in soils from the Upland Area and Transition Area (see Tables 9 and 11, respectively).

Copper is a trace element in some soil minerals, but is less prevalent in natural background soils than chromium. Copper is not an ORP-sensitive element and can occur as a 1+ or 2+ cation. Cu(I) is the dominant form under relatively reducing conditions, where it can form a strong complex with chloride at pH values between 4.3 and 9 units. Cu(II) is dominant under oxidizing conditions. Given the pH conditions observed in the marsh sediments, the upper sediments are expected to be under oxidizing conditions. Deeper sediments in the sloughs may be under reducing conditions. Copper adsorption onto iron oxides is strongly pH dependent, with a change from none to 100 percent occurring at a pH of 3 to 6 units, depending on the geochemical conditions.

2.2.1.4 Lead

Potential sources of lead on RFS include the disposal of leaded paint at the former Kaiser Shipyard and Butler Steel Products sites or into Meeker Slough, as well as emissions from automobiles, fuels, and potentially as a component of metals used in the manufacture of shells and blasting caps and in leaded paint from California Cap Company buildings. Lead was detected in RFS soils and sediment at a much lower frequency than mercury or arsenic, so detailed figures showing its distribution were not prepared. Some elevated concentrations of lead are found in isolated areas of Upland Area soils (see Table 9), Transition Area soils (see Table 11), and marsh sediments (see Tables 16 through 19).

Lead has three valence states (0, +2, and +4), but the most common valence is +2 under most environmental conditions. Under neutral to acidic conditions, Pb(II) is a cationic species in solution in surface or groundwater. Lead can combine with carbonates under alkaline conditions. Lead is strongly adsorbed by iron and manganese oxides, which are common constituents in soil and sediment; however, the sorption is pH-dependent, with less adsorption under acidic conditions.

2.2.2 Polychlorinated Biphenyls

PCBs are a group of 209 different chlorinated biphenyl molecules (known as congeners). Historically, PCBs were manufactured as oils in different formulations, the most common called Aroclor. The most common analytical method for analyzing materials for PCB concentration is through gas chromatography with results reported as one of eight Aroclor mixtures (1016, 1221, 1232, 1242, 1248, 1254, 1260, and 1262). This often provides information on the source of PCBs since different Aroclors were used in different applications. Analytical methods that identify and quantify specific congeners are increasingly being used because PCB toxicity for biological receptors in particular is different for different congeners. Some Aroclors include other organic compounds such as chlorinated benzenes. Both methods have been used to analyze samples from RFS, although most of sample analyses have quantified Aroclors and not congeners. The most common Aroclors found at the RFS were 1248, 1254, and 1260, which are associated with hydraulic fluids and dielectrical fluids in capacitors and transformers (Lowenbach 2002). Until they were restricted in 1977, other uses of PCBs included heat transfer fluids for gas turbines, hydraulic fluids for vacuum pumps, fire retardants, plasticizers in adhesives, textiles, surface coatings, sealants, printing, and carbonless copy paper (Lloyd and others 1975).

PCBs are strongly adsorbed to soil particles and are not readily leached. PCB migration in the environment is generally associated with the transport of soil particles through surface water runoff or storm drains and subsequent transport of sediments in the aquatic environment. Once in the marsh, PCBs adsorbed to sediments could be moved by tidal action, wind, or waves.

Figures 34, 35, 36, and 42 show the distribution of PCBs in soils and sediments in the Upland Area, Transition Area, and Western Stege Marsh, based on current data. As discussed in previous sections, an area containing high concentrations of PCBs (Area M1a in the western portion of Western Stege Marsh was excavated during the remediation activities performed in 2003). The PCBs in Area M1a likely were deposited decades ago and spread throughout Meeker Slough. PCBs appear more widespread at depths below one foot bgs than in the shallower layer above one foot bgs. PCBs do not appear to be as widespread in the eastern portion of the marsh, but rather occur predominantly along the Meeker Slough corridor (BBL 2005b).

2.2.3 Pesticides

Pesticides detected in RFS sediments are DDT and its breakdown products, DDD and DDE, aldrin, alpha-Chlordane, beta-benzene hexachloride, Dieldrin, Endosulfan, gamma–Chlordane, heptachlor epoxide, and Pebulate (see Figure 33). These pesticides strongly adsorb to soil particles and are not readily leached. Although DDT degrades in the environment to DDD and DDE, it is a slow process, as evidenced by its continued presence even though it is has been banned for nearly 30 years. Banned pesticides are not currently used at RFS. Heptachlor also breaks down to heptachlor epoxide, which is often found in tissue samples. In 2004, five samples were collected for analysis of eight proprietary pesticides formerly produced by Stauffer to evaluate whether these pesticides had impacted Western Stege Marsh. Only one detection of Pebulate was found in the five samples.

2.2.4 Other Organic Compounds

Other organic compounds—including DCE, PCE and TCE and their breakdown products, as well as acetone; toluene; and m and p-xylene—were detected in a few shallow groundwater samples from piezometers and Geoprobe borings advanced along part of the boundary with the former Zeneca site. These compounds are soluble, highly volatile, and readily partition from groundwater into soil gas and then into outdoor or indoor air. These compounds have low sorption capacities, so they may not be retained in soil, particularly if little clay or organic matter is present. Figure 20 shows the locations of the shallow and former deep wells on RFS.

2.3 CONCEPTUAL SITE MODEL FOR SEDIMENT TRANSPORT

This section presents a brief CSM of sediment transport in the Western Stege Marsh. Many persistent chemicals, such as metals and hydrophobic organic compounds, adsorb to clay and silt–sized sediment particles. Therefore, an important and often dominant transport mechanism for these chemicals in the aquatic environment is the movement of sediment particles. If surface sediments are eroded and resuspended in the water column, they can be transported by tidal currents and redeposited in areas of reduced current speeds. Sediments impacted by metals and PCBs are still present in the central and western portions of Western Stege Marsh. Since these chemicals are typically adsorbed to sediments, the evaluation of future marsh management strategies requires knowledge of the sediment transport in the area. Should future site risks prove to be unacceptable, knowledge of sediment transport mechanism will be critical for the evaluation of future remediation strategies.

The goal of the sediment transport CSM is to synthesize all available data, describe the characteristics of the system, and describe inferred transport patterns based on the data. The sediment transport CSM will be refined as more information is developed on the area. It will also be used to identify data gaps and to evaluate remedial options.

2.3.1 Sediment Transport Setting

The RFS is located on the eastern shore of the central San Francisco Bay. Water movement in the central bay is driven by the interaction of the tides, winds, and freshwater flow from seasonal streams. Of primary importance is the tidal forcing. The region experiences mixed semi-diurnal tides, consisting of two different high and low tides per day. The mean tidal range for the region, measured from the Berkeley and Richmond Inner Harbor NOAA tidal stations, is 4.2 feet relative to Mean Lower Low Water (MLLW), with a mean higher high tide of 5.9 feet relative to MLLW. Conomos and Peterson (1977) presented an early summary of the general circulation in the San Francisco Bay. Additional discussions about hydrodynamic conditions in the central San Francisco Bay can be found in Cheng and Gartner (1985) and Walters and others (1985).

Hydrodynamic conditions show strong seasonal differences in San Francisco Bay, which are expected to lead to seasonal differences in sediment transport. During the summer, persistent north-to-northwest winds usually occur, with little to no rainfall. During the winter, frequent

storms (cyclonic low-pressure atmospheric systems) typically transit the region and cause strong, gusty south-to-southeast winds over the San Francisco Bay. These storms often bring substantial rainfall to local land areas, with subsequent runoff into the San Francisco Bay (Cheng and Gartner 1985). Local streams and small creeks that enter San Francisco Bay discharge varying amounts of sediment and fresh water during and after flooding. Winter runoff into the north San Francisco Bay and the delta from the Sacramento and San Joaquin River systems influences water levels and flows in the south San Francisco Bay; however, the exchange of water among the north, central, and south portions of San Francisco Bay and the effects of this exchange on circulation and sediment transport are not well understood (Walters and others 1985).

Four processes primarily act to transport sediments in the RFS region:

- Tidal exchange of sediments through the marsh and sloughs. Tidal exchange is responsible for sediment exchange to and from the central San Francisco Bay. The net flux of sediments depends on conditions in the marsh and sloughs, sediment load in the central San Francisco Bay, and seasonal events.

- Delivery of sediments to the marsh and sloughs by upland runoff, which occurs only during seasonal events.

- Delivery of sediments through sloughs by upland runoff into sloughs.

- Wind and wave activity from the San Francisco Bay. Wind and waves generally mobilize sediments through the San Francisco Bay. The net effect of this mobilization can both deliver sediment from the San Francisco Bay and remove sediment from the shoreline regions.

The interplay of these processes is seasonally dependent, but data are currently unavailable to make any conclusions on the magnitude of each relationship. The net long-term sediment transport patterns in the marsh and sloughs are best identified through monitoring topographic change, which is currently being conducted. Each process may also be individually studied as needed to evaluate its role in the overall transport patterns in the RFS region.

The anthropogenic influences along the shoreline of the RFS region have significantly altered the natural transport patterns. The largest influences were the construction of breakwaters and the former SPRR spur, which have trapped sediments. The excavation and backfill activities as part of remediation have also changed the hydrodynamics and sediment loading in the marsh and sloughs. During these activities, any fill above local mudflat levels would likely result in a net erosion of the filled areas into the surrounding waters. Conversely, any fill below local mudflat levels would likely result in a net deposition of sediments into the low regions. Therefore, these activities can change the balance of the processes described above.

2.3.2 Historical Trends

Historical aerial photographs allow for the qualitative evaluation of long-term historic changes in the RFS region. Appendix C includes aerial photographs of the RFS region from 1953 to 2008. In 1953, breakwaters were constructed and subsequent deposition is visible behind the structures. The Meeker Slough channel is larger than the current configuration, but the marsh areas do not appear as extensive as at present. In 1959, the berm for the former SPRR spur was constructed, dividing the inner and outer marsh. Extensive deposition is seen by 1975 in both the inner and outer marsh because sediment delivery from the San Francisco Bay filled in the lower-energy environment. Although the potential exists for slow change occurring in the marsh, the configuration of both the inner and outer marsh has shown no major change since the 1975 photograph. These observations suggest that the largest geomorphologic changes in slough and marsh configuration ended by approximately 1975. Ongoing surveying will assist in assessing the current rates of change.

2.3.3 Contaminant Transport

Contaminated sediments in the region provide a tracer for tracking the dominant pathways in the region. Two chemicals (mercury and PCBs) that were extensively sampled in 2004 are typically considered hydrophobic—meaning they are strongly adsorbed to sediments. Basic to the transport of hydrophobic chemicals is the slow rate of adsorption and desorption of the chemicals (especially those with high partition coefficients) between sedimentary particles and aggregates and the surrounding water, with equilibration times as long as weeks to years. This slow exchange is especially true for chemicals with large partition coefficients, K_p (liter per kilogram), where K_p is defined as:

$$K_p = \frac{C_s}{C_w} \qquad (2\text{-}1)$$

where

C_s = Concentration of the chemical sorbed on the solids (in mg/kg)

C_w = Concentration of the chemical dissolved in the water (in milligrams per liter)

PCBs typically have a large partition coefficient, meaning the transport of the contaminated sediment particles is the primary transport pathway. Therefore, PCBs provide an ideal tracer for sediment movement.

Figure 41 shows the concentrations of mercury in surficial (depths less than 0.5 foot) sediment in the marsh and slough from all sediment sampling events at the RFS. Figure 42 shows the total PCB concentrations in surficial sediments in the marsh and slough. Any sustained transport pathways can be inferred to occur along the gradient from high to low concentrations. Upland runoff to the marsh and sloughs and subsequent tidal exchange are the most likely sediment transport mechanisms responsible for generating the observed gradients. Tidal action will likely continue to diffuse this pattern.

The concentration patterns for both mercury and PCBs show generally higher concentrations toward the northern upland areas, but distinct areas of high concentrations also are disconnected from the upland area and the high concentrations in surface sediments. The heterogeneity is most likely a result of differences in source locations, strengths, and periods of activity. Since the transport mechanisms outlined have likely changed little since the last major anthropogenic alteration in the region (construction of the railway in 1959), the heterogeneity most likely results from source activity into the system. The heterogeneity additionally illustrates that current sediment transport pathways have not widely dispersed the pockets of contaminated sediments.

Two likely scenarios are as follows:

- If the largest historical sources of PCBs have been effectively controlled, the presence of high concentrations in the surface sediments additionally point toward relatively stable sediments with a low level of offshore transport since the times of source activity.

- If the largest sources of PCBs have not been controlled, the high surficial concentrations could indicate significant transport of contaminated sediments during periodic storm events.

2.4 RECEPTORS AND EXPOSURE PATHWAYS

Both humans and wildlife use the Upland Area, Transition Area, and Western Stege Marsh areas of RFS, and thus may be exposed to chemicals in soils, sediments, groundwater, and surface water. This section describes the types of human and wildlife receptors that may use the RFS, the environmental media they may contact, and the routes by which they may be exposed to the detected chemicals.

2.4.1 Human Receptors and Exposure Pathways

As described in Section 1.3, the chemicals remaining in the Upland Area consist of several metals, including arsenic and mercury, which occur at concentrations exceeding H-SSTLs in surface soils in two areas that are currently planned to be remediated. Elevated concentrations of chemicals in the Transition Area are primarily in subsurface soils, while chemical concentrations exceeding E-SSTLs remain in surface sediments in the marsh. VOCs have been identified in the shallow groundwater at the northeastern portion of the Upland Area along the eastern boundary between RFS and the former Zeneca site.

The primary human receptors that may be exposed to the remaining chemicals at RFS include UC Berkeley researchers and employees, RFS staff, RFS tenants, visitors to the Bay Trail and RFS connector trail, and workers planting and weeding in the marsh. Most workers would be exposed only to surface soils from dust or incidental contact and any potential volatilization from the groundwater. Construction workers performing intrusive activities could be exposed to chemicals present in deeper soils. Visitors are likely to be exposed only to dust emitted from RFS surface soils and incidental contact with surface soils along the Bay Trail. These human exposure pathways are described in more detail in the following subsections.

2.4.1.1 Human Receptors

The RFS is located in the City of Richmond, which has a population of approximately 100,000 (U.S. Census Bureau 2000). Historically, the areas surrounding the RFS to the north, west, and east have been used for chemical and industrial facilities, including the former Zeneca site, the former Kaiser Shipyard, the former Butler Steel Products site, the Bio-Rad Facility, the former PG&E facility, and the former Liquid Gold site. Marina Bay, a mixed residential and commercial development (with a population of approximately 3,300 [U.S. Census Bureau 2000]), is located at the former Kaiser Shipyard and Butler Steel properties and is located west of the RFS. Residential areas are also located to the north, across Interstate 580. The rail spur berm that was constructed on the former SPRR right-of-way that traversed the southern portion of the property was purchased by the East Bay Regional Park District in 1997 and developed into the Bay Trail that serves as a bike and walking trail along the margin of San Francisco Bay. Hoffman Marsh and Point Isabel are located 1.5 miles east of the RFS.

Approximately 300 UC Berkeley researchers and employees work at the RFS (UC Berkeley 2006b). Based on the characterizations of the populations on or near the RFS, the following groups of humans could be exposed to chemicals detected at the RFS:

- On-site UC employees, maintenance workers, construction contractors, researchers, and employees of EPA and other on-site tenants, collectively identified as “on-site workers”
- Nearby residents and workers
- Recreational visitors to the Bay Trail and connector trails

- Anglers (people fishing)
- Workers involved with marsh restoration

2.4.1.2 Exposure Pathways

Exposure pathways describe the link among chemicals detected in the environment, the mechanisms by which chemical transport or migration may occur in the environment, the persons potentially exposed to the chemicals, and the routes (such as ingestion) of chemical exposure. Routes of potential chemical exposure include incidental soil or sediment ingestion; dermal (skin) contact with soils, sediment, or surface water; and inhalation of airborne dusts and vapors. Depending on their location and activities, each group of receptors at or near the RFS may be exposed to chemicals as a result of different exposure pathways. A schematic diagram of potential pathways to human receptors is shown on Figure 50.

On-site workers may go outside and walk around the buildings or other portions of the RFS. On-site workers may also conduct projects or testing outdoors. As a consequence of outside activities, these workers may contact soils, resulting in dermal (skin) contact with chemicals in soils. Direct soil contact could also result in incidental ingestion of chemicals in the soils that may adhere to hands. Under certain conditions, wind erosion of soils could also occur, and as a result, chemicals that adsorb to soils could be emitted to the atmosphere.

As described in Section 1.2, a number of investigations have focused on areas where releases may have occurred in the past and remediation activities have removed most of the contaminated soils. The MFA is also currently covered by the Asphalt Pads B and C, is covered with vegetation, and is fenced. Thus, on-site workers are not likely to be exposed to chemicals in surface soils in the future. Further, UC Berkeley has implemented an interim soil management plan that establishes protocols for addressing soil handling and any suspected soil contamination in the future.

Chemicals with low molecular weight and high vapor pressures, such as VOCs, could migrate in gaseous form through soils from contaminated subsurface soils or from groundwater. Vapors emitted from soils or groundwater outside of buildings could hypothetically be dispersed into the atmosphere as a result of wind transport. However, this transport mechanism for soils is not expected to be significant at RFS because no releases of VOCs have been identified in the Upland Area of RFS and results of VOC samples, although somewhat limited, have not detected this class of compounds in upland soils. Chlorinated hydrocarbons (cis-1,2-DCE; TCE; and PCE) have been identified in groundwater in the northeastern portion of RFS and the adjacent Lot 1 area on the former Zeneca site. In 2006, DTSC required Zeneca and CSV to sample groundwater on the RFS side of the property boundary to further characterize the extent of chemicals detected in groundwater samples collected along the former Zeneca site's western boundary. Based on this information, inhalation of vapors intruding into indoor air at the RFS could be a more likely exposure pathway than outdoor exposures because atmospheric mixing by the wind could disperse vapors potentially emitted from groundwater. Indoor air monitoring conducted by UC Berkeley at Buildings 155, 163, 175, 177, 478 over eight sampling events in

2007 also indicated that indoor VOC concentrations at the RFS are typical of concentrations found in indoor air in office buildings throughout the United States (Tetra Tech 2008f). A few VOCs, apparently released from an old combined sanitary sewer/storm drain, were detected in sediments removed from the boundary between the Transition Area and Western Stege Marsh in 2003. Additionally, areas where mercury remains in soil or sediments are at least partially paved or inundated with water for portions of the day, which would restrict any vapor releases. Further, although mercury vapors were detected in the air during previous site remediation activities, these vapors were not identified as a potential health concern (Contra Costa County Health Services and California Department of Health Services 2006).

In addition to office workers and researchers, on-site workers may be involved with or employed as site maintenance workers. These workers could be involved with landscape or building maintenance, including simple construction in support of research projects. These types of workers may have more opportunity for soil contact (such as incidental soil ingestion, dermal contact with soil, and inhalation of airborne dust or vapors). Construction by these or similar workers could also result in contact with deeper soils and possibly shallow groundwater, resulting in incidental ingestion of subsurface soils, dermal contact with soils and groundwater, inhalation of dusts emitted from subsurface soils, and possibly inhalation of vapors emitted from soils or groundwater, if present. Although this work would be expected to occur for a shorter period, these exposures may be higher than for other on-site workers. RFS on-site maintenance staff received the 40-hour Occupational Safety and Heath Administration Hazardous Waste Operations and Emergency Response training (with annual 8-hour refresher courses) and UC Berkeley has implemented a Job Safety Analysis (JSA) procedure and developed an interim soil management plan to ensure that on-site maintenance workers and contractors follow protocols for safe handling of soil at the RFS. In addition, UC Berkeley developed an on-line training system for all onsite workers to inform them of the history, chemicals of possible concern, prohibitions on digging in soil and impacting sensitive ecological habitats (such as the California Clapper Rail habitat), and general health and safety practices at the RFS.

Currently, two groups of residents live in the general vicinity of the RFS: those on the north side of Interstate 580, and those in the Marina Bay housing development located west of Meeker Slough. However, nearby residents are unlikely to spend much, if any, time on the RFS. As a result, direct soil contact that could result in soil ingestion or dermal contact with chemicals in soil or water is not likely to be a complete exposure pathway for this group of residents. Inhalation of airborne dust may be a complete exposure pathway, although it is likely to be highly limited except during construction activities, which are governed by JSA procedures specifically designed to minimize dust generation. The groundwater at RFS is not used as a source for drinking water, thus it is not a complete pathway.

Workers on the industrial properties north and west of the RFS could be exposed to dust and vapors atmospherically transported from soils and sediment. However, since on-site worker exposures to airborne constituents are likely to be very limited or nonexistent, off-site worker exposures are likely to be even more limited or nonexistent, since atmospheric transport of contaminants typically results in further dispersion and dilution of airborne chemicals.

The Bay Trail is located along the southern border of the inner marsh area on the former railroad bed; the trail crosses over Meeker Slough via a bridge. The trail serves as a boundary between the inner and outer marshes. Another footpath is on the Marina Bay side of Meeker Slough, and benches are found on the northeast side of Marina Bay next to the slough. The public can access the Bay Trail, footpath, and parts of the surrounding marsh. Recreational activities likely to occur in this area include hiking and bird watching by the public or nearby residents. People could be exposed during recreation activities to soil or sediments via incidental ingestion and direct contact with soil or sediment and inhalation of airborne dust. Contact with vapors is thought not likely because VOCs potentially released from groundwater are likely to be dispersed in outdoor air because of atmospheric mixing.

As reported in the ATSDR PHA, children are anecdotally known to play near the bridge and the benches near Meeker Slough. Children are more apt to come in contact with or ingest small quantities of soil and could contact surface water. In addition, adult volunteers have been replanting clean areas of the recently remediated portions of Western Stege Marsh. The 2008 ATSDR PHA for the RFS concluded: (1) past, current and future exposure to metals and PCBs for adults from recreating in the Western Stege Marsh does not pose a public health threat, (2) current exposure to metals and PCBs for adults and children/teenagers from restoring the Western Stege Marsh in areas that have been excavated does not pose a public health hazard, and, (3) current and future exposures to children/teenagers who regularly play in the Western Stege Marsh poses a public health hazard (from exposure to the highest concentrations of metals and PCBs in surface water and/or sediment), although this is based on conservative assumptions and that actual exposures are likely much less.

However as an added precaution, fencing and signage have been placed along the recreational path where the public could potentially access the Western Stege Marsh area. Thus, these actions are likely to have substantially reduced public exposures to chemicals remaining in marsh sediments.

Anglers (people fishing) are potentially a subset of recreational receptors to the same set of exposure pathways as the recreational receptors. Additionally, this group of receptors could be exposed to chemicals that originate in sediments or surface water, accumulate in the food chain, and ultimately get taken up by fish in this portion of the bay margin.

2.4.2 Ecological Receptors and Exposure Pathways

This section summarizes the current information on ecological receptors. For the Upland Area, exposure pathways to biota are limited to the upper few feet of soil. For the marsh, there can be exposure to biota from the near-surface soils up to a depth of about 0.5 to 1 foot bgs, the pickleweed and other plants growing in the marsh, and the tidally influenced surface water in Meeker Slough and the tidal channels within the marsh.

Copper may be a chemical of potential concern for exposure to biota in the Upland Area. In the Marsh Area, several metals (such as arsenic, copper, and mercury) and PCBs remain in surface sediments at concentrations exceeding criteria protective of sediment-dwelling biota. However,

current concentrations of most constituents detected in sediments do not exceed the Tier 2 E-SSTL protective of the endangered California clapper rail, except for copper, mercury, and PCBs in localized areas. Several metals detected in surface water exceed criteria protective of aquatic receptors. These determinations suggest that additional evaluations of sediments and marsh waters should be conducted to determine the extent that the remaining contamination may be transported to other portions of the marsh or the nearby San Francisco Bay and the extent of any additional disturbances of the California clapper rail habitat.

The RFS habitats were surveyed in 2003 (URS 2003a), and additional studies of the RFS habitats have been conducted in select areas of the RFS. The following discussion is based on these sources of field information. A general depiction of some of the habitats at RFS, specifically within the marsh, is shown on Figure 51. The Upland Area is primarily terrestrial grassland, including coastal scrub, native grassland, meadows, and seasonal wetlands. Portions of the native grassland include rare coastal prairie grassland, as described below. Manmade landscaped habitats such as herbaceous groundcover and ornamental trees also are present. An old grove of eucalyptus trees planted by the California Cap Company provides roosting and breeding habitat for tree-nesting raptor species.

Stege Marsh is composed of the tidal marsh areas that extend across the southern portion of the RFS and the adjacent properties. The western portion of the marsh is located in the southern portions of RFS. Western Stege Marsh consists of approximately 9 acres of tidal waters, including Meeker Slough, mudflats, and tidal wetlands.

The WSMRP was established by UC Berkeley in September 2002, to implement a cleanup and restoration plan for contaminated areas of the RFS and the Western Stege Marsh. UC Berkeley's goal for the area is to clean up, enhance, and restore the shoreline and habitat in the marsh without compromising the current ecological conditions. Although many anthropogenic activities are harmful, some of these activities can create habitat, as is demonstrated by the success of the Bay Trail. This trail is located on top of a berm that was once part of the SPRR spur built around 1959. The addition of this berm changed the tidal mudflats into a muted tidal marsh, which is currently inhabited by native cordgrass (*Spartina foliosa*), pickleweed (*Salicornia virginica*), and other salt marsh species. These plants provide habitat for endangered species such as the California clapper rail (*Rallus longirostris obsoletus)*.

2.4.2.1 Upland Habitat

Native grasslands at the RFS include areas dominated by any of the native grass species, including California oatgrass (*Danthonia californica*), bunchgrass (*Poaceae*), saline/alkaline grass species, purple needlegrass (*Nassella pulchra*), or saltgrass (*Distichlis spicata*). All of these grassland types are considered rare in the state of California and may have special status classification at a county or state level, although none are listed as species of special concern or as threatened or endangered at the state or federal level (California Department of Fish and Game [CDFG] 2006a).

California native grasslands are a rarity of the coastal prairie ecosystem, but they have not always been fully recognized. One difficulty facing the recognition of the rarity of grasslands is the definition of true "coastal prairie." Most natural "grassland" in California historically consisted of many annual and perennial forb species ("wildflowers") growing in association with relatively few native grass species. The coastal prairie grassland at the RFS is collocated with the Geosciences Well Field (see Figure 5). The upland habitat includes over 6 acres of coastal prairie, containing a rich assortment of native grasses and forbs, including a very rare patch of slender wheatgrass (*Elymus trachycaulus*). These resources have been identified as areas of Unique Restoration Opportunities in the Baylands Ecosystem Habitat Goals Report (http://www.sfei.org/sfbaygoals/docs/goals1999/outline.html) completed through the Wetlands Ecosystems Goals Project.

California oatgrass has been identified throughout the RFS and has benefited from the routine mowing of competing non-native invasive species, including Harding grass (*Phalaris aquatica*) and Coyote brush (*Baccharis pilularis*), that typically suppress oatgrass populations. Purple needlegrass occurs at the RFS in several areas adjacent to or within other grasslands. This is a remnant of the original coastal terrace prairie habitat and promotes soil stability with its deep-reaching roots. Other grasses include rat's tail fescue (*Vulpia myuros*), six-week fescue (*Vulpia bromoides*), and silver European hair grass (*Aira caryophyllea*). Ripgut brome (*Bromus diandrus*), soft chess (*bromus hordeaceus*), and foxtail chess (*Bromus madritensis*) are non-native species commonly observed on disturbed sites and are commonly known as ruderal grasses.

Non-native grasslands areas of the RFS are dominated by either introduced annual or perennial grasses. Introduced Perennial Grassland is typically up to three feet high and occurs throughout the RFS, although this vegetation type is routinely mowed. Both native and non-native herbaceous species occur in the grassland and include soft chess (*Bromus hordeaceus*), velvet grass (*Holcus lanatus*), tall-oatgrass (*Arrhenatherum elatius*), dogtail (*Cynosorus crtistatus*), dandelion (*Taraxacum officinale*), and vernal grass (*Anthoxanthum odoratum*). Associated species include creeping bent grass (*Agrostis stolonifera*), hareleaf (*Lagophylla glandulosa*), orchard grass (*Dactylis glomerata*), Harding grass (*Phalaris aquatica*), California brome (*Bromus carinatus*), California oatgrass (*Danthonia californica*), hairy oatgrass (*Danthonia pilosa*), tufted hairgrass (*Deschampsia cespitosa*), blue wildrye (*Elymus glaucus*), red fescue (*Festuca rubra*), green fescue (*Festuca viridula*), Kentucky bluegrass (*Poa pratensis*), and one-sided bluegrass (*Poa secunda*). Other plants that have been observed in this habitat are bristly oxtongue (*Picris echioides*), English plantain (*Plantago lanceolata*), curly dock (*Rumex crispus*), Italian ryegrass (*Lolium multiflorum*), and meadow barley (*Hordeum brachyantherum*).

The inland portion of the RFS is mainly terrestrial with some seasonal wetlands and contains manmade landscape habitats. These areas consist of exotic herbaceous groundcover and ornamental trees used in landscaping around the buildings. The plants used as groundcover are invasive and are out-competing the native coastal plants. These plants include iceplant (*Carpobrotus* spp.), Algerian ivy (*Hedera canariensis*), firethorn (*Pyracantha* spp.), and cotoneaster (*Cotoneaster* spp.). The landscape plants Asian jasmine

(*Trachelospernum jasminoides*), lily-of-the-Nile (*Agapanthus africanus*), sea lavender (*Limonium perezii*), and sea thrift (*Armeria maritime*) are also exotic, but have not extended beyond the regions where they were planted. Several groves of blue-gum eucalyptus trees (*Eucalyptus globulus*) are present on RFS, as well as plantings of the native California wax-myrtle (*Myrica californica*).

Coastal scrub and mixed ruderal scrub, occurs in the Transition Area, as well as in small patches to the southwest of the EPA Laboratory. Most of the coastal scrub habitat in the Transition Area is disturbed and intermixed with non-native invasive grasses and forbes. In 2003, the habitat type was dominated by coyote brush (*Baccharis piluaris*) and fennel (*Foeniculum vulgare*), but was also associated with pampas grass (*Cortaderia selloana*), Scotch broom (*Cytisus scoparius*), toyon (*Heteromeles arbutifolia*), cotoneaster (*Cotoneaster* spp.), meadow barley (*Hordeum brachyantherum*), wild radish (*Raphanus sativus*), Italian thistle (*Carduus pycnocephalus*), wild oats (*Avena* sp.), ripgut brome (*Bromus diandrus*), and poison oak (*Toxicodendron diversilobum*) (URS 2003a). As described below, much of the non-native species are being actively removed.

2.4.2.2 Marsh Habitats

Marsh at the RFS includes salt marshes and upland seasonal wetland in meadow areas not dominated by grasses, including drainage ditches and shallow depressions that have characteristics of wetland soil and vegetation. Wetland vegetation includes salt grass, sedges and sedge vegetation alliance species, and rush riparian grassland, which consists of rushes and rush riparian alliance species. Saltgrass occurs in the Western Stege Marsh and along Meeker Slough. Rare associations with this habitat type include Jumea-Saltgrass (*Jaumea carnosa-Distichlis spicata*), Saltgrass-Alkali Heath-Jumea (*Distichlis spicata-Frankenia salina-Jaumea carnosa*), and Alkali Saltgrass (*Distichlis spicata*).

Tidal wetlands in the San Francisco Bay are considered natural resources of local, state, and federal concern, and thus constitute a sensitive natural community. The tidal wetland at the RFS was artificially created by grading and by breakwaters for the railroad, evident now as a ridge of high ground. However, colonization by marsh grasses described above has created marsh grass habitat. Since 2005, active planting has occurred at the WSMRP site in both the Marsh and Upland Areas. Results of marsh restoration activities are provided in annual marsh monitoring reports required by the Western Stege Marsh Restoration Monitoring Plan (BBL 2004c).

The coastal marsh habitat along Meeker Slough is dominated by cordgrass (*Spartina* spp.) and pickleweed (*Salicornia virginica*), while the eastern third of the RFS is dominated by salt grass (*Distichlis spicata*) and alkali bulrush (*Scirpus robustus*). Pacific cordgrass (*Spartina foliosa*) is a native, rare and uncommon marsh grass frequently displaced by the colonization of the non-native smooth cordgrass (*Spartina alterniflora*). DNA testing of the cordgrass at the RFS has confirmed that most of the population consists of the native species, while a hybrid between the native and non-native was found along the bayfront. The hybrid plant and the adjacent non-native individuals pose a severe threat to the natural revegetation patterns for the native plant,

which occupies a more restricted range of marsh sediments, produces 3 to 10 times less pollen than the hybrid, and thus develops fewer non-hybrid plants (Grijalv 2004).

2.4.2.3 Ecological Receptors

Upland Receptors

Native and non-native plants persist in all of the habitats present throughout the RFS and provide ample roosting and foraging habitat for many species. Many special-status plant and animal species are both desired and present on the RFS and special attention is paid to their status. Plants species that may be of concern at RFS are the fragrant fritillary (*Fritillaria liliacea*), Loma Prieta hoita (*Hoita strobilina*), western leatherwood (*Dirca occidentalis*), robust monardella (*Monardella villosa* ssp. *globosa*), pallid manzanita (*Arctostaphylos pallida*), bent-flowered fiddleneck (*Amsinckia lunaris*), and the coastal bluff morning glory (*Calystegia purpurata* ssp. *saxicola*). These species were identified as species of concern present in the Richmond area by the California Natural Diversity Database (CNDDB), provided in Table 23 (CDFG 2006a).

Terrestrial invertebrate communities in soil consist of isopods, worms, arachnids, centipedes and millipedes, and insects. Members of the invertebrate community in soil support key functions in ecosystems and are predominant in the shrub canopy, soil surface, and subsurface regions. For example, soil invertebrates are predators, scavengers, detritivores, pollinators, and a source of food for insectivorous wildlife. Invertebrates in soil play an important role in below-ground food webs that may extend several feet below the soil surface. These subsurface invertebrates serve as important detritus consumers and as regulators of decomposition and nutrient cycling.

The RFS provides important habitat for the migratory monarch butterfly (*Danaus plexippus*), and may provide potential habitat for the Callippe silverspot butterfly (*Speyeria callippe callippe*). The Callippe silverspot butterfly is considered important based on its association with the California golden violet (*Viola pedunculata*), which has not been reported on RFS but has the potential to occur. Finally, Lee's micro-blind harvestman (*Microcina leei*) was identified by the CNDDB as a species of concern present in the area. However, no surveys have been conducted to evaluate the likelihood of its presence (CDFG 2006a; URS 2003a).

Many species of terrestrial reptiles, birds, and mammals are likely to use both the Upland Area and marsh for foraging. Reptiles would be expected to forage throughout the RFS on plants, invertebrates, small mammals, and other reptiles. Snake species that may be found throughout the grasslands and eucalyptus groves include the common garter snake (*Thamnophis sirtalis*), western terrestrial garter snake (*Thamnophis elegans)*, gopher snake (*Pituophis catenifer*), and California striped racer (*Masticophis lateralis lateralis).* Lizard species may include alligator lizard (*Elgaria* sp.), western fence lizard (*Sceloporus occidentalis*), coast horned lizard (*Phrynosoma coronatum blainvillii*), and the western skink (*Eumeces skiltonianus*) (CDFG 2006b). Amphibians may be expected to use the freshwater inlets to the marsh, including California newt (*Taricha torosa*), western spadefoot toad (*Spea hammondii*), bullfrog (*Rana catesbeiana*), Pacific treefrog (*Pseudacris regilla*), and Western pond turtle (*Emys marmorata*) (CDFG 2006a, 2006b).

Many species of herbivorous, insectivorous, and carnivorous birds are likely to be found foraging and nesting on RFS. Common passerine birds, including sparrows, loggerhead shrike (*Lanius ludovicianus*), dark-eyed junco (*Junco hyemalis*), and barn swallow (*Hirundo rustica*), would be expected to forage on plants and invertebrates at the Upland Area and marsh (CDFG 2006a, 2006b). Red-winged blackbirds (*Agelaius phoeniceus*) and yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) are common residents near marshes and forage extensively on insects. Raptor species are also found, including common species such as the red-tailed hawk (*Buteo jamaicensis*), other hawk species, northern harrier (*Circus cyaneus*), barn owl (*Tyto alba*), and possibly the white-tailed kite (*Elanus leucurus*). In February 2007, an amateur bird species survey was conducted by the East Bay Birders. This list of species is included in Table 24.

Terrestrial mammals are likely to forage on plants, insects, and small mammals at the inland terrestrial site, and larger mammals may extend to the marsh to also feed on aquatic macroinvertebrates, amphibians, and fish. The omnivorous California ground squirrel (*Spermophilus beecheyi)* is most likely a common and abundant mammalian resident. Herbivorous mammals that may be present include the California vole (*Microtus californicus*), western harvest mouse (*Reithrodontomys megalotis*), house mouse (*Mus musculus*), San Pablo vole (*Microtus californicus sanpabloensis*), cottontail, jackrabbit, and salt marsh harvest mouse (*Reithrodontomys raviventris*). Possible insectivore receptors include shrews (such as the state species of special concern salt marsh wandering shrew, *Sorex vagrans halicoetes*) and bats, such as the pallid bat (*Antrozous pallidus*) and the big free-tailed bat (*Nyctinomops macrotis*) (CDFG 2006a, 2006b). Carnivorous mammal species that may be present include coyote (*Canis latrans*), red fox, kit fox, raccoons, and skunks.

In February 2007, a burrowing owl (*Athena funicular*) was sighted in the vicinity of the RFS. The burrowing owl is a California species of special concern, but is not currently protected under either the State or Federal Endangered Species Acts. The burrowing owl is a small terrestrial owl of open prairie and flat dry grassland habitats where tree and shrub canopies provide less than 30 percent cover, and is the only owl that routinely lives and nests underground, taking over burrows dug by animals such as ground squirrels (*Spermophilus spp).* Burrowing owls are colonially nesting raptors, and colony size is indicative of habitat quality. Although suitable habitat is not present within the marsh, and owls have not been indirectly (pellets, feathers, white wash) or directly (sighting) observed on RFS, it is not uncommon to find burrowing owls in developed and cultivated areas where California ground squirrel populations are active. Therefore, a potential exists for burrowing owls to occur in the upland habitat at RFS.

Aquatic and Marsh Ecological Receptors

Many of the invertebrates, reptiles, birds, and mammals discussed above would be expected to visit and forage at the Marsh when the tide is low. In particular, the red-winged blackbird (*Agelaius phoeniceus*), yellow-headed blackbird (*Xanthocephalus xanthocephalus*), hawk species (*Falconiformes spp.*), bats (*Microchiroptera spp.*), coyote (*Canis latrans*), fox (*Vulpine spp.*), raccoon (*Procom lotor*), and skunks (*Mephitidae spp.*) are associated with habitats adjacent to the wetland areas. Two listed species of predatory birds—the bald eagle

(*Haliaecetus leucocephalus*) and the American peregrine falcon (*Falco peregrinus anatum*)—have a potential to occur at the RFS. Although it is unlikely given the degree of human activity at RFS that either of these tree-nesting raptors would nest in the eucalyptus trees at RFS, they would be expected to use them for roosting. In December 2006, peregrine falcons were observed passing over the RFS and have been observed roosting at the nearby Point Isabel radio towers. Additionally, the salt marsh harvest mouse depends on pickleweed grassland, a type of marsh vegetation. Additional groups of ecological receptors are found at marshes and wetlands exclusively. These ecological receptors include aquatic and benthic invertebrates, fish, and probing shorebirds. The CNDDB (CDFG 2006a) was queried for the Richmond area and the results, including species identified as species of concern, are provided in Table 23.

Invertebrates are found in the inundated marsh channels, within the sediment layer and attached to rocks, debris, or vegetation. These organisms feed on detritus or other sediment-dwelling organisms and are an essential prey for birds and mammals associated with aquatic environments. Small invertebrates expected in this habitat include nematodes, polychaetes, and amphipods. Other arthropods, including isopods such as *Sharma quoin*, yellow shore crab (*Hemigrapsus oregonensis*), Baltic clam (*Macoma balthica*), softshell clam (*Mya arenaria*), and the ribbed mussel (*modiolus demissum*), are expected. Fish species that may make up this taxon group are likely to vary seasonally, and include mosquitofish, anchovies, topsmelt (*Atherinops affinis*), arrow goby (*Clevelandis ios*), yellowfin goby (*Acanthogobius flavimanus*), juvenile starry flounder (*Platichtys stellatus*), and Pacific staghorn sculpin (*Leptocottus armatus*).

Birds found foraging and nesting within the marsh and mudflat possess specialized characteristics for optimal foraging by probing or sweeping while they wade through fluctuating tidal waters. Aquatic birds typical of the landscape include snowy egret (*Egretta thula*), black-crowned night heron (*Nycticorax nycticorax*), great blue heron (*Ardea herodias*), long-billed curlew (*Numenius americanus*), lesser scaup (*Aythya affinis*), and Caspian tern (*Sterna caspia*). Three subspecies of salt marsh song sparrow are also possible residents: the Alameda song sparrow (*Melospiza melodia pusillula*), San Pablo song sparrow (*M. m. sameulis*), and Suisun song sparrow (*M. m. maxillaries*). Gulls, teals, ducks, and geese also may occur on the RFS throughout the year. In February 2007, an amateur bird species survey was conducted by the East Bay Birders. This list of species is included in Table 24.

Populations of the endangered California clapper rail (*Rallus longirostris obsoletus*) are restricted to San Francisco Bay estuaries and marshes. They are known to reside year-round at the RFS and breed from February to late August, using both the Marsh and Upland Area for nesting sites and cover. Clapper rails were observed on RFS during protocol-level surveys conducted in February and March 2003 (URS 2003a). Clapper rails were also observed on RFS during nonprotocol-level surveys conducted in 2006. The California black rail (*Laterallus jamaicensis coturniculus*) is an endangered rail that also occurs in tidal and brackish marshes bordering San Francisco Bay and is often associated with pickleweed. Although this species has the potential to occur at RFS, it has not been recorded and was not found during the 2003 surveys. Other listed species that have the potential to occur, but have not been sighted in the area, are the California least tern and the bank swallow.

The salt marsh harvest mouse is a California state and federally endangered species, which is endemic to the San Francisco Bay and tributaries. It is found almost exclusively in pickleweed (*Salicornia virginica*) salt marsh habitat, which was present at the RFS during the Year 2 monitoring event. Small mammal trapping was conducted at RFS in 1976 and 1990; however, no salt marsh harvest mice were found (Shellhammer 2001, as reported in URS 2003a). Findings from the CNDDB indicated that populations of salt marsh harvest mouse exist in the San Pablo Creek marsh, 5 miles northwest of the RFS, and at the Giant Marsh at Point Pinole Regional Park, 6 miles north of the RFS. These areas include large stretches of undisturbed and undeveloped salt marsh habitats. Protocol-level surveys have not been conducted specifically for the salt marsh harvest mouse at the RFS. However, since pickleweed salt marsh may be restored at the RFS in the future, salt marsh harvest mice may succeed if reintroduced to the area.

2.4.2.4 Potential Exposure Pathways

Potential exposure pathways describe the link among chemicals detected in the environment, the mechanisms by which chemical transport or migration may occur in the environment, the ecological receptors potentially exposed to the chemicals, and the routes (for example, ingestion) of chemical exposure. Routes of potential chemical exposure include uptake into plants and prey species; ingestion of prey items; incidental ingestion of soil, water, or sediment; dermal (skin) contact with soils, sediment, or surface water; and inhalation of airborne dusts and vapors. Depending on their location and activities, each group of ecological receptors that resides or forages at RFS may be exposed to chemicals as a result of different exposure pathways. A schematic diagram of the primary pathways is shown on Figure 52.

All groups of ecological receptors may be potentially exposed to chemicals at RFS through interaction in the food web or with contaminated media. Plants are exposed to chemicals by root uptake of soil, sediment, or surface water. Shrubs and trees can extend roots down several feet to reach deeper soil and shallow groundwater if present, while grasses are typically limited to only shallow (less than 1 foot) rooting depths. Aquatic and benthic invertebrates can take up chemicals in sediment and surface water by osmosis and ingestion of detritus, sediment, or prey; and soil invertebrates take up chemicals in soil by similar mechanisms.

Fish are exposed to chemicals in water by osmosis and ingestion of prey. Chemicals internalized by these lower trophic-level consumers may bioaccumulate, presenting chemicals to the higher trophic-level organisms that feed on the plants, invertebrates, and fish. Shorebirds ingest aquatic and benthic invertebrates and fish, as well as significant amounts of incidental sediment and water as a result of their feeding strategies (probing and sweeping). Herbivorous birds and mammals are exposed to chemicals in plant matter and incidental ingestion of soil via dust and dirt on the plant surface and through cleaning and grooming. Likewise, insectivorous and carnivorous birds and mammals are exposed via ingestion of invertebrate and small mammal tissues and incidental soil ingestion. Herbivorous birds and mammals, insectivorous birds and mammals, and carnivorous mammals are also expected to drink some amount of surface water, presenting another pathway of potential chemical exposure. Carnivorous birds typically obtain their moisture requirements from prey items and are not expected to ingest surface water directly.

3.0 DATA GAPS FOR RICHMOND FIELD STATION

UC Berkeley has completed extensive investigations to assess the nature and extent of chemicals present at the RFS and has completed three phases of remediation and one TCRA to remove contamination found in the Upland Area and the eastern portions of the Transition Area and Western Stege Marsh (see Figure 18).

In 2006, DTSC required additional characterization of chemicals in the shallow and intermediate groundwater zones along the property boundary between RFS and the former Zeneca site. Chlorinated hydrocarbons (cis-1,2-DCE, PCE, and TCE) have been detected in groundwater along the eastern property boundary with the former Zeneca site. Respondents to DTSC Order No. IS/E-RAO 06/07-005 are continuing that investigation under DTSC's oversight to better understand groundwater flow directions and further characterize VOC concentrations along the eastern RFS property boundary.

The following areas of the RFS are identified as data gaps needing additional characterization. UC Berkeley will develop a field sampling workplan that will present recommended investigations, including soil, soil gas, and groundwater sampling, to assess the potential for contamination in these areas. The sampling strategy and data quality objectives for all areas and media will be developed in concurrence with DTSC. For many of the data gaps, there is no evidence from any source that spills occurred in these areas, however, because there chemicals were used or stored in these areas, UC Berkeley proposes further investigation. UC Berkeley plans to use various sampling or screening methods to evaluate the need for further investigation.

- **Groundwater.** Additional characterization of groundwater is needed at the RFS. This includes collecting general hydrogeologic information (groundwater elevations and lithology) to generate a hydrogeologic model and groundwater quality data (chemical concentrations, total dissolved solids concentrations, metals bioavailability data, etc.). Additional characterization is needed to adequately characterize soil and groundwater contamination in the following areas:
    - Building 478 where shallow-zone groundwater containing VOCs have been identified in the vicinity of the nearby Campus Bay Site Lot 1 removal action performed in the summer of 2008.
    - WTA, including the southern portion of the Western Storm Drain line where metals (cadmium, copper, mercury, nickel, and zinc) and PCBs may be present at elevated concentrations.
    - Shallow, Intermediate, and Deep Groundwater Zones along the RFS/Former Zeneca site property boundary that is between the southern portion of the Building 478 area and the southern end of the slurry wall where metals, pesticides, and VOCs have been identified in groundwater.

- The Biologically Active Permeable Barrier wall. The effectiveness of the portion of the BAPB wall located on the RFS property has yet to be assessed and additional information is needed to characterize the shallow and intermediate zone's groundwater quality in the vicinity of the wall.

- Shallow, Intermediate, and Deep Groundwater Zones in various areas across RFS. Additional investigation is needed to adequately characterize intermediate and deep groundwater zones in various areas across the RFS.

- **Sanitary Sewer Lines.** The historical and existing sanitary sewer lines may have possibly served as preferential pathways for contaminant transport at RFS and will be further investigated.

- **Bulb Area (WTA).** Anecdotal information suggests disposal of miscellaneous debris may have occurred in this area. A follow-up magnetic survey performed by DTSC's Geologic Services Unit located a magnetic anomaly indicating the potential presence of buried ferrous metal that DTSC stated "warrants further investigation".

- **Research Facilities.** Many current and historic research facilities used or stored hazardous chemicals. Although there are no indications from any other sources that spills have occurred in most of these areas, there has been limited or no samples collected in these areas. These areas include: the earthquake engineering facilities at Buildings 420 and 421, Buildings 102, 110, 111, 112, 113, 114, 117, 118, 121, 125, 138, 150, 151, 158, 175, 177, 197, 278, 280A, 280B, 450, 460, 470, 474, 478, 480, and 482. There have been reported spills in the vicinity of Building 120 and the RFS Corporation Yard; however, there is no site-specific data available in these two areas.

- **Above Ground Storage Tanks (AST).** The ASTs are in good condition and there have been no reports of releases from the ASTs; however, there is no site-specific data available in the vicinity of the tanks.

- **Engineering Geosciences Well Field.** The Geosciences Well Field was installed in the 1980s and has been used and continues to be used primarily for research on borehole-to-surface electrical resistivity monitoring to accurately map subsurface ground water flow. No site-specific characterization data is available for these wells.

- **Former PCB-containing Transformers Areas (including temporary storage in Building 280B):** There are currently no PCB-containing transformers at the RFS. All former PCB-containing transformers have been removed, and there are no records to indicate that there were any spills or releases in any of the former transformer areas; however, no site-specific characterization data is available for Building 280B or the former transformer areas.

- **Former California Cap Company Test Pit and Dry House.** These two areas were identified as areas where explosions may have occurred during California Cap Company operations. No site-specific characterization data for explosive residues is available for these areas.

- **Former California Cap Company Tram Line.** The tram line's construction, use, how it was maintained, or if historical releases occurred along the various tram lines is not known. No site-specific characterization data exists along several sections of the former tram line.

- **U.S. Briquette Company and Pacific Cartridge Company.** These companies have been identified on historical Sanborn maps from 1912 and 1916 as operating on the property when it was owned by the California Cap Company. No site-specific characterization data exists in the areas these companies reportedly operated.

- **Western Stege Marsh.** Further information is needed to determine if the contaminant concentrations in sediments in the marsh pose a significant risk to human and ecological receptors.

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TABLES

Table 1 Historical and Current Uses of Buildings

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

UCB Building Number	Former Use	Current Use	Decade Built
38	Research facility	Research facility	1990s
100	Dr. O'Brien's Office (Sanitary Engineering)	No longer on site	pre-1940
102	Historic building used for Sanitary Engineering Research; used during operation of the Cap Company, but originally a grain warehouse for Vallejo Ranch	Bioengineering Offices, wet chemistry laboratory, and research facility	pre-1940
103	Support	No longer on site	pre-1940
105	Sanitary Engineering (storage and support)	Support and storage	pre-1940
106	Pilot plant for sewage treatment	No longer on site	pre-1940
110	Sanitary Engineering; part of mercury fulminating plant during Cap Company ownership	Offices	pre-1940
111	Hazardous material storage for Sanitary Engineering and Environmental Health Research Laboratory (SEEHRL)	Support/storage	1980s
112	Sanitary Engineering Research facility	Bioengineering Offices and	1960s
113	Sanitary Engineering (storage and support)	Support/storage	1980s
114	Storage	Hazardous chemical storage	pre-1940
116	Support/storage	Support/storage	1950s
117	Maintenance shop	Support/storage	unknown
118	Fire test research area/Boiler Building from the Cap Company/maintenance shop	Research facility	pre-1940
120	Solvent Storage shed	Support/storage	unknown
121	Storage of grounds maintenance equipment	Support	1950s
125	Composting project for UC, part of the mercury fulminating plant for the Cap Company	Research facility	pre-1940
126	Storage	No longer on site	unknown
127	Sanitary Engineering facility	No longer on site	pre-1940
128	Recycling project and sorting garbage; former Cap Company building, with thick walls to limit explosion damage	Research facility	pre-1940
129	Water technology research	No longer on site	pre-1940
131	Storage and support	No longer on site	pre-1940
138	Hazardous chemical storage	No longer on site	unknown
149	Water technology research	Research facility	unknown
150	Petroleum studies, machine shop for SEEHRL, laboratory for UC San Francisco	Art Practice facility	pre-1940
151	Solar research facility (materials lab)	Research facility	1960s
152	Salt water research, storage	Research facility	pre-1940
153	Salt water research, modeling shop	Research facility	pre-1940
154	Research facility for space station work and evaluating sewage systems; also used to evaluate robotics and anti-irritants for flies and mosquitoes	Research facility	1960s
155	Solar research facility	Research facility	pre-1940
158	Space station work; evaluating sewage systems	Research facility	pre-1940

Table 1 Historical and Current Uses of Buildings (Continued)
Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

UCB Building Number	Former Use	Current Use	Decade Built
159	Offices	Water resource offices	pre-1940
160	Support and storage	Gymnasium	pre-1940
161	Educational training for lead and asbestos abatement; photographic laboratory	Educational Training	pre-1940
162	Restrooms	Restrooms	1950s
163	Support	Ergonomics	pre-1940
164	Helicopter program	Research facility	pre-1940
165	Offices	Offices and Ergonomic	pre-1940
167	Air horn building used for sound research	Garage	1960s
175	Shop and Administration; hazardous chemical storage	Shop and Administration	pre-1940
176	Storage	Storage	pre-1940
177	Offices	Offices	pre-1940
178	Research facility	Research facility	pre-1940
179	Offices	Offices	pre-1940
180	Offices and photo work	Offices	pre-1940
185	Support	Support	pre-1940
190	Security building, homes and offices	Offices	pre-1940
194	Receiving	Receiving	1950s
195	Storage	Storage	unknown
196	Homes and offices	Offices	pre-1940
197	Support	Support	unknown
198	Rock storage	Rock storage	1980s
200	Naval Architecture and Offshore Engineering	No longer on site	after 1950
201	NA; building built in 1990	EPA Laboratory	1990s
275	Naval architecture and research towing tank	Offices	1960s
276	Seawater project and research towing tank	Research facility	1960s
277	Water tanks	Water tank	1960s
278	Storage for hydraulic and coastal Engineering Department	No longer on site	1960s
280	Road surface test building and storage	Road surface test building and storage	Unknown
300	Electromagnetic instruments	Electromagnetic instruments	1970s
400	Library facility	Library facility	1970s, with additions in 1990s and 2005
420	Shaker table for earthquake studies	Shaker table for earthquake studies	1960s
421	Pump shed	Pump shed	1960s
445	Conference rooms	Conference rooms	1960s
450	Transportation studies and machine shop	Research facility	1950s
451	Earthquake research and offices	Offices	1950s
452	Earthquake research and offices	Offices	1950s
453	Earthquake research and offices	Offices	1950s
454	Earthquake research and offices	Offices	1960s
460	Crash Laboratory and chemical storage nearby	Vehicle housing for California	1950s

Table 1 Historical and Current Uses of Buildings (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

UCB Building Number	Former Use	Current Use	Decade Built
470	Forest Products Laboratory furnace	In transition; Forest Products Laboratory is vacating	1950s
471	Forest Products Laboratory	In transition; Forest Products Laboratory is vacating	1950s
472	Forest Products Laboratory, adjacent to chemical use area; spills have occurred here	In transition; Forest Products Laboratory is vacating	1950s
473	Forest Products Laboratory	In transition; Forest Products Laboratory is vacating	1950s
474	Forest Products Laboratory	No longer on site	1950s
475	Forest Products Laboratory	In transition; Forest Products Laboratory is vacating	pre-1940
476	Forest Products Laboratory	No longer on site	pre-1940
478	Forest Products Laboratory, including a wet laboratory, steam kiln, and chemical storage	In transition; Forest Products Laboratory is vacating	1950s
480	Forest Products Laboratory	No longer on site	1950s
482	Pavement research center	Research facility	Unknown
484	Structural test facility, included a wet chemical laboratory	Research facility	1960s
486	Forest Products Laboratory	In transition	1960s
487	Forest Products Laboratory	In transition	1960s
488	Forest Products Laboratory	In transition	Unknown
490	Support and storage	Support and storage	Unknown
1901	Storage	Storage	Unknown

Notes:

EPA U.S. Environmental Protection Agency
NA Not available
UC University of California
UCB University of California, Berkeley

Table 2 California Cap Company Building Numbers and Historical Uses

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Former Building Number	Overlaps with UCB Building Number	California Cap Company Building Use
1		Combination press house
2a	128	China press house
2b		Unknown
3a	128	China press house
3b		Storage
4a		Cap storage
4b	128	Press House
5		Fulminate Storage
6		Top powder weighing house
7		Top powder storage
8		Chinese formations office
9		W.C.
10		Cap packing house
11		Fulminate dryer
12		Fulminate dryer heater tank house
13		Laboratory
14		Sift house
15		Sift house
15a	194	Gasoline pump
16		Incorporating house motor
17		Incorporating house beach
18		Chlorate storage
19		Top composition air dryer
20		Composition air dryer
21		Composition storage house
22		Whale lance house
23		Fulminate rinse and storage
23a		Fulminate rinse and storage
24		Alcohol Warehouse
25		Nitric acid carbon plate
27A	110	New pulvis house
29		Lumber shed
30	102	Can factory
31		Paint
32		Wagon shed
33		Chlorate storage
34	112	Laboratory magazine
35		Storage
36		Storage
38	38	Fuze Packing
39		Transformer house
40	112	W.C.
41	159	Delay Second Pour Building
42	160	Delay Packing Building

Table 2 California Cap Company Building Numbers and Historical Uses (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Former Building Number	Overlaps with UCB Building Number	California Cap Company Building Use
43		Tanks
44	180	Electric fuse packing house
45	113	Change room
46		Tanks on tresle and waste acid tanks on ground
47	164	Fuze Assembly
48	165	Fuze Packing
49		Boiler house/ Plumbing and machine shop
50		Oil tank on ground
51		Oil tank on ground
52		Sugar dryer
53	128	Tin box storage
54		Sift house
55		Cap dry house
56		Cap dry house
57		Cap dry house
58		Cap dry house
59	152	Box shook and carpenter house
60	152	Packing house
61		60,000 gallon water tank
64	155	Water proofing
65		Research laboratory
66	150	Insulating/ Wire Saturating
66a	150	Wire Insulating
66 1/2		Compound mixing building
67	155	Assembling
71	112	Technical department dry house
72	177	Electric fuse plant
73	176	Warehouse
75	175	Annealing room
76	175	Copper recovering furnace room
77	38, 162	Locker Room
78		17,000 gallon water tank
79		Distillate tank in ground
80		Bl. Sm.
81	114	Warehouse
82		Warehouse
83		Warehouse
84		Wire burning house
85	180	Wire cutting
86	161	Match head storage
87		Incorporating house
88a		Fuze Magazine
88b		Electric fuse magazine

Table 2 California Cap Company Building Numbers and Historical Uses (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Former Building Number	Overlaps with UCB Building Number	California Cap Company Building Use
89	154	Hydraulic press house
90		China press house
91		Hydraulic press house
92		Delay Assembling Building
92a		Hydraulic press house
93		Tin box storage
94		Cap packing house
95		Sift house
96		Composition Weighing house
98		W.C.
100	277	Labeling house
101	277	Labeling house
102		Labeling house
103	158	Tin cover storage
104	158	Label dryer
105	153	Labeling house magazine
106	151	Magazine
107a		Labeling house magazine
107b		Storage
108		Pattern Storage
110		Gun cotton dry house
111		Gun cotton magazine
112		Gun cotton magazine
114		Receiving Magazine
116		Cap storage magazine, J Labels
117		Cap storage magazine, M Labels
118		Cap storage magazine, Delay Magazine
119		Cap storage magazine, F Labels
120		Sample cap magazine
122		Testing shed
123		Experimental press house
124		Technical laboratory
124 annex		Technical laboratory annex
125	190	General office
126		Stable
127	1901	Gatesmen's Dwelling
129		Night watchmen's restroom
130		Watchman's Dwelling
131	179	Women's restroom
132		Bunk house
133		Bunk house
134		Bunk house
135	195	Bunk house

Table 2 California Cap Company Building Numbers and Historical Uses (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Former Building Number	Overlaps with UCB Building Number	California Cap Company Building Use
136		Bunk house
137		Bunk house
138		Wash house
139		Cook house
140		Wood shed
142	152	Sawdust storage, restroom
141		Platform
144		Superintendent's Dwelling
145		40 gallon chemical cart
146		Oil Pump House
148	111	Pulvis Storage
149	118	Boiler house
150	196	Shed
151	194	Shed
154		Fulminate steeping shed
157		Sift house
158		Cap packing house
159		Mixing building, new fulminate
160		Fulminate fume condensing house
162		Shed
163		Fume burner (waste gas)
164		Cap storage magazine, fuse magazine
165		Cap storage magazine, L Labels
166		Cap storage magazine
167		Cap storage magazine
170	180	Plugging house
171	180	Match head house
172	180	Match head storage
174		Alcohol platform
175		Alcohol storage tanks
177		Garage
178a		Tunnel
180		Shed
180a		Shed
181		Match Head Cleaning Shed
182	472	Garage
183	112	Laboratory
184		Fomon generator hopper
185		Testing shed
AA		W.C.
AB		Platform
AC		Fulminate dry house
AD		Fulminate tank (underground)

Table 2 California Cap Company Building Numbers and Historical Uses (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Former Building Number	Overlaps with UCB Building Number	California Cap Company Building Use
AE		Fulminate tank (underground)
AF		Tank
AG		Platform
AH		Powder dry house
AI		Wash trough
AJ		Steeping shed
Ak		Powder press house
AL	102	Distillation drum
AM		Hydrant
AN	128	Press house
AO		Packing house
AP		Cap house
AQ		Press house
AR	128	Press house
AS		Powder weighing house
AT		Powder storage house
AU		Drying stand
AV	128	Tin box house
AW		Cap sift house
AX		Cap packing house
AY		Whale lance house
AZ		Cap dry house
BA		Chlorate sift house
BB		Dry house
BC		Kettle
BD		Coal bunker
BE		Tanks
BF		Machine shop
BG		Engine, boiler, blacksmith
BH		Incorporating house
BI		Boiler pit
BJ		Cotton Wringers
BK		Gasoline engine house
BL		Cotton steeping shed
BM		Cotton steeping shed
BN		Cotton shed
BO		Tanks
BP		Boiler pit
BQ		Cotton house, tanks
BR	112	Coal bunker
BS	112	Coal bunker
BT		5 overhead acid tanks
BU	112	Shed

Table 2 California Cap Company Building Numbers and Historical Uses (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Former Building Number	Overlaps with UCB Building Number	California Cap Company Building Use
BV		Cotton dry house
BW		Gasoline engine house
BX		Paint shop
BY	149	Windmill and watertank
BZ		Fuse house
CA		Cap magazine
CB		Sample magazine
CC		Sample magazine
CD		Sample magazine
CE	152	Testing shed
CF		Corporating house
CG		Office
CH	150	W.C.
CI	150	Concrete storagehouse
CJ	114	Packing house magazine
CK	175	Carpenter shop
CL	175	Packing house
CM		Gun cotton magazine
CN		Cap magazine
CO		Laundry
CP	155	Superintendants house
CQ		Warehouse
CR		Gun cotton dry house
CS		Sift house
CT	38	Dupont press house
CU		House
CV		Shed, W.C.
CW		W.C.
CX		Cook house
CY		House
CZ		Platform
DA	196	Barn
DB		House
DC	196	Shed
DD		House
DE		Shed
DF		House
DG		Cess pool
DH	194	Shed
DI		House

Table 2 California Cap Company Building Numbers and Historical Uses (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Notes:

Prior to when UC acquired the RFS property, many California Cap Company buildings were torn down. Buildings that remained were renumbered by UC. Some former California Cap Company buildings were moved following UC's purchase of the property. For example, California Cap Company Building 65, research laboratory, was moved from Egret Way to its current location near Building 102 and renumbered Building 110.

California Cap Company building information is based on Sanborn maps from 1930 and 1941 and an earlier undated map signed by "J. Geo. Smith, C.E., Emeryville."

RFS	Richmond Field Station
UC	University of California
UCB	University of California, Berkeley
W.C.	Water Closet

Table 3 Analytical Results for Pyrite Cinders Soil Samples from the RFS Upland Area (all results in mg/kg)
Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte	Sample ID 05060C180	Sample ID 05060C164	Sample ID 05060C112	Sample ID W. PERI-METER COMP 3	Sample ID RFSPC001	Sample ID RFSPC002	Sample ID RFSPC003	Avg.	95% UCL	TTLC	H-SSTL[a]
Arsenic	23	38	110	44	71	66	70	60	86	500	120
Copper	540	420	820	490	580	760	910	646	811	2,500	98,900
Lead	53	220	260	150	290	74	69	159	247	1,000	750
Mercury	3.9	0.94	0.7	2.1	1.1	0.99	0.88	1.52	2.54	20	494
Zinc	130	230	420	150	350	240	260	254	346	5,000	100,000

Sample ID locations:

05060C180 - One discrete soil sample collected on June 6, 2005 from a small excavation of a tree stump, parking lot east of Building 180.

05060C164 - One discrete soil sample collected on June 6, 2005 from a hand shovel excavation for a water line north side of Building 164.

05060C112 - One discrete soil sample collected on June 6, 2005 from area near former transformer pad north of Building 112 (by RFSPC001).

W. PERI-METER COMP 3 – Composite sample collected November 18, 2005 along the northwest perimeter of Building 155 where cinders were found in near-surface soils next to the foundation. The composited sample consisted of three discrete subsamples collected at various depths between 0 and 12 inches deep from 17 sample locations. This sample probably also contained a small percentage of non-cinder soil, but was predominantly pyrite cinders.

RFSPC001 - One discrete soil sample collected on July 11, 2006 from area near former transformer pad north of Building 112.

RFSPC002 - One discrete soil sample collected on July 11, 2006 from northeast corner of Crow and Owl intersection dig.

RFSPC003 - One discrete soil sample collected on July 11, 2006 from northeast corner of North field (north of Building 167).

Notes:

a	H-SSTLs for construction workers and commercial/industrial workers as reported in Table 3-13 of URS Corporation (2001).
Avg.	Average
H-SSTL	Human health site-specific target level
ID	Identification
mg/kg	Milligrams per kilogram
RFS	Richmond Field Station
TTLC	Total threshold limit concentration
UCL	Upper confidence level

Reference:

URS Corporation. 2001. "Human Health and Ecological Tiered Risk Evaluation, University of California, Berkeley, Richmond Field Station/Stege Marsh, Richmond, California." Final Report. November 21.

Table 4 Reports Completed for Richmond Field Station

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Report Name	Compliance Date	Contractor	Publication Date
Reports Prior to Water Board Order 102 (see Appendix B)			
Field Sampling and Analysis Plan and Tiered Risk Evaluation		URS	December 1999
Field Sampling and Analysis Results		URS	December 2000
Reports Requested in Water Board Order 102 (see Appendix B)			
Human Health Risk Assessment for Subunit 2, including Areas 2A and 2B	October 31, 2001	URS; included Ecological Risk Assessment and Responses to Comments	November 2001 and November 2002
Subunit 2A			
Results of Additional Soil and Groundwater Investigation – Subunit 2A	October 31, 2001	URS	November 2001
Groundwater Sampling and Analyses Monitoring Plan	October 31, 2001	BBL; All Subunit 2 Monitoring Plan	2004
Conceptual Remedial Action Plan	December 15, 2001	LFR	December 2001
Remedial Design Details for Soil and Groundwater Neutralization and Metals Treatment -- Subunit 2A	January 31, 2002	LFR; entire Meade St. Unit URS Phase 1 Addendum	January 2002 URS Phase 1 Addendum – August and Addendum 2 – November 2002
Implementation of Soil and Groundwater Remedial Measures – Subunit 2A	October 31, 2003	URS Phase 1 URS Phase 2	September 2003 December 2004
Workplan for Evaluating Remedial Action Effectiveness – Subunit 2A	January 31, 2004		
1 Year Evaluation of Remedial Action Effectiveness – Subunit 2A	January 31, 2005		
3 Year Evaluation of Remedial Action Effectiveness – Subunit 2A	January 31, 2007, and every 3 years thereafter		

Table 4 Reports Completed for Richmond Field Station (Continued)
Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Report Name	Compliance Date	Contractor	Publication Date
Subunit 2A Stege Marsh			
Results of Additional Soil and Groundwater Investigation – Subunit 2A Stege Marsh	October 31, 2001	URS	November 2001
Sampling and Analyses Monitoring Plan – Subunit 2A Stege Marsh	October 31, 2001	BBL; All Subunit 2 Monitoring Plan	BBL 2004
Remedial Action Plan – Subunit 2A Stege Marsh	July 31, 2002	URS Phase 2	April 2003
Remedial Design Details for Soil and Groundwater Neutralization and Metals Treatment – Subunit 2A Stege Marsh	March 31, 2003	LFR; entire Meade St. Unit URS; Phase 1 Addendum	January 2002 Phase 1 Addendum – August and November 2002
Implementation of Remedial Measures – Subunit 2A Stege Marsh	October 31, 2003	URS Phase 1 URS Phase 2	September 2003 December 2004
Subunit 2B Upland			
Workplan for Soil and Groundwater Investigation and Sampling And Analyses Monitoring Plan – Subunit 2B Upland	December 15, 2001	URS; Phase 3 Monitoring and Notification BBL; All Subunit 2 Monitoring Plan	September 2004 2004
Results of Additional Soil and Groundwater Investigation – Subunit 2B Upland	July 31, 2002		
Remedial Action Plan – Subunit 2B Upland	January 31, 2003	URS Phase BBL Phase 3	April 2003 July 2004
Implementation of Remedial Action Plan – Subunit 2B Upland	September 30, 2003	URS Phase 2 URS Phase 3	December 2004 June 2005
Subunit 2B Western Stege Marsh			
Sampling and Analyses Monitoring Plan – Subunit 2B Western Stege Marsh	December 15, 2001	BBL	August 2004

Table 4 Reports Completed for Richmond Field Station (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Report Name	Compliance Date	Contractor	Publication Date
Subunit 2B Western Stege Marsh (Continued)			
Conceptual Remedial Action Plan – Subunit 2B Western Stege Marsh	July 31, 2002	URS BBL Addendum	December 2002 June 2005
Remedial Action Plan – Subunit 2B Western Stege Marsh	February 28, 2003	URS Phase 2	April 2003
Implementation of Remedial Action Plan – Subunit 2B Western Stege Marsh	March 21, 2004	URS Phase 2	December 2004
Other Reports Required by USACE Nationwide Permit 38			
Nationwide Permit 38 Modification Request		BBL	2003
Feral Animal Management Plan		BBL	January 2004
Invasive/Exotic Vegetation Management Plan		BBL	January 2004
Biological Assessment Report		BBL	July 2003
Stormwater Pollution Prevention Plan		UC Berkeley	October 2003
Soil Management Plan		LFR	January 2001
Other Reports			
Status of California Clapper Rail Western Stege Marsh, RFS		Avocet	2003
Removal Site Evaluation of Mercury in Soil and Groundwater at Former Hg Fulminate Facility, RFS		Jonas & Associates	May 1990
Evaluation of Sources of Metals and Acidity, Stege Marsh		Shepherd Miller	1999
The Natural Areas of RFS		Gutstein	1989
Western Stege Marsh Monitoring Plan		BBL	August 2004
Well Closure Documentation Report		Stellar Environmental Solutions, Inc	May 2006
Draft Soil Sampling and Analysis Plan for Construction of EPA Laboratory		Jonas & Associates	May 1990
DTSC Status Report Update		DTSC	April 2006

Table 4 Reports Completed for Richmond Field Station (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Note:

This table lists the reports requested by the Water Board, with the exception of reports requested to evaluate the effectiveness of the marsh remediation at Subunit 2A and Subunit 2B. This Current Conditions Report includes a discussion of the effectiveness of the remediation. Further evaluations of the effectiveness of the marsh remediation will be conducted under the DTSC order.

BBL	Blasland, Bouck & Lee
DTSC	Department of Toxic Substances Control
EPA	Environmental Protection Agency
LFR	Levine-Fricke-Recon
RFS	Richmond Field Station
UC	University of California
URS	URS Corporation
USACE	U.S. Army Corps of Engineers
Water Board	San Francisco Bay Regional Water Quality Control Board

Table 5 Phase 1 Remediation Summary

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Area	Description	Type of Material	Approximate Area (square feet)	Approximate Depth of Excavation (feet)	Excavated Volume (in-situ cubic yards)	Stabilization
Uplands – Area 1	Former round pond area	Cinders, sediment, soil	39,810	11	13,500 (14,500 total including overburden)	Limestone GAC for approximately 1,500 cy
Marsh – Eastern Portion of Area 2	Marsh	Cinders, sediment	50,580	4	7,500 (9,700 total including vegetation)	CKD
Marsh – Area 3	Marsh	Cinders, sediment	44,170	4	6,500 (11,800 total including vegetation)	CKD
Uplands – Area 4	Southeastern corner of former rectangular pond area	Cinders, sediment	2,100	11	300 (700 total including overburden)	Limestone GAC for approximately 160 cy

Notes:

CKD Cement kiln dust
cy Cubic yard
GAC Granular activated carbon

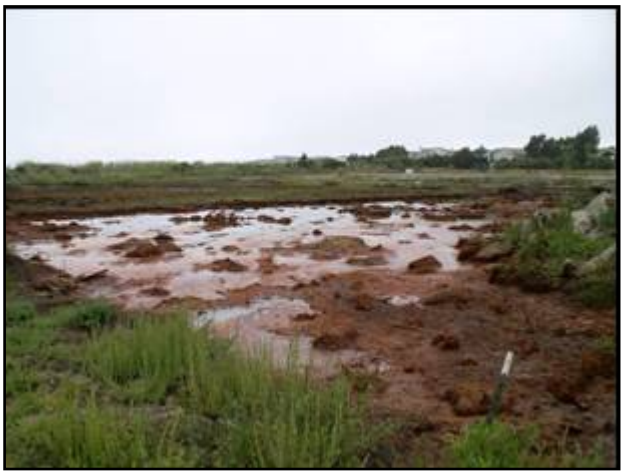

Table 6 Phase 2 Remediation Summary

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Area	Description	Type of Material	Approximate Area (square feet)	Approximate Depth of Excavation (feet)	Excavated Volume (in-situ cubic yards)	Stabilization
Uplands – Area 4 & sanitary sewer line	Former rectangular pond area	Cinders, sediment, soil	80,850	Varied	14,899 (1) (25,677 cy total including 10,778 cy (1) of overburden from Areas 4 and M3)	Limestone for 6,145 cy (Type A) Limestone & Carbon for 4,266 cy (Type B) CKD as needed for 3,785 cy (Type C) None for 703 cy of soil north of old seawall
Misc. Upland Soil	Miscellaneous Upland Soil with cinders	Soil, cinders	N/A	Varied	1,496 (2)	Limestone for 1,496 cy (Type A)
Marsh – Western Portion of Area 2	Marsh	Cinders, sediment, soil	40,175	5	7,721 (3) (8,699 cy total including 978 cy (2) of overburden, vegetation and debris)	CKD & Carbon (Type B)
Marsh – Area M3	Marsh area located adjacent to Area 2	Sediment	25,175	4	3,290 (1) (3,563 cy total including 273 cy (1) of vegetation and overburden)	CKD (Type C)
Marsh – Area M3	Marsh area located adjacent to Area 2	Removed soil berm (incidentally excavated with underlying Type C soil)	11,250	Not applicable	2,866 tons (4)	CKD as needed (Type C)
Marsh – Area M1a	PCB impacted marsh area located at western storm drain outfall	Sediment	2,600	5	464 (1)	CKD (Type D)

Notes:

Type A soil – cinder-affected soils / sediment containing mercury at concentrations less than 50 milligrams per kilogram (mg/kg).

Type B soil – cinder-affected soils / sediment containing mercury at concentrations between 50 and 260 mg/kg.

Type C soil – cinder-affected soils / sediment containing mercury at concentrations greater than 260 mg/kg.

Type D soil – Polychlorinated biphenyl- (PCB) affected soils / sediment.

(1) Quantity based on post excavation survey.

(2) Quantity based on truck counts.

(3) Includes 129 cy of Type A soil excavated from Area 2. Quantity based on post excavation survey.

(4) Quantity based on landfill weight tickets.

CKD	Cement kiln dust
cy	Cubic yard
N/A	Not applicable

Table 7 Phase 3 Remediation Summary

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Remediation Area	Description	Type of Material	Excavated Volume (in-situ cubic yards)	Waste Designation	Placement Location
RA 1	Upland RFS	Cinders and Soil	1,663 (1) (2,847 tons) (2)	Non-RCRA hazardous	Disposed of off site at Kettleman Class I landfill
RA 2	Upland RFS	Soil	260 (1)	Non-hazardous	Disposed of off site at Keller Canyon Class II landfill
RA 2	Upland RFS	Cinders	75 (est.) (128 tons)	Non-RCRA hazardous	Disposed of off site at Kettleman Class I landfill
RA 3	Upland RFS	Soil	69 (1)	Non-hazardous	Disposed of off site at Keller Canyon Class II landfill
RA 4	Upland RFS	Cinders and Soil	801 (1) (1,081 tons) (2)	Non-RCRA hazardous	Disposed of off site at Kettleman Class I landfill
RA 4	Upland RFS	Pipe and Soil	2.64 tons (2)	RCRA-hazardous	Disposed of off site at Kettleman Class I landfill. Stabilized to meet LDR at landfill
RA 5	Upland RFS	Soil	32 (1) (52 tons) (2)	Non-hazardous	Disposed of off site at Keller Canyon Class II landfill
RA 5	Upland RFS	Caulking	< 0.5 (est.)	Non-hazardous	Disposed of off site at Keller Canyon Class II landfill
RA 6	Upland RFS	Soil	409 (1) (667 tons) (2)	Non-RCRA hazardous	Disposed of off site at Kettleman Class I landfill
M3	Marsh	Sediment	39.7 tons (2)	RCRA-hazardous	Disposed of off site at Kettleman Class I landfill

Notes:

(1) Quantity based on surveyed in-situ volume.
(2) Quantity based on landfill weight tickets.
RA 1 Remediation Area 1 was formerly designated as Area of Concern U1 under the rescinded Water Board Order.
RA 2 Remediation Area 2 was formerly designated as Area of Concern U2 under the rescinded Water Board Order.
RA 3 Remediation Area 3 was formerly designated as Area of Concern U3 under the rescinded Water Board Order.
RA 4 Remediation Area 4 was formerly designated as Area of Concern U4 under the rescinded Water Board Order.
RA 5 Remediation Area 5 was formerly designated as Area of Concern U8 under the rescinded Water Board Order.
RA 6 Remediation Area 6 was formerly designated as Area of Concern U6 under the rescinded Water Board Order.
Est. Estimated
LDR Land disposal restrictions
RCRA Resource Conservation and Recovery Act
RFS Richmond Field Station

Table 8 Summary Statistics for Upland Area Soil

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent Detections /Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration
METAL	Antimony	mg/kg	285	2.11%	3.1	4.8	WTA34	4.15	4.30	0.60
METAL	Arsenic	mg/kg	357	98.60%	0.2	126	B15SH	6.15	4.30	8.54
METAL	Barium	mg/kg	5	100.00%	170	310	WTA31	226.00	210.00	49.64
METAL	Beryllium	mg/kg	299	98.33%	0.11	2.5	BLDG 102-3	0.47	0.44	0.21
METAL	Cadmium	mg/kg	366	84.70%	0.2	437	B2MF	3.34	1.40	25.22
METAL	Chromium	mg/kg	345	100.00%	7	110	MF2-14	36.24	35.00	14.26
METAL	Cobalt	mg/kg	5	100.00%	6.3	17	WTA31	10.24	8.50	4.16
METAL	Copper	mg/kg	370	100.00%	4.9	4160	B7	104.05	24.00	260.88
METAL	Lead	mg/kg	366	99.18%	2.4	1140	B2MF	35.14	12.00	89.31
METAL	Mercury	mg/kg	424	95.28%	0.025	1100	MF2-9	26.68	0.94	108.56
METAL	Molybdenum	mg/kg	5	100.00%	1.2	3.6	WTA40	2.44	2.30	0.82
METAL	Nickel	mg/kg	299	100.00%	9.3	230	SH2-11	45.15	38.00	27.72
METAL	Selenium	mg/kg	366	54.37%	0.24	4.5	SM2-14	0.85	0.68	0.60
METAL	Silver	mg/kg	299	8.36%	0.22	1.9	A4-6	0.66	0.56	0.38
METAL	Thallium	mg/kg	299	38.80%	0.29	9.4	SM2-2	1.23	0.93	1.13
METAL	Vanadium	mg/kg	5	100.00%	34	60	WTA34	46.40	46.00	8.62
METAL	Zinc	mg/kg	367	99.73%	10.2	2150	B2MF	115.33	47.80	208.33
VOA	1,1,1,2-Tetrachloroethane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	1,1,1-Trichloroethane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	1,1,2,2-Tetrachloroethane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	1,1,2-Trichloroethane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	1,1-Dichloroethane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	1,1-Dichloroethene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	1,1-Dichloropropene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	1,2,3-Trichlorobenzene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	1,2,3-Trichloropropane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	1,2,4-Trichlorobenzene	mg/kg	5	0.00%	ND	ND	ND	ND	ND	ND
VOA	1,2,4-Trimethylbenzene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	1,2-Dibromo-3-Chloropropane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	1,2-Dibromoethane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	1,2-Dichlorobenzene	mg/kg	5	0.00%	ND	ND	ND	ND	ND	ND
VOA	1,2-Dichloroethane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	1,2-Dichloropropane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	1,3,5-Trimethylbenzene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	1,3-Dichlorobenzene	mg/kg	5	0.00%	ND	ND	ND	ND	ND	ND
VOA	1,3-Dichloropropane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	1,4-Dichlorobenzene	mg/kg	5	0.00%	ND	ND	ND	ND	ND	ND
VOA	2,2-Dichloropropane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND

Table 8 Summary Statistics for Upland Area Soil (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent Detections /Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration
VOA	2-Butanone	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	2-Chlorotoluene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	2-Hexanone	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	4-Chlorotoluene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	4-Methyl-2-Pentanone	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Acetone	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Benzene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Bromobenzene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Bromochloromethane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Bromodichloromethane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Bromoform	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Bromomethane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Carbon disulfide	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Carbon tetrachloride	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Chlorobenzene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Chloroethane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Chloroform	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Chloromethane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Cis-1,2-dichloroethene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Cis-1,3-dichloropropene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Dibromochloromethane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Dibromomethane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Dichlorodifluoromethane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Ethylbenzene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Freon 113	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Isopropylbenzene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	m,p-Xylene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Methyl tert-butyl ether	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Methylene chloride	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	n-Butylbenzene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	n-Propylbenzene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Naphthalene	mg/kg	5	0.00%	ND	ND	ND	ND	ND	ND
VOA	O-xylene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	P-isopropyltoluene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Sec-butylbenzene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Styrene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Tert-butylbenzene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Tetrachloroethene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND

Table 8 Summary Statistics for Upland Area Soil (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent Detections /Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration
VOA	Toluene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	trans-1,2-Dichloroethene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	trans-1,3-Dichloropropene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Trichloroethene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Trichlorofluoromethane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Vinyl acetate	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
VOA	Vinyl chloride	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
SVOA	2,4,5-Trichlorophenol	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	2,4,6-Trichlorophenol	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	2,4-Dichlorophenol	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	2,4-Dimethylphenol	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	2,4-Dinitrophenol	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	2,4-Dinitrotoluene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	2,6-Dinitrotoluene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	2-Chloronaphthalene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	2-Chlorophenol	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	2-Methylnaphthalene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	2-Methylphenol	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	2-Nitroaniline	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	2-Nitrophenol	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	3,3'-Dichlorobenzidine	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	3-Nitroaniline	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	4,6-Dinitro-2-Methylphenol	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	4-Bromophenyl-phenylether	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	4-Chloro-3-Methylphenol	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	4-Chloroaniline	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	4-Chlorophenyl-phenylether	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	4-Methylphenol	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	4-Nitroaniline	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	4-Nitrophenol	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Acenaphthene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Acenaphthylene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Anthracene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Azobenzene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Benzo(a)anthracene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Benzo(a)pyrene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Benzo(b)fluoranthene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Benzo(g,h,i)perylene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND

Table 8 Summary Statistics for Upland Area Soil (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent Detections /Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration
SVOA	Benzo(k)fluoranthene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Benzoic acid	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Benzyl alcohol	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Bis(2-chloroethoxy)methane	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Bis(2-chloroethyl)ether	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Bis(2-chloroisopropyl)ether	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Bis(2-ethylhexyl)phthalate	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Butylbenzylphthalate	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Chrysene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Di-n-butylphthalate	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Di-n-octylphthalate	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Dibenz(a,h)anthracene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Dibenzofuran	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Diethylphthalate	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Dimethylphthalate	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Fluoranthene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Fluorene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Hexachlorobenzene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Hexachlorobutadiene	mg/kg	5	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Hexachlorocyclopentadiene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Hexachloroethane	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Indeno(1,2,3-cd)pyrene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Isophorone	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	N-nitroso-di-n-propylamine	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	N-nitrosodimethylamine	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	N-nitrosodiphenylamine (1)	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Nitrobenzene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Pentachlorophenol	mg/kg	6	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Phenanthrene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Phenol	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Pyrene	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Total LMW PAH	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
SVOA	Total PAH	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
PCB	Aroclor-1016	mg/kg	115	0.00%	ND	ND	ND	ND	ND	ND
PCB	Aroclor-1221	mg/kg	115	0.00%	ND	ND	ND	ND	ND	ND
PCB	Aroclor-1232	mg/kg	115	0.00%	ND	ND	ND	ND	ND	ND
PCB	Aroclor-1242	mg/kg	115	0.00%	ND	ND	ND	ND	ND	ND
PCB	Aroclor-1248	mg/kg	115	8.70%	0.036	7.3	SSD-1	1.46	0.65	2.09

Table 8 Summary Statistics for Upland Area Soil (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent Detections /Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration
PCB	Aroclor-1254	mg/kg	115	27.83%	0.012	0.95	ES3-23	0.13	0.04	0.21
PCB	Aroclor-1260	mg/kg	115	13.91%	0.012	0.23	SD2-14	0.07	0.06	0.06
PCB	Total Aroclor	mg/kg	115	37.39%	0.012	7.3	SSD-1	0.46	0.10	1.17
TPHEXT	Diesel range organics	mg/kg	1	0.00%	ND	ND	ND	ND	ND	ND
TPHEXT	Motor oil range organics	mg/kg	1	0.00%	ND	ND	ND	ND	ND	ND
PH	pH	pH	1	0.00%	ND	ND	ND	ND	ND	ND
ANION	Sulfate	mg/kg	2	100.00%	50	480	PC101	265.00	265.00	215.00
EXP	Explosives	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
EXP	Hmx	mg/kg	1	100.00%	0.37	0.37	ES101	0.37	0.37	NA
TOC	TOC	mg/kg	1	100.00%	700	700	ES102	700.00	700.00	NA

EXP	Explosives
Hmx	High melting explosive
LMW	Low molecular weight
mg/kg	Milligram per kilogram
ND	Not detected
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
SVOA	Semivolatile organics analysis
TOC	Total organic carbon
TPHEXT	Total petroleum hydrocarbons extraction
VOA	Volatile organics analysis

Table 9 Comparison of Chemicals to Criteria for Upland Area Soil Data
Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent Detections/ Analyses	Minimum Detected Conc.	Maximum Detected Conc.	Location(s) of Maximum Results	Average Detected Conc.	Median Detected Conc.	95% UCL	Standard Deviation Detected Conc.	RFS Commerical/ Industrial Worker H-SSTL	Percent Detects Greater than RFS Commercial/ Industrial H-SSTL	RFS Construction Worker H-SSTL	Percent Detects Greater than RFS Construction Worker H-SSTL	RFS Path Recreator H-SSTL	Percent Detects Greater than RFS Path Recreator H-SSTL	Commercial / Industrial CHHSL	Percent Detects Greater than Commercial/ Industrial CHHSL
METAL	Antimony	mg/kg	285	2.11%	3.1	4.8	WTA34	4.15	4.30	3.14	0.60	1060	0.00%	818	0.00%	876	0.00%	380	0.00%
METAL	Arsenic	mg/kg	357	98.60%	0.2	126	B15SH	6.15	4.30	6.85	8.54	120	0.28%	27.3	1.14%	19.1	1.99%	0.24	99.72%
METAL	Beryllium	mg/kg	299	98.33%	0.11	2.5	BLDG 102-3	0.47	0.44	0.48	0.21	475	0.00%	3690	0.00%	4,320	0.00%	1,700	0.00%
METAL	Cadmium	mg/kg	366	84.70%	0.2	437	B2MF	3.34	1.40	5.21	25.22	325	0.32%	147	0.32%	46.8	0.65%	7.5	1.29%
METAL	Chromium	mg/kg	345	100.00%	7	110	MF2-14	36.24	35.00	37.51	14.26	217	0.00%	4480	0.00%	5,900	0.00%	370	0.00%
METAL	Copper	mg/kg	370	100.00%	4.9	4,160	B7	104.05	24.00	188.90	260.88	98,900	0.00%	75,900	0.00%	81,300	0.00%	38,000	0.00%
METAL	Lead	mg/kg	366	99.18%	2.4	1,140	B2MF	35.14	12.00	55.19	89.31	750	0.28%	750	0.28%	400	0.83%	3500	0.00%
METAL	Mercury	mg/kg	424	95.28%	0.025	1,100	MF2-9	26.68	0.94	57.65	108.56	494	0.99%	264	3.22%	513	0.99%	180	3.71%
METAL	Nickel	mg/kg	299	100.00%	9.3	230	SH2-11	45.15	38.00	47.80	27.72	53,200	0.00%	40,900	0.00%	43,800	0.00%	16,000	0.00%
METAL	Selenium	mg/kg	366	54.37%	0.24	4.5	SM2-14	0.85	0.68	0.65	0.60	13,300	0.00%	10,200	0.00%	11,000	0.00%	4,800	0.00%
METAL	Silver	mg/kg	299	8.36%	0.22	1.9	A4-6	0.66	0.56	0.27	0.38	13,300	0.00%	10,200	0.00%	11,000	0.00%	4,800	0.00%
METAL	Thallium	mg/kg	299	38.80%	0.29	9.4	SM2-2	1.23	0.93	0.74	1.13	176	0.00%	135	0.00%	145	0.00%	630	0.00%
METAL	Zinc	mg/kg	367	99.73%	10.2	2,150	B2MF	115.33	47.80	134.90	208.33	100,000	0.00%	100,000	0.00%	100,000	0.00%	100,000	0.00%
PCB	Aroclor-1016	mg/kg	115	0.00%	ND	ND	ND	ND	ND	NA	ND	98.5	ND	50.2	ND	103	ND	NA	ND
PCB	Aroclor-1221	mg/kg	115	0.00%	ND	ND	ND	ND	ND	NA	ND	70.3	ND	10	ND	6.2	ND	NA	ND
PCB	Aroclor-1232	mg/kg	115	0.00%	ND	ND	ND	ND	ND	NA	ND	70.3	ND	10	ND	6.2	ND	NA	ND
PCB	Aroclor-1242	mg/kg	115	0.00%	ND	ND	ND	ND	ND	NA	ND	70.3	ND	10	ND	6.2	ND	NA	ND
PCB	Aroclor-1248	mg/kg	115	8.70%	0.036	7.3	SSD-1	1.46	0.65	0.28	2.09	70.3	0.00%	10	0.00%	6.2	10.00%	NA	ND
PCB	Aroclor-1254	mg/kg	115	27.83%	0.012	0.95	ES3-23	0.13	0.04	0.07	0.21	28.1	0.00%	10	0.00%	6.2	0.00%	NA	ND
PCB	Aroclor-1260	mg/kg	115	13.91%	0.012	0.23	SD2-14	0.07	0.06	0.03	0.06	70.3	0.00%	10	0.00%	6.2	0.00%	NA	ND
PCB	Total Aroclor	mg/kg	115	37.39%	0.012	7.3	SSD-1	0.46	0.10	NA	1.17	NA	NA	NA	NA	NA	NA	0.30	27.91%
SVOA	Pentachlorophenol	mg/kg	6	0.00%	ND	ND	ND	ND	ND	NA	ND	86.3	ND	111	ND	83.3	ND	NA	ND

Notes
All 95% UCLs calculated using ProUCL4
H-SSTL screening levels developed in 2001 under the oversight of the Water Board and will be re-evaluated by DTSC

CHHSL	California Human Health Screening Level
Conc.	Concentration
DTSC	Department of Toxic Substance Control
H-SSTL	Human health site-specific target level
mg/kg	Milligram per kilogram
NA	Not applicable
ND	Not detected
PCB	Polychlorinated biphenyl
RFS	Richmond Field Station
SVOA	Semivolatile organics analysis
UCL	Upper confidence level
Water Board	San Francisco Bay Regional Water Quality Control Board

Table 10 Elevation of Former Tidal Mudflat, Marsh Area

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Location	Elevation (feet NGVD)	Thickness of Soft Sediment Layer (feet)	Elevation of Former Tidal Mudflat (feet NGVD)	Notes
Meeker Slough				
MS1	-1.21	0.1	-1.3	
MS2	0.58	3.2	-2.6	
MS4	-0.23	0.9	-1.1	
MS7	-0.90	0.1	-1.0	
MS17	-0.32	0.0	-0.3	
MS21	0.40	0.1	0.3	
MS23	0.58	0.1	0.5	
MS26	0.41	0.3	0.1	
MS28	0.09	0.3	-0.2	
MS29	-0.83	0.2	-1.0	
MS30	-1.14	> 10.0	< -11.1	Soft sediment greater than 10 inches thick
MS32	-1.13	> 10.0	< -11.1	Soft sediment greater than 10 inches thick
MS34	-1.17	0.1	-1.3	
MS35	-1.58	0.0	-1.6	
SM139	-1.94	1.1	-3.0	
SM158	-1.28	> 10.0	< -11.3	Soft sediment greater than 10 inches thick
Marsh Plain and Small Sloughs				
MS6	0.63	2.0	-1.4	
MS8	0.29	7.0	-6.7	
MS9	0.98	1.0	0.0	
MS10	2.05	>8	>-6	
MS11	1.30	> 10.0	< -8.7	Soft sediment greater than 10 inches thick
MS12	2.31	1.5	0.8	
MS13	2.22	7.8	-5.6	
MS14	1.00	1.5	-0.5	
MS15	1.24	1.2	0.0	
MS16	2.71	2.5	0.2	
MS18	1.98	1.0	1.0	
MS19	3.31	3.7	-0.4	
MS20	3.17	1.6	1.6	

Table 10 Elevation of Former Tidal Mudflat, Marsh Area (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Location	Elevation (feet NGVD)	Thickness of Soft Sediment Layer (feet)	Elevation of Former Tidal Mudflat (feet NGVD)	Notes
Marsh Plain and Small Sloughs (Continued)				
MS22	2.73	2.8	-0.1	
MS24	0.96	1.0	0.0	
MS25	2.67	0.8	1.9	
MS27	2.18	6.6	-4.4	
MS31	1.95	7.2	-5.2	
MS33	1.55	7.9	-6.3	
SM134	2.53	3.0	-0.5	
SM135	2.39	2.4	0.0	
SM136	2.14	7.0	-4.9	
SM140	2.35	5.7	-3.4	
SM141	1.62	7.5	-5.9	
SM142	1.52	2.8	-1.3	
SM143	2.60	> 10.0	< -7.4	Soft sediment greater than 10 inches thick
SM144	2.54	4.3	-1.8	
SM145	2.49	4.3	-1.8	
SM147	2.60	3.3	-0.7	
SM149	2.81	4.1	-1.3	
SM150	2.64	2.8	-0.2	
SM151	1.11	2.1	-1.0	
SM152	1.46	3.0	-1.5	
SM153	2.46	4.0	-1.5	
SM154	1.16	2.3	-1.1	
SM155	1.75	2.4	-0.7	
SM156	1.28	2.2	-0.9	
SM157	1.07	2.3	-1.2	
SM159	3.07	5.2	-2.1	
SM160	2.17	2.8	-0.6	
SM161	2.25	3.3	-1.0	
SM163	2.44	4.1	-1.7	
SM164	2.06	2.7	-0.6	
SM165	2.09	> 10.0	< -7.9	Soft sediment greater than 10 inches thick
SM166	2.27	3.1	-0.8	

Table 10 Elevation of Former Tidal Mudflat, Marsh Area (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Location	Elevation (feet NGVD)	Thickness of Soft Sediment Layer (feet)	Elevation of Former Tidal Mudflat (feet NGVD)	Notes
Marsh Plain and Small Sloughs (Continued)				
SM167	1.88	3.0	-1.1	
SM168	2.46	3.2	-0.7	
SM169	1.35	2.4	-1.0	
SM170	1.52	2.5	-1.0	
SM171	2.03	4.7	-2.7	
SM172	2.33	3.1	-0.8	
SM173	2.76	3.8	-1.0	
SM174	2.64	3.7	-1.1	
SM175	2.94	4.0	-1.1	
SM176	3.27	4.4	-1.1	
SM177	0.82	6.0	< -5.2	
SM178	2.66	5.5	-2.8	
SM179	2.41	4.8	-2.4	
SM180	2.89	4.0	-1.1	
SM181	2.22	> 10.0	< -7.8	Soft sediment greater than 10 inches thick
SM182	2.61	5.4	-2.8	
Bulb				
BLB-1	5.0	3.5	1.5	
BLB-2	5.4	3.0	2.4	
BLB-3	6.9	4.5	2.4	
BLB-4	7.5	6.5	1.0	
BLB-5	8.7	7.5	1.2	
BLB-6	7.1	3.5	3.6	
BLB-7	6.6	6.0	0.6	
BLB-8	7.4	2.5	4.9	

Notes: Information provided in this table from Table 3-6 of the Conceptual Remedial Action Plan Addendum (BBL 2005b).

BBL Blasland, Bouck & Lee
NGVD National geodetic vertical datum

Source:

BBL. 2005b. "Draft Final Conceptual Remedial Action Plan - Addendum, Marsh Portion of Subunit 2B, University of California, Berkeley, Richmond Field Station." June 3.

Table 11 Summary Statistics for Transition Area Soil and Sediment

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent of Detections/ Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration
METAL	Antimony	mg/kg	81	2.47%	9.5	16	BLB-8	12.75	1.75	2.83
METAL	Arsenic	mg/kg	86	100.00%	0.99	700	BLB-2	38.57	6.5	120.15
METAL	Beryllium	mg/kg	83	96.39%	0.17	1	BLB-6	0.47	0.47	0.16
METAL	Cadmium	mg/kg	86	97.67%	0.59	23	BLB-2	2.71	1.5	3.58
METAL	Chromium	mg/kg	86	100.00%	13	110	B5MA, BLB-6	46.30	43	15.87
METAL	Copper	mg/kg	86	100.00%	9.6	3,300	BLB-8	182.62	27.5	465.88
METAL	Lead	mg/kg	86	100.00%	0.2	4,000	BLB-8	85.77	11	430.52
METAL	Mercury	mg/kg	96	97.92%	0.047	260	BLB-2	26.92	0.795	54.08
METAL	Nickel	mg/kg	83	100.00%	20	130	BLB-8	59.40	57	19.55
METAL	Selenium	mg/kg	86	63.95%	0.31	68	BLB-2	2.93	0.655	7.62
METAL	Silver	mg/kg	83	22.89%	0.24	200	BLB-8	12.45	0.15	21.81
METAL	Thallium	mg/kg	83	48.19%	0.29	15	BLB-1	1.33	0.29	1.67
METAL	Zinc	mg/kg	86	100.00%	30	3,500	BLB-8	384.63	75	697.60
PEST	4,4'-DDD	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	4,4'-DDE	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	4,4'-DDT	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	Aldrin	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	alpha-BHC	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	alpha-Chlordane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	beta-BHC	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	delta-BHC	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	Dieldrin	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	Endosulfan I	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	Endosulfan II	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	Endosulfan Sulfate	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	Endrin	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	Endrin Aldehyde	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	gamma-BHC (Lindane)	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	gamma-Chlordane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	Heptachlor	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	Heptachlor Epoxide	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	Methoxychlor	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	Total Chlordanes	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	Total DDTs	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND
PEST	Toxaphene	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND

Table 11 Summary Statistics for Transition Area Soil and Sediment (Continued)
Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent of Detections/ Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration
PCB	Aroclor-1016	mg/kg	9	0.00%	ND	ND	ND	ND	ND	ND
PCB	Aroclor-1221	mg/kg	9	0.00%	ND	ND	ND	ND	ND	ND
PCB	Aroclor-1232	mg/kg	9	0.00%	ND	ND	ND	ND	ND	ND
PCB	Aroclor-1242	mg/kg	9	0.00%	ND	ND	ND	ND	ND	ND
PCB	Aroclor-1248	mg/kg	10	40.00%	0.38	20	OLD OUTFALL 2	6.99	0.0215	6.11
PCB	Aroclor-1254	mg/kg	10	50.00%	0.086	7.7	OLD OUTFALL 2	1.84	0.158	2.27
PCB	Aroclor-1260	mg/kg	10	10.00%	0.029	0.029	BLB-6	0.03	0.00825	0.08
PCB	Aroclor-1262	mg/kg	1	0.00%	ND	ND	ND	ND	ND	ND
PCB	Total Aroclor	mg/kg	10	60.00%	0.086	27.7	OLD OUTFALL 2	6.20	0.3725	8.26
ANION	Sulfate	mg/kg	4	100.00%	75	6,800	SD101	1,908.75	380	2,827.03
PH	pH	PH	82	100.00%	4.1	12.1	PC102	7.11	7.4	1.40
TOC	TOC	mg/kg	2	100.00%	3,400	8,700	OLD OUTFALL 2	6,050	6,050	2,650

Notes:

BHC	Benzene hexachloride
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethene
DDT	Dichlorodiphenyltrichloroethane
mg/kg	Milligram per kilogram
ND	Not detected
PCB	Polychlorinated biphenyl
PEST	Pesticide
TOC	Total organic carbon

Table 12 Comparison of Chemicals to Criteria for Transition Area Soil and Sediment Data
Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent Detections/ Analyses	Minimum Detected Conc.	Maximum Detected Conc.	Location(s) of Maximum Results	Average Detected Conc.	Median Detected Conc.	Standard Deviation Detected Conc.	Ecological Soil PRG	Percent Detects Greater than Ecological Soil PRG	RFS Construction Worker H-SSTL	Percent Detects Greater than RFS Construction Worker H-SSTL	RFS Commerical/ Industrial Worker H-SSTL	Percent Detects Greater than RFS Commercial/ Industrial H-SSTL	Commerical/ Industrial CHHSL	Percent Detects Greater than Commercial/ Industrial CHHSL
METAL	Antimony	mg/kg	81	2.47%	9.5	16	BLB-8	12.75	12.75	3.25	1060	0.00%	6	100.00%	818	0.00%	380	0.00%
METAL	Arsenic	mg/kg	86	100.00%	0.99	700	BLB-2	38.57	6.50	120.15	120	5.81%	19.1	15.12%	27.3	13.95%	0.24	100.00%
METAL	Beryllium	mg/kg	83	96.39%	0.17	1	BLB-6	0.47	0.47	0.15	475	0.00%	NA	NA	3,690	0.00%	1,700	0.00%
METAL	Cadmium	mg/kg	86	97.67%	0.59	23	BLB-2	2.71	1.50	3.60	325	0.00%	4	13.10%	147	0.00%	7.5	9.52%
METAL	Chromium	mg/kg	86	100.00%	13	110	B5MA, BLB-6	46.30	43.00	15.87	217	0.00%	99.6	2.33%	4,480	0.00%	370	0.00%
METAL	Copper	mg/kg	86	100.00%	9.6	3,300	BLB-8	182.62	27.50	465.88	98900	0.00%	69	26.74%	75,900	0.00%	38,000	0.00%
METAL	Lead	mg/kg	86	100.00%	0.2	4,000	BLB-8	85.77	11.00	430.52	750	1.16%	40.5	20.93%	750	1.16%	3500	1.16%
METAL	Mercury	mg/kg	96	97.92%	0.047	260	BLB-2	26.92	0.84	54.52	494	0.00%	0.4	63.83%	264	0.00%	180	2.13%
METAL	Nickel	mg/kg	83	100.00%	20	130	BLB-8	59.40	57.00	19.55	53200	0.00%	120	3.61%	40,900	0.00%	16,000	0.00%
METAL	Selenium	mg/kg	86	63.95%	0.31	68	BLB-2	2.93	0.96	9.16	13300	0.00%	6	7.27%	10,200	0.00%	4,800	0.00%
METAL	Silver	mg/kg	83	22.89%	0.24	200	BLB-8	12.45	1.30	44.28	13300	0.00%	2	36.84%	10,200	0.00%	4,800	0.00%
METAL	Thallium	mg/kg	83	48.19%	0.29	15	BLB-1	1.33	0.86	2.25	176	0.00%	NA	NA	135	0.00%	630	0.00%
METAL	Zinc	mg/kg	86	100.00%	30	3,500	BLB-8	384.63	75.00	697.60	100000	0.00%	106	40.70%	100,000	0.00%	100,000	0.00%
PCB	Aroclor-1016	mg/kg	9	0.00%	ND	ND	ND	ND	ND	ND	98.5	ND	NA	ND	50.2	ND	37	ND
PCB	Aroclor-1221	mg/kg	9	0.00%	ND	ND	ND	ND	ND	ND	70.3	ND	NA	ND	10	ND	NA	ND
PCB	Aroclor-1232	mg/kg	9	0.00%	ND	ND	ND	ND	ND	ND	70.3	ND	NA	ND	10	ND	NA	ND
PCB	Aroclor-1242	mg/kg	9	0.00%	ND	ND	ND	ND	ND	ND	70.3	ND	NA	ND	10	ND	NA	ND
PCB	Aroclor-1248	mg/kg	10	40.00%	0.38	20	OLD OUTFALL 2	6.99	3.79	8.01	70.3	0.00%	0.371	100.00%	10	25.00%	NA	NA
PCB	Aroclor-1254	mg/kg	10	50.00%	0.086	7.7	OLD OUTFALL 2	1.84	0.29	2.94	28.1	0.00%	0.371	40.00%	10	0.00%	11	0.00%
PCB	Aroclor-1260	mg/kg	10	10.00%	0.029	0.029	BLB-6	0.03	0.03	0.00	70.3	0.00%	0.371	0.00%	10	0.00%	NA	NA
PCB	Aroclor-1262	mg/kg	1	0.00%	ND	ND	ND	ND	ND	ND	70.3	ND	NA	ND	10	ND	NA	ND
PCB	Total Aroclor	mg/kg	10	60.00%	0.086	27.7	OLD OUTFALL 2	6.20	0.78	9.92	NA	NA	NA	NA	NA	NA	0.3	83.33%
PEST	4,4'-DDD	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	239	ND	171	ND	9	ND
PEST	4,4'-DDE	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	645	ND	121	ND	6.3	ND
PEST	4,4'-DDT	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	21	ND	21	ND	6.3	ND
PEST	alpha-BHC	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	3.19	ND	3.19	ND	NA	ND
PEST	alpha-Chlordane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	27.1	ND	27.1	ND	NA	ND
PEST	beta-BHC	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	3.19	ND	3.19	ND	NA	ND
PEST	delta-BHC	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	26.6	ND	9.36	ND	NA	ND
PEST	Dieldrin	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	1.18	ND	1.18	ND	0.13	ND
PEST	Endrin	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	10.7	ND	10.7	ND	21	ND
PEST	gamma-BHC (lindane)	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	26.6	ND	26.6	ND	2	ND
PEST	gamma-Chlordane	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	27.1	ND	27.1	ND	NA	ND
PEST	Heptachlor	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	0.19	ND	0.19	ND	0.52	ND
PEST	Heptachlor epoxide	mg/kg	2	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	0.19	ND	0.19	ND	NA	ND

Notes: H-SSTL screening levels developed in 2001 under the oversight of the Water Board and will be re-evaluated by DTSC

BHC	Benzene hexachloride	DL	Detection limit	PCB	Polychlorinated biphenyl
CHHSL	California Human Health Screening Levels	DTSC	Department of Toxic Substance Control	PEST	Pesticides
Conc.	Concentration	H-SSTL	Human health site-specific target level	PRG	Preliminary remediation goal
DDD	Dichlorodiphenyldichloroethane	mg/kg	Milligram per kilogram	RFS	Richmond Field Station
DDE	Dichlorodiphenyldichloroethene	NA	Not applicable	Water Board	San Francisco Bay Regional Water Quality Control Board
DDT	Dichlorodiphenyltrichloroethane	ND	Not detected		

Table 13 Summary Statistics for Off-Site Property North Area Soil

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent of Detections/ Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration
PCB	Aroclor-1016	mg/kg	14	0.00%	ND	ND	ND	ND	ND	ND
PCB	Aroclor-1221	mg/kg	14	0.00%	ND	ND	ND	ND	ND	ND
PCB	Aroclor-1232	mg/kg	14	0.00%	ND	ND	ND	ND	ND	ND
PCB	Aroclor-1242	mg/kg	14	0.00%	ND	ND	ND	ND	ND	ND
PCB	Aroclor-1248	mg/kg	14	0.00%	ND	ND	ND	ND	ND	ND
PCB	Aroclor-1254	mg/kg	14	0.00%	ND	ND	ND	ND	ND	ND
PCB	Aroclor-1260	mg/kg	14	21.43%	0.011	0.028	PCB19	0.02	0.0065	0.01
PCB	Total Aroclor	mg/kg	14	21.43%	0.011	0.028	PCB19	0.02	0.013	0.00
PH	pH	PH	1	100.00%	7	7	SD MH-9	7.00	7	NA

Notes:

mg/kg	Milligram per kilogram
NA	Not available
ND	Not detected
PCB	Polychlorinated biphenyl

Table 14 Summary Statistics for Off-Site Property East Area Soil

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent of Detections/ Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration
METAL	Antimony	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
METAL	Arsenic	mg/kg	8	100.00%	2.8	12	PB102	5.84	5.55	2.90
METAL	Beryllium	mg/kg	8	100.00%	0.31	1	PB102	0.47	0.415	0.21
METAL	Cadmium	mg/kg	8	100.00%	1.2	2.8	PB102	1.75	1.7	0.51
METAL	Chromium	mg/kg	8	100.00%	25	42	PB105	35.38	36.5	4.92
METAL	Copper	mg/kg	8	100.00%	14	4,600	PB102	774.13	32.5	1,513.86
METAL	Lead	mg/kg	8	100.00%	4.4	18	PB102	8.84	8.1	4.15
METAL	Mercury	mg/kg	8	62.50%	0.069	1.7	PB102	0.49	0.1295	0.53
METAL	Nickel	mg/kg	8	100.00%	21	120	PB103, PB105	77.00	71.5	34.24
METAL	Selenium	mg/kg	8	100.00%	0.45	1.6	PB103	0.76	0.675	0.36
METAL	Silver	mg/kg	8	12.50%	0.35	0.35	PB104	0.35	0.15	0.07
METAL	Thallium	mg/kg	8	100.00%	0.42	5.8	PB103	1.77	1.3	1.63
METAL	Zinc	mg/kg	8	100.00%	24	2,700	PB102	401.50	58	870.55
PEST	4,4'-DDD	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
PEST	4,4'-DDE	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
PEST	4,4'-DDT	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
PEST	alpha-BHC	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
PEST	beta-BHC	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
PEST	Chlordane	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
PEST	delta-BHC	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
PEST	Dieldrin	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
PEST	Endrin	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
PEST	gamma-BHC (Lindane)	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
PEST	Heptachlor	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
PEST	Heptachlor Epoxide	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
PEST	Total Chlordanes	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
PEST	Total DDTs	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
PH	Ph	PH	8	100.00%	4.5	7.9	PB104	6.54	7.1	1.26

Notes:

BHC	Benzene hexachloride	mg/kg	Milligram per kilogram
DDD	Dichlorodiphenyldichloroethane	ND	Not detected
DDE	Dichlorodiphenyldichloroethene	PEST	Pesticide
DDT	Dichlorodiphenyltrichloroethane		

Table 15 Summary Statistics for the Western Stege Marsh and Meeker Slough Sediment

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent Detections/ Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration
METAL	Aluminum	mg/kg	3	100.00%	28,100	33,900	SED102	30,767	30,300	2,391
METAL	Antimony	mg/kg	267	14.61%	0.23	22	RMS26	5.71	5.40	4.91
METAL	Arsenic	mg/kg	276	97.83%	1.6	590	RMS18	63.52	21.00	99.11
METAL	Barium	mg/kg	42	100.00%	30	330	RMS21	74.64	69.00	43.35
METAL	Beryllium	mg/kg	267	94.76%	0.11	1.45	M3-CONF-4	0.52	0.52	0.22
METAL	Cadmium	mg/kg	276	88.77%	0.18	30	MS16	4.27	2.80	4.36
METAL	Calcium	mg/kg	3	100.00%	3,270	4,930	SED101	4,033	3,900	684.22
METAL	Chromium	mg/kg	276	100.00%	12	190	RMS26	71.53	74.50	29.50
METAL	Cobalt	mg/kg	42	100.00%	7.2	21	RMS27	14.65	15.00	2.91
METAL	Copper	mg/kg	276	100.00%	6.1	1,500	MS16	172.06	93.00	218.90
METAL	Iron	mg/kg	3	100.00%	42,900	48,800	SED102	46,300	47,200	2,491
METAL	Lead	mg/kg	276	100.00%	2.5	560	MS22	93.56	69.00	90.01
METAL	Magnesium	mg/kg	3	100.00%	13,200	15,800	SED102	14,200	13,600	1,143
METAL	Manganese	mg/kg	3	100.00%	470	877	SED102	622.00	519.00	181.42
METAL	Mercury	mg/kg	288	98.61%	0.049	100	MS16	6.84	1.50	14.19
METAL	Molybdenum	mg/kg	42	88.10%	0.56	8.8	RMS26	2.26	1.50	1.72
METAL	Nickel	mg/kg	267	100.00%	17	140	SM166	72.28	77.00	23.88
METAL	Potassium	mg/kg	3	100.00%	3,810	4,740	SED101	4,350	4,500	394.21
METAL	Selenium	mg/kg	276	66.30%	0.24	21	SM161	2.89	1.40	3.51
METAL	Silver	mg/kg	267	29.59%	0.3	5.3	MS22	1.00	0.84	0.74
METAL	Sodium	mg/kg	3	100.00%	9,510	11,500	SED101	10,193	9,570	924.28
METAL	Thallium	mg/kg	267	14.61%	0.17	2.5	2AU-13	0.90	0.82	0.49
METAL	Vanadium	mg/kg	42	100.00%	37	120	RMS26	77.54	81.50	15.74
METAL	Zinc	mg/kg	276	100.00%	18	4,200	MS16	418.13	260.00	503.23
PCB	Aroclor-1016	mg/kg	245	0.00%	ND	ND	ND	ND	ND	ND
PCB	Aroclor-1221	mg/kg	245	0.00%	ND	ND	ND	ND	ND	ND
PCB	Aroclor-1232	mg/kg	245	0.00%	ND	ND	ND	ND	ND	ND
PCB	Aroclor-1242	mg/kg	245	3.27%	0.02	11	SM182	1.62	0.37	3.55
PCB	Aroclor-1248	mg/kg	245	74.69%	0.015	65	MS22	2.69	0.45	7.29
PCB	Aroclor-1254	mg/kg	245	43.27%	0.017	25	MS22	0.87	0.26	2.60
PCB	Aroclor-1260	mg/kg	245	39.18%	0.011	3.5	MS22	0.18	0.06	0.43
PCB	Aroclor-1262	mg/kg	14	0.00%	ND	ND	ND	ND	ND	ND
PCB	PCB-101	mg/kg	11	100.00%	0.0078	0.22	SM140	0.06	0.04	0.06
PCB	PCB-105	mg/kg	11	81.82%	0.014	0.15	SM140	0.04	0.02	0.04
PCB	PCB-114	mg/kg	11	81.82%	0.0005	0.009	SM140	0.00	0.00	0.00

Table 15 Summary Statistics for the Western Stege Marsh and Meeker Slough Sediment (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent Detections/ Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration
PCB	PCB-118	mg/kg	11	90.91%	0.016	0.27	SM140	0.06	0.03	0.07
PCB	PCB-123	mg/kg	11	0.00%	ND	ND	ND	ND	ND	ND
PCB	PCB-126	mg/kg	11	0.00%	ND	ND	ND	ND	ND	ND
PCB	PCB-128	mg/kg	11	81.82%	0.0015	0.015	SM140	0.00	0.00	0.00
PCB	PCB-138	mg/kg	11	81.82%	0.0083	0.077	SM140	0.02	0.02	0.02
PCB	PCB-153	mg/kg	11	90.91%	0.0063	0.071	SM140	0.02	0.01	0.02
PCB	PCB-156	mg/kg	11	63.64%	0.0016	0.012	SM140	0.00	0.00	0.00
PCB	PCB-157	mg/kg	11	0.00%	ND	ND	ND	ND	ND	ND
PCB	PCB-158	mg/kg	11	0.00%	ND	ND	ND	ND	ND	ND
PCB	PCB-166	mg/kg	11	18.18%	0.0058	0.0067	MS11	0.00	0.00	0.00
PCB	PCB-167	mg/kg	11	9.09%	0.00069	0.00069	MS13	0.00	0.00	0.00
PCB	PCB-169	mg/kg	11	9.09%	0.00025	0.00025	MS1	0.00	0.00	0.00
PCB	PCB-170	mg/kg	11	81.82%	0.0016	0.022	SM140	0.01	0.00	0.01
PCB	PCB-18	mg/kg	11	100.00%	0.0086	1.5	SM140	0.19	0.04	0.42
PCB	PCB-180	mg/kg	11	90.91%	0.0036	0.054	SM140	0.01	0.01	0.01
PCB	PCB-183	mg/kg	11	72.73%	0.00093	0.012	SM140	0.00	0.00	0.00
PCB	PCB-184	mg/kg	11	0.00%	ND	ND	ND	ND	ND	ND
PCB	PCB-187	mg/kg	11	90.91%	0.0025	0.032	SM140	0.01	0.01	0.01
PCB	PCB-189	mg/kg	11	27.27%	0.000087	0.00036	SM158	0.00	0.00	0.00
PCB	PCB-195	mg/kg	11	90.91%	0.00031	0.0041	SM140	0.00	0.00	0.00
PCB	PCB-206	mg/kg	11	72.73%	0.00051	0.0054	SM158	0.00	0.00	0.00
PCB	PCB-28	mg/kg	11	100.00%	0.013	1.1	SM140	0.16	0.05	0.30
PCB	PCB-44	mg/kg	11	100.00%	0.019	0.55	SM140	0.12	0.07	0.15
PCB	PCB-52	mg/kg	11	100.00%	0.028	1.2	SM140	0.20	0.09	0.32
PCB	PCB-60	mg/kg	11	0.00%	ND	ND	ND	ND	ND	ND
PCB	PCB-66	mg/kg	11	100.00%	0.022	0.89	SM140	0.19	0.12	0.24
PCB	PCB-77	mg/kg	11	0.00%	ND	ND	ND	ND	ND	ND
PCB	PCB-8	mg/kg	11	100.00%	0.00087	0.17	SM140	0.02	0.01	0.05
PCB	PCB-81	mg/kg	11	0.00%	ND	ND	ND	ND	ND	ND
PCB	PCB-87	mg/kg	11	63.64%	0.015	0.12	SM140	0.03	0.02	0.03
PCB	PCB-90	mg/kg	11	0.00%	ND	ND	ND	ND	ND	ND
PCB	Total Aroclor	mg/kg	245	79.59%	0.015	93.5	MS22	3.15	0.60	8.84
PCB	Total PCBs	mg/kg	11	100.00%	0.36356	12.9588	SM140	2.34	1.26	3.46
PEST	4,4'-DDD	mg/kg	103	11.65%	0.004	0.083	SM165	0.02	0.01	0.02
PEST	4,4'-DDE	mg/kg	103	13.59%	0.0042	0.49	MS22	0.08	0.03	0.12

Table 15 Summary Statistics for the Western Stege Marsh and Meeker Slough Sediment (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent Detections/ Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration
PEST	4,4'-DDT	mg/kg	103	16.50%	0.0069	20	M1A-CONF-2	1.22	0.03	4.70
PEST	4,4'-Methoxychlor	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
PEST	Aldrin	mg/kg	101	0.99%	0.11	0.11	SM165	0.11	0.11	0.00
PEST	alpha-BHC	mg/kg	103	1.94%	0.002	0.0028	SM140	0.00	0.00	0.00
PEST	alpha-Chlordane	mg/kg	90	12.22%	0.0023	0.12	MS22	0.03	0.01	0.04
PEST	beta-BHC	mg/kg	103	1.94%	0.0049	0.005	MS4	0.00	0.00	0.00
PEST	Butylate	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
PEST	Chlordane	mg/kg	20	0.00%	ND	ND	ND	ND	ND	ND
PEST	Cycloate	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
PEST	delta-BHC	mg/kg	103	2.91%	0.001	79	M1A-CONF-2	26.33	0.00	37.24
PEST	Dieldrin	mg/kg	103	2.91%	0.01	0.8	MS22	0.32	0.14	0.35
PEST	Endosulfan I	mg/kg	101	4.95%	0.0022	0.0064	SM145	0.00	0.01	0.00
PEST	Endosulfan II	mg/kg	101	0.99%	0.0044	0.0044	MS1	0.00	0.00	0.00
PEST	Endosulfan sulfate	mg/kg	101	2.97%	0.00058	0.0009	SM158	0.00	0.00	0.00
PEST	Endrin	mg/kg	103	1.94%	0.0015	0.0065	SED101	0.00	0.00	0.00
PEST	Endrin aldehyde	mg/kg	101	1.98%	0.0014	0.0038	SM139	0.00	0.00	0.00
PEST	Endrin ketone	mg/kg	28	3.57%	0.0018	0.0018	SM158	0.00	0.00	0.00
PEST	EPTC	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
PEST	Fonofos	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
PEST	gamma-BHC (lindane)	mg/kg	103	2.91%	0.022	0.39	MS22	0.15	0.04	0.17
PEST	gamma-Chlordane	mg/kg	90	15.56%	0.0041	0.15	MS22	0.03	0.02	0.04
PEST	Heptachlor	mg/kg	103	0.00%	ND	ND	ND	ND	ND	ND
PEST	Heptachlor epoxide	mg/kg	103	3.88%	0.0047	0.63	SM180	0.28	0.24	0.28
PEST	Methoxychlor	mg/kg	98	3.06%	0.0016	0.012	SM139	0.01	0.00	0.00
PEST	Mirex	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND
PEST	Molinate	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
PEST	Napropamide	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
PEST	Pebulate	mg/kg	8	12.50%	0.14	0.14	SM172	0.14	0.14	0.00
PEST	Total chlordanes	mg/kg	103	18.45%	0.0073	0.63	SM180	0.10	0.03	0.17
PEST	Total DDTs	mg/kg	103	22.33%	0.0148	20	M1A-CONF-2	0.96	0.07	4.06
PEST	Toxaphene	mg/kg	101	0.00%	ND	ND	ND	ND	ND	ND
PEST	Vernolate	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND
TPHEXT	Diesel Range Organics	mg/kg	1	100.00%	760	760	MS10	760.00	760.00	NA
TPHEXT	Motor Oil Range Organics	mg/kg	1	100.00%	1300	1300	MS10	1300.00	1300.00	NA
ANION	Sulfate	mg/kg	1	100.00%	1100	1100	SM110	1100.00	1100.00	NA

Table 15 Summary Statistics for the Western Stege Marsh and Meeker Slough Sediment (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent Detections/ Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration
ORGAN	Organotin	mg/kg	11	0.00%	ND	ND	ND	ND	ND	ND
PH	pH	PH	208	100.00%	4.1	9.4	SM142	7.54	7.50	0.74
TOC	TOC	mg/kg	26	100.00%	200	110000	MS20	26861.54	22800.00	23640.07

Notes:

BHC	Benzene hexachloride
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
mg/kg	Milligram per kilogram
NA	Not availavle
ND	Not detected
ORGAN	Organotins
PCB	Polychlorinated biphenyl
PEST	Pesticides
TPHEXT	Total petroleum hydrocarbons as extractables
TOC	Total organic carbon

Table 16 Comparison of Chemicals to Criteria for the Western Stege Marsh and Meeker Slough Sediment Data
Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent Detections/ Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration	National ER-L Value	Percent of Detects Greater than National ER-L Value	SF Bay Ambient Sediment Concentration (less than 100% fines)	Percent of Detects Greater than SF Bay Ambient Sediment Concentration
METAL	Antimony	mg/kg	267	14.61%	0.23	22	RMS26	5.71	5.40	4.91	NA	NA	NA	NA
METAL	Arsenic	mg/kg	276	97.83%	1.6	590	RMS18	63.52	21.00	99.11	8.2	85.56%	15.3	67.78%
METAL	Beryllium	mg/kg	267	94.76%	0.11	1.45	M3-CONF-4	0.52	0.52	0.22	NA	NA	NA	NA
METAL	Cadmium	mg/kg	276	88.77%	0.18	30	MS16	4.27	2.80	4.36	1.2	74.29%	0.33	99.59%
METAL	Chromium	mg/kg	276	100.00%	12	190	RMS26	71.53	74.50	29.50	81	42.03%	112	4.35%
METAL	Copper	mg/kg	276	100.00%	6.1	1,500	MS16	172.06	93.00	218.90	34	82.61%	68.1	69.57%
METAL	Lead	mg/kg	276	100.00%	2.5	560	MS22	93.56	69.00	90.01	46.7	66.67%	43.2	69.20%
METAL	Mercury	mg/kg	288	98.61%	0.049	100	MS16	6.84	1.50	14.19	0.15	93.31%	0.43	87.32%
METAL	Nickel	mg/kg	267	100.00%	17	140	SM166	72.28	77.00	23.88	20.9	99.63%	112	2.62%
METAL	Selenium	mg/kg	276	66.30%	0.24	21	SM161	2.89	1.40	3.51	NA	NA	0.64	82.51%
METAL	Silver	mg/kg	267	29.59%	0.3	5.3	MS22	1.00	0.84	0.74	1	34.18%	0.58	74.68%
METAL	Thallium	mg/kg	267	14.61%	0.17	2.5	2AU-13	0.90	0.82	0.49	NA	NA	NA	NA
METAL	Zinc	mg/kg	276	100.00%	18	4,200	MS16	418.13	260.00	503.23	150	74.64%	158	74.64%
PCB	Aroclor-1016	mg/kg	245	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PCB	Aroclor-1221	mg/kg	245	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PCB	Aroclor-1232	mg/kg	245	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PCB	Aroclor-1242	mg/kg	245	3.27%	0.02	11	SM182	1.62	0.37	3.55	NA	NA	NA	NA
PCB	Aroclor-1248	mg/kg	245	74.69%	0.015	65	MS22	2.69	0.45	7.29	NA	NA	NA	NA
PCB	Aroclor-1254	mg/kg	245	43.27%	0.017	25	MS22	0.87	0.26	2.60	NA	NA	NA	NA
PCB	Aroclor-1260	mg/kg	245	39.18%	0.011	3.5	MS22	0.18	0.06	0.43	NA	NA	NA	NA
PCB	Aroclor-1262	mg/kg	14	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PCB	Total Aroclors	mg/kg	245	79.59%	0.015	93.5	MS22	3.15	0.60	8.84	0.0227	98.46%	NA	NA
PEST	4,4'-DDD	mg/kg	103	11.65%	0.004	0.083	SM165	0.02	0.01	0.02	NA	NA	NA	NA
PEST	4,4'-DDE	mg/kg	103	13.59%	0.0042	0.49	MS22	0.08	0.03	0.12	0.0022	100.00%	NA	NA
PEST	4,4'-DDT	mg/kg	103	16.50%	0.0069	20	M1A-CONF-2	1.22	0.03	4.70	NA	NA	NA	NA
PEST	alpha-BHC	mg/kg	103	1.94%	0.002	0.0028	SM140	0.00	0.00	0.00	NA	NA	NA	NA
PEST	alpha-Chlordane	mg/kg	90	12.22%	0.0023	0.12	MS22	0.03	0.01	0.04	NA	NA	NA	NA
PEST	beta-BHC	mg/kg	103	1.94%	0.0049	0.005	MS4	0.00	0.00	0.00	NA	NA	NA	NA
PEST	Chlordane	mg/kg	20	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PEST	delta-BHC	mg/kg	103	2.91%	0.001	79	M1A-CONF-2	26.33	0.00	37.24	NA	NA	NA	NA
PEST	Dieldrin	mg/kg	103	2.91%	0.01	0.8	MS22	0.32	0.14	0.35	NA	NA	0.00044	100.00%
PEST	Endrin	mg/kg	103	1.94%	0.0015	0.0065	SED101	0.00	0.00	0.00	NA	NA	NA	NA
PEST	gamma-BHC (lindane)	mg/kg	103	2.91%	0.022	0.39	MS22	0.15	0.04	0.17	NA	NA	NA	NA
PEST	gamma-Chlordane	mg/kg	90	15.56%	0.0041	0.15	MS22	0.03	0.02	0.04	NA	NA	NA	NA
PEST	Heptachlor	mg/kg	103	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PEST	Heptachlor epoxide	mg/kg	103	3.88%	0.0047	0.63	SM180	0.28	0.24	0.28	NA	NA	NA	NA
PEST	Total chlordanes	mg/kg	103	18.45%	0.0073	0.63	SM180	0.10	0.03	0.17	NA	NA	0.0011	100.00%
PEST	Total DDTs	mg/kg	103	22.33%	0.0148	20	M1A-CONF-2	0.96	0.07	4.06	0.00158	100.00%	0.007	100.00%

Notes

BHC	Benzene hexachloride	NA	Not applicable
DDD	Dichlorodiphenyldichloroethane	ND	Not detected
DDE	Dichlorodiphenyldichloroethene	PCB	Polychlorinated biphenyl
DDT	Dichlorodiphenyltrichloroethane	PEST	Pesticide
ER-L	Effects-range low	SF	San Francisco
mg/kg	Milligram per kilogram		

Table 17 Comparison of Chemicals to Criteria for the Western Stege Marsh and Meeker Slough Sediment Data for Samples Collected from 0 to 0.5 feet bgs
Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent Detections/ Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration	National ER-L Value	Percent of Detects Greater than National ER-L Value	SF Bay Ambient Sediment Concentration (less than 100% fines)	Percent of Detects Greater than SF Bay Ambient Sediment Concentration
METAL	Antimony	mg/kg	145	17.93%	0.23	22	RMS26	5.67	2.95	5.88	NA	NA	NA	NA
METAL	Arsenic	mg/kg	146	100.00%	1.6	590	RMS18	42.45	20.00	76.90	8.2	93.84%	15.3	74.66%
METAL	Beryllium	mg/kg	145	97.93%	0.18	1.4	SM172	0.61	0.60	0.20	NA	NA	NA	NA
METAL	Cadmium	mg/kg	146	87.67%	0.18	21	SM152	3.00	1.60	3.20	1.2	57.81%	0.33	99.22%
METAL	Chromium	mg/kg	146	100.00%	12	190	RMS26	80.09	82.00	23.77	81	52.05%	112	3.42%
METAL	Copper	mg/kg	146	100.00%	13	900	RMS26	114.62	89.00	110.93	34	97.26%	68.1	77.40%
METAL	Lead	mg/kg	146	100.00%	9.6	560	MS22	86.58	69.00	73.93	46.7	73.97%	43.2	77.40%
METAL	Mercury	mg/kg	157	98.73%	0.051	69	MS15	2.82	1.26	6.96	0.15	99.35%	0.43	94.84%
METAL	Nickel	mg/kg	145	100.00%	23	140	SM166	80.08	82.00	19.72	20.9	100.00%	112	3.45%
METAL	Selenium	mg/kg	146	57.53%	0.24	8.8	WATERSHED-11	1.79	1.20	1.81	NA	NA	0.64	82.14%
METAL	Silver	mg/kg	145	17.24%	0.3	1.9	MS15	0.69	0.51	0.40	1	12.00%	0.58	40.00%
METAL	Thallium	mg/kg	145	15.86%	0.17	1.6	RMS18, RMS26, SM106	0.79	0.66	0.45	NA	NA	NA	NA
METAL	Zinc	mg/kg	146	100.00%	40	1,800	MS15	318.74	240.00	266.90	150	84.93%	158	84.93%
PCB	Aroclor-1016	mg/kg	154	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PCB	Aroclor-1221	mg/kg	154	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PCB	Aroclor-1232	mg/kg	154	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PCB	Aroclor-1242	mg/kg	154	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PCB	Aroclor-1248	mg/kg	154	85.71%	0.028	39	SM138	2.03	0.49	5.48	NA	NA	NA	NA
PCB	Aroclor-1254	mg/kg	154	49.35%	0.034	4.9	MS34	0.62	0.29	0.97	NA	NA	NA	NA
PCB	Aroclor-1260	mg/kg	154	40.26%	0.011	0.69	MS22	0.09	0.05	0.12	NA	NA	NA	NA
PCB	Aroclor-1262	mg/kg	5	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PCB	Total Aroclors	mg/kg	154	85.71%	0.028	39	SM138	2.43	0.63	5.79	0.0227	100.00%	NA	NA
PEST	4,4'-DDD	mg/kg	69	14.49%	0.004	0.029	MS11	0.01	0.01	0.01	NA	NA	NA	NA
PEST	4,4'-DDE	mg/kg	69	15.94%	0.0042	0.13	MS23	0.05	0.03	0.05	0.0022	100.00%	NA	NA
PEST	4,4'-DDT	mg/kg	69	20.29%	0.0069	0.11	SM139	0.03	0.02	0.03	NA	NA	NA	NA
PEST	alpha-BHC	mg/kg	69	2.90%	0.002	0.0028	SM140	0.00	0.00	0.00	NA	NA	NA	NA
PEST	alpha-Chlordane	mg/kg	64	14.06%	0.0023	0.12	MS22	0.03	0.01	0.04	NA	NA	NA	NA
PEST	beta-BHC	mg/kg	69	1.45%	0.0049	0.0049	MS28	0.00	0.00	0.00	NA	NA	NA	NA
PEST	Chlordane	mg/kg	8	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PEST	delta-BHC	mg/kg	69	2.90%	0.001	0.002	SM153	0.00	0.00	0.00	NA	NA	NA	NA
PEST	Dieldrin	mg/kg	69	1.45%	0.01	0.01	SM176	0.01	0.01	0.00	NA	NA	0.00044	100.00%
PEST	Endrin	mg/kg	69	2.90%	0.0015	0.0065	SED101	0.00	0.00	0.00	NA	NA	NA	NA
PEST	gamma-BHC (lindane)	mg/kg	69	1.45%	0.022	0.022	MS35	0.02	0.02	0.00	NA	NA	NA	NA
PEST	gamma-Chlordane	mg/kg	64	20.31%	0.0041	0.15	MS22	0.03	0.02	0.04	NA	NA	NA	NA
PEST	Heptachlor	mg/kg	69	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PEST	Heptachlor epoxide	mg/kg	69	2.90%	0.0047	0.47	MS35	0.24	0.24	0.23	NA	NA	NA	NA
PEST	Total chlordanes	mg/kg	69	23.19%	0.0073	0.47	MS35	0.07	0.02	0.12	NA	NA	0.0011	100.00%
PEST	Total DDTs	mg/kg	69	24.64%	0.0148	0.203	MS23	0.06	0.05	0.05	0.00158	100.00%	0.007	100.00%

Notes

bgs	Below ground surface	mg/kg	Milligram per kilogram
BHC	Benzene hexachloride	NA	Not applicable
DDD	Dichlorodiphenyldichloroethane	ND	Not detected
DDE	Dichlorodiphenyldichloroethene	PCB	Polychlorinated biphenyl
DDT	Dichlorodiphenyltrichloroethane	PEST	Pesticide
ER-L	Effects-range low	SF	San Francisco

Table 18 Comparison of Chemicals to Criteria for the Western Stege Marsh and Meeker Slough Sediment Data for Samples Collected from 0.5 to 2.5 feet bgs
Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent Detections/ Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration	National ER-L Value	Percent of Detects Greater than National ER-L Value	SF Bay Ambient Sediment Concentration (less than 100% fines)	Percent of Detects Greater than SF Bay Ambient Sediment Concentration
METAL	Antimony	mg/kg	46	19.57%	3.6	9.1	SM161	6.26	5.60	1.80	NA	NA	NA	NA
METAL	Arsenic	mg/kg	54	92.59%	4.6	520	MS16	126.28	99.50	116.44	8.2	96.00%	15.3	86.00%
METAL	Beryllium	mg/kg	46	100.00%	0.16	0.69	SM159	0.46	0.45	0.14	NA	NA	NA	NA
METAL	Cadmium	mg/kg	54	100.00%	0.57	30	MS16	7.33	5.30	5.68	1.2	98.15%	0.33	100.00%
METAL	Chromium	mg/kg	54	100.00%	20	180	MS4	81.06	86.00	30.64	81	55.56%	112	11.11%
METAL	Copper	mg/kg	54	100.00%	7.8	1,500	MS16	351.88	255.00	318.45	34	92.59%	68.1	85.19%
METAL	Lead	mg/kg	54	100.00%	3.6	490	SM134	164.78	140.00	111.43	46.7	88.89%	43.2	90.74%
METAL	Mercury	mg/kg	54	100.00%	0.082	100	MS16	15.37	5.05	21.36	0.15	96.30%	0.43	92.59%
METAL	Nickel	mg/kg	46	100.00%	25	120	SM140, SM180	75.28	75.00	24.42	20.9	100.00%	112	4.35%
METAL	Selenium	mg/kg	54	75.93%	0.67	21	SM161	5.56	4.90	4.74	NA	NA	0.64	100.00%
METAL	Silver	mg/kg	46	73.91%	0.37	5.3	MS22	1.21	1.05	0.97	1	50.00%	0.58	88.24%
METAL	Thallium	mg/kg	46	6.52%	0.63	1.2	SM102	0.98	1.10	0.25	NA	NA	NA	NA
METAL	Zinc	mg/kg	54	100.00%	29	4,200	MS16	824.44	610.00	809.97	150	88.89%	158	88.89%
PCB	Aroclor-1016	mg/kg	46	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PCB	Aroclor-1221	mg/kg	46	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PCB	Aroclor-1232	mg/kg	46	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PCB	Aroclor-1242	mg/kg	46	6.52%	0.042	11	SM182	3.81	0.38	5.09	NA	NA	NA	NA
PCB	Aroclor-1248	mg/kg	46	71.74%	0.015	65	MS22	5.40	0.60	12.04	NA	NA	NA	NA
PCB	Aroclor-1254	mg/kg	46	34.78%	0.033	25	MS22	2.45	0.18	6.05	NA	NA	NA	NA
PCB	Aroclor-1260	mg/kg	46	50.00%	0.021	3.5	MS22	0.40	0.14	0.76	NA	NA	NA	NA
PCB	Aroclor-1262	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PCB	Total Aroclors	mg/kg	46	82.61%	0.015	93.5	MS22	6.26	0.63	15.83	0.0227	97.37%	NA	NA
PEST	4,4'-DDD	mg/kg	16	6.25%	0.012	0.012	MS4	0.01	0.01	0.00	NA	NA	NA	NA
PEST	4,4'-DDE	mg/kg	16	18.75%	0.015	0.49	MS22	0.20	0.09	0.21	0.0022	100.00%	NA	NA
PEST	4,4'-DDT	mg/kg	16	6.25%	0.15	0.15	SM180	0.15	0.15	0.00	NA	NA	NA	NA
PEST	alpha-BHC	mg/kg	16	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PEST	alpha-Chlordane	mg/kg	13	15.38%	0.005	0.11	MS22	0.06	0.06	0.05	NA	NA	NA	NA
PEST	beta-BHC	mg/kg	16	6.25%	0.005	0.005	MS4	0.01	0.01	0.00	NA	NA	NA	NA
PEST	Chlordane	mg/kg	3	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PEST	delta-BHC	mg/kg	16	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PEST	Dieldrin	mg/kg	16	6.25%	0.8	0.8	MS22	0.80	0.80	0.00	NA	NA	0.00044	100.00%
PEST	Endrin	mg/kg	16	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PEST	gamma-BHC (lindane)	mg/kg	16	12.50%	0.035	0.39	MS22	0.21	0.21	0.18	NA	NA	NA	NA
PEST	gamma-Chlordane	mg/kg	13	7.69%	0.0056	0.0056	MS4	0.01	0.01	0.00	NA	NA	NA	NA
PEST	Heptachlor	mg/kg	16	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PEST	Heptachlor epoxide	mg/kg	16	12.50%	0.0079	0.63	SM180	0.32	0.32	0.31	NA	NA	NA	NA
PEST	Total chlordanes	mg/kg	16	18.75%	0.0185	0.63	SM180	0.25	0.11	0.27	NA	NA	0.0011	100.00%
PEST	Total DDTs	mg/kg	16	18.75%	0.027	0.49	MS22	0.25	0.24	0.19	0.00158	100.00%	0.007	100.00%

Notes

bgs	Below ground surface	mg/kg	Milligram per kilogram
BHC	Benzene hexachloride	NA	Not applicable
DDD	Dichlorodiphenyldichloroethane	ND	Not detected
DDE	Dichlorodiphenyldichloroethene	PCB	Polychlorinated biphenyl
DDT	Dichlorodiphenyltrichloroethane	PEST	Pesticide
ER-L	Effects-range low	SF	San Francisco

Table 19 Comparison of Chemicals to Criteria for the Western Stege Marsh and Meeker Slough Sediment Data for Samples Collected from 2.5 to 5 feet bgs
Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent Detections/ Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration	National ER-L Value	Percent of Detects Greater than National ER-L Value	SF Bay Ambient Sediment Concentration (less than 100% fines)	Percent of Detects Greater than SF Bay Ambient Sediment Concentration
METAL	Antimony	mg/kg	58	6.90%	3	6.3	MS5	4.68	4.70	1.33	NA	NA	NA	NA
METAL	Arsenic	mg/kg	58	100.00%	2.6	500	MS5	61.45	14.50	97.49	8.2	68.97%	15.3	44.83%
METAL	Beryllium	mg/kg	58	84.48%	0.11	1.45	M3-CONF-4	0.37	0.35	0.24	NA	NA	NA	NA
METAL	Cadmium	mg/kg	58	81.03%	0.84	14	SM140	3.97	3.20	2.57	1.2	91.49%	0.33	100.00%
METAL	Chromium	mg/kg	58	100.00%	17	150	SM182	48.72	40.50	27.82	81	15.52%	112	1.72%
METAL	Copper	mg/kg	58	100.00%	6.1	730	SM166	150.15	40.50	193.43	34	51.72%	68.1	46.55%
METAL	Lead	mg/kg	58	100.00%	3	230	SM182	60.06	22.00	68.59	46.7	41.38%	43.2	43.10%
METAL	Mercury	mg/kg	58	96.55%	0.071	98	MS22	10.43	2.30	16.94	0.15	82.14%	0.43	71.43%
METAL	Nickel	mg/kg	58	100.00%	17	100	SM143	54.83	56.00	23.80	20.9	98.28%	112	0.00%
METAL	Selenium	mg/kg	58	77.59%	0.27	16	SM182	2.68	0.96	3.35	NA	NA	0.64	75.56%
METAL	Silver	mg/kg	58	27.59%	0.32	2	B7-CONF-2	0.94	0.84	0.38	1	25.00%	0.58	93.75%
METAL	Thallium	mg/kg	58	12.07%	0.7	1.4	M3-CONF-4, SM102, SM106	1.13	1.30	0.30	NA	NA	NA	NA
METAL	Zinc	mg/kg	58	100.00%	18	1,700	SM166	290.10	98.50	353.85	150	44.83%	158	44.83%
PCB	Aroclor-1016	mg/kg	39	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PCB	Aroclor-1221	mg/kg	39	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PCB	Aroclor-1232	mg/kg	39	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PCB	Aroclor-1242	mg/kg	39	12.82%	0.02	0.56	MS1	0.31	0.35	0.23	NA	NA	NA	NA
PCB	Aroclor-1248	mg/kg	39	38.46%	0.017	26	SM143	3.08	0.28	6.58	NA	NA	NA	NA
PCB	Aroclor-1254	mg/kg	39	35.90%	0.017	3.5	SM165	0.41	0.10	0.88	NA	NA	NA	NA
PCB	Aroclor-1260	mg/kg	39	25.64%	0.038	1.4	SM143	0.27	0.09	0.40	NA	NA	NA	NA
PCB	Aroclor-1262	mg/kg	4	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PCB	Total Aroclors	mg/kg	39	56.41%	0.017	27.4	SM143	2.55	0.40	6.08	0.0227	90.91%	NA	NA
PEST	4,4'-DDD	mg/kg	16	6.25%	0.083	0.083	SM165	0.08	0.08	0.00	NA	NA	NA	NA
PEST	4,4'-DDE	mg/kg	16	0.00%	ND	ND	ND	ND	ND	ND	0.0022	ND	NA	ND
PEST	4,4'-DDT	mg/kg	16	12.50%	0.083	20	M1A-CONF-2	10.04	10.04	9.96	NA	NA	NA	NA
PEST	alpha-BHC	mg/kg	16	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PEST	alpha-Chlordane	mg/kg	12	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PEST	beta-BHC	mg/kg	16	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PEST	Chlordane	mg/kg	7	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PEST	delta-BHC	mg/kg	16	6.25%	79	79	M1A-CONF-2	79.00	79.00	0.00	NA	NA	NA	NA
PEST	Dieldrin	mg/kg	16	6.25%	0.14	0.14	SM165	0.14	0.14	0.00	NA	NA	0.00044	100.00%
PEST	Endrin	mg/kg	16	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PEST	gamma-BHC (lindane)	mg/kg	16	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PEST	gamma-Chlordane	mg/kg	12	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PEST	Heptachlor	mg/kg	16	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PEST	Heptachlor epoxide	mg/kg	16	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
PEST	Total chlordanes	mg/kg	16	0.00%	ND	ND	ND	ND	ND	ND	NA	ND	0.0011	ND
PEST	Total DDTs	mg/kg	16	18.75%	0.083	20	M1A-CONF-2	6.72	0.08	9.39	0.00158	100.00%	0.007	100.00%

Notes

bgs	Below ground surface	mg/kg	Milligram per kilogram
BHC	Benzene hexachloride	NA	Not applicable
DDD	Dichlorodiphenyldichloroethane	ND	Not detected
DDE	Dichlorodiphenyldichloroethene	PCB	Polychlorinated biphenyl
DDT	Dichlorodiphenyltrichloroethane	PEST	Pesticide
ER-L	Effects-range low	SF	San Francisco

Table 20 Surface Water Screening Criteria for the Protection of Aquatic Life

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

				California Toxics Rule Criteria for Enclosed Bays and Estuaries[e] (µg/L)								National Recommended Water Quality Criteria[k] (µg/L)						National Ambient Water Quality Criteria (AWQC) for Protection of Saltwater Aquatic Life[l] (µg/L)								
												Saltwater Aquatic Life						Lowest Observed Effect Level (LOEL)								
		San Francisco Bay Basin Plan[a] (µg/L)		Chronic[g]		Acute[g]			Instantaneous Maximum			Chronic[g]		Acute[g]				Chronic[h]		Acute[i]				Other[j]		
Chemical	Pseudonym	Conc.	Footnotes	Conc.	Footnotes	Conc.	20 Percent of Conc.[f]	Footnotes	Conc.	10 Percent of Conc.[f]	Footnotes	Conc.	Footnotes	Conc.	20 Percent of Conc.[f]	DTSC-Recommended Screening Value[n]	Footnotes	Conc.	Footnotes	Conc.	20 Percent of Conc.[f]	DTSC-Recommended Screening Value[n]	Footnotes	Conc.	Footnotes	Selected Toxicity Screening Criteria (µg/L)
Arsenic		36	b	36	(1, 4), ii, kk	69	--	(1, 4), ii, kk	--	--	--	36	A,B,bb	69	--	--	A,B,bb	--	--	2,319	--	--	(3)	13	(2)	36
Cadmium		9.3	b	9.3	(1, 4)	42	--	(1, 4)	--	--	--	8.8	B,bb,gg	40	--	--	B,bb,gg	--	--	--	--	--	--	--	--	8.8
Chromium (total)		50 (VI)	b,m	50 (VI)	m	1100 (VI)	--	--	--	--	--	50 (VI)	B,bb,m	1100 (VI)	--	--	B,bb,m	--	--	--	--	--	--	--	--	50
Copper		4.9	c	3.1	(1, 4), jj, kk	4.8	--	(1, 4), jj, kk	--	--	--	3.1	B,cc,ff	4.8	--	--	B,cc,ff	--	--	--	--	--	--	--	--	3.1
Lead		5.6	b	8.1	(1, 4), m	210	--	(1, 4), l	--	--	--	8.1	B,bb	210	--	--	B,bb	--	--	--	--	--	--	--	--	5.6
Mercury	Mercury, inorganic	0.025	b	--	--	--	--	--	--	--	--	0.94	B,ee,hh	1.8	--	--	B,ee,hh	--	--	--	--	--	--	--	--	0.025
Nickel		8.3	b	8.2	(2, 4), kk	74	--	(1, 4), kk	--	--	--	8.2	B,bb	74	--	--	B,bb	--	--	--	--	--	--	--	--	8.2
Selenium		--	--	71	(1, 4)	290	--	(1, 4)	--	--	--	71	B,bb,dd	290	--	--	B,bb,dd	--	--	--	--	--	--	--	--	71
Silver		2.3	d	--	--	1.9	--	(1, 4)	--	--	--	--	--	1.9	0.38	0.19	B,C	--	--	--	--	--	--	--	--	0.19
Thallium		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,130	426	1,065	--	--	--	426
Zinc		58	c	81	(1, 4), ii, kk	90	--	(4), ii, kk	--	--	--	81	B,bb	90	--	--	B,bb	--	--	--	--	--	--	--	--	81
Aroclor-1248	Polychlorinated biphenyls (PCBs)	--	--	0.03	(5, 6) ll	--	--	--	--	--	--	0.03	aa	--	--	--	--	--	--	10	--	--	--	--	--	.03
Aroclor-1260	Polychlorinated biphenyls (PCBs)	--	--	0.03	(5, 6) ll	--	--	--	--	--	--	0.03	aa	--	--	--	--	--	--	10	--	--	--	--	--	.03

Notes:
Values shaded are those selected as screening criteria.

µg/L Microgram per liter
-- No criterion available
AWCG Ambient Water Quality Criteria
conc. Concentration
DTSC Department of Toxic Substance Control
LOEL Lowest observed effect level

Footnotes:

a California Environmental Protection Agency, Regional Water Quality Control Board, San Francisco Bay Area Region (Water Board). 1995. "San Francisco Bay Basin Plan Water Quality Control Plan." June 21. Table 3-3 Water Quality Objectives for Toxic Pollutants for Surface Water With Salinities Greater Than 5 Parts Per Billion.

b From Water Board "Basin Plan" 4-Day Average (Chronic).

c From Water Board "Basin Plan" 24-Hour and 1-Hour Average (Acute).

d From Water Board "Basin Plan" Instantaneous Maximum.

e From "Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California" (CTR) (EPA 2000) and "Water Quality Control Plan, San Francisco Bay Basin Region" (Water Board 1995). The most appropriate criteria were used.

f Criterion made more suitably protective by means of standard convention of lowering acute values by 80 percent and instantaneous values by 90 percent to make them more appropriate for use under chronic exposure scenarios.

g An acute criterion (EPA identified as Criteria Maximum Concentration [CMC]) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect. The chronic concentration (EPA identified as Criterion Continuous Concentration [CCC]) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect. The CMC and CCC are just two if the six parts of an aquatic life criterion; the other four parts are the acute averaging period, chronic averaging period, acute frequency of allowed exceedence, and chronic frequency of allowed exceedence. Because 304(a) aquatic life criteria are national guidance, they are intended to be protective of the vast majority of the aquatic communities in the United States (EPA 2002a).

h EPA National "AWQC Lowest Observed Effect Level (Chronic)" (Water Board 2000).

i EPA National "AWQC Lowest Observed Effect Level (Acute)" (Water Board 2000).

j EPA National "AWQC Lowest Observed Effect Level (Other)" (Water Board 2000).

k From "National Recommended Water Quality Criteria: 2002" (EPA 2002a) and "Revision of National Recommended Water Quality Criteria." (EPA 2002b), unless otherwise noted.

l In instances where criteria from "Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California" (EPA 2000) refer to the "Water Quality Control Plan, San Francisco Bay Basin Region" (Water Board 1995), Water Board 1995 criteria were used. The Water Board 1995 criteria are distinguished by an "m" in the footnote column.

m Detailed application of this toxicity criterion may require the review and/or summation of analyte isomer, congener, or speciation results, as applicable. Please see applicable regulatory agency source document for additional detail.

n Derived using uncertainty factors (UF) from DTSC (For acute values: divide acute LOAEL by 10 to get a chronic LOAEL).

The following lettered footnotes are derived from EPA "National Recommended Water Quality Criteria: 2002" (EPA 2002b), Table 1 - Priority Toxic Pollutants:

A This recommended water quality criterion was derived from data for arsenic (III), but is applied here to total arsenic, which might imply that arsenic (III) and arsenic (V) are equally toxic to aquatic life and that their toxicities are additive. In the arsenic criteria document (EAP 440/5-84-033, January 1985), Species Mean Acute Values (SMAVs) are given for both arsenic (III) and arsenic (V) for five species, and the ratios of the SMAVs for each species range from 0.6 to 1.7. Chronic values are available for both arsenic (III) and arsenic (V) for one species; for the fathead minnow, the chronic value for arsenic (V) is 0.29 times the chronic value for arsenic (III). No data are known to be available concerning whether the toxicities of the forms of arsenic to aquatic organisms are additive.

B Freshwater and saltwater criteria for metals are expressed in terms of the dissolved metal in the water column. The recommended water quality criteria value was calculated by using the previous 304(a) aquatic life criteria expressed in terms of total recoverable metal, and mulitplying it by a conversion factor (CF). The term "Conversion Factor" (CF) represents the recommended conversio factor for converting a metal criterion expressed as the total recoverable fraction in the water column to a criterion expressed as the dissolved fraction in the water column. (Conversion Factors for saltwater CCCs are currently unavailable. Conversion factors derived for saltwater CMCs have been used for both saltwater CMCs and CCCs). See "Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria," October 1, 1993, by Martha G. Prothro, Acting Assistant Administrator for Water, available from the Water Resource center, USEPA, 401 M St., SW, mail code RC4100, Washington DC 20460; and 40CFR 131.36(b)(1). Conversion Factors applied in the table can be found in Appendix A to the Preamble - Conversion Factors for Dissolved Metals.

C The criterion is based on 304(a) aquatic life criterion issued in 1980 and was issued in one of the following documents: Aldrin/Dieldrin (EPA 440/5-80-019), Chlordane (EPA 440/5-80-027), Dichlorodiphenyltrichloroethane (DDT) (EPA 440/5-80-38), Endosulfan (EPA 440/5-80-046), Endrin (EPA 440/5-80-047), Heptachlor (EPA 440/5-80-052), Hexachlorocyclohexane (EPA 440/5-80-054), Silver (EPA 440/5-80-071), The minimum data requirements and derivation procedures were different in the 1980 Guidelines than in the 1985 Guidelines. For example, a "CMC" derived using the 1980 Guidelines was derived to be used as an instantaneous maximum. If assessment is to be done using an averaging period, the values given should be divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines.

aa This criterion is based on a 304(a) aquatic life criterion issued in 1980 or 1986, and was issued in one of the following documents : Aldrin/Dieldrin (EPA 440/5-80-019), Chlordane (EPA 440/5-80-027), DDT (EPA 440/5-80-038), Endrin (EPA 4405-80-047), Heptachlor (EPA 440/5-80-052), Polychlorinated biphenyls (EPA 440/5-80-068), Toxaphene (EPA 440/5-86-006). This CCC is currently based on the Final Residue Value (FRV) procedure. Since the publication of the Great Lakes Aquatic Life Criteria Guidelines in 1995 (60 FR 15393-15399, March 23, 1995), the EPA no longer uses the Final Residue Value procedure for deriving CCCs for new or revised 304(a) aquatic life criteria. Therefore, the EPA anticipates that future revisions of this CCC will not be based on FRV procedure.

bb This water quality criterion is based on a 304(a) aquatic life criterion that was derived using the 1985 Guidelines (*Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses*, PB85-227046, January 1985) and was issued in one of the following criteria documents: Arsenic (EPA 440/5-84-033), Cadmium (EPA 882-R-01-001), Chromium (EPA 440/5-84-029), Copper (EPA 440/5-84-031), Cyanide (EPA 440/5-84-028), Lead (EPA 440/5-84-027), Nickel (EPA 440/5-86-004), Pentachlorophenol (EPA 440/5-86-009), Toxaphene (EPA 440/5-86-006), Zinc (EPA 440/5-87-003).

cc When the concentration of dissolved organic carbon is elevated, copper is substantially less toxic, and use of Water-Effect Rations might be appropriate.

dd The selenium criteria document (EPA 440/5-87-006, September 1987) provides that if selenium is as toxic to saltwater fishes in the field as it is to freshwater fish in the field, the status of the fish community should be monitored whenever the concentration of selenium exceeds 5.0 mg/L in salt water because the saltwater CCC does not take into account uptake via the food chain.

Table 20 Surface Water Screening Criteria for the Protection of Aquatic Life (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Footnotes (Continued):

ee	This recommended water quality criterion was derived on page 43 of the mercury document (EPA 440/5-84-026, January1985). The saltwater CCC of 0.025 µg/L given on page 23 of the criteria document is based on the Final Residue Value procedure in the 1985 Guidelines. Since the publication of the Great Lakes Aquatic Life Criteria Guidelines in 1995 (60 FR 15393-15399, March 23, 1995), the Agency no longer uses the Final Residue Value procedure for deriving CCCs for new or revised 304(a) aquatic life criteria.
ff	This recommended water quality criterion was derived in Ambient Water Quality Criteria Saltwater Copper Addendum (draft, April 14, 1995) and was promulgated in the Interim final National Toxics Rule (60 FR 22228-222237, May 4, 1995).
gg	EPA is actively working on this criterion, and so this recommended water quality criterion may change substantially in the near future.
hh	This recommended water quality criterion was derived from data for inorganic mercury (II), but is applied here to total mercury. If a substantial portion of the mercury in the water column is methylmercury, this criterion will probably be under protective. In addition, even though inorganic mercury is converted to methylmercury, and methylmercury bioaccumulates to a great extent, this criteri does not account for uptake via the food chain because sufficient data were not available when the criterion was derived.

The following lettered footnotes are derived from EPA "Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California" (EPA 2000).

ii	Criteria for these metals are expressed as a function of the water-effect ratio (WER) (originally footnote I in the CTR).
jj	No criterion for protection of human health from consumption of aquatic organisms (excluding water) was presented in the 1980 criteria document or in the 1986 Quality Criteria for Water. Nevertheless, sufficient information was presented in the 1980 document to allow a calculation of a criterion, even though the results of such calculations were not shown in the document.
kk	These freshwater and saltwater criteria for metals are expressed in terms of dissolved fraction of the metal in the water column. Criterion values were calculated by using EPA's Clean Water Act 304(a) guidance values (described in the total recoverable fraction) and then applying the conversion factors in 131.36(b)() and (2).
ll	PCBs are a class of chemicals that include Aroclors 1242,1254,1221,1232,1248,1260, and 1016. The aquatic life criteria apply to the sum of this set of seven Aroclors.

The following numbered footnotes are derived from "A Compilation of Water Quality Goals" (Water Board 2000). These footnotes directly correlate with the source document.

1	Expressed as dissolved.
2	Pentavalent arsenic [As(V)] effects on plants.
3	For the pentavalent form.
4	Criteria do not apply to waters subject to water quality objectives in Tables III-2A and III-2B of the San Francisco Bay Regional Water Quality Control Board's 1986 Basin Plan.
5	Developed as 24-hour average using 1980 EPA guidelines, but applied as 4-day average in the National Toxics Rule and/or Proposed California Toxics Rule.
6	Applies separately to Aroclors 1242, 1254, 1221, 1232, 1248, 1260, and 1016; based on carcinogenicity at 1-in-a-million risk level.

References:

San Francisco Bay Regional Water Quality Control Board (Water Board). 1995. "San Francisco Bay Basin Plan." San Francisco Bay Region. June 21.

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Table 21 Summary Statistics for Surface and Storm Water Samples

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Chemical	Unit	Number of Analyses	Percent Detections/ Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration	RFS Surface Water Screening Criteria	Percent of Detects Greater than RFS Surface Water Screening Criteria
METAL	Aluminum	µg/L	22	50.00%	33	15,000	SW103	3,270.00	560.00	5,146.73	NA	NA
METAL	Antimony	µg/L	26	0.00%	ND	ND	ND	ND	ND	ND	NA	ND
METAL	Arsenic	µg/L	26	92.31%	1.2	18	SW103	6.88	5.35	5.21	36	0.00%
METAL	Barium	µg/L	26	100.00%	17	82	STW105	38.42	38.00	17.80	NA	NA
METAL	Beryllium	µg/L	26	7.69%	1	1.5	SW101	1.25	1.25	0.25	NA	NA
METAL	Cadmium	µg/L	26	0.00%	ND	ND	ND	ND	ND	ND	8.8	ND
METAL	Calcium	µg/L	22	100.00%	9,300	360,000	SW103	172,240.91	195,000.00	131,227.77	NA	NA
METAL	Chromium	µg/L	26	53.85%	1.2	43	SW103	8.84	3.80	13.14	50	0.00%
METAL	Cobalt	µg/L	26	34.62%	0.61	3.1	SW101	1.80	1.80	0.71	NA	NA
METAL	Copper	µg/L	26	88.46%	4.3	70	SW101	18.72	13.00	18.81	3.1	100.00%
METAL	Iron	µg/L	26	84.62%	40	21,000	SW103	2,636.73	520.00	5,790.35	NA	NA
METAL	Lead	µg/L	26	42.31%	0.65	28	SW103	7.46	3.50	9.08	5.6	18.18%
METAL	Magnesium	µg/L	22	100.00%	2,300	1,100,000	SW103	494,490.91	590,000.00	409,410.48	NA	NA
METAL	Manganese	µg/L	22	100.00%	3.2	3,400	SW101	584.10	80.50	960.45	NA	NA
METAL	Mercury	µg/L	26	30.77%	0.027	1.9	SW102	0.49	0.21	0.63	0.025	100.00%
METAL	Molybdenum	µg/L	26	57.69%	0.97	24	STW106	5.40	3.70	5.38	NA	NA
METAL	Nickel	µg/L	26	65.38%	1.5	42	SW103	8.89	4.20	12.09	8.2	23.53%
METAL	Potassium	µg/L	26	100.00%	1,300	390,000	SW101	166,592.31	190,000.00	127,303.92	NA	NA
METAL	Selenium	µg/L	26	0.00%	ND	ND	ND	ND	ND	ND	71	ND
METAL	Silver	µg/L	26	7.69%	1.5	3.2	SW101	2.35	2.35	0.85	0.19	100.00%
METAL	Sodium	µg/L	22	100.00%	8500	9,100,000	SW103	4,040,704.55	4,700,000.00	3,398,502.25	NA	NA
METAL	Thallium	µg/L	26	7.69%	6	7.7	STW104	6.85	6.85	0.85	426	0.00%
METAL	Vanadium	µg/L	26	73.08%	1.9	41	SW103	8.29	4.90	10.73	NA	NA
METAL	Zinc	µg/L	26	76.92%	12	1,800	STW105	181.80	63.00	385.27	81	40.00%
PCB	Aroclor-1016	µg/L	26	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PCB	Aroclor-1221	µg/L	26	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PCB	Aroclor-1232	µg/L	26	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PCB	Aroclor-1242	µg/L	26	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PCB	Aroclor-1248	µg/L	26	3.85%	0.4	0.4	STW106	0.40	0.40	0.00	0.03	100.00%
PCB	Aroclor-1254	µg/L	26	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PCB	Aroclor-1260	µg/L	26	0.00%	ND	ND	ND	ND	ND	ND	0.03	ND
PCB	Total Aroclor	µg/L	26	3.85%	0.4	0	STW106	0.40	0.40	0.00	NA	NA
PEST	4,4'-DDD	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	4,4'-DDE	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	4,4'-DDT	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Aldrin	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	alpha-BHC	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	alpha-Chlordane	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	beta-BHC	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Butylate	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Chlordane	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Cycloate	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA

Table 21 Summary Statistics for Surface and Storm Water Samples (Continued)
Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Chemical	Unit	Number of Analyses	Percent Detections/ Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration	RFS Surface Water Screening Criteria	Percent of Detects Greater than RFS Surface Water Screening Criteria
PEST	delta-BHC	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Dieldrin	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Endosulfan I	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Endosulfan II	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Endosulfan sulfate	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Endrin	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Endrin aldehyde	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Endrink ketone	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	EPTC	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Fonofos	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	gamma-BHC (lindane)	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	gamma-Chlordane	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Heptachlor	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Heptachlor epoxide	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Methoxychlor	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Molinate	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Napropamide	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Pebulate	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Total Chlordanes	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Total DDTs	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Toxaphene	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PEST	Vernolate	µg/L	4	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
ANION	Nitrate (as N)	mg/L	15	26.67%	0.99	2.3	SW104	1.52	1.40	0.52	NA	NA
ANION	Nitrite (as N)	mg/L	15	0.00%	ND	ND	ND	ND	ND	ND	NA	NA
PH	pH	PH	26	100.00%	6.5	9.1	SW102	7.76	7.80	0.59	NA	NA
SOLIDS	Total dissolved solids	mg/L	11	100.00%	18,300	31,800	SW102	25,654.55	24,800.00	4,977.29	NA	NA
TKN	Total kjedahl nitrogen	mg/L	15	20.00%	0.56	2.5	SW102	1.49	1.40	0.79	NA	NA
TPHOS	Phosphorus	mg/L	15	100.00%	0.1	5.2	SW103	1.31	0.51	1.67	NA	NA

Notes:

µg/L	Microgram per liger	NA	Not available
BHC	Benzene hexachlorid	ND	Not detected
DDD	Dichlorodiphenyldichloroethane	PCB	Polychlorinated biphenyl
DDE	Dichlorodiphenyldichloroethene	PEST	Pesticide
DDT	Dichlorodiphenyltrichloroethane	RFS	Richmond Field Station
EPTC	s-Ethyl dipropylthiocarbamate	TKN	Total kjedahl nitrogen
mg/L	Milligram per liter	TPHOS	Total phosphorus

Table 22 Summary Statistics for Shallow-Zone Groundwater

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent of Detections/ Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration	EPA MCL	Percent of Detects Greater than EPA MCL	Lower of EPA MCL and State MCL	Percent of Detects Greater than Lower of EPA MCL and State MCL	10 Times Saltwater Chronic AWQC	Percent of Detects Greater than 10 Times Saltwater Chronic AWQC
METAL	Antimony	µg/L	59	0.00%	ND	ND		ND	ND	ND	6	ND	6	ND	5,000	ND
METAL	Arsenic	µg/L	66	37.88%	5.2	95	A4-14	28.60	0	19.87	10	72.00%	10	72.00%	360	0.00%
METAL	Barium	µg/L	11	100.00%	13	190	A4-2	38.64	18	49.35	2,000	0.00%	1,000	0.00%	NA	NA
METAL	Beryllium	µg/L	59	6.78%	2.3	6.6	AOC3-GW	4.25	0	1.16	4	50.00%	4	50.00%	NA	NA
METAL	Cadmium	µg/L	66	15.15%	5.4	150	A4-14	37.25	0	20.65	5	100.00%	5	100.00%	88	10.00%
METAL	Chromium	µg/L	59	6.78%	14	160	AOC2-GW	53.75	0	20.96	100	25.00%	50	25.00%	500	0.00%
METAL	Cobalt	µg/L	11	9.09%	110	110	A4-12	110.00	0	31.62	NA	NA	NA	NA	NA	NA
METAL	Copper	µg/L	66	31.82%	10	5,600	H57	541.57	0	846.04	1,300	9.52%	1,300	9.52%	31	42.86%
METAL	Lead	µg/L	66	15.15%	1	16	AOC4-GW	6.08	0	2.67	NA	NA	15	10.00%	85	0.00%
METAL	Mercury	µg/L	61	18.03%	0.24	5.9	MF105	1.23	0	0.86	2	18.18%	2	18.18%	0.25	72.73%
METAL	Molybdenum	µg/L	11	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
METAL	Nickel	µg/L	59	44.07%	21	780	PB16	142.50	0	144.43	100	34.62%	100	34.62%	82	46.15%
METAL	Selenium	µg/L	59	22.03%	5.3	38	A4-14	12.18	0	6.38	50	0.00%	50	0.00%	710	0.00%
METAL	Silver	µg/L	59	0.00%	ND	ND		ND	ND	ND	100	ND	100	ND	9.2	ND
METAL	Thallium	µg/L	59	15.25%	9.5	130	A4-14	36.28	0	19.34	2	100.00%	2	100.00%	NA	NA
METAL	Vanadium	µg/L	11	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
METAL	Zinc	µg/L	66	51.52%	20	27,000	A4-14	2663.24	24	4,211.16	5,000	23.53%	NA	NA	810	23.53%
VOA	1,1,1,2-Tetrachloroethane	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	1,1,1-Trichloroethane	µg/L	19	0.00%	ND	ND		ND	ND	ND	200	ND	200	ND	NA	ND
VOA	1,1,2,2-Tetrachloroethane	µg/L	19	0.00%	ND	ND		ND	ND	ND	NA	ND	1	ND	NA	ND
VOA	1,1,2-Trichloroethane	µg/L	19	0.00%	ND	ND		ND	ND	ND	5	ND	5	ND	NA	ND
VOA	1,1-Dichloroethene	µg/L	19	15.79%	0.3	0.9	UCB-3	0.67	0	0.26	7	0.00%	6	0.00%	NA	NA
VOA	1,1-Dichloropropene	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	1,2,3-Trichlorobenzene	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	1,2,3-Trichloropropane	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	1,2,4-Trichlorobenzene	µg/L	15	0.00%	ND	ND		ND	ND	ND	70	ND	70	ND	1,290	ND
VOA	1,2,4-Trimethylbenzene	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	1,2-Dibromo-3-Chloropropane	µg/L	15	0.00%	ND	ND		ND	ND	ND	0.2	ND	0.2	ND	NA	ND
VOA	1,2-Dibromoethane	µg/L	15	0.00%	ND	ND		ND	ND	ND	0.05	ND	0.05	ND	NA	ND
VOA	1,2-Dichlorobenzene	µg/L	19	0.00%	ND	ND		ND	ND	ND	600	ND	600	ND	1,290	ND
VOA	1,2-Dichloroethane	µg/L	19	26.32%	0.7	10	UCB-1	5.60	0	3.08	5	60.00%	0.5	100.00%	NA	NA
VOA	1,2-Dichloropropane	µg/L	19	0.00%	ND	ND		ND	ND	ND	5	ND	5	ND	30,400	ND
VOA	1,3,5-Trimethylbenzene	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	1,3-Dichlorobenzene	µg/L	19	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	1,290	ND
VOA	1,3-Dichloropropane	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	1,4-Dichlorobenzene	µg/L	19	0.00%	ND	ND		ND	ND	ND	75	ND	5	ND	1,290	ND
VOA	2,2-Dichloropropane	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	2-Butanone	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	2-Chlorotoluene	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	2-Hexanone	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	4-Chlorotoluene	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	4-Methyl-2-Pentanone	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	Acetone	µg/L	15	6.67%	10	10	PB6	10.00	0	2.49	NA	NA	NA	NA	NA	NA
VOA	Benzene	µg/L	15	0.00%	ND	ND		ND	ND	ND	5	ND	1	ND	7,000	ND
VOA	Bromobenzene	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	Bromochloromethane	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	Bromodichloromethane	µg/L	19	0.00%	ND	ND		ND	ND	ND	100	ND	100	ND	64,000	ND
VOA	Bromoform	µg/L	19	0.00%	ND	ND		ND	ND	ND	100	ND	100	ND	NA	ND
VOA	Bromomethane	µg/L	19	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	Carbon Disulfide	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND

Table 22 Summary Statistics for Shallow-Zone Groundwater (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent of Detections/ Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration	EPA MCL	Percent of Detects Greater than EPA MCL	Lower of EPA MCL and State MCL	Percent of Detects Greater than Lower of EPA MCL and State MCL	10 Times Saltwater Chronic AWQC	Percent of Detects Greater than 10 Times Saltwater Chronic AWQC
VOA	Carbon Tetrachloride	µg/L	19	15.79%	2.2	53	PB14	23.73	0	12.15	5	66.67%	0.5	100.00%	64,000	0.00%
VOA	Chlorobenzene	µg/L	19	26.32%	0.4	3.7	PB15	1.64	0	0.92	100	0.00%	70	0.00%	1,290	0.00%
VOA	Chloroethane	µg/L	19	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	Chloroform	µg/L	19	15.79%	2.4	48	PB14	31.80	0	14.25	100	0.00%	100	0.00%	64,000	0.00%
VOA	Chloromethane	µg/L	19	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	Cis-1,2-Dichloroethene	µg/L	19	73.68%	0.3	22	UCB-9	5.56	1.3	5.61	70	0.00%	6	35.71%	NA	NA
VOA	Cis-1,3-Dichloropropene	µg/L	19	0.00%	ND	ND		ND	ND	ND	NA	ND	0.5	ND	NA	ND
VOA	Dibromochloromethane	µg/L	19	0.00%	ND	ND		ND	ND	ND	100	ND	100	ND	64,000	ND
VOA	Dibromomethane	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	64,000	ND
VOA	Dichlorodifluoromethane	µg/L	3	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	64,000	ND
VOA	Ethylbenzene	µg/L	15	0.00%	ND	ND		ND	ND	ND	700	ND	700	ND	NA	ND
VOA	Freon 113	µg/L	19	0.00%	ND	ND		ND	ND	ND	NA	ND	1200	ND	NA	ND
VOA	Freon 12	µg/L	12	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	Hexachlorobutadiene	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	Isopropylbenzene	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	m,p-Xylene	µg/L	15	6.67%	0.8	0.8	PB6	0.80	0	0.20	NA	NA	NA	NA	NA	NA
VOA	Methyl Tert-Butyl Ether	µg/L	15	13.33%	0.3	5.8	UCB-3	3.05	0	1.44	NA	NA	NA	NA	NA	NA
VOA	Methylene Chloride	µg/L	19	0.00%	ND	ND		ND	ND	ND	5	ND	5	ND	NA	ND
VOA	n-Butylbenzene	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	n-Propylbenzene	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	Naphthalene	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	o-Xylene	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	p-Isopropyltoluene	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	sec-Butylbenzene	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	Styrene	µg/L	15	0.00%	ND	ND		ND	ND	ND	100	ND	100	ND	NA	ND
VOA	tert-Butylbenzene	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	Tetrachloroethene	µg/L	19	52.63%	0.6	100	UCB-7	26.93	0.6	28.31	5	50.00%	5	50.00%	4,500	0.00%
VOA	Toluene	µg/L	15	6.67%	0.8	0.8	PB6	0.80	0	0.20	1,000	0.00%	150	0.00%	50,000	0.00%
VOA	trans-1,2-Dichloroethene	µg/L	19	10.53%	0.5	0.9	UCB-3	0.70	0	0.22	100	0.00%	10	0.00%	NA	NA
VOA	trans-1,3-Dichloropropene	µg/L	19	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	Trichloroethene	µg/L	19	78.95%	7.7	1,400	UCB-7, UCB-9	374.85	55	445.99	5	100.00%	5	100.00%	NA	NA
VOA	Trichlorofluoromethane	µg/L	19	0.00%	ND	ND		ND	ND	ND	NA	ND	150	ND	64,000	ND
VOA	Vinyl Acetate	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
VOA	Vinyl Chloride	µg/L	19	15.79%	0.4	1.1	PB15	0.80	0	0.31	2	0.00%	0.5	66.67%	NA	NA
SVOA	Total LMW PAHs	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
SVOA	Total PAHs	µg/L	15	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
SVOA	Pentachlorophenol	µg/L	3	0.00%	ND	ND		ND	ND	ND	1	ND	1	ND	79	ND
PEST	4,4'-DDD	µg/L	4	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
PEST	4,4'-DDE	µg/L	4	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
PEST	4,4'-DDT	µg/L	4	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	0.01	ND
PEST	alpha-BHC	µg/L	4	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
PEST	beta-BHC	µg/L	4	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
PEST	Chlordane	µg/L	4	0.00%	ND	ND		ND	ND	ND	NA	ND	0.1	ND	0.04	ND
PEST	delta-BHC	µg/L	4	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
PEST	Dieldrin	µg/L	4	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	0.019	ND
PEST	Endrin	µg/L	4	0.00%	ND	ND		ND	ND	ND	2	ND	2	ND	0.023	ND
PEST	gamma-BHC (Lindane)	µg/L	4	0.00%	ND	ND		ND	ND	ND	0.2	ND	0.2	ND	1.6	ND
PEST	Heptachlor	µg/L	4	0.00%	ND	ND		ND	ND	ND	0.4	ND	0.01	ND	0.036	ND
PEST	Heptachlor Epoxide	µg/L	4	0.00%	ND	ND		ND	ND	ND	0.2	ND	0.01	ND	0.036	ND
PEST	Total Chlordanes	µg/L	4	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND
PEST	Total DDTs	µg/L	4	0.00%	ND	ND		ND	ND	ND	NA	ND	NA	ND	NA	ND

Table 22 Summary Statistics for Shallow-Zone Groundwater (Continued)
Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Analyte Group	Analyte	Unit	Number of Analyses	Percent of Detections/ Analyses	Minimum Detected Concentration	Maximum Detected Concentration	Location(s) of Maximum Results	Average Detected Concentration	Median Detected Concentration	Standard Deviation Detected Concentration	EPA MCL	Percent of Detects Greater than EPA MCL	Lower of EPA MCL and State MCL	Percent of Detects Greater than Lower of EPA MCL and State MCL	10 Times Saltwater Chronic AWQC	Percent of Detects Greater than 10 Times Saltwater Chronic AWQC
PCB	Aroclor-1016	µg/L	4	0.00%	ND	ND		ND	ND	ND	0.5	ND	0.5	ND	0.3	ND
PCB	Aroclor-1221	µg/L	4	0.00%	ND	ND		ND	ND	ND	0.5	ND	0.5	ND	0.3	ND
PCB	Aroclor-1232	µg/L	4	0.00%	ND	ND		ND	ND	ND	0.5	ND	0.5	ND	0.3	ND
PCB	Aroclor-1242	µg/L	4	0.00%	ND	ND		ND	ND	ND	0.5	ND	0.5	ND	0.3	ND
PCB	Aroclor-1248	µg/L	5	20.00%	0.88	0.88	SD101	0.88	0	0.35	0.5	100.00%	0.5	100.00%	0.3	100.00%
PCB	Aroclor-1254	µg/L	4	0.00%	ND	ND		ND	ND	ND	0.5	ND	0.5	ND	0.3	ND
PCB	Aroclor-1260	µg/L	4	25.00%	1.3	1.3	SL103	1.30	0	0.56	0.5	100.00%	0.5	100.00%	0.3	100.00%
PCB	Total Aroclor	µg/L	5	40.00%	0.88	1.3	SL103	1.09	0	0.55	NA	NA	NA	NA	NA	NA
ANION	Sulfate	mg/L	2	100.00%	780	2,200	PC101	1,490	1,490	710	NA	NA	NA	NA	NA	NA
PH	pH	PH	60	100.00%	4.6	9.7	PC102	6.82	6.9	0.68	NA	NA	NA	NA	NA	NA

Notes:

µg/L	Microgram per liter
AWQC	Ambient water quality criteria
BHC	Benzene hexachloride
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethene
DDT	Dichlorodiphenyltrichloroethane
EPA	U.S. Environmental Protection Agency
LMW	Low molecular weight
MCL	Maximum contaminant level
mg/L	Milligram per liter
NA	Not available
ND	Not detected
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PEST	Pesticide
PRG	Preliminary remediation goal
SVOA	Semivolatile organic analysis
VOA	Volatile organic analysis

Table 23: Species in the USGS Richmond Quad (CNDDB 2006)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

Common Name	Scientific Name	Date of Most Recent Occurrence	Reference Date
Upland			
Plants			
Diablo helianthella	*Helianthella castanea*	7/30/2004	8/4/2006
Loma Prieta hoita	*Hoita strobilina*	6/17/2004	3/9/2005
Western leatherwood	*Dirca occidentalis*	2003	2/2/2006
Robust monardella	*Monardella villosa ssp. globosa*	7/20/2000	3/2/2006
Pallid manzanita	*Arctostaphylos pallida*	3/20/1999	7/11/2006
Bent-flowered fiddleneck	*Amsinckia lunaris*	1995	8/30/2005
Fragrant fritillary	*Fritillaria liliacea*	3/8/1938	2/18/1994
Invertebrates			
Monarch butterfly	*Danaus plexippus*	1/13/1998	6/10/1998
Lee's micro-blind harvestman	*Microcina leei*	12/21/1983	12/8/2004
Birds			
White-tailed kite	*Elanus leucurus*	6/15/1990	11/6/1995
Black-crowned night heron	*Nycticorax nycticorax*	6/15/1990	11/6/1995
San Pablo song sparrow	*Melospiza melodia samuelis*	7/20/1953	4/19/2005
Alameda song sparrow	*Melospiza melodia pusillula*	10/23/1942	4/11/2005
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	5/28/1899	12/29/2005
Mammals			
Salt-marsh harvest mouse	*Reithrodontomys raviventris*	5/15/2001	6/9/2003
San Pablo vole	*Microtus californicus sanpabloensis*	3/23/1986	7/13/1998
Salt-marsh wandering shrew	*Sorex vagrans halicoetes*	1986	7/13/1998
Pallid bat	*Antrozous pallidus*	2/20/1945	9/29/2006
Big free -tailed bat	*Nyctinomops macrotis*	12/18/1916	1/24/2005
Aquatic			
Plants			
Western leatherwood	*Dirca occidentalis*	2003	2/2/2006
Santa Cruz tarplant	*Holocarpha macradenia*	9/6/2002	10/7/2002
Point Reyes bird's-beak	*Cordylanthus maritimus ssp. palustris*	12/16/1990	1/14/2000
Fragrant fritillary	*Fritillaria liliacea*	3/8/1938	2/18/1994
California seablite	*Suaeda californica*	8/17/1912	6/20/1994
Alkali milk-vetch	*Astragalus tener var. tener*	3/24/1900	7/8/2003
Coastal bluff morning-glory	*Calystegia purpurata ssp. saxicola*	4/15/1893	1/13/2003
Invertebrates			
Monarch butterfly	*Danaus plexippus*	1/13/1998	6/10/1998
Bridges' coast range shoulderband	*Helminthoglypta nickliniana bridgesi*	Unknown	11/29/2005
Reptiles			
Western pond turtle	*Emys (=Clemmys) marmorata*	7/11/1992	1/23/1996
Fish			
Sacramento perch	*Archoplites interruptus*	5/17/1980	11/6/1995
Birds			
California clapper rail	*Rallus longirostris obsoletus*	8/12/2003	1/10/2005
California black rail	*Laterallus jamaicensis coturniculus*	5/15/2001	6/9/2003
Caspian tern	*Sterna caspia*	6/30/1990	11/6/1995
Snowy egret	*Egretta thula*	6/15/1990	11/6/1995
San Pablo song sparrow	*Melospiza melodia samuelis*	7/20/1953	4/19/2005
Alameda song sparrow	*Melospiza melodia pusillula*	10/23/1942	4/11/2005
Mammals			
Salt-marsh harvest mouse	*Reithrodontomys raviventris*	5/15/2001	6/9/2003
San Pablo vole	*Microtus californicus sanpabloensis*	3/23/1986	7/13/1998
Salt-marsh wandering shrew	*Sorex vagrans halicoetes*	1986	7/13/1998

Notes:

CNNDB California Natural Diversity Database

USGS United States Geological Survey

Table 24: Species Sighted by the East Bay Birders, February 4, 2007

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

San Francisco Bay Trail: S. 51st St. Richmond to Aquatic Park

Common Name	Scientific Name
American Avocet	*Recurvirostra americana*
American Coot	*Fulica americana*
American Crow	*Corvus brachyrhynchos*
American Goldfinch	*Carduelis tristis*
American Kestrel	*Falco sparverius*
American Pipit	*Anthus rubescens*
American Wigeon	*Anas americana*
Anna's Hummingbird	*Calypte anna*
Belted Kingfisher	*Ceryle alcyon*
Black Phoebe	*Sayornis nigricans*
Black-bellied Plover	*Pluvialis squatarola*
Black-crowned Night-Heron	*Nycticorax nycticorax*
Black-necked Stilt	*Himantopus mexicanus*
Brewer's Blackbird	*Euphagus cyanocephalus*
Bufflehead	*Bucephala albeola*
Burrowing Owl	*Athene cunicularia*
Bushtit	*Psaltriparus minimus*
California Towhee	*Pipilo crissalis*
Canada Goose	*Branta canadensis*
Canvasback	*Aythya valisineria*
Chestnut-backed Chickadee	*Poecile rufescens*
Clark's Grebe	*Aechmophorus clarkii*
Common Goldeneye	*Bucephala clangula*
Double-crested Cormorant	*Phalacrocorax auritus*
Dunlin	*Calidris alpina*
Eared Grebe	*Podiceps nigricollis*
European Starling	*Sturnus vulgaris*
Gadwall	*Anas strepera*
Golden-crowned Sparrow	*Zonotrichia atricapilla*
Great Blue Heron	*Ardea herodias*
Great Egret	*Ardea alba*
Greater Scaup	*Aythya marila*
Green-winged Teal	*Anas crecca*
House Finch	*Carpodacus mexicanus*
Killdeer	*Charadrius vociferus*
Least Sandpiper	*Calidris minutilla*
Lesser Scaup	*Aythya affinis*
Long-billed Curlew	*Numenius americanus*
Long-billed Dowitcher	*Limnodromus scolopaceus*
Mallard	*Anas platyrhynchos*
Marbled Godwit	*Limosa fedoa*
Mew Gull	*Larus canus*
Mourning Dove	*Zenaida macroura*
Northern Harrier	*Circus cyaneus*
Northern Pintail	*Anas acuta*
Northern Shoveler	*Anas clypeata*
Pied-billed Grebe	*Podilymbus podiceps*
Red-tailed Hawk	*Buteo jamaicensis*
Red-winged Blackbird	*Agelaius phoeniceus*
Ring-billed Gull	*Larus delawarensis*
Rock Pigeon	*Columba livia*
Ruddy Duck	*Oxyura jamaicensis*
Snowy Egret	*Egretta thula*
Song Sparrow	*Melospiza melodia*

Table 24: Species Sighted by the East Bay Birders, February 4, 2007 (Continued)

Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California

San Francisco Bay Trail: S. 51st St. Richmond to Aquatic Park	
Common Name	**Scientific Name**
Sora	*Porzana carolina*
Surf Scoter	*Melanitta perspicillata*
Western Grebe	*Aechmophorus occidentalis*
Western Gull	*Larus occidentalis*
Western Meadowlark	*Sturnella neglecta*
Western Sandpiper	*Calidris mauri*
Whimbrel	*Numenius phaeopus*
White-crowned Sparrow	*Zonotrichia leucophrys*
Willet	*Catoptrophorus semipalmatus*
Yellow-rumped Warbler	*Dendroica coronata*