CH2M HILL
155 Grand Avenue
Suite 1000
Oakland, CA 94612
P.O. Box 12681
Oakland, CA 94604-2681
Tel 510.251.2426
Fax 510.893.8205

CH2MHILL

September 20, 2004

Mr. Henry Chui
California Environmental Protection Agency
Department of Toxic Substances Control
700 Heinz Avenue, Suite 200
Berkeley, CA 94710-2737

Subject: Final Investigation Area C3 Remedial Investigation/Feasibility Study Report

Dear Mr. Chui:

Enclosed is the Final Investigation Area C3 Remedial Investigation/Feasibility Study Report, Mare Island, Vallejo, California.

This document was prepared by Lennar Mare Island (LMI) as part of the scope of the Environmental Services Cooperative Agreement to complete remaining environmental work at Mare Island and in accordance with the Consent Agreement between LMI, City of Vallejo, and Department of Toxic Substances Control. The Final Investigation Area C3 Remedial Investigation/Feasibility Study Report incorporates comments received on the Draft from DTSC on April 1, 2004 and from the Regional Water Quality Control Board on August 17, 2004. Responses to comments received on the Draft are provided in Appendix M. Electronic copies of this document can be found on the CD-ROM provided at the back of this binder.

If you have any questions regarding this document, please contact me at (510) 587-7539.

Sincerely,

CH2M HILL

Jeffery C. Morris

Jeffery C. Morris, P.E.

Copy to (with enclosures):

Mr. Gary Riley
Regional Water Quality Control Board
1515 Clay Street, Suite 1400
Oakland, CA 94612

Ms. Carolyn d'Almeida
U.S. EPA Region 9 (SFD 8-1)
75 Hawthorne Street
San Francisco, CA 94105

Ms. Lea Loizos
Arc Ecology
833 Market Street
San Francisco, CA 94103

Ms. Sheila Roebuck
Lennar Mare Island
690 Walnut Avenue, Suite 100
Vallejo, CA 94592

Mr. Gordon Hart
Paul, Hastings, Janofsky, Walker, LLP
55 Second Street, 24th Floor
San Francisco, CA 94105-3411

Mr. Gil Hollingsworth
Mare Island Conversion Division
City of Vallejo
555 Santa Clara Street
Vallejo, CA 94590-5934

Ms. Myrna Hayes
816 Branciforte Street
Vallejo, CA 94590

Mr. Bob Palmer
Caretaker Site Office, SF Bay
410 Palm Ave., Bldg. 1, Suite 161
San Francisco, CA 94130

Additional CH2M HILL copies:
Jeff Morris
Melanie Goode
Sarah Reindel
Starr Dehn
Jim Robbins

Copy to (without enclosures):

Ms. Beckye Stanton, Ph.D.
U.S. Fish and Wildlife Service
2800 Cottage Way, Room W-2605
Sacramento, CA 95825

Mr. Jim Hardwick
California Dept. of Fish & Game
OSPR Headquarters
P.O. Box 944209
Sacramento, CA 94244-2090

Ms. Laurie Sullivan
National Oceanic and Atmospheric Administration
75 Hawthorne Street, 9th Floor
San Francisco, CA 94105

Ms. Patricia Port
U.S. Department of Interior
1111 Jackson Street, Suite 520
Oakland, CA 94607

Mr. Mike Racette
Bay Area Air Quality Management District
939 Ellis Street
San Francisco, CA 94109

Ms. Carol Gaye
801 Southampton Road, #30
Benicia, CA 94510

Mr. Kenneth Browne
109 El Camino Real
Vallejo, CA 94590

Mr. Herminio Sunga
1423 Oakwood Avenue
Vallejo, CA 94591

Mr. Adam A. Chavez
1031 Florida Street
Vallejo, CA 94590-5513

Mr. Albert T. Lliff
260 American Canyon Road, Sp. 119
Vallejo, CA 94503

Mr. Gerald Karr
149 Garden Court
Vallejo, CA 94591

Ms. Diana Krevsky
133 B Street
Vallejo, CA 94590

Ms. Patricia Schader
165 Oddstad Drive, #34
Vallejo, CA 94589

Mr. James O'Loughlin
1449 Sheridan Drive
Napa, CA 94558

Ms. Paula Tygielski
456 East L Street
Benicia, CA 94510

Mr. Steven Goldbeck
San Francisco Bay Commission
50 California Street, Suite 2600
San Francisco, CA 94102

Mr. Dennis Kalson
Solano County Department of
Environmental Health Management
470 Chadbourne Road, Suite 200
Fairfield, CA 94534

Mr. Donald Parker
Vallejo Fire Department
1220 Marin Street
Vallejo, CA 94590

Albert Netto
Solano County Department of
Environmental Management
601 Texas Street
Fairfield, Ca 94533
(UST related documents only)

Dr. Tom Charon, M.D.
Solano County Department of Public Health
275 Beck Avenue
Fairfield, CA 94533

Mr. Chip Gribble
California Environmental
Protection Agency, DTSC
700 Heinz Avenue, Suite 200
Berkeley, CA 94710-2737

Final

Investigation Area C3 Remedial Investigation/Feasibility Study Report Mare Island Vallejo, California

Prepared for

Regulatory Agencies

September 2004

CH2MHILL

155 Grand Avenue, Suite 1000
Oakland, CA 94612

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Acronyms and Abbreviations

ABM	abrasive blast material
AGR	agricultural supply
ARAR	appropriate and relevant or applicable requirement
AST	aboveground storage tank
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylene
CAL/EPA	California Environmental Protection Agency
cc/g	cubic centimeters per gram
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
City	City of Vallejo, California
CLP	Contract Laboratory Program
COMM	ocean, commercial, and sport fishing
COPC	constituent of potential concern
COPEC	constituent of potential ecological concern
DOM	Domestic Pump Station
DTSC	Department of Toxic Substances Control
EETP	Eastern Early Transfer Parcel
EPC	exposure point concentration
ERA	ecological risk assessment
ESL	environmental screening level
EST	estuarine habitat
FOPL	fuel oil pipeline
FRESH	freshwater replenishment to surface waters
FS	feasibility study
gpd	gallons per day
g/cc	grams per cubic centimeter

HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IA	investigation area
IAS	initial assessment study
IND	industrial service supply
IR	installation restoration
IRP	Installation Restoration Program
IWTP	industrial wastewater treatment plant
LMI	Lennar Mare Island, Limited Liability Corporation
$\mu g/100cm^2$	micrograms per 100 square centimeters
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MIGR	fish migration
MINS	Mare Island Naval Shipyard
msl	mean sea level
MUN	municipal and domestic supply
Navy	U.S. Department of Navy
O&M	operation and maintenance
PAH	polynuclear aromatic hydrocarbons
PA/SI	preliminary assessment/site inspection
PCB	polychlorinated biphenyl
PCE	tetrachloroethylene
ppm	parts per million
ppt	parts per thousand
PRC	PRC Environmental Management, Inc.
PRG	preliminary remediation goal
PROC	industrial process supply
QAPP	Quality Assurance Project Plan

RAO	Remedial Action Objective
RAP	Remedial Action Plan
RARE	preservation of rare and endangered species
RBC	risk-based concentrations
RCRA	Resource Conservation and Recovery Act
REC 1	water contact recreation
REC 2	non-contact water recreation
RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure
RWQCB	Regional Water Quality Control Board
SFEI	San Francisco Estuary Institute
SPWN	fish spawning
SSPORTS	Supervisor of Shipbuilding, Conversion, and Repair, Portsmouth, Virginia, Environmental Detachment
S/S	solidification/stabilization
STS	ship-to-shore
SVOC	semivolatile organic compound
SWMU	Solid Waste Management Unit
TCE	tricholorethylene
TCLP	toxicity characteristic leaching procedure
TDS	total dissolved solids
TPH	total petroleum hydrocarbons
TRPH	total recoverable petroleum hydrocarbons
TRV	toxicity reference value
TSCA	Toxic Substances Control Act
TtEMI	Tetra Tech EM, Inc.
UCL	upper confidence limit
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency

USFWS	United States Fish and Wildlife Service
UST	underground storage tank
VOC	volatile organic compound
XRF	X-ray fluorescence
WESTDIV	Naval Facilities Engineering Command, Western Division
WILD	wildlife habitat

Executive Summary

This remedial investigation/feasibility study (RI/FS) report evaluates the Installation Restoration Program (IRP) sites of potential environmental concern at Lennar Mare Island (LMI) in Investigation Area (IA) C3. These sites (presented on Figure 1.3-3) include the following:

- **IR09:** former paint shop at Building 334, former underground storage tanks (USTs) 334-1, 334-2, 334-3, and 334-4, the oil/water separator beneath Building 144, and a former aboveground storage tank farm.
- **IR12:** active electrical substation at Buildings 516 and 516A (polychlorinated biphenyl [PCB] sites 516 AL#01, 516A AL#01, and 516A UL#01).
- **Building 108 Area:** Building 108, former UST 108, former suspect UST 108A (closed by the Regional Water Quality Control Board [RWQCB]), and former waste collection area (referred to as the waterfront central dumpsters).
- **IR14:** former industrial wastewater treatment facility pipelines.

IA C3 also consists of four additional UST sites (USTs 62, 102, 142, and 730), 102 additional PCB sites, 10 sanitary sewer pump stations, and two previously-unidentified sites of potential environmental concern (Storm Sewer at Dry Dock No. 2 and former Ways 3) (all presented on Figure 1.4-1). These sites are not included in this RI/FS report and will be addressed in separate work plans, site characterization summary reports, and/or site closure reports.

This RI/FS report will be used to define response actions in order to obtain regulatory closure at these sites in accordance with the Consent Agreement (LMI et al. 2001a) between LMI, the City of Vallejo, and the State of California Environmental Protection Agency, Department of Toxic Substances Control (DTSC). The objectives of the RI/FS report are to:

- Document the results of the 2002-2004 field investigation.
- Describe and evaluate the physical site characteristics, constituents source characteristics, and nature and extent of contamination.
- Assess the fate and transport of constituents and potential exposure pathways.
- Characterize potential risks of adverse health or environmental affects.
- Assess potential degradation of groundwater and surface water as a result of historic releases in IA C3.
- Define and compare alternative remedial options to address the identified risks.

ES.1 Physical Setting

IA C3 comprises a 50-acre area bound by Mare Island Strait to the east and by industrial areas to the north, west, and south. Most of IA C3 does not fall within the original (1859) Mare Island boundary but consists of fill material. A quay wall extends along the eastern edge, between IA C3 and Mare Island Strait. IA C3 contains four dry docks (Dry Dock Nos. 1, 2, 3, and 4), two building ways (Ways 1 and 2), one pier (Pier 21), and Berths 11 through 20. Land surrounding the structures is paved throughout, and several railroad spurs are located in IA C3. IA C3 is zoned industrial land use according to the *Preliminary Land Use Plan* (LMI 2000). The northernmost portion of IA C3 (including Dry Dock No. 1 and the building ways) is located in the historical core of Mare Island, which is also considered industrial land use.

There are three principal geologic units present in IA C3. From top to bottom stratigraphically, these are as follows:

(1) Fill: unconsolidated heterogeneous material, generally indistinguishable from the underlying Bay Mud

(2) Younger Bay Mud: unconsolidated deposits (silts, clays, organic clays, and some coarser lenses)

(3) Bedrock: silty sandstones and shales that are weathered near the upper surface

The most important hydrogeologic features of IA C3 are as follows:

- Groundwater flow in IA C3 generally moves toward Mare Island Strait (west to east), although flow directions and rates in the shallow water-bearing zone are locally influenced by variations in lithology and the presence of dry docks and utility corridors.
- Groundwater in the unconfined aquifer in the vicinity of IR09, IR12, and the Building 108 Area exists at 4 to 7.5 feet below ground surface (bgs).
- The median expected groundwater velocity in the vicinity of IR09, IR12, and the Building 108 Area is 34 feet per year.
- Groundwater elevations within approximately 50 feet of the Strait are tidally influenced. (The quay wall located near IR09, IR12, and the Building 108 Area does not act as a significant barrier to groundwater flow.)
- The dry docks are partially-relieved hydraulic structures, meaning that holes are drilled through the walls or floor so that groundwater pressure is partially relieved by water draining from the subsurface into the dry dock cavities.

Based on both naturally high total dissolved solids, low yield, and other water quality criteria, groundwater in IA C3 should not be considered a source for municipal and domestic water supply. Industrial water supply, industrial process water supply, agricultural water supply, and freshwater replenishment to surface waters are considered potential beneficial uses for groundwater at IA C3.

The major habitat types found at or around Mare Island include intertidal mudflats and open water, tidal wetlands, non-tidal wetlands, active dredge ponds, and uplands. Within

IA C3, no viable habitat exists in the onshore area because the site is covered entirely with asphalt and buildings. IA C3 is immediately adjacent to the open water of Mare Island Strait. The habitat offshore of IA C3 is characterized as deep-water habitat without adjacent near-shore habitat. The offshore habitat (intertidal mudflat and open water) at Mare Island consists primarily of pelagic and benthic environments that support diverse communities of algal, invertebrate, fish, bird, and mammal species. In addition, there are three types of species of special concern at Mare Island: (1) threatened and endangered species, (2) commercially- or recreationally-important species, and (3) other species valued by society.

ES.2 Remedial Investigation

The following sections summarize the results of the remedial investigation performed at the four IRP sites. Table ES-1 presents a summary of the potential human health and ecological risks at each site, contaminants that dictate the remedial action objectives (RAOs) presented in the feasibility study, preliminary cleanup goals for those contaminants, and the recommended action for each site (based on the results of the feasibility study).

ES.2.1 IR09

IR09 includes the former paint shop at Building 334, four former USTs, an abandoned oil/water separator, a former paint shop varnish plant (including a former aboveground storage tank farm), and adjacent areas. Activities conducted at the former paint shop include paint spraying, mirror manufacturing, silk screening, Tefloning, paint removal, and parts cleaning (Ecology and Environment 1983). The four USTs formerly located southwest of Building 334 (334-1 through 334-4) stored alcohol, linseed oil, waste paint/drier, turpentine, and waste products; piping extended from the four USTs to four holding tanks on the second floor of Building 334. These USTs were abandoned in place in the 1970s and removed in 1987 (ERM-West 1987a-b). A subsurface gravity oil/water separator associated with Building 334 is located east of Building 334. Facility records indicate that this oil/water separator was filled and decommissioned in October 1983 (MINS 1976); this is when the existing Building 144 was constructed in this area.

Paint manufacturing was also conducted at IR09 during the 1920s and 1930s. According to historical photographs and records, an AST farm associated with a former paint shop varnish plant was located south of Building 334 and west of Building 1334 during this period (MINS 1937). Paint manufacturing activities at IR09 ended around 1940, when a paint manufacturing plant was constructed in the northern part of Mare Island Naval Shipyard (MINS).

Analytical data collected at IR09 during site investigations performed between 1983 and 2004 indicate that impacted areas of the site are primarily located south, southwest, and east of Building 334, near the identified sources of contamination: the former USTs, the former AST farm associated with the paint shop varnish plant, and the oil/water separator beneath Building 144. The area south of the former USTs had the highest levels of total petroleum hydrocarbons (TPH)-gasoline-range organics; TPH-diesel-range organics; benzene, toluene, ethylbenzene, and xylene (BTEX) compounds; and lead found in site soils. Representative

TABLE ES-1
Summary of Estimated Site Risks and Proposed Remedial Action in IA C3
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Site	Maximum Potential Human Health Site Cancer Risk	Maximum Potential Human Health Non-cancer Risk (HI)	Maximum Exposure Point Concentration for Lead in Soil (mg/kg)	Ecological Risk	Contaminants Dictating RAOs in the Feasibility Study	Preliminary Cleanup Goal (mg/kg)	Recommended Action
IR09	2×10^{-5}	0.7	1,780	Negligible	Lead TPH-gasoline TPH-diesel TPH-motor-oil	Lead: 750 TPH-gasoline (0-3 feet bgs): 500 TPH-gasoline (3-10 feet bgs): 4,172 TPH-diesel (0-3 feet bgs): 1,000 TPH-diesel (3-10 feet bgs): 4,172 TPH-motor-oil (0-3 feet bgs): 2,500	Perform remedial action for lead, TPH-gasoline, TPH-diesel, and TPH-motor-oil in soil[a]
IR12	3×10^{-5}	16	1,198	Negligible	Aroclor-1260 Lead	Aroclor-1260: 14 Lead: 750	Perform remedial action for Aroclor-1260 and lead in soil[a]
Building 108 Area	2×10^{-5}	0.5	2,830	Negligible	Lead TPH-diesel TPH-motor-oil	Lead: 750 TPH-diesel (0-3 feet bgs): 1,000 TPH-motor-oil (0-3 feet bgs): 2,500	Perform remedial action for lead, TPH-diesel, and TPH-motor-oil in soil[a]
IR14	5×10^{-7}	0.5	< 750	Negligible	N/A	N/A	No Further Action

[a]Alternative S5 - Limited Excavation/Off-site Disposal and Institutional Controls was selected as the best overall performing alternative in the feasibility study.

Notes:

N/A = not applicable.
RAO = Remedial Action Objectives.
mg/kg = milligrams per kilogram.

groundwater data (collected from 1997 to present) for samples collected near the former USTs suggests that groundwater at the site is not impacted.

The most likely migration pathways for contaminants in the soil at IR09 are dissolution of soil contaminants by infiltration, followed by migration through the vadose zone through advection and dispersion, and subsurface lateral migration via groundwater transport through the aquifer to Mare Island Strait. Only low concentrations of constituents have been detected in monitoring wells located nearest to Mare Island Strait, suggesting that the affinity of these constituents to adsorb to soil organic matter prevents the migration of these constituents through the aquifer to the Strait. Mixing along flow lines and biodegradation may also account for the low concentrations of these constituents detected in monitoring wells nearest to the Strait.

The human health risk assessment (HHRA) for IR09 concluded that the exposure point concentration (EPC) for lead in surface soil (1,780 mg/kg) is above the current risk-based level for commercial/industrial workers of 750 mg/kg. The EPC for lead in mixed-zone soil (1,254 mg/kg) also exceeds the current risk-based level of 750 mg/kg. The results of the HHRA indicate that future site conditions at IR09 pose potential excess lifetime cancer risks that are within the risk-management range (10^{-4} to 10^{-6}) for carcinogens. In addition, non-cancer adverse hazard indices (HIs) were estimated to be below 1 for all of the receptors potentially exposed to soil or groundwater. Because these calculated carcinogenic and non-carcinogenic risks are within or below the risk-management range, lead in soil is the only constituent that presents a potential significant risk to human receptors in IR09. Consequently, an RAO was developed in the feasibility study to address lead in soil at IR09.

The results of the ecological risk assessment (ERA) indicate that no analytes had a hazard quotient (HQ) greater than 1 when compared with RWQCB environmental screening levels (ESLs). Therefore, constituents in groundwater at IR09 are found to pose negligible risk to aquatic organisms in the Strait.

The results of a degradation of groundwater assessment indicate that, while arsenic and manganese are present in groundwater at IR09 at concentrations that exceed chemical-specific applicable or relevant and appropriate requirements (ARARs) identified by the RWQCB for groundwater and surface water, these metals are present at concentrations that are within the range of concentrations that are considered ambient. TPH-motor-oil was detected at a concentration that exceeds RWQCB recommended screening criteria (1,400 µg/L) in a groundwater sample collected at IR09 in 1998. However, groundwater samples collected subsequent to that sample contained TPH-motor-oil at concentrations below the recommended screening criteria. Constituents in groundwater at IR09 are therefore not present at concentrations that are degrading waters of the State of California.

Based on guidance provided in *Screening For Environmental Concerns at Sites With Impacted Soil and Groundwater* (RWQCB 2003b) for evaluating petroleum hydrocarbon concentrations in soil and groundwater, TPH-gasoline, TPH-diesel, and TPH-motor-oil are present in soil at IR09 at concentrations that pose an odor/nuisance condition and/or that result in an impact to groundwater. Consequently, RAOs are developed to address these analytes, in addition to lead, in the feasibility study.

ES.2.2 IR12

IR12 comprises an active electrical substation in Building 516, the attached Building 516A, and adjacent areas. Historical records indicate that Building 516 was built in the early 1920s (MINS 1995, 1935, 1922). The one-story square building was constructed of concrete blocks to provide electrical power for the nearby dry docks, waterfront buildings, and facilities. Building 516 remains in use and is operated by Island Energy. Between approximately 1941 and 1991, various types of PCB-oil-filled transformers were located inside Building 516 along the northwest and southwest walls (PRC 1996a).

A transformer leak occurred in 1981 in Building 516 and PCB-containing oil was released. The release occurred in the northwest portion of Building 516, and the oil was released into a trench in the floor of the building that connected to the storm drainage system (IT 1990, 1992). The oil was removed from the trench following the spill, and in 1983, the catch basin was cleaned and the connection to the outside storm drainage system was plugged (Ecology and Environment 1983; IT 1990). SSPORTS later performed scabbling (abrasive removal) of PCB-contaminated concrete flooring inside Buildings 516 and 516A and an abatement action inside the electrical vault beneath Building 516A.

Analytical data collected at IR12 during site investigations performed between 1983 and 2004 indicate that the impacted areas of the site are located in the immediate vicinity of Building 516. The impacted areas of the site have been defined as: (1) surface material (concrete and asphalt) inside Building 516 and the adjacent Building 516A and subsurface vault, (2) soil and groundwater outside the southwest corner of Building 516, and (3) soil outside the northeast corner of Building 516. The primary contaminants at IR12 are Aroclor-1260, lead, and TPH-gasoline. Sampling and analysis of surface material inside Building 516 and the adjacent Building 516A and subsurface vault show that Aroclor-1260 contamination remains in the concrete and asphalt materials following previous scabbling and washing operations performed by the Navy. However, soil samples collected immediately below the floor of Building 516 indicate that Aroclor-1260 contamination of the floor and cable trenches inside Building 516 has not impacted soil beneath the building. PCB-contaminated surface materials at IR12 will be remediated in accordance with the *Final Polychlorinated Biphenyl Work Plan* (CH2M HILL 2003a) and in accordance with the provisions of Toxic Substances Control Act (TSCA) and the United States Environmental Protection Agency (USEPA) Consent Agreement/Final Order (LMI et al. 2001b).

Aroclor-1260 concentrations in soil and groundwater samples collected surrounding Building 516 were highest in the area outside the southwest corner of Building 516. Soil and groundwater samples collected from other locations at IR12, including monitoring wells located downgradient of Building 516, show that other areas of the site have not been impacted by releases of PCB-containing oil from transformers inside Building 516. Outside the northeast corner of Building 516, lead (as well as zinc and mercury) was found in near surface soil samples at concentrations exceeding ambient levels. Elevated metals concentrations may be associated with abrasive blast material identified in borings in this area.

The results of the fate and transport evaluation indicate that the most likely migration pathways for constituents in the soil at IR12 are infiltration, followed by subsurface lateral migration via groundwater transport through the aquifer to Mare Island Strait or the dry

docks. Petroleum hydrocarbons have been detected at low concentrations in groundwater sampled from monitoring wells located adjacent to the Strait; lead has not been detected in groundwater at IR12, suggesting these constituents are not migrating at significant concentrations to the Strait. Due to the strong affinity for of PCBs to adsorb to soil organic material, it would take many centuries for PCBs in groundwater to reach Mare Island Strait, even if traveling through permeable utility backfill. Further, groundwater at IR12 mixes with surface water upon entering Mare Island Strait, which reduces concentrations of contaminants in groundwater by at least a factor of 1,000.

The results of the HHRA indicate that the potential cancer risk estimates for both commercial/industrial workers and construction workers exposed to soil and groundwater at IR12 are within or below the risk-management range, except for the potential exposure of construction workers to mixed-zone soil and groundwater (dermal contact). The HI for construction workers exposed to the mixed-zone soil through dermal contact exceeds 1. The main contributor to this HI is Aroclor-1260 in subsurface soil (i.e., greater than 2 feet bgs). Although an elevated HI was also calculated for dermal exposure of the construction worker receptor to groundwater, this result is most likely overestimated. Groundwater is not expected to pose a potential significant risk to construction workers at IR12. The EPC for lead in surface soil (1,198 mg/kg) at IR12 exceeds the risk-based level for soil for commercial/industrial workers. Based on the results of the HHRA, further evaluation of Aroclor-1260 and lead in soil is warranted in the feasibility study.

A Baseline ERA was performed for IR12 to assess potential for risk to ecological receptors from site-related constituents. All inorganic analytes detected in groundwater at IR12 are at ambient concentrations. Only three organics were detected and retained for further evaluation including acenaphthene, naphthalene, and 1,2,4-trichlorobenzene. Each of these analytes have an HQ less than 1 when compared to RWQCB ESLs. Therefore, risk from groundwater to aquatic organisms in the Mare Island Strait is considered negligible.

The results of a degradation of groundwater assessment indicate that, while arsenic and manganese are present in groundwater at IR12 at concentrations that exceed chemical-specific ARARs identified by the RWQCB for groundwater and surface water, these metals are present at concentrations that are within the range of concentrations that are considered ambient. Constituents in groundwater at IR12 are therefore not present at concentrations that are degrading the waters of the State.

ES.2.3 Building 108 Area

The Building 108 Area contains Building 108 and several other current and former structures, former UST 108, and a former waste collection area (referred to as the waterfront central dumpsters). The eastern part of Building 108 was used by the outside machine shop; the western half was used by welders; and dip tanks for metal cleaning were located in the building. Machine shop operations that occurred both in and around Building 108 may have included grinding, drilling, small-parts fabrication, and metal cleaning. UST 108, which contained a combination of water and fuel product fractions, was removed in December 1992.

The former waterfront central dumpster area is located in the general vicinity between Building 108 and Dry Dock No. 1. A number of dumpsters stored wastes generated by

operations in support of dry dock activities. Wastes that may have been discarded in these dumpsters include paint, paint thinner, brush cleaner, old brushes, paint sludges, resins, paint and solvent containers, oil-covered metal shavings, and asbestos waste. The dumpsters reportedly overflowed at times. Wastes collected in the dumpsters were ultimately transported to the facility landfill for disposal (Ecology and Environment 1983; PRC 1995b).

Analytical data collected at the Building 108 Area during site investigations performed between 1994 and 2004 indicate that impacted areas of the site primarily are located immediately surrounding Building 108 near the identified sources of contamination: former UST 108, the former waterfront dumpsters, and historic machine shop activities in Building 108. The highest concentrations of TPH-diesel-range organics, TPH-motor-oil-range organics, lead, and select polynuclear aromatic hydrocarbon compounds were found in surface and near-surface soil outside the northwest corner of Building 108. Contamination in this area may be associated with the historic machine shop operations or the waterfront central dumpsters.

In the vicinity of the former UST 108, low concentrations of TPH-gasoline-range organics and BTEX compounds were detected in soil that likely represent residual contamination that was not removed when the UST, piping, and surrounding soil were removed in 1992. These compounds were not detected in groundwater near the former UST, however.

The most likely migration pathways for constituents in soil at the Building 108 Area are dissolution of soil constituents by infiltration, followed by migration through the vadose zone through advection and dispersion and subsurface lateral migration via groundwater transport through the aquifer to Mare Island Strait or the dry docks. The concentrations of petroleum hydrocarbons detected in groundwater at the site are low, and biodegradation has likely resulted in a reduction in petroleum hydrocarbon concentrations through natural attenuation. Further, mixing of groundwater with surface water in Mare Island Strait results in a significant reduction in constituent concentrations in the Strait.

EPCs calculated during the HHRA for lead in surface soil (2,830 mg/kg) and mixed-zone soil (1,692 mg/kg) exceed the risk-based level of 750 mg/kg. Lead in soil presents a potential risk to human health. Remedial alternatives will be evaluated in the feasibility study to determine the remedial measure that will most cost-effectively reduce the risk created by elevated levels of lead in surface and subsurface soil in the Building 108 Area. The results of the HHRA indicate that future site conditions at the Building 108 Area pose potential excess lifetime cancer risks that are within the risk-management range (10^{-4} x 10^{-6}) for carcinogens. In addition, non-cancer adverse health effects (HIs) were estimated to be below 1 for all of the receptors potentially exposed to soil or groundwater. Because these calculated carcinogenic and non-carcinogenic risks are within or below the risk-management range, lead is the only constituent that presents a potential significant risk to human receptors in the Building 108 Area.

The results of the ERA indicate that zinc and six organic analytes had HQs greater than 1 when compared to their respective ESLs. HQs for these analytes ranged from 1.04 to 14.1. However, constituent concentrations will be reduced as groundwater mixes with surface water upon entering the Mare Island Strait. As groundwater enters Mare Island Strait, it is reasonable to expect that COPEC concentrations will be reduced by at least a thousand-fold.

If a mixing factor of that magnitude is applied to estimate potential concentrations in Mare Island Strait to which potential receptors might be exposed, risk is reduced to a negligible level. While localized impacts may occur near the discharge if mixing with surface water is not considered, population-level impacts are unlikely to be significant. As a result, risk from groundwater to aquatic organisms in the Mare Island Strait is considered low.

The results of a degradation of groundwater assessment indicate that, while copper, manganese, mercury, and thallium are present in groundwater at the Building 108 Area at concentrations that exceed chemical-specific ARARs identified by the RWQCB for groundwater and surface water, these metals are present at concentrations that are within the range of concentrations that are considered ambient. Zinc was detected in groundwater at concentrations that exceed both chemical-specific ARARs identified by the RWQCB for groundwater and surface water and ambient concentrations for this metal. However, detected concentrations are believed to be elevated due to the presence of colloidal material in groundwater samples and it is expected that dissolved zinc concentrations are within the range of ambient concentrations. Constituents in groundwater at the Building 108 Area are therefore not present at concentrations that are degrading the waters of the State.

Based on guidance provided in *Screening For Environmental Concerns at Sites With Impacted Soil and Groundwater* (RWQCB 2003b) for evaluating petroleum hydrocarbon concentrations in soil and groundwater, TPH-diesel and TPH-motor-oil are present in soil at the Building 108 Area at concentrations that potentially pose an odor/nuisance condition. Consequently, RAOs are developed to address these analytes, in addition to lead, in the feasibility study.

ES.2.4 IR14

IR14 is the industrial wastewater treatment plant (IWTP) collection system underground piping and pump stations, designed to collect, pre-treat, and convey wastewater from various sources to the IWTP. Approximately 550 feet of the total 26,000 linear feet of the IR14 pipeline is located within IA C3. The pipeline is constructed of cement, mortar-lined, ductile iron pipe buried at 2.5 to 4 feet bgs in fill consisting commonly of gravel and silt-sand-gravel mix with some debris (PRC 1996a). There are no industrial wastewater pump stations or pretreatment facilities located in IA C3.

The IWTP and associated piping was constructed in 1972 and operated along with the collection system until base closure in 1996. The Navy performed removal of sludge and residue and flushing of the entire IWTP collection system in 1996. The environmental concerns associated with the IWTP collection system include soil and groundwater contamination that may have resulted from piping system leakage, fill contamination, backfill debris disposal, and/or releases from nearby areas of concern. Abrasive blast material may also be associated with the IWTP collection system.

Chromium was detected in soil above the ambient concentration for fill materials and was the only compound for which additional data collection was required during the 2002-2004 field investigation. The low level of chromium detected in soil during 2002 and the non-detect result recorded for chromium in groundwater along the preferential migration pathway to the Strait indicate that the objectives of the IA C3 Sampling and Analysis Plan have been satisfied. Significant concentrations of other metals, petroleum hydrocarbons, and volatile organic compounds were not detected in soil samples collected at IR14. Therefore,

the nature and extent of soil and groundwater contamination around IR14 within IA C3 has been characterized.

The conclusions of the fate and transport evaluation suggest that, while migration pathways have the potential to transport constituents via groundwater, the constituents at IR14 would not be expected to reach Mare Island Strait for centuries, if at all. Since chromium was not detected in the groundwater sample collected from the most likely preferential migration pathway (permeable utility backfill), it is expected that significant concentrations of metals are not migrating from IR14 towards the Strait via groundwater.

The results of the HHRA indicate that future site conditions at IR14 pose potential lifetime excess cancer risks (4×10^{-7}) that are below the risk-management range (10^{-4} to 10^{-6}) for carcinogens. The non-cancer adverse health effects were estimated to be 1 for all COPCs at IR14 within IA C3, which is equal to the threshold of 1 for non-carcinogens. The evaluation of potential ecological risk posed by IR14 groundwater to aquatic organisms in the Mare Island Strait concluded that the risks are considered negligible.

The results of a degradation of groundwater assessment indicate that chromium, the only constituent that was analyzed in the groundwater sample collected along IR14 in IA C3, is not present at concentrations exceeding chemical-specific ARARs identified by the RWQCB for groundwater and surface water. Constituents in groundwater at IR14 in IA C3 are therefore not present at concentrations that are degrading the waters of the State.

No unacceptable risk to human or ecological receptors is posed by contaminants at IR14 in IA C3, and contaminants are not present in groundwater at concentrations that are degrading waters of the State. Therefore, a feasibility study is not required for the portion of IR14 within IA C3.

ES.3 Feasibility Study

The remedial investigation concluded that constituents in soil at IR09, IR12, and the Building 108 Area are present at concentrations that potentially pose significant risks to human health or the environment. Accordingly, remedial alternatives were developed and evaluated in a feasibility study to determine the remedial measure that most cost-effectively reduces the risk created by elevated levels of constituents in surface and subsurface soil at these sites, while maintaining compliance with state and federal ARARs.

The sites requiring further evaluation are all co-located and contain similar types of contamination. Therefore, although discrete volumes that require remedial action are identified for each site, the evaluation of each alternative depends on the total volume of contaminated media from all sites.

The following five alternatives were developed for the area comprising IR09, IR12, and the Building 108 Area based on the results of the remedial investigation:

- Alternative S1 – No Action
- Alternative S2 – Institutional Controls: Land Use Covenant and Deed Restrictions
- Alternative S3 – Containment: Capping and Institutional Controls
- Alternative S4 – Excavation/Off-site Disposal and Institutional Controls

- Alternative S5 – Limited Excavation/Off-site Disposal and Institutional Controls

All alternatives were screened against each other on the criteria of effectiveness, implementability, and cost. Alternatives S1, S2, S3, and S5 survived the screening process. Alternative S4 was deemed difficult to implement and extremely costly (over four times as costly as other alternatives). In addition, Alternative S4 is not expected to greatly reduce risks to human and ecological receptors beyond levels attainable through implementation of other alternatives. Consequently, this alternative was screened out of the feasibility study for the site.

Detailed and comparative analyses of the remaining alternatives rendered Alternative S5 – Limited Excavation/Off-site Disposal and Institutional Controls the best overall performing alternative. This alternative provides a high degree of protection to human health and the environment, reduces the mobility and volume of the contaminated soil, achieves compliance with ARARs, and provides a high degree of long-term effectiveness. However, the cost for Alternative S5 is nearly twice that of Alternative S3. Alternative S3 – Containment: Capping and Institutional Controls provides a similar level of overall performance to Alternative S5. However, there is no reduction in toxicity or volume, and no treatment is included. In addition, Alternative S3 does not comply with the requirements of TSCA at IR12. Alternative S3 also requires long-term monitoring to ensure continued protectiveness.

1.0 Introduction

This section presents the objectives and structure of this remedial investigation/feasibility study (RI/FS) report for Investigation Area (IA) C3, as well as the site history and physical characteristics of Mare Island. An evaluation of the beneficial uses of groundwater and surface water is also provided in this section.

1.1 Objectives

This RI/FS report has been prepared by CH2M HILL in accordance with the Consent Agreement signed April 16, 2001, between Lennar Mare Island (LMI), the City of Vallejo, and the California Environmental Protection Agency (Cal/EPA), Department of Toxic Substances Control (DTSC) (LMI et al. 2001a). This RI/FS report addresses Installation Restoration Program (IRP) sites IR09, IR12, IR14, and the Building 108 Area.

This RI/FS report will:

- Document the results of the 2002-2004 field investigation.
- Describe and evaluate the physical site characteristics, contaminant source characteristics, and nature and extent of contamination.
- Assess the fate and transport of contaminants and potential exposure pathways.
- Characterize potential risks of adverse health or environmental affects.
- Assess potential degradation of groundwater and surface water as a result of historic releases in IA C3.
- Define and compare alternative remedial options to address the identified risks.

1.2 Report Organization

This RI/FS report is organized according to guidelines presented in the United States Environmental Protection Agency (USEPA) Office of Emergency and Remedial Response Directive 9355.3-01, *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA 1988). This RI/FS report is divided into the following sections:

- Section 1.0 presents the objectives and structure of this report and provides background information on the former Mare Island Naval Shipyard (MINS) and IA C3.
- Section 2.0 describes the methodology used to conduct the RI/FS, including the approach used to collect and evaluate site characterization data, to perform the human health and ecological risk assessments, to assess potential degradation of waters of the State of California, to evaluate applicable or relevant and appropriate requirements (ARARs), and to perform a feasibility study.

- Section 3.0, Section 4.0, Section 5.0, and Section 6.0 present the site background, previous investigations, physical characteristics, the nature and extent of contamination, contaminant fate and transport, a human health risk assessment summary, an ecological risk assessment summary, a degradation of groundwater assessment, and conclusions for IR09, IR12, the Building 108 Area, and IR14, respectively.
- Section 7.0 presents the feasibility study for IR09, IR12, and the Building 108 Area. This section develops, screens, evaluates, and compares remedial alternatives for these three IRP sites.
- Section 8.0 presents a list of references used in the preparation of this RI/FS report.

1.3 Mare Island and IA C3 Site Background

This section summarizes site description, history, and physical and ecological characteristics of Mare Island, with emphasis placed on the background and characteristics that pertain to IA C3.

1.3.1 Site Description

Mare Island is located on a peninsula approximately 30 miles northeast of San Francisco (Figure 1.3-1). The peninsula is bounded to the east, south, and west by the Napa River (Mare Island Strait), Carquinez Strait, and San Pablo Bay, respectively. Mare Island was originally an island comprised of bedrock and natural sediment, covering approximately 1,000 acres, with a surrounding wetlands of approximately 300 acres. Over time, the placement of artificial fill materials and dredge tailings has transformed the island to the current peninsula, which covers over 5,600 acres, excluding the intertidal zone (the area that in inundated between low and high tides).

IA C3 is located in the east-central portion of the former Mare Island, as shown in Figure 1.3-2. The approximately 50-acre area is bounded by Mare Island Strait to the east and by industrial areas to the north, west, and south. As shown in Figure 1.3-2, most of IA C3 does not fall within the original (1859) Mare Island boundary but consists of fill material. A quay wall extends along the eastern edge, between IA C3 and Mare Island Strait. IA C3 contains four dry docks (Dry Dock No. 1, Dry Dock No. 2, Dry Dock No. 3, and Dry Dock No. 4), two building ways (Ways 1 and Ways 2), one pier (Pier 21), and Berths 11 through 20. The locations of these site features and current structures within IA C3 are presented in the 2000 aerial photograph presented in Figure 1.3-3. Land surrounding the structures is paved throughout, and several railroad spurs are located in IA C3. IA C3 is zoned industrial land use according to the *Preliminary Land Use Plan* (LMI 2000). The northernmost portion of IA C3 (including Dry Dock No. 1 and the building ways) is located in the historical core of Mare Island, which is also considered industrial land use. The proposed land-use zones for IA C3 are presented in Figure 1.3-4.

1.3.2 Site History

The Navy purchased Mare Island in 1853 and commenced shipbuilding operations the following year. The primary ship construction and maintenance area of MINS was established along the northeastern shore of the original island adjacent to Mare Island Strait

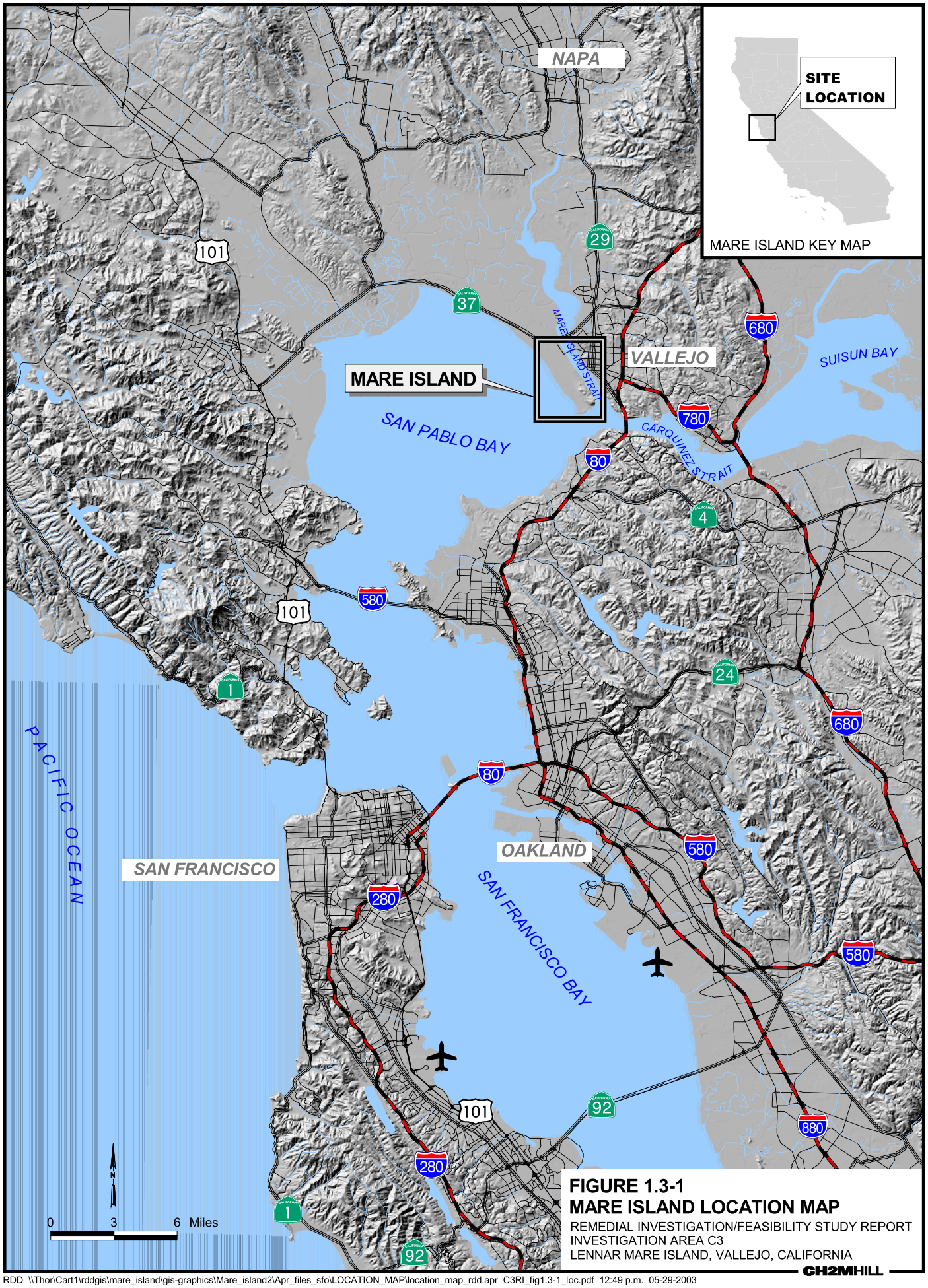

FIGURE 1.3-1
MARE ISLAND LOCATION MAP
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

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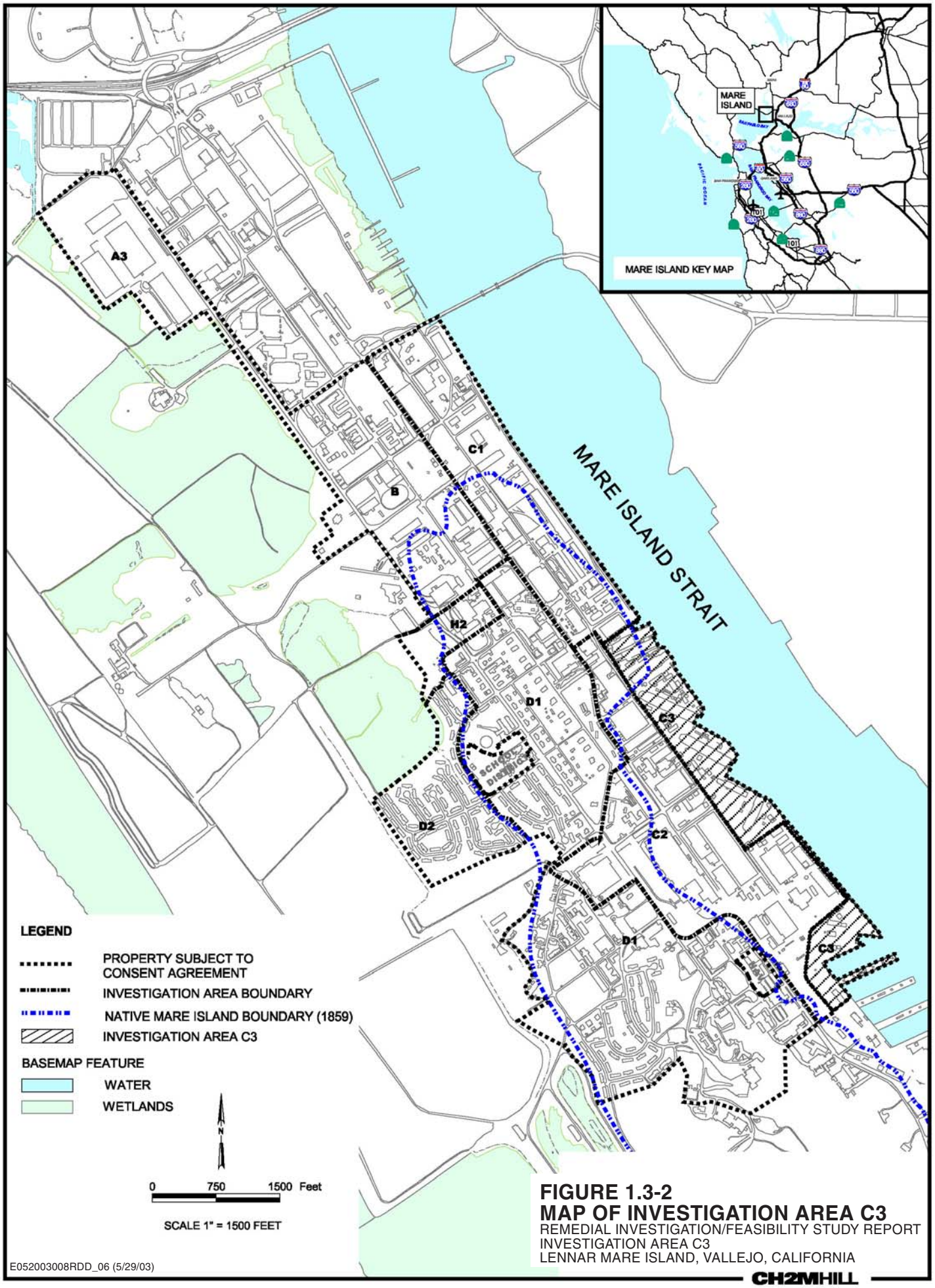

FIGURE 1.3-2
MAP OF INVESTIGATION AREA C3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

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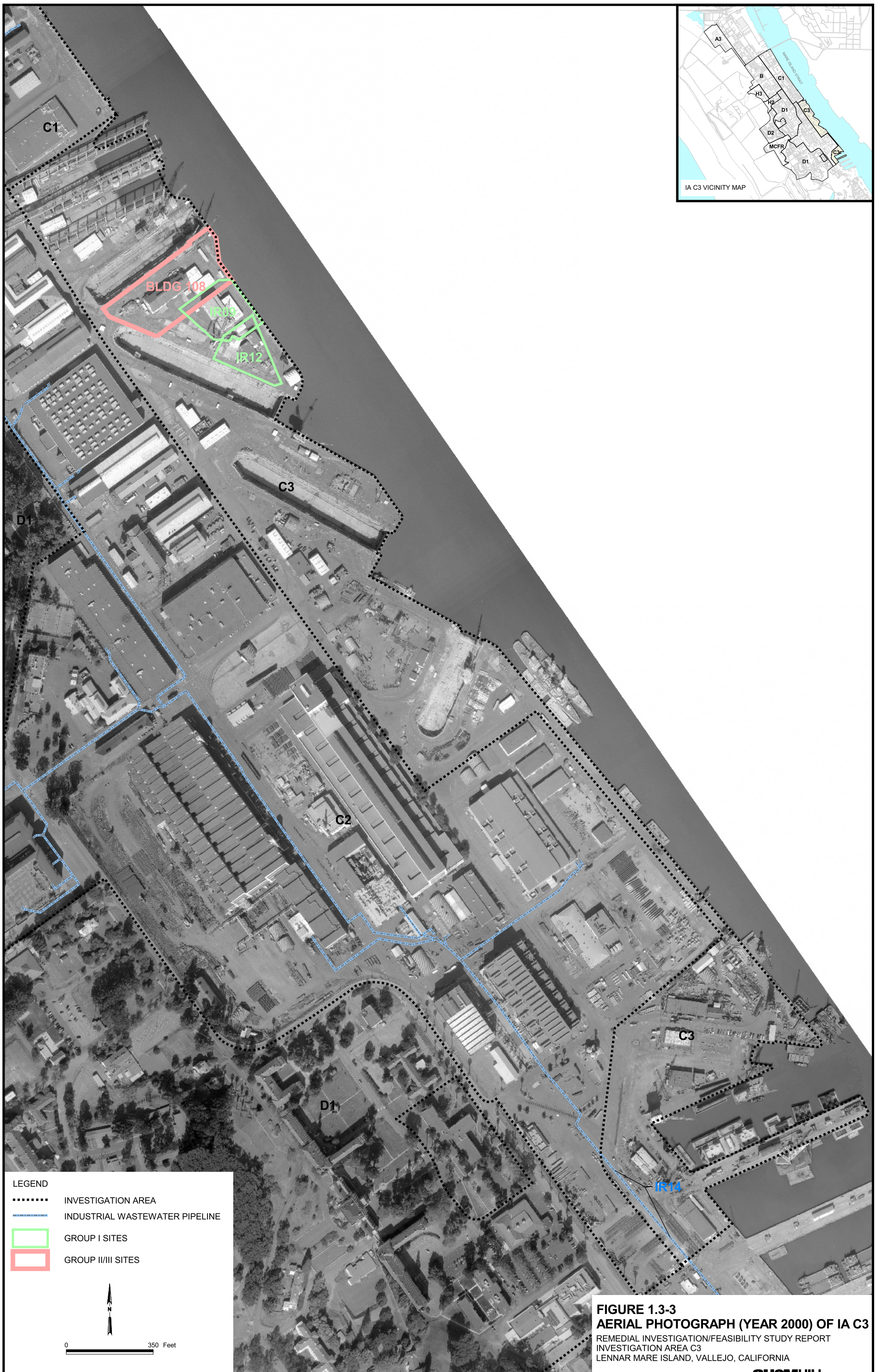

FIGURE 1.3-3
AERIAL PHOTOGRAPH (YEAR 2000) OF IA C3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

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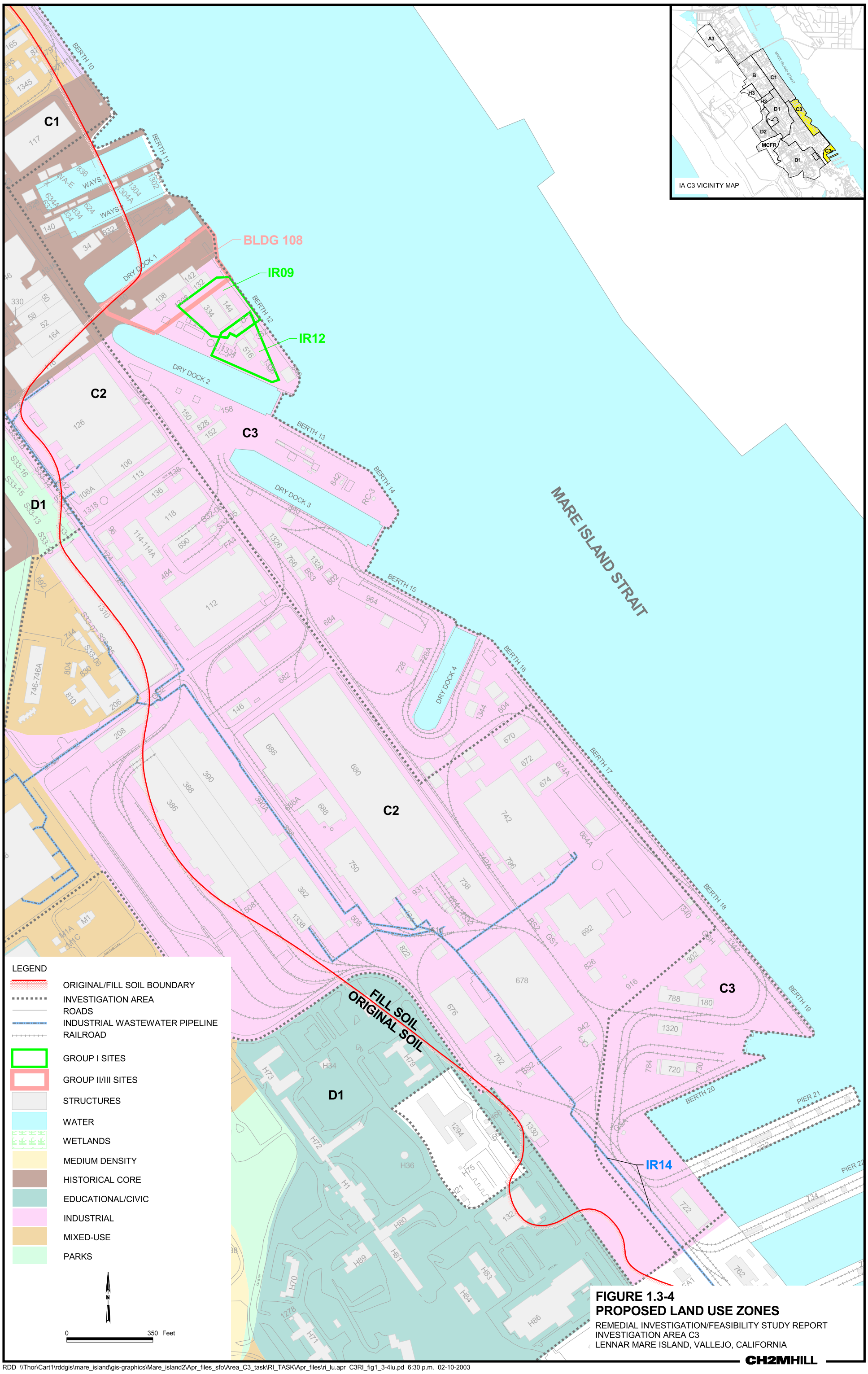

FIGURE 1.3-4
PROPOSED LAND USE ZONES
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

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(north of IA C3). The entire facility saw vast transformations during its years of operation as shipbuilding technologies advanced from wooden to steel construction and wind power to nuclear propulsion. In the early 1920s, the Navy initiated construction and maintenance of submarines at MINS. During World War II, MINS reached peak capacity for shipbuilding, repair, overhaul, and maintenance. Following the war, MINS was considered a primary station for construction and maintenance of the Navy's Pacific fleet of submarines. However, because of changing Navy needs in a postwar environment, shipyard activity decreased. The former MINS was closed on April 1, 1996, after 142 years of operation.

Historically, the land in IA C3 was mostly marshland and was filled when the dry docks, wharves, and quay wall were constructed and the land area was filled. Dry Dock Nos. 1 and 2 were constructed in 1891 and 1910, respectively. After these two structures were completed, wooden wharves were replaced with concrete and steel quay walls (supporting railroad track), effectively extending the shipyard boundary further into Mare Island Strait (PRC 1996a). Dry Dock Nos. 3 and 4 were built in 1940 and 1942, respectively, and Pier 21 was constructed in 1942.

Because of the location of the dry docks and its proximity to Mare Island Strait, past land use in IA C3 has been for industrial purposes relating to shipbuilding, and maintenance and repair of submarines and surface ships. Past uses include ship berthing, authorized ship repair in dry docks, shipfitting and structural steel fabrication, machine shop component machining operations, forging, metal casting, component chemical cleaning and metal plating, wood boat construction, sheet metal fabrication, abrasive blasting, painting of structural steel components, material storage, pattern making to support casting operations, welding, metallurgy laboratory evaluation, repair and overhaul of nuclear components, refueling of nuclear-powered submarines, and trade skills training (SSPORTS 1996a-b).

1.4 Other Investigative Programs

As summarized in the *Final Investigation Area C3 Site Identification Technical Memorandum* (CH2M HILL 2002a), the Navy has performed several investigations at IRP sites in IA C3 since the early 1980s. These investigations include an initial assessment study, verification study, and multiple stages of a remedial investigation. In addition to the investigations associated with the IRP sites, other basewide investigative programs have served to identify additional potential sources of contamination (e.g., polychlorinated biphenyls [PCB] sites, underground storage tanks [USTs], and sanitary sewer pump stations). The sites of potential environmental concern in IA C3 were presented in the *Final Investigation Area C3 Site Identification Technical Memorandum*. The locations of these sites are presented in Figure 1.4-1. Approval to the *Final Investigation Area C3 Site Identification Technical Memorandum* has been provided by DTSC and Regional Water Quality Control Board (RWQCB) (DTSC 2003; RWQCB 2003a).

The following sections summarize the conclusions of the *Final Investigation Area C3 Site Identification Technical Memorandum*, which addressed how each site of potential environmental concern would be carried forward to facilitate eventual closure of IA C3. The sources of contamination that are evaluated in conjunction with the evaluation of an IRP site in this RI/FS report include:

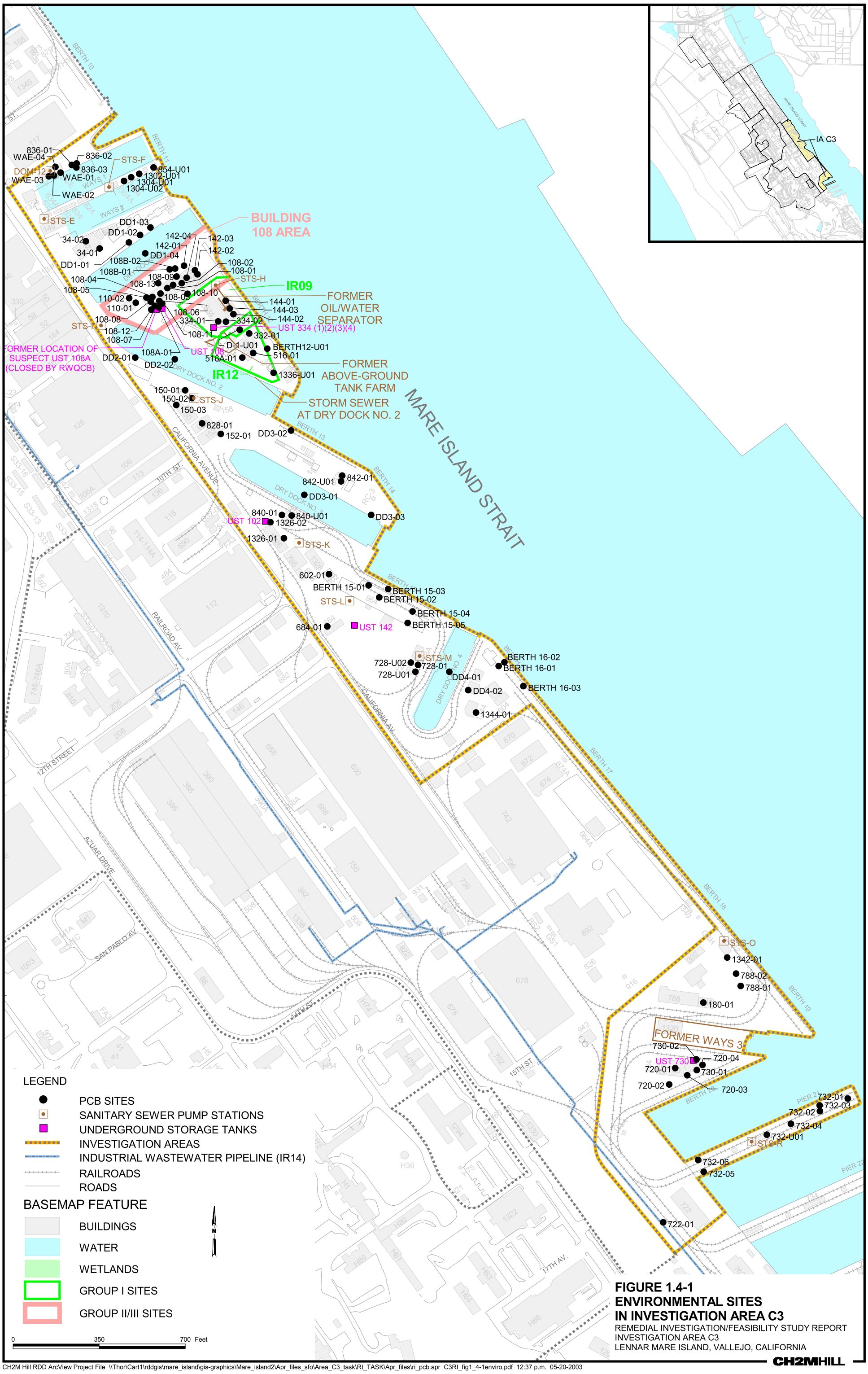

FIGURE 1.4-1
ENVIRONMENTAL SITES IN INVESTIGATION AREA C3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

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CH2M Hill RDD ArcView Project File \\Thor\Cart1\rddgis\mare_island\gis-graphics\Mare_island2\Apr_files_sfo\Area_C3_task\RI_TASK\Apr_files\ri_pcb.apr C3RI_fig1_4-1enviro.pdf 12:37 p.m. 05-20-2003

- USTs 108, 108A, 334-1, 334-2, 334-3, and 334-4
- PCB sites 516 AL #01, 516A AL #01, and 516A UL#01
- Oil Water Separator beneath Building 144
- Former Paint Varnish Plant (including a former AST farm)

1.4.1 UST Program

The UST program at Mare Island included identifying and removing USTs and fuel oil pipeline (FOPL) segments, and performing abatement activities, as necessary. No segments of the FOPL are located in IA C3. Documentation of the UST site assessment, sampling, and abatement activities is contained in many reports, typically specific to certain UST sites. Ten USTs (USTs 62, 102, 108, 108A, 142, 334-1, 334-2, 334-3, 334-4, and 730) within IA C3 have been identified and investigated as part of the Navy UST program. USTs 108 and 108A are located in proximity to other sources of petroleum hydrocarbon contamination at the Building 108 Area, and USTs 334-1, 334-2, 334-3, and 334-4 are a prime source of contamination at IR09. Consequently, analytical data collected during investigations of these UST sites are included in the evaluation of IR09 and the Building 108 Area in this RI/FS report. The remaining four UST sites in IA C3 will be addressed in separate site characterization summary or closure reports in accordance with the RWQCB Order R2-2002-0105. A request for closure of UST sites 108, 108A, 334-1, 334-2, 334-3, and 334-4 will also be documented in separate closure reports in accordance with RWQCB Order R2-2002-0105.

1.4.2 Polychlorinated Biphenyl Program

The PCB program at the MINS included the identification, retrofit, and removal of PCB-containing equipment, assessing locations of potential releases of PCBs, and performing abatement activities, as necessary. Documentation of the PCB site assessment, sampling, and abatement activities is contained in the *Final Basewide Polychlorinated Biphenyl Confirmation Sampling Report* (TtEMI 1998a). One hundred and five PCB sites are located within the boundaries of IA C3 (Figure 1.4-1). Analytical data collected at PCB sites at Building 516 and 516A, which are the source of PCB concrete and soil contamination at IR12, are included in the evaluation of the nature and extent of contamination of IR12 in this RI/FS report. The remaining PCB sites are not addressed in this report. The need for additional sampling and/or remediation at these and other PCB sites in IA C3 is addressed in the *Final Polychlorinated Biphenyl Work Plan* (CH2M HILL 2003a) in accordance with the provisions of the Toxic Substances Control Act (TSCA). Separate reports will document the results of field investigation and remedial activities proposed at PCB sites in IA C3.

1.4.3 Sanitary Sewer Pump Stations

The sanitary sewer system was investigated by the Navy in specific areas of Mare Island where there was reason to suspect potential contamination. Because the sanitary sewer system is a gravity system, the only suspected release locations were the sanitary sewer pump stations. Accordingly, environmental samples were collected at representative pump stations during the Group II/III investigation (PRC 1997a; TtEMI 2000a). These pump stations were further addressed in *Draft Sanitary Sewer Site Identification Technical Memorandum for Mare Island, Vallejo, California* (CH2M HILL 2002b). The purpose of this report was to evaluate the entire sanitary sewer system at Mare Island and identify, based

on operational information and data collected at representative pump stations during the Group II/III Investigation, which sanitary sewer pump stations require further investigation and/or remediation prior to closure. The draft sanitary sewer system technical memorandum concluded that no additional site characteristics or remediation is required for the sanitary sewer system as an environmental site. The 10 sanitary sewer pump stations in IA C3 (DOM-12, STS-E, STS-F, STS-H, STS-I, STS-J, STS-K, STS-L, STS-M, and STS-R) are not evaluated as part of this RI/FS report.

1.4.4 Additional Sites of Potential Environmental Concern

Investigations were performed at four previously-unidentified sites of potential environmental concern (oil/water separator beneath Building 144, Former Paint Varnish Plant [including the former AST farm located west of Building 1334], Storm Sewer at Dry Dock No. 2, and Former Ways 3) during June and December 2002. These sites were not identified in the DTSC Consent Agreement, but were identified during an internal review of historical Navy documentation. The investigations were performed in accordance with the *Draft Limited Investigation Sampling and Analysis Plan for Multiple Sites in Investigation Areas C2 and C3* (CH2M HILL 2002c) and *Multiple Sites Characterization Study of Unknown Sites* (CH2M HILL 2002d). The results of the investigations at the oil/water separator beneath Building 144 and the Former Paint Varnish Plant, which are located at or in proximity to IR09, are included in the evaluations of IR09 in this RI/FS report. The results of the investigations performed at the Storm Sewer at Dry Dock No. 2 and Former Ways 3 are presented and evaluated in separate technical memoranda.

1.5 Physical Characteristics

1.5.1 Surface Features

IA C3 occupies approximately 50 acres in the east-central portion of Mare Island. The topography is generally flat, with elevations of about 6 to 8 feet above mean sea level (msl). Because IA C3 is within the former industrial area of MINS, the area is covered primarily with buildings and pavement. The four dry docks located in IA C3 are constructed of stone and concrete. The bottoms of the dry docks are approximately 40 feet below ground surface (bgs), or approximately 35 feet below msl.

1.5.2 Surface Water

Mare Island is located on the eastern edge of San Pablo Bay near the confluence of the Napa and Sacramento-San Joaquin Rivers. Mare Island Strait to the east of Mare Island and IA C3 (which is also the Napa River mouth) separates Mare Island from the City of Vallejo. The Napa River drains a 230-square-mile area to the north of the Mare Island peninsula, and seasonal variations in flow from the Napa River can affect salinity levels in Mare Island Strait. Most often, the Strait has a salinity above 5 parts per thousand (ppt) and is considered estuarine (SFEI 2000, 2001). Higher freshwater inflows into the Strait during the wet winter months may occasionally cause the salinity levels to drop enough to classify it as freshwater. With seasonal variability in salinity, flow, and sediment deposition, the aquatic environment is highly dynamic.

As IA C3 is covered almost entirely by buildings and paved surfaces, surface water drainage within IA C3 is controlled primarily by the stormwater system. Most rainwater runoff locally flows to stormwater drains. However, some water may otherwise evaporate or seep into the subsurface in areas of localized ponding or through cracks in the pavement.

1.5.3 Geology

The geology of Mare Island can be characterized as an eroded bedrock surface that is exposed in the southern part of the peninsula, overlain by a blanket of unconsolidated Quaternary sediments and fill material at most other locations. The bedrock surface is irregular and deeply incised in some areas, and up to 160 feet of unconsolidated materials overlie the bedrock at some locations on the peninsula. The eroded bedrock forms a subsurface ridge, estimated to be the original extent of Mare Island in 1869, that extends northwest along the axis of the Mare Island peninsula, roughly coinciding with Azuar Drive. The northern extent of the subsurface bedrock ridge is not known, but the ridge is present at least as far north as A Street.

Three principal geologic units have been identified at Mare Island. From top to bottom, stratigraphically, these include (1) fill material, (2) unconsolidated natural deposits, and (3) bedrock. The artificial fill material is a heterogeneous unit consisting of clay, silt, sand, gravel, and debris in varying proportions. The unconsolidated natural deposits consist primarily of a thick sequence of silty clays commonly referred to as “Bay Mud.” The bedrock consists of sandstone, siltstone, and shale.

1.5.3.1 Fill Material

As a result of extensive land reclamation activities at Mare Island, a highly heterogeneous surficial layer of fill material is prevalent at locations outside of the original outline of the island. The fill material consists of silty clays, sands, gravels, organic debris, debris including concrete, asphalt, brick, metal, timber, paint chips, fiberglass, and other solid refuse and is characterized by abrupt and unpredictable changes in material in short lateral and vertical distances.

IA C3 is located primarily outside the original (pre-1869) Mare Island boundary, as shown in Figure 1.3-2, within an area reclaimed with artificial fill. Since much of the fill material is dredged silty clays (Bay Mud), the boundary between the fill and the silty clay in the natural deposits below often is not well-defined.

1.5.3.2 Unconsolidated Natural Deposits

Unconsolidated natural deposits overlie the eroded bedrock surface on much of Mare Island. The composition of unconsolidated natural deposits on the western side of the bedrock ridge differs from the eastern side deposits. IA C3 is located east of the ridge.

On the western side of the bedrock ridge, natural deposits consist of silty clays often known as Bay Mud, with some coarse material lenses interspersed. An apparently relatively extensive sand, commonly referred to as the Lower Sand, has been noted at 50 to 65 feet bgs in several borings on the west side of the bedrock (but not within IA C3). East of the bedrock ridge (the industrial areas of Mare Island including IA C3), unconsolidated natural deposits primarily consist of silty clay and clay, with occasional discontinuous lenses of silty sand

and sandy clay. The unconsolidated materials vary from as little as 5 feet thick on top of the bedrock ridge to more than 105 feet thick near the southern end of the peninsula.

1.5.3.3 Bedrock

The bedrock at Mare Island consists of steeply dipping brown, orange, and tan arkosic sandstone, siltstone, and micaceous shale. Bedrock outcrops exist in the hilly area at the southern end of the peninsula that is now occupied by the golf course, ammunition bunkers, and a residential area along Mesa Avenue. The exposed bedrock at Mare Island is assigned to the undifferentiated Great Valley Sequence on Wagner and Bortungo's (1982) regional geologic map. A more detailed map prepared by Dibblee (1981) identifies the bedrock as arkosic sandstone and micaceous shale of the Cretaceous Panoche Formation.

1.5.4 Hydrogeology

The primary water-bearing zone in IA C3 is a shallow, unconfined aquifer, which includes those parts of the fill and original soil that are below the water table and the top portion of the weathered bedrock. Two deeper water-bearing zones have been identified in the western portion of Mare Island (PRC 1995a). These other water-bearing zones were not encountered by CH2M HILL, and do not appear to be present in IA C3.

1.5.4.1 Groundwater Flow Patterns

Maps of the potentiometric surface of the shallow unconfined aquifer for January 2000 and August 2002 are shown in Figures 1.5-1 and 1.5-2, respectively. Figure 1.5-1 presents the potentiometric surface for the entire IA C3, while Figure 1.5-2 presents groundwater elevation data and potentiometric surface lines for the area between Dry Dock Nos. 1 and 2 only. Groundwater flow in IA C3 generally moves toward Mare Island Strait, although flow directions and rates in the shallow water-bearing zone are locally influenced by variations in lithology and the proximity of dry docks, storm sewers, or municipal sewers. The backfill around the utility corridors and the lenses of coarse fill may act as preferential pathways for groundwater movement. In addition, the dry docks within IA C3 locally act as boundaries to groundwater flow in the near-subsurface unconfined aquifer. As discussed below in Section 1.5.4.2, the quay wall along the eastern edge of IA C3 does not act as a barrier to groundwater flow.

1.5.4.2 Effects of Tidal Influence and Seasonality

Tidal fluctuations in Mare Island Strait have a substantial influence on groundwater levels very near the Strait. For example, well 09W07, which is approximately 30 feet from the Strait, exhibited tidal fluctuations of 5.26 feet during a 5-day period in 1995 (PRC 1996b). The Strait itself had a tidal variation of 6.9 feet during the same period. The tidal variation in well 09W07 shows that the groundwater beneath IA C3 and the surface water of Mare Island Strait are hydraulically connected, and the quay wall does not act as a significant barrier to groundwater flow. It also appears that proximity to utility corridors may increase the effects of the tide upon local groundwater variation. Water levels at locations away from the Strait (approximately greater than 50 feet from the Strait) usually show quite limited tidal effects (less than 1 foot of tidal response). From this observation it is inferred that tidal influence does not have appreciable influence on the groundwater flow direction more than about 50 feet inland.

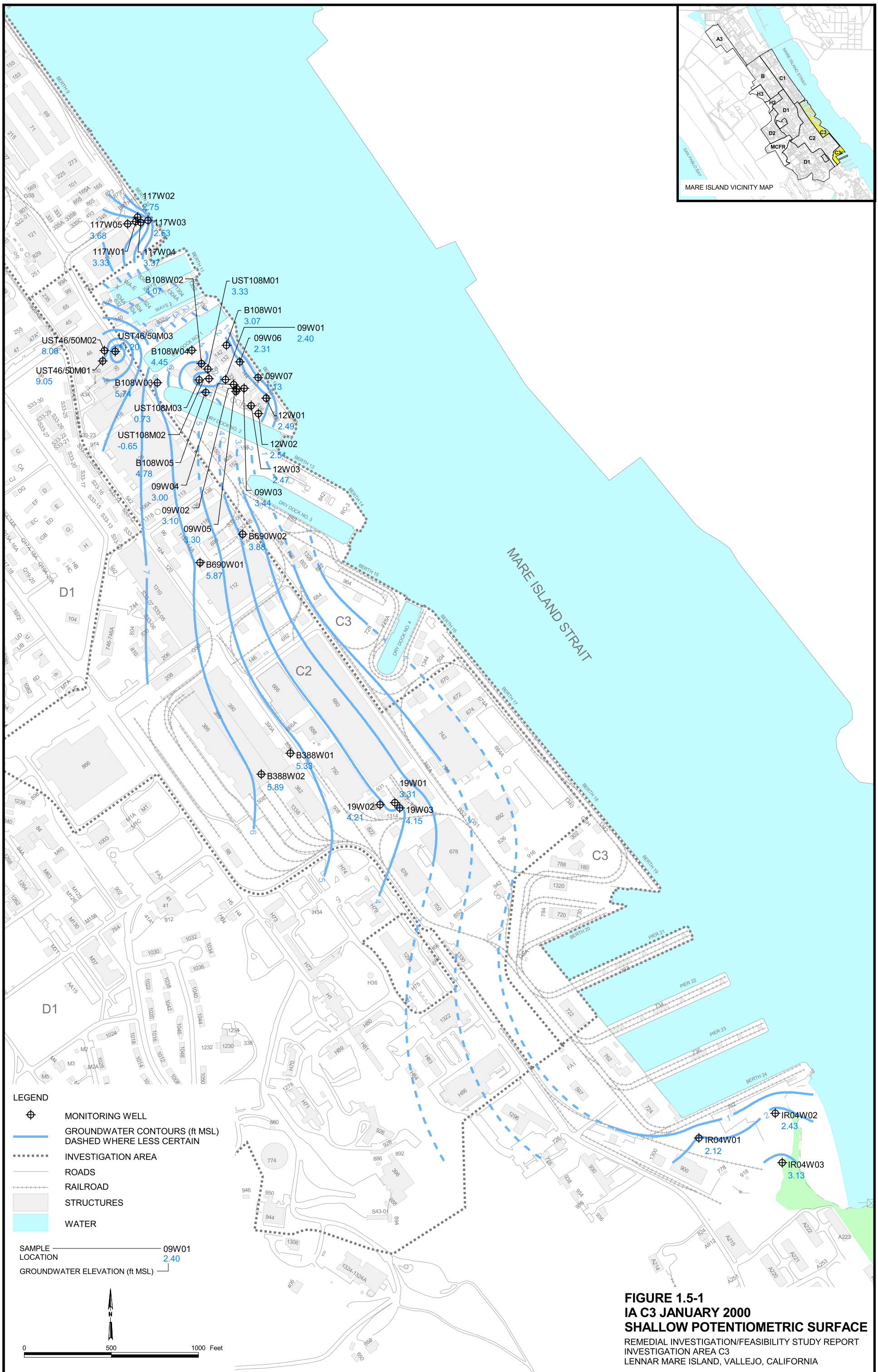

FIGURE 1.5-1
IA C3 JANUARY 2000
SHALLOW POTENTIOMETRIC SURFACE

REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

CH2MHILL

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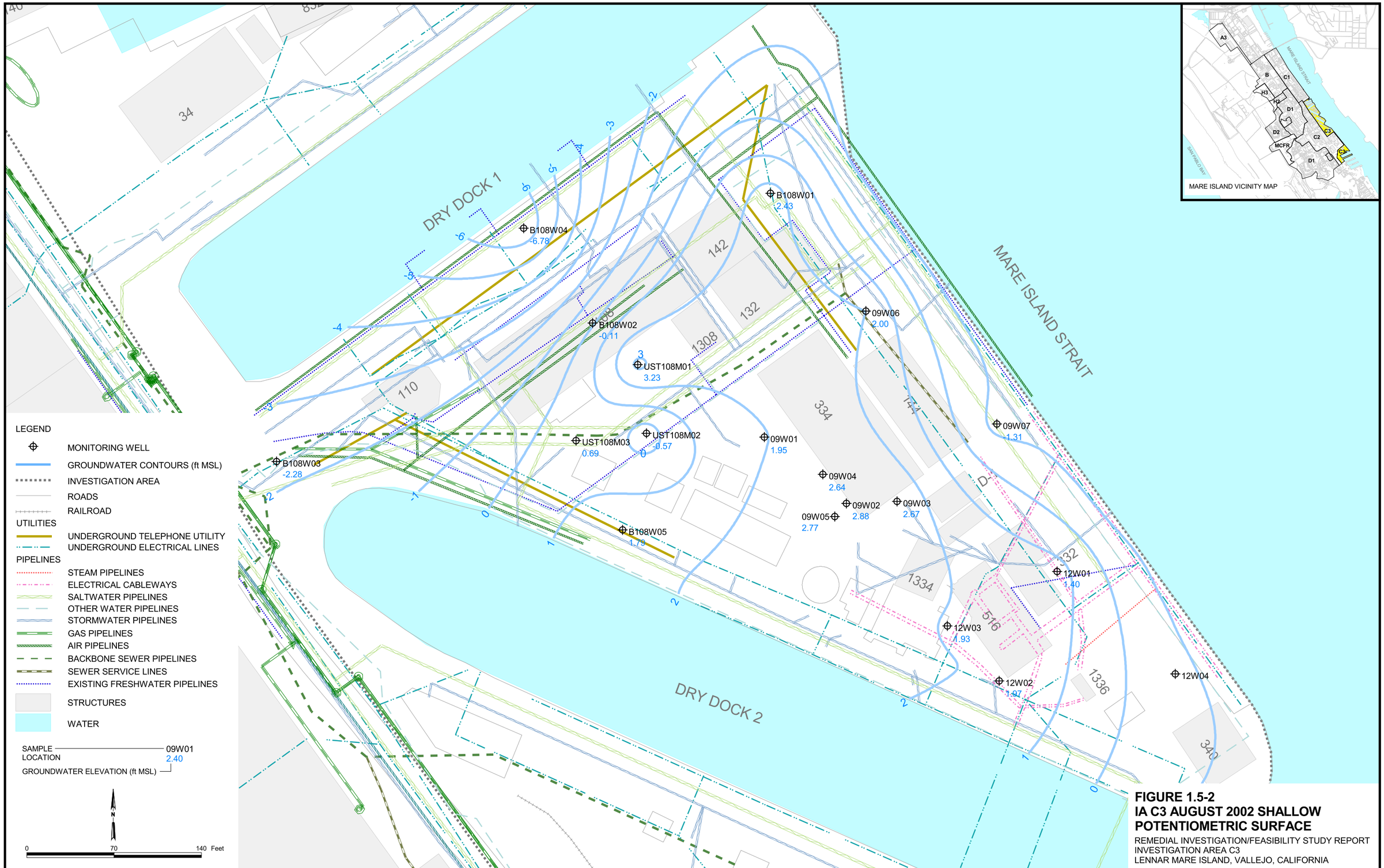

FIGURE 1.5-2
IA C3 AUGUST 2002 SHALLOW POTENTIOMETRIC SURFACE

REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

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In general, water levels in monitoring wells in IA C3 are highest during the wet season (November to April) and lowest during the dry season (May to October) (TtEMI 1999a, 2000a).

1.5.5 Climate

The climate of the North Bay area, including Mare Island, is generally warm and dry in summer and cool and wet in winter, with overall temperatures moderated by the proximity of San Francisco Bay. The average seasonal temperatures in the North Bay area as recorded between 1970 and 2001 at the Martinez Pumping Station (4 miles southeast of Mare Island), range between 70 to 75°F in the summer and 45 to 51°F in the winter (Western Regional Climate Service 2001).

Meteorological data was also recorded at the Mare Island industrial wastewater treatment plant (IWTP) between 1984 and 1990. This data is unpublished and documented in *Wastewater Monitoring IWTP Operation Summary Sheets Years 1990-1994/Meteorological Records Years 1984-1990 & 1992/Daily Precipitation & Max Temp Years 1970-1995* (TtEMI 1998b-d). Analysis of this unpublished meteorological data reports daily average air temperatures at the Mare Island IWTP at 58 °F between 1984 and 1988. The average annual temperatures ranged from 49 to 95°F in summer and 38 to 74°F in winter for the same duration.

On average, precipitation in the North Bay area occurs 60 days per year, with an estimated 19.6 inches annually, as measured between 1970 and 2000 at the Martinez Pumping Station. Approximately 55 percent of total precipitation occurs in the winter months between December and February (Western Regional Climate Service 2001).

Daily average wind speeds measured at the Mare Island power plant were typically 5 to 10 knots to the south or west. Maximum velocities of 20 to 30 knots were often recorded, particularly during winter months as described in the *Mare Island Weather Statistics* tables documented in the *Meteorological Records for Years 1984 to 1990* (MINS 1990).

1.5.6 Ecological Features

The major habitat types found at or around Mare Island include intertidal mudflats and open water, tidal wetlands, non-tidal wetlands, active dredge ponds, and uplands. The habitat types and species of concern are described in the ecological risk assessments for onshore and offshore areas of Mare Island (TtEMI 2002a-b). Within IA C3, no viable habitat exists in the onshore area because the site is covered entirely with asphalt and buildings. IA C3 is immediately adjacent to the open water of Mare Island Strait. The offshore habitat and special-status species that may occur near Mare Island are described below.

1.5.6.1 Offshore Habitats

The offshore areas consist of habitat below the mean high-tide line, which generally includes the intertidal mudflats (located west of Mare Island) as well as open water. The habitat offshore of IA C3 is characterized as deep-water habitat without adjacent near-shore habitat.

The offshore habitat (intertidal mudflat and open water) at Mare Island consists primarily of pelagic and benthic environments that support diverse communities of algal, invertebrate, fish, bird, and mammal species. The dominant types of vegetation found in this region are

algae (USFWS 1992), including microalgae (primarily diatoms) and macroalgae (such as red and green algae). Some of the dominant species include sea lettuce, green algae, red algae, and many species of diatoms. Invertebrates in this region include those associated with sediments as well as some free-swimming forms. Brackish-water shrimp and several other shrimp are likely to be found here, along with several crabs and snails. Invertebrates in the sediments are likely to include ostracods, worms, the oligochaete *Tubificoides brownae,* and polychaete worms. Bivalves present include clams, oysters, and three types of mussels. Other common organisms include barnacles.

California-native fish that occur in this region include the jacksmelt and the starry flounder. Chinook salmon, including spring, fall, late fall, and winter-run races, are known to migrate through the San Francisco Bay, with some passing near Mare Island (WESTDIV and the City of Vallejo 1998; Emmett et al. 1991). Similarly, steelhead may enter Mare Island Strait during migration (Archaeological Resource Service 1986). Pacific staghorn sculpin, three-spine stickleback, shiner perch, and both white and green sturgeon are also likely to occur there (WESTDIV and the City of Vallejo 1998; PRC 1997b; Emmett et al. 1991). Marine fish such as the brown rockfish and the plainfin midshipman may use this habitat as well (WESTDIV and City of Vallejo 1998). A number of exotic, or nonnative, fish, including the yellowfin goby, striped bass, and the arrow goby are also residents.

Ducks such as goldeneyes, scaups, surf scoters, and canvasbacks are known to occur in this area. The California brown pelican has been observed at Dikes 12 and 14, as has the spotted sandpiper (SSPORTS 1997). Several species of grebes also occur at the site. Other Mare Island shore and wading birds that are likely to forage in mud flat habitat include the American avocet, willet, marbled godwit, western sandpiper, dunlin, snowy egret, great egret, Forster's tern, and great blue heron.

Several aquatic mammals may occur near Mare Island. The harbor seal is the only mammal expected to make significant use of muddy beaches such as those in Dikes 12 and 14 (USFWS 1992). Local residents have observed seals in this general area. The California sea lion also occurs in San Francisco Bay and may occur around Mare Island (Ingles 1965). River otters have been sighted off the shore of Mare Island as well, though this species does not make significant use of this shoreline as habitat (USDA 1989).

1.5.6.2 Species of Special Concern

Three types of species of special concern are discussed in the following subsections: (1) threatened and endangered species, (2) commercially- or recreationally-important species, and (3) other species valued by society.

Threatened and Endangered Species. Several fish, birds, and mammals, listed as threatened or endangered by the state or federal government, reside in Mare Island Strait. These special-status species are listed in Table 1.5-1.

Winter-run Chinook salmon appear in Carquinez Strait as escaping (pre-spawning) adults and as smolts moving into the ocean. The Sacramento splittail and longfin smelt have been caught in nearshore waters but do not spawn in the area. The west shore of Mare Island constitutes the bulk of the most important green sturgeon nursery in San Francisco Bay (PRC 1996b). Federal- and state-listed raptors, such as the peregrine falcon, have been sighted near Mare Island.

TABLE 1.5-1
Special-status Species Observed or Potentially Present in Offshore Habitats at Mare Island
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Category	Common Name	Scientific Name	Federal Status	State Status	Habitat	Species Presence
Fish	Delta Smelt	*Hypomesus transpacificus*	FT	CT	Sacramento Delta and its sloughs; freshwater	P
	Green Sturgeon	*Acipenser medirostris*	FSC	CSC	Western shore of Mare Island	P
	Longfin Smelt	*Spirinchus thaleichthys*	FSC	CSC	Nearshore waters; salt or brackish waters	P
	Sacramento Splittail	*Pogonichthys macrolepidotus*	FPT	CSC	Nearshore waters as larvae, moving into deeper offshore waters as they mature	P
	Chinook Salmon	*Oncorhynchus tshawytscha*				O[2]
	- fall run	*Oncorhynchus tshawytscha*	FC	CSC	East of the Carquinez Strait; Sacramento River and its tributaries	P
	- late-fall run	*Oncorhynchus tshawytscha*	FC	CSC	East of the Carquinez Strait; Sacramento River and its tributaries	P
	- winter run	*Oncorhynchus tshawytscha*	FE	CE	Honker Bay, Suisun Bay, Carquinez Strait	P
	- spring run	*Oncorhynchus tshawytscha*	FT	CT	Honker Bay, Suisun Bay, Carquinez Strait	P
	Rainbow trout (Steelhead)	*Oncorhynchus mykiss*				P
	- Central Valley evolutionarily significant unit	*Oncorhynchus mykiss*	FT	None	Suisun Bay, Carquinez Strait	P
	- Central California Coast evolutionarily significant unit	*Oncorhynchus mykiss*	FT	None	Drainages of the San Francisco and San Pablo Bays	P
Birds	American White Pelican	*Pelecanus erythrorhynchos*	None	CSC	Salt ponds of San Francisco Bay	O
	California Brown Pelican	*Pelecanus occidentalis californicus*	FE	CE CFP	Estuarine, marine, subtidal, and marine pelagic habitats along the California coast	P

TABLE 1.5-1
Special-status Species Observed or Potentially Present in Offshore Habitats at Mare Island
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Category	Common Name	Scientific Name	Federal Status	State Status	Habitat	Species Presence
Birds Continued	Elegant Tern	*Sterna elegans*	FSC	CSC	Shallow ocean water and saline emergent wetlands	P
	Black Tern	*Chlidonias niger*	FSC	CSC	Fairly common on bays, salt ponds, river mouths, and pelagic waters during spring and fall migrations	O
	Double-crested Cormorant	*Phalacrocorax auritus*	None	CSC	Found in fresh, salt, and estuarine waters	O
	Barrow's Goldeneye	*Bucephala islandica*	None	CSC HS	Found in estuarine and brackish lacustrine waters	O
	California Gull	*Larus californicus*	None	CSC	Freshwater and saline emergent wetlands	O
	Osprey	*Pandion haliaetus*	None	CSC	Large fish-bearing waters	O[2]

Notes:

FE Federal Endangered Species.
FT Federal Threatened Species.
FPT Federal Proposed Threatened Species.
FSC Federal Species of Concern.
CE California Endangered Species.
CT California Threatened Species.
CSC California Species of Special Concern.
HS Species designated for harvest under the California State Fish and Game Code and U.S. Fish and Wildlife Service regulation
O Observed during surveys or incidentally during field investigation.
O[2] Observed occasional visitor.
P Potentially present at or near Mare Island.

The presence of the salt marsh harvest mouse, an endangered species endemic to the marshes of San Francisco Bay, is of particular concern for some portions of Mare Island. However, salt marsh harvest mouse habitat is not present in IA C3.

Commercially- or Recreationally-important Species. Recreational fishing for striped bass, starry flounder, sculpin, shad, and other species occurs from the pier and from boats along the shores of Mare Island Strait. In addition, the western shore of the island is the most important nursery area in the Bay Delta for Dungeness crab and Bay shrimp (Ecology and Environment 1983), and the shore supports recreational fishing for these species.

Other Species of Value. Harbor seals, which are protected under the Marine Mammal Protection Act, feed in waters surrounding Mare Island, including Mare Island Strait. Harbor seals feed mainly on sculpin, shad, gobies, and Dungeness crab (Harvey and Torok 1994). Additionally, many migrating birds use the vicinity of Mare Island. These birds are protected by the Migratory Bird Treaty Act, which includes provisions against toxic contamination.

1.6 Beneficial Use of Groundwater and Surface Water

1.6.1 Beneficial Use of Groundwater

The USEPA policy for groundwater classification is set forth in the preamble to the National Contingency Plan (55 Federal Register 8752-8756). This policy uses the groundwater classification system provided in the *EPA Guidelines for Groundwater Classification under the EPA Groundwater Protection Strategy* (USEPA 1986). Under this policy, groundwater is classified in one of three categories (Class I, II, or III) according to ecological importance, replaceability, and vulnerability considerations. Irreplaceable groundwater that is currently used by a substantial population or groundwater that supports a vital habitat is considered Class I. Class II groundwater consists of groundwater that is currently being used or water that might be used as a source of drinking water in the future. Groundwater that cannot be used for drinking water because of insufficient quality (e.g., high salinity or widespread naturally occurring contamination) or quantity is considered Class III.

The 1995 *Water Quality Control Plan for the San Francisco Bay Region* (Basin Plan) (RWQCB 1995) defines the following potential beneficial uses of groundwater:

- Municipal and domestic supply (MUN)
- Industrial service supply (IND)
- Industrial process supply (PROC)
- Agricultural supply (AGR)
- Freshwater replenishment to surface waters (FRESH)

Groundwater at Mare Island is neither currently, nor historically used for domestic, agricultural, or industrial water supply. While groundwater quality and quantity beneath IA C3 are not sufficient to support the beneficial uses described in the Basin Plan, groundwater at IA C3 is considered by the RWQCB to have the potential future beneficial uses of industrial service water supply, industrial process water supply, agricultural supply, and freshwater replenishment to surface water.

This assessment of the potential beneficial uses of groundwater at IA C3 focuses on potential future beneficial uses of MUN. The technical memorandum *Assessment of the MUN Beneficial Use Designation for the Eastern Early Transfer Parcel, Mare Island, Vallejo, California* (CH2M HILL 2003b) evaluates the potential for groundwater beneath the Eastern Early Transfer Parcel (EETP) at Mare Island to be used for MUN. The conclusions of this technical memorandum are summarized in the following section.

1.6.1.1 Municipal and Domestic Water Supply

All groundwaters of the State are considered to be suitable, or potentially suitable, for municipal or domestic water supply unless one or more of the following criterion specified in State and Regional Water Board Resolutions No. 88-63 and 89-39 are met:

- The total dissolved solids (TDS) concentrations exceed 3,000 mg/L and it is not reasonably expected by the RWQCB that the groundwater could supply a public water system.
- There is contamination, either by natural processes or by human activity, that cannot reasonably be treated for domestic use using either Best Management Practices or best economically-achievable treatment practices.
- The water source does not provide sufficient water to supply a single well capable of producing an average, sustained yield of 200 gallons per day (gpd).

The federal requirements are contained in 40 CFR Section 146.4, which specifies an aquifer or a portion thereof, that meets the criteria for an "underground source of drinking water" may be considered an exempted aquifer if:

- It does not currently serve as a source of drinking water.
- It cannot now and will not in the future serve as a source of drinking water because it is mineral, hydrocarbon, or geothermal energy producing; it is situated at a depth or location which makes recovery of water for drinking water purposes economically or technologically impractical; or it is so contaminated that it would be economically or technologically impractical to render that water fit for human consumption.
- The total dissolved solids content of the groundwater is more than 3,000 mg/L and less than 10,000 mg/L and it is not reasonably expected to supply a public water system.
- The aquifer does not yield more than 150 gpd.

The Technical Memorandum *Assessment of the MUN Beneficial Use Designation for the Eastern Early Transfer Parcel, Mare Island, California* (CH2M HILL 2003b) compares TDS concentration and yield information collected in IA C3 to the state criterion listed above for potential use as a municipal or domestic water supply. Based on both naturally high TDS and low yield, the technical memorandum concluded that groundwater in the EETP should not be considered a potential drinking water source. The specific findings of this evaluation for IA C3 groundwater wells are summarized below. While the technical memorandum only compares site-specific TDS and yield information against state criteria, the following discusses both state and federal criteria.

Maximum TDS concentrations in groundwater wells at IR09, IR12, and Building 108 Area in IA C3 exceed the federal TDS criteria of 10,000 mg/L for drinking water. The maximum TDS concentration in the majority (67 percent) of individual wells, at each IRP site, and in IA C3 as a whole exceeds the state TDS criteria of 3,000 mg/L. TDS concentrations detected in wells at these IRP sites and the surrounding area are presented in Figure 1.6-1.

The low-flow rate purging results from the June 1999 and January 2000 groundwater sampling events were used to estimate groundwater yield within the area between Dry Dock No. 1 and Dry Dock No. 2 (TtEMI 2000a-b). Because pumping rates of greater than approximately 95 gpd were not attempted during the slow-purge sampling, it is possible that some wells within IA C3 could sustain yields greater than the federal criteria of 150 gpd. Although the results are inconclusive for specific monitoring points, 80 percent of wells in IA C3 for which there are data cannot support the federal yield criteria of 150 gpd or the state criteria of 200 gpd. The quantity of groundwater that can be extracted from the aquifer represented by these wells is, therefore, not high enough for the aquifer to be considered a source of drinking water.

The individual wells with lower maximum TDS values would likely result in increased TDS values above the state and federal thresholds if the wells were pumped at a rate of 150 to 200 gpd. The proximity of these wells to Mare Island Strait and the fact that the dry docks impede groundwater flow from inland areas make it likely that long-term pumping would increase saltwater intrusion from the Strait, resulting in increased TDS concentrations. The TDS concentrations in excess of 10,000 mg/L in nearby wells (less than 100 feet away) is strong evidence for free exchange between Mare Island Strait and the groundwater beneath IA C3.

While there are no wells located in IA C3 south of Dry Dock No. 3, adjacent wells in IA C2 can be used to determine if IA C3 groundwater meets state and federal criteria. Figure 1.6-1 shows that wells upgradient of the southern portions of IA C3 (B690W01 and B690W02, 21W01 through 21W05, B388W01 and B388W02, 19W01 through 19W03, USTH74MW0100, and USTH74MW0101) have high levels of TDS. As groundwater moves towards the Strait from the wells located in IA C2, the TDS concentrations are likely to increase even more. Therefore, these data collected from these wells suggest that the groundwater in the southern portion of IA C3 exceeds the state and federal TDS criteria.

In conclusion, based on the poor quality and low quantity (yield), the groundwater beneath IA C3 should not be considered MUN under the state criteria and should be considered Class III under USEPA criteria.

1.6.2 Beneficial Use of Surface Water

IA C3 is located adjacent to Mare Island Strait, the discharge point of the Napa River to San Pablo Bay. Most often, salinity levels in the Strait characterize it as estuarine (SFEI 2000, 2001). However, freshwater discharge from the Napa River affects the salinity in Mare Island Strait on a seasonal basis. Higher freshwater inflows during the wet winter months may occasionally cause the salinity levels to drop enough to classify Mare Island Strait as freshwater.

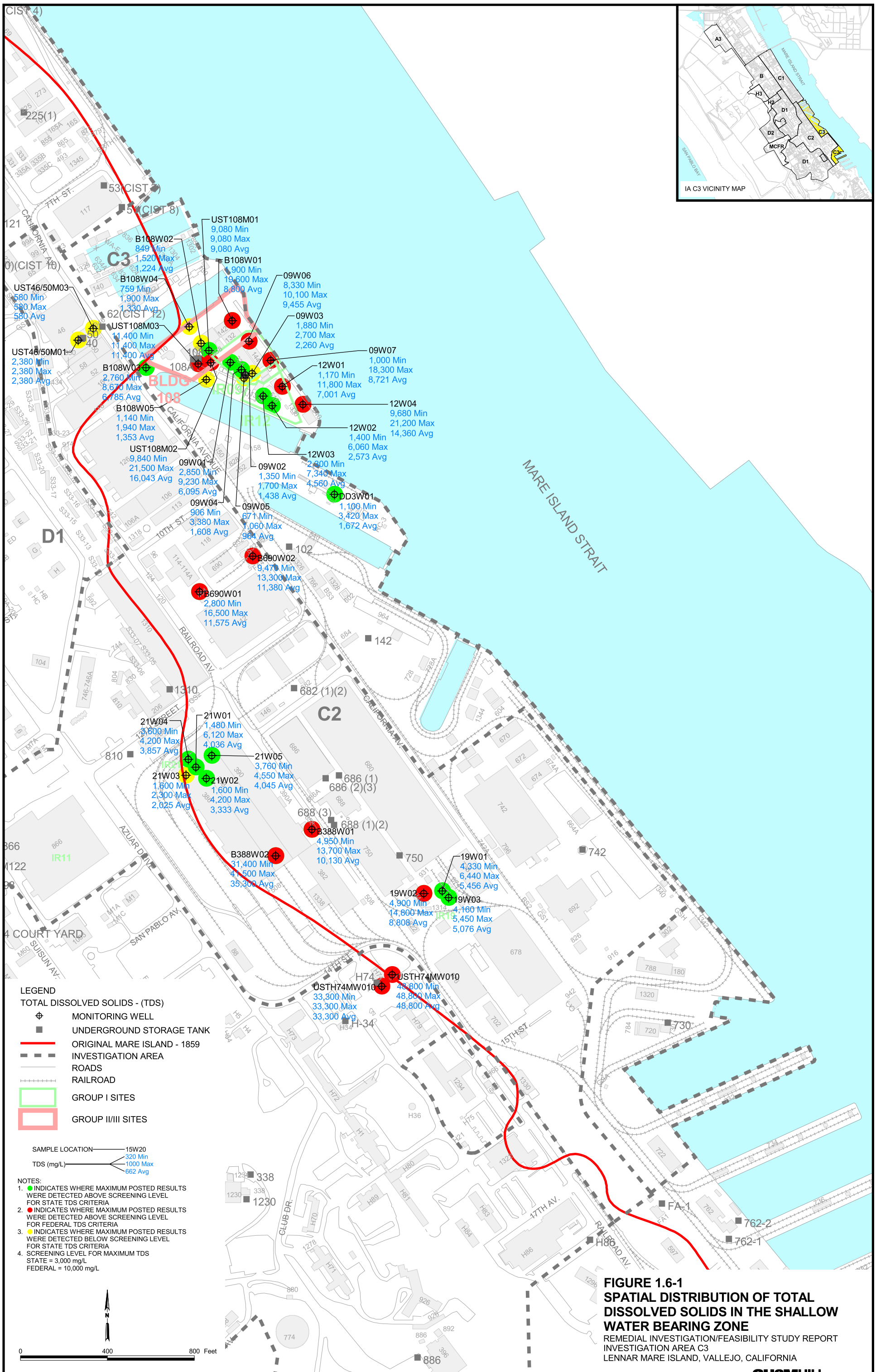

FIGURE 1.6-1
SPATIAL DISTRIBUTION OF TOTAL DISSOLVED SOLIDS IN THE SHALLOW WATER BEARING ZONE
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

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The Napa River and San Pablo Bay are identified in the Basin Plan as having beneficial uses associated with ecological habitat and recreational uses, specifically:

- Estuarine Habitat (EST)
- Fish Migration (MIGR)
- Ocean, Commercial, and Sport Fishing (COMM)
- Preservation of Rare and Endangered Species (RARE)
- Water Contact Recreation (REC 1)
- Non-contact Water Recreation (REC 2)
- Fish Spawning (SPWN)
- Wildlife Habitat (WILD)

Ecological characterization of the offshore habitat and special-status species that may occur in Mare Island Strait are described in Section 1.5.6.

2.0 Approach to the Remedial Investigation and Feasibility Study at Investigation Area C3

This section presents the methodology used to conduct the RI/FS for IR09, IR12, the Building 108 Area, and IR14 in IA C3. This section summarizes the approaches that were used to collect and evaluate site characterization data, to perform the human health and ecological risk assessments, to evaluate ARARs, to assess potential degradation of groundwater at IA C3, and to perform a feasibility study.

2.1 2002 through 2004 Field Investigation Activities

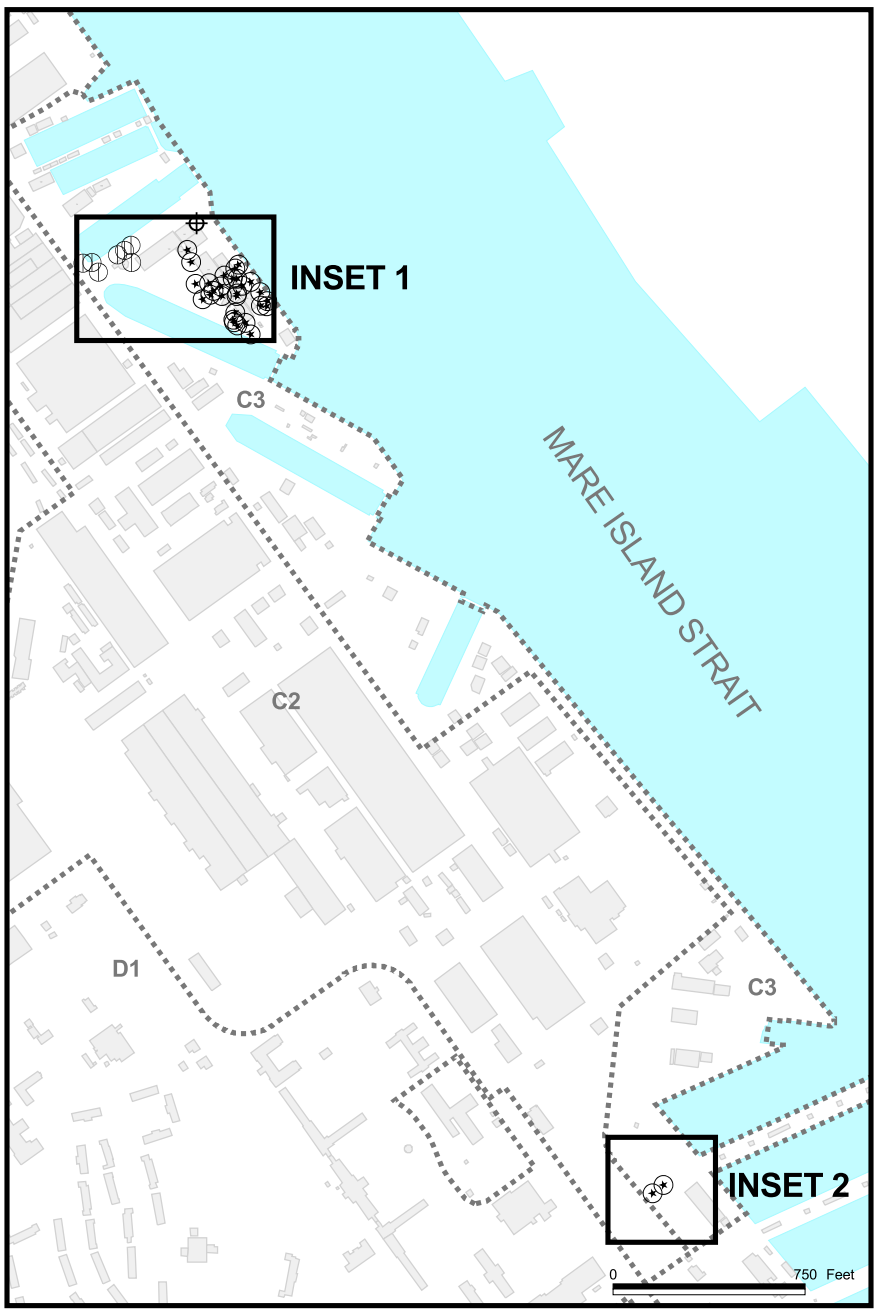
Field investigation activities at IRP sites in IA C3 were performed by CH2M HILL between June 2002 and July 2004. The activities included:

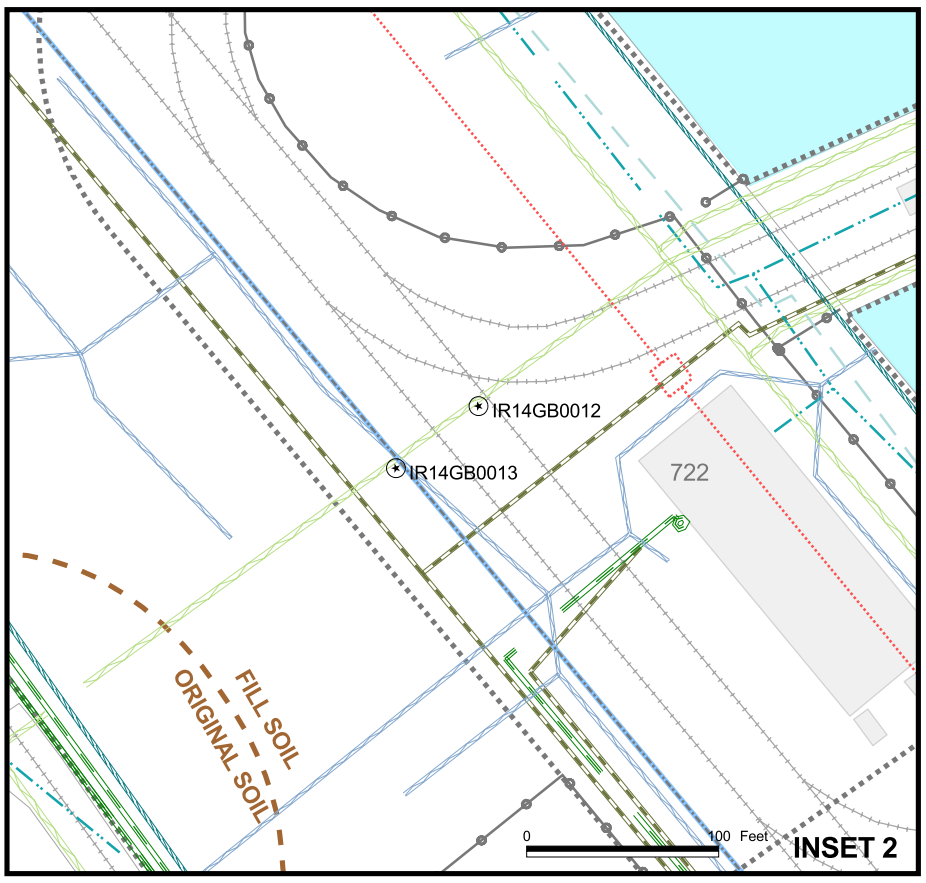
- Investigation in June 2002 at certain previously-unidentified sites of potential environmental concern in IA C3.
- Implementation of the *Investigation Area C3 Sampling and Analysis Plan* between July and October 2002 at IR09, IR12, Building 108 Area, and IR14.
- Multiple-site characterization study in December 2002 and January 2003 at certain previously-unidentified sites of potential environmental concern in IA C3.
- Quarterly groundwater monitoring between January 2003 and July 2004.

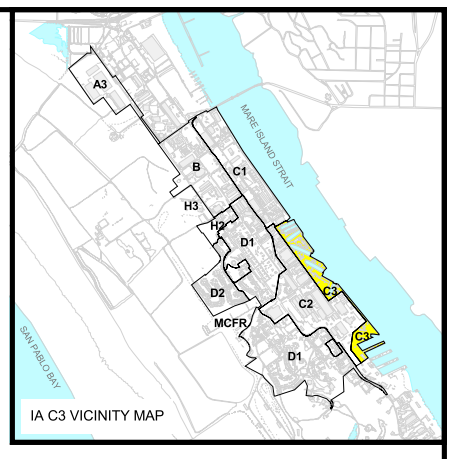
The objectives of the 2002-2004 field investigation were to collect additional information at specified sites in IA C3 to supplement the historical, Navy-generated information such that the resulting, combined data set would assist in the assessment of whether a release occurred at the site and assist in the preparation of an RI/FS report. Specific data collection strategies and data quality objectives were presented in the *Limited Investigation Sampling and Analysis Plan for Multiple Sites in Investigation Areas C2 and C3* (CH2M HILL 2002c); the IA C3 SAP (CH2M HILL 2002e-f); and the *Work Plan for Additional Characterization of Multiple Sites in Investigation Area C3* (CH2M HILL 2002g). Sampling locations during the 2002-2004 field investigation at IRP sites in IA C3 are presented in Figure 2.1-1.

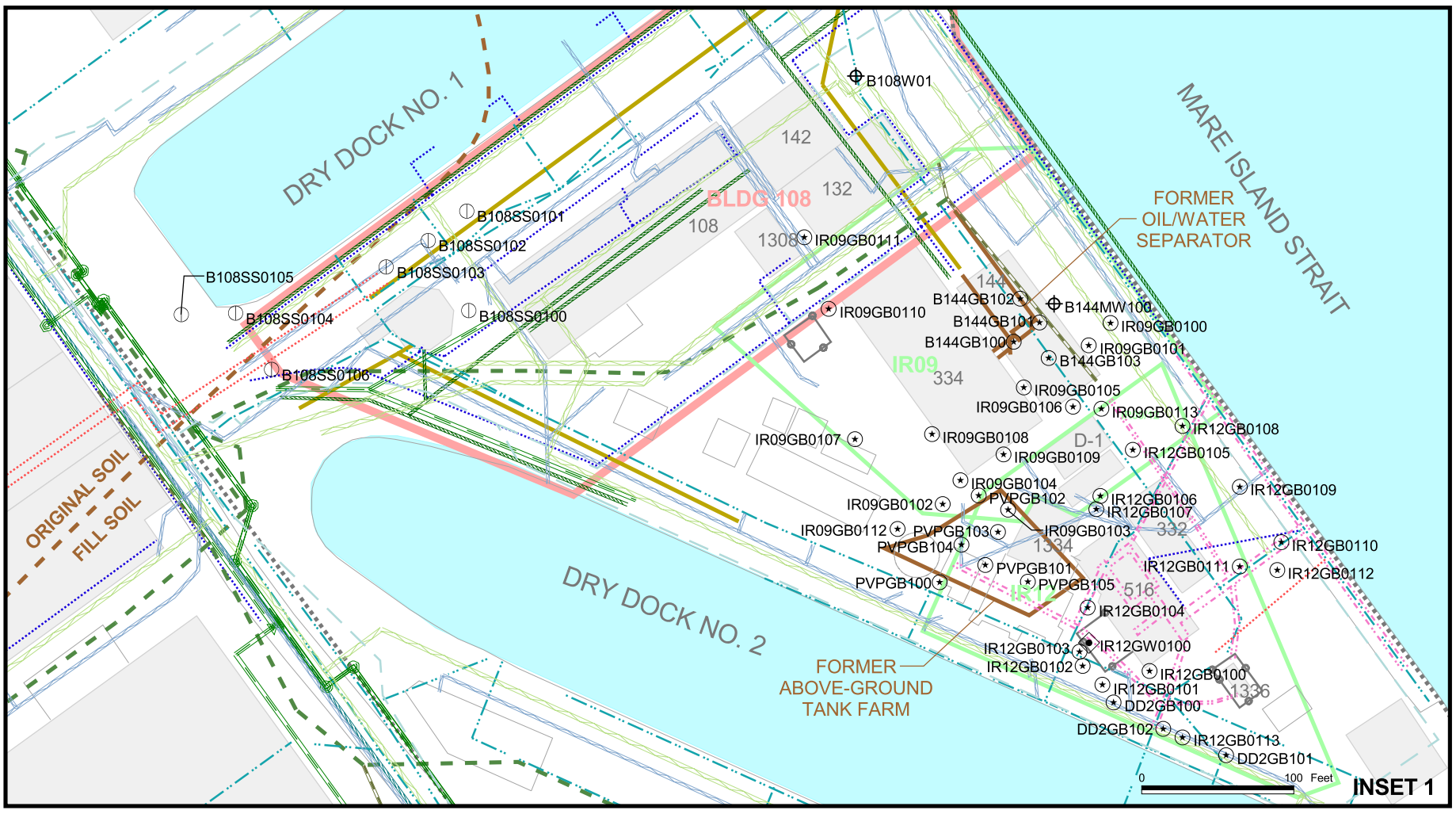
Appendix A presents a summary of the field investigation methods performed at IRP sites in IA C3 during the 2002-2004 field investigation, including drilling, collecting soil and groundwater samples, installing and developing monitoring wells, surveying, and managing investigation-derived waste. Appendix A also identifies deviations from the sampling regimen proposed in the sampling plans and the rationale for those deviations.

Analytical data collected during the 2002-2004 field investigation were validated according to procedures outlined in the Mare Island *Quality Assurance Project Plan* (QAPP) (CH2M HILL 2001). A summary of the results of the data validation process performed for









LEGEND

- GEOPROBE
- MONITORING WELL
- SURFACE SOIL SAMPLE
- GROUNDWATER SAMPLE
- INVESTIGATION AREA
- ROADS
- FENCE
- RAILROAD
- GROUP I SITES
- GROUP II/III SITES
- STRUCTURES
- WATER

UTILITIES

- UNDERGROUND ELECTRICAL LINES
- UNDERGROUND TELEPHONE UTILITY

PIPELINES

- INDUSTRIAL WASTEWATER PIPELINE
- STEAM PIPELINES
- ELECTRICAL CABLEWAYS
- SALTWATER PIPELINES
- OTHER WATER PIPELINES
- STORMWATER PIPELINES
- GAS PIPELINES
- AIR PIPELINES
- BACKBONE SEWER PIPELINES
- SEWER SERVICE LINES
- EXISTING FRESHWATER PIPELINES
- COMPRESSED AIR PIPELINES

FIGURE 2.1-1
2002 THROUGH 2004 FIELD INVESTIGATION SAMPLING LOCATIONS IN IA C3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

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analytical data collected from IRP sites in IA C3 in 2002-2004 is presented in Appendix B. Based on a review of method blank, field blank, field duplicate, laboratory control, duplicate matrix spike samples, and other analytical parameters, there was no indication of contamination from field or laboratory processes. A limited number of the analytical data required flagging during the data review and validation process. The analytical data were found to be of acceptable quality and can be used in the project decision-making process without further qualification.

2.2 Integration of Existing and New Data

As discussed in Section 1.4, the Navy investigated IRP sites in IA C3 through multiple investigations beginning in the 1980s. The Navy transitioned the environmental data collected during those investigations to CH2M HILL, including a portion of the MINS electronic environmental database containing environmental data collected by the Navy in the EETP. Appendix B summarizes the quality control procedures associated with the Navy-collected data.

Information collected during the 2002-2004 field investigation activities was integrated with the historical, Navy-generated information collected at the IRP sites in IA C3; the combined data set is used as the basis for site evaluation. The analytical, survey, lithologic, and hydrologic data collected during the 2002-2004 field investigation were added to the electronic environmental database. This facilitated the evaluation of a complete data set for each IRP site.

The following appendices to this report contain information collected during the 2002-2004 field investigation as well as information previously collected by the Navy:

- Appendix C provides the lithologic logs.
- Appendix D provides well construction diagrams.
- Appendix E provides water-level measurements.
- Appendix F provides analytical data.

Other Navy-generated field information at IRP sites in IA C3, such as a tidal influence study (PRC 1996b) and a slug test report (Uribe & Associates 1999), were previously published separately by the Navy and are not reproduced as appendices to this report.

2.3 Site Characterization Approach

The IRP sites in IA C3 were previously investigated by the Navy through various studies and investigations between the early 1980s and 2000. The *Investigation Area C3 Sampling and Analysis Plan* (CH2M HILL 2002e-f) evaluated the historical data collected at the IRP sites in IA C3 to assess the completeness and accuracy of the Navy-collected data to define the conceptual site model, including source characteristics, the nature and extent of contamination, the contaminated transport pathways and fate, and the effects on human health and the environment. Based on that evaluation, specific data were identified as necessary to complete the objectives of this RI/FS report. The additional data were collected during the 2002-2004 field activities (see Section 2.1) to meet the data quality objectives identified in the SAP and are incorporated into this RI/FS report.

This RI/FS report is based on the combined data set from all investigations at the IRP sites in IA C3. Site characterization information for each site is presented in Sections 3.0 through 6.0. The nature and extent of contamination is evaluated by considering analytical methods, analytical results, spatial relationships, source characteristics, and temporal trends. Specific methods for data evaluation at the IRP sites in IA C3 are described below.

2.3.1 Ambient Metals Concentrations

Ambient concentrations of metals in soil and groundwater at Mare Island were developed by the Navy and approved by the DTSC for use in environmental investigations and restorations at Mare Island. Ambient values were developed for select metals to identify naturally-occurring conditions, or conditions unrelated to site-specific industrial activities, against which site concentrations are compared to identify conditions that may be attributable to site activities. The ambient concentrations are defined in the *Final Compilation of Technical Memorandum on Ambient Analyses of Metals in Soils and Groundwater, Mare Island, California* (TtEMI 2002c). The ambient concentrations in soil and groundwater are discussed below.

2.3.1.1 Ambient Metal Concentrations in Soil

Metals for which ambient levels in soil were established were those of most concern for risk characterization, including carcinogenic metals and other metals that may pose significant adverse human health and ecological effects (TtEMI 2002c). Ambient concentrations at Mare Island have been established for 15 selected metals. Twelve other metals for which analysis was performed do not have established ambient concentrations.

Ambient metal concentrations for the selected metals were defined for both original soil within the Mare Island coastline of 1859 and for imported fill that was used at Mare Island after 1859. Figure 1.3-2 presents the delineation between original soil and fill material in IA C3. As presented in the figure, all four IRP sites in IA C3 are located on fill material and, therefore, ambient concentrations for Mare Island fill materials are relevant for comparison to detected metal concentrations in soil in IA C3. The ambient concentrations are shown in Table 2.3-1.

2.3.1.2 Ambient Metal Concentrations in Shallow Groundwater

Ambient concentrations for 24 selected metals in shallow groundwater at Mare Island have been established. These concentrations, based on filtered sample results, are shown in Table 2.3-2.

2.3.2 Navy On-site Laboratory Data

The Navy established on on-site laboratory at Mare Island for the analysis of soil and groundwater samples collected at Mare Island between approximately 1993 and 1999. The on-site laboratory analyzed soil samples for total petroleum hydrocarbons (TPH)-purgeables; TPH-extractables; PCBs; benzene, toluene, ethylbenzene, and xylene (BTEX) compounds; metals; and pH. The on-site laboratory analyzed water samples for TPH-purgeables, BTEX compounds, pH, conductivity, and turbidity. Soil and groundwater samples to be analyzed for these parameters typically were sent to the on-site laboratory for

analysis. Approximately 15 percent of the samples sent to the on-site laboratory were also submitted to an off-site, DTSC-certified laboratory as split samples.

TABLE 2.3-1
Ambient Concentration for Metals in Fill Soils
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Metal	Ambient Concentration of Metals in Fill at Mare Island (95th percentile) (mg/kg)	Lower Range of the Ambient Data Set (mg/kg)[a]	Upper Range of the Ambient Data Set (mg/kg)[b]	Mean of the Ambient Data Set (mg/kg)[c]
Aluminum	35,000	1,170	47,400	19,000
Antimony	8.5	0.35	16.5	0.9
Arsenic	36	0.72	48.8	10
Beryllium	0.9[d]	0.10	0.90	0.60
Cadmium	5.2	0.05	5.7	0.7
Chromium	140	5.30	148	85
Copper	120	5.7	148	67
Iron	62,000	14,050	109,120	43,000
Lead	59	2.1	60	25
Manganese	1,600	27.1	13,559	707
Mercury	2	0.02	69.7	0.2
Nickel	130	7.0	148	67
Thallium	DL[e]	0.22	8.4	0.3
Vanadium	190	4.4	220	120
Zinc	230	12.21	290	130

[a]Minimum detected concentration in ambient data set, after exclusion of anomalously low values.
[b]Maximum detected concentration in ambient data set, after exclusion of anomalously high values.
[c]Mean values for non-parametric distributions were estimated as the 50th percentile of the distribution.
[d]Ambient limit for beryllium was set at the maximum detected value in the ambient data set because a parametric estimate of the 95th percentile would have exceeded that value.
[e]At the request of the regulatory agencies, the ambient limit for thallium was set at the detection limit.

Notes:
DL = detection limit.
mg/kg = milligrams per kilogram.
Source: TtEMI 2002c.

Considering the information provided by the Navy pertaining to the analysis of soil samples for metals by the on-site laboratory using energy dispersion X-ray fluorescence (XRF) methodology, CH2M HILL completed an evaluation to determine the appropriate use of the XRF data. The evaluation of the XRF data is included in Appendix B. The evaluation consisted of a statistical comparison of split sample results for metals by both the on-site laboratory using XRF methodology, and an off-site, DTSC-certified laboratory using approved USEPA analytical methods for metals, including inductively-coupled plasma spectroscopy or atomic absorption. The evaluation concluded that sufficient correlation did not exist to consider the XRF data definitive data for use in risk assessments. Additional discussion is presented in Appendix B.

Based upon this evaluation, XRF results for metals in soil are included in this RI/FS report in site characterization statistical summaries for completeness (although the results are tabulated separately from off-site laboratory metals data) and are considered useful in assessing the nature and extent of site contamination. However, the XRF metals results typically are not used in the risk assessments without further evaluation.

TABLE 2.3-2
Ambient Concentration of Metals in Shallow Groundwater at Mare Island
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Analyte	Ambient Concentration of Metals in Shallow Groundwater at Mare Island (95th Percentile) (µg/L)	Lower Range of the Ambient Data Set (µg/L)[a]	Upper Range of the Ambient Data Set (µg/L)[b]
Aluminum	480	234	766
Antimony	5.6	6.5	21.1
Arsenic	78	4.5	107
Barium	1,200	13.3	1,740
Beryllium	1.6	1.1	6.2
Cadmium	16	16.7	114.0
Calcium	680,000	26,900	1,600,000
Chromium	22	4.4	133.0
Cobalt	100	4	229
Copper	33	1.8	269.0
Iron	140,000	17.8	75,600
Lead	10	1.4	15.2
Magnesium	1,500,000	42,100	1,640,000
Manganese	5,400	242	7,130
Mercury	0.22	0.25	0.98
Molybdenum	8.8	9.6	13.3
Nickel	7.5	5.2	83.3
Potassium	210,000	2,960	302,000
Selenium	12	13.7	22.3
Silver	15	4.4	32.3
Sodium	7,400,000	175,000	9,520,000
Thallium	DL[c]	N/A	N/A
Vanadium	140	7.2	297
Zinc	260	4.4	442.0

[a] Minimum detected concentration in ambient data set, after exclusion of anomalously low values.
[b] Maximum detected concentration in ambient data set, after exclusion of anomalously high values.
[c] At the request of the regulatory agencies, the ambient limit for thallium was set at the detection limit.

Notes:
N/A = not available.
DL = detection limit.

Source: TtEMI 2002c.

2.3.3 Analytical Data Evaluation

Complete analytical results from the previous investigations of IR09, IR12, the Building 108 Area, and IR14 are presented in Appendix F. To synthesize the large amount of data for evaluation, each parameter is presented in statistical summary tables for each IRP site. These statistical summary tables were developed for both soil and groundwater, and present the following information: the total number of samples; the number of detections; the frequency of detection; the minimum, maximum and average results; sample date and location (including depth) of the maximum concentration detected; and the minimum and maximum detection limit. A statistical summary table for concrete, asphalt, and wipe samples from IR12 is also provided in this report.

The following describes general rules for evaluation of analytical data:

- For areas that have had removal actions, the site characterization considers the current remaining concentrations of chemicals. Analytical data that are no longer representative of site conditions because of removal actions are flagged as "removed" in the database and are not included in statistical summary tables.
- As discussed, the Navy operated an on-site laboratory at Mare Island for certain analyses, and approximately 15 percent of the samples analyzed by the on-site laboratory were also analyzed by an off-site laboratory as split samples. For those split sample pairs, only the result from the off-site laboratory is used in the evaluation.
- Data from duplicate samples and other field quality control samples are not included in the statistical summary tables.
- Metals results in soil are compared to established ambient concentrations to assess the likelihood of metals concentrations resulting from site activity. Metals data for samples analyzed at the on-site laboratory by XRF methodology are tabulated separately and used qualitatively for assessing the nature and extent of contamination.
- For metals results in groundwater, data are segregated between filtered samples and unfiltered samples. Metals results are compared to established ambient concentrations for filtered groundwater to assess the likelihood of metals concentrations resulting from site activity.
- The media being evaluated are soil and groundwater (and concrete, asphalt, and wipe samples at IR12). Sediment data collected from inside structures that do not represent a release to the environment are not evaluated in this RI/FS report. Other than at IR12, analytical data for wood, concrete, asphalt, or wipe samples were not used, because these data were developed for PCB sites. In addition, toxicity characteristic leaching procedure data are not included in the statistical summary tables.
- Analytical data are rounded to two significant figures for presentation.

2.4 Human Health Risk Assessment Approach

This section presents a brief summary of the general approach used to conduct the human health risk assessment (HHRA) at IA C3. A more detailed description can be found in the

Risk Assessment Approach Technical Memorandum for Lennar Mare Island (CH2M HILL 2002h) and in Appendix G to this report.

2.4.1 Objectives

The HHRA for IA C3 provides risk managers with a basis for evaluating whether action is warranted to mitigate potential health effects from soil or groundwater at the four IRP sites in IA C3. This assessment is accomplished by characterizing potential cancer risks and risks of adverse non-cancer health effects associated with contaminants at IA C3. The HHRA considers "baseline conditions," that is, a case in which no remedy is implemented for chemical contamination at the site.

2.4.2 Methods

The methods used to conduct the HHRA for IA C3 are consistent with the USEPA and DTSC risk assessment guidance, as documented in *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual* (Part A) (USEPA 1989), *Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (DTSC 1992), and other pertinent USEPA and DTSC guidance documents and memoranda. The USEPA and DTSC risk assessment framework consists of the following four basic steps:

- Data Evaluation/Hazard Identification
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization

Each of these steps is described below. Details of each step of the HHRA are provided in Appendix G.

2.4.2.1 Data Evaluation/Hazard Identification

The first step of the HHRA consists of reviewing and evaluating available data and identifying constituents of potential concern (COPCs) in media at the site. Data sets are compiled for use in the HHRA based on the following:

- Media of concern (e.g., soil and groundwater)
- Soil depth intervals of concern depending on the identified potential receptors and physical features of the site (e.g., depth of tanks)
- Exposure area boundaries depending on the current and future uses of the site

COPCs for HHRAs are analytes in the database that have been detected at least once in an environmental medium and are not essential human nutrients. For metals, site concentrations are compared to ambient metals concentrations at Mare Island. Metals with site concentrations that are not significantly different than ambient concentrations are not considered COPCs.

Although some inorganic constituents may be eliminated as site-related COPCs, ambient risks will be calculated for those constituents and presented in the risk characterization section of the HHRA. In addition, total risks (risks associated with all detected constituents)

plus incremental risks (i.e., incremental risks above ambient levels) will be presented in the HHRA.

Petroleum hydrocarbon mixtures (i.e., TPH) detected in samples are not considered as COPCs. Health risks associated with potential exposure to petroleum hydrocarbons are evaluated using the detected concentrations of BTEX, other individual mononuclear aromatic compounds, polynuclear aromatic hydrocarbons (PAH), and other component compounds that have toxicity values assigned by USEPA or DTSC.

2.4.2.2 Exposure Assessment

The second step of the HHRA involves evaluating potential exposure pathways for COPCs and the potential human populations that could be exposed to these COPCs either now or in the future. For IA C3, the sites evaluated in the HHRA are located in areas where the planned future use is industrial. Therefore, the potential receptors for these sites are industrial workers and construction workers. The following scenarios are evaluated quantitatively in the HHRA:

- Exposure of commercial/industrial workers and construction workers to surface soil (0 to 2 feet bgs) through ingestion, dermal contact, and inhalation of particulates and volatile organic compounds (VOCs).
- Exposure of construction workers to mixed-zone soil (0 to 10 feet bgs) through ingestion, dermal contact, and inhalation of particulates and VOCs.
- Exposure of construction workers to groundwater through dermal contact and inhalation of VOCs.
- Exposure of commercial/industrial workers to VOCs inside buildings (i.e., VOCs that volatilize from subsurface soil or groundwater).

In addition to these scenarios, a future residential scenario is evaluated to provide information for future risk-management decisions. The results of the residential scenarios are presented in an attachment to Appendix G.

Exposure point concentrations (EPCs) are calculated for each COPC in each exposure area. An exposure area is the portion of a site in which receptors may regularly live or work. The data from an exposure area are grouped to calculate an upper-bound average concentration for each COPC that is then used in the risk calculations. For IA C3, each IRP site is considered an exposure area. The rationale for each IRP site being a separate exposure area is based on the assumption that IRP sites were identified by potential sources of contamination that are related to the particular type of activities that occurred in these areas. Therefore, each IRP site is associated with a type of industrial activity. Future worker activity patterns are difficult to predict; therefore, the assumption is made that the IRP site exposure areas are also appropriate for evaluating future exposure conditions.

2.4.2.3 Toxicity Assessment

The third step of the HHRA consists of compiling toxicity values that characterize potential adverse health effects from exposure to COPCs.

The following are the sources of toxicity values that are used in the HHRAs (in order of preference):

- Cal/EPA California Cancer Potency Values (Cal/EPA 2002). This table provides a compilation of slope factors (SFs) developed or approved by offices and departments within Cal/EPA.
- USEPA Integrated Risk Information System (IRIS). IRIS is an on-line database that contains USEPA-approved reference doses (RfDs) and SFs (USEPA 2002a). RfDs and SFs have received extensive review and are recognized as high-quality, agency-wide consensus information.
- USEPA Region 9 table of preliminary remediation goals (PRGs) (USEPA 2002b). The USEPA Region 9 PRG table includes RfDs and SFs from IRIS and Health Effects Assessment Summary Tables (HEAST). In addition, it includes toxicity values from National Center for Environmental Assessment (part of the USEPA Office of Research and Development) that are not yet available on IRIS or that have been withdrawn from IRIS, pending further evaluation.
- USEPA HEAST (USEPA 1997). HEAST provides a listing of provisional RfDs and SFs that have undergone agency review but that have not achieved agency-wide consensus.

2.4.2.4 Risk Characterization

The fourth step of the HHRA combines the results of the previous three steps to quantitatively characterize potential risks to human health associated with exposure to COPCs at the area evaluated. Potential cancer risks, adverse non-cancer health effects, and lead exposures are evaluated.

Neither USEPA nor Cal/EPA publishes RfDs for lead, a COPC known to cause adverse health effects. The potential for health effects from exposure to lead is addressed by comparing lead concentrations with a risk-based level. Currently, DTSC recommends using the USEPA Region 9 PRG of 750 milligrams per kilogram (mg/kg) as a risk-based level for lead for commercial/industrial and construction worker scenarios (Wade 2002a).

Potential excess lifetime cancer risks and non-cancer health hazards are summarized in the risk characterization section in the context of the USEPA risk-management range (i.e., 1×10^{-6} to 1×10^{-4} cancer risk and a hazard index [HI] of 1) and the uncertainties associated with the risk and hazard estimates.

The following four types of risk estimates are presented in the HHRA:

- Site cancer risks and site HIs – Risk estimates associated with exposure to COPCs for the site; includes contribution to risks and HIs associated with ambient levels of metal COPCs.
- Total cancer risks and total HIs – Risk estimates associated with exposure to all detected constituents at the site.
- Ambient cancer risks and ambient HIs – Risk estimates associated with ambient concentrations of metals at the site.
- Incremental cancer risks and incremental HIs – Risk estimates associated with the chemical releases from the site; contribution from ambient levels of metals COPCs are not included in these risk estimates.

2.5 Ecological Risk Assessment Approach

This section presents a brief summary of the general approach used to conduct the Baseline Ecological Risk Assessment (ERA) at IA C3. A more detailed description can be found in the *Risk Assessment Technical Memorandum for Lennar Mare Island* (CH2M HILL 2002h) and in Appendix H of this report.

2.5.1 Objectives

The objective of the Baseline ERA is to quantitatively and qualitatively describe the magnitude and likelihood of adverse effects to plants and animals resulting from exposure to hazardous waste constituents that may be released from IRP sites in IA C3 under current or potential future land uses.

2.5.2 Overall Approach

The overall approach to the Baseline ERA for IA C3 is consistent with the phased approach recommended by USEPA guidance and California-specific guidance available from the DTSC. Evaluation of risks from chemical stressors is conducted for aquatic organisms in the Mare Island Strait that may be impacted by contaminated groundwater seeping into Mare Island Strait.

A screening-level evaluation was performed to evaluate habitats and potential receptors present and to determine whether complete exposure pathways exist. No detailed terrestrial risk assessments were performed because no habitat exists within IA C3. However, a more detailed evaluation was performed in relation to Mare Island Strait because the potential for groundwater contamination from IA C3 exists. The results of a previous screening-level ERA for IA C3 are presented in Section 12 of the *Final Onshore Ecological Risk Assessment, Mare Island, California* (TtEMI 2002a). Sediments in Mare Island Strait are not evaluated in this assessment because they were evaluated in the revised final Offshore ERA (TtEMI 2002b).

The evaluation is based on the following assumptions and constraints typical for current ERAs:

- Evaluation of current exposures is based on existing conditions.
- Groundwater has potential to enter Mare Island Strait.
- Future land use for IA C3, including IR09, IR12, the Building 108 Area, and IR14, is indicated in the LMI land-use plan as industrial (LMI 2000). The surrounding property will have similar land use as the IA C3 parcel.
- The abiotic medium of primary ecological concern is groundwater.
- Current chemical concentrations are present at a steady state and will not change over time.
- Chemicals not detected or analyzed are not present or evaluated.
- For direct exposure to chemicals in water, each chemical is as bioavailable as the chemical upon which the toxicity information is based.

- Toxicological information that has been used represents information currently available from literature and database searches, as well as the results of site-specific studies and bioassay tests.

ERAs are designed to follow three major steps including problem formulation, analysis, and risk characterization. Each step is briefly described below.

2.5.3 Problem Formulation

Problem formulation involves compiling information on the physical and ecological setting, identifying the sources of contaminants, selecting representative ecological receptor species, evaluating exposure pathways, determining assessment endpoints and measures, and selecting constituents of potential ecological concern (COPECs). The end result of problem formulation is the ecological conceptual site model (CSM), which is used to focus the remaining evaluation of COPECs during the analysis and risk characterization steps.

Much of Mare Island was developed to provide facilities for the Navy, and ecological habitat is limited. Ecological characterization was conducted to identify habitats within and near IA C3 sites and to identify potential ecological receptors (i.e., plants and animals). Information was obtained through reconnaissance-level site visits to IA C3 sites as well as review of previous Navy documents and other literature sources. Section 1.2.5 describes the ecological characteristics of Mare Island pertinent to IA C3.

The portions of Mare Island that are covered by buildings, roads, parking lots, or similar facilities do not provide opportunity for ecological receptors to be exposed to contaminants unless the contaminants are transported off site into adjacent habitats. The most significant habitat adjacent to IA C3 is the Mare Island Strait located east of the site. Thus, the focus of the Baseline ERA is on potential exposure of receptors in the Mare Island Strait.

Representative species include aquatic organisms such as aquatic invertebrates, fish, and non-rooted aquatic plants. Selection criteria for representative ecological receptors include:

- Receptor is relevant to the assessment endpoints.
- Receptor does or could use habitats on or adjacent to the IA.
- Receptor is important to either the structure or function of the ecosystem.
- Receptor is known to be either sensitive or highly exposed to contaminants on or near the site.
- Receptor is statutorily protected (i.e., threatened or endangered species, migratory birds).

Exposure pathways refer to the media and routes through which inorganic and organic contaminants may reach ecological receptors. Potential exposure pathways must meet specific criteria for an exposure to occur. Aside from necessary habitat for ecological receptors, a complete exposure pathway must satisfy:

- Contaminant source (e.g., chemicals in soil, water, other).
- Mechanism for contaminant release and transport (e.g., surface-water runoff).
- Exposure point (e.g., water).
- Feasible route of exposure (e.g., ingestion).
- Receptor (e.g., plant, fish, other).

Direct contact or uptake by aquatic organisms from groundwater transported into Mare Island Strait is the only potentially complete exposure pathway; therefore, this is the only pathway that was evaluated both quantitatively and qualitatively.

Assessment endpoints are statements of the environmental values to be protected. The assessment endpoints for the Baseline ERA are:

- Survival of communities of aquatic plants and invertebrate animals that are characteristic of local habitats.
- Survival and reproduction of populations of fish that are characteristic of local habitats.
- Survival and reproduction of individuals of special-status species (e.g., threatened or endangered species) that may occur in local habitats.

All site-related constituents found in groundwater are identified as COPECs. Organic compounds detected in groundwater are assumed to be site-related and retained as COPECs. Inorganic chemicals found are retained as COPECs if the maximum detected concentration is above the established ambient level.

2.5.4 Analysis

The analysis consists of the exposure assessment and the ecological effects assessment. The nature and magnitude of the interaction between COPECs in environmental media and ecological receptors is described and quantified in the exposure assessment. Because receptors differ in their mobility and, ultimately, in the exposure they receive to contaminants via media, receptors are evaluated using an EPC. The EPC may be the 95 upper confidence limit (UCL95) of the mean or the maximum detected concentration in groundwater, depending on the distribution of the data. The EPC serves as a conservative estimate of COPEC concentrations that may be encountered by receptors.

The ecological effects assessment consists of an evaluation of available toxicity or other effects information that can be used to relate the concentrations of COPECs and adverse effects in ecological receptors. Data used to evaluate ecological risks resulting from exposure to COPECs in IA C3 includes single-chemical toxicity data from literature sources. Literature-derived single-chemical toxicity data, also known as benchmarks, allow for comparison against site-specific contaminant concentrations in media or estimated dose levels.

2.5.5 Risk Characterization

In the risk characterization, an estimate of risk is developed by integrating the problem formulation and the exposure/effects analyses to estimate the likelihood of impacts to ecological receptors from exposure to COPECs. The result is a hazard quotient (HQ) that gives an indication of magnitude of risk. Potential risk to receptors in habitat adjacent to IA C3 is determined by using both quantitative and qualitative evaluations. Uncertainties and limitations associated with the risk assessment data and methodology are also evaluated.

If COPECs from areas with habitat, receptors, and potentially complete exposure pathways are found to exceed the ecological effects concentrations and are considered to pose risk

after both quantitative and qualitative evaluation, they are identified as constituents of ecological concern (COEC) at the conclusion of the Baseline ERA. These COECs are considered to pose a risk to the identified ecological receptors and similarly exposed organisms (i.e., the assessment endpoints) and are recommended for further evaluation or remediation.

2.6 Applicable or Relevant and Appropriate Requirements

Section 121(d) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 states that remedial actions must attain (or justify the waiver of) any federal or more stringent state environmental standards, requirements, criteria, or limitations that are determined to be ARARs. Although Mare Island is not listed as a Superfund site under CERCLA, the CERCLA process is being applied and used as guidance for the investigation and cleanup, as overseen by the state of California. As with Superfund sites, ARARs are an important part of this process and, once identified, will need to be attained to the extent practicable.

Applicable requirements are those cleanup standards, criteria, or limitations promulgated under federal or state law that specifically address the situation at a site. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not applicable, address problems or situations sufficiently similar to the circumstances of the proposed response action and are well-suited to the conditions of the site.

ARARs generally are classified into three categories: chemical-specific, location-specific, and action-specific requirements. Chemical-specific ARARs include those laws and requirements that regulate the release to the environment of materials possessing certain chemical or physical characteristics or containing specified chemical compounds. These requirements generally set health- or risk-based concentration limits or discharge limitations for specific hazardous substances. Location-specific ARARs are those requirements that relate to the geographical or physical position of the site, rather than the nature of the contaminants or the proposed site remedial actions. Action-specific ARARs are requirements that define acceptable handling, treatment, and disposal procedures for hazardous substances. An analysis of the chemical-, location-, and action-specific ARARs for IA C3 is presented in Appendix I. Chemical- and action-specific ARARs have been identified by the RWQCB for consideration for chemicals and activities in IA C3 (RWQCB 2004a); these RWQCB-identified ARARs are also presented in Appendix I.

The chemical-specific ARARs identified are those that establish numerical limits associated with water quality in Mare Island Strait, and that establish prescriptive standards for concentrations of constituents in soil and concrete. These ARARs include:

- TSCA.
- National Toxics Rule and California Toxics Rule.
- National Recommended Water Quality Criteria.
- San Francisco Bay Water Quality Control Plan.
- Resources Conservation and Recovery Act.

- State Water Resources Control Board (SWRCB) Resolution 68-16.
- SWRCB Resolution 92-49.

The primary location-specific ARARs include:

- National Historic Preservation Act, National Historic Landmarks Program, and National Register of Historic Places.
- Archaeological and Historic Preservation Act and Archaeological Resources Protection Act.
- City of Vallejo Municipal Code – Architectural Heritage and Historic Preservation Ordinance.

Action-specific ARARs include:

- Requirements pertaining to the management (e.g., transportation, storage, and disposal) of solid and hazardous waste generated by an action.
- Regulations covering particulate air emissions and erosion control for remedial activities that involve excavation, clearing, grading, and other earthmoving activities.
- Regulations requiring the treatment and permitting of wastewater discharge for those remedial activities resulting in the generation of wastewater.

2.7 Approach to the Degradation of Groundwater Assessment

The RWQCB has requested that, in addition to the beneficial use assessment (Section 1.6), the HHRA (Appendix G), and the Baseline ERA (Appendix H), an assessment of whether contamination from the site has degraded the waters of the State of California as per SWRCB Resolution No. 68-16 and SWRCB Resolution No. 92-49 be completed. The RWQCB was consulted on how to make this assessment. The RWQCB stated that groundwater has not been degraded if downgradient wells contain groundwater with concentrations of constituents below their respective ambient surface water standards. If downgradient wells have concentrations of constituents above their respective ambient surface water standards, then a determination of whether the source and any secondary sources have been removed needs to be completed. Any ongoing sources that are impacting groundwater need to be addressed prior to or, in conjunction with, the groundwater assessment. If the upgradient sources have been removed and there is still groundwater above ambient water standards, then a technical and economic evaluation needs to be completed to determine the most appropriate remedial alternative for the groundwater.

Assessments of groundwater degradation for IR09, IR12, the Building 108 Area, and IR14 are presented in Sections 3.7, 4.7, 5.7, and 6.7, respectively. These assessments are performed by comparing analytical data for groundwater samples collected from monitoring wells adjacent to Mare Island Strait in IA C3 to the chemical-specific ARARs identified by the RWQCB for groundwater and surface water (Appendix I).

2.8 Feasibility Study Approach

The feasibility study was prepared to assist in selecting remedial actions for the IRP sites within IA C3 for which potential risks to human health or the environment are identified in the HHRA and the ERA. The feasibility study is based on the standard criteria specified in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and the USEPA *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA 1988). The primary objectives achieved by this feasibility study are to:

- Identify potential response actions, technologies, and process options to address the potential risks at each IRP site.
- Screen the technologies and process options.
- Assemble feasible and appropriate remedial alternatives.
- Provide detailed evaluations of the remedial alternatives.
- Perform a comparative analysis of the alternatives.

2.8.1 Integrated Evaluation

The approach to developing and evaluating alternatives for IA C3 is based on an integrated strategy that considers the proximity of the IRP sites to each other. The sites requiring further evaluation are all co-located and contain similar types of contamination. Therefore, although discrete volumes that require remedial action are identified for each site, the evaluation of an alternative will depend on the total volume of contaminated media from all sites. For example, the excavation and disposal of soil from a particular site will be evaluated in considering the fact that there may be other sites where excavation and disposal will be implemented. The volume of soil at these other sites will be included in the overall evaluation of the alternative. This integrated approach has the advantage of identifying issues that will be important during remedial design/remedial action, as well as ensuring that the alternatives are accurately evaluated.

2.8.2 Derivation of Preliminary Cleanup Goals

To provide a basis for conducting the feasibility study, preliminary cleanup goals are defined. The preliminary cleanup goals are used in combination with the site characterization data to estimate the locations and volumes of contaminated media that must be addressed by the alternatives. In the context of the feasibility study, these volumes represent the locations that are addressed by the various alternatives and are referred to as "target volumes." The preliminary cleanup goals also provide the benchmarks for evaluating the performance of alternatives. To provide goals for the contaminants present in IA C3, consideration was given to ARARs (e.g., TSCA), and risk-based numbers estimated to be protective of the human and ecological receptors. The actual derivation of preliminary cleanup goals for soil and the definition of target volumes are presented in Section 7.0.

2.8.3 Alternative Development and Screening

A range of alternatives is called for in the CERCLA guidance (USEPA 1988) to provide an assortment of performance and cost options. The variety of options considered for the media of concern include containment, excavation, and institutional controls. A screening and evaluation of a range of various options are provided in Appendix J.

2.8.4 Detailed Alternatives Analysis

The nine CERCLA evaluation criteria considered in the detailed alternatives analysis include:

- Overall protection of human health and the environment.
- Compliance with ARARs.
- Long-term effectiveness and permanence.
- Reduction of toxicity, mobility, or volume through treatment.
- Short-term effectiveness.
- Implementability.
- Cost.
- State acceptance.
- Community acceptance.

The NCP [40 CFR Section 300.430(e)(9)(iii)] categorizes these nine criteria into three groups: (1) threshold criteria, (2) primary balancing criteria, and (3) modifying criteria. Each type of criteria has its own weight when it is evaluated. Threshold criteria are requirements that each alternative must meet to be eligible for selection as the preferred alternative and include overall protection of human health and the environment and compliance with ARARs (unless a waiver is obtained).

Primary balancing criteria are used to weigh effectiveness and cost tradeoffs among alternatives. The primary balancing criteria include long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. The primary balancing criteria represent the main technical criteria upon which the alternative evaluation is based. Modifying criteria include state acceptance and community acceptance, and may be used to modify aspects of the preferred alternative when preparing the Remedial Action Plan (RAP).

Modifying criteria are generally evaluated after public comment on the feasibility study and the proposed RAP. Accordingly, only the seven threshold and primary balancing criteria are in the detailed analysis phase. The following sections provide descriptions of the first seven evaluation criteria. The detailed analysis of the alternatives is provided in Section 7.0 of this report.

2.8.4.1 Criterion 1—Overall Protection of Human Health and the Environment

This evaluation criterion assesses how each alternative provides and maintains adequate protection of human health and the environment. Alternatives are assessed to determine whether they can adequately protect human health and the environment from unacceptable risks posed by contaminants present at the site, in both the short and long term. This criterion is also used to evaluate how risks would be eliminated, reduced, or controlled

through treatment, engineering, institutional controls, or other remedial activities. The considerations evaluated during the analysis of each alternative for overall protection of human health and the environment are presented in Table 2.8-1.

TABLE 2.8-1
Overall Protection of Human Health and the Environment
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Analysis Factor	Considerations
Human Health Protection	Likelihood that the alternative reduces risk to future commercial/ industrial workers because of exposure by direct contact, ingestion, or inhalation of surface soil
	Likelihood that the alternative reduces risk to future construction workers because of exposure by direct contact, ingestion, or inhalation of subsurface soil
	Likelihood that the alternative reduces risk to future construction workers because of exposure by dermal contact with or inhalation of VOCs in groundwater
Environmental Protection	Likelihood that the alternative reduces risk to terrestrial receptors because of ingestion, dermal contact, or root uptake of surface soil
	Likelihood that the alternative reduces risk to terrestrial receptors because of ingestion, dermal contact, or root uptake of subsurface soil
	Likelihood that the alternative reduces the threat to groundwater quality posed by the remaining contaminants

2.8.4.2 Criterion 2—Compliance with ARARs

This evaluation criterion is used to determine if each alternative would attain federal and state ARARs, or whether invoking waivers to specific ARARs is adequately justified. Other information, such as advisories, criteria, or guidance, is considered, where appropriate, during the ARARs analysis. The considerations evaluated during the analysis of the ARARs applicable to each alternative are presented in Table 2.8-2. ARARs for the IA C3 remedial actions in terms of action-specific, location-specific, and chemical-specific requirements are identified in Appendix I.

TABLE 2.8-2
Compliance with ARARs
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Analysis Factor	Considerations
Chemical-specific ARARs	Likelihood that the alternative will achieve compliance with chemical-specific ARARs within a reasonable period of time
	If it appears that compliance with chemical-specific ARARs will not be achieved, the evaluation of whether a waiver is appropriate
Location-specific ARARs	Determination of whether any location-specific ARARs (e.g., preservation of historical sites) apply to the alternative

TABLE 2.8-2
Compliance with ARARs
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Analysis Factor	Considerations
	Likelihood that the alternative will achieve compliance with the location-specific ARARs
	Evaluation of whether a waiver is appropriate if the location-specific ARARs cannot be met
Action-specific ARARs	Likelihood that the alternative will achieve compliance with action-specific ARARs
	Evaluation of whether a waiver is appropriate if the action-specific ARARs cannot be met
Other criteria and guidance	Likelihood that the alternative will achieve compliance with other criteria, such as risk-based criteria

2.8.4.3 Criterion 3—Long-term Effectiveness and Permanence

This evaluation criterion addresses the long-term effectiveness and permanence of maintaining the protection of human health and the environment after implementing the remedial action imposed by the alternative. The primary components of this criterion are the magnitude of residual risk remaining at the site after remedial objectives have been met and the extent and effectiveness of controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes. The considerations evaluated during the analysis of each alternative for long-term effectiveness and permanence are presented in Table 2.8-3. The components addressed for each alternative are described in more detail in the following subsections.

Magnitude of Residual Risk. The magnitude of residual risk at the end of remedial activities is measured by numerical standards such as cancer risk levels or the volume or concentration of contaminants remaining on the site. The characteristics of the residuals remaining on site are also evaluated considering their volume, toxicity, mobility, and propensity to bioaccumulate.

Adequacy and Reliability of Controls. The adequacy and reliability of controls that are used to either manage treatment residuals or untreated materials that remain at the site after attaining preliminary remedial goals are evaluated. This criterion includes an assessment of containment systems and institutional controls to evaluate the degree of confidence that they adequately handle potential problems and provide sufficient protection. The criterion also addresses long-term reliability, the need for long-term management and monitoring of the site, and the potential need to replace technical components (e.g., cap) of the alternative.

TABLE 2.8-3
Long-term Effectiveness and Permanence
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Analysis Factor	Considerations
Magnitude of residual risks	Identity of remaining risks (risks due to treatment residuals), and risks due to untreated residual contamination.
	Magnitude of the remaining risks.
Adequacy and reliability of controls	Likelihood that the technologies will meet required process efficiencies or performance specifications.
	Type and degree of long-term management required.
	Long-term monitoring requirements.
	Operation and maintenance (O&M) functions that must be performed.
	Difficulties and uncertainties associated with long-term O&M functions.
	Potential need for technical components replacement.
	Magnitude of threats or risks should the remedial action need replacement.
	Degree of confidence that controls can adequately handle potential problems.
	Uncertainties associated with land disposal of residuals and untreated wastes.

2.8.4.4 Criterion 4—Reduction of Toxicity, Mobility, or Volume through Treatment

This evaluation criterion addresses the anticipated performance of the alternative's treatment technologies in permanently and significantly reducing toxicity, mobility, and/or volume of hazardous materials at the site. The NCP prefers remedial actions where treatment is used to reduce the principal threats at a site through destruction of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media. The considerations evaluated during the analysis of each alternative for reduction of toxicity, mobility, or volume of contaminants present at a given site are presented in Table 2.8-4.

2.8.4.5 Criterion 5—Short-term Effectiveness

This evaluation criterion considers the effect of each remedial alternative on the protection of human health and the environment during the construction and implementation process. The short-term effectiveness evaluation only addresses protection prior to meeting the remedial action objectives. The considerations evaluated during the analysis of each alternative for short-term effectiveness are presented in Table 2.8-5.

TABLE 2.8-4
Reduction of Toxicity, Mobility, or Volume through Treatment
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Analysis Factor	Considerations
Treatment process and remedy	Likelihood that the treatment process addresses the principal threat
	Special requirements for the treatment process
Amount of hazardous material destroyed or treated	Portion (mass) of contaminant that is destroyed
	Portion (mass) of contaminant that is treated
Reduction in toxicity, mobility, or volume	Extent that the total mass of contaminants is reduced
	Extent that the mobility of contaminants is reduced
	Extent that the volume of contaminants is reduced
Irreversibility of treatment	Extent that the effects of the treatment are irreversible
Type and quantity of treatment residual	Residuals that will remain
	Quantities and characteristics of the residuals
	Risk posed by the treatment residuals
Statutory preference for treatment as a principal element	Extent to which the scope of the action covers the principal threats
	Extent to which the scope of the action reduces the inherent hazards posed by the principal threats at the site

TABLE 2.8-5
Short-term Effectiveness
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Analysis Factors	Considerations
Protection of the community during the remedial action	Risks to the community that must be addressed
	How the risks will be addressed and mitigated
	Remaining risks that cannot be readily controlled
Protection of workers during remedial actions	Risks to the workers that must be addressed
	How the risks will be addressed and mitigated
	Remaining risks that cannot be readily controlled
Environmental impacts	Environmental impacts that are expected with the construction and implementation of the alternative
	Mitigation measures that are available and reliability to minimize potential impacts
	Impacts that cannot be avoided, should the alternative be implemented
Time until remedial action objectives are achieved	Time to achieve protection against the threats being addressed
	Time until any remaining threats are addressed
	Time until remedial action objectives are achieved

2.8.4.6 Criterion 6—Implementability

This criterion evaluates the technical feasibility and administrative feasibility (i.e., the ease or difficulty) of implementing each alternative and the availability of required services and materials during its implementation. The considerations evaluated during the analysis of each alternative for implementability are presented in Table 2.8-6.

TABLE 2.8-6
Implementability
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Analysis Factors	Considerations
Technical Feasibility	
Ability to construct and operate the technology	Difficulties associated with the construction
	Uncertainties associated with the construction
Reliability of the technology	Likelihood that technical problems will lead to schedule delays
Ease of undertaking additional remedial action	Likely future remedial actions that may be anticipated
	Difficulty implementing additional remedial actions
Monitoring considerations	Migration or exposure pathways that cannot be monitored adequately
	Risks of exposure, should the monitoring be insufficient to detect failure
Administrative Feasibility	
Coordination with other agencies	Steps required to coordinate with regulatory agencies
	Steps required to establish long-term or future coordination among agencies
	Ease of obtaining permits for off-site activities, if required
Availability of Services and Materials	
Availability of treatment, storage capacity, and disposal services	Availability of adequate treatment, storage capacity, and disposal services
	Additional capacity that is necessary
	Whether lack of capacity prevents implementation
	Additional provisions required to ensure that additional capacity is available
Availability of necessary equipment and specialists	Availability of adequate equipment and specialists
	Additional equipment or specialists that are required
	Whether there is a lack of equipment or specialists
	Additional provisions required to ensure that equipment and specialists are available
Availability of prospective technologies	Whether technologies under consideration are generally available and sufficiently demonstrated
	Further field applications needed to demonstrate that the technologies may be used full-scale to treat the waste at the site
	When technology should be available for full-scale use
	Whether more than one vendor will be available to provide a competitive bid

2.8.4.7 Criterion 7—Cost

This criterion evaluates the cost of implementing each alternative. The cost of an alternative encompasses all engineering, construction, and O&M costs incurred over the life of the project. The assessment against this criterion is based on the estimated present worth of these costs for each alternative. Present worth is used to estimate expenditures such as construction and O&M that occur over different lengths of time. This allows costs for remedial alternatives to be compared by discounting all costs to the year that the alternative is implemented.

The present worth of a project represents the amount of money which, if invested in the initial year of the remedy and disbursed as needed, would be sufficient to cover all costs associated with the remedial action. As stated in the RI/FS guidance (USEPA 1988), these estimated costs are expected to provide an accuracy of plus 50 percent to minus 30 percent.

3.0 IR09

3.1 Site Background

3.1.1 Site Description

IR09 includes the former paint shop (Building 334), four former USTs, an abandoned oil/water separator, a former paint shop varnish plant (including a former aboveground storage tank farm), and adjacent areas. IR09 is located in the area bounded by Dry Dock No. 1, Dry Dock No. 2, and Mare Island Strait. IR09 is approximately 1.1 acres and consists of structures and paved areas. The ground surface in IR09 is approximately 8 feet above msl. IR09 also includes Building 144, an inactive crane cable house (Building D-1), two closed diesel ASTs, and an electrical substation. Primary underground utilities in the area include storm and sanitary sewer pipelines. Current site features are shown in Figure 3.1-1.

Four USTs were formerly located at Building 334 in IR09. Analytical data collected during investigations of these UST sites are included in the evaluation of IR09 in this RI/FS report. A request for closure of these USTs will be made in a separate report in accordance with RWQCB Order No. R2-2002-0105.

There are six PCB sites located within the boundaries of IR09 (CH2M HILL 2002a). These PCB sites (associated with Building 334, Building 144, and the crane cable house electrical substation) are addressed in a PCB work plan that identifies the PCB sites that require additional investigation (CH2M HILL 2003a) and are not discussed in this document. A ship-to-shore sanitary sewer pump station (STS-H) is located in the northern portion of the site, to the northwest of Building 144. This pump station is addressed in the *Sanitary Sewer System Site Identification Technical Memorandum* (CH2M HILL 2002b) and is not discussed in this document.

3.1.2 Site History

MINS facility maps illustrate that, prior to the 1870s, most of IA C3 was marshland. Dry Dock No. 1, under construction for many years, was completed by 1891. Historical records indicate that in the late 1800s, a marine railway and its associated wet basin were located in the vicinity of IR09. The wet basin was designed to hold a floating dry dock and to serve as an alternative location for ship repair. The marine railway was also designed to supplement the floating dock. The marine railway and the wet basin were abandoned during the construction of Dry Dock No. 2 (Archaeological Resource Service 1986). By 1910, Dry Dock No. 2 and the quay wall were built, and the land between Dry Dock Nos. 1 and 2 was filled.

Building 334, a three-story, steel-frame structure, was constructed in 1918 and used as a paint shop until 1974 (SSPORTS 1996a; MINS 1995). Activities that were conducted at the former paint shop included paint spraying, mirror manufacturing, silk screening, Tefloning, paint removal and parts cleaning (Ecology and Environment 1983). The four USTs formerly located southwest of Building 334 (334-1 through 334-4) stored alcohol, linseed oil, waste

FIGURE 3.1-1
IR09 SAMPLE LOCATIONS MAP
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

CH2MHILL

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paint/drier, turpentine, and waste products; piping extended from the four USTs to four holding tanks on the second floor of Building 334. These USTs were abandoned in place in the 1970s and removed in 1987 (ERM-West 1987a-b). A subsurface gravity oil/water separator associated with Building 334 is located east of Building 334. Facility records indicate that this oil/water separator was filled and decommissioned in October 1983 (MINS 1976); this is when the existing Building 144 was constructed in this area. The oil/water separator is located beneath the existing Building 144 (Figure 3.1-1). Building 334 was converted to waterfront office space in 1974 and has not been in use since the base closed in 1996.

Paint manufacturing was also conducted at IR09 during the 1920s and 1930s. According to historical photographs and records, an AST farm associated with a former paint shop varnish plant was located south of Building 334 and west of Building 1334 during this period (MINS 1937). Paint manufacturing activities at IR09 terminated around 1940, when a paint manufacturing plant was constructed in the northern part of MINS. The location of the former AST farm at IR09 is presented in Figure 3.1-1.

MINS facility maps indicate that several other structures were located at IR09 throughout its history. Former Building 154, a latrine, was built to the west of Building 334 in the early 1910s, several years prior to the construction of Building 334. Another latrine (former Building 422) and a storage warehouse (former Building 384) were also constructed to the west of Building 334 in the early 1920s (SSPORTS 1996a; MINS 1935). Buildings 154, 422, and 384 were demolished in the early 1980s.

The existing crane cable house (Building D-1) and associated electrical substation located southeast of Building 334 were constructed by 1970. The locations of these facilities are presented in Figure 3.1-1. These structures serviced the inactive nuclear refueling crane located between IR09 and Dry Dock No. 2. The electrical substation is being investigated as a PCB site (Building D-1 UL#01). A 400-gallon diesel AST was located within the substation. This AST, likely used for backup power, was emptied and cleaned in March 1995 (CH2M HILL 2002a) and is no longer present. A 300-gallon diesel AST is located off the western corner of Building 334 (under cover and within a concrete berm). This AST, likely used to fuel equipment for nuclear refueling operations, was emptied and cleaned in February 1996 (CH2M HILL 2002a). Both of these ASTs were closed in place by the Navy. Closure in place involved emptying and rinsing the AST and disposing of AST contents (CH2M HILL 2002a). The existing Building 144 located east of Building 334 was built in 1983 and was used as a field office until base closure (SSPORTS 1996a).

3.1.3 Chronology of Investigations

The following discusses previous studies and investigations at IR09. The Navy's IRP work at this site began in the early 1980s. The Navy transitioned environmental investigation and cleanup responsibilities to LMI in 2001.

3.1.3.1 Initial Assessment Study

In 1983, an initial assessment study (IAS) was completed that assessed potential soil and groundwater contamination from past operations at MINS (Ecology and Environment 1983). The study consisted of a record review and site reconnaissance. According to the IAS, the paint shop was located in Building 334 for over 50 years. Operations in the paint shop

generated approximately 200 gallons of wastewater per day. The wastewater, which contained alcohol, ketones, thinners, epoxies, paints, cleaner, silver nitrate, glacial acetic acid, and tetrafluoroethene, was discharged to a separator and the sanitary sewer system. Periodically, solids and floating debris were collected from the separator and disposed of at the off-site facility landfill. Solid wastes, including paint sludge, paint brushes, paint and solvent containers, and rags, were collected in the central waterfront dumpsters north of the IR09 Area prior to disposal at the off-site facility landfill.

3.1.3.2 IR09 Preliminary Investigation

A preliminary investigation was conducted to support UST closure activities and assess if a release from the four USTs at Building 334 had affected surrounding soil. The results of the preliminary investigation were documented in the *Final Report, Naval Shipyard Mare Island LUST Site Investigation, January 1987* (ERM-West 1987a). The investigation was conducted in November 1986 and consisted of drilling 12 borings to a depth of approximately 12.5 feet bgs, with the collection of two soil samples in each boring for total petroleum hydrocarbons (TPH) and metals analysis. The study concluded that contamination in some of the soil samples exceeded RWQCB requirements for UST closure; therefore, cleanup would be necessary during UST removal.

3.1.3.3 UST Removal

The four USTs adjacent to Building 334 were removed in March 1987. UST removal activities were documented in the *Final Report, Naval Shipyard Mare Island, Underground Tank Removal and Subsurface Investigation June 1987* (ERM-West 1987b). Prior to UST removal, residual liquid samples were collected from three of the four USTs. (The linseed oil UST was dry.) Mineral spirits and water were detected in the residual liquid samples collected from the waste paint/drier UST and the turpentine UST. All of the USTs contained residual liquid that had fuel-related constituents such as benzene, toluene, ethylbenzene, and xylene (BTEX) compounds. Individual USTs also contained phenols, lead, chromium, mercury, and/or waste materials deemed ignitable.

The USTs, lines, and surrounding soil were removed and disposed off site. Four soil samples were collected from the sidewalls of the excavation. Three of the four soil samples collected from the sidewalls had TPH concentrations less than 1,000 milligrams per kilogram (mg/kg), and one soil sample had a TPH concentration of 8,000 mg/kg (north end). Therefore, additional soil removal was necessary to the north of the UST excavation. Soil at the excavation boundaries was re-tested at the completion of the soil removal; the results indicated that the excavation sidewalls satisfied RWQCB guidelines. The integrity of the four USTs and the size and depth of the excavation were not reported. Soil removed from the excavation that was not suitable for backfill was disposed at the facility landfill, and the excavation was backfilled with clean material. The backfill material included coarse aggregate at the bottom of the excavation, geotextile fabric covering the aggregate, and clean imported fill above the fabric to ground surface. During backfill operations, a 4-inch-diameter polyvinyl chloride extraction well (later identified as 09W05) was installed near the eastern corner of the excavation.

A composite groundwater sample, collected from water accumulated within the excavation just after the UST removal, had phenol, BTEX, chromium, copper, lead, arsenic, and

mercury levels that exceeded standards established by the California Department of Health Services. However, this groundwater sample was unfiltered and may have artificially high metals concentrations due to inclusion of soil particles. This study recommended the installation of additional groundwater wells and additional investigation of residual contaminant levels.

3.1.3.4 Phase I Remedial Investigation

The objectives of the Phase I remedial investigation were to verify the presence or absence of residual waste constituents in the soil and groundwater from past leakage of USTs at the site and to delineate (to the extent possible) the vertical and horizontal movement of these constituents (IT 1992). Four soil borings were advanced to a depth of 15 feet, sampled, and converted to monitoring wells (09W01 through 09W04). Soil and groundwater samples were collected. The investigation was conducted from April 1990 through November 1991. The results of the Phase I remedial investigation were documented in the *Site Characterization Summary for Phase I Remedial Investigation NSY Mare Island* (IT 1992). This site characterization confirmed residual contamination and suggested a possible second source. An additional phase of remedial investigation was recommended to complete the site characterization and to support a baseline risk assessment.

3.1.3.5 Resource Conservation and Recovery Act (RCRA) Facility Assessment and Preliminary Assessment/Site Inspection (PA/SI) for Non-radiological Sites

The *RCRA Facility Assessment Preliminary Review* (Kearny 1987) and the *Preliminary Assessment/Site Inspection for Nonradiological Sites* (PRC 1995b) involved a records search and site reconnaissance that focused on the separator at Building 334 that was identified in the IAS. Collection of additional records, interviews, and visual surveys were performed during the PA/SI to identify the specific location of the separator and its association with the IR09 site. The PA/SI final report recommended no further action for the separator at Building 334 (PRC 1995b).

3.1.3.6 Phase II Remedial Investigation

Between November 1993 and June 1995, a Phase II remedial investigation was conducted to: (1) supplement the information collected during previous investigations at IR09; (2) characterize site conditions more completely; and (3) determine the nature of the contamination. Results of the Phase II remedial investigation were documented in the *Remedial Investigation Report, Operable Unit 3, Mare Island* (PRC 1996a). This work included: (1) collecting soil samples from nine vacuum excavations (IR09VB001 through IR09VB009) surrounding the subsurface utility lines (e.g., storm, sanitary sewer); (2) collecting soil and groundwater samples from 17 GeoProbe® borings (IR09GB001 through IR09GB017); (3) installing two groundwater monitoring wells (09W06 and 09W07) between Building 334 and Mare Island Strait; (4) collecting groundwater samples from all IR09 wells; (5) laboratory analysis; and (6) performing a tidal influence study. The tidal study was described in detail in a separate document, the *Technical Memorandum: Tidal Influence Study, Mare Island* (PRC 1996b), which preceded the remedial investigation report.

The Phase II remedial investigation included the preparation of a baseline human health risk assessment. The *Baseline Human Health Risk Assessment Addendum to the Remedial Investigation Report, Operable Unit 3, Mare Island* presented an evaluation of the potential

risks associated with environmental contamination at IR09 in the absence of remedial action (PRC 1997c). The preliminary risk calculations indicated that human health risks from contaminants at IR09 in the unchanged site configuration are within the risk-management range and the evaluation of remedial alternatives is not warranted.

3.1.3.7 Basewide Groundwater Monitoring Program

The five monitoring wells constructed during the UST removal work and the Phase I remedial investigation (09W01 through 09W05) were sampled seven times between February 1991 and June 1999 as part of the basewide groundwater monitoring program. The two monitoring wells installed during the Phase II remedial investigation (09W06 and 09W07) were sampled six times between February 1995 and June 1999 as part of the basewide groundwater monitoring program. Generally, these quarterly monitoring events included measurement of the groundwater level at each well and extraction of a groundwater sample from selected wells for subsequent analysis for organic and inorganic contaminants (PRC 1994a-f; TtEMI 1998e-f, 1999a-c, 2000b-e, 2001).

3.1.3.8 Offshore Ecological Risk Assessment (ERA)

An Offshore ERA was conducted to evaluate risks to ecological receptors from site-specific stressors present in offshore areas. Results of the Offshore ERA were documented in the *Revised Final Offshore Areas Ecological Risk Assessment, Mare Island* (TtEMI 2002b). The Offshore ERA evaluated impacts from contaminated sediments in the Mare Island Strait and performed both clam and amphipod bioassays using sediment and pore water collected from the Strait. Overall conclusions stated that chemicals in offshore sediments do not pose an unacceptable risk to populations of benthic invertebrates. Additionally, food-chain modeling suggested that population -level risks to birds and mammals were negligible.

3.1.3.9 Limited Investigation of Multiple Sites in Investigation Areas C2 and C3

A limited investigation of previously-unidentified sites of environmental concern in IA C2 and C3 was performed in June 2002. This investigation included two sites associated with IR09: the Former Paint Shop Varnish Plant, and the suspect oil/water separator beneath Building 144. The purpose of the limited investigation was to evaluate the potential for a release of contaminants to the environment and identify those sites that require further investigation and/or remediation. As part of the limited investigation, soil samples were collected from three soil borings at the Paint Shop Varnish Plant (PVPGB100, PVPGB101, and PVPGB102), and soil and groundwater samples were collected from two soil borings at the Building 144 oil/water separator (B144GB100 and B144GB101). The results of the limited investigation, documented in the *Final Limited Investigation Report for Multiple Sites in Investigation Areas C2 and C3* (CH2M HILL 2003c), indicated that a confirmed release to the environment had occurred at these two sources, and the DTSC requested additional site investigations.

3.1.3.10 Implementation of the IA C3 SAP

Field activities at IR09 were performed between July and October 2002 consistent with the *Investigation Area C3 Sampling and Analysis Plan* (CH2M HILL 2002e-f). The field activities included the collection of 33 soil samples from 14 borings (IR09GB0100 through IR09GB0113) for lead, TPH-gasoline-range organics, TPH-diesel-range-organics,

TPH-motor-oil-range organics, VOCs, and PAH analysis to refine the conceptual site model and to support the human health risk assessment. In addition, groundwater samples were collected from four existing wells in IR09 for total dissolved solids analysis, and water-level elevations were measured on two separate occasions (August and October 2002) to supplement previously-collected hydrologic and geochemistry information.

3.1.3.11 Characterization of Multiple Sites in Investigation Areas C2 and C3

Additional site characterization activities at previously-unidentified sites of environmental concern associated with IR09 (the Former Paint Shop Varnish Plant and Building 144 Oil/Water Separator) were performed in December 2002 and January 2003 in accordance with the *Work Plan for Additional Characterization of Multiple Sites in Investigation Area C3 (*CH2M HILL 2002d). The additional site characterization included: (1) the collection of soil and groundwater samples from three GeoProbe® borings (B144GB101 [at the same location as boring B144GB101, advanced during the limited investigation], B144GB102, and B144GB103); (2) one groundwater monitoring well (B144MW100) at the Building 144 Oil/Water Separator; and (3) the collection of soil and groundwater samples from three GeoProbe® borings (PVPGB103, PVPGB104, and PVPGB105) at the Former Paint Shop Varnish Plant.

3.1.3.12 2003/2004 Groundwater Monitoring

To complete the characterization of groundwater at IR09 and ensure contaminants are not present in groundwater at locations downgradient of potential sources of contamination, groundwater samples were collected from three monitoring wells (09W03, 09W07, and B144MW100) during one to four quarterly monitoring events performed between January 2003 and May 2004. Groundwater samples were submitted for analysis of organic and inorganic constituents. The depth to groundwater was also recorded during each monitoring even (Appendix E).

3.2 Physical and Ecological Characteristics

3.2.1 Surface Features

The IR09 site is relatively flat and is paved or covered with buildings.

3.2.2 Surface Water

No surface water bodies are present within the boundaries of IR09. Surface water runoff from the area discharges into the stormwater system. However, storm sewer Outfall STS-20, which is east of IR09 at Mare Island Strait, was plugged and sealed in 1994 to prevent stormwater discharge to Mare Island Strait (MINS 1994).

3.2.3 Geology

IR09, IR12, and the Building 108 Area all lie within the parcel of land referred to as the "triangle area," which is almost completely bounded by Dry Dock No. 1, Dry Dock No. 2, and Mare Island Strait (refer to Figure 1.2-3). Together the three IRP sites contain approximately 80 percent of the land in the triangle area. Because the three IRP sites are contiguous in a relatively small area with well-defined boundaries, the hydrogeologic

characteristics of the sites are quite similar. What follows is a hydrogeologic description of the triangle area as a whole, with a few references to features which are unique to individual IRP sites.

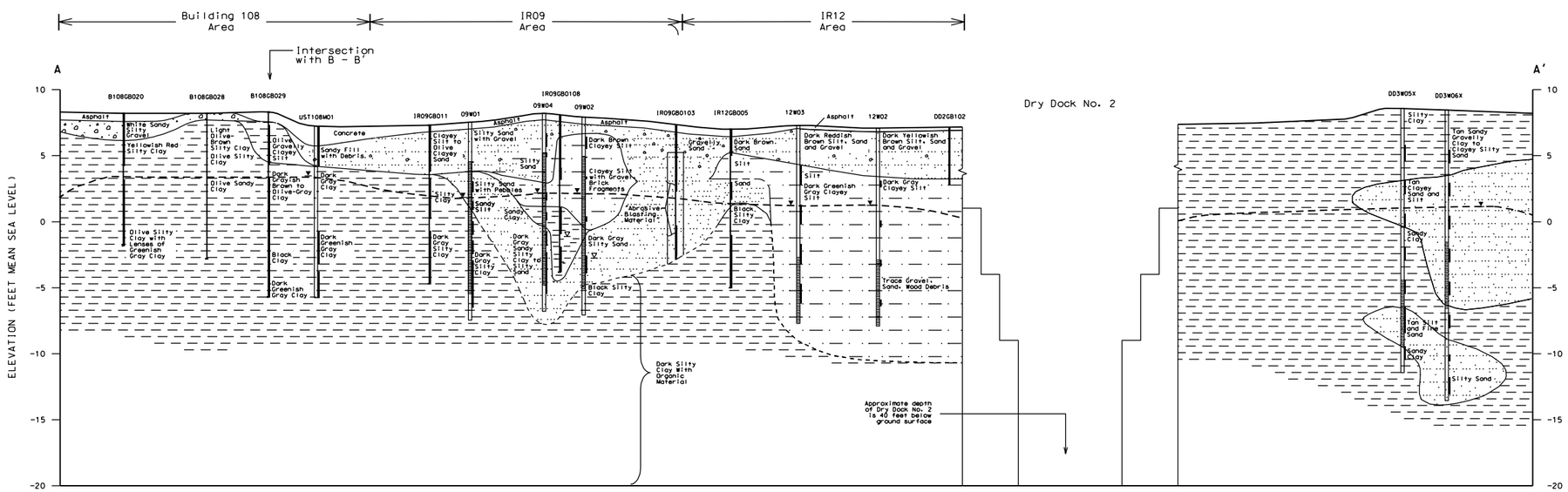
Three geologic units have been identified in the triangle area, including from ground surface: (1) artificial fill material, underlain by (2) unconsolidated natural deposits (original soil), underlain by (3) bedrock (PRC 1996a). The fill material can be subdivided into a coarser heterogeneous unit (clay, silt, sand, gravel, and debris in varying proportions), representing imported fill, and a more homogeneous unit (primarily silty clay), representing dredge spoils. The coarser heterogeneous unit often was not present in borings within the Building 108 Area. The thickness of the fill material is typically around 2 to 5 feet but has been identified at thicknesses of up to 16 feet. Coarse material, including abrasive blast material (ABM) in some locations, was used as backfill in utility corridors. These backfill zones extend to several feet below the water table.

Original soil consists of a silty clay, which is commonly referred to as Younger Bay Mud and other primarily fine-grained material derived from the weathering of local bedrock. It is assumed that in some locations silty clay dredge spoils rest directly atop naturally-deposited silty clay (Bay Mud); hence, the boundary between these soils is not readily distinguishable. Bedrock is a mixed unit of weathered sandstone, siltstone, and shale. Figure 3.2-1 is a cross section that passes through the triangle area parallel to Mare Island Strait, and Figure 3.2-2 is a cross section that passes through the Building 108 Area perpendicular to Mare Island Strait. The thickness of the unconsolidated original soil is largely unknown because drilling was almost always halted short of reaching the bedrock. There are two exceptions: at well 12W01 bedrock apparently was encountered at 11 feet bgs according to the text of the 1996 remedial investigation (PRC 1996a), although the boring log for this location did not indicate consolidated material. At GeoProbe® boring IR09GB014, bedrock was encountered at 10.5 feet bgs during 2002.

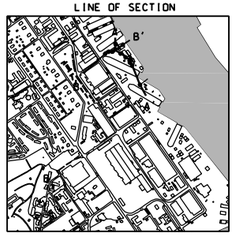
3.2.4 Hydrogeology

The water-bearing zone in the triangle area is an unconfined aquifer, which includes those parts of the fill and original soil that are below the water table and the upper weathered section of the bedrock. In general, groundwater in the unconfined aquifer exists at 4 to 7.5 feet bgs. Groundwater elevations recorded at IA C3 monitoring wells between November 1992 and April 2004 are provided in Appendix E. With some local exceptions, the shallow groundwater in IA C3 generally flows west to east (Figure 1.2-7). Water-level contours indicate that drainage toward Dry Dock No. 1 to the north may exist in the Building 108 Area in the dry season (Figure 1.2-8). Groundwater flow directions and rates in the water-bearing zone probably are influenced by variations in lithology, including the proximity of storm and/or municipal sewers. The backfill around utility corridors and the lenses of coarse fill may act as preferential pathways for potential contaminant migration; this is discussed in more detail below.

Dry Dock Nos. 1 and 2, which bound the triangle area to approximately 40 feet bgs on the north and west sides, are potential pathways for groundwater leaving the site by seepage through the walls of these dry docks. The proportion of the near-subsurface groundwater that moves toward the dry docks is unknown. Based on observations made by an employee of J.A. Jones, the contractor responsible for operating and maintaining the dry docks, it



LINE OF SECTION



NOTES

1. This is one interpretation based on available data. Other interpretations are possible.
2. Lithologic descriptors are abbreviated for presentation purposes.
3. Depths to bedrock are unknown across this section.

LEGEND

Monitoring Well
Recovered Interval
Screened Interval

Direct Push Boring
Recovered Interval

Wells-Static Water Level May/June 1999

Contact-Dashed Where Approximate, Queried Where Uncertain

Linear Dimension Unknown Not Drawn To Scale

Silt-Sand-Gravel-Clay Mixtures

Silty Sand

Silt

Clay

25 0 25 50
SCALE IN FEET
VERTICAL EXAGGERATION=10X

FIGURE 3.2-1
GEOLOGIC CROSS-SECTION A-A'
REMEDIAL INVESTIGATION
INVESTIGATION AREA C3
MARE ISLAND, CALIFORNIA

CH2MHILL

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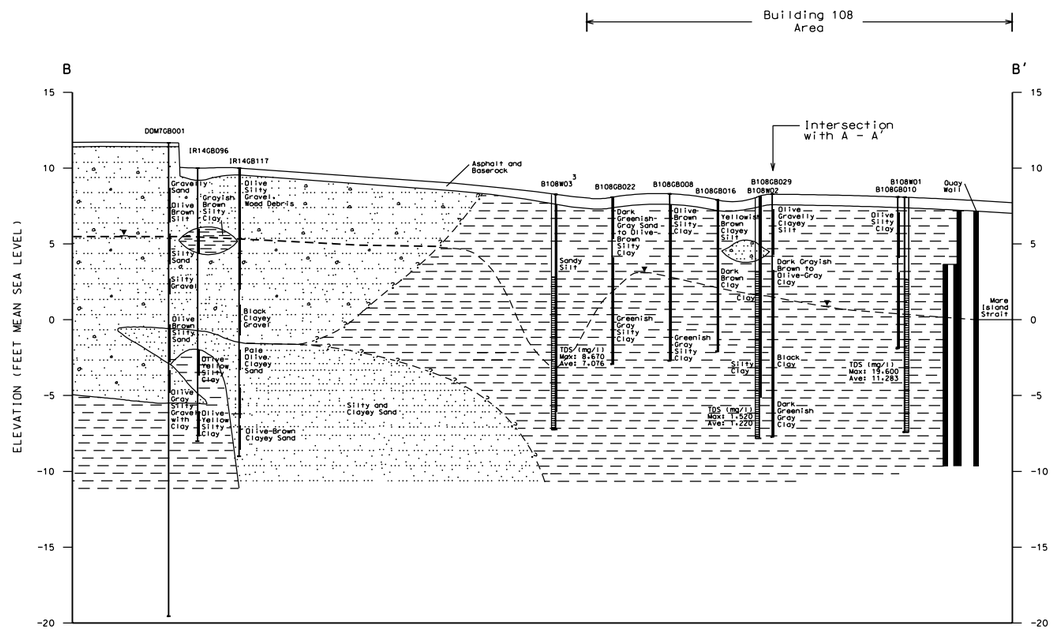
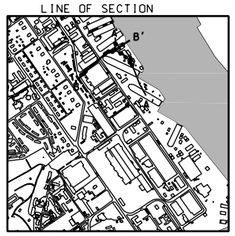


LINE OF SECTION



NOTES

1. This is one interpretation based on available data. Other interpretations are possible.
2. Lithologic descriptors are abbreviated for presentation purposes.
3. Well B108W03 historically has had lower water levels than other wells in the area. This is attributed to the presence of several subsurface utilities nearby.

LEGEND

Direct Push Boring

Recovered Interval

Inferred Static Water Level May/June 1999

Lithologic Contact. Dashed Where Approximate and Queried Where Uncertain

Silt Sand Gravel Clay Mixtures

Silty/Clayey Sand

Silt

Clay

50 0 50 100
SCALE IN FEET
VERTICAL EXAGGERATION = 20

FIGURE 3.2-2
GEOLOGIC CROSS-SECTION B-B'
REMEDIAL INVESTIGATION
INVESTIGATION AREA C3
MARE ISLAND, CALIFORNIA

CH2MHILL

Project_No 164204 20-FEB-2003 cto249d.dgn

seems clear that some groundwater leaves the triangle area through the side walls of the dry docks (Bennett 2001). The dry docks are partially-relieved hydraulic structures, meaning that holes are drilled through the walls or floor so that groundwater pressure is partially relieved by water draining from the subsurface into the dry dock cavities. Groundwater that enters the dry docks in this way is collected, along with precipitation, and is delivered to sumps at the base of the dry docks, where it is pumped into the sanitary wastewater system (Bennett 2001). Therefore, while the dry docks' walls may inhibit free exchange between near-subsurface groundwater in the triangle area and groundwater in the rest of Mare Island, groundwater is discharged from the triangle area into the dry docks. Therefore, the dry docks are considered potential pathways for release of groundwater-borne contamination.

Between Dry Dock Nos. 1 and 2, at the west edge of the Building 108 Area, is an approximately 110-foot-wide strip of land that connects the near-subsurface groundwater within the triangle area to the groundwater in the rest of Mare Island. Wet-season groundwater levels indicate that the west-to-east ambient groundwater flow direction that is predominant in IA C3 persists through this narrow strip into the Building 108 Area.

The eastern boundary of the triangle area is a quay wall that separates the area from Mare Island Strait. The quay wall is a concrete structure that was built to serve two main purposes. First, part of the quay wall was a berth for ships in port at MINS (Berth 12, refer to Figure 1.4-1). As such, it supported the structures used to secure and service ships in port. Second, the wall served as a housing for a main utility conduit that runs parallel to shore and contained lines for freshwater, saltwater (fire suppression), and electrical service. It is built upon sheet piles that are driven into the subsurface. There are some indications that the quay wall can impede movement of free-phase petroleum floating on the water table beneath IR03 in IA C1 to the north (PRC 1996a). However, the quay wall is not considered an impermeable barrier to groundwater flow for at least two reasons. First, monitoring wells drilled near the shoreline of IR09 are quite responsive to tidal changes in the Mare Island Strait water level, as discussed in Section 1.5.4.2. Therefore, the groundwater of the triangle area and the waters of Mare Island Strait are hydraulically connected. Second, groundwater levels in wells within the triangle area indicate that the local water table slopes in the direction of the strait (Figures 3.2-1 and 3.2-2). Both of these facts suggest that groundwater discharge into Mare Island Strait past the quay wall represents a pathway for contaminant release from all three IRP sites within the triangle area.

There are many utility corridors for electrical, water, and storm sewer utilities in the near-subsurface of the triangle area that may be preferential pathways for groundwater flow. The trenches that were excavated to create these corridors typically were backfilled with coarse-grained material and may therefore provide pathways for rapid groundwater movement.

Slug tests were performed at four monitoring wells within IR09 in 1991 (IT 1992). In 1999, a slug test and a pump-down test were performed on separate wells in Building 108 (Uribe & Associates 1999). The pump-down test was performed using a pump to remove a slug of water from well B108W03 and monitoring the water level recovery with time. This test was performed instead of a slug test on well B108W03 because previously-determined purge rates from water quality sampling on this well indicated that well recovery from a slug injection would be extremely slow. Data from this pump-down test were analyzed with the

same procedure used for slug test data (Uribe & Associates 1999). Table 3.2-1 shows the hydraulic conductivity results from the well testing. As expected, conductivities are generally higher in those wells that are screened partly within coarse material (i.e., silty gravel) than in those wells that are screened completely within finer material (i.e., silty clay).

Hydraulic gradients vary across the triangle area depending on stratigraphy and proximity to the quay wall and dry docks. Previous estimates range from 0.004 in IR09 (TtEMI 2000f) to 0.04 in IR12 (PRC 1996a). Field- or laboratory-measured porosities of sediments within the areas of interest are not available. The assumed effective porosity for all sediments was 0.15±0.05. Using the values for hydraulic conductivity shown in Table 3.2-1, and these estimates of hydraulic gradient and effective porosity, the median expected groundwater velocity is 34 feet/year. This estimate of groundwater velocity ignores the effects of retardation, dispersion, degradation, or other processes that affect the concentration and movement of groundwater contaminants.

TABLE 3.2-1
Hydraulic Conductivity Results from Aquifer Testing in IR09 and the Building 108 Area
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Well	Hydraulic Conductivity (ft/day)	Test Method	Lithology Adjacent to Well Screen
09W01	2.3	Slug	Silty gravel, silty clay
09W02	4.5	Slug	Clayey silt, silty sand, silty clay
09W03	0.23	Slug	Silty clay
09W04	18	Slug	Gravel, silty sand w/ gravel, silty clay
B108W01	0.54	Slug	Clay, sandy clayey silt
B108W03	8.2×10^{-3}	Pump-down [a]	Sandy silt

[a] Refer to text for explanation.

3.2.5 Ecology

No viable habitat exists within IR09 because the site is covered entirely with asphalt and buildings. Mare Island Strait is located directly northeast of IR09. A brief description of this offshore habitat can be found in Section 1.5.6.

3.3 Nature and Extent of Contamination

This section discusses the nature and extent of soil and groundwater contamination at IR09. Analytical soil and groundwater data, collected during the investigations discussed in Section 3.1.3, are provided in Appendices F1 and F2, respectively. The sampling approach employed for the remedial investigation was judgmental; that is, samples were collected from locations suspected to be the most highly contaminated, as indicated by site history. Additional sampling locations were then selected in subsequent phases of investigation based on the results of previous investigations and additional knowledge of site history to establish the extent of the possible contamination found. Over 240 soil and groundwater samples were collected at IR09 between January 1991 and May 2004 from the approximately

60 locations shown in Figure 3.1-1.[1] Samples collected from IR09 were analyzed for a wide variety of chemical constituents, including petroleum hydrocarbons, VOCs, semivolatile organic compounds (SVOCs), PAHs, PCBs, pesticides, and metals.

3.3.1 Soil

A summary of soil data for IR09 is provided in Table 3.3-1. For each analytical constituent, Table 3.3-1 shows the number of samples analyzed, the number of detected results of that constituent,[2] the average result, the maximum result, and the frequency of detection. For metals analysis, Table 3.3-1 shows the ambient concentration for Mare Island fill material (see also Table 2.3-1) and identifies the number of samples with metal results greater than the respective ambient concentration. The following is a discussion of the analytical results presented in Table 3.3-1.

3.3.1.1 Petroleum Hydrocarbon Compounds

As indicated in Table 3.3-1, soil samples analyzed for petroleum hydrocarbon analysis showed these were the most frequently-detected group of organic compounds at IR09. The interpretation of petroleum hydrocarbon analysis results accounts for the type of analytical method that does not characterize the chemical composition of the samples. While the analytical methods were developed to characterize fuel contamination, the methods are non-specific; that is, non-petroleum based hydrocarbons or organic compounds with a boiling point within the method range would yield a positive indication of the presence of "petroleum hydrocarbons." Petroleum hydrocarbon analysis is used as a non-specific measure of the extent of organic compounds, while chemical-specific data supplement and assess the specific characteristics and toxicity of the organic compounds.

TPH-gasoline-range Organics. TPH-gasoline-range organics[3] was detected in 33 out of the 133 soil samples analyzed. Figure 3.3-1 shows the distribution of TPH-gasoline-range organics in soil at IR09. The highest concentration of TPH-gasoline-range organics (16,000 mg/kg) was found in 1994 in a soil sample collected at 5 feet bgs from IR09GB008. Other detected concentrations of TPH-gasoline-range organics in soil samples from IR09 were between 1 and 7,300 mg/kg. Approximately half of the detected concentrations of TPH-gasoline-range organics in soil at IR09 were less than 100 mg/kg.

The 12 samples with TPH-gasoline-range organics concentrations greater than 1,000 mg/kg in soil at IR09 were collected at depth (typically greater than 5 feet bgs) from locations south, southwest, and east of Building 334 and east of Building 144, including the vicinity of the former USTs, the former AST farm associated with the Paint Shop Varnish Plant, and the Building 144 Oil/Water Separator. As shown in Figure 3.3-1, the extent of contamination is defined by concentrations less than 100 mg/kg at locations outside these source areas .

The sample with the highest TPH-gasoline range organics concentration was collected from IR09GB008 located south of Building 334 and south of the former USTs. Other than this sample, the highest TPH-gasoline-range organics concentrations in soil samples collected

[1] Approximately 40 percent of the entire IR09 data set was collected during the 2002-2004 field investigation.
[2] Includes those samples for which a compound was quantified at a concentration below the analytical reporting limit.
[3] The terms TPH-gasoline and gasoline are used in this document with the same meaning.

Table 3.3-1

Investigation Area C3, IR09 Statistical Summary Table of Analytical Soil Data

Future Land Use: Industrial

Land Type: Fill Material

Analyte	CAS Number	Analysis Type	Background Concentration for Metals (mg/kg)	Source of Background Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Background Concentration for Metals	Average Result (mg/kg)	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)
SOIL - IR09																	
Petroleum Hydrocarbon Compounds																	
DIESEL	DRO	Laboratory			133	47		1.7E+02	1.0E+00	7.5E+03	1/28/1991	09W03	5.5	6.0	35%	0.0E+00	1.1E+03
GASOLINE	GRO	Laboratory			133	33		3.7E+02	1.5E+00	1.6E+04	3/31/1994	IR09GB008	5.0	5.5	25%	0.0E+00	7.1E+02
MOTOR OIL	MRO	Laboratory			125	38		1.7E+02	1.9E+01	5.9E+03	11/16/1994	IR09GB013	0.5	2.0	30%	1.4E+01	1.5E+03
TRPH	TRPH	Laboratory			10	5		7.3E+02	1.9E+01	7.0E+03	11/16/1994	IR09GB013	0.5	2.0	50%	7.0E-03	5.3E+02
UNKNOWN DIESEL RANGE	UDRO	Laboratory			4	4		9.9E+02	3.9E+01	2.4E+03	3/31/1994	IR09GB008	5.0	5.5	100%	3.3E+01	4.0E+02
UNKNOWN GASOLINE RANGE	UGRO	Laboratory			6	6		1.1E+02	4.8E-01	5.1E+02	4/1/1994	IR09GB007	6.0	7.8	100%	6.4E-02	6.3E+01
Volatile Organic Compounds																	
1,1,1,2-TETRACHLOROETHANE	630-20-6	Laboratory			26	0		2.5E-02							0%	5.3E-03	5.9E-01
1,1,1-TRICHLOROETHANE	71-55-6	Laboratory			44	0		1.6E-02							0%	0.0E+00	5.9E-01
1,1,2,2-TETRACHLOROETHANE	79-34-5	Laboratory			43	0		1.6E-02							0%	0.0E+00	5.9E-01
1,1,2-TRICHLOROETHANE	79-00-5	Laboratory			44	0		1.6E-02							0%	0.0E+00	5.9E-01
1,1,2-TRICHLOROTRIFLUOROETHANE	76-13-1	Laboratory			26	0		2.7E-02							0%	5.3E-03	5.9E-01
1,1-DICHLOROETHANE	75-34-3	Laboratory			44	0		1.6E-02							0%	0.0E+00	5.9E-01
1,1-DICHLOROETHENE	75-35-4	Laboratory			44	0		1.6E-02							0%	0.0E+00	5.9E-01
1,2,3-TRICHLOROPROPANE	96-18-4	Laboratory			26	0		2.5E-02							0%	5.3E-03	5.9E-01
1,2,4-TRICHLOROBENZENE	120-82-1	Laboratory			40	0		1.1E-01							0%	0.0E+00	3.5E+00
1,2,4-TRIMETHYLBENZENE	95-63-6	Laboratory			26	2		8.4E-01	1.5E-01	2.1E+01	12/16/2002	PVPGB104	1.5	2.0	8%	5.3E-03	1.2E+00
1,2-DIBROMO-3-CHLOROPROPANE	96-12-8	Laboratory			26	0		5.0E-02							0%	1.1E-02	1.2E+00
1,2-DICHLOROETHANE	107-06-2	Laboratory			44	0		1.6E-02							0%	0.0E+00	5.9E-01
1,2-DICHLOROETHENE (TOTAL)	540-59-0	Laboratory			18	0		3.7E-03							0%	0.0E+00	2.0E-02
1,2-DICHLOROPROPANE	78-87-5	Laboratory			44	0		1.6E-02							0%	0.0E+00	5.9E-01
1,3,5-TRIMETHYLBENZENE	108-67-8	Laboratory			26	2		3.2E-01	5.9E-02	7.7E+00	12/16/2002	PVPGB104	1.5	2.0	8%	5.3E-03	1.2E+00
1,3-DICHLOROBENZENE	541-73-1	Laboratory			40	0		1.1E-01							0%	0.0E+00	3.5E+00
1,4-DIOXANE	123-91-1	Laboratory			1	1		2.4E-01	2.4E-01	2.4E-01	7/25/2002	IR09GB0113	1.5	2.0	100%	1.4E-01	1.4E-01
2-BUTANONE	78-93-3	Laboratory			44	0		7.1E-02							0%	0.0E+00	3.0E+00
2-CHLOROTOLUENE	95-49-8	Laboratory			26	0		2.5E-02							0%	5.3E-03	5.9E-01
2-HEXANONE	591-78-6	Laboratory			17	0		3.6E-03							0%	0.0E+00	2.0E-02
4-METHYL-2-PENTANONE	108-10-1	Laboratory			43	0		7.2E-02							0%	0.0E+00	3.0E+00
ACETONE	67-64-1	Laboratory			36	7		9.5E-02	3.0E-02	9.3E-02	11/5/1993	IR09VB004	7.8	8.3	19%	0.0E+00	3.0E+00
ACROLEIN	107-02-8	Laboratory			1	0		3.0E+00							0%	5.9E+00	5.9E+00
ACRYLONITRILE	107-13-1	Laboratory			26	0		2.7E-01							0%	5.3E-02	5.9E+00
BENZENE	71-43-2	Laboratory			115	2		2.9E-02	1.8E-02	6.0E-01	1/28/1991	09W03	5.5	6.0	2%	0.0E+00	5.9E-01
BROMOBENZENE	108-86-1	Laboratory			26	0		2.5E-02							0%	5.3E-03	5.9E-01
BROMODICHLOROMETHANE	75-27-4	Laboratory			44	0		1.6E-02							0%	0.0E+00	5.9E-01
BROMOFORM	75-25-2	Laboratory			44	0		1.6E-02							0%	0.0E+00	5.9E-01
BROMOMETHANE	74-83-9	Laboratory			44	0		1.6E-02							0%	0.0E+00	5.9E-01
CARBON DISULFIDE	75-15-0	Laboratory			44	1		1.7E-02	5.0E-03	5.0E-03	1/26/1995	09W07	12.5	13.3	2%	0.0E+00	5.9E-01
CARBON TETRACHLORIDE	56-23-5	Laboratory			44	0		1.6E-02							0%	0.0E+00	5.9E-01
CHLOROBENZENE	108-90-7	Laboratory			43	0		1.6E-02							0%	0.0E+00	5.9E-01
CHLOROETHANE	75-00-3	Laboratory			44	0		1.6E-02							0%	0.0E+00	5.9E-01
CHLOROFORM	67-66-3	Laboratory			44	1		1.6E-02	3.0E-03	3.0E-03	11/17/1994	IR09GB012	1.0	2.5	2%	0.0E+00	5.9E-01
CHLOROMETHANE	74-87-3	Laboratory			44	0		1.6E-02							0%	0.0E+00	5.9E-01
CIS-1,2-DICHLOROETHENE	156-59-2	Laboratory			26	0		2.5E-02							0%	5.3E-03	5.9E-01
CIS-1,3-DICHLOROPROPENE	10061-01-5	Laboratory			18	0		3.7E-03							0%	0.0E+00	2.0E-02
CYCLOHEXANE	110-82-7	Laboratory			19	1		1.0E-02	6.6E-02	6.6E-02	12/19/2002	B144MW100	5.0	5.5	5%	1.2E-02	2.4E-02

Table 3.3-1

Investigation Area C3, IR09 Statistical Summary Table of Analytical Soil Data

Future Land Use: Industrial

Land Type: Fill Material

Analyte	CAS Number	Analysis Type	Background Concentration for Metals (mg/kg)	Source of Background Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Background Concentration for Metals	Average Result (mg/kg)	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)
SOIL - IR09																	
DIBROMOCHLOROMETHANE	124-48-1	Laboratory			44	0		1.6E-02							0%	0.0E+00	5.9E-01
DICHLORODIFLUOROMETHANE	75-71-8	Laboratory			26	0		2.5E-02							0%	5.3E-03	5.9E-01
ETHYLBENZENE	100-41-4	Laboratory			115	14		2.2E-01	5.0E-03	1.2E+01	3/31/1994	IR09GB008	5.0	5.5	12%	0.0E+00	6.2E-01
ETHYLENE DIBROMIDE	106-93-4	Laboratory			26	0		2.7E-02							0%	5.3E-03	5.9E-01
HEXANE	110-54-3	Laboratory			26	0		5.0E-02							0%	1.1E-02	1.2E+00
ISOPROPYLBENZENE	98-82-8	Laboratory			26	2		3.2E-02	1.1E-02	2.0E-01	12/16/2002	PVPGB104	1.5	2.0	8%	5.3E-03	5.9E-01
METHYL METHACRYLATE	80-62-6	Laboratory			19	0		6.9E-03							0%	1.2E-02	2.4E-02
METHYL TERTIARY BUTYLETHER	1634-04-4	Laboratory			37	0		2.0E-02							0%	5.3E-03	5.9E-01
METHYLENE CHLORIDE	75-09-2	Laboratory			44	0		3.1E-02							0%	0.0E+00	1.2E+00
N-BUTYLBENZENE	104-51-8	Laboratory			26	2		3.3E-02	2.6E-02	2.1E-01	12/16/2002	PVPGB104	1.5	2.0	8%	5.3E-03	5.9E-01
N-PROPYLBENZENE	103-65-1	Laboratory			26	2		1.6E-01	3.6E-02	3.6E+00	12/16/2002	PVPGB104	1.5	2.0	8%	5.3E-03	1.2E+00
O-XYLENE	95-47-6	Laboratory			37	1		2.0E-02	2.7E-02	2.7E-02	12/16/2002	PVPGB104	1.5	2.0	3%	1.1E-03	5.9E-01
SEC-BUTYLBENZENE	135-98-8	Laboratory			26	2		1.6E-01	2.7E-02	3.5E+00	12/16/2002	PVPGB104	1.5	2.0	8%	5.3E-03	1.2E+00
STYRENE	100-42-5	Laboratory			43	0		1.6E-02							0%	0.0E+00	5.9E-01
TERT-BUTYLBENZENE	98-06-6	Laboratory			26	3		2.7E-02	1.4E-02	2.5E-02	12/19/2002	B144GB101	7.0	7.5	12%	5.3E-03	5.9E-01
TETRACHLOROETHENE	127-18-4	Laboratory			43	1		1.7E-02	3.2E-02	3.2E-02	11/23/1993	IR09VB009	2.7	3.2	2%	0.0E+00	5.9E-01
TOLUENE	108-88-3	Laboratory			115	5		3.5E-02	3.0E-03	9.5E-01	1/28/1991	09W03	5.5	6.0	4%	0.0E+00	5.9E-01
TRANS-1,2-DICHLOROETHENE	156-60-5	Laboratory			26	0		2.5E-02							0%	5.3E-03	5.9E-01
TRANS-1,3-DICHLOROPROPENE	10061-02-6	Laboratory			18	0		3.7E-03							0%	0.0E+00	2.0E-02
TRICHLOROETHENE	79-01-6	Laboratory			44	1		1.6E-02	3.0E-03	3.0E-03	11/23/1993	IR09VB009	2.7	3.2	2%	0.0E+00	5.9E-01
VINYL ACETATE	108-05-4	Laboratory			8	0		0.0E+00							0%	0.0E+00	0.0E+00
VINYL CHLORIDE	75-01-4	Laboratory			44	0		1.6E-02							0%	0.0E+00	5.9E-01
XYLENE (TOTAL)	1330-20-7	Laboratory			115	13		3.3E-01	5.0E-03	1.6E+01	3/31/1994	IR09GB008	5.0	5.5	11%	0.0E+00	7.4E-01
Semi-Volatile Organic Compounds																	
1,2-DICHLOROBENZENE	95-50-1	Laboratory			40	0		1.1E-01							0%	0.0E+00	3.5E+00
1,4-DICHLOROBENZENE	106-46-7	Laboratory			40	0		1.1E-01							0%	0.0E+00	3.5E+00
2,4,5-TRICHLOROPHENOL	95-95-4	Laboratory			21	0		5.2E-01							0%	0.0E+00	8.8E+00
2,4,6-TRICHLOROPHENOL	88-06-2	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
2,4-DICHLOROPHENOL	120-83-2	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
2,4-DIMETHYLPHENOL	105-67-9	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
2,4-DINITROPHENOL	51-28-5	Laboratory			19	0		6.1E-01							0%	0.0E+00	2.1E+00
2-CHLORONAPHTHALENE	91-58-7	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
2-CHLOROPHENOL	95-57-8	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
2-METHYL-4,6-DINITROPHENOL	534-52-1	Laboratory			19	0		6.1E-01							0%	0.0E+00	2.1E+00
2-METHYLNAPHTHALENE	91-57-6	Laboratory			14	0		2.7E-01							0%	0.0E+00	3.5E+00
2-METHYLPHENOL	95-48-7	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
2-NITROANILINE	88-74-4	Laboratory			21	0		7.8E-01							0%	0.0E+00	8.8E+00
2-NITROPHENOL	88-75-5	Laboratory			14	0		2.7E-01							0%	0.0E+00	3.5E+00
3,3'-DICHLOROBENZIDINE	91-94-1	Laboratory			21	0		5.1E-01							0%	0.0E+00	3.5E+00
3-NITROANILINE	99-09-2	Laboratory			14	0		6.7E-01							0%	0.0E+00	8.8E+00
4-BROMOPHENYL-PHENYLETHER	101-55-3	Laboratory			14	0		2.7E-01							0%	0.0E+00	3.5E+00
4-CHLORO-3-METHYLPHENOL	59-50-7	Laboratory			14	0		2.7E-01							0%	0.0E+00	3.5E+00
4-CHLOROANILINE	106-47-8	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
4-CHLOROPHENYL-PHENYLETHER	7005-72-3	Laboratory			14	0		2.7E-01							0%	0.0E+00	3.5E+00
4-METHYLPHENOL	106-44-5	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
4-NITROANILINE	100-01-6	Laboratory			14	0		6.7E-01							0%	0.0E+00	8.8E+00
4-NITROPHENOL	100-02-7	Laboratory			21	0		7.8E-01							0%	0.0E+00	8.8E+00

Table 3.3-1

Investigation Area C3, IR09 Statistical Summary Table of Analytical Soil Data

Future Land Use: Industrial

Land Type: Fill Material

Analyte	CAS Number	Analysis Type	Background Concentration for Metals (mg/kg)	Source of Background Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Background Concentration for Metals	Average Result (mg/kg)	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)
SOIL - IR09																	
ACENAPHTHENE	83-32-9	Laboratory			46	4		4.4E-01	6.9E-01	2.3E+00	12/19/2002	B144GB101	5.0	5.5	9%	0.0E+00	9.6E+00
ACENAPHTHYLENE	208-96-8	Laboratory			46	0		4.6E-01							0%	0.0E+00	2.0E+01
ANTHRACENE	120-12-7	Laboratory			47	4		1.0E-01	1.3E-02	2.3E-01	12/19/2002	B144GB102	2.0	2.5	9%	0.0E+00	3.5E+00
BENZO(A)ANTHRACENE	56-55-3	Laboratory			47	15		1.2E-01	2.1E-02	4.1E-01	12/19/2002	B144GB102	2.0	2.5	32%	0.0E+00	3.5E+00
BENZO(A)PYRENE	50-32-8	Laboratory			47	19		1.3E-01	1.8E-02	4.1E-01	12/19/2002	B144GB102	2.0	2.5	40%	0.0E+00	3.5E+00
BENZO(B)FLUORANTHENE	205-99-2	Laboratory			47	22		1.3E-01	1.1E-02	8.7E-01	7/25/2002	IR09GB0113	1.5	2.0	47%	0.0E+00	3.5E+00
BENZO(G,H,I)PERYLENE	191-24-2	Laboratory			14	2		1.9E-01	1.4E-01	6.1E-01	11/16/1994	IR09GB013	0.5	2.0	14%	0.0E+00	3.5E+00
BENZO(K)FLUORANTHENE	207-08-9	Laboratory			47	13		1.1E-01	6.0E-03	2.6E-01	12/19/2002	B144GB102	2.0	2.5	28%	0.0E+00	3.5E+00
BENZOIC ACID	65-85-0	Laboratory			11	4		9.2E-01	4.6E-01	1.4E+00	1/25/1991	09W02	2.5	3.0	36%	0.0E+00	2.1E+00
BENZYL ALCOHOL	100-51-6	Laboratory			4	0		0.0E+00							0%	0.0E+00	0.0E+00
BIPHENYL	92-52-4	Laboratory			7	0		2.0E-01							0%	3.8E-01	4.3E-01
BIS(2-CHLOROETHOXY)METHANE	111-91-1	Laboratory			14	0		2.7E-01							0%	0.0E+00	3.5E+00
BIS(2-CHLOROETHYL)ETHER	111-44-4	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
BIS(2-CHLOROISOPROPYL)ETHER	108-60-1	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
BIS(2-ETHYLHEXYL)PHTHALATE	117-81-7	Laboratory			21	1		2.6E-01	4.9E-01	4.9E-01	6/20/2002	PVPGB101	7.0	7.5	5%	0.0E+00	3.5E+00
BUTYLBENZYLPHTHALATE	85-68-7	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
CARBAZOLE	86-74-8	Laboratory			17	0		3.1E-01							0%	3.8E-01	3.5E+00
CHRYSENE	218-01-9	Laboratory			47	14		1.2E-01	2.0E-02	3.1E-01	12/19/2002	B144GB102	2.0	2.5	30%	0.0E+00	3.5E+00
DI-N-BUTYLPHTHALATE	84-74-2	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
DI-N-OCTYLPHTHALATE	117-84-0	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
DIBENZ(A,H)ANTHRACENE	53-70-3	Laboratory			46	4		1.3E-01	5.3E-02	2.2E-01	12/16/2002	PVPGB104	1.5	2.0	9%	0.0E+00	3.5E+00
DIBENZOFURAN	132-64-9	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
DIETHYLPHTHALATE	84-66-2	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
DIMETHYLPHTHALATE	131-11-3	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
FLUORANTHENE	206-44-0	Laboratory			47	26		1.8E-01	2.6E-02	1.6E+00	7/17/2002	IR09GB0105	1.0	1.5	55%	0.0E+00	3.5E+00
FLUORENE	86-73-7	Laboratory			47	4		1.3E-01	6.8E-02	2.1E-01	7/17/2002	IR09GB0102	6.0	6.5	9%	0.0E+00	3.5E+00
HEXACHLOROBENZENE	118-74-1	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
HEXACHLOROBUTADIENE	87-68-3	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
HEXACHLOROCYCLOPENTADIENE	77-47-4	Laboratory			21	0		5.1E-01							0%	0.0E+00	3.5E+00
HEXACHLOROETHANE	67-72-1	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
INDENO(1,2,3-CD)PYRENE	193-39-5	Laboratory			49	17		1.2E-01	1.1E-02	1.8E-01	12/16/2002	PVPGB104	1.5	2.0	35%	0.0E+00	3.5E+00
INDENO(1,2,3-CD)PYRENE	193-39-5	Laboratory			49	17		1.2E-01	1.1E-02	1.8E-01	7/17/2002	IR09GB0104	1.0	1.5	35%	0.0E+00	3.5E+00
ISOPHORONE	78-59-1	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
N-NITROSO-DI-N-PROPYLAMINE	621-64-7	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
N-NITROSODIPHENYLAMINE (1)	86-30-6	Laboratory			21	0		2.5E-01							0%	0.0E+00	3.5E+00
NAPHTHALENE	91-20-3	Laboratory			46	6		4.4E-01	5.7E-02	2.3E+00	7/18/2002	IR09GB0109	6.0	6.5	13%	0.0E+00	9.6E+00
PENTACHLOROPHENOL	87-86-5	Laboratory			21	0		7.8E-01							0%	0.0E+00	8.8E+00
PHENANTHRENE	85-01-8	Laboratory			14	2		2.6E-01	5.6E-02	2.1E-01	11/17/1994	IR09GB012	1.0	2.5	14%	0.0E+00	3.5E+00
PHENOL	108-95-2	Laboratory			21	3		3.2E-01	3.1E-01	1.1E+00	3/30/1994	IR09GB009	2.0	3.5	14%	0.0E+00	3.5E+00
PYRENE	129-00-0	Laboratory			47	22		1.9E-01	4.6E-02	2.1E+00	7/17/2002	IR09GB0105	1.0	1.5	47%	0.0E+00	3.5E+00
PCB Compounds																	
AROCLOR-1016	12674-11-2	Laboratory			10	0		8.5E-02							0%	3.8E-02	8.4E-01
AROCLOR-1221	11104-28-2	Laboratory			10	0		1.7E-01							0%	7.6E-02	1.7E+00
AROCLOR-1232	11141-16-5	Laboratory			10	0		8.5E-02							0%	3.8E-02	8.4E-01
AROCLOR-1242	53469-21-9	Laboratory			10	0		8.5E-02							0%	3.8E-02	8.4E-01
AROCLOR-1248	12672-29-6	Laboratory			10	0		8.5E-02							0%	3.8E-02	8.4E-01
AROCLOR-1254	11097-69-1	Laboratory			10	0		8.5E-02							0%	3.8E-02	8.4E-01

Table 3.3-1

Investigation Area C3, IR09 Statistical Summary Table of Analytical Soil Data

Future Land Use: Industrial

Land Type: Fill Material

Analyte	CAS Number	Analysis Type	Background Concentration for Metals (mg/kg)	Source of Background Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Background Concentration for Metals	Average Result (mg/kg)	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)
SOIL - IR09																	
AROCLOR-1260	11096-82-5	Laboratory			70	1		5.7E-02	9.0E-02	9.0E-02	11/5/1993	IR09VB003	7.6	8.1	1%	3.8E-02	8.4E-01
Pesticides																	
4,4'-DDD	72-54-8	Laboratory			10	0		8.5E-03							0%	3.8E-03	8.4E-02
4,4'-DDE	72-55-9	Laboratory			10	0		8.5E-03							0%	3.8E-03	8.4E-02
4,4'-DDT	50-29-3	Laboratory			10	0		8.5E-03							0%	3.8E-03	8.4E-02
ALDRIN	309-00-2	Laboratory			10	0		4.4E-03							0%	1.9E-03	4.3E-02
ALPHA-BHC	319-84-6	Laboratory			10	0		4.4E-03							0%	1.9E-03	4.3E-02
ALPHA-CHLORDANE	5103-71-9	Laboratory			10	2		2.6E-02	2.3E-03	2.3E-01	3/30/1994	IR09GB009	7.0	8.0	20%	1.9E-03	4.3E-02
BETA-BHC	319-85-7	Laboratory			10	0		4.4E-03							0%	1.9E-03	4.3E-02
DELTA-BHC	319-86-8	Laboratory			10	0		4.4E-03							0%	1.9E-03	4.3E-02
DIELDRIN	60-57-1	Laboratory			10	0		8.5E-03							0%	3.8E-03	8.4E-02
ENDOSULFAN I	959-98-8	Laboratory			10	0		4.4E-03							0%	1.9E-03	4.3E-02
ENDOSULFAN II	33213-65-9	Laboratory			10	0		8.5E-03							0%	3.8E-03	8.4E-02
ENDOSULFAN SULFATE	1031-07-8	Laboratory			10	0		8.5E-03							0%	3.8E-03	8.4E-02
ENDRIN	72-20-8	Laboratory			10	0		8.5E-03							0%	3.8E-03	8.4E-02
ENDRIN ALDEHYDE	7421-93-4	Laboratory			10	0		8.5E-03							0%	3.8E-03	8.4E-02
ENDRIN KETONE	53494-70-5	Laboratory			10	1		8.7E-03	1.1E-02	1.1E-02	11/17/1994	IR09GB012	1.0	2.5	10%	3.8E-03	8.4E-02
GAMMA-BHC (LINDANE)	58-89-9	Laboratory			10	0		4.4E-03							0%	1.9E-03	4.3E-02
GAMMA-CHLORDANE	12789-03-6	Laboratory			10	2		3.0E-02	2.7E-03	2.7E-01	3/30/1994	IR09GB009	7.0	8.0	20%	1.9E-03	4.3E-02
HEPTACHLOR	76-44-8	Laboratory			10	0		4.4E-03							0%	1.9E-03	4.3E-02
HEPTACHLOR EPOXIDE	1024-57-3	Laboratory			10	0		4.4E-03							0%	1.9E-03	4.3E-02
METHOXYCHLOR	72-43-5	Laboratory			10	0		4.4E-02							0%	1.9E-02	4.3E-01
TOXAPHENE	8001-35-2	Laboratory			10	0		4.4E-01							0%	1.9E-01	4.3E+00
Metals																	
ALUMINUM	7429-90-5	Laboratory	3.5E+04	b	22	22	0	1.7E+04	2.3E+03	3.1E+04	6/21/2002	B144GB101	5.0	5.5	100%	3.0E+00	8.6E+01
ANTIMONY	7440-36-0	XRF	8.5E+00	b	68	23	3	5.0E+00	2.9E+00	1.5E+01	1/26/1995	09W07	4.0	4.5	34%	1.0E+01	1.0E+01
ANTIMONY	7440-36-0	Laboratory	8.5E+00	b	53	19	0	6.2E-01	2.5E-01	3.1E+00	12/16/2002	PVPGB103	7.0	7.5	36%	0.0E+00	3.5E+00
ARSENIC	7440-38-2	Laboratory	3.6E+01	b	55	54	1	1.3E+01	5.5E-01	8.0E+01	6/20/2002	PVPGB102	2.5	3.0	98%	0.0E+00	5.5E+00
BARIUM	7440-39-3	Laboratory			55	55	0	3.2E+02	1.1E+01	1.1E+03	1/25/1991	09W01	6.5	7.0	100%	0.0E+00	1.8E+00
BERYLLIUM	7440-41-7	Laboratory	9.0E-01	b	55	39	22	7.1E-01	4.3E-01	2.4E+00	11/5/1993	IR09VB004	7.8	8.3	71%	0.0E+00	1.2E+00
CADMIUM	7440-43-9	XRF	5.2E+00	b	68	4	0	4.9E+00	2.7E+00	4.9E+00	4/1/1994	IR09GB007	3.0	3.5	6%	1.0E+01	1.0E+01
CADMIUM	7440-43-9	Laboratory	5.2E+00	b	55	35	2	1.1E+00	1.4E-01	8.2E+00	12/8/1994	IR09GB015	1.0	2.0	64%	0.0E+00	1.2E+00
CALCIUM	7440-70-2	XRF			68	68	0	2.4E+04	5.5E+03	1.0E+05	3/29/1994	IR09GB010	5.5	6.0	100%	1.0E+01	1.0E+01
CALCIUM	7440-70-2	Laboratory			10	10	0	1.7E+04	2.7E+03	7.3E+04	3/30/1994	IR09GB009	7.0	8.0	100%	2.5E+00	4.6E+01
CHROMIUM	7440-47-3	XRF	1.4E+02	b	68	68	18	1.2E+02	4.4E+01	1.9E+02	11/23/1993	IR09VB005	6.8	7.3	100%	1.0E+01	1.0E+01
CHROMIUM	7440-47-3	Laboratory	1.4E+02	b	55	55	4	1.6E+02	8.5E+00	1.9E+03	12/16/2002	PVPGB103	5.0	5.5	100%	0.0E+00	5.6E+02
CHROMIUM	7440-47-3	Laboratory	1.4E+02	b	55	55	4	1.6E+02	8.5E+00	1.9E+03	12/16/2002	PVPGB103	7.0	7.5	100%	0.0E+00	5.6E+02
COBALT	7440-48-4	XRF			68	0	0	5.0E+00							0%	1.0E+01	1.4E+01
COBALT	7440-48-4	Laboratory			55	52	0	2.1E+01	4.9E+00	5.5E+01	12/16/2002	PVPGB105	8.0	8.5	95%	0.0E+00	3.5E+00
COPPER	7440-50-8	XRF	1.2E+02	b	68	68	13	1.2E+02	1.5E+01	2.1E+03	3/29/1994	IR09GB010	5.5	6.0	100%	1.0E+01	1.0E+01
COPPER	7440-50-8	Laboratory	1.2E+02	b	55	55	8	8.8E+01	3.1E+01	2.4E+02	12/19/2002	B144GB102	2.0	2.5	100%	0.0E+00	2.4E+00
HEXAVALENT CHROMIUM	18540-29-9	Laboratory			10	1	0	2.3E-01	2.2E+00	2.2E+00	1/25/1991	09W02	2.5	3.0	10%	0.0E+00	5.0E-02
IRON	7439-89-6	XRF	6.2E+04	b	68	68	3	4.7E+04	1.3E+04	1.0E+05	4/1/1994	IR09GB002	3.0	3.5	100%	1.0E+01	1.0E+01
IRON	7439-89-6	Laboratory	6.2E+04	b	22	22	0	3.7E+04	2.1E+04	5.2E+04	11/5/1993	IR09VB004	7.8	8.3	100%	1.5E+00	8.6E+01
LEAD	7439-92-1	XRF	5.9E+01	b	68	66	25	2.6E+02	5.9E+00	5.1E+03	11/17/1994	IR09GB012	6.0	6.5	97%	1.0E+01	1.0E+01
LEAD	7439-92-1	Laboratory	5.9E+01	b	82	81	55	6.5E+02	2.2E+00	2.0E+04	7/17/2002	IR09GB0102	6.0	6.5	99%	0.0E+00	1.2E+03

Table 3.3-1

Investigation Area C3, IR09 Statistical Summary Table of Analytical Soil Data

Future Land Use: Industrial

Land Type: Fill Material

Analyte	CAS Number	Analysis Type	Background Concentration for Metals (mg/kg)	Source of Background Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Background Concentration for Metals	Average Result (mg/kg)	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)
SOIL - IR09																	
MAGNESIUM	7439-95-4	Laboratory			10	10	0	8.2E+03	1.4E+03	1.5E+04	11/5/1993	IR09VB004	7.8	8.3	100%	3.4E+00	3.4E+01
MANGANESE	7439-96-5	XRF	1.6E+03	b	68	68	5	9.3E+02	1.9E+02	2.6E+03	1/26/1995	09W07	4.0	4.5	100%	1.0E+01	1.0E+01
MANGANESE	7439-96-5	Laboratory	1.6E+03	b	22	22	3	7.4E+02	8.6E+01	1.8E+03	6/20/2002	PVPGB100	5.0	5.5	100%	6.0E-02	1.2E+00
MANGANESE	7439-96-5	Laboratory	1.6E+03	b	22	22	3	7.4E+02	8.6E+01	1.8E+03	4/1/1994	IR09GB007	6.0	7.8	100%	6.0E-02	1.2E+00
MERCURY	7439-97-6	XRF	2.0E+00	b	2	2	2	9.7E+01	6.6E+00	1.9E+02	4/1/1994	IR09GB007	3.0	3.5	100%	1.0E+01	1.0E+01
MERCURY	7439-97-6	Laboratory	2.0E+00	b	54	44	10	2.0E+00	5.0E-02	2.9E+01	6/20/2002	PVPGB102	2.5	3.0	81%	0.0E+00	2.4E+00
MOLYBDENUM	7439-98-7	XRF			68	1	0	5.0E+00	4.0E+00	4.0E+00	11/23/1993	IR09VB005	4.5	5.0	1%	1.0E+01	1.0E+01
MOLYBDENUM	7439-98-7	Laboratory			55	37	0	1.3E+00	2.6E-01	1.6E+01	6/20/2002	PVPGB101	2.5	3.0	67%	0.0E+00	3.5E+00
NICKEL	7440-02-0	XRF	1.3E+02	b	68	67	0	6.2E+01	1.4E+01	1.1E+02	11/23/1993	IR09VB005	6.8	7.3	99%	1.0E+01	1.5E+01
NICKEL	7440-02-0	Laboratory	1.3E+02	b	55	55	6	1.8E+02	1.8E+01	1.7E+03	12/16/2002	PVPGB103	2.0	2.5	100%	0.0E+00	4.7E+00
NICKEL	7440-02-0	Laboratory	1.3E+02	b	55	55	6	1.8E+02	1.8E+01	1.7E+03	12/16/2002	PVPGB103	5.0	5.5	100%	0.0E+00	4.7E+00
POTASSIUM	7440-09-7	XRF			68	68	0	1.4E+04	2.9E+03	2.1E+04	11/23/1993	IR09VB009	2.7	3.2	100%	1.0E+01	1.0E+01
POTASSIUM	7440-09-7	Laboratory			10	9	0	2.2E+03	3.3E+02	3.8E+03	1/26/1995	09W06	9.3	10.0	90%	5.6E+00	1.7E+02
SELENIUM	7782-49-2	Laboratory			54	30	0	7.1E-01	3.1E-01	3.9E+00	12/16/2002	PVPGB104	3.5	4.0	56%	0.0E+00	6.9E+00
SILVER	7440-22-4	XRF			68	4	0	4.9E+00	2.9E+00	4.7E+00	11/17/1994	IR09GB012	12.0	12.5	6%	1.0E+01	1.0E+01
SILVER	7440-22-4	Laboratory			55	13	0	1.9E-01	1.4E-01	4.4E-01	12/16/2002	PVPGB104	1.5	2.0	24%	0.0E+00	2.4E+00
SODIUM	7440-23-5	Laboratory			10	9	0	1.5E+03	4.8E+02	4.8E+03	1/26/1995	09W07	12.5	13.3	90%	1.8E+01	4.6E+01
THALLIUM	7440-28-0	Laboratory		d	55	15	15	2.4E-01	1.3E-01	1.1E+00	6/20/2002	PVPGB102	2.5	3.0	27%	0.0E+00	3.0E+00
TIN	7440-31-5	XRF			68	68	0	1.4E+01	7.3E+00	6.0E+01	3/31/1994	IR09GB004	11.5	12.0	100%	1.0E+01	1.0E+01
TIN	7440-31-5	Laboratory			12	5	0	3.3E+00	3.4E+00	1.1E+01	6/21/2002	B144GB100	5.0	5.5	42%	1.1E+00	1.1E+01
TITANIUM	7440-32-6	XRF			68	68	0	4.2E+03	1.4E+03	1.0E+04	4/1/1994	IR09GB002	3.0	3.5	100%	1.0E+01	1.0E+01
VANADIUM	7440-62-2	XRF	1.9E+02	b	68	68	6	1.3E+02	4.3E+01	3.5E+02	12/14/1993	IR09VB006	1.8	2.0	100%	1.0E+01	1.0E+01
VANADIUM	7440-62-2	Laboratory	1.9E+02	b	55	52	2	1.3E+02	1.6E+01	2.4E+03	6/20/2002	PVPGB101	2.5	3.0	95%	0.0E+00	1.3E+01
ZINC	7440-66-6	XRF	2.3E+02	b	68	68	15	2.7E+02	3.1E+01	4.1E+03	4/1/1994	IR09GB007	3.0	3.5	100%	1.0E+01	1.0E+01
ZINC	7440-66-6	Laboratory	2.3E+02	b	55	55	25	5.0E+02	7.4E+01	3.1E+03	6/20/2002	PVPGB102	2.5	3.0	100%	0.0E+00	6.1E+00
General Chemistry																	
TOC	7440-44-0	Laboratory			1	1		7.1E+03	7.1E+03	7.1E+03	12/8/1994	IR09GB015	1.0	2.0	100%	1.6E+02	1.6E+02

[1] - Source Definition

a - Ambient Background Concentration (95th percentile) at Mare Island Naval Shipyard
b - Ambient Metal Concentrations in Artificial Fill - Mare Island
c - Ambient Metal Concentrations in Original Island Soil - Mare Island
d - At the request of the regulatory agencies, the ambient limit was set to the detection limit.

Data from the following types of samples were excluded from this statistical summary query: 1) duplicate or other quality control samples; 2) split samples; 3) removed samples; and 4) samples analyzed using the toxicity characteristic leaching procedure (TCLP) or by the waste extraction test (WET). In addition, rejected data was excluded from this query.

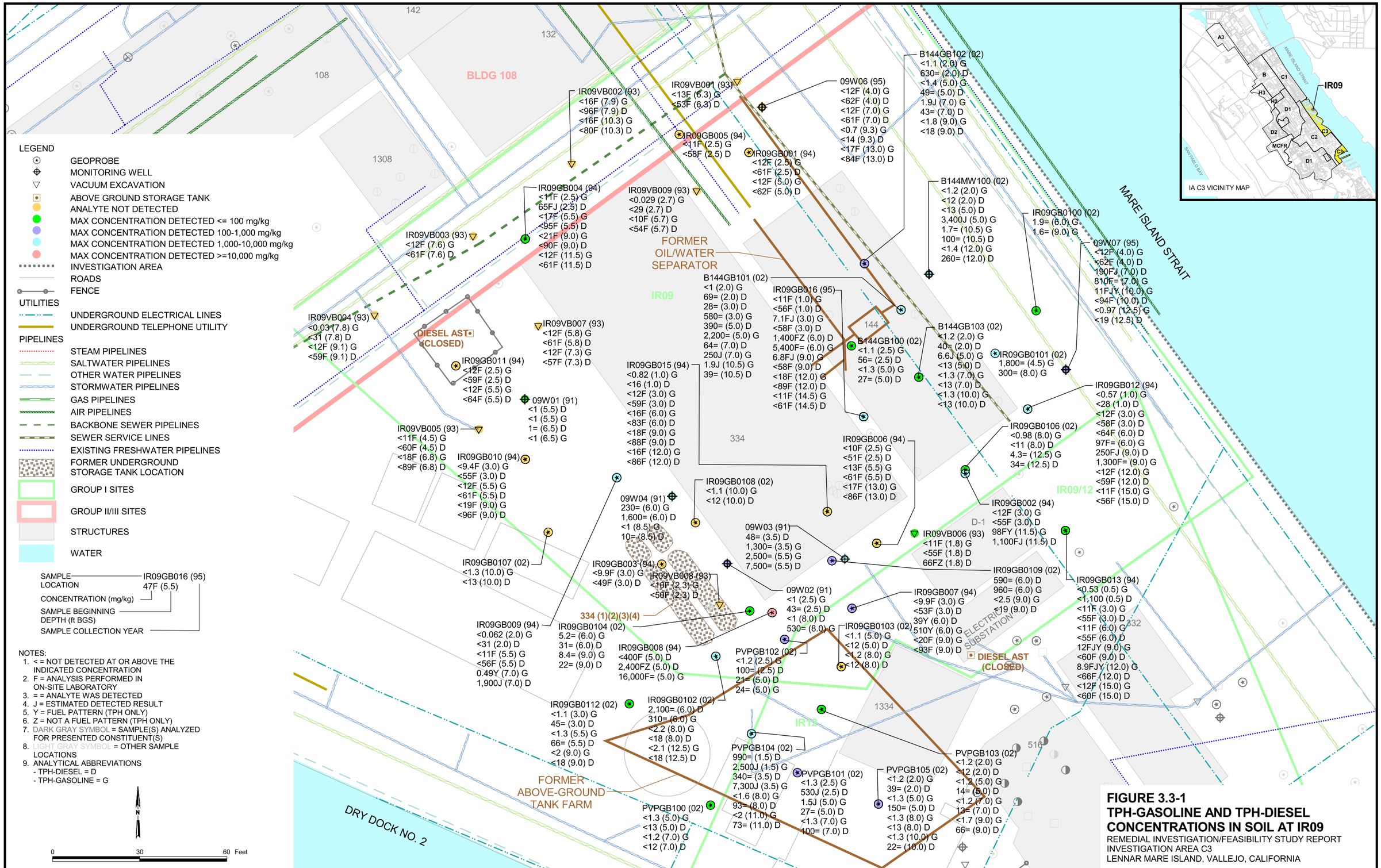


FIGURE 3.3-1
TPH-GASOLINE AND TPH-DIESEL CONCENTRATIONS IN SOIL AT IR09
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

CH2MHILL

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south of Building 334 and south of the former USTs (2,500 and 960 mg/kg, respectively) were found in samples from 09W03 and IR09GB0109 respectively. The elevated TPH-gasoline-range organics concentrations in soil in this area appear to be limited to the 5- to 7-foot depth range, as concentrations of TPH-gasoline-range organics at greater depths were less than analytical detection limits. TPH-gasoline-range organics analysis assesses the quantity of low-molecular-weight organic compounds (typical in gasoline) in a soil sample. Based on the location and depth of the soil samples with the highest levels of TPH-gasoline-range organics (south of the former USTs at 5 to 7 feet bgs), the analytical results likely represent the types of substances previously stored in the USTs (alcohol, linseed oil, waste paint/drier, turpentine, and waste paint/drier) rather than petroleum-based substances.

Soil samples from five borings inside and surrounding Building 144 had concentrations of TPH-gasoline-range organics greater than 1,000 mg/kg. The samples in this area with TPH-gasoline-range organics greater than 1,000 mg/kg were all collected between 5 and 9 feet bgs. Again, the concentrations of TPH-gasoline-range organics in soil at greater depths were less than analytical detection limits. The source of the TPH-gasoline-range organics in this part of the site likely is attributable to the oil/water separator.

TPH-gasoline-range organics was found above 1,000 mg/kg in one boring at the former AST farm (PVPGB104), at 1.5 and 3.5 feet bgs. Other soil samples collected in the vicinity of the former AST farm had TPH-gasoline-range organics concentrations less than 25 mg/kg.

TPH-diesel-range Organics. TPH-diesel range organics[4] was detected in 47 of 133 soil samples analyzed. Figure 3.3-1 shows the distribution of TPH-diesel range organics in soil at IR09. The highest detected TPH-diesel range organics concentration, 7,500 mg/kg, was found in a sample collected in 1991 from 09W03 at 5.5 feet bgs. This location is south of Building 334, near the sample with the highest TPH-gasoline-range organics concentration. Again, the levels of diesel-range organics in soil samples in this area likely represent the types of substances previously stored in the USTs (alcohol, linseed oil, turpentine, and waste paint/drier), rather than diesel.

Other detected concentrations of TPH-diesel range organics in soil at IR09 ranged from 1 to 2,100 mg/kg. Of the 47 detected concentrations of TPH-diesel-range organics in soil samples collected from IR09, approximately 65 percent were less than 100 mg/kg, and approximately 90 percent were less than 1,000 mg/kg. Four of the five soil samples with TPH-diesel range organics concentrations greater than 1,000 mg/kg were collected in the vicinity of the former USTs, 5 to 7 feet bgs. As shown in Figure 3.3-1, the extent of contamination is defined by TPH-diesel-range organics concentrations less than 100 mg/kg.

Other Petroleum Hydrocarbon Results. TPH-motor-oil range organics[5] was detected in 38 of 125 samples analyzed. Approximately 90 percent of the detected TPH-motor-oil range organics and total recoverable petroleum hydrocarbon (TRPH) concentrations in soil at IR09 were less than 1,000 mg/kg. The highest detected concentration, 5,900 mg/kg, was found in a surface soil sample collected in 1994 from IR09GB013 at 0.5 foot bgs. This is the same

[4] The terms TPH-diesel and diesel are also used in this document with the same meaning.

[5] The terms TPH-motor-oil and motor-oil are also used in this document with the same meaning.

sample with the highest TRPH concentration (7,000 mg/kg). This surface soil sample is located east of the cable crane house and not associated with a known source.

With the exception of this sample, the TPH-motor-oil range organics results show somewhat similar patterns related to probable sources, in that nine of the 10 highest TPH-motor-oil-range organics concentrations (between 320 and 2,200 mg/kg) found in soil samples from IR09 were collected from locations south of the USTs (typically, 5 to 7 feet bgs), and in the vicinity of the former AST farm and the Building 144 oil/water separator.

3.3.1.2 VOC Compounds

As shown in Table 3.3-1, the VOCs were detected infrequently in soil samples collected from IR09. The most frequently-detected VOCs were BTEX compounds ethylbenzene, toluene, and xylene(s).

BTEX Compounds. One-hundred-fifteen soil samples collected from IR09 were analyzed for BTEX compounds. These compounds were detected in 2 to 12 percent of the samples analyzed. Benzene was detected in two samples; ethylbenzene was detected in 14 samples, toluene was detected in five samples, and xylenes were detected in 13 samples. The samples with the highest BTEX concentrations (09W03 at 5.5 feet bgs; IR09GB008 at 5 feet bgs) were collected in the area corresponding with the highest TPH-gasoline-range organics concentrations found at the site: south of Building 334 and south of the former USTs, 5 to 7 feet bgs.

Detected concentrations of BTEX compounds ranged from 0.003 mg/kg (toluene) to 16 mg/kg (xylenes). The distribution of BTEX compounds is generally similar to the distribution of petroleum hydrocarbons. The highest concentrations of the individual BTEX compounds were found in samples collected between 5 and 6 feet bgs from 09W03 and IR09GB008, located south of the former USTs and south of Building 334, in the same area as the samples with the highest TPH-gasoline and TPH-diesel-range organics concentrations. Most of the detected BTEX concentrations were found in soil samples collected from locations south, southwest, and east of Building 334, east of Building 144, south of the former USTs, and in the vicinity of the former AST farm and the Building 144 oil/water separator. About 40 percent of the detected BTEX results were found in the same soil samples that had concentrations of TPH-gasoline greater than 1,000 mg/kg.

The maximum concentrations of benzene (0.6 mg/kg), toluene (0.95 mg/kg), ethylbenzene (12 mg/kg) and xylenes (16 mg/kg) found in soil at IR09 are several orders of magnitude less than the respective USEPA Region 9 preliminary remediation goals (PRGs)[6] of 1.3, 520, 20, and 420 mg/kg for the direct contact exposure pathway in an industrial setting.

Other VOC Compounds. Other VOC compounds detected in soil at IR09 were 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, 1,4-dioxane, acetone, carbon disulfide, chloroform, cyclohexane, isopropylbenzene, n-butylbenzene, n-propylbenzene, sec-butylbenzene, tert-butylbenzene, TCE, and PCE. Other than acetone, which is a common laboratory contaminant, these compounds were detected in only one to three soil samples collected from IR09, at isolated locations and depths throughout the site. Over half of the

[6] PRGs are risk-based concentrations developed by U.S. EPA for use in site screening to help identify areas, contaminants and conditions to warrant further attention at a particular site.

samples with detected concentrations of these compounds were found in samples collected from PVPGB104 at samples collected at 1.5 and 3.5 feet bgs. These compounds are likely the result of former paint shop operations but were not found in the immediate vicinity of the former USTs.

The concentration of these compounds was found between 0.003 mg/kg (TCE and chloroform) and 21 mg/kg (1,2,4-trimethylbenzene), and 15 percent of the results were quantified at concentrations below the analytical reporting limit. The maximum concentrations of detected VOCs are one to five orders of magnitude less than the respective USEPA Region 9 PRGs for the direct-contact exposure pathway in an industrial setting, and are less than the respective RWQCB environmental screening levels (ESLs) for soil where groundwater is not a current or potential source of drinking water.

3.3.1.3 Polynuclear Aromatic Hydrocarbon Compounds

Forty-six soil samples collected throughout IR09 were analyzed for PAHs. As shown in Table 3.3-1, 15 different PAH compounds were detected in soil at IR09: acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene. These compounds were found in two to 22 of the soil samples analyzed for PAHs.

Concentrations of detected PAH compounds ranged from 0.006 mg/kg (benzo(k)fluoranthene) to 2.3 mg/kg (naphthalene and acenaphthene). Of the PAH results identified in Table 3.3-1 as detections, approximately 10 percent were quantified at concentrations at or below the analytical reporting limit.

Soil samples for PAH analysis were collected in all areas of the site. However, the distribution of detected results is generally similar to the pattern of petroleum hydrocarbons found in soil at IR09. Samples with detected concentrations of PAHs were typically collected at locations south, southwest, and east of Building 334 and east of Building 144, including in the vicinity of the former AST farm and the Building 144 oil/water separator. However, depths of samples with detected PAH concentrations are not limited to the 5- to 7-foot depth range in these areas, and samples with detected concentrations of PAHs were collected between the surface and 14 feet bgs. Correlation between TPH and PAH results is not as direct as the TPH/BTEX correlation, in that PAHs were not found in some areas near the former USTs with the highest petroleum hydrocarbon results, and PAHs were found in some areas of the former AST farm where petroleum hydrocarbons were not detected.

The detected concentration of PAHs (with the exception of benzo(a)pyrene) were all less than the respective USEPA Region 9 PRGs for the direct-contact exposure pathway in an industrial setting, and the RWQCB ESLs for soil where groundwater is not a current or potential source of drinking water. The maximum detected concentration of benzo(a)pyrene (0.41 mg/kg) exceeded the USEPA Region 9 PRG (0.21 mg/kg) and the ESL (0.13 mg/kg). This sample was collected near the Building 144 oil/water separator (B144GB102) at 2 feet bgs. The remaining detected concentrations in soil at IR09 of benzo(a)pyrene were between 0.018 and 0.2 mg/kg.

3.3.1.4 Other Organic Compounds

Other organic compounds detected in soil samples collected from IR09 were benzoic acid, bis(2-ethylhexyl)phthalate, phenol, Aroclor-1260, alpha chlordane, endrin ketone, and gamma chlordane. Detected concentrations of these compounds are sporadic, and no systematic association with known source areas is discernible. Some of these constituents are known or suspected laboratory contaminants.

Bis(2-ethylhexyl)phthalate was found in one of 21 samples for which it was analyzed, at a concentration of 0.49 mg/kg. The presence of bis(2-ethylhexyl)phthalate is likely the result of laboratory contamination.

Phenol was detected in three of 21 samples for which it was analyzed. Samples with detected phenol concentrations are all located in shallow soil, in three isolated locations at the site. The maximum concentration of phenol is 2.1 mg/kg, several orders of magnitude lower than the USEPA Region 9 PRG of 100,000 mg/kg.

Benzoic acid was found in four of 11 samples at a maximum concentration of 1.4 mg/kg. The four samples with detected concentrations of benzoic acid were collected from 09W01 and 09W02, between 3 and 8 feet bgs. Based on the location and depth of the detected benzoic acid concentrations, the source may be associated with the former USTs. The maximum benzoic acid concentration of 1.4 mg/kg, is six orders of magnitude lower than the USEPA Region 9 PRG of 100,000 mg/kg.

Aroclor-1260 was the only PCB compound detected in soil samples collected from IR09. Aroclor-1260 was found in only one of 70 samples at a concentration of 0.092 mg/kg in a vacuum boring located north of Building 334 at 7.6 feet bgs. This concentration is less than the respective USEPA Region 9 PRG or RWQCB ESL of 0.74 mg/kg.

Three different pesticide compounds were detected infrequently in soil samples collected from IR09. Both alpha chlordane and gamma chlordane were only detected in samples from IR09GB009, located west of Building 334, at a maximum concentration of 0.23 and 0.027 mg/kg, respectively. Endrin ketone was found in one of 10 samples at a concentration of 0.011 at 1 foot bgs in a sample collected near Building 144.

3.3.1.5 Metals

Table 3.3-1 provides of summary of metals results in soil samples collected from IR09, and distinguishes the results between “laboratory” analysis and XRF analysis. Laboratory analysis means analysis of soil samples by a fixed laboratory using Contract Laboratory Program (CLP) methods. XRF analysis means analysis of soil samples by the Navy’s Mare Island on-site laboratory using XRF methodology. Eighteen of the 27 metals listed in Table 3.3-1 were analyzed in soil samples collected from IR09 by both laboratory analysis, and by XRF analysis. The other 10 metals were analyzed by laboratory analysis, only. The purpose of distinguishing the laboratory analysis and the XRF analysis is because laboratory methods measure the acid-soluble fraction of the metals, while the XRF method measures the total metals concentration, and are considered less representative than other analytical methods (Appendix B). In general, approximately twice as many samples were analyzed for metals by XRF methodology alone as were analyzed by CLP methods.

As discussed in Section 2.3, ambient values of select metals in both native island materials and fill soils at Mare Island have been established. Ambient values for selected metals at Mare Island establish naturally-occurring conditions against which site concentrations can be compared to identify conditions that may be attributable to site activities. Table 3.3-1 shows the ambient value for fill soils (appropriate because of the location of IR09), and identifies the number of samples with metals results greater than the respective ambient concentration. Of the 27 metals analyzed for in soil samples collected from IR09, ambient levels have been established for 15.

As indicated in Table 3.3-1, 13 different metals were found at concentrations exceeding the ambient value by CLP methods. Of these, only lead, zinc, beryllium, mercury, copper and nickel were found at concentrations exceeding the upper range of the ambient data set and at a frequency that suggests an association with site activities. The metal most frequently found at concentrations exceeding the ambient level in soil samples collected from IR09 was lead; the distribution of lead is shown in Figure 3.3-2. Other metals found at elevated concentrations in soil samples from IR09 were, zinc, beryllium, mercury, copper and nickel. These compounds are discussed below.

Lead. Figure 3.3-2 shows the distribution of lead concentrations in soil at IR09. Fifty-five of 82 soil samples analyzed by an off-site laboratory contained lead at concentrations exceeding the ambient concentration for lead in fill materials (59 mg/kg). The soil sample that contained the highest lead concentration, 20,000 mg/kg, was collected at 6 feet bgs from IR09GB0102. This sample was collected from the same general area outside the southwest corner of Building 334, and depth as soil samples with the highest petroleum hydrocarbon concentrations. The concentration of lead in other samples collected from IR09 was one to three orders of magnitude lower than the concentration of lead in this sample.

Of the 81 soil samples with detected lead concentrations that were analyzed by CLP methods, about 15 percent were less than the established ambient concentration for fill materials, and about 65 percent were less than 1,000 mg/kg. As shown in Figure 3.3-2, the 13 soil samples analyzed by CLP methods with lead concentrations greater than 1,000 mg/kg were collected from locations south, southwest, and east of Building 334 and east of Building 144, including the vicinity of the former USTs, the former AST farm, and the Building 144 oil/water separator. The extent of lead contamination is defined by concentrations outside these source areas less than 1,000 mg/kg. The paint products used at the site likely contained lead, and the lead concentrations in soil in this area are believed to represent a release of paint products from the USTs, the former AST farm, and the Building 144 oil/water separator. The XRF results greater than 1,000 mg/kg lead showed similar patterns. Sample results from XRF analysis are denoted with an “F” in Figure 3.3-2.

Zinc. Zinc was detected above the established ambient level for fill materials (230 mg/kg) in 25 of 55 soil samples analyzed by CLP methods. The sample with the highest zinc concentration by CLP methods (3,100 mg/kg) was found in PVPGB102, collected at 2.5 feet bgs in the vicinity of the former AST farm. The sample with the highest zinc concentration by XRF (4,100 mg/kg) was found in IR09GB007, collected at 3 feet bgs in the area south of the former USTs. Similar to lead, the 10 samples with zinc concentrations greater than 1,000 mg/kg were collected from locations south, southwest, and east of Building 334 and east of

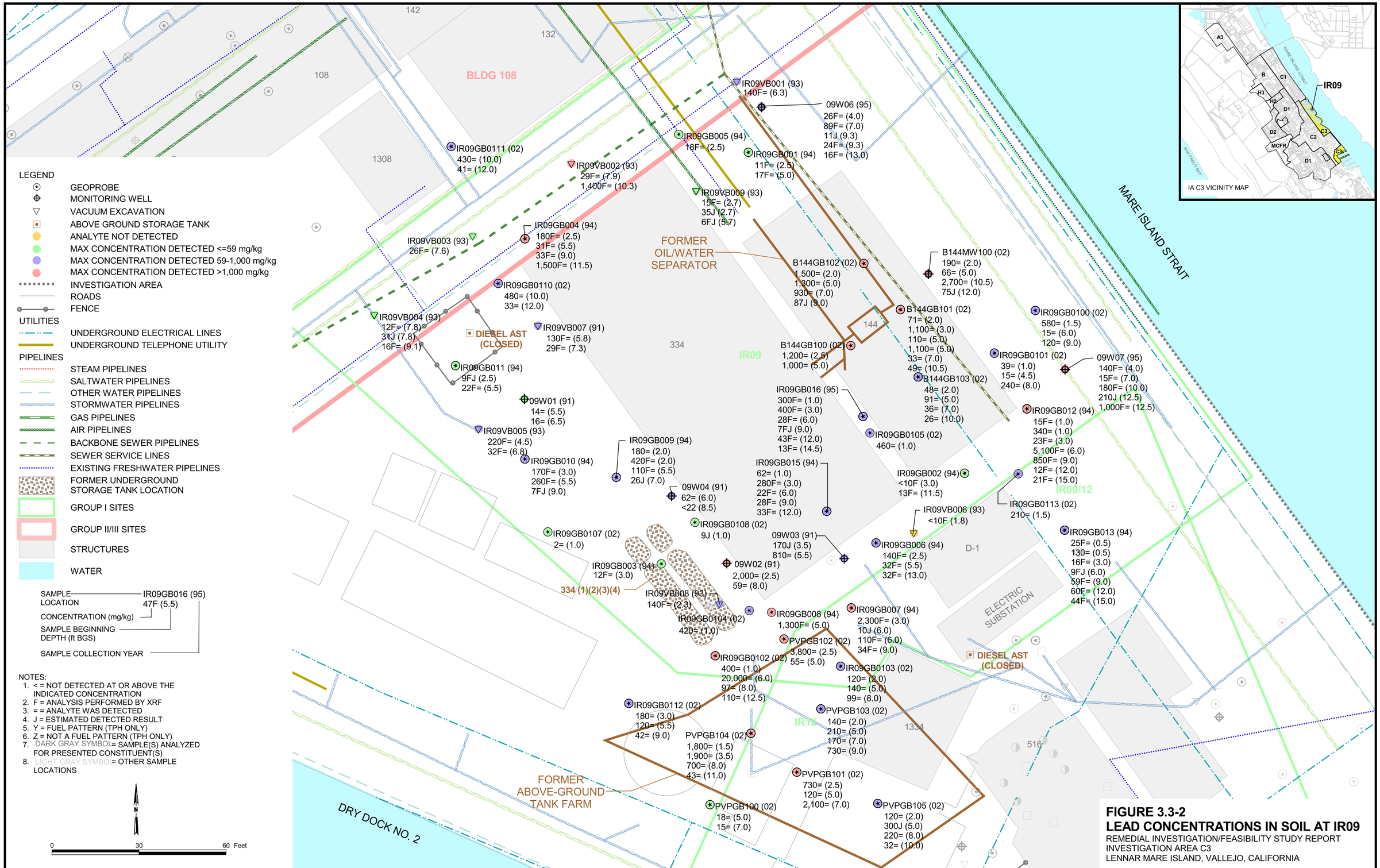

FIGURE 3.3-2
LEAD CONCENTRATIONS IN SOIL AT IR09
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

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Building 144, including the vicinity of the former USTs, the former AST farm, and the Building 144 oil/water separator.

Beryllium. Beryllium was detected above the established ambient level for fill materials (0.9 mg/kg) in 22 of 55 soil samples analyzed by CLP methods. Twenty of the 22 soil samples with concentrations of beryllium greater than the established ambient level were collected from locations south, southwest, and east of Building 334 and east of Building 144, including the vicinity of the former USTs, the former AST farm, and the Building 144 oil/water separator. The beryllium concentrations in these samples ranged from 0.94 to 2 mg/kg.

Mercury. Mercury was detected above the established ambient level for fill materials (2 mg/kg) in 10 of 54 soil samples analyzed by CLP methods. The highest concentrations of mercury were found in soil samples collected from the former AST farm. Of the 10 samples from IR09 with mercury concentrations greater than the established ambient level, six were collected from the area of the former AST farm at depths between 1 and 8 feet bgs and had mercury concentrations between 3 and 29 mg/kg.

Copper. Copper was detected above the established ambient level for fill materials (120 mg/kg) in eight of 55 soil samples analyzed by CLP methods. All eight samples were collected from locations south, southwest, and east of Building 334 and east of Building 144, including the vicinity of the former USTs, the former AST farm, and the Building 144 oil/water separator. The copper concentrations in these samples ranged from 126 to 235 mg/kg. The maximum copper concentration analyzed by XRF was collected in IR09GB010, located north of the former USTs at 5.5 feet bgs.

Nickel. Nickel was detected above the established ambient level for fill materials (130 mg/kg) in six of 55 soil samples analyzed by CLP methods. The six samples were all collected from three borings in the vicinity of the former AST farm (IR09GB0103, PVPGB103, and PVPGB101) and had nickel concentrations between 460 and 1,700 mg/kg. ABM was identified in borings IR09GB0103 and PVPGB103 between 1 and 10 feet bgs, corresponding with the highest nickel concentrations found in soil samples at IR09. These elevated levels of nickel result from the ABM and are not representative of soil conditions absent the ABM.

3.3.2 Groundwater

A summary of groundwater data for IR09 is provided in Table 3.3-2. For each compound, Table 3.3-2 shows the number of samples analyzed, the number of detected results of that compound[7], the average result, the maximum result, and the frequency of detection. For metals analysis, Table 3.3-2 shows the ambient concentration for shallow groundwater at Mare Island (see also Table 2.3-2) and identifies the number of samples with metal results greater than the respective ambient concentration.

Only groundwater data collected since June 1997 are included in Table 3.3-2. Data collected since June 1997 most accurately reflect current conditions. A complete set of analytical groundwater data for IR09 is provided in Table F2 in Appendix F.

[7] Includes those samples for which a compound was quantified at a concentration below the analytical reporting limit.

The following is a discussion of the results of the analytical categories in Table 3.3-2 (petroleum hydrocarbon compounds, VOCs, SVOCs, and metals). The natural geochemistry of IR09 groundwater was discussed in Section 1.6.

3.3.2.1 Petroleum Hydrocarbons

As indicated in Table 3.3-2, approximately 25 groundwater samples were collected from locations throughout IR09 since 1997 for petroleum hydrocarbon analysis. Three-quarters of the detected concentrations were below 1,000 µg/L.

The highest concentration of petroleum hydrocarbons found in groundwater at IR09 was detected in a sample collected from well 09W06 in February 1998. The concentration of TPH-motor-oil-range organics in this sample was 400,000 µg/L. This concentration is anomalously high compared with concentrations of petroleum hydrocarbons in groundwater found elsewhere at IR09 and in other samples collected from well 09W06. All other groundwater samples collected from 09W06 contained TPH-motor-oil-range organics at concentrations less than 600 µg/L, including two groundwater samples collected from 09W06 after February 1998. TPH-motor-oil-range organics were not detected in soil samples collected from 09W06 in four samples between 4 and 13.5 feet bgs, nor was it detected in soil samples surrounding 09W06 (IR09GB001, IR09VB001, IR09GB005). These data demonstrate that the high concentration of TPH-motor-oil-range organics in the sample collected from 09W06 in February 1998 is not representative of groundwater conditions at IR09.

Historically, the groundwater sample with the highest concentration of TPH-gasoline-range organics at IR09 was collected in 1994. (This sample is not shown in Table 3.3-2 as it was collected prior to 1997.) This sample was collected at IR09GB003, adjacent to the former USTs outside the southwest corner of Building 334, and had a TPH-gasoline-range organics concentration of 20,000 µg/L. Similar to soil in this area, the analytical results likely represent the types of substances previously stored in the USTs (alcohol, linseed oil, waste paint/drier, turpentine, and waste paint/drier) rather than petroleum-based substances. Other petroleum hydrocarbon concentrations in groundwater near the former USTs were much lower, however. In the latest monitoring event, groundwater samples collected from 09W03, located near the highest concentrations of petroleum hydrocarbons in soil, did not contain TPH-gasoline-range organics, TPH-diesel-range organics, or TPH-motor-oil-range organics at concentrations exceeding reporting limits.

Other than the samples described above, the only other groundwater samples collected since 1997 with petroleum hydrocarbon concentrations greater than 1,000 µg/L were collected from GeoProbe® borings near the former AST farm (PVPGB104 and PVPGB105) and near the Building 144 oil/water separator (B144GB101). Detected concentrations of petroleum hydrocarbons in groundwater collected from these three borings ranged from 750 µg/L (TPH-gasoline-range organics in PVPGB104) to 2,300 µg/L (TPH-diesel-range organics and TPH-motor-oil-range organics in B144GB101 and PVPGB105). However, concentrations of petroleum hydrocarbons in samples collected from downgradient wells (B144MW100, 09W07) were lower. Groundwater samples collected from these wells between November 1997 and May 2004 contained petroleum hydrocarbons at concentrations ranging from 30 to 370 µg/L.

Table 3.3-2

Investigation Area C3, IR09 Statistical Summary Table of Analytical Groundwater Data

Analyte	CAS Number	Filtered/ Unfiltered	Ambient Concentration for Metals (ug/L)	Source of Ambient Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Ambient Concentration for Metals	Average Result (ug/L)	Minimum Detection (ug/L)	Maximum Detection (ug/L)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (ug/L)	Maximum Detection Limit (ug/L)
WATER - IR09																	
Petroleum Hydrocarbon Compounds																	
DIESEL	DRO	Unfiltered			25	8		2.3E+03	5.0E+01	2.3E+03	6/28/2002	B144GB101	5.9	13.6	32%	1.0E+02	1.0E+05
GASOLINE	GRO	Unfiltered			24	9		9.8E+01	2.8E+01	7.5E+02	12/18/2002	PVPGB104	3.0	12.0	38%	5.0E+01	1.0E+02
MOTOR OIL	MRO	Unfiltered			25	6		1.8E+04	1.8E+02	4.0E+05	2/25/1998	09W06			24%	1.0E+02	1.0E+05
Volatile Organic Compounds																	
1,1,1-TRICHLOROETHANE	71-55-6	Unfiltered			15	0		5.0E-01							0%	1.0E+00	1.0E+00
1,1,2,2-TETRACHLOROETHANE	79-34-5	Unfiltered			23	0		7.0E-01							0%	1.0E+00	1.0E+01
1,1,2-TRICHLOROETHANE	79-00-5	Unfiltered			23	0		7.0E-01							0%	1.0E+00	1.0E+01
1,1-DICHLOROETHANE	75-34-3	Unfiltered			15	0		5.0E-01							0%	1.0E+00	1.0E+00
1,1-DICHLOROETHENE	75-35-4	Unfiltered			23	0		7.0E-01							0%	1.0E+00	1.0E+01
1,2,4-TRICHLOROBENZENE	120-82-1	Unfiltered			19	0		1.3E+00							0%	1.0E+00	1.0E+01
1,2-DIBROMO-3-CHLOROPROPANE	96-12-8	Unfiltered			15	0		5.0E-01							0%	1.0E+00	1.0E+00
1,2-DICHLOROETHANE	107-06-2	Unfiltered			23	0		6.1E-01							0%	5.0E-01	1.0E+01
1,2-DICHLOROPROPANE	78-87-5	Unfiltered			23	0		7.0E-01							0%	1.0E+00	1.0E+01
1,3-DICHLOROBENZENE	541-73-1	Unfiltered			27	0		9.1E-01							0%	1.0E+00	1.0E+01
2-BUTANONE	78-93-3	Unfiltered			1	0		2.5E+00							0%	5.0E+00	5.0E+00
2-HEXANONE	591-78-6	Unfiltered			9	0		2.5E+00							0%	5.0E+00	5.0E+00
4-METHYL-2-PENTANONE	108-10-1	Unfiltered			15	0		2.5E+00							0%	5.0E+00	5.0E+00
ACETONE	67-64-1	Unfiltered			6	1		6.1E+00	3.4E+01	3.4E+01	6/25/1999	09W07			17%	1.0E+00	1.0E+00
ACROLEIN	107-02-8	Unfiltered			3	0		8.3E+00							0%	1.0E+01	2.0E+01
ACRYLONITRILE	107-13-1	Unfiltered			8	0		2.1E+01							0%	1.0E+01	2.0E+02
BENZENE	71-43-2	Unfiltered			24	0		6.0E-01							0%	5.0E-01	1.0E+01
BROMOCHLOROMETHANE	74-97-5	Unfiltered			15	0		5.0E-01							0%	1.0E+00	1.0E+00
BROMODICHLOROMETHANE	75-27-4	Unfiltered			23	0		7.0E-01							0%	1.0E+00	1.0E+01
BROMOFORM	75-25-2	Unfiltered			23	0		7.0E-01							0%	1.0E+00	1.0E+01
BROMOMETHANE	74-83-9	Unfiltered			23	0		7.0E-01							0%	1.0E+00	1.0E+01
CARBON DISULFIDE	75-15-0	Unfiltered			15	2		5.3E-01	5.0E-01	1.0E+00	5/29/1998	09W07			13%	1.0E+00	1.0E+00
CARBON TETRACHLORIDE	56-23-5	Unfiltered			23	0		6.1E-01							0%	5.0E-01	1.0E+01
CHLOROBENZENE	108-90-7	Unfiltered			23	0		7.0E-01							0%	1.0E+00	1.0E+01
CHLOROETHANE	75-00-3	Unfiltered			15	0		5.0E-01							0%	1.0E+00	1.0E+00
CHLOROFORM	67-66-3	Unfiltered			15	0		5.0E-01							0%	1.0E+00	1.0E+00
CHLOROMETHANE	74-87-3	Unfiltered			15	0		5.0E-01							0%	1.0E+00	1.0E+00
CIS-1,2-DICHLOROETHENE	156-59-2	Unfiltered			16	3		7.2E-01	1.0E+00	2.0E+00	6/1/1998	09W06			19%	1.0E+00	1.0E+00
CIS-1,2-DICHLOROETHENE	156-59-2	Unfiltered			16	3		7.2E-01	1.0E+00	2.0E+00	8/31/1998	09W06			19%	1.0E+00	1.0E+00
CIS-1,3-DICHLOROPROPENE	10061-01-5	Unfiltered			15	0		3.7E-01							0%	5.0E-01	1.0E+00
DIBROMOCHLOROMETHANE	124-48-1	Unfiltered			23	0		7.0E-01							0%	1.0E+00	1.0E+01
ETHANE	74-84-0	Unfiltered			1	0		1.0E+00							0%	2.0E+00	2.0E+00
ETHYLBENZENE	100-41-4	Unfiltered			24	0		7.1E-01							0%	1.0E+00	1.0E+01
ETHYLENE	74-85-1	Unfiltered			1	0		5.0E-01							0%	1.0E+00	1.0E+00
ETHYLENE DIBROMIDE	106-93-4	Unfiltered			15	0		5.0E-01							0%	1.0E+00	1.0E+00
METHYL TERTIARY BUTYLETHER	1634-04-4	Unfiltered			2	0		1.8E+00							0%	2.0E+00	5.0E+00
METHYLENE CHLORIDE	75-09-2	Unfiltered			23	0		9.6E-01							0%	1.0E+00	1.0E+01
O-XYLENE	95-47-6	Unfiltered			1	1		1.5E+00	1.5E+00	1.5E+00	6/28/2002	B144GB101	5.9	13.6	100%	1.0E+00	1.0E+00
STYRENE	100-42-5	Unfiltered			15	0		5.0E-01							0%	1.0E+00	1.0E+00
TETRACHLOROETHENE	127-18-4	Unfiltered			23	0		7.0E-01							0%	1.0E+00	1.0E+01
TOLUENE	108-88-3	Unfiltered			24	0		6.9E-01							0%	1.0E+00	1.0E+01

Table 3.3-2

Investigation Area C3, IR09 Statistical Summary Table of Analytical Groundwater Data

Analyte	CAS Number	Filtered/ Unfiltered	Ambient Concentration for Metals (ug/L)	Source of Ambient Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Ambient Concentration for Metals	Average Result (ug/L)	Minimum Detection (ug/L)	Maximum Detection (ug/L)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (ug/L)	Maximum Detection Limit (ug/L)
WATER - IR09																	
TRANS-1,2-DICHLOROETHENE	156-60-5	Unfiltered			23	2		7.1E-01	6.0E-01	8.0E-01	8/31/1998	09W06			9%	1.0E+00	1.0E+01
TRANS-1,3-DICHLOROPROPENE	10061-02-6	Unfiltered			15	0		3.7E-01							0%	5.0E-01	1.0E+00
TRICHLOROETHENE	79-01-6	Unfiltered			23	0		7.0E-01							0%	1.0E+00	1.0E+01
VINYL CHLORIDE	75-01-4	Unfiltered			23	0		6.1E-01							0%	5.0E-01	1.0E+01
XYLENE (TOTAL)	1330-20-7	Unfiltered			16	0		5.3E-01							0%	1.0E+00	2.0E+00
Semi-Volatile Organic Compounds																	
1,2-DICHLOROBENZENE	95-50-1	Unfiltered			27	0		9.1E-01							0%	1.0E+00	1.0E+01
1,4-DICHLOROBENZENE	106-46-7	Unfiltered			27	0		9.1E-01							0%	1.0E+00	1.0E+01
2,4,5-TRICHLOROPHENOL	95-95-4	Unfiltered			8	0		1.1E+01							0%	1.3E+01	2.5E+01
2,4,6-TRICHLOROPHENOL	88-06-2	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
2,4-DICHLOROPHENOL	120-83-2	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
2,4-DIMETHYLPHENOL	105-67-9	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
2,4-DINITROPHENOL	51-28-5	Unfiltered			8	0		1.1E+01							0%	1.3E+01	2.5E+01
2-CHLORONAPHTHALENE	91-58-7	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
2-CHLOROPHENOL	95-57-8	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
2-METHYL-4,6-DINITROPHENOL	534-52-1	Unfiltered			8	0		1.1E+01							0%	1.3E+01	2.5E+01
2-METHYLNAPHTHALENE	91-57-6	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
2-METHYLPHENOL	95-48-7	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
2-NITROANILINE	88-74-4	Unfiltered			8	0		1.1E+01							0%	1.3E+01	2.5E+01
2-NITROPHENOL	88-75-5	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
3,3'-DICHLOROBENZIDINE	91-94-1	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
3-NITROANILINE	99-09-2	Unfiltered			8	0		1.1E+01							0%	1.3E+01	2.5E+01
4-BROMOPHENYL-PHENYLETHER	101-55-3	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
4-CHLORO-3-METHYLPHENOL	59-50-7	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
4-CHLOROANILINE	106-47-8	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
4-CHLOROPHENYL-PHENYLETHER	7005-72-3	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
4-METHYLPHENOL	106-44-5	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
4-NITROANILINE	100-01-6	Unfiltered			8	0		1.1E+01							0%	1.3E+01	2.5E+01
4-NITROPHENOL	100-02-7	Unfiltered			8	0		1.1E+01							0%	1.3E+01	2.5E+01
ACENAPHTHENE	83-32-9	Unfiltered			15	2		3.1E+00	1.3E-01	7.4E+00	12/18/2002	PVPGB104	3.0	12.0	13%	1.0E-01	1.0E+01
ACENAPHTHYLENE	208-96-8	Unfiltered			15	0		2.7E+00							0%	1.0E-01	1.0E+01
ANTHRACENE	120-12-7	Unfiltered			15	0		2.5E+00							0%	1.0E-01	1.0E+01
BENZO(A)ANTHRACENE	56-55-3	Unfiltered			15	0		2.5E+00							0%	1.0E-01	1.0E+01
BENZO(A)PYRENE	50-32-8	Unfiltered			15	0		2.5E+00							0%	1.0E-01	1.0E+01
BENZO(B)FLUORANTHENE	205-99-2	Unfiltered			15	0		2.5E+00							0%	1.0E-01	1.0E+01
BENZO(G,H,I)PERYLENE	191-24-2	Unfiltered			9	0		4.1E+00							0%	1.0E-01	1.0E+01
BENZO(K)FLUORANTHENE	207-08-9	Unfiltered			15	1		2.5E+00	1.1E-01	1.1E-01	12/18/2002	PVPGB104	3.0	12.0	7%	1.0E-01	1.0E+01
BIS(2-CHLOROETHOXY)METHANE	111-91-1	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
BIS(2-CHLOROETHYL)ETHER	111-44-4	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
BIS(2-CHLOROISOPROPYL)ETHER	108-60-1	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
BIS(2-ETHYLHEXYL)PHTHALATE	117-81-7	Unfiltered			8	0		1.9E+00							0%	2.0E+00	4.0E+00
BUTYLBENZYLPHTHALATE	85-68-7	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
CARBAZOLE	86-74-8	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
CHRYSENE	218-01-9	Unfiltered			15	0		2.5E+00							0%	1.0E-01	1.0E+01
DI-N-BUTYLPHTHALATE	84-74-2	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
DI-N-OCTYLPHTHALATE	117-84-0	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
DIBENZ(A,H)ANTHRACENE	53-70-3	Unfiltered			15	0		2.5E+00							0%	1.0E-01	1.0E+01

Table 3.3-2

Investigation Area C3, IR09 Statistical Summary Table of Analytical Groundwater Data

Analyte	CAS Number	Filtered/ Unfiltered	Ambient Concentration for Metals (ug/L)	Source of Ambient Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Ambient Concentration for Metals	Average Result (ug/L)	Minimum Detection (ug/L)	Maximum Detection (ug/L)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (ug/L)	Maximum Detection Limit (ug/L)
WATER - IR09																	
DIBENZOFURAN	132-64-9	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
DIETHYLPHTHALATE	84-66-2	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
DIMETHYLPHTHALATE	131-11-3	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
FLUORANTHENE	206-44-0	Unfiltered			15	0		2.5E+00							0%	1.0E-01	1.0E+01
FLUORENE	86-73-7	Unfiltered			15	1		2.5E+00	5.2E-01	5.2E-01	12/18/2002	PVPGB104	3.0	12.0	7%	1.0E-01	1.0E+01
HEXACHLOROBENZENE	118-74-1	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
HEXACHLOROBUTADIENE	87-68-3	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
HEXACHLOROCYCLOPENTADIENE	77-47-4	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
HEXACHLOROETHANE	67-72-1	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
INDENO(1,2,3-CD)PYRENE	193-39-5	Unfiltered			15	0		2.5E+00							0%	1.0E-01	1.0E+01
ISOPHORONE	78-59-1	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
N-NITROSO-DI-N-PROPYLAMINE	621-64-7	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
N-NITROSODIPHENYLAMINE (1)	86-30-6	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
NAPHTHALENE	91-20-3	Unfiltered			15	1		2.7E+00	3.5E-01	3.5E-01	5/3/2004	B144MW0100			7%	1.0E-01	1.0E+01
PENTACHLOROPHENOL	87-86-5	Unfiltered			8	0		1.1E+01							0%	1.3E+01	2.5E+01
PHENANTHRENE	85-01-8	Unfiltered			9	0		4.1E+00							0%	1.0E-01	1.0E+01
PHENOL	108-95-2	Unfiltered			8	0		4.6E+00							0%	5.0E+00	1.0E+01
PYRENE	129-00-0	Unfiltered			15	0		2.5E+00							0%	1.0E-01	1.0E+01
PCB Compounds																	
AROCLOR-1016	12674-11-2	Unfiltered			9	0		2.7E-01							0%	4.7E-01	1.0E+00
AROCLOR-1221	11104-28-2	Unfiltered			9	0		2.7E-01							0%	4.7E-01	1.0E+00
AROCLOR-1232	11141-16-5	Unfiltered			9	0		2.7E-01							0%	4.7E-01	1.0E+00
AROCLOR-1242	53469-21-9	Unfiltered			9	0		2.7E-01							0%	4.7E-01	1.0E+00
AROCLOR-1248	12672-29-6	Unfiltered			9	0		2.7E-01							0%	4.7E-01	1.0E+00
AROCLOR-1254	11097-69-1	Unfiltered			9	0		2.7E-01							0%	4.7E-01	1.0E+00
AROCLOR-1260	11096-82-5	Unfiltered			9	0		2.7E-01							0%	4.7E-01	1.0E+00
Pesticides																	
4,4'-DDD	72-54-8	Unfiltered			8	0		4.9E-02							0%	9.4E-02	1.0E-01
4,4'-DDE	72-55-9	Unfiltered			8	0		4.9E-02							0%	9.4E-02	1.0E-01
4,4'-DDT	50-29-3	Unfiltered			8	0		4.9E-02							0%	9.4E-02	1.0E-01
ALDRIN	309-00-2	Unfiltered			8	0		2.4E-02							0%	4.7E-02	5.0E-02
ALPHA-BHC	319-84-6	Unfiltered			8	0		2.4E-02							0%	4.7E-02	5.0E-02
ALPHA-CHLORDANE	5103-71-9	Unfiltered			8	0		2.4E-02							0%	4.7E-02	5.0E-02
BETA-BHC	319-85-7	Unfiltered			8	0		2.4E-02							0%	4.7E-02	5.0E-02
DELTA-BHC	319-86-8	Unfiltered			8	0		2.4E-02							0%	4.7E-02	5.0E-02
DIELDRIN	60-57-1	Unfiltered			8	0		4.9E-02							0%	9.4E-02	1.0E-01
ENDOSULFAN I	959-98-8	Unfiltered			8	0		2.4E-02							0%	4.7E-02	5.0E-02
ENDOSULFAN II	33213-65-9	Unfiltered			8	0		4.9E-02							0%	9.4E-02	1.0E-01
ENDOSULFAN SULFATE	1031-07-8	Unfiltered			8	0		4.9E-02							0%	9.4E-02	1.0E-01
ENDRIN	72-20-8	Unfiltered			8	0		4.9E-02							0%	9.4E-02	1.0E-01
ENDRIN ALDEHYDE	7421-93-4	Unfiltered			8	0		4.9E-02							0%	9.4E-02	1.0E-01
ENDRIN KETONE	53494-70-5	Unfiltered			8	0		4.9E-02							0%	9.4E-02	1.0E-01
GAMMA-BHC (LINDANE)	58-89-9	Unfiltered			8	0		2.4E-02							0%	4.7E-02	5.0E-02
GAMMA-CHLORDANE	12789-03-6	Unfiltered			8	0		2.4E-02							0%	4.7E-02	5.0E-02
HEPTACHLOR	76-44-8	Unfiltered			8	0		4.9E-03							0%	9.4E-03	1.0E-02
HEPTACHLOR EPOXIDE	1024-57-3	Unfiltered			8	0		4.9E-03							0%	9.4E-03	1.0E-02

Table 3.3-2

Investigation Area C3, IR09 Statistical Summary Table of Analytical Groundwater Data

Analyte	CAS Number	Filtered/ Unfiltered	Ambient Concentration for Metals (ug/L)	Source of Ambient Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Ambient Concentration for Metals	Average Result (ug/L)	Minimum Detection (ug/L)	Maximum Detection (ug/L)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (ug/L)	Maximum Detection Limit (ug/L)
WATER - IR09																	
METHOXYCHLOR	72-43-5	Unfiltered			8	0		2.5E-01							0%	4.7E-01	5.0E-01
TOXAPHENE	8001-35-2	Unfiltered			8	0		1.5E+00							0%	2.8E+00	3.0E+00
Metals																	
ALUMINUM	7429-90-5	Filtered	4.8E+02	a	14	2	0	2.5E+01	6.5E+01	1.3E+02	12/18/2002	PVPGB105	3.4	12.0	14%	7.4E+00	5.0E+01
ALUMINUM	7429-90-5	Unfiltered	4.8E+02	a	7	6	1	1.7E+04	4.7E+01	1.2E+05	6/28/2002	B144GB101	5.9	13.6	86%	3.4E+01	5.0E+02
ANTIMONY	7440-36-0	Filtered	5.6E+00	a	14	3	1	2.4E+00	2.4E+00	2.0E+01	12/18/2002	PVPGB103	2.8	12.0	21%	6.5E-01	2.5E+00
ANTIMONY	7440-36-0	Unfiltered	5.6E+00	a	7	0	0	1.2E+00							0%	2.0E+00	2.5E+00
ARSENIC	7440-38-2	Filtered	7.8E+01	a	14	11	0	9.4E+00	2.7E+00	3.8E+01	9/1/1998	09W06			79%	8.0E-01	2.8E+00
ARSENIC	7440-38-2	Unfiltered	7.8E+01	a	7	2	0	2.1E+01	7.1E+01	7.1E+01	6/28/2002	B144GB101	5.9	13.6	29%	2.0E+00	2.8E+00
BARIUM	7440-39-3	Filtered	1.2E+03	a	14	14	0	3.4E+02	1.5E+01	8.3E+02	11/19/1997	09W06			100%	1.0E-01	1.0E+00
BARIUM	7440-39-3	Unfiltered	1.2E+03	a	7	7	1	7.4E+02	1.5E+02	3.2E+03	6/28/2002	B144GB101	5.9	13.6	100%	1.0E+00	1.0E+00
BERYLLIUM	7440-41-7	Filtered	1.6E+00	a	14	0	0	2.4E-01							0%	1.0E-01	1.0E+00
BERYLLIUM	7440-41-7	Unfiltered	1.6E+00	a	7	1	1	6.3E-01	3.2E+00	3.2E+00	6/28/2002	B144GB101	5.9	13.6	14%	4.1E-01	1.0E+00
CADMIUM	7440-43-9	Filtered	1.6E+01	a	14	0	0	2.6E-01							0%	1.5E-01	1.0E+00
CADMIUM	7440-43-9	Unfiltered	1.6E+01	a	7	1	1	2.4E+00	1.6E+01	1.6E+01	6/28/2002	B144GB101	5.9	13.6	14%	3.3E-01	1.0E+00
CALCIUM	7440-70-2	Filtered	6.8E+05	a	17	17	0	9.2E+04	1.2E+04	2.1E+05	10/18/2002	09W07			100%	3.8E+00	5.0E+03
CALCIUM	7440-70-2	Unfiltered	6.8E+05	a	6	6	0	9.6E+04	5.9E+04	1.7E+05	6/28/1999	09W01			100%	3.1E+01	3.1E+01
CHROMIUM	7440-47-3	Filtered	2.2E+01	a	14	2	0	8.3E-01	2.0E+00	2.9E+00	12/18/2002	PVPGB103	2.8	12.0	14%	2.0E-01	3.5E+00
CHROMIUM	7440-47-3	Unfiltered	2.2E+01	a	7	1	1	4.6E+01	3.1E+02	3.1E+02	6/28/2002	B144GB101	5.9	13.6	14%	2.0E+00	3.5E+00
COBALT	7440-48-4	Filtered	1.0E+02	a	14	6	0	1.2E+00	1.1E+00	3.8E+00	6/2/1998	09W06			43%	2.5E-01	2.8E+00
COBALT	7440-48-4	Unfiltered	1.0E+02	a	7	1	1	2.3E+01	1.5E+02	1.5E+02	6/28/2002	B144GB101	5.9	13.6	14%	1.0E+00	2.8E+00
COPPER	7440-50-8	Filtered	3.3E+01	a	14	3	0	1.1E+00	1.3E+00	3.4E+00	12/18/2002	PVPGB105	3.4	12.0	21%	3.5E-01	3.5E+00
COPPER	7440-50-8	Unfiltered	3.3E+01	a	7	1	1	1.3E+02	8.7E+02	8.7E+02	6/28/2002	B144GB101	5.9	13.6	14%	2.0E+00	3.5E+00
FERROUS IRON	IRON, FERROU	Filtered			2	0	0	1.5E+02							0%	2.0E+02	4.0E+02
HEXAVALENT CHROMIUM	18540-29-9	Unfiltered			7	1	0	7.1E+00	2.0E+01	2.0E+01	6/28/1999	09W02			14%	1.0E+01	1.0E+01
IRON	7439-89-6	Filtered	1.4E+05	a	17	13	0	9.6E+02	1.1E+02	3.9E+03	9/1/1998	09W06			76%	5.6E+00	1.0E+02
IRON	7439-89-6	Unfiltered	1.4E+05	a	7	7	1	3.9E+04	4.5E+02	2.5E+05	6/28/2002	B144GB101	5.9	13.6	100%	8.9E+00	5.0E+02
LEAD	7439-92-1	Filtered	1.0E+01	a	14	3	1	6.0E+00	3.8E+00	6.9E+01	12/18/2002	PVPGB104	3.0	12.0	21%	6.0E-01	2.2E+00
LEAD	7439-92-1	Unfiltered	1.0E+01	a	7	1	1	1.2E+03	8.4E+03	8.4E+03	6/28/2002	B144GB101	5.9	13.6	14%	1.0E+00	2.2E+01
MAGNESIUM	7439-95-4	Filtered	1.5E+06	a	17	17	0	2.0E+05	1.1E+04	6.2E+05	10/18/2002	09W07			100%	3.8E+00	5.0E+03
MAGNESIUM	7439-95-4	Unfiltered	1.5E+06	a	6	6	0	1.1E+05	2.4E+04	3.9E+05	6/25/1999	09W07			100%	5.6E+01	5.6E+01
MANGANESE	7439-96-5	Filtered	5.4E+03	a	15	15	0	3.7E+02	1.6E+01	1.0E+03	2/25/1998	09W06			100%	2.0E-01	2.0E+01
MANGANESE	7439-96-5	Unfiltered	5.4E+03	a	7	7	1	1.3E+03	7.4E+01	5.6E+03	6/28/2002	B144GB101	5.9	13.6	100%	1.0E+00	1.7E+00
MERCURY	7439-97-6	Filtered	2.2E-01	a	13	0	0	6.3E-02							0%	5.0E-02	2.0E-01
MERCURY	7439-97-6	Unfiltered	2.2E-01	a	8	1	1	1.8E+00	1.4E+01	1.4E+01	6/28/2002	B144GB101	5.9	13.6	13%	5.0E-02	4.0E-01
MOLYBDENUM	7439-98-7	Filtered	8.8E+00	a	14	11	8	1.5E+01	1.4E+00	6.7E+01	12/18/2002	PVPGB103	2.8	12.0	79%	2.5E-01	3.9E+00
MOLYBDENUM	7439-98-7	Unfiltered	8.8E+00	a	7	1	0	2.8E+00	7.8E+00	7.8E+00	6/28/2002	B144GB101	5.9	13.6	14%	1.0E+00	3.9E+00
NICKEL	7440-02-0	Filtered	7.5E+00	a	14	8	2	3.5E+00	2.1E+00	1.1E+01	6/2/1998	09W06			57%	3.0E-01	4.8E+00
NICKEL	7440-02-0	Unfiltered	7.5E+00	a	7	1	1	5.5E+01	3.7E+02	3.7E+02	6/28/2002	B144GB101	5.9	13.6	14%	2.0E+00	4.8E+00
NITRATE (AS N)	NITRATE (AS N)	Filtered			2	0	0	3.1E+02							0%	2.5E+02	1.0E+03
POTASSIUM	7440-09-7	Filtered	2.1E+05	a	17	15	2	9.1E+04	6.9E+03	2.5E+05	11/21/1997	09W07			88%	3.7E+00	5.0E+03
POTASSIUM	7440-09-7	Unfiltered	2.1E+05	a	6	6	0	3.1E+04	6.4E+03	1.2E+05	6/25/1999	09W07			100%	2.0E+02	2.0E+02
SELENIUM	7782-49-2	Filtered	1.2E+01	a	14	2	0	1.7E+00	2.2E+00	9.7E+00	12/18/2002	PVPGB105	3.4	12.0	14%	9.0E-01	4.0E+00
SELENIUM	7782-49-2	Unfiltered	1.2E+01	a	7	1	0	2.5E+00	5.3E+00	5.3E+00	6/28/2002	B144GB101	5.9	13.6	14%	2.0E+00	4.0E+00
SILVER	7440-22-4	Filtered	1.5E+01	a	14	0	0	1.1E+00							0%	1.5E-01	2.3E+01
SILVER	7440-22-4	Unfiltered	1.5E+01	a	7	1	0	2.6E+00	1.0E+00	1.0E+00	6/28/2002	B144GB101	5.9	13.6	14%	1.0E+00	2.3E+01
SODIUM	7440-23-5	Filtered	7.4E+06	a	17	17	0	1.7E+06	1.0E+05	4.9E+06	10/18/2002	09W07			100%	9.5E+01	3.0E+04

Table 3.3-2

Investigation Area C3, IR09 Statistical Summary Table of Analytical Groundwater Data

Analyte	CAS Number	Filtered/ Unfiltered	Ambient Concentration for Metals (ug/L)	Source of Ambient Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Ambient Concentration for Metals	Average Result (ug/L)	Minimum Detection (ug/L)	Maximum Detection (ug/L)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (ug/L)	Maximum Detection Limit (ug/L)
WATER - IR09																	
SODIUM	7440-23-5	Unfiltered	7.4E+06	a	6	6	0	9.5E+05	1.4E+05	3.6E+06	6/25/1999	09W07			100%	5.6E+01	2.8E+03
THALLIUM	7440-28-0	Filtered		d	14	0	0	1.3E+00							0%	9.0E-01	9.0E+00
THALLIUM	7440-28-0	Unfiltered		d	7	0	0	8.0E-01							0%	1.0E+00	1.7E+00
TIN	7440-31-5	Filtered			5	0	0	5.0E+00							0%	1.0E+01	1.0E+01
TIN	7440-31-5	Unfiltered			1	0	0	5.0E+00							0%	1.0E+01	1.0E+01
VANADIUM	7440-62-2	Filtered	1.4E+02	a	14	2	0	3.1E+00	7.0E+00	7.9E+00	2/27/1998	09W07			14%	3.0E-01	1.0E+01
VANADIUM	7440-62-2	Unfiltered	1.4E+02	a	7	1	1	8.6E+01	5.9E+02	5.9E+02	6/28/2002	B144GB101	5.9	13.6	14%	4.1E+00	1.0E+01
ZINC	7440-66-6	Filtered	2.6E+02	a	14	10	0	1.2E+01	6.4E+00	2.8E+01	6/29/1999	09W06			71%	3.0E-01	9.0E+00
ZINC	7440-66-6	Unfiltered	2.6E+02	a	7	7	1	1.0E+03	9.4E+00	7.2E+03	6/28/2002	B144GB101	5.9	13.6	100%	5.0E+00	9.0E+00
General Chemistry																	
ALKALINITY BICARBONATE	ALKB	Unfiltered			4	4		5.0E+05	3.9E+05	5.5E+05	10/21/2002	09W05			100%	5.0E+03	5.0E+03
ALKALINITY CARBONATE	ALKC	Unfiltered			4	0		2.5E+03							0%	5.0E+03	5.0E+03
CHLORIDE	16887-00-6	Unfiltered			18	18		3.3E+06	9.3E+04	9.1E+06	10/18/2002	09W07			100%	1.0E+04	5.0E+05
HARDNESS	HARDNESS	Unfiltered			5	5		2.5E+05	9.2E+04	3.6E+05	4/10/2003	B144MW0100			100%	2.5E+03	5.0E+03
NITRATE (AS N)	NITRATE (AS N)	Unfiltered			1	0		5.0E+01							0%	1.0E+02	1.0E+02
NITRATE/NITRITE	14797-55-8	Unfiltered			14	1		2.2E+02	1.2E+02	1.2E+02	6/25/1999	09W07			7%	5.0E+01	1.0E+03
NITRITE	14797-65-0	Unfiltered			7	0		3.6E+03							0%	1.0E+03	1.0E+04
ORTHO-PHOSPHATE	14265-44-2	Unfiltered			14	6		3.2E+02	1.5E+02	6.5E+02	6/28/1999	09W01			43%	2.0E+01	1.0E+03
SULFATE	14808-79-8	Unfiltered			20	15		2.4E+05	7.0E+03	9.6E+05	6/25/1999	09W07			75%	1.0E+03	2.5E+05
TDS	TDS	Unfiltered			18	18		6.6E+06	6.7E+05	1.8E+07	10/18/2002	09W07			100%	1.0E+04	5.0E+05
Other																	
DIBUTYLTIN	683-18-1	Unfiltered			8	0		2.4E-01							0%	4.7E-01	5.0E-01
METHANE	74-82-8	Unfiltered			1	1		1.6E+04	1.6E+04	1.6E+04	4/7/2003	09W07			100%	1.0E+00	1.0E+00
MONOBUTYLTIN	1118-46-3	Unfiltered			8	0		2.4E-01							0%	4.7E-01	5.0E-01
TETRABUTYLTIN	1461-25-2	Unfiltered			8	0		2.4E-01							0%	4.7E-01	5.0E-01
TRIBUTYLTIN	1461-22-9	Unfiltered			8	0		2.4E-01							0%	4.7E-01	5.0E-01

[1] Source Definition (TtEMI 2002)

a - Ambient Metal Background Concentration (95th percentile) in shallow groundwater at Mare Island Naval Shipyard
b - Ambient Metal Concentrations in Artificial Fill Material - Mare Island
c - Ambient Metal Concentrations in Original Island Soil - Mare Island
d - At the request of the regulatory agencies, the ambient level was set to the detection limit

Data from the following types of samples were excluded from this statistical summary query table: 1) duplicate or other quality control samples results; 2) split samples results; 3) removed samples results; and 4) samples analyzed using the toxicity characteristic leaching procedure (TCLP) or by the waste extraction test (WET) data; and 5) . In addition, rejected data was excluded from this query.

Data are rounded to two significant figures for presentation.
To calculate the average concentration, one-half the detection limit was used for U-qualified data.

3.3.2.2 VOC Compounds

As indicated in Table 3.3-2, VOCs were detected infrequently in groundwater at IR09. Most VOC compounds were not detected in groundwater samples from IR09. Five VOCs (acetone, carbon disulfide, cis-1,2-dichloroethene, o-xylene, and trans-1,2-dichloroethene) were detected in one to three groundwater samples collected at IR09 since 1997. Approximately 15 percent of the detected results were quantified at concentrations less than the analytical reporting limit. The presence of acetone, which was detected in one of six groundwater samples since 1997 (and one of 54 samples historically), is likely the result of laboratory contamination.

The compounds carbon disulfide, cis-1,2-dichloroethene, o-xylene, and trans-1,2-dichloroethene were detected in groundwater samples collected after 1997 in the eastern part of the site (09W06, 09W07, and B144GB101). Other than carbon disulfide (which was detected in one soil sample collected from 09W07 at 12.5 feet bgs), these compounds were not detected in soil in the eastern part of the site. The concentrations of cis-1,2-dichloroethene, o-xylene, and trans-1,2-dichloroethene found in groundwater at IR09 are one to four orders of magnitude lower than the respective RWQCB ESLs of 590, 13, and 590 µg/L. Based on these data, the occurrence of VOCs in these few groundwater samples is considered random and not representative of groundwater conditions.

BTEX compounds, which were the most frequently detected class of VOC compounds in soil samples at IR09, were not found in groundwater after 1997 (with the exception of the one detected concentration of o-xylene in B144GB101). Prior to 1997, BTEX compounds were detected only in groundwater samples collected in the vicinity of the former USTs: benzene was detected in groundwater samples from 09W02 and 09W04; ethylbenzene was detected in groundwater samples from IR09GB003; toluene was detected in groundwater samples from 09W03 and IR09GB003; and xylenes were detected in groundwater samples from 09W04 and IR09GB003. The concentration of BTEX compounds detected in groundwater in these samples ranged between 0.3 µg/L benzene and 9,800 µg/L xylenes, and were below the numeric water quality criteria for priority toxic pollutants (40 CFR 131.38). Again, BTEX compounds were not detected in groundwater samples collected since 1997 (Table 3.3-2).

3.3.2.3 SVOC Compounds

As shown in Table 3.3-2, the vast majority of SVOC compounds were not detected in groundwater samples collected from IR09 since 1997. Only four SVOC compounds were detected in one to two groundwater samples collected from IR09 since 1997. PCB and pesticide compounds were not detected in groundwater at IR09.

The four SVOC compounds detected in groundwater at IR09 were the PAHs acenaphthene, benzo(k)fluoranthene, fluorene, and napthalene. These compounds were detected in one to two of 15 groundwater samples collected since 1997 and were not detected in any of the previous 38 groundwater samples collected at IR09. The PAH compounds were detected in samples collected from PVPGB104 in December 2002, near the former AST farm and B144MW100 in May 2004. The detected concentrations of acenaphthene (up to 7.4 µg/L), benzo(k)fluoranthene (0.11 µg/L), fluorene (0.52 µg/L), and naphthalene (035 µg/L) in these samples are below the respective RWQCB ESLs of 23, 0.4, 3.9, and 24 µg/L.

3.3.2.4 Metals

Table 3.3-2 provides a summary of metals results in groundwater samples collected from IR09 and distinguishes the results between filtered samples (dissolved metals results) and unfiltered samples (total metals results). Approximately 14 filtered and seven non-filtered groundwater samples collected from IR09 were analyzed for metals.

As discussed in Section 2.3, ambient values for 24 metals in shallow groundwater at Mare Island have been established. Table 3.3-2 shows the ambient concentration for shallow groundwater at Mare Island based on filtered results (see also Table 2.3-2) and identifies the number of samples with metal results greater than the respective ambient concentration.

Several metals were found in IR09 groundwater samples at concentrations greater than the established ambient level. Aluminum, antimony, arsenic barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, potassium, selenium, silver, vanadium, and zinc were all detected since 1997 in IR09 groundwater samples at concentrations exceeding the detection limit. Of these metals, arsenic, selenium, and silver were detected at concentrations below the respective ambient concentrations. Of the remaining metals, all except antimony, lead, molybdenum, nickel, and potassium were detected above the respective ambient concentration in just one unfiltered sample collected from B144GB101 in 2002. Since the ambient levels are based on filtered results, the reason that metals concentrations in this groundwater sample exceed the ambient levels may be because of suspended particulates, rather than due to site activities. Other groundwater samples in the vicinity of the Building 144 oil/water separator, including B144MW100 downgradient of the Building 144 oil/water separator, did not contain metals concentrations greater than the established ambient levels. The following discusses the metals (antimony, lead, molybdenum, nickel, and potassium) detected in filtered groundwater samples at concentrations greater than the established ambient level.

Molybdenum. Molybdenum was detected above the established ambient concentration in eight of 13 filtered groundwater samples collected at IR09. The samples with molybdenum concentrations greater than the established ambient level were found in the two wells closest to Mare Island Strait (09W06 and 09W07) and grab groundwater samples in the vicinity of the former AST farm (PVPGB103, PVPGB104, and PVPGB105). Four of the 13 samples with molybdenum concentrations greater than the ambient level were found in four separate monitoring events at one well (09W06, located in the northern part of the site adjacent to Mare Island Strait) at concentrations between 9 and 39 µg/L (exceeding the ambient level of 8.8 µg/L). The highest detected molybdenum concentration was 67 µg/L, found in PVPGB103. Molybdenum was not detected above ambient concentrations in 55 soil samples analyzed by an off-site laboratory.

Nickel. Nickel was detected above the established ambient concentration in two of 13 filtered groundwater samples collected from IR09. The samples were both collected in February and June 1998 from 09W06, located in the northern part of the site adjacent to Mare Island Strait. The two samples from this well contained dissolved nickel at 9.2 and 10.6 µg/L, which only slightly exceeds the ambient metals concentration of nickel of 7.5 µg/L and are less than the upper range of the background data set (83.3 µg/L).

Potassium. Potassium was detected at concentrations above the established ambient concentration in two of 16 filtered groundwater samples collected from IR09 since 1997. The two samples with concentrations of potassium in groundwater greater than the ambient value (210,000 µg/L) were both found at 09W07, one of the wells nearest to Mare Island Strait. Based on the information in Table 2.3-2, the concentration of potassium, an essential human nutrient, in groundwater at IR09 is considered to be within the natural range of concentrations in Mare Island Strait, the discharge area for groundwater in IA C3.

Antimony and Lead. Antimony and lead were each detected above the ambient concentration in one of 13 filtered groundwater samples. Both of these metals were found in groundwater in the vicinity of the former AST farm. Antimony was found in a sample collected from PVPGB103, and lead was found in a sample collected from PVPGB104. The maximum concentration of antimony (20 µg/L) is within the upper range of the ambient data set. The concentration of lead in the groundwater sample from PVPGB104 was 69 µg/L.

3.3.3 Summary of the Nature and Extent of Contamination at IR09

The nature and extent of contamination at IR09 has been defined through the analysis of soil and groundwater samples collected during multiple investigations over 12 years. The sampling strategy was judgmental, with the objective to characterize the nature and extent of contamination, building on results of previous investigations and knowledge of site history. Over 240 soil and groundwater samples have been collected from approximately 60 separate locations throughout the site. Samples collected from IR09 have been analyzed for a wide variety of chemical constituents.

The analytical data collected at IR09 indicate that impacted areas of the site are primarily located south, southwest, and east of Building 334, in the vicinity of the former USTs, the former AST farm associated with the Paint Shop Varnish Plant, and the Building 144 oil/water separator.

Soil samples with the highest levels of TPH-gasoline-range organics (up to 16,000 mg/kg), TPH-diesel-range organics (up to 7,500 mg/kg), BTEX compounds (up to 16 mg/kg total xylenes), and select PAH compounds were collected near (typically south of) the former USTs outside the southwest corner of Building 334, at 5 to 7 feet bgs (same depth as groundwater). Based on contaminant type and locations, the presence of these compounds are most likely associated with a release from the former USTs. The petroleum hydrocarbon results are believed to represent the types of materials stored in the USTs. Representative groundwater data (collected from 1997 to present) for samples collected near the former USTs suggests that groundwater is not impacted. The monitoring well closest to the soil sample most impacted by petroleum hydrocarbons is 09W03; groundwater samples collected from 09W03 during six monitoring events were not found to contain detectable levels of BTEX compounds and did not contain TPH-gasoline-range organics or TPH-diesel-range-organics at concentrations exceeding analytical reporting limits during the last monitoring event (April 2003). Other wells near the former USTs (09W02 and 09W05) contained petroleum hydrocarbons at concentrations less than 100 µg/L during the last monitoring event.

Other areas of the IR09 site that were found to contain organic constituents were the former AST farm and the Building 144 oil/water separator. Soil and groundwater samples collected

near the two sources generally contained organic constituents at lower concentrations, compared with concentrations in samples collected near the former USTs.

The impacted areas in the vicinity of the former USTs, the former AST farm, and the Building 144 oil/water separator have been defined laterally and vertically through petroleum hydrocarbon analysis (Figure 3.3-1), while chemical-specific analysis provides more definitive information on the specific characteristics and toxicity of the organic compounds. The constituent analysis indicates that the organic compounds present typically are BTEX compounds and PAHs. The samples with detected BTEX and PAH compounds in both soil and groundwater were mostly collected in the vicinity of the identified sources (former USTs, the former AST farm, and the Building 144 oil/water separator) and generally correlate with the results of petroleum hydrocarbon analysis. The concentrations of BTEX and PAH concentrations in soil and groundwater in these areas are low in comparison to analytical detection limits, USEPA Region 9 PRGs for the direct-contact soil pathway, RWQCB ESLs for soil that is not a current or potential source of drinking water, and numeric water quality criteria in 40 CFR Part 131.38.

Samples with metals concentrations exceeding the established background level at concentrations and frequencies suggesting site impact typically were collected from locations south, southwest, and east of Building 334 and east of Building 144, including the vicinity of the former USTs, the former AST farm, and the Building 144 oil/water separator.

The metal found most frequently in soil samples at concentrations exceeding the ambient level was lead; lead is presumed to have been used in the paint products at the site. The soil sample with the highest lead concentration (20,000 mg/kg) was collected just south of the former USTs at 6 feet bgs (near the highest petroleum hydrocarbon result in soil at IR09). The extent of lead contamination associated with the source areas (former USTs, former AST farm, and the Building 144 oil/water separator) is shown in Figure 3.3-2. Other metals, including zinc, beryllium, mercury, copper, and nickel, were found at the highest concentrations in the vicinity of the same sources. Nickel was found at concentrations an order of magnitude higher than the established ambient level in two borings with identified ABM near the former AST farm. No other metals appeared to be elevated in these two borings.

Metals results in groundwater show that concentrations of metals were not frequently found above established ambient levels. Metals above ambient levels were either found in the vicinity of the former USTs or the former AST farm or were considered not associated with site activities.

3.4 Contaminant Fate and Transport

This section presents an evaluation of the physical and chemical characteristics that may influence the mobility and behavior of contaminants in IR09. Based on the evaluation presented in the previous section, TPH-gasoline, TPH-diesel, benzene, and lead were selected for inclusion in this fate and transport evaluation. These analytes represent the groups of contaminants (i.e., petroleum hydrocarbons, VOCs, and metals) that most significantly contribute to soil and/or groundwater contamination in IR09. Although the fate and transport evaluation is streamlined to include only these analytes, all analytes are

included in the human health and ecological risk assessment evaluations (summarized in Sections 3.5 and 3.6, respectively).

The most probable fate and transport of contaminants in IR09 and potential pathways for on- and off-site migration are identified in this section. The probable migration pathways presented in the conceptual site model (Figure 3.4-1) are based on the results of the fate and transport evaluation presented in this section.

3.4.1 Conceptual Site Model

3.4.1.1 Potential Sources

Potential sources of contamination in IR09 include:

- USTs 334-1, 334-2, 334-3, and 334-4.
- Paint Shop and Varnish Plant (including the former AST farm).
- Oil/water separator beneath Building 144.
- Activities and operations at Building 334.

3.4.1.2 Potential Release Mechanisms

Potential release mechanisms that resulted from various operations performed in IR09 include:

- Subsurface leaks of separate-phase hydrocarbons from the former USTs and oil/water separator to the water table.
- Surface releases from the former AST farm associated with the Paint Shop Varnish Plant south of Building 334.
- Surface releases resulting from operations in Building 334 (former paint shop).

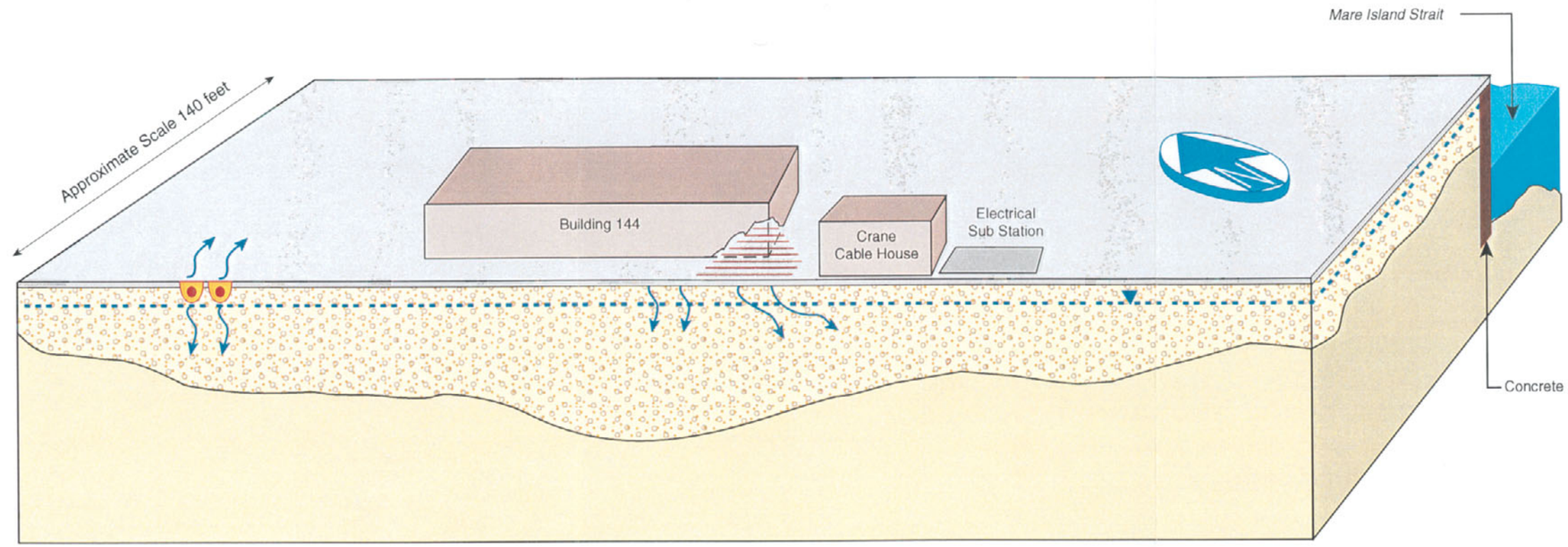
3.4.1.3 Potential Contamination Migration Pathways

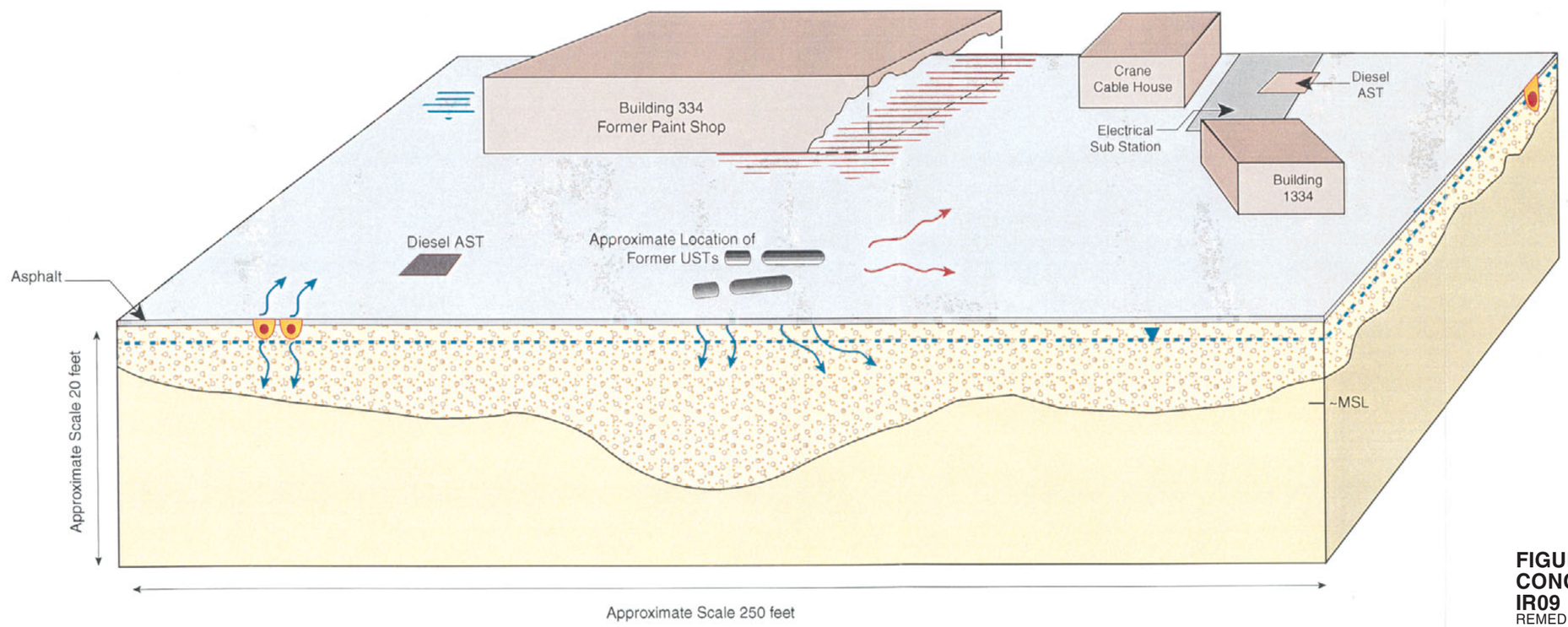
Potential migration pathways for contaminants at IR09 include:

- Historical downward and lateral migration of separate-phase hydrocarbons from the former USTs and oil/water separator to and along the water table surface; subsequent vertical migration of separate-phase hydrocarbons is consistent with fluctuations in groundwater elevation.
- Dissolution of surface soil contaminants by infiltration of precipitation and other surface water sources though cracks in the pavement; migration into deeper subsurface soil and groundwater through advection and dispersion.
- Lateral migration consistent with groundwater flow direction (Figures 1.5-1 and 1.5-2).
- Lateral transport through utility lines and more permeable utility line backfill.
- Volatilization to the atmosphere.

EXPLANATION

- Approximate extent of lead contamination exceeding screening criteria
- Approximate extent of TPH contamination exceeding screening criteria
- Artificial Fill
- Silty Clay
- Utilities
- Potential transport of contaminants
- Shallow Water-Bearing Zone Potentiometric Surface (May 1999)
- ~MSL Approximate Mean Sea Level Datum





SOURCE: TETRA TECH, 2000

FIGURE 3.4-1
CONCEPTUAL SITE MODEL
IR09
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

CH2MHILL

E092002002RDD_01 (9/9/02)

3.4.2 Fate and Transport Evaluation

This section presents an evaluation of the physical and chemical characteristics that may influence the mobility and behavior, in soil and groundwater, of contaminants identified in the previous section. The most probable fate and transport of contaminants in IR09 and potential pathways for on- and off-site migration are identified. A more detailed discussion of the fate and transport processes and physical and chemical properties of specific chemicals is presented in Appendix K.

The potential migration pathways for contaminants in soil at IR09 include the following:

- Historical downward and lateral migration of separate-phase hydrocarbons
- Downward migration of contaminants in the vadose zone with the infiltration of rainwater
- Volatilization to air (does not apply to lead)

Pathways that are considered unlikely in paved areas include (1) surface erosion by wind or water and (2) surface runoff to Mare Island Strait due to lack of contact with contaminated media.

The entire IR09 area is paved. Downward migration with infiltration and volatilization to air are considered migration pathways, even in paved areas, due to cracks and joints in the pavement. However, the ability of contaminants to migrate via these pathways is somewhat reduced compared to unpaved areas. Although separate-phase hydrocarbons have not been observed in borings advanced in IR09, historical leaks from the former USTs and oil/water separator likely resulted in the release of separate-phase hydrocarbons to subsurface soil near the surface of the water table in the past. The highest concentrations of petroleum hydrocarbons have been detected at a depth that corresponds to the approximate depth to groundwater (approximately 5 feet bgs), suggesting that the separate-phase liquid—which may have also contained metals such as lead—likely migrated over limited distances over the water table surface through low-permeability soil. Analytical data collected in the vicinity of the former USTs and oil/water separator (Figure 3.3-1) suggest that separate-phase hydrocarbons did not migrate over significant distances and/or have biodegraded over time. The affinity for petroleum hydrocarbons to adsorb to soil and the high retention capacity of separate-phase hydrocarbons in a fine-grained soil matrix reduces the distance over which the separate-phase hydrocarbons can migrate in the subsurface. Because separate-phase hydrocarbons have not been observed in borings advanced over the past 14 years at the site, separate-phase hydrocarbons are no longer considered to be present in the subsurface. Consequently, the migration of separate-phase hydrocarbons is not evaluated as a potential future migration pathway in the following paragraphs.

Contaminants that reach groundwater can potentially travel through the following migration pathways:

- Migration to Mare Island Strait through the bulk soil
- Migration along relatively permeable utility line backfill
- Volatilization to air (does not apply to lead)

To estimate the potential travel times for groundwater contamination at IR09 to reach Mare Island Strait, a simple set of calculations based on Darcy's Law and fundamental adsorption chemistry is used. The first step in the calculations is to estimate the velocity of groundwater moving from IR09 to the Strait. This velocity can be calculated using the following form of Darcy's Law:

$$v = (KI/\theta) \quad (1)$$

Where:

v = bulk groundwater velocity (feet/day).
K = hydraulic conductivity of the aquifer (feet/day).
I = horizontal hydraulic gradient (foot/foot).
θ = transport, or effective, porosity of the aquifer (volume/volume).

For IR09, a representative hydraulic conductivity for the shallow aquifer based on numerical modeling studies is approximately 1 foot/day (CH2M HILL 2002i). The steepest horizontal hydraulic gradient between IR09 and Mare Island Strait is approximately 0.018 foot/foot (Figure 1.5-1). The transport porosity of the sediments observed at the site is assumed to be 0.15. Based on these assumed hydraulic properties and the equation presented above, the bulk groundwater velocity at IR09 is approximately 0.12 foot/day or 44 feet/year.

However, due to the interaction between contaminants and the aquifer solids through which they move, contaminants typically travel at velocities less than native groundwater. The degree to which the velocity of contaminant movement is reduced typically is expressed as a retardation factor. The retardation factor of a contaminant is defined as the velocity of the bulk groundwater divided by the velocity of the contaminant of interest. In other words, if a particular contaminant moves through the aquifer at half the speed of the bulk groundwater, it would have a retardation factor of 2.0.

The retardation factor of a contaminant can be calculated based on the value of the distribution coefficient for that contaminant. Distribution coefficients typically are measured in the laboratory and are a measure of the affinity of a particular compound for the soil surfaces and/or soil organic matter present in the aquifer. The following equation shows the mathematical relationship between distribution coefficients and retardation factors:

$$R = (1+ (\rho_b K_D/\theta_T)) \quad (2)$$

Where:

K_D = distribution coefficient of the contaminant of interest (ml/g).
θ_T = total porosity of the aquifer (volume/volume).
ρ_b = bulk density of the aquifer (g/ml).
R = retardation factor.

Theoretically, utility line backfill that may be more permeable than the surrounding soil may act as preferential pathways for contaminant transport when the water table rises into the backfill. However, field investigation activities in 2002 did not identify greater amounts of sandy or gravelly materials surrounding the limited utility lines encountered. This evaluation presumes that backfill materials different from the surrounding bulk soils exist at

IR09. If contaminated groundwater reaches more permeable utility line backfill, transport times could be reduced by one or more orders of magnitude. Assuming a backfill with a hydraulic conductivity of 10 feet/day, groundwater transport to Mare Island Strait would occur approximately 10 times faster (based on the increased hydraulic conductivity) through the utility line backfill. This decrease in travel time is approximate due to uncertainty in K_D values, backfill composition, groundwater levels, and hydraulic gradient within the backfill.

An evaluation was performed to determine the amount of mixing of groundwater flow that occurs as it enters Mare Island Strait, documented in the *Draft Technical Memorandum on the Dilution of Groundwater to Mare Island Strait* (CH2M HILL 2003d). The amount of mixing of the groundwater is quantified as the ratio of two flows, the flow in Mare Island Strait along the quay wall that runs along the eastern edge of IA C3, and the effluent flow rate of groundwater as it discharges from the quay wall between Dry Dock Nos. 1 and 2 into the Strait. This ratio can be expressed as:

$$Mixing = \frac{Q_{Mare\ Island\ Strait}}{Q_{GroundwaterWaterEffluent\ From\ IA\ C3}} \tag{3}$$

The lowest 10th percentile ambient current in Mare Island Strait was used to determine the near worse-case condition that would produce the lowest mixing and thus the highest concentrations from a groundwater plume into the receiving waters. The lowest 10th percentile currents for Mare Island Strait were calculated from predictions of current velocities in the Strait made by Nautical Software's Tides and Currents program (Nautical Software 1996). A high level of mixing is experienced by a groundwater plume as it enters Mare Island Strait. The difference between the Darcy velocity of the groundwater plumes and the ambient current velocity in Mare Island Strait is primarily responsible for the mixing. Based on the results of this evaluation, the 10th percentile ambient currents in Mare Island Strait produce a mixing factor of over 1,000. Therefore, if a groundwater constituent does reach Mare Island Strait, its concentration will be reduced by over 1,000-fold when the discharging groundwater mixes with the surface water in the Strait.

The chemical characteristics controlling the fate of soil and groundwater contaminants in IR09 are discussed in the following sections. Based on the characteristics detailed below, the most likely migration pathways for specific contaminants can be determined.

3.4.2.1 Petroleum Hydrocarbons and BTEX

The fate of TPH-gasoline (including benzene) and TPH-diesel detected in soil is expected to be controlled by: (1) adsorption reactions between contaminants and soil mineral surfaces or soil organic matter of the soil material in IR09; (2) biodegradation via the microbial community present in the subsurface; and (3) volatilization and diffusion to the atmosphere or groundwater (TPH-gasoline and benzene only). Because of these mechanisms, elevated levels of petroleum hydrocarbons and BTEX compounds have not migrated significant distances through soil in the vadose zone. As summarized in Section 3.3.3, elevated concentrations of petroleum hydrocarbons and BTEX compounds are limited to the vicinity of the former USTs, oil/water separator, and former AST farm.

In comparison with TPH-diesel and TPH-motor-oil, TPH-gasoline is more volatile, more soluble, and more mobile in soils and groundwater. The lighter components of TPH-gasoline may volatilize to air at IR09. Some components of TPH-gasoline (notably benzene) adsorb weakly to fine-grained soil and soil organic matter and can migrate significant distances at velocities comparable to native groundwater. TPH-gasoline and TPH-diesel in soil are both expected to migrate downward with infiltrating precipitation, and the fact that TPH-gasoline, benzene, and TPH-diesel have been detected in groundwater suggests this has occurred. Transport velocities and biodegradation rates affect the dimension of groundwater plumes when TPH-gasoline and TPH-diesel reach groundwater. A TPH-diesel groundwater plume will typically have a lesser extent than a TPH-gasoline plume with a similar source, due to the greater affinity of the TPH-diesel components to adsorb to soil organic matter. Concentrations of TPH contaminants in soils and groundwater are expected to diminish over time as a result of natural attenuation processes such as chemical and biological degradation and diffusion.

TPH-gasoline has been detected sporadically in monitoring wells at IR09. The highest concentration of TPH-gasoline in groundwater at IR09 was found in one sample collected in 1994 near the former USTs outside the southwest corner of Building 334. Other than this 1994 sample, however, TPH-gasoline has only been found in less than 30 percent of groundwater samples collected near the former USTs, at a maximum concentration of 130 µg/L. In monitoring wells located closest to the Strait (09W07 and B144MW100), TPH-gasoline was detected only at low concentrations (up to 370 µg/L) in 1999 through 2004. Benzene was detected in two wells in 1991 (09W02 and 09W04) and has not been detected in groundwater at IR09 since 1991. These results suggest that the maximum impacts of TPH-gasoline and benzene have already been expressed at IR09 and that concentrations and aerial extent have declined since that time. TPH-diesel was detected in groundwater samples collected in 2002 from two locations near the former above ground tank farm (at concentrations of 1,500 to 1,900 µg/L), approximately 75 feet from Dry Dock No. 2. It is possible that similar concentrations have migrated to Dry Dock No. 2; groundwater that migrates toward Dry Dock No. 2 will be collected in the sanitary wastewater system. TPH-diesel was also detected at a concentration of 2,300 µg/L at GeoProbe® boring B144GB101 in 2002, which is within the footprint of Building 144 (approximately 70 feet from the Strait). Groundwater samples collected downgradient from this boring (at B144MW100) in 2003 and 2004 did not contain TPH-diesel at concentrations greater than the analytical detection limits. This suggests that significant levels of TPH-diesel in groundwater are not migrating to the Strait. The affinity of TPH-diesel to adsorb to soil organic matter prevents leaching from soil to groundwater and, thus, the migration of TPH-diesel to Mare Island Strait.

3.4.2.2 Metals

The fate of metals likely will be controlled by reactions such as cation exchange, which results in adsorption of contaminants to soil mineral surfaces or soil organic matter. Their fate likely will be controlled by precipitation reactions leading to the formation of secondary mineral phases.

As presented in Section 3.5, lead is the primary risk-generating metal detected at IR09. The high distribution coefficient of lead ($K_d \approx 100$ cubic centimeters per gram [cc/g]) (Dragun

1988) indicates a very strong affinity for soil. Analytical data in IA C3 (Appendix F) indicate that neutral to alkaline conditions prevail in soil, making inorganic compounds less soluble, with lesser tendency to migrate with infiltrating precipitation. Lead is not expected to migrate significant distances in soil at IR09, due to its high distribution coefficient. This is confirmed by analytical soil data collected at the site, which indicate that elevated lead concentrations in soil are limited to the vicinity of the former USTs, oil/water separator, and AST farm (Figure 3.3-2). In addition, lead has only been detected above the ambient concentration in one groundwater sample, suggesting that the strong affinity of lead to soil organic matter prevents the migration of lead to groundwater. Lead was detected in groundwater above the ambient concentration at PVPGB104 but has not been detected above analytical detection limits during monitoring events since 1997 in monitoring well 09W07, which is roughly downgradient of this boring. This suggests that the strong affinity of lead to soil organic matter also prevents the migration of lead in groundwater through the aquifer.

3.4.2.3 Conclusions

The most likely migration pathways for contaminants in the soil at IR09 are dissolution of soil contaminants by infiltration, followed by migration through the vadose zone through advection and dispersion and subsurface lateral migration via groundwater transport through the aquifer to Mare Island Strait. While elevated levels of TPH-gasoline, TPH-diesel, benzene, and lead (the four analytes that represent the groups of contaminants [i.e., petroleum hydrocarbons, VOCs, and metals] that most significantly contribute to soil and/or groundwater contamination in IR09) historically have been detected in groundwater at the site, these contaminants have been detected at low concentrations in monitoring wells located nearest to Mare Island Strait. The affinity for TPH-diesel and lead to adsorb to soil organic matter prevents the migration of these contaminants in groundwater. In addition, the data for TPH-gasoline and benzene suggest that the maximum impacts of TPH-gasoline and benzene detected in the early 1990s have already been expressed at IR09, and that concentrations and the aerial extent of contamination have declined through natural attenuation. Mixing along flow lines and biodegradation may also account for the low concentrations of these constituents detected in monitoring wells nearest to the Strait. Further, while site data indicate a release of contaminants to the Strait is unlikely, mixing of these contaminants in groundwater would occur upon entering the Strait, which would minimize the impacts of potential contamination to aquatic organisms. The baseline ecological risk assessment evaluates the baseline risk to aquatic organisms in the Strait (as summarized in Section 3.6).

3.5 Human Health Risk Assessment Summary

This section summarizes the HHRA conducted for IR09. The complete HHRA is presented in Appendix G. The results of the HHRA are based on the following key assumptions and approaches:

- Domestic uses of groundwater are not evaluated because the groundwater at Mare Island is not considered a potential municipal and domestic supply (Section 1.6).

- Human health exposures for current or future standard commercial/industrial worker and construction worker scenarios were evaluated using concentrations of COPCs at 0 to 2 feet bgs. In addition, exposures for future construction worker scenarios were evaluated using concentrations of COPCs at 0 to 10 feet bgs.
- The HHRA provides estimates of potential excess lifetime cancer risks and non-cancer adverse health impacts to humans under RME conditions. RME conditions represent upper-bound estimates of exposure that are within the range of plausible exposures.

The following sections summarize: (1) exposure pathways, receptors, and environmental media; (2) HHRA constituents of potential concern; and (3) risk characterization results for IR09.

3.5.1 Exposure Pathways and Environmental Media

IR09 is located in an area that is designated for industrial reuse. Therefore, future commercial/industrial workers and construction workers are evaluated for this site. To provide for the possibility of changes in the reuse planning, a residential receptor was also evaluated, and the results are presented in an attachment to Appendix G.

Exposure pathways evaluated for these receptors include:

- Incidental ingestion of soil.
- Dermal contact with soil.
- Inhalation of vapors from soil in outdoor air.
- Inhalation of chemicals sorbed to soil suspended in air as dust.
- Dermal contact with groundwater (construction workers only).
- Inhalation of volatiles from groundwater in outdoor air (construction workers only).
- Inhalation of volatiles from groundwater and subsurface soil in indoor air (commercial/industrial workers only).

The HHRA estimated potential risk based on analytical data for soil collected from the 0 to 2 feet bgs depth interval for commercial/industrial and construction workers and from the 0 to 10 feet bgs depth interval (i.e., mixed-zone soil) for construction workers. Analytical data from groundwater collected between 1997 and May 2004 were also used to estimate risk.

EPCs associated with direct contact (dermal contact or incidental ingestion of soil) were based directly on measured concentrations. Chemical concentrations in air (vapors) were not measured directly. As a result, vapor concentrations from groundwater and soil were estimated using appropriate fate and transport models. Dust-in-air concentrations were estimated using a particulate emission factor.

3.5.2 HHRA Constituents of Potential Concern

COPCs for the human health risk assessment were identified by including each detected constituent in soil as a COPC, except for metals. Metals were eliminated as COPCs in soil if

the site concentrations were not significantly different than ambient concentrations for fill materials. COPCs for soils include 11 metals, SVOCs, and VOCs. COPCs for groundwater include metals, SVOCs, and VOCs. The COPCs selected for human health risk assessment for IR09 are shown in Table G.2-5.

3.5.3 Risk Characterization Results

A discussion of the RME scenario risks is provided below; a summary of the risks estimated for all scenarios is presented in Table 3.5-1. Risk characterization results indicate that future site conditions at IR09 pose potential excess lifetime cancer risks that are within the risk-management range (10^{-4} to 10^{-6}) for carcinogens. The estimated potential cancer risk for an industrial worker exposed to surface soil is 5×10^{-6}. The main contributors to the potential cancer risk are polynuclear aromatic hydrocarbons (benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene). The estimated potential cancer risk for construction workers exposed to surface soil is 2×10^{-7}. The estimated potential cancer risk for a construction worker exposed to mixed-zone soil is 3×10^{-7}. The estimated potential cancer risk for a construction worker exposed to groundwater through dermal contact is 5×10^{-9}. Potential cancer risk for a construction worker exposed to groundwater through inhalation of volatiles was not calculated because the VOCs detected in groundwater are not carcinogenic.

TABLE 3.5-1
Summary of Estimated Risks at IR09
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Site	Exposure Scenario/Receptor	Cancer	Non-Cancer	Greatest Chemical Contributors
IR09	Surface Soil/Industrial Worker	5×10^{-6}	0.4	PAHs (cancer)
	Surface Soil/Construction Worker	2×10^{-7}	0.2	
	Subsurface Soil/Construction Worker	3×10^{-7}	0.06	
	Groundwater/ Construction Worker – Inhalation	NC	4×10^{-8}	
	Groundwater/ Construction Worker – Dermal	5×10^{-9}	0.006	

NC = not calculated.

Non-cancer adverse health effects (hazard indices, or HI) were estimated to be below the threshold of 1 for all of the receptors potentially exposed to soil or groundwater. No COPC or group of COPCs contributes significantly to the total estimated HI.

Neither the USEPA nor Cal/EPA publishes RfDs for lead, a COPC known to cause adverse health effects. Based on current DTSC guidance, the potential for health effects from exposure to lead was addressed by comparing EPCs for lead to a risk-based level (i.e., the USEPA Region 9 PRG for industrial scenarios – 750 mg/kg) (Wade 2002b). Soil concentrations below the lead risk-based level are not considered to represent a potential health threat in an industrial scenario. The exposure point concentration calculated for lead in surface soil is the maximum detected value of 1,780 mg/kg. The exposure point

concentration calculated for lead in mixed-zone soil is the UCL95 based on a lognormal distribution of 1,254 mg/kg. Both of these EPCs exceed the risk-based level of 750 mg/kg.

As several VOCs were detected in groundwater and soil in IA C3, a screening-level evaluation was performed to determine if the indoor air pathway (i.e., volatilization of VOCs from groundwater or soil to indoor air) might be a significant exposure pathway for future receptors. As a conservative first step in this evaluation, maximum detected concentrations of VOCs in groundwater and soil for IA C3 were compared to risk-based concentrations (RBCs) based on potential exposure to VOCs in indoor air for an industrial scenario. All of the groundwater and soil data collected within IA C3 were used for this first step of the evaluation. These RBCs were developed using the Johnson and Ettinger model. No constituents in groundwater had concentrations in IA C3 that exceeded the RBC. Thirteen constituents in soil have maximum detected concentration in IA C3 that exceeded the RBC.

As a second step in the screening-level evaluation, the EPCs for the IRP sites were compared to the RBCs for the constituents that had maximum detected concentrations greater than the RBCs, because EPCs are more representative of overall soil conditions at an IRP site. Since the infinite source (Tier 1) model indicated an exceedance of the RBCs for 13 VOCs, a more rigorous estimate was obtained using additional site-specific data and the finite-source model for soil contamination. Tier 2 RBCs were calculated for the nine constituents in soil that had EPCs greater than the Tier 1 RBCs using the advanced version of the Johnson and Ettinger model (USEPA 2003). The EPCs for all the constituents that exceeded Tier 1 RBCs were less than the Tier 2 RBCs. These results indicate that the indoor air exposure pathway is not expected to be significant for VOCs volatilizing from soil to indoor air in IR09. Based on the screening-level evaluation, no significant exposure is likely for the indoor air pathway for IR09.

The HHRA developed four different sets of risk estimates for each soil exposure scenario evaluated:

- **Site Cancer Risk and Site HI –** defined in this HHRA as the cancer risk or HI from exposure to all COPCs identified at a site. Site risk or HI includes (1) risk or HI from all metal COPCs and (2) risk or HI from all detected organic COPCs. For metals, the risk or HI metals associated with the ambient levels have not been subtracted from the risk estimate.

- **Total Cancer Risk and Total HI –** defined as the cancer risk or HI from exposure to all analytes at a site. This total risk or HI includes (1) risk or HI from all detected metals and (2) risk or HI from all detected organic analytes.

- **Ambient Cancer Risk and Ambient HI –** defined as the cancer risk or HI from exposure to ambient concentrations of metals at a site. Ambient risk or HI is the risk or HI from those detected metals for which ambient limits have been established.

- **Incremental Cancer Risk and Incremental HI –** defined as the cancer risk or HI attributable to chemical releases at a site. Incremental risk or HI includes (1) risk or HI from metals present at concentrations greater than ambient and (2) risk or HI from all detected organic analytes. The ambient risk or HI of metals COPCs has been subtracted from the risk estimate or HI.

These definitions and the approach for calculating the risk estimates were developed specifically for Mare Island in consultation with USEPA and DTSC (TtEMI 2001). The approach for calculating these different risk estimates is described in Appendix G. The primary differences in the risk estimates are as follows:

- Chemicals selected for evaluation
- EPCs used to estimate the cancer risks and HIs

Site risk and incremental risk represent the risks from potential exposure to COPCs only. Total risk represents the risk from exposure to all detected analytes. That is, total risk includes risks associated with (1) chemicals present as a result of site-related activities and (2) chemicals (metals) present because they occur naturally in the environment but are not related to site activities. The ambient risk estimate represents the risk from exposure to 14 of the 15 metals for which ambient limits have been developed at Mare Island. (Lead is excluded from the total risk estimates because cancer risk estimate and HQs were not prepared for this metal.) The incremental risk estimate is the difference between total risk and ambient risk estimates, as follows:

Incremental Risk = Total Risk - Ambient Risk

The EPCs used for the site risk and total risk estimates are the lesser of the UCL95 and maximum concentration detected at the site for both organic and inorganic chemicals. The EPCs used for the ambient risk estimate depend on whether the metal was selected as a COPC at IR09. For metals present at ambient concentrations only, the EPC is the lesser of the UCL95 and maximum detected concentration. That is, the EPC represents the ambient conditions measured at IR09. For metal COPCs, which by definition are present at IR09 at concentrations above ambient levels, the site-specific ambient concentration is unknown. For these metals, the ambient limit (95th percentile of the ambient data set) for Mare Island was used. Accordingly, the EPCs used for the incremental risk estimate are therefore equal to the EPC used for the total risk estimate minus the EPC used for the ambient risk estimates. In cases where this results is a negative number, the incremental risk is assigned a value of zero.

Table 3.5-2 summarizes the results for the four types of risk estimates for IR09. As shown in Table 3.5-2, the total, ambient, site, and incremental risks are within the risk-management range. The main contributors to the total and ambient risks are ambient levels of arsenic in soil.

3.6 Ecological Risk Assessment Summary

A Baseline ERA was performed for IR09 to assess potential for risk to ecological receptors from site-related contaminants. The approach used for the Baseline ERA is described in Section 2.5, and the complete Baseline ERA is presented in Appendix H. The approach for this Baseline ERA is modeled after that developed by DTSC (1996) and USEPA (1997, 1998), and was used to assess ecological risks presented by constituents of potential ecological concern (COPECs).

TABLE 3.5-2
Summary of Estimated Risks at IR09
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Exposure Scenario/Receptor	Mixed-zone Soil							
	Ambient		Total		Site		Incremental	
	Cancer	Non-cancer	Cancer	Non-cancer	Cancer	Non-cancer	Cancer	Non-cancer
Future Industrial Worker								
Surface Soil	2×10^{-5}	0.4	2×10^{-5}	0.7	5×10^{-6}	0.4	4×10^{-6}	0.3
Future Construction Worker								
Surface Soil	7×10^{-7}	0.3	8×10^{-7}	0.4	2×10^{-7}	0.1	2×10^{-7}	0.1
Mixed-zone Soil (0 to 10 feet bgs)	5×10^{-7}	0.3	8×10^{-7}	0.4	3×10^{-7}	0.04	3×10^{-7}	0.04

A Baseline ERA includes the collection and interpretation of biological or abiotic media data to further refine the conclusions of a screening-level ERA. TtEMI performed the screening-level ERA for IA C3 (TtEMI 2002a).

3.6.1 Problem Formulation

Ecological receptors are not present at IR09, as the site is largely paved and covered by buildings. However, ecological receptors are present at Mare Island Strait, which is located on the east side of IR09. The Strait supports diverse communities of algal, invertebrate, fish, bird, and mammal species.

Representative ecological receptors were identified for characterization of ecological risk in this offshore habitat and include aquatic organisms such as fish, non-rooted aquatic plants, and aquatic invertebrates.

COPECs at IR09 were identified through evaluation of available groundwater data. Groundwater was analyzed for total and dissolved metals using unfiltered and filtered (45 microns) samples, respectively. Organics were analyzed using unfiltered samples. Inorganic COPECs were selected by screening maximum detected concentrations against ambient values. The screening-level evaluation considered the background concentration in shallow groundwater as established for Mare Island (TtEMI 2002c). An inorganic constituent detected in groundwater was not considered a COPEC and was ultimately omitted from the risk assessment, if its maximum detected concentration was below the respective ambient value. If an analyte was detected but did not have an ambient value for comparison, the analyte was retained for evaluation. Inorganic analytes in groundwater at the IR09 for which ambient values were available were within the ambient concentration in shallow groundwater (UCL95), except molybdenum and nickel. All organic compounds were assumed to be site-related and were retained as COPECs, without comparison to ambient values. Based on this screening-level evaluation, molybdenum, nickel, and seven organics were retained as COPECs.

3.6.2 Analysis

Groundwater from within IA C3 was assumed to be representative of water in Mare Island Strait because of its potential to discharge to the Strait. Because aquatic organisms in surface water (i.e., non-rooted plants, invertebrates, and fish) are mobile, and the medium in which they reside is spatially variable, exposure point concentrations (EPCs) are best represented by the UCL95 of the mean. However, the maximum detected concentration was used as the EPC for many COPECs at IR09 because of the statistical distribution of the data. Groundwater on site may have much higher contamination levels than the water that may eventually discharge to the Strait. Consequently, estimates of effects on aquatic organisms based on groundwater data are very conservative.

Ecological risk was evaluated by comparing site-related concentrations (EPCs) to toxicity reference values (TRVs). For this evaluation, ecological screening levels published by the RWQCB (2003a) were selected as TRVs. The ecological screening levels present the more conservative of saltwater and freshwater benchmarks. Because the Strait has varying salinity levels due to varying freshwater flow from the Napa River, the Strait may be considered freshwater or estuarine depending on season. As a result, the ecological screening levels serve as conservative benchmarks for evaluating risk to aquatic organisms in the Strait. In addition, acute TRVs from the RWQCB (2003b) were used to refine the estimate of potential risk for those analytes that exceeded the ecological screening levels.

3.6.3 Risk Characterization

For aquatic organisms, the EPC for each analyte in groundwater was divided by its respective TRV, resulting in a quantitative estimation of risk known as a hazard quotient. HQs greater than 1 were further analyzed qualitatively. Cumulative risks (hazard indices, or HIs) were not estimated for aquatic organisms because of the limited toxicity information available for evaluation of cumulative effects.

All chemicals with HQs greater than 1 were considered to pose some potential risk and were qualitatively evaluated further for the representative species. Qualitative evaluations assessed chemical information (magnitude of HQ and frequency of detection), incremental risk, potential dilution, and confidence in the benchmark using less conservative assumptions to predict a more reasonable potential for exposure and effects.

None of the retained analytes had an HQ greater than 1 when compared to RWQCB ecological screening levels. Therefore, contaminants in groundwater at IR09 are found to pose negligible risk to aquatic organisms in the Strait.

3.7 Degradation of Groundwater Assessment

Analytical data for groundwater samples collected from monitoring wells 09W07, 09W06, and B144MW100 were used to assess the quality of groundwater entering Mare Island Strait adjacent to IR09. These monitoring wells are located 30 to 60 feet away from Mare Island Strait. All analytes detected in these samples were screened against the chemical-specific ARARs for groundwater and surface water identified by the RWQCB (Appendix I). Select analytes were detected at concentrations exceeding the criteria. The primary sources of groundwater contamination at the site (USTs 334-1 through 334-4) were removed in 1987.

Remaining potential sources of groundwater contamination (contaminated soil) will be addressed during implementation of one of the remedial alternatives identified and evaluated in the feasibility study, which is presented in Section 7.0.

Maximum concentrations of analytes in groundwater in 09W07, 09W06, and B144MW100 were compared to the chemical-specific ARARs identified by the RWQCB for groundwater and surface water for those analytes. Two analytes detected in groundwater at IR09 had maximum concentrations that exceeded one or more numeric criteria (arsenic and manganese). The chemical-specific RWQCB-identified ARARs for arsenic and manganese are presented in Table 3.7-1. (Comparisons of criteria to metals concentrations were performed using analytical results for filtered groundwater samples. These data are considered more representative of dissolved metals concentrations than data for non-filtered samples.) With exception to the Basin Plan water quality objectives for agricultural supply, which apply to groundwater, each of the criteria identified in Table 3.7-1 apply to surface water. Because groundwater in IA C3 mixes with surface water upon entering Mare Island Strait and constituent concentrations are reduced by a factor of at least 1,000 upon entering the Strait, comparison of constituent concentrations in groundwater to surface water criteria results in a conservative determination of analytes that potentially impact surface water in the Strait. Further, this assessment is conservative because it compares the lowest of the criteria presented in Table 3.7-1 to the maximum detected concentration of each analyte.

Table 3.7-2 compares the maximum arsenic and manganese concentrations detected in groundwater at IR09 to the ambient concentration of these metals in groundwater at Mare Island (TtEMI 2002c). As presented in the table, arsenic and manganese are present at concentrations below the corresponding ambient concentration. Therefore, metals concentrations in groundwater discharged from IR09 to Mare Island Strait meet the standards of state anti-degradation and cleanup policies (SWRCB 1992, 1995).

While there are no chemical-specific ARARs for petroleum hydrocarbon constituents in groundwater or surface water, TPH-motor-oil was detected in groundwater near Mare Island Strait at IR09 at concentrations that exceed 1,400 µg/L. This value was used at Treasure Island (TtEMI 1999d) and was identified by the RWQCB as the appropriate value to use in identifying petroleum hydrocarbon concentrations in groundwater at the surface water discharge point that may adversely impact surface water (RWQCB 2004b). TPH-motor-oil was detected at a maximum concentration of 400,000 µg/L in groundwater near Mare Island Strait at IR09. The concentration was detected in a sample collected from monitoring well 09W06 in February 1998. However, two samples collected from this well subsequent to this sample (in June and September 1998) did not contain TPH-motor-oil at concentrations exceeding low analytical reporting limits (230 to 250 µg/L). These data suggest that elevated TPH-motor-oil concentrations are not present in groundwater in the vicinity of this well. Based on this information, TPH-motor-oil is not present at concentrations that are degrading waters of the State.

TABLE 3.7-1
Chemical-specific ARARs Identified by the Regional Water Quality Control Board for Select Constituents in Groundwater and Surface Water at IR09
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

	Chemical-specific ARARs in Groundwater	**Chemical-specific ARARs in Surface Water**													
	San Francisco Bay Basin Plan [a]	**San Francisco Bay Basin Plan [a]**		**California Toxics Rule Criteria for Enclosed Bays and Estuaries [b]**					**National Ambient Water Quality Criteria [c]**						
Parameter	**Water Quality Objectives for Agricultural Supply (µg/L)**	**Water Quality Objective for Surface Waters with Salinity Greater than 5 ppt (µg/L)**	**Water Quality Objective for Surface Waters with Salinity Less than 5 ppt (µg/L)**	**Freshwater CMC [d] (µg/L)**	**Freshwater CCC [e] (µg/L)**	**Saltwater CMC [d] (µg/L)**	**Saltwater CCC [e] (µg/L)**	**Human Health (Aquatic Organisms Consumption Only (µg/L)**	**Freshwater CMC [d] (µg/L)**	**Freshwater CCC [e] (µg/L)**	**Saltwater CMC [d] (µg/L)**	**Saltwater CCC [e] (µg/L)**	**Human Health (Aquatic Organisms Consumption Only (µg/L)**	**Most Conservative Criteria (µg/L)**	**Maximum Detected Concentration (µg/L)**
Arsenic	5,000 (threshold) 20,000 (limit)	36 (4-day average) 69 (1-hour average)	190 (4-day average) 360 (1-hour average)	340 [f]	150 [f]	69 [f]	36 [f]	--	340 [f]	150 [f]	69	36	0.14 [g]	0.14	38
Manganese	200 (threshold) 10,000 (limit)	--	--	--	--	--	--	--	--	--	--	--	--	200	995

Notes:

[a] Water Quality Control Plan, San Francisco Bay Basin (Region 2). June 2, 1995.
[b] 40 CFR Part 131.38.
[c] USEPA. Office of Science and Technology. National Recommended Water Quality Criteria: 2002, EPA-822-R-02-047. November 2002.
[d] Criteria Maximum Concentration (CMC) = the highest concentration of a pollutant to which aquatic life can be exposed for a short period of time (1-hour average) without deleterious effects.
[e] Criteria Continuous Concentration (CCC) = the highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4 days) without deleterious effects.
[f] Based on dissolved concentrations.
[g] Criteria based on carcinogenicity of 10^{-6} risk.

-- No criteria.

TABLE 3.7-2
Ambient Groundwater Concentrations for Select Constituents at IR09
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Analyte	Maximum Detected Concentration (µg/L)	Ambient Concentration in Shallow Groundwater (TtEMI 2002c) (µg/L)	Detected Concentrations Within Ambient Range?
Arsenic	38	78	Yes
Manganese	995	5,400	Yes

3.8 Conclusions of the Remedial Investigation at IR09

The nature and extent of soil and groundwater contamination at IR09 has been defined by data collected during the 2002-2004 field investigation, as well as data collected during previous investigations. The analytical data collected at IR09 indicate that impacted areas of the site are primarily located south, southwest, and east of Building 334, near the identified sources of contamination: the former USTs, the former AST farm associated with the Paint Shop Varnish Plant, and the Building 144 oil/water separator.

The area south of the former USTs had the highest levels of TPH-gasoline-range organics (up to 16,000 mg/kg), TPH-diesel-range organics (up to 7,500 mg/kg), BTEX compounds (up to 16 mg/kg total xylenes), and lead (20,000 mg/kg) found in site soils. The highest concentrations of these compounds were typically found at depths of 5 to 7 feet bgs, and concentrations of these constituents in soil outside this depth zone are markedly lower. Representative groundwater data (collected from 1997 to present) for samples collected near the former USTs suggests that groundwater is not impacted. Soil and groundwater samples from the former AST farm and the Building 144 oil/water separator generally contained organic constituents at lower concentrations, compared with concentrations in samples collected near the former USTs.

The most likely migration pathways for contaminants in the soil at IR09 are dissolution of soil contaminants by infiltration, followed by migration through the vadose zone through advection and dispersion and subsurface lateral migration via groundwater transport through the aquifer to Mare Island Strait. Only low concentrations of contaminants have been detected in monitoring wells located nearest to Mare Island Strait, suggesting that the affinity of these contaminants to adsorb to soil organic matter prevents the migration of these contaminants through the aquifer to the Strait. Mixing along flow lines and biodegradation may also account for the low concentrations of these constituents detected in monitoring wells nearest to the Strait.

The HHRA for IR09 concluded that the EPC for lead in surface soil (1,780 mg/kg) is above the current risk-based level for commercial/industrial workers of 750 mg/kg. The risk-based level is based on current guidance from DTSC (Personal Communication with Michael Wade/DTSC; November 20, 2002). The EPC for lead in mixed-zone soil (1,254 mg/kg) also exceeds the current risk-based level of 750 mg/kg. The results of the HHRA indicate that future site conditions at IR09 pose potential excess lifetime cancer risks

that are within the risk-management range (10^{-4} to 10^{-6}) for carcinogens. In addition, non-cancer adverse HIs were estimated to be below 1 for all of the receptors potentially exposed to soil or groundwater. Because these calculated carcinogenic and non-carcinogenic risks are within or below the risk-management range, lead in soil is the only constituent that presents a potential significant risk to human receptors in IR09.

The results of the ERA indicate that all retained analytes have HQs less than 1 when compared to RWQCB ESLs. Therefore, contaminants in groundwater at IR09 are found to pose negligible risk to aquatic organisms in the Strait.

The results of the degradation of groundwater assessment indicate that, while arsenic and manganese are present in groundwater at IR09 at concentrations that exceed chemical-specific ARARs identified by the RWQCB for groundwater and surface water, these metals are present at concentrations that are within the range of concentrations that are considered ambient. TPH-motor-oil was detected at a concentration that exceeds RWQCB-recommended screening criteria (1,400 µg/L) in a groundwater sample collected at IR09 in 1998. However, groundwater samples collected subsequent to that sample contained TPH-motor-oil at concentrations below the recommended screening criteria. Constituents in groundwater at IR09 are therefore present at concentrations that meet State anti-degradation and cleanup policies (SWRCB 1992, 1995).

Based on guidance provided in *Screening For Environmental Concerns at Sites With Impacted Soil and Groundwater* (RWQCB 2003b) and based on RWQCB comments on Tier 2 screening levels at petroleum hydrocarbon sites at LMI (RWQCB 2004b), petroleum hydrocarbons are present in soil at IR09 at concentrations that potentially pose an odor/nuisance condition. In addition, petroleum hydrocarbons are present in soil at the site at concentrations that, due to leaching, may adversely impact groundwater. Consequently, the need to perform a remedial action in areas of IR09 that contain elevated levels of petroleum hydrocarbons will be evaluated in the feasibility study presented in Section 7.0 of this report.

Based on the results of the HHRA, lead in soil presents a potential significant risk to human health at IR09. In addition, petroleum hydrocarbons are present in soil at the site at concentrations that exceed screening levels derived using RWQCB guidance. Therefore, remedial action objectives to address lead and petroleum hydrocarbons in soil at IR09 will be developed in the feasibility study presented in Section 7.0. Based on the results of the HHRA, ERA, and degradation of groundwater assessment, constituents in groundwater do not pose a risk to human or ecological receptors and are not degrading waters of the State. Therefore, remedial alternatives are not developed in the feasibility study to address constituents in groundwater at IR09.

4.0 IR12

4.1 Site Background

4.1.1 Site Description

IR12 comprises an active electrical substation in Building 516, the attached Building 516A, and adjacent areas. IR12 is located in the area bounded by Dry Dock No. 1, Dry Dock No. 2, Mare Island Strait, and IR09. IR12 covers about 0.9 acre and consists of structures and paved areas. The ground surface in IR12 is about 7 to 8 feet above msl. IR12 also includes Building 1336, Building 332, and Building 1334, and an area that overlaps with IR09 that includes an inactive crane cable house (D-1) and associated electrical substation. Current site features are shown in Figure 4.1-1.

Primary underground utilities in the area of IR12 consist of electrical cableways, stormwater pipelines, a steam line, and a freshwater supply line. The underground electrical cableways carry electrical service lines to and from Building 516. The cableways beneath the concrete flooring of the building consist of cast-in-place or prefabricated concrete. The electrical cableways are typically 2 feet wide and 2 feet deep, with an array of cylindrical cavities through which high-power electrical cables run (PRC 1996a). A subsurface vault is located beneath the outdoor electrical substation west of Building 516 (Building 516A), the lower portion of which is below the groundwater table. The vault is located at approximately 8 feet bgs.

One stormwater pipeline approximately 40 feet southwest of Building 516 runs parallel with Dry Dock No. 2 and extends to Outfall STS-22 at Mare Island Strait. The other stormwater pipeline runs northeast of Building 516 to the quay wall at Outfall STS-21 at Mare Island Strait. Both Outfalls STS-21 and STS-22 were plugged and sealed in 1994 to prevent stormwater discharge to Mare Island Strait (MINS 1994).

4.1.2 Site History

MINS facility maps illustrate that, prior to the 1870s, most of IA C3 was marshland. Dry Dock No. 1, under construction for many years, was completed by 1891. Historical records indicate that in the late 1800s, a marine railway and its associated wet basin were located in the vicinity of IR12. The wet basin was designed to hold a floating dry dock and to serve as an alternative location for ship repair. The marine railway was also designed to supplement the floating dock. The marine railway and the wet basin were abandoned during the construction of Dry Dock No. 2 (Archaeological Resource Service 1986). By 1910, Dry Dock No. 2 and the quay wall were built, the land between Dry Dock Nos. 1 and 2 was filled, and the first structure was built in the filled area between the dry docks.

Historical records indicate that Building 516, the Electrical Distribution Center, was built in the early 1920s (MINS 1995, 1935, 1922). The one-story square building was constructed of concrete blocks to provide electrical power for the nearby dry docks, waterfront buildings,

FIGURE 4.1-1
IR12 SAMPLE LOCATIONS MAP
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

CH2MHILL

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and facilities. Building 516 remains in use and is operated by Island Energy. Between approximately 1941 and 1991, various types of PCB oil-filled transformers were located inside Building 516 along the northwest and southwest walls (PRC 1996a). In 1981, a transformer leak occurred in Building 516 and PCB-containing oil was released (Ecology and Environment 1983). The release occurred in the northwest portion of Building 516, and the oil was released into an electrical cableway in the floor of the building that connected to the storm drainage system (IT 1990). The oil was removed from the electrical cableway following the spill and, in 1983, the catch basin was cleaned and the connection to the outside storm drainage system was plugged (Ecology and Environment 1983; IT 1990).

MINS facility maps indicate that Building 516 was the first permanent structure at IR12. By 1925, Building 590, designated the paint shop annex, was constructed north of Building 516. By 1931, Building 620, a varnish shed, was constructed west of Building 516 (MINS 1935; SSPORTS 1996a). These two buildings likely were associated with the former paint shop varnish plant that operated in the site vicinity prior to 1940. Buildings 590 and 620 were removed by 1944. By 1970, Building 516A (the outdoor electrical substation on the west side of Building 516) and the crane cable house and associated electrical substation were constructed. By 1989, the remaining structures at the site (Building 332, Building 1336) were constructed. Building 332 was used as an office/shop area, and Building 1336 is another electrical substation.

Since the closure of MINS in 1996, buildings at IR12 have not been occupied with regularity. Building 516, which is an active electrical substation, is accessed about once a week for limited operation and maintenance work.

4.1.3 Chronology of Investigations

The following discusses previous studies and investigations at IR12. The Navy's IRP work at this site began in the early 1980s. The Navy transitioned environmental investigation and cleanup responsibilities to LMI in 2001.

4.1.3.1 Initial Assessment Study

In 1983, an IAS was completed that assessed potential soil and groundwater contamination from past operations at MINS (Ecology and Environment 1983). The IAS consisted of a record review and site reconnaissance. The IAS identified the PCB release in Building 516 and noted that, although the oil was removed in a timely manner by base personnel, PCBs concentrations in excess of 47 parts per million (ppm) remained. No information was reported in the IAS about the type, number, or location of sample collection inside Building 516.

4.1.3.2 Phase I Remedial Investigation

The Phase I remedial investigation focused on determining the extent of residual PCBs within Building 516 (IT 1992). The Phase I remedial investigation determined if porous concrete, sediment, and water in electrical cableway trenches still contained elevated levels of PCBs. The Phase I remedial investigation was conducted from April 1990 through November 1991. Three concrete-chip samples (IR12-CH02, IR12-CH03, and IR12-CH04), one sediment sample (12-SD01), and one surface water sample (12-SW02) were collected from the electrical cableways and sumps inside Building 516 in the northwest part of the building

where the spill occurred. The results of the Phase I remedial investigation were documented in the *Site Characterization Summary for Phase I Remedial Investigation NSY Mare Island,* and indicated that elevated concentrations of PCBs were present in the walls of the concrete cableways and in the sediments at the bottom of the cableways. The Phase I remedial investigation concluded that detected PCB concentrations exceeded TSCA standards for cleanup, and concluded that additional investigation was required.

4.1.3.3 Phase II Remedial Investigation

A Phase II remedial investigation was conducted between April 1993 and October 1994 to supplement the information collected during previous investigations at IR12 to more completely characterize site conditions and determine the extent of contamination in and around Building 516. Results of the Phase II remedial investigation were documented in the *Remedial Investigation Report, Operable Unit 3, Mare Island* (PRC 1996a). This work included data collection both inside and outside Building 516.

Inside Building 516, the Phase II remedial investigation included: (1) collecting concrete core sampling at 10 locations (IR12CB001 through IR12CB010) within the floor and electrical cableways inside Building 516 in September 1994; (2) collecting soil samples by hand-auger borings below the concrete flooring inside Building 516 at the 10 locations where concrete core samples were collected (IR12CB001 through IR12CB010) in October 1994 and January 1995; (3) collecting sediment samples in three locations (IR12SS001 through IR12SS003) within the electrical cableways inside and near the southern end of Building 516 in January 1995; and (4) laboratory analysis.

Outside Building 516, the Phase II remedial investigation included: (1) collecting soil samples from seven vacuum excavations (IR12VB001 through IR12VB007) surrounding subsurface utility lines (e.g., the electrical cableways, storm sewer pipelines, and the steam line) between November and December 1993 and in January 1995; (2) collecting one grab groundwater sample from vacuum excavation IR12VB002; (3) collecting subsurface soil samples from 10 GeoProbe® borings (IR12GB001 through IR12GB010) in November 1994; (4) collecting wipe samples at 11 locations (IR12WP001 through IR12WP010 and IR12WP013) within stormwater catch basins and electrical cableways in April 1993 and September 1994; (5) installing three groundwater monitoring wells (12W01 through 12W03) in January 1995 and collecting groundwater samples; and (6) laboratory analysis.

The Phase II remedial investigation included the preparation of a baseline human health risk assessment. The *Baseline Human Health Risk Assessment Addendum to the Remedial Investigation Report, Operable Unit 3, Mare Island* presents an evaluation of the potential risks associated with environmental contamination at IR12 in the absence of remedial action (PRC 1997c). The preliminary risk calculations indicated that that human health risks from contaminants at IR12 in the unchanged site configuration are within the risk management range and the evaluation of remedial alternatives is not warranted.

4.1.3.4 Investigation of the Storm Sewer System

An investigation of the storm sewer system in IA C3 was performed in September and October 1994 to evaluate the impact of the 1981 release of PCBs from Building 516 on the storm sewer system. Soil and sediment in approximately 30 manholes and catch basins in the area between Dry Dock Nos. 1 and 2 and Mare Island Strait were sampled; elevated PCB

concentrations were detected in samples collected from select manholes and catch basins (SSPORTS 1997b). Storm sewer Outfalls STS-20, STS-21, and STS-22 and associated tributary catch basins and manholes in the area between Dry Dock Nos. 1 and 2 and Mare Island Strait were subsequently plugged and sealed to prevent stormwater discharge to Mare Island Strait. The Navy notified the RWQCB of the existence of PCBs in storm sewer piping in this area in a letter dated November 22, 1994 (MINS 1994). Selected storm sewer catch basins and manholes were also sampled in June 1997. Analytical results confirmed that sediment in the storm sewer pipeline extending east of Dry Dock No. 2 contained elevated concentrations of PCBs (SSPORTS 1997b).

4.1.3.5 Basewide Groundwater Monitoring Program

The three monitoring wells at IR12 (12W01 through 12W03) installed during the Phase II remedial investigation were sampled five times between February 1995 and June 1999 as part of the basewide groundwater monitoring program. Generally, these monitoring events included measurement of the groundwater level at each well and extraction of a groundwater sample from selected wells for subsequent analysis for organic and inorganic contaminants (TtEMI 1998e-f, 1999a-c, 2000b-e, 2001).

4.1.3.6 Offshore Ecological Risk Assessment

An offshore ecological risk assessment was conducted to evaluate risks to ecological receptors from site-specific stressors present in offshore areas. Results of the Offshore ERA were documents in the *Revised Final Offshore Areas Ecological Risk Assessment, Mare Island* (TtEMI 2002b). The Offshore ERA evaluated impacts from contaminated sediments in the Mare Island Strait and performed both clam and amphipod bioassays using sediment and pore water collected from the Strait. Overall conclusions stated that constituents in offshore sediments do not pose an unacceptable risk to populations of benthic invertebrates. Additionally, food-chain modeling suggested that population-level risks to birds and mammals were negligible.

4.1.3.7 Basewide Polychlorinated Biphenyl Confirmation Sampling

The PCB program at the former MINS included identifying and assessing locations of potential releases of PCBs and performing abatement activities as necessary. SSPORTS interim assessment activities included the collection of wipe samples from four locations inside Building 516, as well as one water and five solid samples at Building 516A in April 1996, as documented in *Polychlorinated Biphenyl Assessment for Dry Dock Number Two Property* (SSPORTS 1996c). Subsequent confirmation sampling was performed by TtEMI in July 1997. TtEMI collected two concrete samples inside Building 516 (PC1551 and PC1552), two concrete samples at Building 516A (PC1571 and PC1573), and two asphalt samples adjacent to Building 516A (PC1572 and PC1574), as documented in the *Final Basewide Polychlorinated Biphenyl Confirmation Sampling Summary Report* (TtEMI 1998a).

In February 1999, SSPORTS collected 11 concrete and 5 wipe samples (9-0173 through 9-0188) from the center section of the Building 516 floor (SSPORTS 1999a).

4.1.3.8 Scabbling of Concrete Surfaces in Building 516 and 516A

Based on the results of previous sampling, SSPORTS performed scabbling (abrasive removal) of PCB-contaminated concrete flooring inside Building 516 in February 1999.

Scabbling was performed only in the northern portion of the flooring and only on the exposed floor, not beneath the electrical equipment. Following the scabbling, 16 concrete samples (9-0109 to 9-0125) were collected (SSPORTS 1999b; 1999c). No scabbling was performed inside the trenches and sumps in the floor of Building 516.

The concrete pad at Building 516A was also remediated via scabbling. Four separate scabbling actions took place between June 1998 and April 1999 at Building 516A. After each scabbling action, concrete samples were collected to assess the effectiveness of the scabbling to remove PCB contamination from the concrete, and re-scabbling was ordered for areas where samples showed that PCB contamination remained. Scabbling was only performed on the exposed concrete pad, not beneath the electrical equipment. Over 35 concrete samples were collected following the four successive scabbling events (SSPORTS 1998a-c, 1999d). Nine of these samples (8-1359, 8-1361, 8-1362, 8-1366, 8-1368, 8-1369, 9-1014, 9-1015, and 9-1017) represent post-scabbling site conditions. TtEMI collected three post-scabbing concrete samples in February and August 1999 at Building 516A (PC7105, PC7106, and PC8683).

4.1.3.9 Cleaning and Sampling of Electrical Vault in Building 516A

Based on the results of interim sampling of the sediment inside the electrical vault beneath Building 516A conducted by SSPORTS in 1998, an abatement action was performed in January 1999. This action consisted of pumping out the standing water and sediment within the vault, power washing all surfaces with standing water stains, and removing and disposing the cleaning fluids. Seven concrete samples (9-0057 to 9-0063) and one wipe sample (9-0064) were collected from within the vault after the cleaning action was completed (SSPORTS 1998d).

4.1.3.10 Cleaning of the Storm Sewer System

PCB contamination in the storm sewer system at Dry Dock No. 2 was addressed through a limited cleaning program performed by the Navy in June 1999. Dirt and sediments were removed from the five manholes and catch basins (C-57, C-58, C-59, M65, and STS-22) found to contain the greatest concentrations of PCBs in sediment during the 1994 and 1997 investigations of the storm sewer system. These manholes and catch basins are located between Building 516 and Outfall STS-22. The five manholes and catch basins were power-washed. In addition, an approximately 200-foot section of storm sewer pipeline (extending from manhole M65 to catch basin C-57) was vacuum-tested and flushed. One section of this pipeline could not be flushed due to a reported break in the pipeline. Soil adjacent to this break was investigated and characterized during an investigation performed in 2002, as documented in the *Technical Memorandum for the Storm Sewer Line at Dry Dock No. 2* (CH2M HILL 2003e) (Sections 4.1.3.11 and 4.1.3.13).

4.1.3.11 Limited Investigation of Multiple Sites in Investigation Areas C2 and C3

A limited investigation of previously-unidentified sites of environmental concern in IA C2 and C3 was performed in June 2002. This investigation included one site associated with IR12: the storm sewer line at Dry Dock No. 2. The purpose of the limited investigation was to evaluate the potential for a release of contaminants to the environment and identify the sites that require further investigation and/or remediation. As part of the limited investigation, soil samples were collected from two locations at the Dry Dock No. 2 storm sewer

(DD2GB100 and DD2GB101). In addition, a video survey of the storm sewer line at Dry Dock No. 2 was attempted. The results of the limited investigation, documented in the *Final Limited Investigation Report for Multiple Sites in Investigation Areas C2 and C3* (CH2M HILL 2003c), indicated that, while a release to the environment had not been confirmed at this source, DTSC requested additional site investigation.

4.1.3.12 Implementation of the LMI IA C3 SAP

Field activities at IR12 were performed between July and October 2002, consistent with the *Investigation Area C3 Sampling and Analysis Plan* (CH2M HILL 2002e-f). The field activities at IR12 consisted of the installation of one groundwater monitoring well (12W04), the collection of 37 soil samples from 15 borings (IR12GB0100 through IR12GB0114), and the collection of groundwater samples from two borings (IR12GB0101 and IR12GB0102) and three monitoring wells. Soil and groundwater samples were analyzed for lead, PCBs, TPH-gasoline, TPH-diesel, TPH-motor-oil, VOCs, and PAHs to refine the conceptual site model and to support the human health and ecological risk assessments. Groundwater samples were also collected from three existing monitoring wells at IR12 for TDS analysis, and water-level elevations were measured on two separate occasions (August and October 2002) to supplement previously-collected hydrologic and geochemistry information. In addition, one groundwater sample (IR12GW0100) was collected from the subsurface vault at Building 516A to assess the concentrations of PCBs in accumulated groundwater approximately 3 years after the vault was decontaminated.

4.1.3.13 Characterization of Multiple Sites in Investigation Areas C2 and C3

Additional site characterization activities at previously-unidentified sites of environmental concern associated with IR12 (the storm sewer line at Dry Dock No. 2) were performed in December 2002 in accordance with the *Work Plan for Additional Characterization of Multiple Sites in Investigation Area C3 (*CH2M HILL 2002g). The additional site characterization included the collection of soil samples from one location at the storm sewer line at Dry Dock No. 2 (DD2GB102). The results of this investigation are documented in *Draft Technical Memorandum for the Storm Sewer Line at Dry Dock No. 2* (CH2M HILL 2003e). DTSC concluded that no further action was warranted to address soil in the vicinity of the reported storm sewer pipeline break in a letter dated August 16, 2004 (DTSC 2004).

4.1.3.14 2003/2004 Groundwater Monitoring

To complete the characterization of groundwater at IR12, groundwater samples were collected from three monitoring wells (12W01, 12W02, and 12W04) during two to five quarterly monitoring events performed between January 2003 and July 2004. Groundwater samples collected from 12W01 were submitted for laboratory analysis of petroleum hydrocarbons, PCBs, and VOCs. Groundwater samples collected from 12W02 were submitted for analysis of PCBs. Groundwater samples collected from 12W04 were submitted for analysis of petroleum hydrocarbons, VOCs, PAHs, and PCBs. In addition, the depth to groundwater was recorded during each quarterly monitoring event.

4.2 Physical and Ecological Characteristics

4.2.1 Surface Features

The IR12 site is relatively flat and is paved or covered with buildings.

4.2.2 Surface Water

No surface water bodies are present within the boundaries of IR12. Surface water runoff from the area discharges into the stormwater system. However, Storm Sewer Outfalls STS-21 and STS-22, which are adjacent to IR12, were plugged and sealed in 1994 to prevent stormwater discharge to Mare Island Strait (MINS 1994).

4.2.3 Geology

IR12 lies entirely within the triangle area that also includes the contiguous IR09 and the Building 108 Area sites. Because these sites are contiguous and in an area with well-defined lateral boundaries, the geology of all three sites was discussed together in Section 3.2.3.

4.2.4 Hydrogeology

IR12 lies entirely within the triangle area which also includes the contiguous IR09 and Building 108 investigation sites. Because these sites are contiguous and in an area with well-defined lateral boundaries, the hydrogeology of all three sites was discussed together in Section 3.2.4.

4.2.5 Ecology

No viable habitat exists within IR12 because the site is covered entirely with asphalt and buildings. Mare Island Strait is located directly northeast of IR12. A brief description of this offshore habitat can be found in Section 1.5.6.

4.3 Nature and Extent of Contamination

This section discusses the nature and extent of surface material, soil, and groundwater contamination at IR12. Analytical data for these media at IR12, collected during the investigations discussed in Section 4.1.3, are provided in Appendices F3, F4, and F5, respectively. This section also presents a summary of the PCB concentrations detected in sediments collected from Mare Island Strait and storm sewer catch basins and manholes in the vicinity of IR12.

The sampling approach employed for the remedial investigation was judgmental; that is, samples were collected from locations suspected to be the most highly contaminated, as indicated by site history. Additional sampling locations were then selected in subsequent phases of investigation, based on the results of previous investigations and additional knowledge of site history, to establish the extent of the possible contamination found. In total, over 290 samples were collected at IR12 between March 1991 and July 2004, from the approximately 140 locations shown in Figure 4.1-1.[8] Samples collected from IR12 were

[8] Approximately 20 percent of the entire IR12 data set was collected during the 2002-2004 field investigation.

analyzed for a wide variety of chemical parameters including petroleum hydrocarbons, VOCs, SVOCs, PAHs, PCBs, pesticides, and metals.

4.3.1 Concrete, Asphalt, and Wipe Samples

This section discusses analytical results from asphalt, concrete, and wipe samples collected at IR12. A summary of asphalt, concrete, and wipe data for IR12 is provided in Table 4.3-1. As indicated in the table, the primary constituent detected in concrete, asphalt, and wipe samples from IR12 was Aroclor-1260. Figure 4.3-1 presents Aroclor-1260 concentrations in concrete, asphalt, and wipe samples resulting from historical use of PCB-containing transformers at Buildings 516 and 516A. Sample results on the figure represent concentrations in samples collected after any remedial action (cleaning, scabbling).

Inside Building 516, concrete core, concrete-chip, and wipe samples were collected during previous investigations. The highest concentration of Aroclor-1260 in a concrete-chip sample (44,000 mg/kg) was found in IR12-CH02 collected in 1991 from within a concrete cable trench. The highest concentration of Aroclor-1260 in a wipe sample (56,000 micrograms per 100 square centimeters [$\mu g/100cm^2$]) was found in IR12WP004 collected in 1993 from within a concrete cable trench.

The maximum concentration of Aroclor-1260 in concrete chip samples from the floor (not including the cable trenches/sumps) of Building 516 was 13,000 mg/kg in sample 9-0111. The remaining concentrations of Aroclor-1260 found from the floor of Building 516 in concrete-chip samples ranged from less than 1 to 150 mg/kg. The concentration of Aroclor-1260 in wipe samples from the floor of Building 516 ranged from less than 5 to 29 μg/wipe. The highest concentrations of Aroclor-1260 were found in the northern portion of Building 516. These concentrations were detected after scabbling activities were completed, as discussed in Section 4.1.3.

Building 516A is the outdoor electrical substation to the west of Building 516. The concrete surface of Building 516A was scabbled in 1998 and 1999 to remove concrete surface contamination. Figure 4.3-1 shows concentrations of Aroclor-1260 in concrete following the scabbling activities. The highest concentration of Aroclor-1260 on the surface of the concrete pad was 13 mg/kg in chip sample 9-1014. All other chip samples from the concrete surface of Building 516A were less than 1 mg/kg. Samples PC1572 and PC1574 were collected from the asphalt surface outside the fenced area of Building 516A, which was not scabbled. The concentration of Aroclor-1260 in these samples was 40 and 27 mg/kg, respectively.

A subsurface vault is located beneath Building 516A. As discussed in Section 4.1.3, the vault was decontaminated in January 1999. Following the decontamination activities, samples were collected from the floor, walls, and ceiling of the vault. Figure 4.3-1 shows concentrations of Aroclor-1260 in the vault following the cleaning activities. The seven concrete-chip samples ranged in concentration from 190 to 17,000 mg/kg. The one wipe sample result was 2,200 μg/wipe.

Table 4.3-1

Investigation Area C3, IR12 Statistical Summary Table of Analytical Concrete, Asphalt and Wipe Data

Future Land Use: Industrial

Land Type: Fill Material

Analyte	CAS Number	Analysis Type	Background Concentration for Metals (mg/kg)	Source of Background Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Background Concentration for Metals	Average Result (mg/kg) or (ug/wipe)	Minimum Detection (mg/kg) or (ug/wipe)	Maximum Detection (mg/kg) or (ug/wipe)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (mg/kg) or (ug/wipe)	Maximum Detection Limit (mg/kg) or (ug/wipe)
ASPHALT - IR12																	
PCB Compounds																	
AROCLOR-1016	12674-11-2	Laboratory			2	0		1.7E+00							0%	6.6E-02	6.7E+00
AROCLOR-1221	11104-28-2	Laboratory			2	0		3.4E+00							0%	1.3E-01	1.3E+01
AROCLOR-1232	11141-16-5	Laboratory			2	0		1.7E+00							0%	6.6E-02	6.7E+00
AROCLOR-1242	53469-21-9	Laboratory			2	0		1.7E+00							0%	6.6E-02	6.7E+00
AROCLOR-1248	12672-29-6	Laboratory			2	0		1.7E+00							0%	6.6E-02	6.7E+00
AROCLOR-1254	11097-69-1	Laboratory			2	1		1.7E+00	4.0E-02	4.0E-02	7/10/1997	PC1508	0.0	0.0	50%	6.6E-02	6.7E+00
AROCLOR-1260	11096-82-5	Laboratory			2	2		1.4E+01	2.5E-01	2.7E+01	7/11/1997	PC1574	0.0	0.0	100%	6.6E-02	6.7E+00
CONCRETE - IR12																	
PCB Compounds																	
AROCLOR-1016	12674-11-2	Laboratory			28	0		1.6E-01							0%	0.0E+00	1.7E+00
AROCLOR-1221	11104-28-2	Laboratory			28	0		1.9E-01							0%	0.0E+00	2.6E+00
AROCLOR-1232	11141-16-5	Laboratory			28	0		1.6E-01							0%	0.0E+00	1.7E+00
AROCLOR-1242	53469-21-9	Laboratory			28	0		1.6E-01							0%	0.0E+00	1.7E+00
AROCLOR-1248	12672-29-6	Laboratory			28	0		1.6E-01							0%	0.0E+00	1.7E+00
AROCLOR-1254	11097-69-1	Laboratory			28	2		1.8E-01	1.0E-01	5.3E-01	9/28/1994	IR12CB001	0.8	0.8	7%	0.0E+00	1.7E+00
AROCLOR-1260	11096-82-5	Laboratory			71	47		1.2E+03	2.2E-02	4.4E+04	3/26/1991	IR12-CH02	1.0	1.1	66%	0.0E+00	1.7E+00
Pesticides																	
4,4'-DDD	72-54-8	Laboratory			3	0		0.0E+00							0%	0.0E+00	0.0E+00
4,4'-DDE	72-55-9	Laboratory			3	0		0.0E+00							0%	0.0E+00	0.0E+00
4,4'-DDT	50-29-3	Laboratory			3	0		0.0E+00							0%	0.0E+00	0.0E+00
ALDRIN	309-00-2	Laboratory			3	0		0.0E+00							0%	0.0E+00	0.0E+00
ALPHA-BHC	319-84-6	Laboratory			3	0		0.0E+00							0%	0.0E+00	0.0E+00
ALPHA-CHLORDANE	5103-71-9	Laboratory			3	0		0.0E+00							0%	0.0E+00	0.0E+00
BETA-BHC	319-85-7	Laboratory			3	0		0.0E+00							0%	0.0E+00	0.0E+00
DELTA-BHC	319-86-8	Laboratory			3	0		0.0E+00							0%	0.0E+00	0.0E+00
DIELDRIN	60-57-1	Laboratory			3	0		0.0E+00							0%	0.0E+00	0.0E+00
ENDOSULFAN I	959-98-8	Laboratory			3	0		0.0E+00							0%	0.0E+00	0.0E+00
ENDOSULFAN II	33213-65-9	Laboratory			3	0		0.0E+00							0%	0.0E+00	0.0E+00
ENDOSULFAN SULFATE	1031-07-8	Laboratory			3	0		0.0E+00							0%	0.0E+00	0.0E+00
ENDRIN	72-20-8	Laboratory			3	0		0.0E+00							0%	0.0E+00	0.0E+00
ENDRIN KETONE	53494-70-5	Laboratory			3	0		0.0E+00							0%	0.0E+00	0.0E+00
GAMMA-BHC (LINDANE)	58-89-9	Laboratory			3	0		0.0E+00							0%	0.0E+00	0.0E+00
GAMMA-CHLORDANE	12789-03-6	Laboratory			3	0		0.0E+00							0%	0.0E+00	0.0E+00
HEPTACHLOR	76-44-8	Laboratory			3	0		0.0E+00							0%	0.0E+00	0.0E+00
HEPTACHLOR EPOXIDE	1024-57-3	Laboratory			3	0		0.0E+00							0%	0.0E+00	0.0E+00
METHOXYCHLOR	72-43-5	Laboratory			3	0		0.0E+00							0%	0.0E+00	0.0E+00
TOXAPHENE	8001-35-2	Laboratory			19	0		1.2E+00							0%	0.0E+00	1.0E+01
WIPE - IR12																	
PCB Compounds																	
AROCLOR-1016	12674-11-2	Laboratory			10	0		1.1E+02							0%	1.0E-01	2.0E+03
AROCLOR-1221	11104-28-2	Laboratory			10	0		4.3E+02							0%	4.0E-01	8.0E+03
AROCLOR-1232	11141-16-5	Laboratory			10	0		3.2E+02							0%	3.0E-01	6.0E+03
AROCLOR-1242	53469-21-9	Laboratory			10	0		2.2E+02							0%	2.0E-01	4.0E+03

Table 4.3-1 **Future Land Use: Industrial**

Investigation Area C3, IR12 Statistical Summary Table of Analytical Concrete, Asphalt and Wipe Data **Land Type: Fill Material**

Analyte	CAS Number	Analysis Type	Background Concentration for Metals (mg/kg)	Source of Background Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Background Concentration for Metals	Average Result (mg/kg) or (ug/wipe)	Minimum Detection (mg/kg) or (ug/wipe)	Maximum Detection (mg/kg) or (ug/wipe)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (mg/kg) or (ug/wipe)	Maximum Detection Limit (mg/kg) or (ug/wipe)
WIPE - IR12																	
AROCLOR-1248	12672-29-6	Laboratory			10	0		2.2E+02							0%	2.0E-01	4.0E+03
AROCLOR-1254	11097-69-1	Laboratory			10	0		2.2E+02							0%	2.0E-01	4.0E+03
AROCLOR-1260	11096-82-5	Laboratory			20	17		3.3E+03	6.2E-01	5.6E+04	4/8/1993	IR12WP004	999.0	999.0	85%	2.0E-01	4.0E+03

[1] - Source Definition

a - Ambient Background Concentration (95th percentile) at Mare Island Naval Shipyard
b - Ambient Metal Concentrations in Artificial Fill - Mare Island
c - Ambient Metal Concentrations in Original Island Soil - Mare Island
d - At the request of the regulatory agencies, the ambient limit was set to the detection limit.

Data from the following types of samples were excluded from this statistical summary query: 1) duplicate or other quality control samples; 2) split samples; 3) removed samples; and 4) samples analyzed using the toxicity characteristic leaching procedure (TCLP) or by the waste extraction test (WET). In addition, rejected data was excluded from this query.

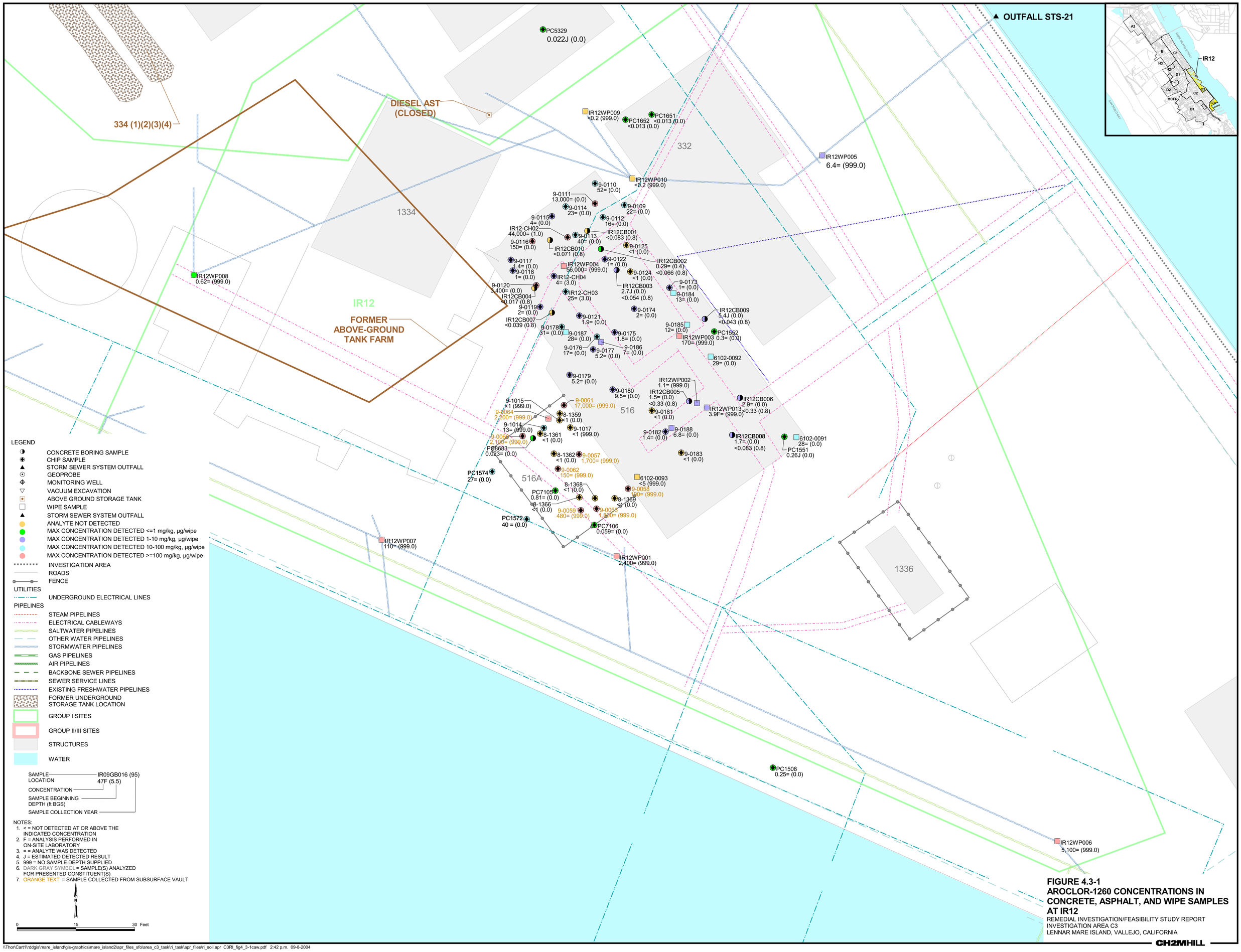

FIGURE 4.3-1
AROCLOR-1260 CONCENTRATIONS IN CONCRETE, ASPHALT, AND WIPE SAMPLES AT IR12
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

CH2MHILL

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4.3.2 Soil

A summary of soil data for IR12 is provided in Table 4.3-2. For each compound, the table shows the number of samples analyzed, the number of detected results of that compound,[9]the average result, the maximum result, and the frequency of detection. For metals analysis, the table shows the ambient concentration for Mare Island fill material (see also Table 2.3-1) and identifies the number of samples with metal results greater than the respective ambient concentration.

The following is a discussion of the analytical results for each of the analytical categories in Table 4.3-2 (PCBs, petroleum hydrocarbons, VOCs, SVOCs, and metals).

4.3.2.1 Polychlorinated Biphenyls

Based on the historical use of Building 516 as an electrical substation with PCB-containing transformers, much of the characterization of soils at IR12 focused on assessing the concentration of PCBs. As was found with concrete and asphalt contamination at IR12, the primary PCB compound found in soil samples at IR12 was Aroclor-1260. One hundred twenty-one soil samples collected from locations throughout IR12 were analyzed for Aroclor-1260; Aroclor-1260 was detected in 26 samples. Figure 4.3-2 shows the distribution of Aroclor-1260 in soil at IR12.

Three of the four highest concentrations of Aroclor-1260 (420, 170, and 14 mg/kg) were found in samples collected from two borings (12W02 and IR12VB007), located outside the southwestern corner of Building 516. Other detected concentrations of Aroclor-1260 ranged from 0.05 to 23 mg/kg, with over 70 percent of the detected Aroclor-1260 concentrations in soil at IR12 less than 1 mg/kg.

The samples with the highest concentrations of Aroclor-1260 were found near the subsurface electrical conduit outside of, and near the southwestern corner of, Building 516. These samples were collected between 2 and 7 feet bgs. As shown in Figure 4.3-2, Aroclor-1260 concentrations were not detected above 1 mg/kg in locations south, east, and west of this area, suggesting that the extent of elevated Aroclor-1260 concentrations is limited to the subsurface soils near the southwest corner of Building 516.

Fifteen soil samples were collected from nine locations between 1 and 7.5 feet bgs beneath Building 516. Aroclor-1260 was not found above laboratory detection limits in any of these samples, indicating that contamination of the floor and cable trenches inside Building 516 has not impacted soil beneath the building.

Soil samples were collected from eight locations to the north, west, and south of Building 516A and the subsurface vault. With the exception of the two sample locations previously mentioned outside the southwestern corner of Building 516, Aroclor-1260 was detected in only two of 21 samples surrounding the vault, at a maximum detected concentration of 0.46 mg/kg. These data indicate that, with the exception of the area outside the southwest corner of the Building 516 (south of the Building 516A vault), contamination from inside the vault has not impacted soil surrounding the vault.

[9] Includes those samples for which a compound was quantified at a concentration below the analytical reporting limit.

Table 4.3-2

Investigation Area C3, IR12 Statistical Summary Table of Analytical Soil Data

Future Land Use: Industrial

Land Type: Fill Material

Analyte	CAS Number	Analysis Type	Background Concentration for Metals (mg/kg)	Source of Background Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Background Concentration for Metals	Average Result (mg/kg)	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)
SOIL - IR12																	
Petroleum Hydrocarbon Compounds																	
DIESEL	DRO	Laboratory			90	9		5.4E+01	3.7E+01	9.3E+02	11/22/1994	IR12GB010	8.5	9.0	10%	1.1E+01	1.5E+02
GASOLINE	GRO	Laboratory			87	23		1.9E+02	1.5E+00	4.4E+03	11/18/1994	IR09GB014	6.0	6.5	26%	3.1E-02	4.9E+02
MOTOR OIL	MRO	Laboratory			90	17		6.4E+01	8.3E+00	1.2E+03	11/30/1994	IR12GB003	0.5	2.5	19%	1.1E+01	5.5E+02
TRPH	TRPH	Laboratory			6	2		2.3E+01	4.0E+00	1.1E+02	11/18/1994	IR09GB014	0.5	2.0	33%	6.0E-01	2.5E+01
UNKNOWN DIESEL RANGE	UDRO	Laboratory			5	5		1.4E+02	1.6E+01	3.9E+02	11/30/1993	IR12VB003	5.6	6.1	100%	3.1E+01	6.2E+01
UNKNOWN GASOLINE RANGE	UGRO	Laboratory			3	3		3.6E+01	7.4E+00	9.1E+01	11/29/1994	IR12GB005	11.5	12.0	100%	1.2E+01	1.7E+01
Volatile Organic Compounds																	
1,1,1,2-TETRACHLOROETHANE	630-20-6	Laboratory			6	0		1.1E-01							0%	5.4E-03	6.6E-01
1,1,1-TRICHLOROETHANE	71-55-6	Laboratory			12	0		1.2E-01							0%	5.4E-03	1.5E+00
1,1,2,2-TETRACHLOROETHANE	79-34-5	Laboratory			12	0		1.2E-01							0%	5.4E-03	1.5E+00
1,1,2-TRICHLOROETHANE	79-00-5	Laboratory			12	0		1.2E-01							0%	5.4E-03	1.5E+00
1,1,2-TRICHLOROTRIFLUOROETHANE	76-13-1	Laboratory			6	0		1.1E-01							0%	5.4E-03	6.6E-01
1,1-DICHLOROETHANE	75-34-3	Laboratory			12	0		1.2E-01							0%	5.4E-03	1.5E+00
1,1-DICHLOROETHENE	75-35-4	Laboratory			12	0		1.2E-01							0%	5.4E-03	1.5E+00
1,2,3-TRICHLOROPROPANE	96-18-4	Laboratory			6	0		1.1E-01							0%	5.4E-03	6.6E-01
1,2,4-TRICHLOROBENZENE	120-82-1	Laboratory			12	0		1.5E-01							0%	5.4E-03	6.6E-01
1,2,4-TRIMETHYLBENZENE	95-63-6	Laboratory			6	0		1.1E-01							0%	5.4E-03	6.6E-01
1,2-DIBROMO-3-CHLOROPROPANE	96-12-8	Laboratory			6	0		2.1E-01							0%	1.1E-02	1.3E+00
1,2-DICHLOROETHANE	107-06-2	Laboratory			12	0		1.2E-01							0%	5.4E-03	1.5E+00
1,2-DICHLOROETHENE (TOTAL)	540-59-0	Laboratory			6	0		1.3E-01							0%	1.1E-02	1.5E+00
1,2-DICHLOROPROPANE	78-87-5	Laboratory			12	0		1.2E-01							0%	5.4E-03	1.5E+00
1,3,5-TRIMETHYLBENZENE	108-67-8	Laboratory			6	0		1.1E-01							0%	5.4E-03	6.6E-01
1,3-DICHLOROBENZENE	541-73-1	Laboratory			12	0		1.5E-01							0%	5.4E-03	6.6E-01
2-BUTANONE	78-93-3	Laboratory			12	0		3.3E-01							0%	1.1E-02	3.2E+00
2-CHLOROTOLUENE	95-49-8	Laboratory			6	0		1.1E-01							0%	5.4E-03	6.6E-01
2-HEXANONE	591-78-6	Laboratory			6	0		1.3E-01							0%	1.1E-02	1.5E+00
4-METHYL-2-PENTANONE	108-10-1	Laboratory			12	0		3.3E-01							0%	1.1E-02	3.2E+00
ACETONE	67-64-1	Laboratory			12	0		3.3E-01							0%	1.1E-02	3.2E+00
ACROLEIN	107-02-8	Laboratory			4	0		1.6E+00							0%	5.8E-02	6.6E+00
ACRYLONITRILE	107-13-1	Laboratory			6	0		1.1E+00							0%	5.4E-02	6.6E+00
BENZENE	71-43-2	Laboratory			91	0		4.3E-02							0%	5.4E-03	1.5E+00
BROMOBENZENE	108-86-1	Laboratory			6	0		1.1E-01							0%	5.4E-03	6.6E-01
BROMODICHLOROMETHANE	75-27-4	Laboratory			12	0		1.2E-01							0%	5.4E-03	1.5E+00
BROMOFORM	75-25-2	Laboratory			12	0		1.2E-01							0%	5.4E-03	1.5E+00
BROMOMETHANE	74-83-9	Laboratory			12	0		1.2E-01							0%	5.4E-03	1.5E+00
CARBON DISULFIDE	75-15-0	Laboratory			12	0		1.2E-01							0%	5.4E-03	1.5E+00
CARBON TETRACHLORIDE	56-23-5	Laboratory			12	0		1.2E-01							0%	5.4E-03	1.5E+00
CHLOROBENZENE	108-90-7	Laboratory			12	0		1.2E-01							0%	5.4E-03	1.5E+00
CHLOROETHANE	75-00-3	Laboratory			12	0		1.2E-01							0%	5.4E-03	1.5E+00
CHLOROFORM	67-66-3	Laboratory			12	0		1.2E-01							0%	5.4E-03	1.5E+00
CHLOROMETHANE	74-87-3	Laboratory			12	0		1.2E-01							0%	5.4E-03	1.5E+00
CIS-1,2-DICHLOROETHENE	156-59-2	Laboratory			6	0		1.1E-01							0%	5.4E-03	6.6E-01
CIS-1,3-DICHLOROPROPENE	10061-01-5	Laboratory			6	0		1.3E-01							0%	1.1E-02	1.5E+00
DIBROMOCHLOROMETHANE	124-48-1	Laboratory			12	0		1.2E-01							0%	5.4E-03	1.5E+00
DICHLORODIFLUOROMETHANE	75-71-8	Laboratory			6	0		1.1E-01							0%	5.4E-03	6.6E-01

Table 4.3-2

Investigation Area C3, IR12 Statistical Summary Table of Analytical Soil Data

Future Land Use: Industrial

Land Type: Fill Material

Analyte	CAS Number	Analysis Type	Background Concentration for Metals (mg/kg)	Source of Background Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Background Concentration for Metals	Average Result (mg/kg)	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)
SOIL - IR12																	
ETHYLBENZENE	100-41-4	Laboratory			91	14		1.0E-01	3.0E-02	1.9E+00	11/18/1994	IR09GB014	6.0	6.5	15%	5.4E-03	1.5E+00
ETHYLENE DIBROMIDE	106-93-4	Laboratory			6	0		1.1E-01							0%	5.4E-03	6.6E-01
HEXANE	110-54-3	Laboratory			6	0		2.1E-01							0%	1.1E-02	1.3E+00
ISOPROPYLBENZENE	98-82-8	Laboratory			6	0		1.1E-01							0%	5.4E-03	6.6E-01
METHYL TERTIARY BUTYLETHER	1634-04-4	Laboratory			6	0		1.1E-01							0%	5.4E-03	6.6E-01
METHYLENE CHLORIDE	75-09-2	Laboratory			12	0		1.7E-01							0%	1.1E-02	1.5E+00
N-BUTYLBENZENE	104-51-8	Laboratory			6	0		1.1E-01							0%	5.4E-03	6.6E-01
N-PROPYLBENZENE	103-65-1	Laboratory			6	0		1.1E-01							0%	5.4E-03	6.6E-01
O-XYLENE	95-47-6	Laboratory			6	0		1.1E-01							0%	5.4E-03	6.6E-01
SEC-BUTYLBENZENE	135-98-8	Laboratory			6	0		1.1E-01							0%	5.4E-03	6.6E-01
STYRENE	100-42-5	Laboratory			12	0		1.2E-01							0%	5.4E-03	1.5E+00
TERT-BUTYLBENZENE	98-06-6	Laboratory			6	0		1.1E-01							0%	5.4E-03	6.6E-01
TETRACHLOROETHENE	127-18-4	Laboratory			12	1		1.2E-01	4.0E-03	4.0E-03	11/23/1993	IR12VB002	1.8	2.3	8%	5.4E-03	1.5E+00
TOLUENE	108-88-3	Laboratory			91	11		5.6E-02	4.0E-02	4.2E-01	11/21/1994	IR12GB002	5.5	6.0	12%	5.4E-03	1.5E+00
TRANS-1,2-DICHLOROETHENE	156-60-5	Laboratory			6	0		1.1E-01							0%	5.4E-03	6.6E-01
TRANS-1,3-DICHLOROPROPENE	10061-02-6	Laboratory			6	0		1.3E-01							0%	1.1E-02	1.5E+00
TRICHLOROETHENE	79-01-6	Laboratory			12	0		1.2E-01							0%	5.4E-03	1.5E+00
VINYL CHLORIDE	75-01-4	Laboratory			12	0		1.2E-01							0%	5.4E-03	1.5E+00
XYLENE (TOTAL)	1330-20-7	Laboratory			91	15		3.3E-01	9.0E-02	1.6E+01	11/18/1994	IR09GB014	6.0	6.5	16%	5.4E-03	1.5E+00
Semi-Volatile Organic Compounds																	
1,2-DICHLOROBENZENE	95-50-1	Laboratory			12	0		1.5E-01							0%	5.4E-03	6.6E-01
1,4-DICHLOROBENZENE	106-46-7	Laboratory			12	0		1.5E-01							0%	5.4E-03	6.6E-01
2,4,5-TRICHLOROPHENOL	95-95-4	Laboratory			6	0		4.8E-01							0%	8.9E-01	1.0E+00
2,4,6-TRICHLOROPHENOL	88-06-2	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
2,4-DICHLOROPHENOL	120-83-2	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
2,4-DIMETHYLPHENOL	105-67-9	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
2,4-DINITROPHENOL	51-28-5	Laboratory			6	0		4.8E-01							0%	8.9E-01	1.0E+00
2-CHLORONAPHTHALENE	91-58-7	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
2-CHLOROPHENOL	95-57-8	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
2-METHYL-4,6-DINITROPHENOL	534-52-1	Laboratory			6	0		4.8E-01							0%	8.9E-01	1.0E+00
2-METHYLNAPHTHALENE	91-57-6	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
2-METHYLPHENOL	95-48-7	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
2-NITROANILINE	88-74-4	Laboratory			6	0		4.8E-01							0%	8.9E-01	1.0E+00
2-NITROPHENOL	88-75-5	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
3,3'-DICHLOROBENZIDINE	91-94-1	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
3-NITROANILINE	99-09-2	Laboratory			6	0		4.8E-01							0%	8.9E-01	1.0E+00
4-BROMOPHENYL-PHENYLETHER	101-55-3	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
4-CHLORO-3-METHYLPHENOL	59-50-7	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
4-CHLOROANILINE	106-47-8	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
4-CHLOROPHENYL-PHENYLETHER	7005-72-3	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
4-METHYLPHENOL	106-44-5	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
4-NITROANILINE	100-01-6	Laboratory			6	0		4.8E-01							0%	8.9E-01	1.0E+00
4-NITROPHENOL	100-02-7	Laboratory			6	0		4.8E-01							0%	8.9E-01	1.0E+00
ACENAPHTHENE	83-32-9	Laboratory			15	1		2.2E-01	1.0E-01	1.0E-01	1/27/1995	12W03	3.2	4.5	7%	7.2E-02	2.0E+00
ACENAPHTHYLENE	208-96-8	Laboratory			15	0		3.6E-01							0%	1.4E-01	3.8E+00
ANTHRACENE	120-12-7	Laboratory			15	2		1.0E-01	9.9E-02	3.3E-01	1/27/1995	12W03	3.2	4.5	13%	7.2E-03	4.2E-01
BENZO(A)ANTHRACENE	56-55-3	Laboratory			15	5		2.5E-01	1.1E-02	1.3E+00	1/27/1995	12W03	3.2	4.5	33%	7.2E-03	4.2E-01

Table 4.3-2

Investigation Area C3, IR12 Statistical Summary Table of Analytical Soil Data

Future Land Use: Industrial

Land Type: Fill Material

Analyte	CAS Number	Analysis Type	Background Concentration for Metals (mg/kg)	Source of Background Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Background Concentration for Metals	Average Result (mg/kg)	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)
SOIL - IR12																	
BENZO(A)PYRENE	50-32-8	Laboratory			15	5		3.2E-01	8.1E-03	1.6E+00	1/27/1995	12W03	3.2	4.5	33%	7.2E-03	4.2E-01
BENZO(B)FLUORANTHENE	205-99-2	Laboratory			15	6		3.2E-01	9.8E-03	2.3E+00	1/27/1995	12W03	3.2	4.5	40%	7.2E-03	4.2E-01
BENZO(G,H,I)PERYLENE	191-24-2	Laboratory			6	1		2.6E-01	5.8E-01	5.8E-01	1/27/1995	12W03	3.2	4.5	17%	3.5E-01	4.2E-01
BENZO(K)FLUORANTHENE	207-08-9	Laboratory			15	2		1.5E-01	4.1E-01	6.3E-01	1/27/1995	12W03	3.2	4.5	13%	7.2E-03	4.2E-01
BIS(2-CHLOROETHOXY)METHANE	111-91-1	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
BIS(2-CHLOROETHYL)ETHER	111-44-4	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
BIS(2-CHLOROISOPROPYL)ETHER	108-60-1	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
BIS(2-ETHYLHEXYL)PHTHALATE	117-81-7	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
BUTYLBENZYLPHTHALATE	85-68-7	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
CARBAZOLE	86-74-8	Laboratory			6	1		1.9E-01	1.6E-01	1.6E-01	1/27/1995	12W03	3.2	4.5	17%	3.5E-01	4.2E-01
CHRYSENE	218-01-9	Laboratory			15	6		2.2E-01	1.3E-02	1.1E+00	1/27/1995	12W03	3.2	4.5	40%	7.2E-03	4.2E-01
DI-N-BUTYLPHTHALATE	84-74-2	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
DI-N-OCTYLPHTHALATE	117-84-0	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
DIBENZ(A,H)ANTHRACENE	53-70-3	Laboratory			15	1		1.1E-01	2.1E-01	2.1E-01	1/27/1995	12W03	3.2	4.5	7%	1.4E-02	4.2E-01
DIBENZOFURAN	132-64-9	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
DIETHYLPHTHALATE	84-66-2	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
DIMETHYLPHTHALATE	131-11-3	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
FLUORANTHENE	206-44-0	Laboratory			15	4		2.9E-01	3.7E-02	2.0E+00	1/27/1995	12W03	3.2	4.5	27%	7.2E-03	4.2E-01
FLUORENE	86-73-7	Laboratory			15	1		9.9E-02	1.0E-01	1.0E-01	1/27/1995	12W03	3.2	4.5	7%	1.4E-02	4.2E-01
HEXACHLOROBENZENE	118-74-1	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
HEXACHLOROBUTADIENE	87-68-3	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
HEXACHLOROCYCLOPENTADIENE	77-47-4	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
HEXACHLOROETHANE	67-72-1	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
INDENO(1,2,3-CD)PYRENE	193-39-5	Laboratory			15	5		2.3E-01	7.5E-03	1.0E+00	7/18/2002	IR12GB0100	1.0	1.5	33%	7.2E-03	4.2E-01
ISOPHORONE	78-59-1	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
N-NITROSO-DI-N-PROPYLAMINE	621-64-7	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
N-NITROSODIPHENYLAMINE (1)	86-30-6	Laboratory			6	0		2.0E-01							0%	3.5E-01	4.2E-01
NAPHTHALENE	91-20-3	Laboratory			15	2		2.0E-01	2.0E-02	8.8E-02	1/26/1995	12W01	6.5	7.7	13%	7.2E-02	2.0E+00
PENTACHLOROPHENOL	87-86-5	Laboratory			6	0		4.8E-01							0%	8.9E-01	1.0E+00
PHENANTHRENE	85-01-8	Laboratory			6	2		3.7E-01	4.0E-02	1.4E+00	1/27/1995	12W03	3.2	4.5	33%	3.5E-01	4.2E-01
PHENOL	108-95-2	Laboratory			6	2		3.8E-01	1.3E-01	1.3E+00	11/18/1994	IR09GB014	0.5	2.0	33%	3.5E-01	4.2E-01
PYRENE	129-00-0	Laboratory			15	7		3.5E-01	2.8E-02	2.0E+00	1/27/1995	12W03	3.2	4.5	47%	7.2E-03	4.2E-01
PCB Compounds																	
AROCLOR-1016	12674-11-2	Laboratory			45	0		4.2E-02							0%	3.5E-02	4.3E-01
AROCLOR-1221	11104-28-2	Laboratory			45	0		5.3E-02							0%	3.5E-02	8.5E-01
AROCLOR-1232	11141-16-5	Laboratory			45	0		4.2E-02							0%	3.5E-02	4.3E-01
AROCLOR-1242	53469-21-9	Laboratory			45	0		4.2E-02							0%	3.5E-02	4.3E-01
AROCLOR-1248	12672-29-6	Laboratory			45	0		4.2E-02							0%	3.5E-02	4.3E-01
AROCLOR-1254	11097-69-1	Laboratory			45	1		5.3E-02	5.6E-01	5.6E-01	7/18/2002	IR12GB0106	1.0	1.5	2%	3.5E-02	4.3E-01
AROCLOR-1260	11096-82-5	Laboratory			121	26		5.3E+00	5.0E-02	4.2E+02	1/23/1995	IR12VB007	2.2	2.7	21%	3.5E-02	4.3E-01
Pesticides																	
4,4'-DDD	72-54-8	Laboratory			10	0		5.3E-03							0%	4.0E-03	4.3E-02
4,4'-DDE	72-55-9	Laboratory			10	0		5.3E-03							0%	4.0E-03	4.3E-02
4,4'-DDT	50-29-3	Laboratory			10	0		5.3E-03							0%	4.0E-03	4.3E-02
ALDRIN	309-00-2	Laboratory			10	0		2.6E-03							0%	2.0E-03	2.1E-02
ALPHA-BHC	319-84-6	Laboratory			10	0		2.6E-03							0%	2.0E-03	2.1E-02

Table 4.3-2

Investigation Area C3, IR12 Statistical Summary Table of Analytical Soil Data

Future Land Use: Industrial

Land Type: Fill Material

Analyte	CAS Number	Analysis Type	Background Concentration for Metals (mg/kg)	Source of Background Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Background Concentration for Metals	Average Result (mg/kg)	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)
SOIL - IR12																	
ALPHA-CHLORDANE	5103-71-9	Laboratory			10	0		2.6E-03							0%	2.0E-03	2.1E-02
BETA-BHC	319-85-7	Laboratory			10	0		2.6E-03							0%	2.0E-03	2.1E-02
DELTA-BHC	319-86-8	Laboratory			10	0		2.6E-03							0%	2.0E-03	2.1E-02
DIELDRIN	60-57-1	Laboratory			10	0		5.3E-03							0%	4.0E-03	4.3E-02
ENDOSULFAN I	959-98-8	Laboratory			10	0		2.6E-03							0%	2.0E-03	2.1E-02
ENDOSULFAN II	33213-65-9	Laboratory			10	0		5.3E-03							0%	4.0E-03	4.3E-02
ENDOSULFAN SULFATE	1031-07-8	Laboratory			10	0		5.3E-03							0%	4.0E-03	4.3E-02
ENDRIN	72-20-8	Laboratory			10	0		5.3E-03							0%	4.0E-03	4.3E-02
ENDRIN ALDEHYDE	7421-93-4	Laboratory			10	0		5.3E-03							0%	4.0E-03	4.3E-02
ENDRIN KETONE	53494-70-5	Laboratory			10	0		5.3E-03							0%	4.0E-03	4.3E-02
GAMMA-BHC (LINDANE)	58-89-9	Laboratory			10	0		2.6E-03							0%	2.0E-03	2.1E-02
GAMMA-CHLORDANE	12789-03-6	Laboratory			10	0		2.6E-03							0%	2.0E-03	2.1E-02
HEPTACHLOR	76-44-8	Laboratory			10	0		2.6E-03							0%	2.0E-03	2.1E-02
HEPTACHLOR EPOXIDE	1024-57-3	Laboratory			10	0		2.6E-03							0%	2.0E-03	2.1E-02
METHOXYCHLOR	72-43-5	Laboratory			10	0		2.6E-02							0%	2.0E-02	2.1E-01
TOXAPHENE	8001-35-2	Laboratory			10	0		2.6E-01							0%	2.0E-01	2.1E+00
Metals																	
ALUMINUM	7429-90-5	Laboratory	3.5E+04	b	10	10	0	1.6E+04	6.4E+03	2.8E+04	11/23/1993	IR12VB002	1.8	2.3	100%	2.2E+00	6.5E+00
ANTIMONY	7440-36-0	XRF	8.5E+00	b	22	6	0	4.6E+00	2.6E+00	4.8E+00	11/23/1993	IR12VB002	1.8	2.3	27%	1.0E+01	1.0E+01
ANTIMONY	7440-36-0	Laboratory	8.5E+00	b	9	1	0	1.7E-01	3.9E-01	3.9E-01	1/27/1995	12W03	3.2	4.5	11%	2.3E-01	4.1E-01
ARSENIC	7440-38-2	Laboratory	3.6E+01	b	10	10	0	8.3E+00	1.1E+00	1.3E+01	11/22/1994	IR12GB004	10.5	12.0	100%	3.6E-01	6.8E-01
BARIUM	7440-39-3	Laboratory			10	10	0	1.7E+02	3.2E+01	2.5E+02	11/29/1994	IR12GB006	5.5	6.5	100%	8.1E-01	2.0E+00
BERYLLIUM	7440-41-7	Laboratory	9.0E-01	b	10	4	1	3.2E-01	3.3E-01	1.8E+00	11/23/1993	IR12VB002	1.8	2.3	40%	2.0E-02	2.5E-01
CADMIUM	7440-43-9	XRF	5.2E+00	b	22	2	0	4.8E+00	2.3E+00	3.2E+00	1/26/1995	12W02	7.0	7.5	9%	1.0E+01	1.0E+01
CADMIUM	7440-43-9	Laboratory	5.2E+00	b	10	6	0	5.6E-01	3.5E-01	2.2E+00	11/29/1994	IR12GB006	0.5	2.8	60%	4.0E-02	5.0E-01
CALCIUM	7440-70-2	XRF			22	22	0	3.2E+04	8.4E+03	8.8E+04	1/27/1995	12W03	10.0	10.5	100%	1.0E+01	1.0E+01
CALCIUM	7440-70-2	Laboratory			10	10	0	2.9E+04	3.1E+03	9.4E+04	11/29/1994	IR12GB006	0.5	2.8	100%	1.7E+00	4.7E+01
CHROMIUM	7440-47-3	XRF	1.4E+02	b	22	22	2	1.1E+02	7.0E+01	1.6E+02	1/27/1995	12W03	13.0	13.5	100%	1.0E+01	1.0E+01
CHROMIUM	7440-47-3	Laboratory	1.4E+02	b	10	10	0	3.4E+01	9.3E+00	7.5E+01	11/22/1994	IR12GB004	10.5	12.0	100%	1.7E-01	1.3E+00
COBALT	7440-48-4	XRF			22	0	0	5.4E+00							0%	1.0E+01	2.8E+01
COBALT	7440-48-4	Laboratory			10	9	0	1.6E+01	3.5E+00	2.6E+01	11/18/1994	IR09GB014	0.5	2.0	90%	1.2E-01	1.8E+00
COPPER	7440-50-8	XRF	1.2E+02	b	22	22	1	8.3E+01	3.3E+01	1.2E+02	11/18/1994	IR09GB014	6.0	6.5	100%	1.0E+01	1.0E+01
COPPER	7440-50-8	Laboratory	1.2E+02	b	10	10	0	5.8E+01	3.4E+01	6.8E+01	11/29/1994	IR12GB006	0.5	2.8	100%	6.0E-02	1.3E+00
HEXAVALENT CHROMIUM	18540-29-9	Laboratory			4	0	0	2.5E-02							0%	5.0E-02	5.0E-02
IRON	7439-89-6	XRF	6.2E+04	b	22	22	0	4.5E+04	3.3E+04	5.8E+04	11/30/1993	IR12VB003	5.6	6.1	100%	1.0E+01	1.0E+01
IRON	7439-89-6	Laboratory	6.2E+04	b	10	10	0	3.1E+04	2.4E+04	4.1E+04	11/18/1994	IR09GB014	0.5	2.0	100%	2.2E+00	4.3E+00
LEAD	7439-92-1	XRF	5.9E+01	b	22	22	4	3.2E+01	1.0E+01	1.9E+02	11/30/1993	IR12VB003	3.3	3.8	100%	1.0E+01	1.0E+01
LEAD	7439-92-1	Laboratory	5.9E+01	b	16	16	5	1.7E+02	8.3E+00	1.3E+03	11/29/1994	IR12GB006	0.5	2.8	100%	1.3E-01	4.5E+01
MAGNESIUM	7439-95-4	Laboratory			10	10	0	9.2E+03	2.7E+03	1.2E+04	11/18/1994	IR09GB014	0.5	2.0	100%	2.4E+00	3.5E+01
MANGANESE	7439-96-5	XRF	1.6E+03	b	22	22	7	1.4E+03	4.7E+02	3.9E+03	1/27/1995	12W03	7.0	7.5	100%	1.0E+01	1.0E+01
MANGANESE	7439-96-5	Laboratory	1.6E+03	b	10	10	1	9.4E+02	1.4E+02	2.9E+03	11/29/1994	IR12GB006	5.5	6.5	100%	6.0E-02	7.5E-01
MERCURY	7439-97-6	Laboratory	2.0E+00	b	10	8	1	9.2E-01	9.0E-02	7.0E+00	11/29/1994	IR12GB006	0.5	2.8	80%	2.0E-02	6.0E-01
MOLYBDENUM	7439-98-7	XRF			22	0	0	5.0E+00							0%	1.0E+01	1.0E+01
MOLYBDENUM	7439-98-7	Laboratory			10	0	0	2.3E-01							0%	1.5E-01	2.3E+00
NICKEL	7440-02-0	XRF	1.3E+02	b	22	22	0	6.3E+01	3.5E+01	9.6E+01	11/18/1994	IR09GB014	15.0	15.5	100%	1.0E+01	1.0E+01
NICKEL	7440-02-0	Laboratory	1.3E+02	b	10	10	0	4.1E+01	9.3E+00	8.4E+01	11/22/1994	IR12GB004	10.5	12.0	100%	3.0E-01	2.5E+00
POTASSIUM	7440-09-7	XRF			22	22	0	1.5E+04	1.1E+04	1.9E+04	11/18/1994	IR09GB014	12.0	12.5	100%	1.0E+01	1.0E+01

Table 4.3-2

Investigation Area C3, IR12 Statistical Summary Table of Analytical Soil Data

Future Land Use: Industrial

Land Type: Fill Material

Analyte	CAS Number	Analysis Type	Background Concentration for Metals (mg/kg)	Source of Background Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Background Concentration for Metals	Average Result (mg/kg)	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)
SOIL - IR12																	
POTASSIUM	7440-09-7	Laboratory			10	10	0	1.8E+03	2.0E+02	3.3E+03	1/26/1995	12W01	6.5	7.7	100%	1.2E+01	4.3E+02
SELENIUM	7782-49-2	Laboratory			10	0	0	2.9E-01							0%	4.9E-01	8.6E-01
SILVER	7440-22-4	XRF			22	1	0	5.0E+00	4.1E+00	4.1E+00	1/26/1995	12W02	4.0	4.5	5%	1.0E+01	1.0E+01
SILVER	7440-22-4	Laboratory			10	0	0	1.0E-01							0%	9.0E-02	1.0E+00
SODIUM	7440-23-5	Laboratory			10	9	0	1.1E+03	3.8E+02	3.3E+03	11/22/1994	IR12GB004	10.5	12.0	90%	1.9E+01	3.4E+01
THALLIUM	7440-28-0	Laboratory		d	10	0	0	2.5E-01							0%	4.3E-01	7.5E-01
TIN	7440-31-5	XRF			22	22	0	1.1E+01	6.8E+00	2.4E+01	11/30/1993	IR12VB003	3.3	3.8	100%	1.0E+01	1.0E+01
TITANIUM	7440-32-6	XRF			22	22	0	3.7E+03	2.8E+03	4.8E+03	1/27/1995	12W03	13.0	13.5	100%	1.0E+01	1.0E+01
VANADIUM	7440-62-2	XRF	1.9E+02	b	22	22	0	1.3E+02	9.0E+01	1.8E+02	1/27/1995	12W03	13.0	13.5	100%	1.0E+01	1.0E+01
VANADIUM	7440-62-2	Laboratory	1.9E+02	b	10	10	0	6.1E+01	1.5E+01	1.4E+02	11/18/1994	IR09GB014	0.5	2.0	100%	1.2E-01	1.1E+01
ZINC	7440-66-6	XRF	2.3E+02	b	22	22	2	1.2E+02	6.5E+01	3.1E+02	11/30/1993	IR12VB003	3.3	3.8	100%	1.0E+01	1.0E+01
ZINC	7440-66-6	Laboratory	2.3E+02	b	10	10	1	2.3E+02	7.2E+01	1.4E+03	11/29/1994	IR12GB006	0.5	2.8	100%	2.0E-02	1.0E+00
General Chemistry																	
TOC	7440-44-0	Laboratory			5	3		6.1E+03	9.3E+03	1.1E+04	11/29/1994	IR12GB006	0.5	2.8	60%	1.1E+02	1.9E+02

[1] - Source Definition

a - Ambient Background Concentration (95th percentile) at Mare Island Naval Shipyard
b - Ambient Metal Concentrations in Artificial Fill - Mare Island
c - Ambient Metal Concentrations in Original Island Soil - Mare Island
d - At the request of the regulatory agencies, the ambient limit was set to the detection limit.

Data from the following types of samples were excluded from this statistical summary query: 1) duplicate or other quality control samples; 2) split samples; 3) removed samples; and 4) samples analyzed using the toxicity characteristic leaching procedure (TCLP) or by the waste extraction test (WET). In addition, rejected data was excluded from this query.

FIGURE 4.3-2
AROCLOR-1260 CONCENTRATIONS IN SOIL AT IR12
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

CH2MHILL

\\Thor\Cart1\rddgis\mare_island\gis-graphics\Mare_island2\Apr_files_sfo\Area_C3_task\RI_TASK\Apr_files\ri_soil.apr C3RI_fig4_3-2soil_AR.pdf 1:26 p.m. 05-20-2003

Several soil samples were collected adjacent to utility lines at IR09 to assess the potential for the utility lines to act as a preferential transport pathway for PCBs through the bulk soils. Soil samples collected along utility lines east of Building 516 and 332 (and oriented perpendicular to Mare Island Strait), including the storm sewer line leading to Outfall STS-21, as well as along the storm sewer line south of Building 516 leading to Outfall STS-22, indicated no significant transport of PCB contamination. Adjacent to storm and electrical lines oriented perpendicular to Mare Island Strait and east of Buildings 516 and 332, Aroclor-1260 was detected in two of four samples at a maximum concentration of 0.62 mg/kg. Along the storm sewer south of Building 516 (leading to Outfall STS-22), eight samples were collected from five points along the line. Aroclor-1260 was detected in two of eight samples at a maximum concentration of 1.7 mg/kg.

4.3.2.2 Petroleum Hydrocarbon Compounds

As an indicator of impacts from industrial operations other than the use of PCB-containing equipment at IR12, characterization of soils at IR12 also focused on petroleum hydrocarbon compounds. Over 85 soil samples collected from throughout IR12 were analyzed for petroleum hydrocarbons. Figure 4.3-3 shows the distribution of the most frequently detected petroleum hydrocarbon in soil at IR12, TPH-gasoline-range organics.

TPH-gasoline-range organics. TPH-gasoline-range organics were found in 23 soil samples (out of 87 samples analyzed). Of the 23 detected TPH-gasoline-range organics concentrations in soil samples at IR12, approximately 50 percent were less than 100 mg/kg, and 80 percent were less than 1,000 mg/kg. Samples with TPH-gasoline-range organics concentrations greater than 100 were found in two general locations: to the north of Building 516 and to the east of Building 332.

Three of the four samples with TPH-gasoline-range organics concentrations greater than 1,000 mg/kg were collected in a localized area north of Buildings 516 and 332, near the boundary of the IR09 site. These samples were collected from IR09GB014, IR12GB006, and IR12VB003, in 1993 and 1994 at depths of 5 to 7 feet bgs, and contained TPH-gasoline-range organics at concentrations of 4,400, 3,000, and 2,800 mg/kg, respectively. There is no known source of elevated TPH-gasoline-range organics concentrations in this area, although based on the depth, relative location and type of petroleum hydrocarbon identified, the TPH-gasoline-range organics concentrations in this area may be associated with the former USTs at IR09 (USTs 334-1, 334-2, 334-3, and 334-4). TPH-gasoline-range organics concentrations in deeper soil samples in this area (greater than 7 feet bgs) were less than 100 mg/kg.

Soil samples with TPH-gasoline-range organics concentrations greater than 100 mg/kg were also found in four borings east of Building 516. Detected TPH-gasoline-range organics concentrations from IR12GB010, IR12GB001, 12W01, and IR12GB0108 ranged from 140 to 3,200 mg/kg in samples collected from 5 to 10 feet bgs.

TPH-diesel-range organics. TPH-diesel-range organics were found in nine soil samples (out of 90 analyzed) at IR12. All concentrations of TPH-diesel-range organics at IR12 were less than 1,000 mg/kg, and eight of nine detected TPH diesel-range organics concentrations were less than 500 mg/kg. The highest detected TPH-diesel-range organics concentration of 930 mg/kg was found in IR12GB010 in 1994 at 8.5 to 9 feet bgs. This sample is located east

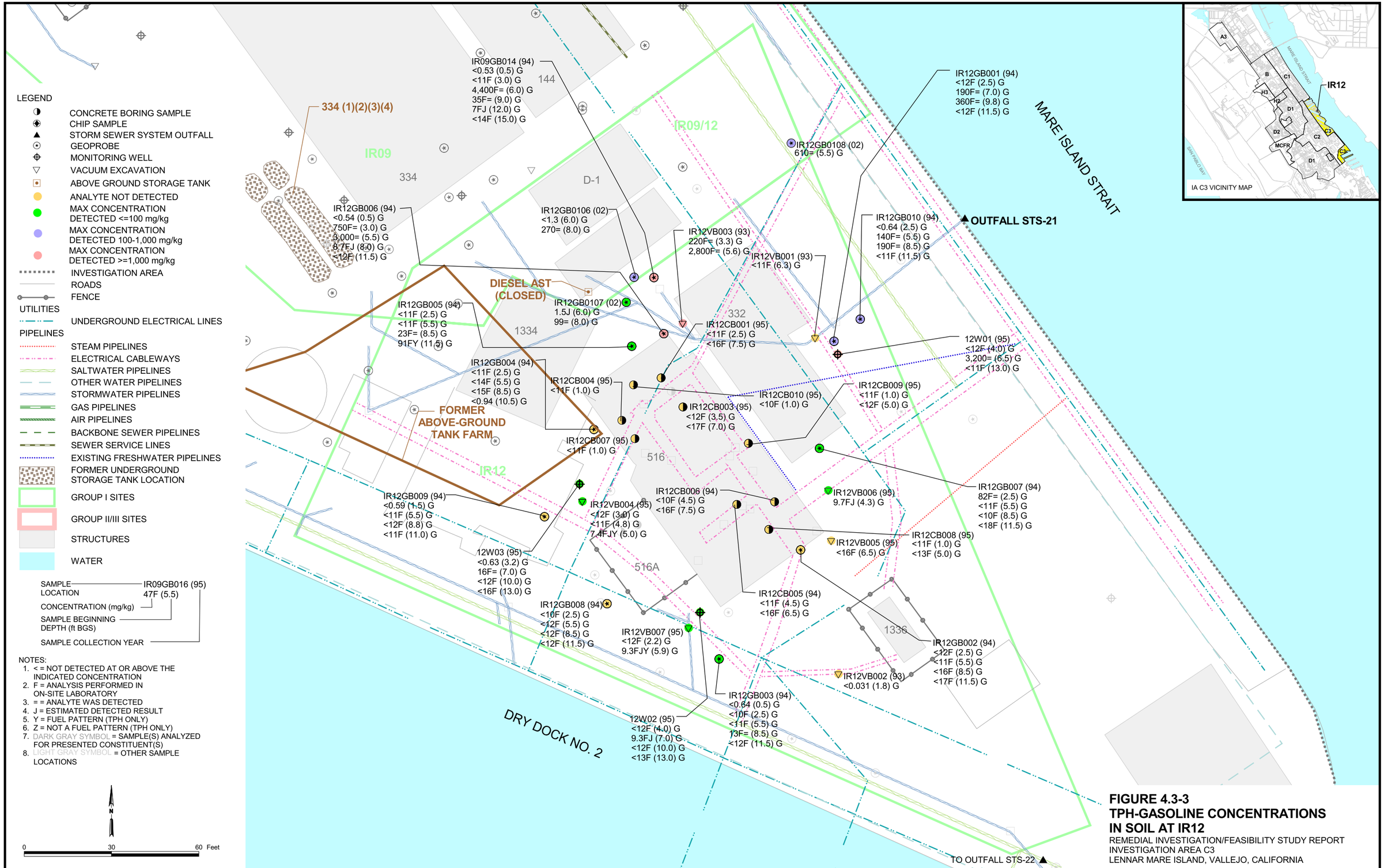

FIGURE 4.3-3
TPH-GASOLINE CONCENTRATIONS IN SOIL AT IR12
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of Building 332 and not associated with a known source. Detected concentrations of TPH-diesel-range organics were found in sporadic locations throughout the IR12 site, and no pattern of distribution is discernable from the data.

TPH-motor-oil-range Organics. TPH-motor-oil-range organics were found in 17 soil samples (out of 90 analyzed) at IR12. The highest TPH-motor-oil-range organics concentration of 1,200 mg/kg was found in a surface soil sample collected from IR12GB003 in 1994. This is located south of Building 516. Other than this sample, all other detected concentrations of TPH-motor-oil-range organics were below 1,000 mg/kg, and approximately 65 percent were less than 100 mg/kg. Detected concentrations of TPH-motor-oil-range organics were found in sporadic locations throughout the IR12 site, and no pattern of distribution is discernable from the data.

4.3.2.3 VOC Compounds

As shown in Table 4.3-2, VOC compounds generally were not detected in soil samples collected from IR12, with the exception of a few of the BTEX compounds. These results are discussed below.

BTEX Compounds. Ninety-one soil samples collected from throughout IR12 were analyzed for BTEX compounds. Benzene was not detected in any of the 91 samples; ethylbenzene was detected in 14 of 91 samples (at concentrations ranging from 0.03 to 1.9 mg/kg); toluene was detected in 11 of 91 samples (at concentrations ranging from 0.04 to 0.42 mg/kg); and toluene was detected in 15 of 91 samples (at concentrations ranging from 0.09 to 1.6 mg/kg). Approximately 33 percent of the detected BTEX concentrations were quantified at concentrations below the analytical reporting limit.

The general distribution of detected BTEX compounds in soil at IR12 corresponds with the distribution of TPH-gasoline. Soil samples with the highest (i.e., greater than 1 mg/kg) detected concentrations of BTEX compounds were found in the same locations with the highest TPH-gasoline concentrations (e.g., IR09GB014, IR12GB006, IR12VB003) in soil at IR12, in the area outside the northeast corner of Building 516 in the 5- to 7-foot bgs range.

Low levels of BTEX compounds (less than 1 mg/kg) were also found at sporadic locations to the east, south, and west of Building 516, between 3 and 16 feet bgs, in no discernable pattern.

The maximum concentrations of ethylbenzene, toluene, and xylenes found in soil at IR12 are several orders of magnitude less than the respective USEPA Region 9 PRGs of 2, 520, and 420 mg/kg for the direct-contact exposure pathway in an industrial setting. Further, the maximum concentrations of ethylbenzene, toluene, and xylenes found in soil at IR12 are less than the respective RWQCB ESL of 13, 9.3, and 1.5 mg/kg for soil where groundwater is not a current or potential source of drinking water.

Other VOCs. The only other VOC detected in soil samples from IR12 was TCE, which was detected in one of 12 samples at a concentration of 0.004 mg/kg (less than the USEPA Region 9 PRG of 0.11 mg/kg).

4.3.2.4 SVOC Compounds

As shown in Table 4.3-2, SVOC compounds were detected infrequently in soil samples from IR12. Of the SVOC compounds found at IR12, the most frequently detected were PAHs.

Polynuclear Aromatic Hydrocarbons. Fifteen soil samples collected from IR12 were analyzed for PAHs. As shown in Table 4.3-2, 15 different PAH compounds were detected: acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene. These compounds were found in between one and seven of the 15 soil samples collected from IR12 and analyzed for PAHs.

Concentrations of detected PAH compounds ranged from 0.0075 mg/kg (indeno(1,2,3-cd)pyrene) to 2.3 mg/kg (benzo(b)fluoranthene). Of the PAH results identified in Table 4.3-2 as detected results, approximately 20 percent were quantified at concentrations lower than the analytical reporting limit. With the exception of select PAHs in three samples, the PAHs in soil samples at IR12 were found at concentrations less than the USEPA Region 9 PRGs for the direct-contact exposure pathway in an industrial setting and the RWQCB ESLs for soil where groundwater is not a current or potential source of drinking water.

The maximum concentration of 13 of 15 PAH compounds was found in one sample collected from 12W03, located west of Building 516, at 3.2 feet bgs. This sample location does not correspond with patterns of detected PCBs or TPH at IR12. The concentration of benzo(a)pyrene, benzo(b)fluoranthene, and benzo(g,h,i)perylene, exceeded the respective USEPA Region 9 PRG or ESL in three soil samples collected at IR12. The samples with PAH concentrations exceeding the USEPA Region 9 PRG or ESL were collected from 12W03 (west of Building 516) at 3.2 feet bgs, as well as surface soil samples collected from IR12GB0100 and IR12GB0101 (south of Building 516). The occurrence of PAHs is likely indicative of asphalt or creosote incorporated into the shallow soil as a result of surface asphalt repairs performed over the decades of industrial operations in the vicinity of IR12.

Other SVOC Compounds. The only other SVOC compounds detected in soil at IR12 were carbazole (detected in one of six samples) and phenol (detected in two of six samples). No pesticide compounds were found in soil samples collected from IR12. Carbazole was detected at a concentration of 0.16 mg/kg, which is less than the reporting limit of 0.42 mg/kg (and less than the USEPA Region 9 PRG of 86 mg/kg for the direct-contact exposure pathway in an industrial setting). Phenol was detected at a maximum concentration of 1.3 mg/kg (less than the USEPA Region 9 PRG of 100,000 mg/kg for the direct-contact exposure pathway in an industrial setting

4.3.2.5 Metals

Table 4.3-2 provides of summary of metals results in soil samples collected from IR12, and distinguishes the results between “laboratory” analysis and “XRF” analysis. Laboratory analysis means analysis of soil samples by an off-site laboratory using CLP methods. XRF analysis means analysis of soil samples by the Navy’s Mare Island on-site laboratory using XRF methodology. Seventeen of the 25 metals listed in Table 4.3-2 were analyzed for in soil samples collected from IR12 by both laboratory analysis and by XRF analysis. Ten metals

were analyzed for by laboratory analysis, only and two metals (tin and titanium) were analyzed by XRF methods only. In general, approximately twice as many samples were analyzed for metals by XRF methodology as were analyzed by CLP methods.

As discussed in Section 2.3, ambient values of select metals in both native island materials and fill soils at Mare Island have been established. Ambient values for selected metals at Mare Island establish naturally-occurring conditions against which site concentrations can be compared to identify conditions that may be attributable to site activities. Table 4.3-2 shows the ambient value for fill soils (appropriate because of the location of IR12) and identifies the number of samples with metals results greater than the respective ambient concentration. Of the 27 metals analyzed for in soil samples collected from IR12, ambient levels have been established for 15.

As indicated in Table 4.3-2, five different metals (beryllium, lead, manganese, mercury, and zinc) were found at concentrations exceeding the ambient value for fill materials by CLP methods. The metal most frequently found at concentrations exceeding the ambient level in soil samples collected from IR12 was lead; the distribution of lead in soil at IR 12 is shown in Figure 4.3-4.

Five of the 16 soil samples analyzed by CLP methods contained lead at concentrations exceeding the ambient concentration for lead in fill materials (59 mg/kg). The soil sample with the highest lead concentration (1,300 mg/kg) was collected in surface soil at IR12GB006. Other lead concentrations found in soil samples at IR12, both by laboratory and by XRF methodologies, were below 530 mg/kg, and most (over 75 percent) were below the established ambient concentration.

The sample with the highest lead concentration (IR12GB006 at 0.5 to 2.8 feet bgs), is located outside and near the northeast corner of Building 516. This is in the same general area where abrasive blast material was identified in borings IR12GB0106 and IR12GB006. This sample also contained the highest concentration of mercury and zinc found in soil samples at IR12 above the respective ambient value. A nearby sample (IR12VB003 at 3.3 to 3.8 feet bgs), located outside the northeast corner of Building 516, had lead, manganese, and zinc concentrations, by XRF, greater than the established ambient concentrations. The other seven soil samples with lead concentrations greater than the ambient value, both by CLP and XRF methods, were located at sporadic locations throughout IR12.

4.3.3 Groundwater

A summary of groundwater data for IR12 is provided in Table 4.3-3. For each compound, the table shows the number of samples analyzed, the number of detected results of that compound[10], the average result, the maximum result, and the frequency of detection. For metals analysis, the table shows the ambient concentration for shallow groundwater at Mare Island (see also Table 2.3-2) and identifies the number of samples with metal results greater than the respective ambient concentration.

[10] Includes those samples for which a compound was quantified at a concentration below the analytical reporting limit.

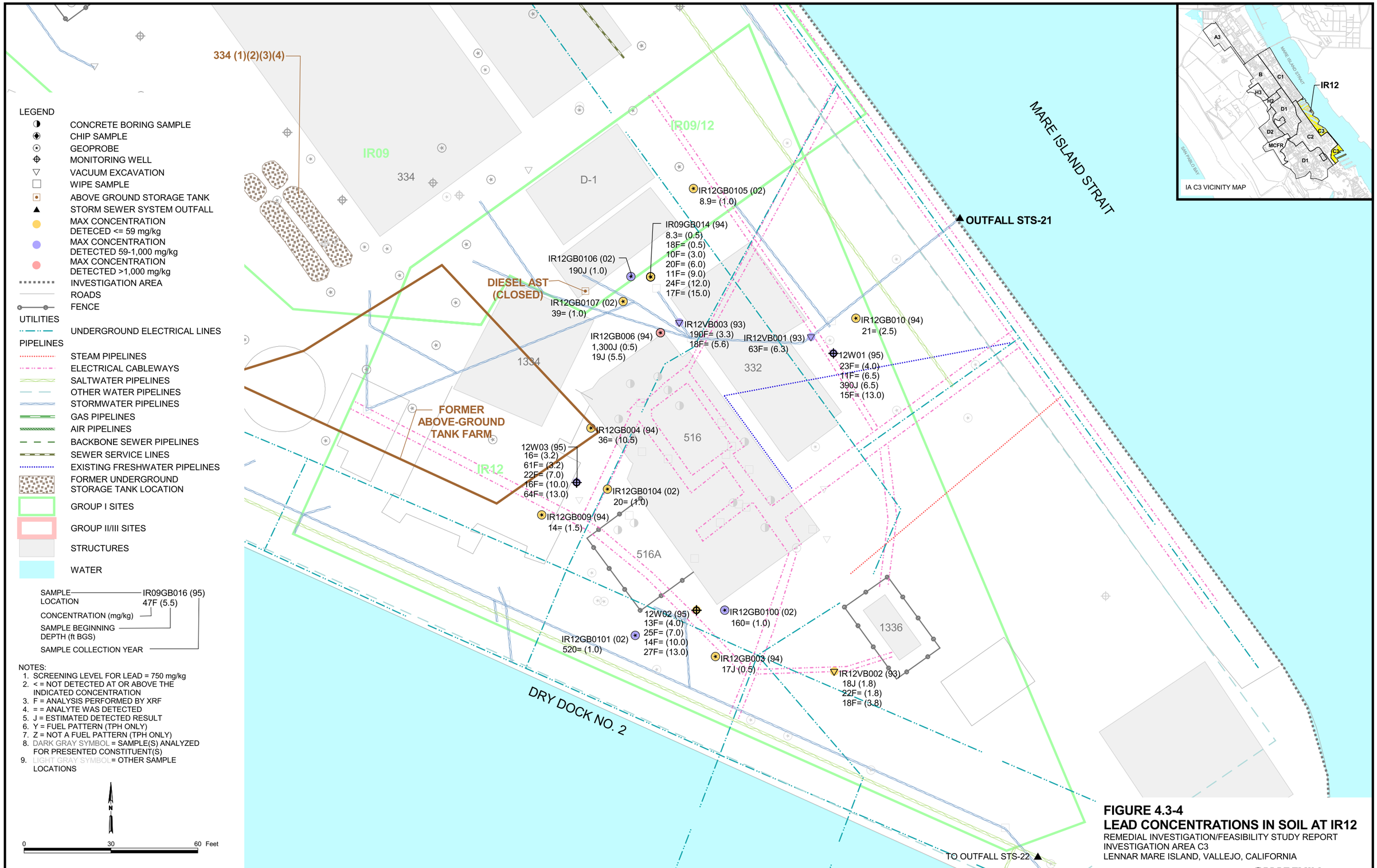

FIGURE 4.3-4
LEAD CONCENTRATIONS IN SOIL AT IR12
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Table 4.3-3

Investigation Area C3, IR12 Statistical Summary Table of Analytical Groundwater Data

Analyte	CAS Number	Filtered/ Unfiltered	Ambient Concentration for Metals (ug/L)	Source of Ambient Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Ambient Concentration for Metals	Average Result (ug/L)	Minimum Detection (ug/L)	Maximum Detection (ug/L)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (ug/L)	Maximum Detection Limit (ug/L)
WATER - IR12																	
Petroleum Hydrocarbon Compounds																	
DIESEL	DRO	Unfiltered			18	4		2.2E+02	2.6E+02	7.0E+02	5/22/1998	12W02			22%	1.0E+02	5.0E+02
GASOLINE	GRO	Unfiltered			17	9		2.5E+02	2.5E+01	1.8E+03	6/25/1999	12W02			53%	5.0E+01	1.0E+02
MOTOR OIL	MRO	Unfiltered			18	2		1.6E+02	1.4E+02	1.6E+02	8/21/1998	12W01			11%	1.0E+02	5.0E+02
Volatile Organic Compounds																	
1,1,1-TRICHLOROETHANE	71-55-6	Unfiltered			12	0		6.7E-01							0%	1.0E+00	5.0E+00
1,1,2,2-TETRACHLOROETHANE	79-34-5	Unfiltered			18	0		6.1E-01							0%	1.0E+00	5.0E+00
1,1,2-TRICHLOROETHANE	79-00-5	Unfiltered			18	0		6.1E-01							0%	1.0E+00	5.0E+00
1,1-DICHLOROETHANE	75-34-3	Unfiltered			12	0		6.7E-01							0%	1.0E+00	5.0E+00
1,1-DICHLOROETHENE	75-35-4	Unfiltered			18	0		6.1E-01							0%	1.0E+00	5.0E+00
1,2,4-TRICHLOROBENZENE	120-82-1	Unfiltered			12	5		2.1E+02	7.0E+00	8.4E+02	5/22/1998	12W02			42%	1.0E+00	1.0E+02
1,2-DIBROMO-3-CHLOROPROPANE	96-12-8	Unfiltered			12	0		6.7E-01							0%	1.0E+00	5.0E+00
1,2-DICHLOROETHANE	107-06-2	Unfiltered			18	0		4.9E-01							0%	5.0E-01	5.0E+00
1,2-DICHLOROPROPANE	78-87-5	Unfiltered			18	0		6.1E-01							0%	1.0E+00	5.0E+00
1,3-DICHLOROBENZENE	541-73-1	Unfiltered			18	7		4.2E+01	5.0E+00	2.2E+02	5/22/1998	12W02			39%	1.0E+00	1.0E+02
2-HEXANONE	591-78-6	Unfiltered			12	0		3.3E+00							0%	5.0E+00	2.5E+01
4-METHYL-2-PENTANONE	108-10-1	Unfiltered			12	0		3.3E+00							0%	5.0E+00	2.5E+01
ACETONE	67-64-1	Unfiltered			1	0		5.0E-01							0%	1.0E+00	1.0E+00
ACROLEIN	107-02-8	Unfiltered			3	0		1.0E+01							0%	2.0E+01	2.0E+01
ACRYLONITRILE	107-13-1	Unfiltered			6	0		1.0E+01							0%	2.0E+01	2.0E+01
BENZENE	71-43-2	Unfiltered			18	0		4.9E-01							0%	5.0E-01	5.0E+00
BROMOCHLOROMETHANE	74-97-5	Unfiltered			12	0		6.7E-01							0%	1.0E+00	5.0E+00
BROMODICHLOROMETHANE	75-27-4	Unfiltered			18	0		6.1E-01							0%	1.0E+00	5.0E+00
BROMOFORM	75-25-2	Unfiltered			18	0		6.1E-01							0%	1.0E+00	5.0E+00
BROMOMETHANE	74-83-9	Unfiltered			18	0		6.1E-01							0%	1.0E+00	5.0E+00
CARBON DISULFIDE	75-15-0	Unfiltered			12	0		6.7E-01							0%	1.0E+00	5.0E+00
CARBON TETRACHLORIDE	56-23-5	Unfiltered			18	0		4.9E-01							0%	5.0E-01	5.0E+00
CHLOROBENZENE	108-90-7	Unfiltered			18	6		2.2E+00	1.0E+00	1.9E+01	6/25/1999	12W03			33%	1.0E+00	5.0E+00
CHLOROETHANE	75-00-3	Unfiltered			12	0		6.7E-01							0%	1.0E+00	5.0E+00
CHLOROFORM	67-66-3	Unfiltered			12	0		6.7E-01							0%	1.0E+00	5.0E+00
CHLOROMETHANE	74-87-3	Unfiltered			12	0		6.7E-01							0%	1.0E+00	5.0E+00
CIS-1,2-DICHLOROETHENE	156-59-2	Unfiltered			12	0		6.7E-01							0%	1.0E+00	5.0E+00
CIS-1,3-DICHLOROPROPENE	10061-01-5	Unfiltered			12	0		4.8E-01							0%	5.0E-01	5.0E+00
DIBROMOCHLOROMETHANE	124-48-1	Unfiltered			18	0		6.1E-01							0%	1.0E+00	5.0E+00
ETHYLBENZENE	100-41-4	Unfiltered			18	0		6.1E-01							0%	1.0E+00	5.0E+00
ETHYLENE DIBROMIDE	106-93-4	Unfiltered			12	0		6.7E-01							0%	1.0E+00	5.0E+00
METHYL TERTIARY BUTYLETHER	1634-04-4	Unfiltered			1	0		1.0E+00							0%	2.0E+00	2.0E+00
METHYLENE CHLORIDE	75-09-2	Unfiltered			18	0		8.6E-01							0%	1.0E+00	5.0E+00
STYRENE	100-42-5	Unfiltered			12	0		6.7E-01							0%	1.0E+00	5.0E+00
TETRACHLOROETHENE	127-18-4	Unfiltered			18	0		6.1E-01							0%	1.0E+00	5.0E+00
TOLUENE	108-88-3	Unfiltered			18	0		6.1E-01							0%	1.0E+00	5.0E+00
TRANS-1,2-DICHLOROETHENE	156-60-5	Unfiltered			18	0		6.1E-01							0%	1.0E+00	5.0E+00
TRANS-1,3-DICHLOROPROPENE	10061-02-6	Unfiltered			12	0		4.8E-01							0%	5.0E-01	5.0E+00
TRICHLOROETHENE	79-01-6	Unfiltered			18	0		6.1E-01							0%	1.0E+00	5.0E+00
VINYL CHLORIDE	75-01-4	Unfiltered			18	0		4.9E-01							0%	5.0E-01	5.0E+00
XYLENE (TOTAL)	1330-20-7	Unfiltered			12	0		6.7E-01							0%	1.0E+00	5.0E+00

Table 4.3-3

Investigation Area C3, IR12 Statistical Summary Table of Analytical Groundwater Data

Analyte	CAS Number	Filtered/ Unfiltered	Ambient Concentration for Metals (ug/L)	Source of Ambient Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Ambient Concentration for Metals	Average Result (ug/L)	Minimum Detection (ug/L)	Maximum Detection (ug/L)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (ug/L)	Maximum Detection Limit (ug/L)
WATER - IR12																	
Semi-Volatile Organic Compounds																	
1,2-DICHLOROBENZENE	95-50-1	Unfiltered			18	4		3.5E+00	6.0E+00	2.2E+01	5/22/1998	12W02			22%	1.0E+00	5.0E+00
1,4-DICHLOROBENZENE	106-46-7	Unfiltered			18	8		3.8E+01	6.0E+00	1.8E+02	5/22/1998	12W02			44%	1.0E+00	1.0E+02
2,4,5-TRICHLOROPHENOL	95-95-4	Unfiltered			12	0		1.0E+01							0%	1.0E+01	2.6E+01
2,4,6-TRICHLOROPHENOL	88-06-2	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
2,4-DICHLOROPHENOL	120-83-2	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
2,4-DIMETHYLPHENOL	105-67-9	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
2,4-DINITROPHENOL	51-28-5	Unfiltered			12	0		1.0E+01							0%	1.0E+01	2.6E+01
2-CHLORONAPHTHALENE	91-58-7	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
2-CHLOROPHENOL	95-57-8	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
2-METHYL-4,6-DINITROPHENOL	534-52-1	Unfiltered			12	0		1.0E+01							0%	1.0E+01	2.6E+01
2-METHYLNAPHTHALENE	91-57-6	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
2-METHYLPHENOL	95-48-7	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
2-NITROANILINE	88-74-4	Unfiltered			12	0		1.0E+01							0%	1.0E+01	2.6E+01
2-NITROPHENOL	88-75-5	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
3,3'-DICHLOROBENZIDINE	91-94-1	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
3-NITROANILINE	99-09-2	Unfiltered			12	0		1.0E+01							0%	1.0E+01	2.6E+01
4-BROMOPHENYL-PHENYLETHER	101-55-3	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
4-CHLORO-3-METHYLPHENOL	59-50-7	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
4-CHLOROANILINE	106-47-8	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
4-CHLOROPHENYL-PHENYLETHER	7005-72-3	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
4-METHYLPHENOL	106-44-5	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
4-NITROANILINE	100-01-6	Unfiltered			12	0		1.0E+01							0%	1.0E+01	2.6E+01
4-NITROPHENOL	100-02-7	Unfiltered			12	0		1.0E+01							0%	1.0E+01	2.6E+01
ACENAPHTHENE	83-32-9	Unfiltered			17	2		4.9E+00	2.0E+00	2.4E+01	10/18/2002	12W04			12%	1.0E+00	1.0E+01
ACENAPHTHYLENE	208-96-8	Unfiltered			17	0		3.5E+00							0%	1.0E+00	1.0E+01
ANTHRACENE	120-12-7	Unfiltered			17	0		3.4E+00							0%	2.0E-01	1.0E+01
BENZO(A)ANTHRACENE	56-55-3	Unfiltered			17	0		3.4E+00							0%	2.0E-01	1.0E+01
BENZO(A)PYRENE	50-32-8	Unfiltered			17	0		3.3E+00							0%	1.0E-01	1.0E+01
BENZO(B)FLUORANTHENE	205-99-2	Unfiltered			17	0		3.3E+00							0%	1.0E-01	1.0E+01
BENZO(G,H,I)PERYLENE	191-24-2	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
BENZO(K)FLUORANTHENE	207-08-9	Unfiltered			17	0		3.3E+00							0%	1.0E-01	1.0E+01
BIS(2-CHLOROETHOXY)METHANE	111-91-1	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
BIS(2-CHLOROETHYL)ETHER	111-44-4	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
BIS(2-CHLOROISOPROPYL)ETHER	108-60-1	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
BIS(2-ETHYLHEXYL)PHTHALATE	117-81-7	Unfiltered			12	0		1.9E+00							0%	2.0E+00	4.0E+00
BUTYLBENZYLPHTHALATE	85-68-7	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
CARBAZOLE	86-74-8	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
CHRYSENE	218-01-9	Unfiltered			17	0		3.4E+00							0%	2.0E-01	1.0E+01
DI-N-BUTYLPHTHALATE	84-74-2	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
DI-N-OCTYLPHTHALATE	117-84-0	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
DIBENZ(A,H)ANTHRACENE	53-70-3	Unfiltered			17	0		3.4E+00							0%	2.0E-01	1.0E+01
DIBENZOFURAN	132-64-9	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
DIETHYLPHTHALATE	84-66-2	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
DIMETHYLPHTHALATE	131-11-3	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
FLUORANTHENE	206-44-0	Unfiltered			17	0		3.4E+00							0%	2.0E-01	1.0E+01
FLUORENE	86-73-7	Unfiltered			17	0		3.4E+00							0%	2.0E-01	1.0E+01

Table 4.3-3

Investigation Area C3, IR12 Statistical Summary Table of Analytical Groundwater Data

Analyte	CAS Number	Filtered/ Unfiltered	Ambient Concentration for Metals (ug/L)	Source of Ambient Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Ambient Concentration for Metals	Average Result (ug/L)	Minimum Detection (ug/L)	Maximum Detection (ug/L)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (ug/L)	Maximum Detection Limit (ug/L)
WATER - IR12																	
HEXACHLOROBENZENE	118-74-1	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
HEXACHLOROBUTADIENE	87-68-3	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
HEXACHLOROCYCLOPENTADIENE	77-47-4	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
HEXACHLOROETHANE	67-72-1	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
INDENO(1,2,3-CD)PYRENE	193-39-5	Unfiltered			17	0		3.4E+00							0%	2.0E-01	1.0E+01
ISOPHORONE	78-59-1	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
N-NITROSO-DI-N-PROPYLAMINE	621-64-7	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
N-NITROSODIPHENYLAMINE (1)	86-30-6	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
NAPHTHALENE	91-20-3	Unfiltered			17	1		3.5E+00	1.3E+00	1.3E+00	10/18/2002	12W04			6%	1.0E+00	1.0E+01
PENTACHLOROPHENOL	87-86-5	Unfiltered			12	0		1.0E+01							0%	1.0E+01	2.6E+01
PHENANTHRENE	85-01-8	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
PHENOL	108-95-2	Unfiltered			12	0		4.7E+00							0%	5.0E+00	1.0E+01
PYRENE	129-00-0	Unfiltered			17	0		3.4E+00							0%	2.0E-01	1.0E+01
PCB Compounds																	
AROCLOR-1016	12674-11-2	Unfiltered			25	1		5.5E-01	8.5E-01	8.5E-01	7/1/2004	12W02			4%	2.0E-01	1.0E+01
AROCLOR-1221	11104-28-2	Unfiltered			25	0		5.3E-01							0%	4.0E-01	1.0E+01
AROCLOR-1232	11141-16-5	Unfiltered			25	0		5.2E-01							0%	2.0E-01	1.0E+01
AROCLOR-1242	53469-21-9	Unfiltered			25	0		5.2E-01							0%	2.0E-01	1.0E+01
AROCLOR-1248	12672-29-6	Unfiltered			25	0		5.2E-01							0%	2.0E-01	1.0E+01
AROCLOR-1254	11097-69-1	Unfiltered			25	0		5.2E-01							0%	2.0E-01	1.0E+01
AROCLOR-1260	11096-82-5	Unfiltered			25	12		2.6E+00	1.4E+00	1.3E+01	8/21/1998	12W02			48%	2.0E-01	1.0E+01
AROCLOR-1260	11096-82-5	Unfiltered			25	12		2.6E+00	1.4E+00	1.3E+01	2/27/1998	12W02			48%	2.0E-01	1.0E+01
Pesticides																	
4,4'-DDD	72-54-8	Unfiltered			10	0		4.5E-02							0%	2.0E-02	1.0E-01
4,4'-DDE	72-55-9	Unfiltered			10	0		4.5E-02							0%	2.0E-02	1.0E-01
4,4'-DDT	50-29-3	Unfiltered			10	0		4.5E-02							0%	2.0E-02	1.0E-01
ALDRIN	309-00-2	Unfiltered			10	1		7.4E-02	5.2E-01	5.2E-01	6/25/1999	12W03			10%	4.8E-02	5.0E-01
ALPHA-BHC	319-84-6	Unfiltered			10	0		2.3E-02							0%	1.0E-02	5.2E-02
ALPHA-CHLORDANE	5103-71-9	Unfiltered			10	0		2.3E-02							0%	1.0E-02	5.2E-02
BETA-BHC	319-85-7	Unfiltered			10	0		2.3E-02							0%	1.0E-02	5.2E-02
DELTA-BHC	319-86-8	Unfiltered			10	1		4.2E-02	2.2E-01	2.2E-01	5/22/1998	12W03			10%	1.0E-02	5.2E-02
DIELDRIN	60-57-1	Unfiltered			10	0		4.5E-02							0%	2.0E-02	1.0E-01
ENDOSULFAN I	959-98-8	Unfiltered			10	0		2.3E-02							0%	1.0E-02	5.2E-02
ENDOSULFAN II	33213-65-9	Unfiltered			10	0		4.5E-02							0%	2.0E-02	1.0E-01
ENDOSULFAN SULFATE	1031-07-8	Unfiltered			10	0		4.5E-02							0%	2.0E-02	1.0E-01
ENDRIN	72-20-8	Unfiltered			10	0		4.5E-02							0%	2.0E-02	1.0E-01
ENDRIN ALDEHYDE	7421-93-4	Unfiltered			10	0		4.5E-02							0%	2.0E-02	1.0E-01
ENDRIN KETONE	53494-70-5	Unfiltered			10	0		4.5E-02							0%	2.0E-02	1.0E-01
GAMMA-BHC (LINDANE)	58-89-9	Unfiltered			10	0		2.3E-02							0%	1.0E-02	5.2E-02
GAMMA-CHLORDANE	12789-03-6	Unfiltered			10	0		2.3E-02							0%	1.0E-02	5.2E-02
HEPTACHLOR	76-44-8	Unfiltered			10	1		1.0E-02	6.0E-02	6.0E-02	6/25/1999	12W03			10%	9.5E-03	5.0E-02
HEPTACHLOR EPOXIDE	1024-57-3	Unfiltered			10	0		4.9E-03							0%	9.5E-03	1.0E-02
METHOXYCHLOR	72-43-5	Unfiltered			10	0		2.3E-01							0%	1.0E-01	5.2E-01
TOXAPHENE	8001-35-2	Unfiltered			10	0		1.4E+00							0%	1.0E+00	3.1E+00
Metals																	

Table 4.3-3

Investigation Area C3, IR12 Statistical Summary Table of Analytical Groundwater Data

Analyte	CAS Number	Filtered/ Unfiltered	Ambient Concentration for Metals (ug/L)	Source of Ambient Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Ambient Concentration for Metals	Average Result (ug/L)	Minimum Detection (ug/L)	Maximum Detection (ug/L)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (ug/L)	Maximum Detection Limit (ug/L)
WATER - IR12																	
ALUMINUM	7429-90-5	Filtered	4.8E+02	a	9	1	0	9.1E+00	3.1E+01	3.1E+01	8/21/1998	12W01			11%	8.0E+00	1.8E+01
ALUMINUM	7429-90-5	Unfiltered	4.8E+02	a	3	0	0	1.7E+01							0%	3.4E+01	3.4E+01
ANTIMONY	7440-36-0	Filtered	5.6E+00	a	9	0	0	7.0E-01							0%	7.0E-01	1.8E+00
ANTIMONY	7440-36-0	Unfiltered	5.6E+00	a	3	0	0	1.3E+00							0%	2.5E+00	2.5E+00
ARSENIC	7440-38-2	Filtered	7.8E+01	a	9	4	0	2.9E+00	3.3E+00	8.1E+00	8/21/1998	12W01			44%	8.0E-01	2.1E+00
ARSENIC	7440-38-2	Unfiltered	7.8E+01	a	3	0	0	1.4E+00							0%	2.8E+00	2.8E+00
BARIUM	7440-39-3	Filtered	1.2E+03	a	9	9	0	3.1E+02	3.4E+01	6.7E+02	5/22/1998	12W03			100%	1.0E-01	3.0E-01
BARIUM	7440-39-3	Unfiltered	1.2E+03	a	3	3	0	2.6E+02	7.3E+01	5.1E+02	6/25/1999	12W03			100%	1.0E+00	1.0E+00
BERYLLIUM	7440-41-7	Filtered	1.6E+00	a	9	0	0	8.3E-02							0%	1.0E-01	2.0E-01
BERYLLIUM	7440-41-7	Unfiltered	1.6E+00	a	3	0	0	2.0E-01							0%	4.1E-01	4.1E-01
CADMIUM	7440-43-9	Filtered	1.6E+01	a	9	0	0	1.3E-01							0%	2.0E-01	3.0E-01
CADMIUM	7440-43-9	Unfiltered	1.6E+01	a	3	0	0	1.7E-01							0%	3.3E-01	3.3E-01
CALCIUM	7440-70-2	Filtered	6.8E+05	a	11	11	0	1.1E+05	3.1E+04	2.2E+05	8/21/1998	12W01			100%	3.8E+00	5.0E+03
CALCIUM	7440-70-2	Unfiltered	6.8E+05	a	3	3	0	8.4E+04	4.4E+04	1.2E+05	6/25/1999	12W03			100%	3.1E+01	3.1E+01
CHROMIUM	7440-47-3	Filtered	2.2E+01	a	9	2	0	9.7E-01	1.4E+00	5.2E+00	2/25/1998	12W01			22%	2.0E-01	8.0E-01
CHROMIUM	7440-47-3	Unfiltered	2.2E+01	a	3	0	0	1.8E+00							0%	3.5E+00	3.5E+00
COBALT	7440-48-4	Filtered	1.0E+02	a	9	6	0	2.1E+00	1.9E+00	4.3E+00	8/21/1998	12W01			67%	2.5E-01	6.0E-01
COBALT	7440-48-4	Unfiltered	1.0E+02	a	3	0	0	1.4E+00							0%	2.8E+00	2.8E+00
COPPER	7440-50-8	Filtered	3.3E+01	a	9	3	0	3.4E+00	2.2E+00	2.5E+01	5/22/1998	12W03			33%	3.5E-01	1.2E+00
COPPER	7440-50-8	Unfiltered	3.3E+01	a	3	0	0	1.8E+00							0%	3.5E+00	3.5E+00
HEXAVALENT CHROMIUM	18540-29-9	Unfiltered			3	0	0	5.0E+00							0%	1.0E+01	1.0E+01
IRON	7439-89-6	Filtered	1.4E+05	a	11	8	0	1.1E+03	1.5E+02	5.2E+03	10/18/2002	12W03			73%	7.2E+00	1.0E+02
IRON	7439-89-6	Unfiltered	1.4E+05	a	3	2	0	2.9E+03	7.1E+02	7.9E+03	6/25/1999	12W03			67%	8.9E+00	8.9E+00
LEAD	7439-92-1	Filtered	1.0E+01	a	9	0	0	5.5E-01							0%	6.0E-01	1.7E+00
LEAD	7439-92-1	Unfiltered	1.0E+01	a	3	0	0	1.1E+00							0%	2.2E+00	2.2E+00
MAGNESIUM	7439-95-4	Filtered	1.5E+06	a	11	11	0	1.4E+05	2.7E+04	3.4E+05	10/18/2002	12W04			100%	3.8E+00	5.0E+03
MAGNESIUM	7439-95-4	Unfiltered	1.5E+06	a	3	3	0	1.0E+05	3.9E+04	1.6E+05	6/25/1999	12W03			100%	5.6E+01	5.6E+01
MANGANESE	7439-96-5	Filtered	5.4E+03	a	9	9	0	1.4E+03	3.7E+02	3.3E+03	8/21/1998	12W01			100%	2.5E-01	1.3E+00
MANGANESE	7439-96-5	Unfiltered	5.4E+03	a	3	3	0	8.5E+02	4.6E+02	1.2E+03	6/25/1999	12W01			100%	1.7E+00	1.7E+00
MERCURY	7439-97-6	Filtered	2.2E-01	a	9	0	0	5.0E-02							0%	1.0E-01	1.0E-01
MERCURY	7439-97-6	Unfiltered	2.2E-01	a	3	0	0	2.5E-02							0%	5.0E-02	5.0E-02
MOLYBDENUM	7439-98-7	Filtered	8.8E+00	a	9	8	0	4.1E+00	3.7E+00	7.0E+00	2/27/1998	12W02			89%	2.5E-01	1.0E+00
MOLYBDENUM	7439-98-7	Unfiltered	8.8E+00	a	3	0	0	2.0E+00							0%	3.9E+00	3.9E+00
NICKEL	7440-02-0	Filtered	7.5E+00	a	9	7	0	1.5E+00	1.4E+00	2.6E+00	5/22/1998	12W01			78%	3.0E-01	1.0E+00
NICKEL	7440-02-0	Unfiltered	7.5E+00	a	3	0	0	2.4E+00							0%	4.8E+00	4.8E+00
POTASSIUM	7440-09-7	Filtered	2.1E+05	a	11	11	0	4.1E+04	9.0E+03	1.0E+05	10/18/2002	12W04			100%	3.7E+00	5.0E+03
POTASSIUM	7440-09-7	Unfiltered	2.1E+05	a	3	3	0	2.0E+04	8.3E+03	2.9E+04	6/25/1999	12W03			100%	2.0E+02	2.0E+02
SELENIUM	7782-49-2	Filtered	1.2E+01	a	9	1	0	8.6E-01	9.9E-01	9.9E-01	2/25/1998	12W01			11%	9.0E-01	2.2E+00
SELENIUM	7782-49-2	Unfiltered	1.2E+01	a	3	0	0	2.0E+00							0%	4.0E+00	4.0E+00
SILVER	7440-22-4	Filtered	1.5E+01	a	9	1	0	2.5E-01	1.6E-01	1.6E-01	2/25/1998	12W01			11%	1.5E-01	7.0E-01
SILVER	7440-22-4	Unfiltered	1.5E+01	a	1	0	0	1.1E+00							0%	2.3E+00	2.3E+00
SODIUM	7440-23-5	Filtered	7.4E+06	a	11	11	0	1.5E+06	5.3E+05	3.1E+06	10/18/2002	12W04			100%	4.7E+01	3.0E+04
SODIUM	7440-23-5	Unfiltered	7.4E+06	a	3	3	0	1.2E+06	6.9E+05	1.5E+06	6/25/1999	12W01			100%	5.6E+02	5.6E+02
THALLIUM	7440-28-0	Filtered		d	9	0	0	7.0E-01							0%	1.4E+00	1.4E+00
THALLIUM	7440-28-0	Unfiltered		d	3	0	0	8.5E-01							0%	1.7E+00	1.7E+00
VANADIUM	7440-62-2	Filtered	1.4E+02	a	9	0	0	2.3E-01							0%	3.0E-01	6.0E-01
VANADIUM	7440-62-2	Unfiltered	1.4E+02	a	3	0	0	2.0E+00							0%	4.1E+00	4.1E+00
ZINC	7440-66-6	Filtered	2.6E+02	a	9	5	0	4.5E+00	5.1E+00	1.6E+01	2/25/1998	12W01			56%	3.0E-01	1.5E+00

Table 4.3-3

Investigation Area C3, IR12 Statistical Summary Table of Analytical Groundwater Data

Analyte	CAS Number	Filtered/ Unfiltered	Ambient Concentration for Metals (ug/L)	Source of Ambient Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Ambient Concentration for Metals	Average Result (ug/L)	Minimum Detection (ug/L)	Maximum Detection (ug/L)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (ug/L)	Maximum Detection Limit (ug/L)
WATER - IR12																	
ZINC	7440-66-6	Unfiltered	2.6E+02	a	3	0	0	4.5E+00							0%	9.0E+00	9.0E+00
General Chemistry																	
ALKALINITY BICARBONATE	ALKB	Unfiltered			2	2		8.4E+05	6.9E+05	9.9E+05	10/18/2002	12W04			100%	5.0E+03	5.0E+03
ALKALINITY CARBONATE	ALKC	Unfiltered			2	0		2.5E+03							0%	5.0E+03	5.0E+03
CHLORIDE	16887-00-6	Unfiltered			14	14		2.3E+06	6.3E+05	5.1E+06	10/18/2002	12W04			100%	4.0E+04	5.0E+05
NITRATE/NITRITE	14797-55-8	Unfiltered			12	1		2.3E+02	1.2E+02	1.2E+02	5/22/1998	12W02			8%	5.0E+01	1.0E+03
NITRITE	14797-65-0	Unfiltered			9	0		2.8E+03							0%	1.0E+03	1.0E+04
ORTHO-PHOSPHATE	14265-44-2	Unfiltered			12	3		2.8E+02	1.4E+02	2.7E+02	6/25/1999	12W03			25%	2.0E+01	1.0E+03
ORTHO-PHOSPHATE	14265-44-2	Unfiltered			12	3		2.8E+02	1.4E+02	2.7E+02	6/25/1999	12W01			25%	2.0E+01	1.0E+03
SULFATE	14808-79-8	Unfiltered			14	12		1.0E+05	4.8E+04	2.0E+05	2/25/1998	12W01			86%	3.0E+03	6.3E+04
TDS	TDS	Unfiltered			16	15		4.6E+06	1.2E+06	9.8E+06	10/18/2002	12W04			94%	1.0E+04	2.0E+05
Other																	
DIBUTYLTIN	683-18-1	Unfiltered			9	0		2.5E-01							0%	4.8E-01	5.1E-01
MONOBUTYLTIN	1118-46-3	Unfiltered			9	0		2.5E-01							0%	4.8E-01	5.1E-01
TETRABUTYLTIN	1461-25-2	Unfiltered			9	0		2.5E-01							0%	4.8E-01	5.1E-01
TRIBUTYLTIN	1461-22-9	Unfiltered			9	0		2.5E-01							0%	4.8E-01	5.1E-01

[1] Source Definition (TtEMI 2002)

a - Ambient Metal Background Concentration (95th percentile) in shallow groundwater at Mare Island Naval Shipyard
b - Ambient Metal Concentrations in Artificial Fill Material - Mare Island
c - Ambient Metal Concentrations in Original Island Soil - Mare Island
d - At the request of the regulatory agencies, the ambient level was set to the detection limit

Data from the following types of samples were excluded from this statistical summary query table: 1) duplicate or other quality control samples results; 2) split samples results; 3) removed samples results; and 4) samples analyzed using the toxicity characteristic leaching procedure (TCLP) or by the waste extraction test (WET) data; and 5) . In addition, rejected data was excluded from this query.

Data are rounded to two significant figures for presentation.
To calculate the average concentration, one-half the detection limit was used for U-qualified data.

Only groundwater data collected since June 1997 are included in Table 4.3-3. Data collected since June 1997 most accurately reflect current conditions. A complete set of analytical groundwater data for IR12 is provided in Appendix F5.

The following is a discussion of the results of the analytical categories in Table 4.3-3 (petroleum hydrocarbon compounds, VOCs, SVOCs, and metals). The natural geochemistry of IR12 groundwater was discussed in Section 1.6.

4.3.3.1 Polychlorinated Biphenyls

As indicated in Table 4.3-3, Aroclor-1260 and Aroclor-1016 were the only PCB compounds detected in groundwater at IR12. Aroclor-1260 was detected in 12 of 25 samples since 1997 and 15 of 32 samples historically. Aroclor-1260 concentrations in groundwater samples collected from IR12 since 1997 are shown in Figure 4.3-5. Aroclor-1260 has been detected at concentrations ranging from 1.4 to 13 µg/L since 1997.

Aroclor-1260 was detected in groundwater at three locations: at IR12 monitoring wells 12W02 and 12W03 and in the subsurface vault beneath Building 516A (IR12GW0100). These locations are in proximity to and west of Buildings 516 and 516A. PCBs were not detected in groundwater samples collected in monitoring wells located between Building 516 and Mare Island Strait.

The highest concentrations of Aroclor-1260 found in groundwater at IR12 since 1997 were found in 12W02. Monitoring well 12W02 is located outside the southwest corner of Building 516, which is the location of the highest Aroclor-1260 concentrations found in site soils. The maximum concentration (13 µg/L) was detected in samples collected during two events in 1998. Aroclor-1260 was detected at lower concentrations (2.3 to 4.7 µg/L) in groundwater sampled from this well during five quarterly monitoring events performed between August 2003 and July 2004. These data suggest that Aroclor-1260 concentrations in groundwater at this location are decreasing over time.

As shown in Figure 4.3-5, Aroclor-1260 was not detected in samples collected in 2002 from two locations west of the vault or in the last monitoring event at 12W03. Aroclor-1260 was also not detected in groundwater samples collected between 1998 and 2003 from monitoring wells located downgradient of 12W02 (12W01 and 12W04). These results suggest that, similar to Aroclor-1260 results in soil, the extent of elevated Aroclor-1260 concentrations in groundwater is limited to the area outside the southwest corner of Building 516.

Aroclor-1016 has only been detected in one groundwater sample during groundwater monitoring events performed historically at IR12. Aroclor-1016 was detected at a concentration of 0.85 µg/L at 12W02 in July 2004. Aroclor-1016 was not detected in groundwater samples collected from wells (12W01 and 12W04) located downgradient of 12W02, indicating that the extent of elevated Aroclor-1016 concentrations in groundwater is limited to the area outside the southwest corner of Building 516.

4.3.3.2 Petroleum Hydrocarbons

As indicated in Table 4.3-3, 18 unfiltered groundwater samples were collected from IR12 since 1997 for petroleum hydrocarbon analysis. Of all detected concentrations, about 25 percent are below 100 µg/L, and 95 percent are below 1,000 µg/L. About 15 percent were quantified at concentrations below the analytical reporting limit.

FIGURE 4.3-5
AROCLOR-1260 CONCENTRATIONS IN GROUNDWATER AT IR12

REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
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One groundwater sample from IR12 had a petroleum hydrocarbon concentration greater than 1,000 µg/L. A sample collected from 12W02 in June 1999 had a TPH-gasoline-range organics concentration of 1,800 µg/L. Monitoring well 12W02 is located outside the southwest corner of Building 516. Petroleum hydrocarbon concentrations were higher in samples collected from west of Building 516 than from east of Building 516. Samples from the wells closest to Mare Island Strait (12W01 and 12W04) had lower concentrations; TPH-gasoline was detected in two of four samples collected from 12W01 in 1998 at concentrations of 29 and 40 µg/L, and petroleum hydrocarbons were not detected in two groundwater samples collected from 12W04 in 2002.

4.3.3.3 Chlorobenzene Compounds

As indicated in Table 4.3-3, the majority of the detected VOC and SVOC compounds in groundwater at IR12 were chlorobenzene compounds. The compounds detected were chlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, and 1,2,4-trichlorobenzene. These compounds were detected in four to eight of the groundwater samples collected from IR12 since 1997. Chlorobenzene compounds were not detected in soil samples from IR12.

Typically, the highest levels of these compounds were found in 12W02, located outside the southwest corner of Building 516. The concentration of these compounds were generally found to decrease in 12W02 between 1995 and 1999. Chlorobenzene was also found in groundwater samples collected from 12W03. Only about 5 percent of the detected chlorobenzene compounds from IR12 groundwater were found in wells nearest Mare Island Strait (12W01 and 12W04).

Concentrations of detected chlorobenzene compounds ranged from 1.0 µg/L (chlorobenzene) to 840 µg/L (1,2,4-trichlorobenzene), with about 15 percent of the detected results quantified at concentrations below the reporting limit. Detected concentrations of chlorobenzenes in groundwater at IR12 were below the numeric criteria for priority toxic pollutants in 40 CFR 131.38.

The PCB formulations used in the electrical equipment contain a variety of chlorinated aromatics in addition to the biphenyls. As such, it is likely that the PCB-containing oil releases from the electrical equipment in Building 516 are the sources of the chlorinated aromatics in the groundwater at IR12.

4.3.3.4 Polynuclear Aromatic Hydrocarbons

Only two PAH compounds were detected in groundwater samples collected from IR12. Two PAH compounds were detected in a single well (12W04) in 2002. The PAH compounds (acenaphthene and naphthalene) were detected at maximum respective concentrations of 24 µg/L and 1.3 µg/L. These concentrations are below the numeric water quality criteria for toxic pollutants for acenaphthene (1,200 µg/L) and the RWQCB ESL for naphthalene of 24 µg/L.

4.3.3.5 Pesticides

Only three pesticide compounds were detected in groundwater samples collected from IR12. Three pesticide compounds were each detected in one sample collected from a single

well (12W03), located west of Building 516. The pesticide compounds (aldrin, delta-BHC, and heptachlor) were detected at concentrations between 0.06 and 0.52 µg/L. These compounds were not detected in four other sampling events at this well. As stated previously, pesticide compounds were not detected in soil samples at IR12.

4.3.3.6 Metals

Table 4.3-3 provides a summary of metals results in groundwater samples collected from IR12 and distinguishes the results between filtered samples (dissolved metals results) and unfiltered samples (total metals results). As discussed in Section 2.3, ambient values for 24 metals in shallow groundwater at Mare Island have been established. Table 4.3-3 shows the ambient concentration for shallow groundwater at Mare Island based on filtered results (see also Table 2.3-2) and identifies the number of samples with metal results greater than the respective ambient concentration. The only metal without an established ambient value is hexavalent chromium, which was not detected in groundwater samples collected from IR12.

As indicated in Table 4.3-3, metals were not detected in groundwater samples collected at IR12 above the established ambient concentrations.

4.3.4 Sediments

Sediments in Mare Island Strait near IR12 may have been impacted as a result of a former release of PCB-contaminated oil in Building 516. PCB-contaminated oil likely migrated through electrical cableways to the storm sewer pipeline following the 1981 release. Elevated PCB concentrations (up to 11,500 mg/kg) were detected in sediment samples collected from storm sewer manholes and catch basins in the area between Dry Dock No. 1, Dry Dock No. 2, and Mare Island Strait during 1994 and 1997 (SSPORTS 1997b). Dirt and sediments were removed from the five manholes and catch basins (C-57, C-58, C-59, M65, and STS-22) previously found to contain the greatest concentrations of PCBs in sediment (325 to 11,500 mg/kg) in 1999. Verification sediment samples were not collected subsequent to the removal of sediments from the manholes and catch basins.

Sediments sampled from Mare Island Strait adjacent to storm sewer Outfall STS-22 (south of IR12) in 2002 contained elevated concentrations of Aroclor-1260 and Aroclor-1016. A sample collected below 34 feet of sediment contained Aroclor-1260 and Aroclor-1016 at concentrations of 1,200 mg/kg and 15 mg/kg, respectively. Significantly lower PCB concentrations (up to 0.6 mg/kg) were detected in samples collected 0, 8, and 16 feet below the sediment surface (TtEMI 2002d). Sediments in Mare Island Strait are a Navy-retained condition and will be addressed in a separate report.

Based on the results of previous investigations performed by the Navy, it is concluded that PCBs are no longer being released to Mare Island Strait through storm sewer Outfall STS-22. This outfall was plugged and sealed in 1994, and catch basins, manholes, and storm sewer piping adjacent to Dry Dock No. 2 were cleaned and flushed in 1999 to prevent further release to the Strait (SSPORTS 1997b; CH2M HILL 2003e). These previous actions, along with planned soil remedial actions (Section 7.0), will ensure that sediments in Mare Island Strait are no longer impacted as a result of the historic release in Building 516. Evaluation of sediments are being addressed by the Navy in other documents. Sediments are not evaluated further in this RI/FS report.

4.3.5 Summary of the Nature and Extent of Contamination at IR12

The nature and extent of contamination at IR12 has been defined through the analysis of samples collected during multiple investigations over 12 years. The sampling strategy was judgmental, with the objective to characterize the nature and extent of contamination, building on results of previous investigations and knowledge of site history. Over 280 samples have been collected from approximately 140 separate locations throughout the site. Samples collected from IR12 have been analyzed for a wide variety of chemical constituents.

Sampling and analysis of surface material inside Building 516 and the adjacent Building 516A and subsurface vault show that Aroclor-1260 contamination remains in the concrete and asphalt materials, following previous scabbling and washing operations by the Navy. The highest remaining Aroclor-1260 concentrations inside Building 516 are located within the concrete cable trenches and the floor in the northern part of the Building 516 interior. Elevated Aroclor-1260 concentrations also remain in the concrete walls and floor of the vault beneath Building 516A.

Soil samples collected immediately below the floor of Building 516, however, showed that Aroclor-1260 contamination of the floor and cable trenches inside Building 516 has not impacted soil beneath the building. Aroclor-1260 was not detected in 15 soil samples collected from nine locations beneath Building 516 (between 1 and 7.5 feet bgs).

The extent of Aroclor-1260 contamination surrounding Buildings 516 and 516A is shown in Figures 4.3-2 and 4.3-5. Aroclor-1260 concentrations in soil and groundwater samples collected outside Building 516 were highest in the area outside the southwest corner of Building 516, near 12W02. Three of the four highest concentrations of Aroclor-1260 in soil were found in this area, and the highest concentration of Aroclor-1260 in groundwater during the most recent sampling events was found in this area. Samples collected in other areas immediately surrounding the subsurface vault beneath Building 516A indicate that, with the exception of the area outside the southwest corner of Building 516 (south of the Building 516A vault), contamination from inside the vault has not impacted soil surrounding the vault.

Soil and groundwater samples from other locations at IR12 show that other areas of the site have not been impacted by the PCBs. Aroclor-1260 was not detected in groundwater samples collected east of Building 516, the part of the site closest to Mare Island Strait. Soil samples collected adjacent to utility lines indicated no significant transport of PCB contamination.

Lead was the metal most frequently found at concentrations exceeding the ambient level in soil samples collected from IR12. The extent of lead contamination at IR12 is shown in Figure 4.3-4. The samples with metals concentrations exceeding ambient levels were primarily found in near surface soil, outside and near the northeast corner of Building 516 in the vicinity of identified ABM. Metals were not detected in groundwater samples collected at IR12 above the established ambient levels.

Petroleum hydrocarbon analysis of soil samples collected from throughout IR12 indicate that the most frequently-detected hydrocarbon range was TPH-gasoline. Three of the four soil samples with the highest concentrations of TPH-gasoline-range organics were found in the area located outside the northeast corner of Building 516, at a depth of 5 to 7 feet bgs.

The extent of TPH-gasoline contamination at IR12 is shown in Figure 4.3-3. There is no known source of elevated TPH-gasoline concentrations in this area, although based on the depth, relative location, and type of petroleum hydrocarbon identified, the TPH-gasoline-range organics concentrations in this area may be associated with the former USTs at IR09. The samples with the highest BTEX compounds in soil were also found in the same area and depth as the highest TPH-gasoline-range organics concentrations. The concentrations of BTEX compounds in soil in this area, however, are lower than the USEPA Region 9 PRGs and the RWQCB ESLs.

Other organic compounds including TCE, carbazole, phenol, and select PAH compounds were found in soil samples at isolated locations and depths. The concentrations of these compounds were low based on comparison to analytical detection limits, USEPA Region 9 PRGs, and RWQCB ESLs. The frequency of detection and the concentrations found suggest that the presence of these compounds in soil samples collected from IR12 represent isolated occurrences associated with past industrial operations, anomalous levels associated with the fill materials, or may be associated with the asphalt pavement.

In groundwater, the well from which organic compounds were found at the highest levels and most frequent occurrence was 12W02. This well is located outside the southwest corner of Building 516, in the vicinity of the highest Aroclor-1260 concentrations in soil. In addition to having the highest concentrations of Aroclor-1260 in recent groundwater sampling, this well had the highest concentration of petroleum hydrocarbons and chlorobenzenes found in groundwater at IR12 (and was the only well at the site where many of these compounds were found in groundwater). Analytical data indicate Aroclor-1260 concentrations in groundwater at this well are decreasing over time.

Other organic compounds, including select PAH and pesticide compounds, were found in groundwater samples at extremely low frequencies. The concentrations of these compounds in groundwater were below RWQCB ESLs and water quality criteria for toxic pollutants. The location, frequency of detection, and concentrations found suggest that the presence of these compounds in groundwater is sporadic and not associated with industrial activities within and near IR12.

Elevated concentrations of PCBs historically have been detected on sediment samples collected from Mare Island Strait and storm sewer catch basins and manholes in the vicinity of IR12. Dirt and sediments were removed from catch basins and manholes with the greatest concentrations of PCBs. As a result of previous actions performed by the Navy, sediments in Mare Island Strait are no longer impacted as a result of the historic release in Building 516.

4.4 Contaminant Fate and Transport

This section presents an evaluation of the physical and chemical characteristics that may influence the mobility and behavior of contaminants in IR12. Based on the evaluation presented in the previous section, TPH-gasoline, Aroclor-1260, and lead were selected for inclusion in this fate and transport evaluation. These analytes represent the groups of contaminants (i.e., petroleum hydrocarbons, PCBs, and metals) that most significantly contribute to soil and/or groundwater contamination in IR12. Although the fate and transport evaluation is streamlined to include only these analytes, all analytes are included

in the human health and ecological risk assessment evaluations (summarized in Sections 4.5 and 4.6, respectively). The most probable fate and transport of contaminants in IR12 and potential pathways for on- and off-site migration are identified in this section. The probable migration pathways presented in the conceptual site model (Figure 4.4-1) are based on the results of the fate and transport evaluation presented in this section.

4.4.1 Conceptual Site Model

4.4.1.1 Potential Sources

Potential sources of contamination in IR12 include:

- PCB-containing transformers inside Building 516 and in the fenced area west of Building 516 (PCB Sites 516 and 516A).
- Sources in IR09 (i.e., former USTs and former AST farm).

4.4.1.2 Potential Release Mechanisms

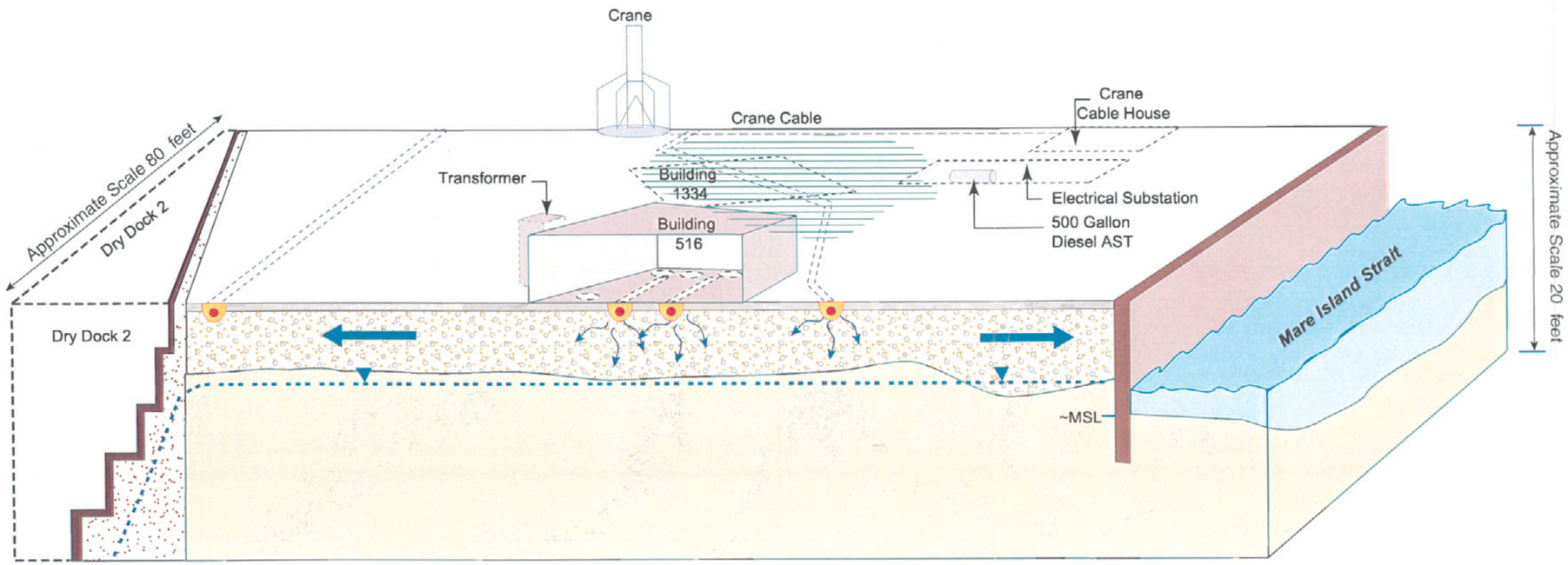
Potential release mechanisms that resulted from various operations performed in IR12 include:

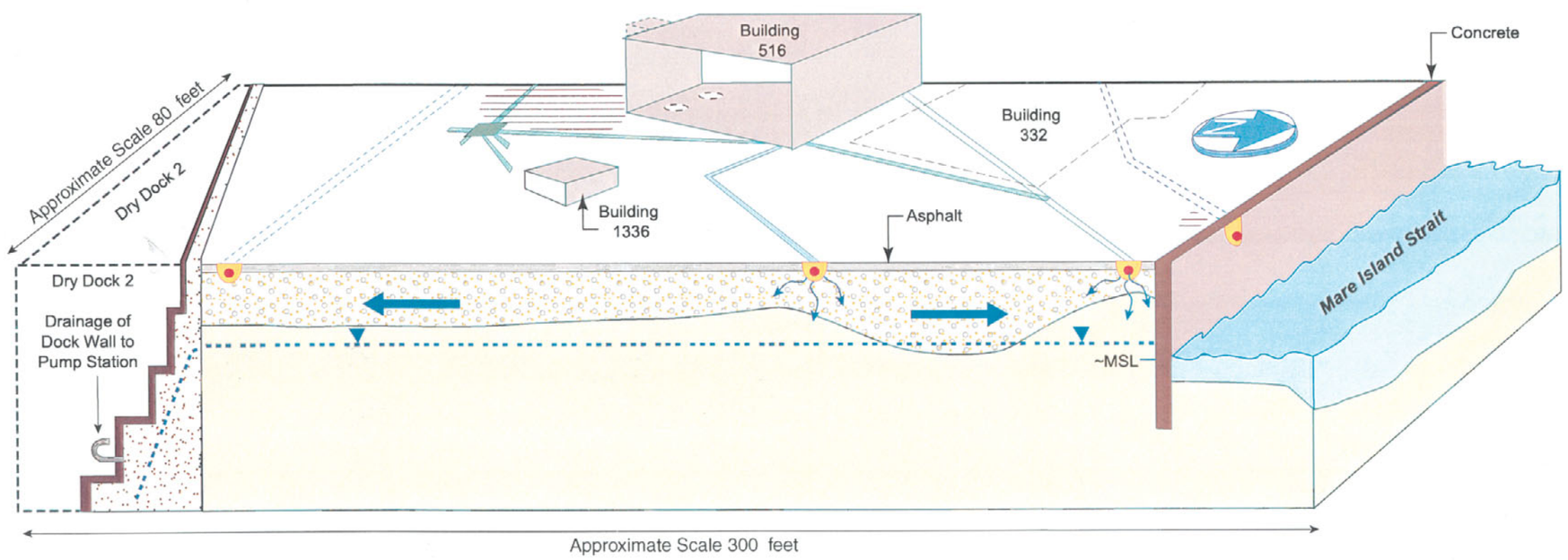
- Releases of PCBs from the transformers housed in Building 516 and in the fenced area west of Building 516 to electrical cableways, to the storm sewer pipeline, and to the subsurface vault located west of Building 516.
- Releases of PCBs from the subsurface vault, which is tidally influenced, located west of Building 516 to low-permeability soil (i.e., bulk soil and utility line backfill).
- Releases of industrial wastes from sources in IR12, IR09, and the Building 108 Area to the stormwater pipeline located adjacent to Dry Dock No. 2.
- Surface and subsurface releases from sources in and around IR09 (former USTs 334-1, 334-2, 334-3, and 334-4 and former AST farm)

4.4.1.3 Potential Contamination Migration Pathways

Potential migration pathways for constituents in soil at IR12 include:

- Lateral and downward transport of free-phase PCBs through permeable utility line backfill and bulk soil in the vadose zone. Also lateral transport of free-phase PCBs through electrical cableways inside and around Building 516.
- Lateral transport of free-phase PCBs at the surface of the water table.
- Dissolution of soil constituents by infiltration of precipitation and other surface water sources though cracks in the pavement; migration into groundwater through advection and dispersion.
- Lateral migration consistent with groundwater flow direction (Figures 1.5-1 and 1.5-2).





EXPLANATION

- Artificial Fill
- Silty Clay
- Approximate Extent of TPH-gr Contamination
- Approximate Extent of Aroclor-1260 Contamination
- Utilities
- Potential Transport of Contaminants
- Groundwater Flow Direction
- Shallow Water-Bearing Zone Potentiometric Surface (May 1999)
- Former Transformer
- Storm Drain
- Electrical Cable ways
- Steam Line
- ~MSL Approximate Mean Sea Level Datum

SOURCE: TETRA TECH, 2000

FIGURE 4.4-1
CONCEPTUAL SITE MODEL
IR12
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

E092002002RDD_01 (9/9/02)

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- Lateral transport through the stormwater pipeline adjacent to Dry Dock No. 2 to the storm sewer outfall located south of IR12 (STS-22).
- Volatilization to the atmosphere.

4.4.2 Fate and Transport Evaluation

This section presents an evaluation of the physical and chemical characteristics that may influence the mobility and behavior of constituents identified in the previous section. The most probable fate and transport of constituents in IR12 and potential pathways for on- and off-site migration are identified.

A more detailed discussion of the fate and transport processes and physical and chemical properties of specific constituents is presented in Appendix K.

The potential migration pathways for soil constituents in IR12 include:

- Historical downward and lateral migration of PCBs through low-permeability utility backfill material and bulk soil and through electrical cableways.
- Lateral transport of free-phase PCBs at the surface of the water table.
- Downward migration of soil contaminants with the infiltration of rainwater.
- Lateral transport through the stormwater pipeline adjacent to Dry Dock No. 2 to the storm sewer outfall located south of IR12 (STS-22).
- Volatilization to air.

Pathways that are considered unlikely in paved areas include (1) surface erosion by wind or water and (2) surface runoff to Mare Island Strait, due to lack of contact with contaminated media.

IR12 is completely paved. Downward migration with infiltration and volatilization to air are considered migration pathways even in paved areas due to cracks and joints in the pavement. However, the ability of constituents to migrate via these pathways may be reduced compared to unpaved areas. Although industrial wastes are no longer discharged through the storm sewer system, historical transport of industrial wastes through the storm sewer pipeline to storm sewer outfalls likely resulted in releases to surrounding soil. Such releases likely account for the elevated Aroclor-1260 concentration (1.7 mg/kg) detected south of IR12 adjacent to the stormwater pipeline. Because industrial wastes are no longer discharged through the stormwater pipeline, and because much of the pipeline was flushed in June 1999 (CH2M HILL 2003e), lateral migration of industrial wastes (including PCBs in IR12) through the pipeline is not considered a potential future migration pathway of constituents and is not evaluated as such in this section. In addition, because storm sewer Outfall STS-22 is plugged, migration of wastes through the pipeline to Mare Island Strait is not considered a potential future migration pathway.

These migration pathways for groundwater constituents include:

- Migration along relatively permeable utility line backfill.
- Migration to Mare Island Strait as shallow groundwater discharges to the east of IR12.

- Volatilization to the atmosphere (only applies to TPH-gasoline; Aroclor-1260 and lead are non-volatile).

To estimate the potential travel times for groundwater contamination at IR12 to reach Mare Island Strait, a simple set of calculations based on Darcy's Law and fundamental adsorption chemistry were performed consistent with the equations and methodology provided in Section 3.4 for IR09. For IR12, a representative hydraulic conductivity for the shallow aquifer based on numerical modeling studies is approximately 1 foot/day (CH2M HILL 2002i). The steepest horizontal hydraulic gradient between IR12 and the nearby Strait and dry docks is 0.04 foot/foot (Figure 1.5-2). The transport porosity of the aquifer at the site is assumed to be 0.15. Based on these assumed hydraulic properties and the equation presented in Section 3.4, the bulk groundwater velocity at IR12 is approximately 0.27 foot/day, or 97 feet/year. As presented in Section 3.4, constituent concentrations in groundwater will be reduced by a factor of at least 1,000 as groundwater mixes with surface water in the Strait.

Due to the interaction between constituents and the aquifer solids through which they move, constituents typically travel at velocities less than native groundwater. The degree to which the velocity of constituent movement is reduced typically is expressed as a retardation factor. The retardation factor of a constituent can be calculated based on the value of the distribution coefficient for that constituent (see Section 3.4 for details).

The chemical characteristics controlling the fate of soil and groundwater constituents in IR12 are discussed in the following sections. Based on the characteristics detailed below, the most likely migration pathways for specific constituents can be determined.

4.4.2.1 Petroleum Hydrocarbons

The fate of TPH-gasoline detected in soil is expected to be controlled by (1) adsorption reactions between constituents and soil mineral surfaces or soil organic matter of the soil material in IR12, (2) biodegradation via the microbial community present in the subsurface, and (3) volatilization and diffusion to the atmosphere or groundwater.

In comparison with TPH-diesel and TPH-motor-oil, TPH-gasoline is more volatile, more soluble, and more mobile in soils and groundwater. The lighter components of TPH-gasoline may volatilize to air at IR12. Some components of TPH-gasoline (notably benzene) adsorb weakly to fine-grained soil and soil organic matter and can migrate significant distances at velocities comparable to native groundwater. TPH-gasoline in soil is expected to migrate downward with infiltrating precipitation, and the fact that TPH-gasoline has been detected in groundwater suggests this has occurred. Concentrations of TPH contaminants in soils and groundwater are expected to diminish over time as a result of natural attenuation processes such as chemical and biological degradation and diffusion.

Transport velocities and biodegradation rates affect the dimension of groundwater plumes caused when TPH-gasoline reaches groundwater. A groundwater sample collected from monitoring well 12W02, which is located approximately 45 feet from Dry Dock No. 2, in June 1999 contained TPH-gasoline at a concentration of 1,800 µg/L, which is the maximum concentration detected at IR12. Although concentrations at that location may have declined through biodegradation, it is also possible that similar concentrations have migrated to Dry Dock No. 2 (the June 1999 sampling is the most recent for TPH-gasoline). Groundwater

that migrates toward Dry Dock No. 2 will be collected in the sanitary wastewater system. Groundwater samples from the wells closest to Mare Island Strait (12W01 and 12W04) had lower concentrations; TPH-gasoline was detected in two of four samples collected from 12W01 in 1998 at concentrations of 29 and 40 µg/L, and petroleum hydrocarbons were not detected in two groundwater samples collected from 12W04 in 2002 and 2003. These results suggest that petroleum hydrocarbons in groundwater at IR12 are not migrating to Mare Island Strait.

4.4.2.2 Metals

The fate of metals likely will be controlled by reactions such as cation exchange, which results in adsorption of constituents to soil mineral surfaces or soil organic matter. Their fate will also likely be controlled by precipitation reactions leading to the formation of secondary mineral phases.

Lead was the primary risk-generating metal detected at IR12. The high distribution coefficient of lead ($K_d \approx 100$ cc/g; Dragun 1988) indicates a very strong affinity for soil. Analytical data in IR12 (Appendix F) indicate that neutral-to-alkaline conditions prevail in the areas of exposed soil, making inorganic compounds less soluble, with lesser tendency to migrate with infiltrating precipitation. Lead is not expected to migrate significant distances in soil at IR12, due to its high distribution coefficient.

Lead has not been detected in groundwater above ambient concentrations at IR12, suggesting that it has not migrated to groundwater. However, in order to thoroughly present the fate and transport of lead, it is assumed that lead becomes dissolved into groundwater at the location of boring IR12GB0101, which is the location closest to surface water where soil concentrations are greater than the ambient concentration for fill material. Boring IR12GB0101 is located approximately 25 feet from Dry Dock No. 2. The distribution coefficient for lead is typically around 100 cc/g (Dragun 1988). Using the equation presented in Section 3.4, and assuming a total aquifer porosity of 0.35 and a bulk density of 1.8 grams per cubic centimeter (g/cc), these values imply retardation factors of over 500. In other words, due to the affinity of lead for the aquifer solids, lead will travel more than 500 times more slowly than the native groundwater, or less than 0.19 foot/year. Using the bulk groundwater velocity calculated above (97 feet/year), the shortest distance to Dry Dock No. 2 (25 feet), and the retardation factor (R=500), these calculations suggest that it will take over a century (130 years) for lead in groundwater to reach Dry Dock No. 2 through the aquifer.

It should be noted that the influence of dispersion during transport may reduce the arrival time of the leading edge of the contaminant plume; given the long travel times computed here, any reduction due to dispersion would be relatively insignificant. In addition, the assumptions made above about flow and transport parameters at IR12 are estimates based on current knowledge of site conditions. Any change from the assumptions above may affect the calculation of travel times.

4.4.2.3 Polychlorinated Biphenyls

PCBs, specifically Aroclor-1260, have extremely low solubility in water, extremely low vapor pressures, and do not readily volatilize. PCBs strongly adsorb to soil and soil organic matter and are not expected to migrate significantly through infiltration of precipitation.

The organic carbon partitioning coefficient (K_{oc}) of Aroclor-1260 is on the order of 200,000 cc/g (Oak Ridge National Laboratory 2003), indicating a very strong affinity for soil. PCBs detected in subsurface soil are not expected to volatilize into the atmosphere.

Although free-phase PCBs have not been observed at IR12 in utility backfill or electrical cableways during recent investigations, site history and analytical data indicate that free-phase PCBs once migrated through these pathways. Elevated concentrations of Aroclor-1260 (170 and 420 mg/kg) have been detected south of the vault at Building 516A along electrical cableways, suggesting that free-phase PCBs previously migrated from the vault through the backfill material that surrounds the cableways, through the cableways themselves, and through bulk soil along the surface of the water table. Analytical data collected along the cableways (Figures 4.3-2) suggest that free-phase PCBs did not migrate over significant distances. Low concentrations of Aroclor-1260 (less than analytical detection limits) were detected further away from the vault along electrical cableways and utility backfill. The affinity for PCBs to adsorb to soil and the high retention capacity of free-phase PCBs in a fine-grained soil matrix reduces the distance over which the free-phase PCBs can migrate in the subsurface. Because free-phase PCBs have not been observed in borings advanced at IR12, free-phase PCBs are considered to no longer be present at the site, and the migration of free-phase PCBs through the vadose zone is not evaluated as a potential future migration pathway of contaminants.

Although PCBs have been detected in groundwater samples at IR12, the groundwater samples were not filtered prior to analysis and were turbid (as indicated by the elevated TDS concentrations [1,400 to 7,400 mg/L] detected in these samples), suggesting that the PCB concentrations are likely representative of soil, rather than groundwater, contamination. The highest Aroclor-1260 concentrations in groundwater were detected at the same location (12W02) that contained an elevated Aroclor-1260 concentration in soil (170 mg/kg). If PCBs were present in groundwater, they would travel more slowly than metals, with retardation factors of over 1,000 for Aroclor-1260, resulting in a transport velocity of approximately 0.097 foot/year. Due to the extreme affinity of PCBs for soil organic material, PCB groundwater plumes tend to be very limited in extent. It would take several centuries (over 400 years) for Aroclor-1260 contamination in groundwater to reach Dry Dock No. 2 from the location of the greatest detection of Aroclor-1260 in groundwater (12W02).

Relatively permeable utility line backfill may act as preferential pathways for constituent transport when the water table rises into the backfill. If contaminated groundwater reaches the backfill, transport times could be reduced by one or more orders of magnitude. Assuming a backfill with a hydraulic conductivity of 10 feet/day, groundwater transport to Mare Island Strait would occur approximately 10 times faster (based on the increased hydraulic conductivity) through the utility line backfill or in 13 years for lead. Travel times for Aroclor-1260 would be greater than 40 years. This travel time is approximate due to uncertainty in K_D values, backfill composition, groundwater levels, and hydraulic gradient within the backfill.

4.4.2.4 Conclusions

The most likely migration pathways for constituents in the soil at IR12 are dissolution into infiltrating water, followed by subsurface lateral migration via groundwater transport

through the aquifer to Mare Island Strait or the Dry Docks. While it is possible that petroleum hydrocarbons have migrated to Dry Dock No. 2, the concentrations of petroleum hydrocarbons detected at IR12 are low, and biodegradation likely has resulted in a reduction in petroleum hydrocarbon concentrations over time. Analytical data suggest the petroleum hydrocarbons in groundwater are not migrating to Mare Island Strait. Lead has not been detected in groundwater at IR12 above ambient levels, suggesting that lead in soil has not migrated to groundwater. PCBs have a strong affinity for soil organic material and will not migrate over significant distances in groundwater. It would take many centuries for Aroclor-1260 concentrations in groundwater to reach Mare Island Strait through the aquifer, and over 40 years if traveling through permeable utility backfill.

4.5 Human Health Risk Assessment Summary

This section summarizes the HHRA conducted for IR12. The complete HHRA is presented in Appendix G. Concrete, asphalt, and wipe data associated with PCB sites 516 AL#01, 516A AL#01, and 516A UL#01 were not evaluated in the HHRA for IR12. These media will be addressed consistent with the *Final Polychlorinated Biphenyl Work Plan* (CH2M HILL 2003a). The results of the HHRA are based on the following key assumptions and approaches:

- Domestic uses of groundwater are not evaluated because the groundwater at Mare Island is not considered a municipal and domestic water supply (Section 1.6).
- Human health exposures for current or future standard commercial/industrial worker and construction worker scenarios were evaluated using concentrations of COPCs in the top 2 feet of soil (0 to 2 bgs). In addition, exposures for future construction worker scenarios were evaluated using concentrations of COPCs in the top 10 feet of soil (0 to 10 feet bgs).
- The HHRA provides estimates of potential excess lifetime cancer risks and non-cancer adverse health impacts to humans under RME conditions. RME conditions represent upper-bound estimates of exposure that are within the range of plausible exposures.

The results of the HHRA are discussed in the following sections and include:

- Exposure pathways, receptors, and environmental media.
- HHRA constituents of potential concern.
- Risk characterization results.

4.5.1 Exposure Pathways and Environmental Media

IR12 is located in an area that is designated for industrial reuse. Therefore, future commercial/industrial workers and construction workers are evaluated for this site. To provide for the possibility of changes in the reuse planning, a residential receptor was also evaluated, and the results are presented in an attachment to Appendix G.

Exposure pathways evaluated for these receptors include:

- Incidental ingestion of soil.
- Dermal contact with soil.

- Inhalation of vapors from soil in outdoor air.
- Inhalation of chemicals sorbed to soil suspended in air as dust.
- Dermal contact with groundwater (construction workers only).
- Inhalation of volatiles from groundwater in outdoor air (construction workers only).
- Inhalation of volatiles from groundwater and subsurface soil in indoor air (commercial/ industrial workers only).

The HHRA estimated potential risk based on analytical data for soil collected from the 0 to 2 feet bgs depth interval for commercial/industrial and construction workers and from the 0 to 10 feet bgs depth interval (i.e., mixed-zone soil) for construction workers. Analytical data from groundwater collected between February 1998 and July 2004 were also used to estimate risk.

EPCs associated with direct contact (dermal contact or incidental ingestion of soil) were based directly on measured concentrations. Chemical concentrations in air (vapors), however, were not measured directly. As a result, vapor concentrations from groundwater and soil were estimated using appropriate fate and transport models. Dust-in-air concentrations were estimated using a particulate emission factor.

4.5.2 HHRA Constituents of Potential Concern

COPCs for human health risk assessment were identified by including each detected constituent as a COPC, except for metals in soil. Metals were eliminated as COPCs in soil if the site concentrations were not significantly different than ambient concentrations for fill materials. COPCs for soils include metals, PCBs, SVOCs, and VOCs. COPCs for groundwater include metals, PCBs, SVOCs, and VOCs. The COPCs selected for human health risk assessment for IR12 are shown in Table G.2-5.

4.5.3 Risk Characterization Results

A discussion of the RME scenario risks is provided below; a summary of the risks estimated for all scenarios is presented in Table 4.5-1. Risk characterization results indicate that future site conditions at IR12 pose potential excess lifetime cancer risks that are within the risk-management range (10^{-4} x 10^{-6}) for carcinogens. The estimated potential cancer risk for an industrial worker exposed to surface soil is 2×10^{-5}. The main contributors to the potential cancer risk are PAHs (benzo(a)pyrene, benzo(a)anthracene, and indeno(1,2,3-cd)pyrene). The estimated potential cancer risk for construction workers exposed to surface soil is 7 x 10^{-7}. The estimated potential cancer risk for a construction worker exposed to mixed-zone soil is 4 x 10^{-6}. The estimated potential cancer risk for a construction worker exposed to groundwater through dermal contact is 9 x 10^{-11}. The estimated potential cancer risk for a construction worker exposed to groundwater through inhalation of volatiles is 9 x 10^{-7}.

TABLE 4.5-1
Summary of Estimated Risks at IR12
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Site	Exposure Scenario/Receptor	Cancer	Non-cancer	Greatest Chemical Contributors
IR12	Surface Soil/Industrial Worker	2×10^{-5}	0.1	PAHs (cancer)
	Surface Soil/Construction Worker	8×10^{-7}	0.09	
	Subsurface Soil/Construction Worker	1×10^{-5}	15	Aroclor-1260 (non-cancer)
	Groundwater/Construction Worker – Inhalation	9×10^{-11}	0.00001	
	Groundwater/Construction Worker – Dermal	9×10^{-7}	1.6	Aroclor-1260 (cancer and non-cancer)

Non-cancer adverse health effects (HI) were estimated to be below the threshold of 1 for all of the receptors potentially exposed to soil or groundwater except for the construction worker exposed to mixed-zone soil and groundwater by dermal contact. The HI for the construction worker scenario for mixed-zone soil is 15 due to the presence of Aroclor-1260 in soil. The HI for the construction worker potentially exposed to groundwater through dermal contact is 2, primarily due to the presence of Aroclor-1260 in groundwater.

It is important to note that the HIs for the construction worker scenarios are based on a chronic RfD for Aroclor-1260 (reference dose for Aroclor-1254 is used as a surrogate for Aroclor-1260) because a subchronic RfD is not available. Chronic RfDs typically are used for exposure periods greater than 7 years, and the construction worker scenario for Mare Island is based on an assumed exposure period of 3 months. The study used to develop the RfD for Aroclor-1254 was based on a subchronic exposure period and consequently, an uncertainty factor of 3 was used to extrapolate from subchronic exposure to chronic exposure to determine the chronic RfD (i.e., subchronic dose was divided by 3 to obtain the chronic RfD). Consequently, by using the chronic RfD to evaluate subchronic exposure periods for construction workers, the HI is most likely overestimated.

In addition to the uncertainties with using the chronic RfD for the construction worker scenario, there are other uncertainties associated with the groundwater dermal exposure scenario that are likely to overestimate risks. These uncertainties include:

- Aroclor-1260 was detected in 12 of 25 samples collected from three wells located in IR12. It has not been detected in groundwater samples collected from 12W03 since 1999. The concentrations of Aroclor-1260 in 12W02 have decreased since 1998 when the maximum concentration of 13 µg/L was recorded. Samples collected from 12W01 during 2004 contained Aroclor-1260 at concentrations ranging from 2 to 3.2 µg/L.
- The groundwater sample that had a reported result of 13 µg/L for Aroclor-1260 had an elevated TDS concentration (2,300 mg/L), suggesting that the Aroclor-1260 may be associated with colloidal particles and not available for absorption through the skin.

- It is assumed that construction workers would be exposed to groundwater for 10 days during a project. This is a conservative estimate of exposure because trenches will be pumped to preclude water inundation, and actual exposure of construction workers will be minimal.

Neither the USEPA nor Cal/EPA publishes RfDs for lead, a COPC known to cause adverse health effects. Based on current DTSC guidance, the potential for health effects from exposure to lead was addressed by comparing EPCs for lead to a risk-based level (i.e., the USEPA Region 9 PRG for industrial scenarios, 750 mg/kg). Soil concentrations below the lead risk-based level are not considered to represent a potential health threat in an industrial scenario. The EPC calculated for lead in surface soil is an upper-bound average concentration calculated using the bootstrap method (See Attachment 3 of Appendix G), 1,198 mg/kg. The EPC calculated for lead in mixed-zone soil is 581 mg/kg, also based on the bootstrap method. The EPC for surface soil exceeds the risk-based level of 750 mg/kg. The EPC for mixed-zone soil is less than the risk-based level.

As several VOCs were detected in groundwater and soil in IA C3, a screening-level evaluation was performed to determine if the indoor air pathway (i.e., volatilization of VOCs from groundwater or soil to indoor air) might be a significant exposure pathway for future receptors. As a conservative first step in this evaluation, maximum detected concentrations of VOCs in groundwater and soil for IA C3 were compared to RBCs based on potential exposure to VOCs in indoor air for an industrial scenario. All of the groundwater and soil data collected within IA C3 were used for this first step of the evaluation. These risk-based concentrations were developed using the Johnson and Ettinger model. No constituents in groundwater had concentrations in IA C3 that exceeded the RBCs. Thirteen constituents in soil in IA C3 had maximum detected concentrations that exceeded the Tier 1 RBCs. As a second step in the screening-level evaluation, the EPCs for the IRP sites were compared to the RBCs for the constituents that had maximum detected concentrations greater than the RBCs, because the EPCs are more representative of overall soil and groundwater conditions at an IRP site. The EPCs for tetrachloroethylene and xylenes in soil exceed the screening level soil RBCs at IR12.

Since the infinite-source (Tier 1) model indicated an exceedance of the RBCs for 13 VOCs, a more rigorous estimate was obtained using additional site-specific data and the finite-source model for soil contamination. The IR12 EPCs do not exceed Tier 2 RBCs, indicating that the indoor air exposure pathway is not expected to be significant for VOCs volatilizing from soil to indoor air at IR12.

The HHRA developed four different sets of risk estimates for each soil exposure scenario evaluated. The definitions of the four sets of risk estimates are provided in Section 3.5.3. The approach for calculating these different risk estimates is described in Appendix G.

Table 4.5-2 summarizes the results for the four types of risk estimates for IR12. As shown in Table 4.5-2, the total, ambient, site, and incremental risks for IR12 are below or within the risk-management range except for the non-cancer HI for construction workers potentially exposed to mixed-zone soil due to the presence of Aroclor-1260. Based on the results of the HHRA, further evaluation of Aroclor-1260 and lead in soil is warranted in the feasibility study. Because of the uncertainties associated with the groundwater dermal contact scenario

for construction workers, the HI for Aroclor-1260 (1.6) is most likely overestimated; therefore, additional evaluation of groundwater in the feasibility study is not warranted.

TABLE 4.5-2
Summary of Estimated Risks at IR12
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Exposure Scenario/Receptor	Mixed-zone Soil							
	Ambient		Total		Site		Incremental	
	Cancer	Non-cancer	Cancer	Non-cancer	Cancer	Non-cancer	Cancer	Non-cancer
Future Industrial Worker								
Surface Soil	8×10^{-6}	0.4	3×10^{-5}	0.5	2×10^{-5}	0.1	2×10^{-5}	0.1
Future Construction Worker								
Surface Soil	3×10^{-7}	0.3	1×10^{-6}	0.4	8×10^{-7}	0.09	8×10^{-7}	0.09
Mixed-zone Soil (0 to 10 feet bgs)	3×10^{-7}	0.3	1×10^{-5}	16	1×10^{-5}	15	1×10^{-5}	15

4.6 Ecological Risk Assessment Summary

A Baseline ERA was performed for IR12 to assess potential for risk to ecological receptors from site-related contaminants. The approach used for the Baseline ERA is described in Section 2.5, and the complete Baseline ERA is presented in Appendix H. The approach for this Baseline ERA is modeled after that developed by DTSC (1996) and USEPA (1997, 1998) and was used to assess ecological risks presented by COPECs.

A Baseline ERA includes the collection and interpretation of biological or abiotic media data to further refine the conclusions of a screening-level ERA. TtEMI performed the screening-level ERA for IA C3 (TtEMI 2002a).

4.6.1 Problem Formulation

Ecological receptors are not present at IR12, as the site is largely paved and covered by buildings. However, ecological receptors are present at Mare Island Strait, which is located on the east side of IR12. The Strait supports diverse communities of algal, invertebrate, fish, bird, and mammal species.

Representative ecological receptors were identified for characterization of ecological risk in this offshore habitat and include aquatic organisms such as fish, non-rooted aquatic plants, and aquatic invertebrates.

COPECs at IR12 were identified through evaluation of available groundwater data. Groundwater was analyzed for total and dissolved metals using unfiltered and filtered (45 microns) samples, respectively. Organics were analyzed using unfiltered samples. Inorganic COPECs were selected by screening maximum detected concentrations in dissolved samples against ambient values. The screening-level evaluation considered the ambient concentration in shallow groundwater as established for Mare Island

(TtEMI 2002c). An inorganic constituent detected in groundwater was not considered a COPEC and was ultimately omitted from the risk assessment if its maximum detected concentration was below the respective ambient value. If an analyte was detected but did not have a ambient value for comparison, it was retained for evaluation. All inorganic analytes in groundwater at the IR12 were within the ambient concentration in shallow groundwater (95th percentile). All organic compounds were assumed to be site-related and were retained as COPECs, without comparison to ambient values. Based on this screening-level evaluation, three organics were retained as COPECs.

4.6.2 Analysis

Groundwater from within IA C3 was assumed to be representative of water in Mare Island Strait because of its potential to discharge to the Strait. Because aquatic organisms in surface water (i.e., non-rooted plants, invertebrates, and fish) are mobile and the medium they reside in is spatially variable, EPCs are best represented by the 95-percent UCL of the mean. However, the maximum detected concentration was used as the EPC for most COPECs at IR12 because of the statistical distribution of the data. Groundwater on site may have much higher contamination levels than the water that may eventually discharge to the Strait. Consequently, estimates of effects on aquatic organisms based on groundwater data are very conservative.

Ecological risk was evaluated by comparing site-related concentrations (EPCs) to TRVs. For this evaluation, ecological screening levels published by the RWQCB (2003a) were selected as TRVs. The ecological screening levels present the more conservative of saltwater and freshwater benchmarks. Because the Strait has varying salinity levels due to varying freshwater flow from the Napa River, the Strait may be considered freshwater or estuarine depending on season. As a result, the ecological screening levels serve as conservative benchmarks for evaluating risk to aquatic organisms in the Strait. In addition, acute TRVs from the RWQCB (2003b) were used to refine the estimate of potential risk for those analytes that exceeded the ecological screening levels.

4.6.3 Risk Characterization

For aquatic organisms, the EPC for each analyte in groundwater was divided by its respective TRV, resulting in a quantitative estimation of risk known as a hazard quotient. HQs greater than 1 were further analyzed qualitatively. Cumulative risks (HIs) were not estimated for aquatic organisms because of the limited toxicity information available for evaluation of cumulative effects.

All constituents with HQs greater than 1 were considered to pose some potential risk and were qualitatively evaluated further for the representative species. Qualitative evaluations assessed chemical information (magnitude of HQ and frequency of detection), incremental risk, potential dilution, and confidence in the benchmark using less conservative assumptions to predict a more reasonable potential for exposure and effects.

All inorganic analytes detected in groundwater at IR12 are at ambient concentrations. Only three organics were detected and retained for further evaluation including acenaphthene, naphthalene, and 1,2,4-trichlorobenzene. The HQ for each of these analytes is less than 1.

Therefore, risk from groundwater to aquatic organisms in the Mare Island Strait is considered negligible.

4.7 Degradation of Groundwater Assessment

Analytical data for groundwater samples collected from monitoring wells 12W01 and 12W04 were used to assess the quality of groundwater entering Mare Island Strait adjacent to IR12. These monitoring wells are located 35 to 60 feet away from Mare Island Strait. All analytes detected in these samples were screened against the chemical-specific ARARs for groundwater and surface water identified by the RWQCB (Appendix I). Select analytes were detected at concentrations exceeding the criteria. Potential sources of groundwater contamination (contaminated soil) that remain at the site will be addressed during implementation of one of the remedial alternatives identified and evaluated in the feasibility study, which is presented in Section 7.0.

Arsenic and manganese were the only analytes that were detected at concentrations that exceed the chemical-specific ARARs identified by the RWQCB for groundwater and surface water, as presented in Table 4.7-1. (Comparisons of criteria to metals concentrations were performed using analytical results for filtered groundwater samples. These data are considered more representative of dissolved metals concentrations than data for non-filtered samples.) With exception to the Basin Plan water quality objectives for agricultural supply, which apply to groundwater, each of the criteria identified in Table 4.7-1 apply to surface water. Because groundwater in IA C3 mixes with surface water upon entering Mare Island Strait, comparison of constituent concentrations in groundwater to surface water criteria results in a conservative determination of analytes that potentially impact surface water in the Strait. Further, this assessment is conservative because it compares the lowest of the criteria presented in Table 4.7-1 to the maximum detected concentration of each analyte.

Arsenic and manganese were detected at concentrations less than the corresponding ambient concentrations, as presented in Table 4.7-2. Therefore, metals concentrations in groundwater discharged from IR12 to Mare Island Strait meet the standards of state anti-degradation and cleanup policies (SWRCB 1992, 1995).

4.8 Conclusions of the Remedial Investigation at IR12

The nature and extent of surface material, soil, and groundwater contamination in IR12 has been defined by data collected during the 2002-2004 field investigation as well as data collected during previous investigations. The analytical data collected at IR12 indicate that the impacted areas of the site are located in the immediate vicinity of Building 516. The impacted areas of the site have been defined as: (1) surface material (concrete and asphalt) inside Building 516 and the adjacent Building 516A and subsurface vault, (2) soil and groundwater outside the southwest corner of Building 516, and (3) soil outside the northeast corner of Building 516. The primary contaminants at IR12 are Aroclor-1260, lead, and TPH-gasoline.

Sampling and analysis of surface material inside Building 516 and the adjacent Building 516A and subsurface vault show that Aroclor-1260 contamination remains in the concrete and asphalt materials following previous scabbling and washing operations performed by

TABLE 4.7-1
Chemical-specific ARARs Identified by the Regional Water Quality Control Board for Select Constituents in Groundwater and Surface Water at IR12
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

	Chemical-Specific ARARs in Groundwater	**Chemical-Specific ARARs in Surface Water**													
	San Francisco Bay Basin Plan [a]	**San Francisco Bay Basin Plan [a]**		**California Toxics Rule Criteria for Enclosed Bays and Estuaries [b]**					**National Ambient Water Quality Criteria [3]**						
Parameter	**Water Quality Objectives for Agricultural Supply (µg/L)**	**Water Quality Objective for Surface Waters with Salinity Greater than 5 ppt (µg/L)**	**Water Quality Objective for Surface Waters with Salinity Less than 5 ppt (µg/L)**	**Freshwater CMC [d] (µg/L)**	**Freshwater CCC [e] (µg/L)**	**Saltwater CMC [d] (µg/L)**	**Saltwater CCC [e] (µg/L)**	**Human Health (Aquatic Organisms Consumption Only (µg/L)**	**Freshwater CMC [d] (µg/L)**	**Freshwater CCC [e] (µg/L)**	**Saltwater CMC [d] (µg/L)**	**Saltwater CCC [e] (µg/L)**	**Human Health (Aquatic Organisms Consumption Only (µg/L)**	**Most Conservative Criteria (µg/L)**	**Maximum Detected Concentration (µg/L)**
Arsenic	5,000 (threshold) 20,000 (limit)	36 (4-day average) 69 (1-hour average)	190 (4 day average) 360 (1 hour average)	340 [f]	150 [f]	69 [f]	36 [f]	--	340 [f]	150 [f]	69	36	0.14 [g]	0.14	8.1
Manganese	200 (threshold) 10,000 (limit)	--	--	--	--	--	--	--	--	--	--	--	--	200	3,260

Notes:

[a] Water Quality Control Plan, San Francisco Bay Basin (Region 2). June 2, 1995.
[b] 40 CFR Part 131.38.
[c] United States Environmental Protection Agency (USEPA). Office of Science and Technology. National Recommended Water Quality Criteria: 2002, EPA-822-R-02-047. November 2002.
[d] Criteria Maximum Concentration (CMC) = the highest concentration of a pollutant to which aquatic life can be exposed for a short period of time (1-hour average) without deleterious effects.
[e] Criteria Continuous Concentration (CCC) = the highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4 days) without deleterious effects.
[f] Based on dissolved concentrations.
[g] Criteria based on carcinogenicity of 10-6 risk.

-- No criteria.

TABLE 4.7-2
Ambient Groundwater Concentrations for Select Constituents at IR12
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Analyte	Maximum Detected Concentration (µg/L)	Ambient Concentration in Shallow Groundwater (TtEMI 2002c) (µg/L)	Detected Concentrations Within Ambient Range?
Arsenic	8.1	78	Yes
Manganese	3,260	5,400	Yes

the Navy. However, soil samples collected immediately below the floor of Building 516 indicate that Aroclor-1260 contamination of the floor and cable trenches inside Building 516 has not impacted soil beneath the building. PCB-contaminated surface materials at IR12 will be remediated in accordance with the *Final Polychlorinated Biphenyl Work Plan* (CH2M HILL 2003a) and in accordance with the provisions of TSCA and the USEPA Consent Agreement/Final Order.

Aroclor-1260 concentrations in soil and groundwater samples collected surrounding Building 516 were highest in the area outside the southwest corner of Building 516, near 12W02. Groundwater samples from 12W02 were also found to contain the highest concentrations of chlorobenzene compounds at IR12. Soil and groundwater samples collected from other locations at IR12, including monitoring wells located downgradient of Building 516, show that other areas of the site have not been impacted by releases of PCB-containing oil from transformers inside Building 516.

Outside the northeast corner of Building 516, lead (as well as zinc and mercury) was found in near surface soil samples at concentrations exceeding ambient levels. Elevated metals concentrations may be associated with ABM identified in borings in this area. Further, the highest concentrations of TPH-gasoline-range organics (as well as BTEX compounds) in soil samples collected from IR12 were found outside the northeast corner of Building 516, 5 to 7 feet bgs. There is no known source of elevated TPH-gasoline concentrations in this area, although based on the depth, relative location and type of petroleum hydrocarbon identified, the TPH-gasoline-range organics concentrations in this area may be associated with the former USTs at IR09 (these sources of contamination are addressed with IR09 in Section 3.0).

The results of the fate and transport evaluation indicate that the most likely migration pathways for contaminants in the soil at IR12 are infiltration, followed by subsurface lateral migration via groundwater transport through the aquifer to Mare Island Strait or the dry docks. Petroleum hydrocarbons have been detected at low concentrations in groundwater sampled from monitoring wells located adjacent to the Strait and lead has not been detected in groundwater at IR12, suggesting these contaminants are not migrating at significant concentrations to the Strait. It would take many centuries for PCBs in groundwater to reach Mare Island Strait, even if traveling through permeable utility backfill, due to the strong affinity for of PCBs to adsorb to soil organic material. Further, groundwater at IR12 will be

subject to the affects of mixing upon entering Mare Island Strait, which reduces concentrations of contaminants in groundwater by at least a factor of 1,000.

The results of the HHRA indicate that the potential cancer risk estimates for both commercial/industrial workers and construction workers exposed to soil and groundwater at IR12 are within or below the risk-management range except for the potential exposure of construction workers to mixed-zone soil and groundwater (dermal contact). The HI of 15 for construction workers exposed to the mixed-zone soil through dermal contact exceeds 1. The main contributor to this HI is Aroclor-1260 in subsurface soil (i.e., greater than 2 feet bgs). The EPC for lead in surface soil (1,198 mg/kg) at IR12 exceeds the risk-based level for soil for commercial/industrial workers (750 mg/kg). Based on the results of the HHRA, further evaluation of Aroclor-1260 and lead in soil is warranted in the feasibility study. Although an elevated HI (1.6) was also calculated for dermal exposure of the construction worker receptor to groundwater, this result is most likely overestimated, as presented in Section 4.5. Groundwater is not expected to pose a potential significant risk to construction workers at IR12. Further, the application of institutional controls will serve to minimize risks to construction workers exposed to groundwater at the site. Institutional controls are a component to the alternatives presented in the feasibility study in Section 7.0.

A Baseline ERA was performed for IR12 to assess potential for risk to ecological receptors from site-related contaminants. All inorganic analytes detected in groundwater at IR12 are at ambient concentrations. Only three organics were detected and retained for further evaluation including acenaphthene, naphthalene, and 1,2,4-trichlorobenzene. The HQ for each of these analytes is less than 1 when compared to RWQCB ESLs. Therefore, risk from groundwater to aquatic organisms in the Mare Island Strait is considered negligible.

The results of the degradation of groundwater assessment indicate that, while arsenic and manganese are present in groundwater at IR12 at concentrations that exceed chemical-specific ARARs identified by the RWQCB for groundwater and surface water, these metals are present at concentrations that are within the range of concentrations that are considered ambient. Constituents in groundwater at IR12 are therefore not present at concentrations that are degrading the waters of the State.

Based on the results of the HHRA, lead and Aroclor-1260 in soil present a potential significant risk to human health at IR12. Therefore, remedial action objectives to address lead and Aroclor-1260 in soil at IR12 will be developed in the feasibility study presented in Section 7.0. Based on the results of the HHRA, ERA, and degradation of groundwater assessment, constituents in groundwater do not pose a risk to human or ecological receptors and are not degrading waters of the State. Therefore, remedial alternatives are not being developed in the feasibility study to address constituents in groundwater at IR12.

5.0 Building 108 Area

5.1 Site Background

5.1.1 Site Description

The Building 108 Area contains Building 108 and several other current and former structures, former UST 108, and a former waste collection area (referred to as the waterfront central dumpsters). The Building 108 Area is located in the area bounded by Dry Dock No. 1, Dry Dock No. 2, and Mare Island Strait. The Building 108 Area covers about 2.3 acres and consists of structures and paved areas. A small portion of the Building 108 Area overlaps with IR09. The ground surface at the Building 108 Area is about 8 feet above msl. Existing features of the Building 108 Area are presented in Figure 5.1-1.

There are two UST sites located within the Building 108 Area (UST 108 and UST 108A). UST 108 was removed in 1992. A request for closure for UST 108 will be made in a separate report in accordance with RWQCB Order R2-2002-0105. UST 108A is a suspect tank location that has been closed by the RWQCB. The RWQCB concurred that UST 108A did not exist and that no further action is necessary at this UST site (RWQCB 2002).

There are 23 PCB sites located within the boundaries of the Building 108 Area (CH2M HILL 2002a). These PCB sites (associated with Buildings 108, 108A, 108B, 110, and 142) are addressed in a PCB work plan that identifies the PCB sites that require additional investigation (CH2M HILL 2003a) and are not discussed in this document. A ship-to-shore sanitary sewer pump station (STS-H) is located southeast of Building 132. This pump station is addressed in the *Sanitary Sewer System Site Identification Technical Memorandum* (CH2M HILL 2002b) and is not discussed in this document.

5.1.2 Site History

MINS facility maps illustrate that, prior to the 1870s, most of IA C3 was marshland. Dry Dock No. 1, under construction for many years, was completed by 1891. Historical records indicate that in the late 1800s, a marine railway and its associated wet basin were located in the vicinity of Building 108. The wet basin was designed to hold a floating dry dock and to serve as an alternative location for ship repair. The marine railway was also designed to supplement the floating dock. The marine railway and the wet basin were abandoned during the construction of Dry Dock No. 2 (Archaeological Resource Service 1986). By 1910, Dry Dock No. 2 and the quay wall were built, and the land between Dry Dock Nos. 1 and 2 was filled.

Building 108 is a two-story building built in 1911 as a shipwright shop/office in support of the dry dock (MINS 1995). According to the PA/SI, the eastern part of the building was used by the outside machine shop, the western half was used by welders, and dip tanks for metal cleaning were located in the building (PRC 1995b). Machine shop operations that may have occurred in and around Building 108 include grinding, drilling, small-parts fabrication,

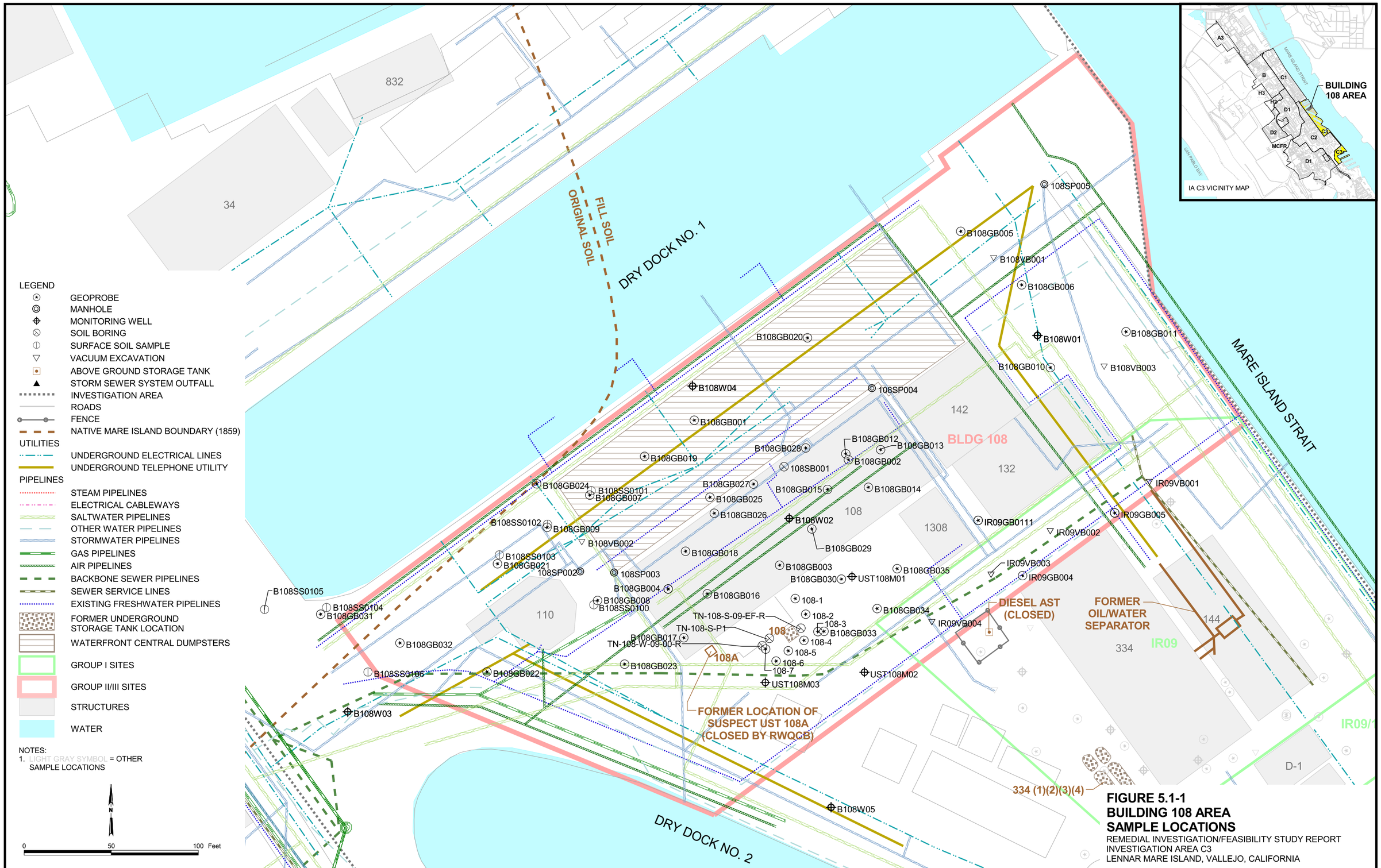

FIGURE 5.1-1
BUILDING 108 AREA
SAMPLE LOCATIONS
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

CH2MHILL

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and metal cleaning. According to historical MINS documents, in 1962 the building was used for waterfront storage on the first floor and office space on the second floor in support of the dry docks. Building 108 was in active use from 1911 until base closure in 1996, and the floor in Building 108 was dirt during most of its history (PRC 1997a). However, most of the floor in Building 108 is currently paved with asphalt and concrete.

The former waterfront central dumpster area is located in the general vicinity between Building 108 and Dry Dock No. 1. According to the IAS and the PA/SI, a number of dumpsters stored wastes generated by operations in support of dry dock activities. Wastes that may have been discarded in these dumpsters include paint, paint thinner, brush cleaner, old brushes, paint sludges, resins, paint and solvent containers, oil-covered metal shavings, and asbestos waste. The dumpsters reportedly overflowed at times. Wastes collected in the dumpsters were ultimately transported to the facility landfill for disposal (Ecology and Environment 1983; PRC 1995b).

Other structures at the Building 108 Area include a former UST and current and former buildings. UST 108 was located southwest of Building 108. The 710-gallon UST, containing a combination of water and fuel product fractions, was removed in December 1992. In 1900, Building 110, located west of Building 108, was constructed as a pumphouse for the dry docks. Building 120, a latrine, was located northeast of Building 108 from approximately 1914 to 1922. In 1919, two buildings (Building 108A and Building 470) were constructed to the south of Building 108. Former Building 108A was used for material storage until demolished in 1963; Building 470 was used as a shavings bin until demolished in 1943 (SSPORTS 1996a). Building 108B, an outdoor electrical substation, was constructed in 1964, and Building 1308, used for paint storage, was constructed in 1969 (SSPORTS 1996a). Buildings 132 and 142 were constructed in 1983 and used for chemical storage and as a nuclear work facility (SSPORTS 1996a). Structures at the site have been inactive since the base was closed in 1996.

5.1.3 Chronology of Investigations

The following summarizes the chronology of investigations performed under the IRP at the Building 108 Area. The Navy's IRP work at this site began in the mid-1980s. The Navy transitioned environmental investigation and cleanup responsibilities to LMI in 2001.

5.1.3.1 RCRA Facility Assessment and PA/SI for Non-radiological Sites

Based on a records review of former shipyard operations, the *RCRA Facility Assessment Preliminary Review, Mare Island Naval Shipyard* identified the waterfront central dumpsters located north of Building 108 as a potential source of contamination to soil, surface water, subsurface gas and air (Kearny 1987). The PA/SI evaluated the outside machine shop past disposal and accumulation practices (Solid Waste Management Unit [SWMU] No. 105, 118, 119, and 120) and the waterfront central dumpsters (SWMU No. 67). The preliminary assessment included a records search and site reconnaissance. The site investigation included the collection of four soil samples from one boring drilled downgradient of the suspected historical dumpster location (108SB001) and sediment from four storm drain catch basins (108SP002 through 108SP005) in March 1994. Based on the PA/SI results, documented in the *Preliminary Assessment/Site Inspection, Final Summary Report,*

Non-radiological Sites, the Building 108 Area was recommended for additional investigation as a Group II/III site (PRC 1995b).

5.1.3.2 UST Removal and Assessment

Removal activities associated with UST 108, previously located near the southwestern corner of Building 108, were documented in *Technical Memorandum, Underground Storage Tank Removal, Underground Storage Tank Sites 243, 108, A-190, 505, H-34* (PRC 1993). Removal activities at UST 108 began on December 7, 1992 and were completed on January 6, 1993. One groundwater (TN-108-W-00-R) and two soil samples—one from the UST excavation (TN-108-S-09-EF-R) and one from the piping trench excavation (TN-108-S-P1)—were collected in December 1992 to evaluate potential contamination associated with the UST. Analytical results indicated that petroleum was released in the surrounding soil and groundwater as described in the *Final Underground Storage Tank Removal and Preliminary Site Assessment Summary Report* (PRC 1994g).

Subsequent to the UST removal activities, soil samples from seven probe holes (108-1 to 108-7) were collected in November 1993 to evaluate the extent of petroleum and metals contamination, as documented in the *Draft Technical Memorandum, GEOPROBE® Soil Sampling Results, Underground Storage Tank Sites: 46/50, 108, 243-1/243-2, 505, 810, 886, and IWTP* (PRC 1993). In May 1997, three temporary groundwater wells were installed (UST108M01, UST108M02, and UST108M03) to characterize contaminant migration and distribution, as documented in *Draft Site Closure Report, UST Sites A-71, A-226, A-246E, A-259, A-914, IWTP, 46/50, 108, 521, 627, and 886, Mare Island, California* (TtEMI 1998g). This report concluded that UST 108 was appropriate for closure and that no further remedial action was required.

5.1.3.3 Group II/III Investigation

The Building 108 Area was included in the Group II/III investigation to further characterize soil and groundwater at the site. The initial investigation was proposed in the *Group II and III Accelerated Study Field Sampling and Analysis Plan* (PRC 1997a). Following the initial sampling in September 1997, at least three other rounds of investigation occurred at the Building 108 Area between April 1998 and April 1999 during the Group II/III investigation, with the investigation planning and results of subsequent sampling rounds discussed between representatives of the Navy and regulatory agencies (MINS 1999). In total, the Group II/III investigation included (1) collecting soil samples from three vacuum excavations (B108VB001 to B108VB003) surrounding the subsurface storm sewer lines; (2) collecting soil and groundwater samples from 35 GeoProbe® borings (B108GB001 through B108GB035); (3) installing five groundwater monitoring wells (B108W01 through B108W05); (4) collecting groundwater samples from the five groundwater monitoring wells; and (5) laboratory analysis.

Results of the Group II/III investigation at the Building 108 Area were presented in a *Revised Internal Draft Investigation Area C2, Site Inspections and Remedial Investigations, Mare Island* (TtEMI 2000f, unpublished).

5.1.3.4 Basewide Groundwater Monitoring Program

The five monitoring wells at Building 108 installed during the Group II/III investigation (B108W01 through B108W05) were each sampled four times between April 1999 and January 2000, as part of the basewide groundwater monitoring program. Generally, these quarterly monitoring events included measurement of the groundwater level at each well and extraction of a groundwater sample from selected wells for subsequent analysis for organic and inorganic contaminants (TtEMI 1998e-f; 1999a-c; 2000b-e; 2001).

5.1.3.5 Offshore Ecological Risk Assessment

An Offshore ERA was conducted to evaluate risks to ecological receptors from site-specific stressors present in offshore areas. Results of the Offshore ERA were documented in the *Revised Final Offshore Areas Ecological Risk Assessment, Mare Island* (TtEMI 2002b). The Offshore ERA evaluated impacts from contaminated sediments in the Mare Island Strait and performed both clam and amphipod bioassays using sediment and pore water collected from the Strait. Results of a clam bioassay concluded that potential toxicity exists near the Building 108 Area. However, overall conclusions stated that constituents in offshore sediments do not pose an unacceptable risk to populations of benthic invertebrates. Additionally, food-chain modeling suggested that population-level risks to birds and mammals were negligible.

5.1.3.6 Implementation of the LMI IA C3 SAP

Field activities at the Building 108 Area were performed between July and October 2002, consistent with the *Investigation Area C3 Sampling and Analysis Plan* (CH2M HILL 2002e-f). The field activities included the collection of seven surface soil samples (B108SS0100 through B108SS0106) analyzed for lead, PAHs, TPH-diesel, and TPH-motor-oil to support the HHRA and to evaluate the lateral extent of elevated petroleum hydrocarbons near the western end of Dry Dock 1. In addition, groundwater samples were collected from existing monitoring well B108W01 and analyzed for zinc to support the ecological risk assessment. Groundwater samples were collected from B108W01 and four other existing monitoring wells at the Building 108 Area for TDS analysis, and water-level elevations were measured on two separate occasions to supplement previously collected hydrologic and geochemistry information.

5.1.3.7 2003/2004 Groundwater Monitoring

Groundwater samples were collected from monitoring well B108W01 during six quarterly monitoring events performed between January 2003 and June 2004 and were submitted for analysis of zinc. Groundwater samples were filtered with a 0.45 µm filter prior to analysis to assist in the characterization of dissolved zinc concentrations in groundwater and to support the degradation of groundwater assessment (Section 5.7).

5.2 Physical and Ecological Characteristics

5.2.1 Surface Features

Except for the dirt floor in one section inside Building 108, the Building 108 Area is flat and paved.

5.2.2 Surface Water

No surface water bodies are present within the boundaries of the Building 108 Area. Surface water runoff from the area discharges into the stormwater system. The Building 108 Area is located adjacent to Mare Island Strait.

5.2.3 Geology

The Building 108 Area lies entirely within the triangle area, which also includes the contiguous IR09 and IR12 investigation sites. Because these sites are contiguous and in an area with well-defined lateral boundaries, the geology of all three sites was discussed together in Section 3.2.3.

5.2.4 Hydrogeology

The Building 108 Area lies entirely within the triangle area, which also includes the contiguous IR09 and IR12 investigation sites. Because these sites are contiguous and in an area with well-defined lateral boundaries, the hydrogeology of all three sites was discussed together in Section 3.2.4.

5.2.5 Ecology

No viable habitat exists within Building 108 Area because the site is covered entirely with asphalt and buildings. Mare Island Strait is located directly northeast of the Building 108 Area. A brief description of this offshore habitat can be found in Section 1.5.6.

5.3 Nature and Extent of Contamination

This section discusses the nature and extent of soil and groundwater contamination in the Building 108 Area. Analytical soil and groundwater data collected at the Building 108 Area, collected during the investigations discussed in Section 5.1.3, are provided in Appendices F6 and F7, respectively. The sampling approach employed for the remedial investigation was judgmental; that is, samples were collected from locations suspected to be the most highly contaminated, as indicated by site history. In total, over 250 soil and groundwater samples were collected between December 1992 and June 2004 from the Building 108 Area from the approximately 75 locations shown in Figure 5.1-1.[11] Samples collected from the Building 108 Area were analyzed for a wide variety of chemical parameters including petroleum hydrocarbons, VOCs, SVOCs, PAHs, PCBs, pesticides, and metals.

5.3.1 Soil

A summary of soil data for Building 108 Area is provided in Table 5.3-1. For each compound, Table 5.3-1 shows the number of samples analyzed, the number of detected results of that compound,[12] the average result, the maximum result, and the frequency of detection. For metals analysis, Table 5.3-1 shows the ambient concentration for Mare Island

[11] Approximately 5 percent of the entire Building 108 area data set was collected during the 2002-2004 field investigation.
[12] Includes those samples for which a compound was quantified at a concentration below the analytical reporting limit.

Table 5.3-1

Investigation Area C3, Building 108 Area Statistical Summary Table of Analytical Soil Data

Future Land Use: Industrial

Land Type: Fill Material

Analyte	CAS Number	Analysis Type	Background Concentration for Metals (mg/kg)	Source of Background Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Background Concentration for Metals	Average Result (mg/kg)	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)
SOIL - BUILDING 108 AREA																	
Petroleum Hydrocarbon Compounds																	
DIESEL	DRO	Laboratory			110	30		1.1E+03	1.3E+00	1.1E+05	4/30/1998	B108GB007	0.0	0.5	27%	1.0E+00	1.0E+03
GASOLINE	GRO	Laboratory			49	6		1.9E+00	6.5E-01	4.0E+00	12/18/1992	TN-108-S-09-EF-R	9.0	9.0	12%	3.0E-02	1.6E+01
MOTOR OIL	MRO	Laboratory			95	66		1.3E+03	6.6E+00	4.3E+04	4/30/1998	B108GB007	0.0	0.5	69%	5.2E+00	2.6E+03
TRPH	TRPH	Laboratory			5	3		2.5E+02	1.1E+02	7.9E+02	3/3/1994	108SB001	1.0	1.5	60%	5.1E-01	2.7E+01
UNKNOWN	UNKNOWN	Laboratory			4	0		1.6E+01							0%	2.5E+01	4.7E+01
UNKNOWN GASOLINE RANGE	UGRO	Laboratory			4	0		3.2E-01							0%	5.8E-01	6.6E-01
Volatile Organic Compounds																	
1,1,1-TRICHLOROETHANE	71-55-6	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
1,1,2,2-TETRACHLOROETHANE	79-34-5	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
1,1,2-TRICHLOROETHANE	79-00-5	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
1,1-DICHLOROETHANE	75-34-3	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
1,1-DICHLOROETHENE	75-35-4	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
1,2,4-TRICHLOROBENZENE	120-82-1	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
1,2-DICHLOROETHANE	107-06-2	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
1,2-DICHLOROETHENE (TOTAL)	540-59-0	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
1,2-DICHLOROPROPANE	78-87-5	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
1,3-DICHLOROBENZENE	541-73-1	Laboratory			27	0		2.7E-01							0%	1.9E-01	2.3E+00
2-BUTANONE	78-93-3	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
2-HEXANONE	591-78-6	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
4-METHYL-2-PENTANONE	108-10-1	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
ACETONE	67-64-1	Laboratory			23	2		2.2E-02	9.3E-02	2.9E-01	9/26/1997	B108VB002	8.0	8.5	9%	1.1E-02	1.9E-02
BENZENE	71-43-2	Laboratory			45	0		8.6E-03							0%	5.0E-03	8.0E-02
BROMODICHLOROMETHANE	75-27-4	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
BROMOFORM	75-25-2	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
BROMOMETHANE	74-83-9	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
CARBON DISULFIDE	75-15-0	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
CARBON TETRACHLORIDE	56-23-5	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
CHLOROBENZENE	108-90-7	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
CHLOROETHANE	75-00-3	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
CHLOROFORM	67-66-3	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
CHLOROMETHANE	74-87-3	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
CIS-1,3-DICHLOROPROPENE	10061-01-5	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
DIBROMOCHLOROMETHANE	124-48-1	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
ETHYLBENZENE	100-41-4	Laboratory			45	3		1.0E-02	1.3E-03	6.4E-02	12/18/1992	TN-108-S-09-EF-R	9.0	9.0	7%	5.0E-03	8.0E-02
METHYLENE CHLORIDE	75-09-2	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
STYRENE	100-42-5	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
TETRACHLOROETHENE	127-18-4	Laboratory			23	3		6.1E-03	2.0E-03	7.0E-03	4/30/1998	B108GB019	5.5	6.0	13%	1.1E-02	1.9E-02
TOLUENE	108-88-3	Laboratory			45	5		8.5E-03	3.0E-03	8.0E-03	9/23/1997	B108GB001	4.0	4.5	11%	5.0E-03	8.0E-02
TRANS-1,3-DICHLOROPROPENE	10061-02-6	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
TRICHLOROETHENE	79-01-6	Laboratory			23	1		8.0E-03	4.3E-02	4.3E-02	9/24/1997	B108GB003	1.8	2.3	4%	1.1E-02	1.9E-02
VINYL CHLORIDE	75-01-4	Laboratory			23	0		6.4E-03							0%	1.1E-02	1.9E-02
XYLENE (TOTAL)	1330-20-7	Laboratory			45	6		3.4E-02	4.0E-03	6.4E-01	12/18/1992	TN-108-S-09-EF-R	9.0	9.0	13%	5.0E-03	2.4E-01
Semi-Volatile Organic Compounds																	
1,2-DICHLOROBENZENE	95-50-1	Laboratory			27	0		2.7E-01							0%	1.9E-01	2.3E+00

Table 5.3-1

Investigation Area C3, Building 108 Area Statistical Summary Table of Analytical Soil Data

Future Land Use: Industrial

Land Type: Fill Material

Analyte	CAS Number	Analysis Type	Background Concentration for Metals (mg/kg)	Source of Background Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Background Concentration for Metals	Average Result (mg/kg)	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)
SOIL - BUILDING 108 AREA																	
1,4-DICHLOROBENZENE	106-46-7	Laboratory			27	0		2.7E-01							0%	1.9E-01	2.3E+00
2,4,5-TRICHLOROPHENOL	95-95-4	Laboratory			27	0		1.3E+00							0%	9.7E-01	1.2E+01
2,4,6-TRICHLOROPHENOL	88-06-2	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
2,4-DICHLOROPHENOL	120-83-2	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
2,4-DIMETHYLPHENOL	105-67-9	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
2,4-DINITROPHENOL	51-28-5	Laboratory			21	0		1.5E+00							0%	9.7E-01	1.2E+01
2-CHLORONAPHTHALENE	91-58-7	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
2-CHLOROPHENOL	95-57-8	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
2-METHYL-4,6-DINITROPHENOL	534-52-1	Laboratory			27	0		1.3E+00							0%	9.7E-01	1.2E+01
2-METHYLNAPHTHALENE	91-57-6	Laboratory			27	3		4.6E-01	2.3E-01	2.0E+00	9/24/1997	B108GB002	4.0	4.3	11%	3.9E-01	4.7E+00
2-METHYLPHENOL	95-48-7	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
2-NITROANILINE	88-74-4	Laboratory			27	0		1.3E+00							0%	9.7E-01	1.2E+01
2-NITROPHENOL	88-75-5	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
3,3'-DICHLOROBENZIDINE	91-94-1	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
3-NITROANILINE	99-09-2	Laboratory			26	0		1.3E+00							0%	9.7E-01	1.2E+01
4-BROMOPHENYL-PHENYLETHER	101-55-3	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
4-CHLORO-3-METHYLPHENOL	59-50-7	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
4-CHLOROANILINE	106-47-8	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
4-CHLOROPHENYL-PHENYLETHER	7005-72-3	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
4-METHYLPHENOL	106-44-5	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
4-NITROANILINE	100-01-6	Laboratory			27	0		1.3E+00							0%	9.7E-01	1.2E+01
4-NITROPHENOL	100-02-7	Laboratory			26	0		1.1E+00							0%	9.7E-01	9.5E+00
ACENAPHTHENE	83-32-9	Laboratory			32	0		5.5E-01							0%	7.6E-02	4.7E+00
ACENAPHTHYLENE	208-96-8	Laboratory			32	0		6.6E-01							0%	1.5E-01	4.7E+00
ANTHRACENE	120-12-7	Laboratory			32	1		4.3E-01	6.3E-02	6.3E-02	9/26/1997	B108VB002	8.0	8.5	3%	7.6E-03	4.7E+00
BENZO(A)ANTHRACENE	56-55-3	Laboratory			32	3		4.7E-01	2.0E-01	1.6E+00	7/17/2002	B108SS0101	1.0	1.5	9%	7.6E-03	4.7E+00
BENZO(A)PYRENE	50-32-8	Laboratory			32	5		4.5E-01	1.0E-02	4.2E-01	7/17/2002	B108SS0100	1.0	1.5	16%	7.6E-03	4.7E+00
BENZO(B)FLUORANTHENE	205-99-2	Laboratory			32	5		5.5E-01	2.1E-02	2.9E+00	7/17/2002	B108SS0101	1.0	1.5	16%	7.6E-03	4.7E+00
BENZO(G,H,I)PERYLENE	191-24-2	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
BENZO(K)FLUORANTHENE	207-08-9	Laboratory			32	2		4.5E-01	2.5E-01	4.0E-01	7/17/2002	B108SS0101	1.0	1.5	6%	7.6E-03	4.7E+00
BIS(2-CHLOROETHOXY)METHANE	111-91-1	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
BIS(2-CHLOROETHYL)ETHER	111-44-4	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
BIS(2-CHLOROISOPROPYL)ETHER	108-60-1	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
BIS(2-ETHYLHEXYL)PHTHALATE	117-81-7	Laboratory			27	1		5.8E-01	9.6E+00	9.6E+00	9/24/1997	B108GB004	8.0	8.0	4%	1.5E-01	1.9E+00
BUTYLBENZYLPHTHALATE	85-68-7	Laboratory			27	1		6.3E-01	4.4E+00	4.4E+00	9/24/1997	B108GB004	8.0	8.0	4%	3.9E-01	4.7E+00
CARBAZOLE	86-74-8	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
CHRYSENE	218-01-9	Laboratory			32	6		3.7E-01	2.3E-02	6.4E-01	8/19/1998	B108GB029	9.0	9.5	19%	7.6E-03	4.7E+00
DI-N-BUTYLPHTHALATE	84-74-2	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
DI-N-OCTYLPHTHALATE	117-84-0	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
DIBENZ(A,H)ANTHRACENE	53-70-3	Laboratory			32	0		4.5E-01							0%	1.5E-02	4.7E+00
DIBENZOFURAN	132-64-9	Laboratory			27	2		4.2E-01	1.8E-01	4.2E-01	9/24/1997	B108GB002	4.0	4.3	7%	3.9E-01	4.7E+00
DIETHYLPHTHALATE	84-66-2	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
DIMETHYLPHTHALATE	131-11-3	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
FLUORANTHENE	206-44-0	Laboratory			32	7		3.7E-01	1.7E-02	9.3E-01	8/19/1998	B108GB029	9.0	9.5	22%	7.6E-03	4.7E+00
FLUORENE	86-73-7	Laboratory			32	0		4.5E-01							0%	1.5E-02	4.7E+00
HEXACHLOROBENZENE	118-74-1	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
HEXACHLOROBUTADIENE	87-68-3	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
HEXACHLOROCYCLOPENTADIENE	77-47-4	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00

Table 5.3-1

Investigation Area C3, Building 108 Area Statistical Summary Table of Analytical Soil Data

Future Land Use: Industrial

Land Type: Fill Material

Analyte	CAS Number	Analysis Type	Background Concentration for Metals (mg/kg)	Source of Background Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Background Concentration for Metals	Average Result (mg/kg)	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)
SOIL - BUILDING 108 AREA																	
HEXACHLOROETHANE	67-72-1	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
INDENO(1,2,3-CD)PYRENE	193-39-5	Laboratory			32	4		4.9E-01	1.1E-02	7.7E-01	7/17/2002	B108SS0100	1.0	1.5	13%	7.6E-03	4.7E+00
ISOPHORONE	78-59-1	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
N-NITROSO-DI-N-PROPYLAMINE	621-64-7	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
N-NITROSODIPHENYLAMINE (1)	86-30-6	Laboratory			27	0		5.0E-01							0%	3.9E-01	4.7E+00
NAPHTHALENE	91-20-3	Laboratory			32	3		4.6E-01	2.7E-01	1.3E+00	9/24/1997	B108GB002	4.0	4.3	9%	7.6E-02	4.7E+00
PENTACHLOROPHENOL	87-86-5	Laboratory			27	0		1.3E+00							0%	9.7E-01	1.2E+01
PHENANTHRENE	85-01-8	Laboratory			27	5		3.8E-01	6.2E-02	1.2E+00	8/19/1998	B108GB029	9.0	9.5	19%	3.9E-01	4.7E+00
PHENOL	108-95-2	Laboratory			27	7		5.0E-01	9.1E-02	1.2E+00	9/24/1997	B108GB004	8.0	8.0	26%	3.9E-01	4.7E+00
PYRENE	129-00-0	Laboratory			32	8		3.6E-01	1.1E-02	6.2E-01	8/19/1998	B108GB029	9.0	9.5	25%	7.6E-03	4.7E+00
PCB Compounds																	
AROCLOR-1016	12674-11-2	Laboratory			27	0		1.8E-02							0%	7.1E-03	2.3E-01
AROCLOR-1221	11104-28-2	Laboratory			27	0		3.4E-02							0%	1.4E-02	4.7E-01
AROCLOR-1232	11141-16-5	Laboratory			27	0		1.8E-02							0%	7.1E-03	2.3E-01
AROCLOR-1242	53469-21-9	Laboratory			27	0		1.8E-02							0%	7.1E-03	2.3E-01
AROCLOR-1248	12672-29-6	Laboratory			27	0		1.8E-02							0%	7.1E-03	2.3E-01
AROCLOR-1254	11097-69-1	Laboratory			27	0		1.8E-02							0%	7.1E-03	2.3E-01
AROCLOR-1260	11096-82-5	Laboratory			33	5		2.9E-02	7.9E-03	9.1E-02	9/26/1997	B108VB002	8.0	8.5	15%	7.1E-03	2.3E-01
Pesticides																	
4,4'-DDD	72-54-8	Laboratory			21	0		2.3E-03							0%	7.1E-04	2.3E-02
4,4'-DDE	72-55-9	Laboratory			21	0		2.3E-03							0%	7.1E-04	2.3E-02
4,4'-DDT	50-29-3	Laboratory			21	0		2.3E-03							0%	7.1E-04	2.3E-02
ALDRIN	309-00-2	Laboratory			21	3		2.0E-03	7.9E-04	1.5E-02	9/24/1997	B108GB004	8.0	8.0	14%	3.9E-04	1.2E-02
ALPHA-BHC	319-84-6	Laboratory			21	0		1.2E-03							0%	3.6E-04	1.2E-02
ALPHA-CHLORDANE	5103-71-9	Laboratory			21	0		1.2E-03							0%	3.6E-04	1.2E-02
BETA-BHC	319-85-7	Laboratory			21	0		1.2E-03							0%	3.6E-04	1.2E-02
DELTA-BHC	319-86-8	Laboratory			21	1		1.2E-03	1.0E-03	1.0E-03	9/26/1997	B108VB002	8.0	8.5	5%	3.6E-04	1.2E-02
DIELDRIN	60-57-1	Laboratory			21	0		2.3E-03							0%	7.1E-04	2.3E-02
ENDOSULFAN I	959-98-8	Laboratory			21	0		1.2E-03							0%	3.6E-04	1.2E-02
ENDOSULFAN II	33213-65-9	Laboratory			21	0		2.3E-03							0%	7.1E-04	2.3E-02
ENDOSULFAN SULFATE	1031-07-8	Laboratory			21	0		2.3E-03							0%	7.1E-04	2.3E-02
ENDRIN	72-20-8	Laboratory			21	0		2.3E-03							0%	7.1E-04	2.3E-02
ENDRIN ALDEHYDE	7421-93-4	Laboratory			21	1		2.4E-03	2.0E-03	2.0E-03	9/24/1997	B108GB002	4.0	4.3	5%	7.1E-04	2.3E-02
ENDRIN KETONE	53494-70-5	Laboratory			21	3		2.4E-03	1.0E-03	1.9E-03	9/24/1997	B108GB002	4.0	4.3	14%	7.1E-04	2.3E-02
GAMMA-BHC (LINDANE)	58-89-9	Laboratory			21	1		1.2E-03	1.0E-03	1.0E-03	9/25/1997	B108VB001	7.0	7.5	5%	3.6E-04	1.2E-02
GAMMA-CHLORDANE	12789-03-6	Laboratory			21	1		1.2E-03	1.5E-03	1.5E-03	9/24/1997	B108GB002	4.0	4.3	5%	3.6E-04	1.2E-02
HEPTACHLOR	76-44-8	Laboratory			21	1		1.0E-03	8.8E-04	8.8E-04	9/24/1997	B108GB002	4.0	4.3	5%	3.5E-04	1.2E-02
HEPTACHLOR EPOXIDE	1024-57-3	Laboratory			21	1		1.0E-03	6.1E-04	6.1E-04	9/2/1998	B108GB026	7.5	8.0	5%	3.5E-04	1.2E-02
METHOXYCHLOR	72-43-5	Laboratory			21	0		1.2E-02							0%	3.6E-03	1.2E-01
TOXAPHENE	8001-35-2	Laboratory			21	0		1.1E-01							0%	3.6E-02	1.2E+00
Metals																	
ALUMINUM	7429-90-5	Laboratory	3.5E+04	b	31	31	0	1.9E+04	5.1E+03	3.0E+04	9/26/1997	B108VB002	8.0	8.5	100%	1.1E+00	1.3E+01
ANTIMONY	7440-36-0	XRF	8.5E+00	b	86	18	3	5.4E+00	2.5E+00	1.7E+01	8/19/1998	B108GB029	0.0	0.5	21%	1.0E+01	1.0E+01
ANTIMONY	7440-36-0	Laboratory	8.5E+00	b	28	9	1	1.3E+00	4.0E-01	1.6E+01	4/30/1998	B108GB020	1.5	2.0	32%	2.9E-01	3.5E+00
ARSENIC	7440-38-2	XRF	3.6E+01	b	66	31	0	8.5E+00	7.2E+00	2.1E+01	5/7/1998	B108GB017	5.5	6.0	47%	1.0E+01	1.0E+01

Table 5.3-1

Investigation Area C3, Building 108 Area Statistical Summary Table of Analytical Soil Data

Future Land Use: Industrial

Land Type: Fill Material

Analyte	CAS Number	Analysis Type	Background Concentration for Metals (mg/kg)	Source of Background Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Background Concentration for Metals	Average Result (mg/kg)	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)
SOIL - BUILDING 108 AREA																	
ARSENIC	7440-38-2	Laboratory	3.6E+01	b	31	29	2	1.1E+01	4.1E+00	4.3E+01	8/19/1998	B108GB029	10.0	10.5	94%	2.4E-01	5.6E+00
BARIUM	7440-39-3	Laboratory			31	31	0	3.0E+02	4.0E+01	1.0E+03	8/13/1998	B108GB025	2.0	2.5	100%	1.5E-01	1.3E+00
BERYLLIUM	7440-41-7	Laboratory	9.0E-01	b	31	21	7	6.2E-01	2.2E-01	2.4E+00	11/5/1993	IR09VB004	7.8	8.3	68%	2.4E-02	2.7E-01
CADMIUM	7440-43-9	XRF	5.2E+00	b	86	8	3	5.4E+00	2.4E+00	2.8E+01	8/19/1998	B108GB026	2.0	2.5	9%	1.0E+01	1.0E+01
CADMIUM	7440-43-9	Laboratory	5.2E+00	b	32	9	0	7.6E-01	8.2E-02	4.9E+00	9/24/1997	B108GB004	8.0	8.0	28%	3.7E-02	5.3E-01
CALCIUM	7440-70-2	XRF			86	86	0	3.4E+04	4.7E+03	1.3E+05	8/13/1998	B108GB025	0.0	0.5	100%	1.0E+01	1.0E+01
CALCIUM	7440-70-2	Laboratory			31	31	0	3.2E+04	3.3E+03	1.6E+05	4/6/1999	B108GB034	0.0	0.5	100%	1.5E+01	4.6E+01
CHROMIUM	7440-47-3	XRF	1.4E+02	b	86	86	15	1.1E+02	1.7E+01	2.2E+02	8/13/1998	B108GB025	0.0	0.5	100%	1.0E+01	1.0E+01
CHROMIUM	7440-47-3	Laboratory	1.4E+02	b	32	32	2	1.1E+02	6.9E+00	1.9E+03	12/18/1992	TN-108-S-09-EF-R	9.0	9.0	100%	9.0E-02	2.0E+00
COBALT	7440-48-4	XRF			86	1	0	5.2E+00	2.1E+01	2.1E+01	11/14/1993	108-2	2.0	4.0	1%	1.0E+01	1.0E+01
COBALT	7440-48-4	Laboratory			31	31	0	1.9E+01	2.7E+00	3.3E+01	3/3/1994	108SB001	4.0	4.5	100%	6.3E-02	2.1E+00
COPPER	7440-50-8	XRF	1.2E+02	b	86	86	14	1.1E+02	1.5E+01	1.6E+03	5/1/1998	B108GB015	3.5	4.0	100%	1.0E+01	1.0E+01
COPPER	7440-50-8	Laboratory	1.2E+02	b	31	31	5	1.5E+02	1.3E+01	1.8E+03	9/24/1997	B108GB004	8.0	8.0	100%	1.2E-01	1.2E+00
HEXAVALENT CHROMIUM	18540-29-9	Laboratory			9	0	0	5.4E-02							0%	5.0E-02	4.4E-01
IRON	7439-89-6	XRF	6.2E+04	b	86	86	0	4.4E+04	4.5E+03	6.0E+04	8/19/1998	B108GB027	2.0	2.5	100%	1.0E+01	1.0E+01
IRON	7439-89-6	Laboratory	6.2E+04	b	31	31	2	3.8E+04	1.3E+04	1.0E+05	8/19/1998	B108GB029	10.0	10.5	100%	5.5E-01	1.1E+01
LEAD	7439-92-1	XRF	5.9E+01	b	86	84	30	3.4E+02	6.9E+00	1.2E+04	4/29/1998	B108GB018	1.5	2.0	98%	1.0E+01	1.0E+01
LEAD	7439-92-1	Laboratory	5.9E+01	b	39	39	19	4.7E+02	1.2E+01	4.5E+03	8/13/1998	B108GB025	2.0	2.5	100%	2.1E-01	2.3E+02
MAGNESIUM	7439-95-4	Laboratory			31	31	0	9.0E+03	1.1E+03	1.8E+04	9/24/1997	B108GB004	3.5	4.0	100%	2.4E-01	3.4E+01
MANGANESE	7439-96-5	XRF	1.6E+03	b	86	86	16	1.5E+03	3.1E+02	3.9E+04	8/25/1998	B108GB030	2.0	2.5	100%	1.0E+01	1.0E+01
MANGANESE	7439-96-5	Laboratory	1.6E+03	b	31	31	5	1.1E+03	2.4E+02	4.8E+03	4/6/1999	B108GB034	2.0	2.5	100%	5.3E-02	7.3E-01
MERCURY	7439-97-6	XRF	2.0E+00	b	80	1	1	5.9E+00	6.7E+01	6.7E+01	8/19/1998	B108GB029	6.0	6.5	1%	1.0E+01	1.0E+01
MERCURY	7439-97-6	Laboratory	2.0E+00	b	32	22	5	9.5E-01	7.0E-02	7.1E+00	8/13/1998	B108GB025	2.0	2.5	69%	5.0E-02	1.6E-01
MOLYBDENUM	7439-98-7	XRF			20	0	0	5.0E+00							0%	1.0E+01	1.0E+01
MOLYBDENUM	7439-98-7	Laboratory			31	11	0	1.8E+01	2.4E+01	1.9E+02	9/24/1997	B108GB004	8.0	8.0	35%	9.6E-02	2.2E+00
NICKEL	7440-02-0	XRF	1.3E+02	b	86	83	2	7.0E+01	2.3E+01	1.4E+02	8/25/1998	B108GB030	2.0	2.5	97%	1.0E+01	1.0E+01
NICKEL	7440-02-0	Laboratory	1.3E+02	b	32	32	2	1.2E+02	8.2E+00	1.7E+03	12/18/1992	TN-108-S-09-EF-R	9.0	9.0	100%	7.9E-02	2.4E+00
POTASSIUM	7440-09-7	XRF			86	86	0	1.5E+04	6.9E+03	2.7E+04	8/19/1998	B108GB026	0.5	1.0	100%	1.0E+01	1.0E+01
POTASSIUM	7440-09-7	Laboratory			31	31	0	2.1E+03	3.0E+02	4.6E+03	9/26/1997	B108VB002	8.0	8.5	100%	1.8E+00	1.3E+02
SELENIUM	7782-49-2	Laboratory			30	7	0	1.0E+00	8.9E-01	3.2E+00	4/6/1999	B108GB034	2.0	2.5	23%	3.9E-01	7.0E+00
SILVER	7440-22-4	XRF			86	2	0	4.9E+00	2.2E+00	3.5E+00	5/8/1998	B108GB006	2.0	2.5	2%	1.0E+01	1.0E+01
SILVER	7440-22-4	Laboratory			27	4	0	3.9E-01	2.0E-01	6.9E+00	9/24/1997	B108GB004	8.0	8.0	15%	6.1E-02	9.7E-01
SODIUM	7440-23-5	Laboratory			31	26	0	1.3E+03	2.8E+02	8.8E+03	9/24/1997	B108GB004	8.0	8.0	84%	8.4E+00	8.4E+01
THALLIUM	7440-28-0	Laboratory		d	31	6	6	8.6E-01	5.0E-01	1.1E+01	4/6/1999	B108GB034	2.0	2.5	19%	2.6E-01	1.9E+00
TIN	7440-31-5	XRF			96	94	0	2.9E+01	4.3E+00	1.3E+03	8/19/1998	B108GB029	10.0	10.5	98%	1.0E+01	1.0E+01
TITANIUM	7440-32-6	XRF			96	96	0	4.0E+03	1.5E+03	6.9E+03	4/29/1998	B108GB018	1.5	2.0	100%	1.0E+01	1.0E+01
VANADIUM	7440-62-2	XRF	1.9E+02	b	86	84	4	1.3E+02	6.7E+01	2.1E+02	8/19/1998	B108GB029	6.0	6.5	98%	1.0E+01	1.0E+01
VANADIUM	7440-62-2	Laboratory	1.9E+02	b	31	31	0	5.7E+01	1.2E+01	1.0E+02	5/8/1998	B108GB006	8.0	8.5	100%	9.8E-02	1.0E+01
ZINC	7440-66-6	XRF	2.3E+02	b	86	86	19	3.1E+02	4.9E+01	5.6E+03	8/19/1998	B108GB026	2.0	2.5	100%	1.0E+01	1.0E+01
ZINC	7440-66-6	Laboratory	2.3E+02	b	32	32	6	4.5E+02	3.4E+01	9.4E+03	9/24/1997	B108GB004	8.0	8.0	100%	2.1E-01	1.5E+00

[1] - Source Definition

a - Ambient Background Concentration (95th percentile) at Mare Island Naval Shipyard
b - Ambient Metal Concentrations in Artificial Fill - Mare Island
c - Ambient Metal Concentrations in Original Island Soil - Mare Island
d - At the request of the regulatory agencies, the ambient limit was set to the detection limit.

fill material (see also Table 2.3-1) and identifies the number of samples with metal results greater than the respective ambient concentration.

The following is a discussion of the analytical results for each of the analytical categories in Table 5.3-1 (petroleum hydrocarbons, VOCs, SVOCs, PCBs, pesticides, and metals).

5.3.1.1 Petroleum Hydrocarbon Compounds

As indicated in Table 5.3-1, petroleum hydrocarbon compound analysis yielded the highest frequency in detected results in soil samples collected from the Building 108 Area. The distribution of the petroleum compounds with the highest number of detected results, TPH-diesel-range organics and TPH-motor oil-range organics, is shown in Figures 5.3-1 and 5.3-2, respectively.

TPH-diesel-range Organics. TPH-diesel-range organics were detected in 30 of the 110 soil samples analyzed. The highest detected concentration of TPH-diesel-range organics was 110,000 mg/kg; this concentration was anomalously high compared with other detected TPH-diesel-range organics concentrations in site soils of 1.3 to 1,200 mg/kg. Of the 30 detected concentrations of TPH-diesel-range organics in soil samples from Building 108 Area, 65 percent were less than 100 mg/kg, and 90 percent were less than 1,000 mg/kg.

The three samples with the highest TPH-diesel-range organics concentrations (110,000, 1,200, and 680 mg/kg) were collected in 1998 in shallow soil (0 to 2 feet bgs) from borings B108GB007, B108GB008, and B108GB009), located outside of and near the northwest corner of Building 108. However, samples collected at greater depths in B108GB007, B108GB008, and B108GB009 contained relatively lower TPH-diesel-range organics concentrations. Further, TPH-diesel-range organics were not detected at concentrations above 100 mg/kg in shallow subsurface in soil samples collected west and east of these boring locations, suggesting that the extent of elevated TPH-diesel-range organics concentrations is limited to surface and shallow subsurface soil near the northwestern corner of Building 108. Based upon the shallow depth of petroleum hydrocarbons, the source of the contamination in this area is likely associated with a surface release, possibly from the waterfront central dumpsters or activities associated with the machine shop.

Another area outside Building 108 that was found to contain detectable TPH-diesel-range organics concentrations was near the former UST 108, located near the southwest corner of Building 108. The highest TPH-diesel-range organics concentrations in this area (650 and 310 mg/kg) were found in 1992 soil samples TN-108-S-P1 and TN-108-S-09-EF-R, respectively. However, confirmation soil samples collected at step-out locations from UST 108 (borings 108-1 through 108-7) contained TPH-diesel-range organics concentrations less than 10 mg/kg at depths ranging from 0.5 to 5 feet bgs. These data indicate that detectable levels of TPH-diesel-range organics in soil, as a result of releases from the UST and associated piping, are localized to the area immediately surrounding the location of the former UST.

TPH-motor-oil-range Organics. TPH-motor-oil-range organics were detected in 66 of the 95 soil samples analyzed. Figure 5.3-2 presents the distribution of TPH-motor-oil concentrations in soil across the Building 108 Area. Of the 66 detected concentrations of TPH-motor-oil-range organics in soil samples from Building 108 Area, approximately 50 percent were less than 100 mg/kg, and 75 percent were less than 1,000 mg/kg. The

LEGEND

- GEOPROBE SAMPLE
- SOIL BORING SAMPLE
- SURFACE SOIL SAMPLE
- VACUUM EXCAVATION SAMPLE
- ABOVE GROUND STORAGE TANK
- STORM SEWER SYSTEM OUTFALL
- ANALYTE NOT DETECTED
- MAX CONCENTRATION DETECTED =<100 mg/kg
- MAX CONCENTRATION DETECTED 100-1,000 mg/kg
- MAX CONCENTRATION DETECTED 1,000-10,000 mg/kg
- MAX CONCENTRATION DETECTED >10,000 mg/kg
- INVESTIGATION AREA
- ROADS
- FENCE
- NATIVE MARE ISLAND BOUNDARY (1859)

UTILITIES

- UNDERGROUND TELEPHONE UTILITY
- UNDERGROUND ELECTRICAL LINES

PIPELINES

- STEAM PIPELINES
- ELECTRICAL CABLEWAYS
- SALTWATER PIPELINES
- OTHER WATER PIPELINES
- STORMWATER PIPELINES
- GAS PIPELINES
- AIR PIPELINES
- BACKBONE SEWER PIPELINES
- SEWER SERVICE LINES
- EXISTING FRESHWATER PIPELINES
- FORMER UNDERGROUND STORAGE TANK LOCATION
- WATERFRONT CENTRAL DUMPSTERS
- GROUP I SITES
- GROUP II/III SITES
- STRUCTURES
- WATER

SAMPLE LOCATION — IR09GB016 (95)
CONCENTRATION (mg/kg) — 47F (5.5)
SAMPLE BEGINNING DEPTH (ft BGS)
SAMPLE COLLECTION YEAR

NOTES:

1. < = NOT DETECTED AT OR ABOVE THE INDICATED CONCENTRATION
2. F = ANALYSIS PERFORMED IN ON-SITE LABORATORY
3. = = ANALYTE WAS DETECTED
4. J = ESTIMATED DETECTED RESULT
5. Y = FUEL PATTERN (TPH ONLY)
6. Z = NOT A FUEL PATTERN (TPH ONLY)
7. DARK GRAY SYMBOL = SAMPLE(S) ANALYZED FOR PRESENTED CONSTITUENT(S)
8. LIGHT GRAY SYMBOL = OTHER SAMPLE LOCATIONS

N

0 50 100 Feet

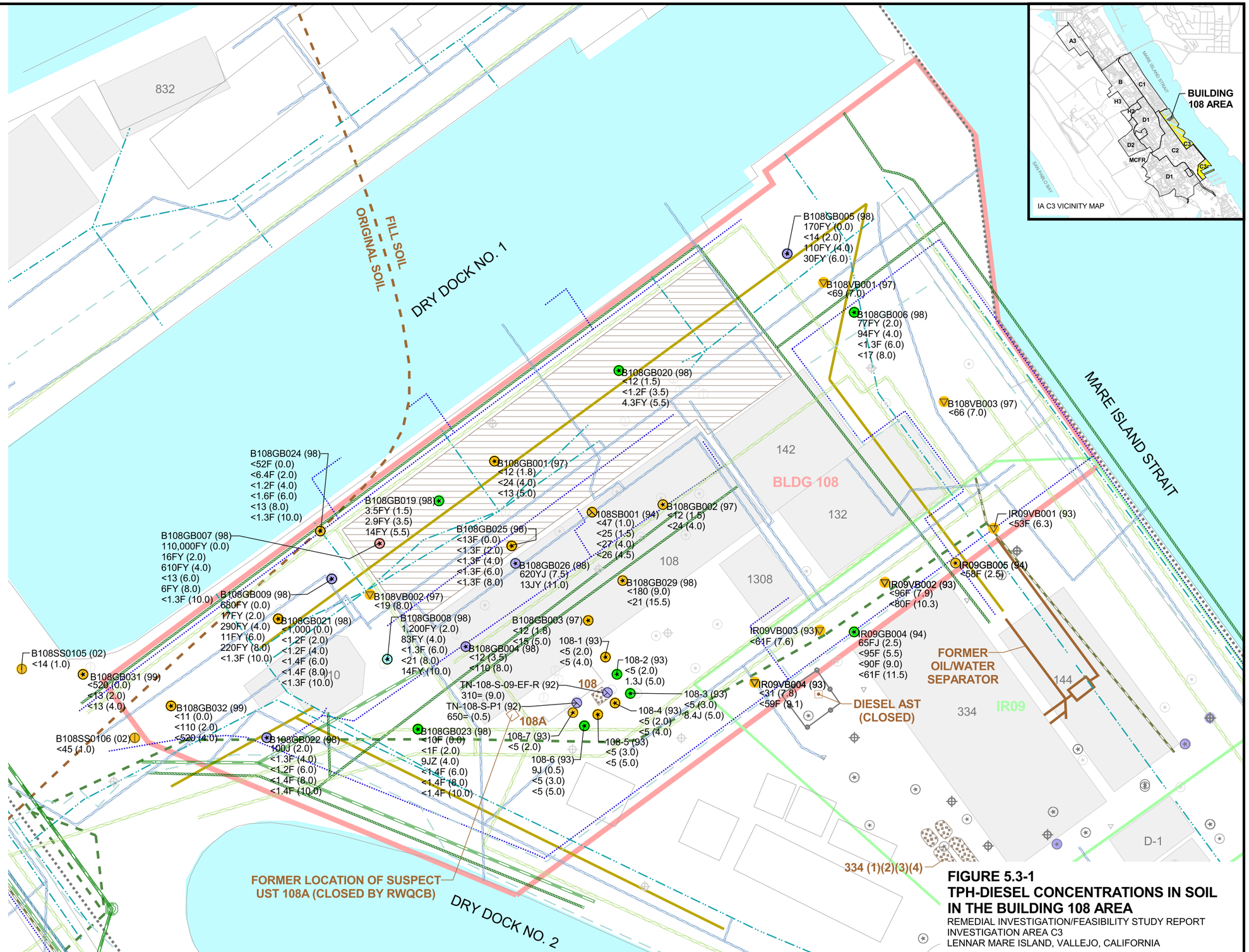

FIGURE 5.3-1
TPH-DIESEL CONCENTRATIONS IN SOIL IN THE BUILDING 108 AREA
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

CH2MHILL

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LEGEND

- GEOPROBE SAMPLE
- SOIL BORING SAMPLE
- SURFACE SOIL SAMPLE
- VACUUM EXCAVATION SAMPLE
- ABOVE GROUND STORAGE TANK
- STORM SEWER SYSTEM OUTFALL
- ANALYTE NOT DETECTED
- MAX CONCENTRATION DETECTED =<100 mg/kg
- MAX CONCENTRATION DETECTED 100-1,000 mg/kg
- MAX CONCENTRATION DETECTED 1,000-10,000 mg/kg
- MAX CONCENTRATION DETECTED >10,000 mg/kg
- INVESTIGATION AREA
- ROADS
- FENCE
- NATIVE MARE ISLAND BOUNDARY (1859)

UTILITIES

- UNDERGROUND TELEPHONE UTILITY
- UNDERGROUND ELECTRICAL LINES

PIPELINES

- STEAM PIPELINES
- ELECTRICAL CABLEWAYS
- SALTWATER PIPELINES
- OTHER WATER PIPELINES
- STORMWATER PIPELINES
- GAS PIPELINES
- AIR PIPELINES
- BACKBONE SEWER PIPELINES
- SEWER SERVICE LINES
- EXISTING FRESHWATER PIPELINES
- FORMER UNDERGROUND STORAGE TANK LOCATION
- WATERFRONT CENTRAL DUMPSTERS
- GROUP I SITES
- GROUP II/III SITES
- STRUCTURES
- WATER

SAMPLE LOCATION — IR09GB016 (95)
CONCENTRATION (mg/kg) — 47F (5.5)
SAMPLE BEGINNING DEPTH (ft BGS)
SAMPLE COLLECTION YEAR

NOTES:

1. < = NOT DETECTED AT OR ABOVE THE INDICATED CONCENTRATION
2. F = ANALYSIS PERFORMED IN ON-SITE LABORATORY
3. = = ANALYTE WAS DETECTED
4. J = ESTIMATED DETECTED RESULT
5. Y = FUEL PATTERN (TPH ONLY)
6. Z = NOT A FUEL PATTERN (TPH ONLY)
7. DARK GRAY SYMBOL = SAMPLE(S) ANALYZED FOR PRESENTED CONSTITUENT(S)
8. LIGHT GRAY SYMBOL = OTHER SAMPLE LOCATIONS

N

0 50 100 Feet

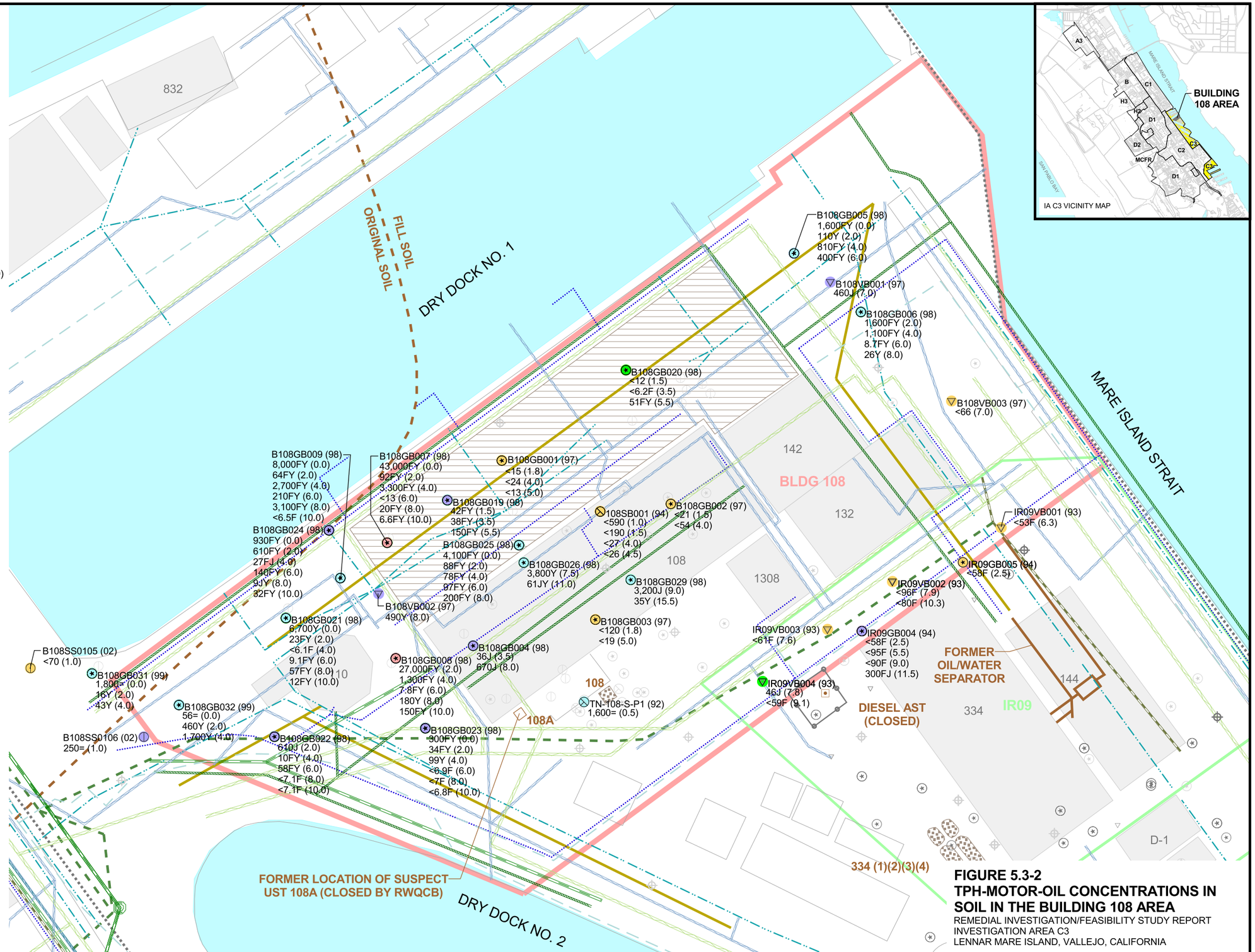

FIGURE 5.3-2
TPH-MOTOR-OIL CONCENTRATIONS IN SOIL IN THE BUILDING 108 AREA
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

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highest concentrations of TPH-motor-oil-range organics were generally found in surface soil outside and near the northwest corner of Building 108 and within the footprint of Building 108.

The soil sample with the highest TPH-diesel-range organics concentration at Building 108 was also the sample with the highest TPH-motor-oil-range organics concentration. Similar to TPH-diesel-range organics, the five samples with the highest TPH-motor-oil-range organics concentrations were collected in 1998 in shallow soil (0 to 2 feet bgs) from borings B108GB007, B108GB008, B108GB009, B108GB021, and B108GB025), located outside of and near the northwest corner of Building 108. The concentration of TPH-motor-oil-range organics in these samples was 43,000, 27,000, 8,000, 6,700, and 4,100 mg/kg. As was found with the distribution of TPH-diesel-range organics in this area, samples collected at greater depths in these borings contained relatively lower TPH-motor-oil-range organics concentrations. TPH-motor-oil-range organics concentrations in surface soil samples surrounding the above-listed boring locations were also relatively lower (up to three orders of magnitude), suggesting that the distribution of TPH-motor-oil-range organics concentrations is limited to surface and shallow subsurface soil near the northwestern corner of Building 108. Based upon the shallow depth of petroleum hydrocarbons, the source of the contamination in this area is likely associated with a surface release, possibly from the waterfront central dumpsters or activities associated with the machine shop.

Inside Building 108, TPH-motor-oil-range organics were found in six of 14 samples, with half of the concentrations below 100 mg/kg. The highest concentrations (3,600 and 3,200 mg/kg) were found in samples collected in 1998 at 7.5 and 9 feet bgs, respectively. TPH-motor-oil-range organics concentrations in deeper samples from these two locations were two orders of magnitude lower than these concentrations. The elevated concentrations are limited in their distribution and likely are due to historical activities within the former machine shop in Building 108.

Other Petroleum Hydrocarbon Compounds. As indicated in Table 5.3-1, TPH-gasoline-range organics were detected at a lower frequency rate in soil samples collected from the Building 108 Area than either TPH-diesel-range or TPH-motor-oil-range organics, and at far lower concentrations. TPH-gasoline-range organics were detected in six of the 49 soil samples analyzed. Detected concentrations of TPH-gasoline-range organics in soil samples collected from the Building 108 Area ranged from 0.65 to 4.0 mg/kg. The highest TPH-gasoline-range organics concentration was found in a 1992 sample near the former UST 108 (TN-108-S-09-EF-R) outside and near the southwest corner of Building 108. TRPH analysis was only performed on a limited number of soil samples collected from the Building 108 Area. TRPH was detected in three out of the five soil samples for which it was analyzed. The highest TRPH concentrations, 360 and 790 mg/kg, were found in 1994 samples from 108SB001, located inside Building 108, at 1 to 2 feet bgs, respectively.

5.3.1.2 VOC Compounds

As shown in Table 5.3-1, VOCs were infrequently detected in soil samples collected from the Building 108 Area. Most VOC compounds were not detected in soil samples at the Building 108 Area. The VOCs that were detected (toluene, ethylbenzene, xylenes, trichloroethylene [TCE], tetrachloroethylene [PCE], and acetone) are discussed below. Generally, each VOC was only sporadically detected in soil samples from the Building 108 Area, and no pattern of

distribution is discernable from the data. Only one VOC compound was detected in any single boring (except for TN-108-S-09-EF-R in which both ethylbenzene and xylenes were detected).

BTEX Compounds. Forty-five soil samples collected from the Building 108 Area were analyzed for benzene, toluene, ethylbenzene, and xylenes between 1992 and 1998. These samples were collected from 24 boring locations throughout the Building 108 site, at depths ranging from 0.5 to 9 feet bgs. Benzene was not detected in any of the 45 samples; toluene was detected in five of the 45 samples (at concentrations ranging from 0.003J to 0.008 mg/kg); ethylbenzene was detected in three of the 45 samples (at concentrations ranging from 0.0013 to 0.064 mg/kg); and xylenes were detected in six of the 45 samples (at concentrations ranging from 0.004J to 0.64 mg/kg).

Of the detected BTEX compounds, all were either:

- Found in samples collected near former UST 108, outside and near the southwestern corner of Building 108.
- Quantified at a concentration less than the analytical reporting limit.

The maximum concentrations of toluene, ethylbenzene and xylenes found in soil at the Building 108 Area are several orders of magnitude less than the respective USEPA Region 9 PRGs of 520, 20, and 420 mg/kg for the direct-contact exposure pathway in an industrial setting. Further, the maximum concentrations of toluene, ethylbenzene, and xylenes found in soil at the Building 108 Area are less than the respective RWQCB ESL of 9.3, 13, and 1.5 mg/kg for soil where groundwater is not a current or potential source of drinking water.

Other VOC Compounds. Other VOC compounds detected in soil at the Building 108 Area were TCE, PCE, and acetone. These compounds occur only sporadically and at concentrations that were near or below the respective reporting limit. Acetone was detected in two out of the 23 soil samples for which it was analyzed, at concentrations of 0.093 and 0.29 mg/kg. Considering the infrequent occurrence in soil samples and that the concentrations were near the reporting limits for acetone (0.011 mg/kg), the presence of acetone in soil samples collected from the Building 108 Area is likely the result of laboratory contamination.

TCE was detected in one of the 23 soil samples for which it was analyzed, at a concentration of 0.043 mg/kg. PCE was detected in three of the 23 soil samples for which it was analyzed at concentrations ranging from 0.002 to 0.007 mg/kg. The samples with detected concentrations of TCE and PCE were located between 1.5 and 6 feet bgs at isolated locations inside Building 108 and in the vicinity of the historical waterfront central dumpsters. Each of the detected TCE and PCE concentrations in soil at the Building 108 Area were quantified at concentrations below the analytical reporting limit.

The maximum concentrations of TCE and PCE found in soil at the Building 108 Area are one to four orders of magnitude less than the respective USEPA Region 9 PRGs of 0.11 and 3.4 mg/kg for the direct-contact exposure pathway in an industrial setting. The maximum concentrations of TCE and PCE found in soil at the Building 108 Area are also less than the respective RWQCB ESL of 0.73 and 0.25 mg/kg for soil where groundwater is not a current or potential source of drinking water.

5.3.1.3 SVOC Compounds

Soil samples collected from throughout the Building 108 Area were analyzed for SVOCs. As shown in Table 5.3-1, most SVOC compounds generally were only infrequently detected in soil samples from the Building 108 Area. Of the SVOC compounds found at the Building 108 site, the most frequently detected were PAHs. PAHs and other detected SVOCs are discussed below.

Polynuclear Aromatic Hydrocarbons. Thirty-two soil samples collected from the Building 108 Area were analyzed for PAHs. These samples were collected from 1 to 16 feet bgs from 12 boring and five surface sample locations. These sample locations were within the footprint of Building 108, east and west of Building 108, and in the area of the historical waterfront dumpsters. Twelve different PAH compounds were detected: 2-methylnaphthalene; anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, fluoranthene, ideno(1,2,3-cd)pyrene, napthalene, phenanthrene, and pyrene. The PAH compounds were detected in one to eight of the 32 samples analyzed for PAHs.

Concentrations of detected PAH compounds ranged from 0.01 mg/kg (benzo(a)pyrene) to 2.9 mg/kg (benzo(b)flouranthene). However, of the PAH results identified in Table 5.3-1 as detections, approximately 50 percent were quantified at concentrations lower than the analytical reporting limit. Further, the detected PAH concentrations (with the exception of benzo(a)pyrene and benzo(b)fluoranthene) were less than the USEPA Region 9 PRGs for the direct-contact exposure pathway in an industrial setting and the RWQCB ESLs for soil where groundwater is not a current or potential source of drinking water.

Two PAH compounds found in soil samples collected from the Building 108 Area (benzo(a)pyrene and benzo(b)fluoranthene) were detected at a maximum concentration that exceeded the USEPA Region 9 PRG for the direct-contact exposure pathway in an industrial setting and the RWQCB ESL for soil where groundwater is not a current or potential source of drinking water. The maximum concentration of benzo(a)pyrene (0.42 mg/kg) and benzo(b)fluoranthene (2.9 mg/kg) exceeded the respective PRG of 0.21 and 2.1 mg/kg and the respective ESL of 0.13 and 1.3 mg/kg. Benzo(a)pyrene and benzo(b)fluoranthene were detected in five of 32 samples, and one of five detected results were quantified at concentrations below the analytical reporting limit.

The highest concentrations of PAH compounds, including benzo(a)pyrene and benzo(b)fluoranthene, were detected in surface soil samples B108SS0100, B108SS0101, and B108SS0102. These surface soil samples are located outside the northwest corner of Building 108 and correspond with locations with the highest TPH-motor-oil and TPH-diesel concentrations in soil (B108GB008, B108GB007, and B108GB009, respectively). Based upon the shallow depth, the occurrence of PAHs in this area is likely associated with a surface release, possibly from the waterfront central dumpsters or activities associated with the machine shop, or may be indicative of asphalt or creosote incorporated into the shallow soil as a result of surface asphalt repairs performed over the decades of industrial operations in the vicinity of Building 108.

Other SVOC Compounds. Twenty-seven soil samples collected from 13 locations at the Building 108 Area from 1 to 10 feet bgs were analyzed for other SVOC compounds. Other SVOC compounds detected were bis(2-ethylhexyl)pthalate, butylbenzylphthalate,

dibenzofuran, and phenol. These four compounds were detected in one to seven of the 27 samples, at maximum concentrations of 9.6, 4.4, 0.42, and 1.2 mg/kg, respectively.

The compounds bis(2-ethylhexyl)pthalate and butylbenzylphthalate are common laboratory contaminants and considering the infrequent occurrence, the presence of these compounds in soil samples collected from the Building 108 Area is likely the result of laboratory contamination.

The samples with detected concentrations of dibenzofuran and phenol were collected from isolated locations inside Building 108 and in the vicinity of the historical waterfront central dumpsters between 1.5 and 8 feet bgs. Each of the detected dibenzofuran and phenol concentrations in soil at the Building 108 Area were quantified at concentrations below the analytical reporting limit.

As a basis for comparison, the maximum concentrations of dibenzofuran and phenol found in soil at the Building 108 Area are four to five orders of magnitude less than the respective USEPA Region 9 PRGs of 3,100 and 100,000 mg/kg for the direct-contact exposure pathway in an industrial setting. The maximum concentration of phenol found in soil at the Building 108 Area is also less than the respective RWQCB ESL of 19 mg/kg for soil where groundwater is not a current or potential source of drinking water.

5.3.1.4 Polychlorinated Biphenyls

Twenty-seven soil samples collected from the Building 108 Area were analyzed for PCBs. An additional six samples were analyzed specifically for Aroclor-1260. Aroclor-1260 was the only PCB compound detected in soil samples collected from the Building 108 Area. Aroclor-1260 was detected in only five of 33 soil samples at concentrations ranging from 0.0079 to 0.091 mg/kg. Of these, the reported Aroclor-1260 concentrations were below the analytical detection limit in two samples.

The five samples with detected concentrations of Aroclor-1260 were collected from 1.8 to 8.5 feet bgs, at isolated locations throughout the Building 108 Area. Two of the five samples with detected concentrations of Aroclor-1260 were collected from GeoProbe® borings inside Building 108, and three were collected at locations outside the building in vacuum excavation samples.

The maximum concentration of Aroclor-1260 (0.091 mg/kg) is less than the USEPA Region 9 PRG of 0.74 mg/kg for the direct-contact exposure pathway in an industrial setting.

5.3.1.5 Pesticides

Twenty-one soil samples collected from the Building 108 Area were analyzed for pesticides. As indicated in Table 5.3-1, eight individual pesticide compounds were detected in soil samples collected from the Building 108 Area: aldrin, delta-BHC, endrin aldehyde, endrin ketone, gamma-BHC, gamma chlordane, heptachlor, and heptachlor epoxide. These pesticides were detected in one to three samples each at maximum concentrations of 0.015, 0.001, 0.002, 0.0019, 0.001, 0.0015, 0.00088, and 0.00061 mg/kg, respectively. These pesticides were detected in samples collected from sporadic locations within the footprint of Building 108 and in the vicinity of the former waterfront dumpsters, all between 4 and 8.5 feet bgs.

The maximum concentration of pesticides found in soils in the Building 108 Area are two to four orders of magnitude less than the USEPA Region 9 PRGs for the direct-contact exposure pathway in an industrial setting. The PRGs for aldrin, gamma-BHC, gamma-chlordane, heptachlor and heptachlor epoxide are 0.1, 2.9, 11, and 0.19 mg/kg, respectively. Further, for those pesticide compounds found in soil at the Building 108 site for which the RWQCB has established an ESL, the concentrations found in site soils were less than the respective ESL. The maximum concentration of aldrin, heptachlor, and heptachlor epoxide found in soil samples from the Building 108 Area were less than the respective ESLs of 0.1, 0.014, and 0.015 mg/kg.

5.3.1.6 Metals

Table 5.3-1 provides of summary of metals results in soil samples collected from the Building 108 Area, and distinguishes the results between "laboratory" analysis and "XRF" analysis. Laboratory analysis means analysis of soil samples by an off-site laboratory using CLP methods. XRF analysis means analysis of soil samples by the Navy's Mare Island on-site laboratory using XRF methodology. Seventeen of the 27 metals listed in Table 5.3-1 were analyzed for in soil samples collected from the Building 108 site by both laboratory analysis, and by XRF analysis. The other 10 metals were analyzed for by laboratory analysis, only. In general, approximately twice as many samples were analyzed for metals by XRF methodology as were analyzed by other analytical methods.

As discussed in Section 2.3, ambient values of select metals in both native island materials and fill soils at Mare Island have been established. Ambient values for selected metals at Mare Island establish naturally-occurring conditions against which site concentrations can be compared to identify conditions that may be attributable to site activities. Table 5.3-1 shows the ambient value for fill soils (appropriate because of the location of the Building 108 Area site) and identifies the number of samples with metals results greater than the respective ambient concentration. Of the 27 metals analyzed for in soil samples collected from the Building 108 Area, ambient levels have been established for 15.

As indicated in Table 5.3-1, 12 different metals were found at concentrations exceeding the ambient value by CLP methods. Of these, eight were found at concentrations exceeding the upper range of the ambient data set and at a frequency that suggests an association with site activities. The metal most frequently found at concentrations exceeding the ambient level in soil samples collected from the Building 108 Area was lead; the distribution of lead is shown in Figure 5.3-3. Other metals found above ambient concentrations in soil samples from the Building 108 Area were chromium, manganese, beryllium, copper, nickel, thallium, and zinc. These compounds are discussed below.

Lead. Figure 5.3-3 shows the distribution of lead concentrations in soil at the Building 108 Area. Nineteen of the 39 soil samples analyzed by CLP methods contained lead at concentrations exceeding the ambient concentration for lead in fill materials (59 mg/kg). The soil sample that contained the maximum lead concentration, 4,500 mg/kg, was collected at 2 feet bgs from B108GB025, which is located immediately north of Building 108. Elevated lead concentrations (1,000 to 2,800 mg/kg) were also found in

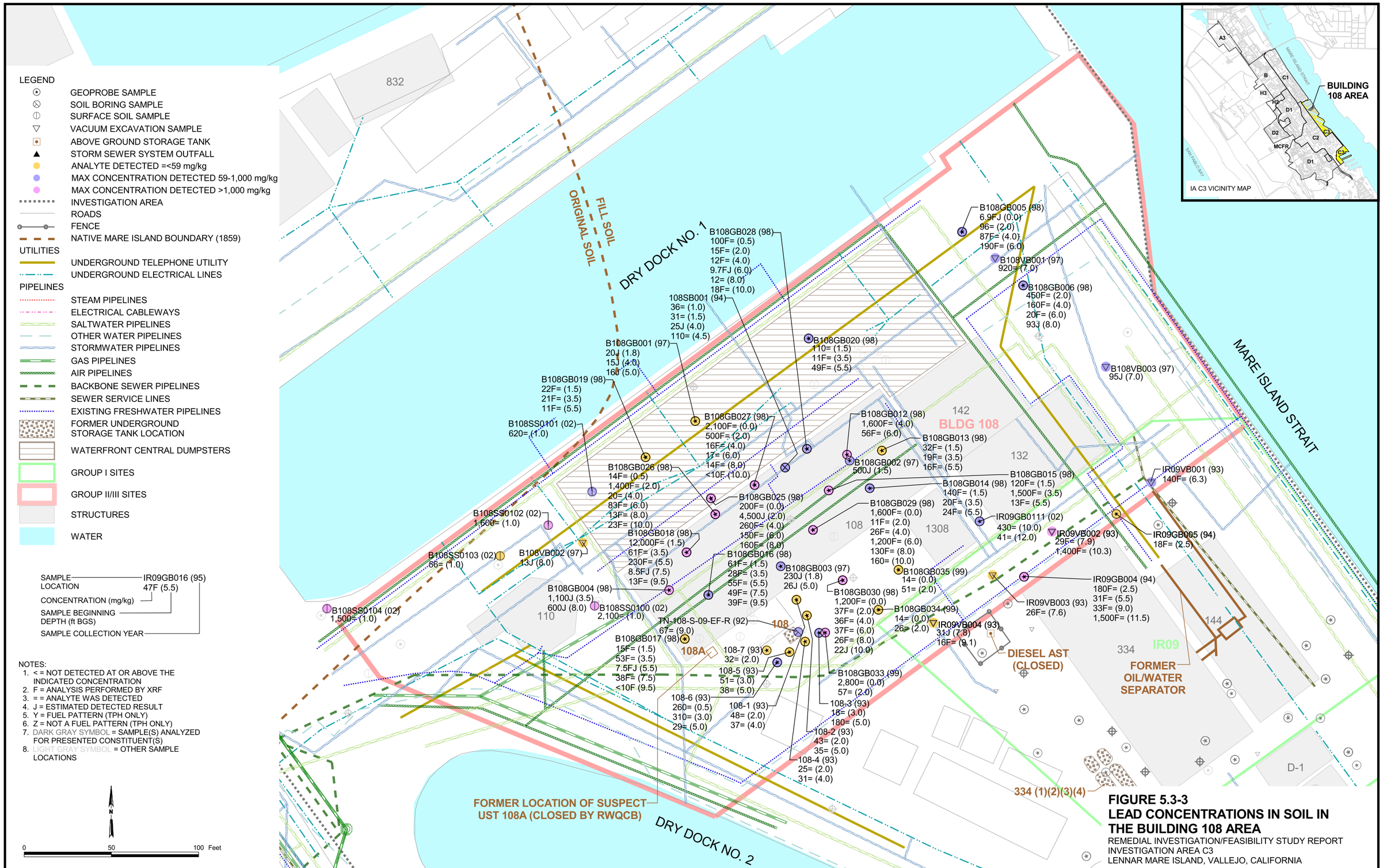

FIGURE 5.3-3
LEAD CONCENTRATIONS IN SOIL IN THE BUILDING 108 AREA
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

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samples collected from 0 to 7 feet bgs at locations northwest, south, and within the footprint of Building 108. Thirty of the 86 soil samples analyzed by XRF contained lead at concentrations exceeding the ambient concentration. The maximum lead concentration by XRF was found in a sample collected at 1.5 feet bgs in B108GB018, located within the footprint of Building 108. Sample results from XRF analysis are denoted with an "F" in Figure 5.3-3.

As shown in Figure 5.3-3, the highest lead concentrations typically were found in the shallowest soil sample in a boring, particularly to the northwest and south of Building 108. Lead concentrations in samples collected at greater depths were lower and typically less than the established ambient concentration. The source of elevated lead concentrations in soil is likely associated with the former machine shop activities (e.g., grinding, drilling, small-parts fabrication, metal cleaning, and welding). The highest concentrations of lead were found in surface and near surface soil in the area near the northwest corner of Building 108. The locations of highest lead concentrations correspond with the highest TPH and PAH concentrations in site soils.

Zinc. Zinc was found in six of 32 samples analyzed by CLP methods at concentrations exceeding the ambient concentration for fill materials (230 mg/kg). The maximum concentration detected by CLP methods, 9,400 mg/kg, was found in a sample collected at 8 feet bgs in B108GB004, located inside Building 108, which is considerably higher than other detected zinc concentrations (up to 600 mg/kg). Samples that were analyzed by XRF were generally found to contain zinc at concentrations similar in magnitude to those analyzed by CLP methods. The five soil samples with zinc concentrations greater than 1,000 mg/kg, either by XRF or CLP methods, were all located within the footprint of Building 108 and are likely associated with former machine shop activities.

Manganese. Manganese concentrations in soil samples collected at the Building 108 Area and analyzed by CLP methods ranged from 240 to 4,800 mg/kg. Five of the 31 samples contained manganese at a concentration exceeding the ambient soil concentration for fill materials (1,600 mg/kg). Samples that were analyzed by XRF generally were found to contain manganese at concentrations similar in magnitude to those analyzed by CLP methods, with the exception of one sample collected from B108GB030 (located south of Building 108) at 2 feet bgs that contained a manganese concentration of 39,000 mg/kg. Samples with manganese concentrations greater than the established ambient level, analyzed by both CLP and XRF methods, were found:

- Within the footprint of Building 108 between 1 and 8.5 feet bgs (may be associated with machine shop activities).
- In the vicinity of the former UST 108 between 0.5 and 10 feet bgs (may be associated with the ABM observed in the UST backfill).

Chromium. Chromium was found at concentrations exceeding the ambient level in fill materials (140 mg/kg) in two of the 32 samples for which it was analyzed by CLP methods. The highest chromium concentration (1,900 mg/kg) was found in a sample collected from the excavation base of UST 108 and was one to three orders of magnitude greater than other chromium results (6.9 to 290 mg/kg). This localized, elevated chromium concentration likely was associated with ABM, which was observed in the UST backfill and piping trench

during excavation activities. The only other sample analyzed by CLP methods found to contain chromium a concentration (285 mg/kg) greater than the established ambient level was collected from B108GB004 (located inside Building 108) at a depth of 8 feet bgs. Samples analyzed by XRF generally were found to contain chromium at concentrations similar in magnitude to those analyzed by CLP methods. Fifteen of the 86 samples analyzed by XRF with chromium concentrations above the established ambient level had chromium concentrations between 140 and 220 mg/kg. Chromium concentrations greater than the established ambient level, analyzed by both CLP and XRF methods, were found:

- Within Building 108 between 5.5 and 10.5 feet bgs (may be associated with machine shop activities).
- Immediately north of Building 108 in surface soil in the vicinity of the former waterfront central dumpsters).
- From vacuum excavation borings between 8 and 10 feet bgs (may be associated with ABM).
- In the vicinity of the former UST 108 between 2 and 8.5 feet bgs (likely associated with the ABM observed in the UST backfill).

Beryllium. Beryllium was found at concentrations exceeding the ambient level in fill materials (0.9 mg/kg) in seven of the 31 samples for which it was analyzed by CLP methods. The maximum concentration of beryllium was found in a vacuum excavation sample at a depth of 8 feet bgs. Other beryllium concentrations greater than the established ambient level were between 1.3 and 2.1 mg/kg and were found in samples collected from 108SB001 located inside Building 108 between 1 and 5 feet bgs. Beryllium concentrations found inside Building 108 likely are associated with the former machine shop.

Copper. Copper was found at concentrations exceeding the ambient level in fill materials (120 mg/kg) in five of the 31 samples for which it was analyzed by CLP methods. The highest concentration (1,800 mg/kg) was found in a sample collected from 8 feet bgs inside Building 108. Samples that were analyzed by XRF generally were found to contain copper at concentrations similar in magnitude to those analyzed by CLP methods. Copper was detected above the ambient concentration in 14 of the 86 samples for which it was analyzed by XRF, at concentrations up 1,600 mg/kg. Samples with copper concentrations greater than the established ambient level, analyzed by both CLP and XRF methods, were collected at locations predominantly within the footprint of Building 108, between 0.5 and 10.5 feet bgs. Copper concentrations found inside Building 108 likely are associated with the former machine shop.

Nickel. Nickel was found in two of 32 soil samples at concentrations exceeding the ambient value for fill materials (130 mg/kg), as analyzed by CLP methods. The maximum nickel concentration was found in the same sample that contained the maximum chromium concentration, collected from the excavation of the former UST at 9 feet bgs. The nickel concentration at this location likely is associated with ABM, which was observed in the UST backfill and piping. The other sample with a nickel concentration exceeding the ambient level was collected from a location inside Building 108 (B108GB004) at 8 feet bgs. Nickel was also found in two of 86 soil samples at concentrations exceeding the ambient value, as

analyzed by XRF. Both samples were collected from B108GB030, located south of Building 108, at 2 and 4 feet bgs.

Thallium. Thallium was detected in six of the 31 samples for which it was analyzed by CLP methods. Thallium was detected at concentrations between 0.5 and 1 mg/kg in soil samples collected between 6 and 8.5 feet bgs in three locations within the footprint of Building 108. Thallium also was detected at concentrations between 4 and 11 mg/kg in soil samples collected between 0 and 2.5 feet bgs at two locations south of Building 108. Thallium concentrations found inside Building 108 likely are associated with the former machine shop.

5.3.2 Groundwater

A summary of groundwater data for the Building 108 Area is provided in Table 5.3-2. For each compound, the table shows the number of samples analyzed, the number of detected results of that compound[13], the average result, the maximum result, and the frequency of detection. For metals analysis, the table shows the ambient concentration for shallow groundwater at Mare Island (see also Table 2.3-2) and identifies the number of samples with metal results greater than the respective ambient concentration.

Only groundwater data collected since January 1998 are included in Table 5.3-2 and in the discussion that follows. Data collected since January 1998 most accurately reflect current conditions. A complete set of analytical groundwater data for the Building 108 Area is provided in Appendix F7.

The following is a discussion of the results of the analytical categories in Table 5.3-2 (petroleum hydrocarbon compounds, VOCs, SVOCs, and metals). The natural geochemistry of the Building 108 Area groundwater was discussed in Section 1.6 and indicates that the Building 108 Area groundwater is brackish.

5.3.2.1 Petroleum Hydrocarbons

Consistent with the results of soil sampling at the Building 108 Area, petroleum hydrocarbon compounds (primarily TPH-diesel and TPH-motor-oil) were the organic compounds most frequently detected in groundwater samples collected from the site. The following discusses petroleum hydrocarbon results in groundwater at the Building 108 Area.

TPH-diesel. TPH-diesel was detected at concentrations ranging from 40 to 1,900 µg/L in 17 of the 29 samples for which it was analyzed. Three of these detected results were below the analytical reporting limit. TPH-diesel was found in groundwater collected from five separate wells across the Building 108 site, as well as from four borings outside Building 108 to the east and west. The sample with the maximum detected TPH-diesel concentration (1,900 µg/L) was collected in July 1999 from monitoring well B108W02, which is located within the footprint of Building 108. Two samples collected from this well subsequent to the July 1999 sampling event had substantially lower TPH-diesel concentrations (180 and 56 µg/L). Grab groundwater samples collected in 1998 from three borings outside and near

[13] Includes those samples for which a compound was quantified at a concentration below the analytical reporting limit.

Table 5.3-2

Investigation Area C3, Building 108 Area Statistical Summary Table of Analytical Groundwater Data

Analyte	CAS Number	Filtered/ Unfiltered	Ambient Concentration for Metals (ug/L)	Source of Ambient Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Ambient Concentration for Metals	Average Result (ug/L)	Minimum Detection (ug/L)	Maximum Detection (ug/L)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (ug/L)	Maximum Detection Limit (ug/L)
WATER - BUILDING 108 AREA																	
Petroleum Hydrocarbon Compounds																	
DIESEL	DRO	Unfiltered			29	17		2.5E+02	4.0E+01	1.9E+03	7/6/1999	B108W02			59%	5.0E+01	2.0E+02
GASOLINE	GRO	Unfiltered			21	4		3.2E+01	3.0E+01	1.4E+02	7/6/1999	B108W02			19%	5.0E+01	5.0E+01
MOTOR OIL	MRO	Unfiltered			29	14		1.6E+02	5.0E+01	1.4E+03	5/4/1998	B108GB008	6.1	10.2	48%	1.0E+02	2.0E+02
Volatile Organic Compounds																	
1,1,1-TRICHLOROETHANE	71-55-6	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
1,1,2,2-TETRACHLOROETHANE	79-34-5	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
1,1,2-TRICHLOROETHANE	79-00-5	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
1,1-DICHLOROETHANE	75-34-3	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
1,1-DICHLOROETHENE	75-35-4	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
1,2,4-TRICHLOROBENZENE	120-82-1	Unfiltered			20	1		3.9E+00	9.3E-01	9.3E-01	10/8/1999	B108W02			5%	1.0E+00	1.1E+01
1,2-DICHLOROETHANE	107-06-2	Unfiltered			3	0		2.5E-01							0%	5.0E-01	5.0E-01
1,2-DICHLOROETHENE (TOTAL)	540-59-0	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
1,2-DICHLOROPROPANE	78-87-5	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
1,3-DICHLOROBENZENE	541-73-1	Unfiltered			20	1		3.4E+00	1.4E-01	1.4E-01	10/8/1999	B108W02			5%	1.0E+00	1.1E+01
2-BUTANONE	78-93-3	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
2-HEXANONE	591-78-6	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
4-METHYL-2-PENTANONE	108-10-1	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
ACETONE	67-64-1	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
BENZENE	71-43-2	Unfiltered			3	0		2.5E-01							0%	5.0E-01	5.0E-01
BROMODICHLOROMETHANE	75-27-4	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
BROMOFORM	75-25-2	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
BROMOMETHANE	74-83-9	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
CARBON DISULFIDE	75-15-0	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
CARBON TETRACHLORIDE	56-23-5	Unfiltered			3	0		2.5E-01							0%	5.0E-01	5.0E-01
CHLOROBENZENE	108-90-7	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
CHLOROETHANE	75-00-3	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
CHLOROFORM	67-66-3	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
CHLOROMETHANE	74-87-3	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
CIS-1,3-DICHLOROPROPENE	10061-01-5	Unfiltered			3	0		2.5E-01							0%	5.0E-01	5.0E-01
DIBROMOCHLOROMETHANE	124-48-1	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
ETHYLBENZENE	100-41-4	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
METHYLENE CHLORIDE	75-09-2	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
STYRENE	100-42-5	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
TETRACHLOROETHENE	127-18-4	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
TOLUENE	108-88-3	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
TRANS-1,3-DICHLOROPROPENE	10061-02-6	Unfiltered			3	0		2.5E-01							0%	5.0E-01	5.0E-01
TRICHLOROETHENE	79-01-6	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
VINYL CHLORIDE	75-01-4	Unfiltered			3	0		2.5E-01							0%	5.0E-01	5.0E-01
XYLENE (TOTAL)	1330-20-7	Unfiltered			3	0		1.0E+00							0%	2.0E+00	2.0E+00
Semi-Volatile Organic Compounds																	
1,2-DICHLOROBENZENE	95-50-1	Unfiltered			20	1		3.4E+00	6.8E-01	6.8E-01	10/8/1999	B108W02			5%	1.0E+00	1.1E+01
1,4-DICHLOROBENZENE	106-46-7	Unfiltered			20	1		3.4E+00	6.8E-01	6.8E-01	10/8/1999	B108W02			5%	1.0E+00	1.1E+01
2,4,5-TRICHLOROPHENOL	95-95-4	Unfiltered			20	0		1.0E+01							0%	3.0E+00	2.7E+01
2,4,6-TRICHLOROPHENOL	88-06-2	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01

Table 5.3-2

Investigation Area C3, Building 108 Area Statistical Summary Table of Analytical Groundwater Data

Analyte	CAS Number	Filtered/ Unfiltered	Ambient Concentration for Metals (ug/L)	Source of Ambient Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Ambient Concentration for Metals	Average Result (ug/L)	Minimum Detection (ug/L)	Maximum Detection (ug/L)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (ug/L)	Maximum Detection Limit (ug/L)
WATER - BUILDING 108 AREA																	
2,4-DICHLOROPHENOL	120-83-2	Unfiltered			20	1		3.9E+00	1.0E+00	1.0E+00	10/8/1999	B108W02			5%	1.0E+00	1.1E+01
2,4-DIMETHYLPHENOL	105-67-9	Unfiltered			20	1		7.0E+00	6.2E+01	6.2E+01	10/8/1999	B108W02			5%	1.0E+00	1.1E+01
2,4-DINITROPHENOL	51-28-5	Unfiltered			20	0		1.0E+01							0%	3.0E+00	2.7E+01
2-CHLORONAPHTHALENE	91-58-7	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
2-CHLOROPHENOL	95-57-8	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
2-METHYL-4,6-DINITROPHENOL	534-52-1	Unfiltered			20	0		1.0E+01							0%	3.0E+00	2.7E+01
2-METHYLNAPHTHALENE	91-57-6	Unfiltered			20	1		5.5E+00	3.2E+01	3.2E+01	10/8/1999	B108W02			5%	1.0E+00	1.1E+01
2-METHYLPHENOL	95-48-7	Unfiltered			20	1		4.6E+00	1.4E+01	1.4E+01	10/8/1999	B108W02			5%	1.0E+00	1.1E+01
2-NITROANILINE	88-74-4	Unfiltered			20	0		1.0E+01							0%	3.0E+00	2.7E+01
2-NITROPHENOL	88-75-5	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
3,3'-DICHLOROBENZIDINE	91-94-1	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
3-NITROANILINE	99-09-2	Unfiltered			20	0		1.0E+01							0%	3.0E+00	2.7E+01
4-BROMOPHENYL-PHENYLETHER	101-55-3	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
4-CHLORO-3-METHYLPHENOL	59-50-7	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
4-CHLOROANILINE	106-47-8	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
4-CHLOROPHENYL-PHENYLETHER	7005-72-3	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
4-METHYLPHENOL	106-44-5	Unfiltered			20	2		8.5E+00	3.4E+01	6.3E+01	7/6/1999	B108W02			10%	1.0E+00	1.1E+01
4-NITROANILINE	100-01-6	Unfiltered			20	0		1.0E+01							0%	3.0E+00	2.7E+01
4-NITROPHENOL	100-02-7	Unfiltered			20	0		1.0E+01							0%	3.0E+00	2.7E+01
ACENAPHTHENE	83-32-9	Unfiltered			20	1		4.2E+00	5.7E+00	5.7E+00	10/8/1999	B108W02			5%	1.0E+00	1.1E+01
ACENAPHTHYLENE	208-96-8	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
ANILINE	62-53-3	Unfiltered			9	0		1.3E+01							0%	2.4E+01	2.7E+01
ANTHRACENE	120-12-7	Unfiltered			20	1		4.0E+00	2.1E+00	2.1E+00	10/8/1999	B108W02			5%	1.0E+00	1.1E+01
BENZO(A)ANTHRACENE	56-55-3	Unfiltered			20	1		3.9E+00	3.8E-01	3.8E-01	10/11/1999	B108W05			5%	1.0E+00	1.1E+01
BENZO(A)PYRENE	50-32-8	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
BENZO(B)FLUORANTHENE	205-99-2	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
BENZO(G,H,I)PERYLENE	191-24-2	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
BENZO(K)FLUORANTHENE	207-08-9	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
BIS(2-CHLOROETHOXY)METHANE	111-91-1	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
BIS(2-CHLOROETHYL)ETHER	111-44-4	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
BIS(2-CHLOROISOPROPYL)ETHER	108-60-1	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
BIS(2-ETHYLHEXYL)PHTHALATE	117-81-7	Unfiltered			20	0		3.5E+00							0%	1.0E+00	1.1E+01
BUTYLBENZYLPHTHALATE	85-68-7	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
CARBAZOLE	86-74-8	Unfiltered			20	1		4.7E+00	1.7E+01	1.7E+01	10/8/1999	B108W02			5%	1.0E+00	1.1E+01
CHRYSENE	218-01-9	Unfiltered			20	1		3.9E+00	3.5E-01	3.5E-01	10/11/1999	B108W05			5%	1.0E+00	1.1E+01
DI-N-BUTYLPHTHALATE	84-74-2	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
DI-N-OCTYLPHTHALATE	117-84-0	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
DIBENZ(A,H)ANTHRACENE	53-70-3	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
DIBENZOFURAN	132-64-9	Unfiltered			20	1		4.1E+00	3.4E+00	3.4E+00	10/8/1999	B108W02			5%	1.0E+00	1.1E+01
DIETHYLPHTHALATE	84-66-2	Unfiltered			20	1		3.9E+00	1.0E+00	1.0E+00	8/17/1999	B108W03			5%	1.0E+00	1.1E+01
DIMETHYLPHTHALATE	131-11-3	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
FLUORANTHENE	206-44-0	Unfiltered			20	1		3.9E+00	4.6E-01	4.6E-01	10/8/1999	B108W02			5%	1.0E+00	1.1E+01
FLUORENE	86-73-7	Unfiltered			20	1		4.2E+00	6.5E+00	6.5E+00	10/8/1999	B108W02			5%	1.0E+00	1.1E+01
HEXACHLOROBENZENE	118-74-1	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
HEXACHLOROBUTADIENE	87-68-3	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
HEXACHLOROCYCLOPENTADIENE	77-47-4	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
HEXACHLOROETHANE	67-72-1	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
INDENO(1,2,3-CD)PYRENE	193-39-5	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01

Table 5.3-2

Investigation Area C3, Building 108 Area Statistical Summary Table of Analytical Groundwater Data

Analyte	CAS Number	Filtered/ Unfiltered	Ambient Concentration for Metals (ug/L)	Source of Ambient Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Ambient Concentration for Metals	Average Result (ug/L)	Minimum Detection (ug/L)	Maximum Detection (ug/L)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (ug/L)	Maximum Detection Limit (ug/L)
WATER - BUILDING 108 AREA																	
ISOPHORONE	78-59-1	Unfiltered			20	2		3.7E+00	2.4E-01	4.1E-01	10/8/1999	B108W02			10%	1.0E+00	1.1E+01
N-NITROSO-DI-N-PROPYLAMINE	621-64-7	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
N-NITROSODIMETHYLAMINE	62-75-9	Unfiltered			9	0		1.3E+01							0%	2.4E+01	2.7E+01
N-NITROSODIPHENYLAMINE (1)	86-30-6	Unfiltered			20	0		4.1E+00							0%	1.0E+00	1.1E+01
NAPHTHALENE	91-20-3	Unfiltered			20	1		7.2E+00	6.7E+01	6.7E+01	10/8/1999	B108W02			5%	1.0E+00	1.1E+01
PENTACHLOROPHENOL	87-86-5	Unfiltered			20	0		7.0E+00							0%	3.0E+00	2.5E+01
PHENANTHRENE	85-01-8	Unfiltered			20	1		4.2E+00	5.6E+00	5.6E+00	10/8/1999	B108W02			5%	1.0E+00	1.1E+01
PHENOL	108-95-2	Unfiltered			20	2		4.7E+00	3.0E+00	1.9E+01	10/8/1999	B108W02			10%	1.0E+00	1.1E+01
PYRENE	129-00-0	Unfiltered			20	1		3.9E+00	3.0E-01	3.0E-01	10/8/1999	B108W02			5%	1.0E+00	1.1E+01
Metals																	
ALUMINUM	7429-90-5	Filtered	4.8E+02	a	3	0	0	1.7E+01							0%	2.0E+01	5.0E+01
ALUMINUM	7429-90-5	Unfiltered	4.8E+02	a	14	4	0	5.4E+01	9.0E+01	2.2E+02	4/27/1999	B108W02			29%	1.6E+01	8.0E+01
ANTIMONY	7440-36-0	Filtered	5.6E+00	a	3	0	0	2.3E+00							0%	2.5E+00	6.0E+00
ANTIMONY	7440-36-0	Unfiltered	5.6E+00	a	14	0	0	2.6E+00							0%	1.0E+00	3.0E+01
ARSENIC	7440-38-2	Filtered	7.8E+01	a	3	2	0	2.3E+01	2.2E+01	4.7E+01	10/7/1999	B108W03			67%	1.0E+00	2.0E+01
ARSENIC	7440-38-2	Unfiltered	7.8E+01	a	14	5	0	3.6E+00	5.7E+00	9.6E+00	7/6/1999	B108W05			36%	1.0E+00	6.0E+00
BARIUM	7440-39-3	Filtered	1.2E+03	a	3	3	0	7.9E+01	2.5E+01	1.1E+02	10/7/1999	B108W03			100%	1.0E+00	2.0E+02
BARIUM	7440-39-3	Unfiltered	1.2E+03	a	14	13	0	1.3E+02	3.9E+01	2.7E+02	7/1/1999	B108W01			93%	7.2E-01	2.0E+02
BERYLLIUM	7440-41-7	Filtered	1.6E+00	a	3	0	0	9.0E-01							0%	4.1E-01	4.0E+00
BERYLLIUM	7440-41-7	Unfiltered	1.6E+00	a	14	0	0	6.5E-01							0%	1.1E-01	4.0E+00
CADMIUM	7440-43-9	Filtered	1.6E+01	a	3	0	0	1.4E+00							0%	3.3E-01	5.0E+00
CADMIUM	7440-43-9	Unfiltered	1.6E+01	a	14	3	0	1.3E+00	2.0E-01	2.2E+00	4/26/1999	B108W01			21%	1.7E-01	5.0E+00
CALCIUM	7440-70-2	Filtered	6.8E+05	a	7	7	0	1.6E+05	3.0E+04	2.3E+05	10/18/2002	B108W03			100%	2.0E+01	5.0E+03
CALCIUM	7440-70-2	Unfiltered	6.8E+05	a	14	14	0	7.7E+04	2.2E+04	2.1E+05	10/8/1999	B108W01			100%	2.0E+01	5.0E+03
CHROMIUM	7440-47-3	Filtered	2.2E+01	a	3	0	0	2.8E+00							0%	3.0E+00	1.0E+01
CHROMIUM	7440-47-3	Unfiltered	2.2E+01	a	14	3	0	2.5E+00	2.5E+00	2.7E+00	4/27/1999	B108W05			21%	4.1E-01	1.0E+01
COBALT	7440-48-4	Filtered	1.0E+02	a	3	0	0	9.6E+00							0%	2.8E+00	5.0E+01
COBALT	7440-48-4	Unfiltered	1.0E+02	a	14	1	0	6.5E+00	5.9E-01	5.9E-01	4/26/1999	B108W04			7%	2.9E-01	5.0E+01
COPPER	7440-50-8	Filtered	3.3E+01	a	3	1	0	2.1E+00	3.1E+00	3.1E+00	10/7/1999	B108W03			33%	3.0E+00	2.5E+01
COPPER	7440-50-8	Unfiltered	3.3E+01	a	14	2	0	5.2E+00	8.3E+00	1.4E+01	1/25/2000	B108W01			14%	1.2E+00	2.5E+01
HEXAVALENT CHROMIUM	18540-29-9	Unfiltered			16	0	0	5.0E+00							0%	1.0E+01	1.0E+01
IRON	7439-89-6	Filtered	1.4E+05	a	7	5	0	2.2E+03	3.3E+02	6.8E+03	10/7/1999	B108W03			71%	5.0E+00	1.0E+02
IRON	7439-89-6	Unfiltered	1.4E+05	a	14	14	0	1.4E+03	1.2E+02	1.1E+04	10/8/1999	B108W02			100%	2.5E+00	1.0E+02
LEAD	7439-92-1	Filtered	1.0E+01	a	3	0	0	2.5E+00							0%	1.0E+00	1.1E+01
LEAD	7439-92-1	Unfiltered	1.0E+01	a	14	4	0	1.9E+00	1.4E+00	5.9E+00	4/27/1999	B108W02			29%	9.5E-01	1.1E+01
MAGNESIUM	7439-95-4	Filtered	1.5E+06	a	7	7	0	2.6E+05	2.1E+04	4.9E+05	10/18/2002	B108W01			100%	5.6E+01	5.0E+03
MAGNESIUM	7439-95-4	Unfiltered	1.5E+06	a	14	14	0	9.5E+04	1.9E+04	4.0E+05	10/8/1999	B108W01			100%	2.0E+00	5.0E+03
MANGANESE	7439-96-5	Filtered	5.4E+03	a	3	3	0	8.1E+02	5.0E+01	1.4E+03	7/9/1999	B108W03			100%	1.7E+00	1.5E+01
MANGANESE	7439-96-5	Unfiltered	5.4E+03	a	14	14	0	5.2E+02	5.9E+00	1.7E+03	10/8/1999	B108W02			100%	2.4E-01	1.5E+01
MERCURY	7439-97-6	Filtered	2.2E-01	a	3	1	0	8.7E-02	1.1E-01	1.1E-01	7/9/1999	B108W03			33%	5.0E-02	2.0E-01
MERCURY	7439-97-6	Unfiltered	2.2E-01	a	10	1	0	6.5E-02	1.2E-01	1.2E-01	1/25/2000	B108W01			10%	5.0E-02	2.0E-01
MOLYBDENUM	7439-98-7	Filtered	8.8E+00	a	3	0	0	2.0E+00							0%	3.0E+00	5.0E+00
MOLYBDENUM	7439-98-7	Unfiltered	8.8E+00	a	14	0	0	1.5E+00							0%	4.4E-01	5.0E+00
NICKEL	7440-02-0	Filtered	7.5E+00	a	3	0	0	9.1E+00							0%	4.8E+00	4.0E+01
NICKEL	7440-02-0	Unfiltered	7.5E+00	a	14	1	0	6.5E+00	2.8E+00	2.8E+00	4/27/1999	B108W05			7%	3.6E-01	4.0E+01
POTASSIUM	7440-09-7	Filtered	2.1E+05	a	7	7	0	6.9E+04	6.6E+03	1.7E+05	10/18/2002	B108W01			100%	2.0E+02	5.0E+03
POTASSIUM	7440-09-7	Unfiltered	2.1E+05	a	14	13	0	3.1E+04	6.8E+03	1.2E+05	10/8/1999	B108W01			93%	1.2E+01	5.0E+03

Table 5.3-2

Investigation Area C3, Building 108 Area Statistical Summary Table of Analytical Groundwater Data

Analyte	CAS Number	Filtered/ Unfiltered	Ambient Concentration for Metals (ug/L)	Source of Ambient Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Ambient Concentration for Metals	Average Result (ug/L)	Minimum Detection (ug/L)	Maximum Detection (ug/L)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (ug/L)	Maximum Detection Limit (ug/L)
WATER - BUILDING 108 AREA																	
SELENIUM	7782-49-2	Filtered	1.2E+01	a	3	0	0	2.3E+00							0%	4.0E+00	5.0E+00
SELENIUM	7782-49-2	Unfiltered	1.2E+01	a	14	3	0	3.0E+00	1.7E+00	4.3E+00	10/8/1999	B108W01			21%	1.0E+00	2.5E+01
SILVER	7440-22-4	Filtered	1.5E+01	a	3	0	0	4.3E+00							0%	4.0E+00	1.2E+01
SILVER	7440-22-4	Unfiltered	1.5E+01	a	14	0	0	2.4E+00							0%	8.0E-01	1.2E+01
SODIUM	7440-23-5	Filtered	7.4E+06	a	7	7	0	2.3E+06	4.0E+05	4.5E+06	10/18/2002	B108W01			100%	3.0E+02	1.0E+05
SODIUM	7440-23-5	Unfiltered	7.4E+06	a	14	14	0	7.4E+05	1.2E+05	3.6E+06	10/8/1999	B108W01			100%	3.0E+01	2.5E+05
THALLIUM	7440-28-0	Filtered		d	3	0	0	2.1E+00							0%	1.0E+00	1.0E+01
THALLIUM	7440-28-0	Unfiltered		d	14	1	1	1.9E+00	2.0E+00	2.0E+00	7/1/1999	B108W01			7%	1.0E+00	1.0E+01
VANADIUM	7440-62-2	Filtered	1.4E+02	a	3	2	0	1.3E+01	7.1E+00	7.4E+00	1/25/2000	B108W03			67%	3.0E+00	5.0E+01
VANADIUM	7440-62-2	Unfiltered	1.4E+02	a	14	8	0	5.1E+00	1.2E+00	1.3E+01	1/25/2000	B108W04			57%	5.5E-01	5.0E+01
ZINC	7440-66-6	Filtered	2.6E+02	a	10	8	4	2.4E+02	1.0E+01	9.2E+02	1/12/2004	B108W01			80%	2.0E+00	2.0E+01
ZINC	7440-66-6	Unfiltered	2.6E+02	a	14	9	2	9.0E+01	3.8E+00	8.9E+02	7/1/1999	B108W01			64%	9.6E-01	2.0E+01
General Chemistry																	
ALKALINITY BICARBONATE	ALKB	Unfiltered			4	4		5.2E+05	1.4E+05	1.2E+06	10/18/2002	B108W03			100%	5.0E+03	5.0E+03
ALKALINITY CARBONATE	ALKC	Unfiltered			4	0		2.5E+03							0%	5.0E+03	5.0E+03
CHLORIDE	16887-00-6	Unfiltered			21	21		2.1E+06	1.6E+05	7.9E+06	10/18/2002	B108W01			100%	2.0E+02	1.0E+06
NITRATE+NITRITE AS NITROGEN	NITRATE+NITRI	Unfiltered			1	0		1.0E+02							0%	2.0E+02	2.0E+02
NITRATE/NITRITE	14797-55-8	Unfiltered			16	5		1.3E+03	2.0E+02	2.0E+03	1/25/2000	B108W03			31%	5.0E+01	2.5E+04
NITRITE	14797-65-0	Unfiltered			4	0		5.0E+03							0%	2.5E+03	3.1E+04
ORTHO-PHOSPHATE	14265-44-2	Unfiltered			13	12		2.3E+02	3.0E+01	1.3E+03	10/11/1999	B108W03			92%	1.0E+01	5.0E+01
SULFATE	14808-79-8	Unfiltered			21	20		2.2E+05	5.0E+02	8.1E+05	10/18/2002	B108W01			95%	2.0E+02	3.1E+05
TDS	TDS	Unfiltered			21	21		4.8E+06	7.6E+05	2.0E+07	10/18/2002	B108W01			100%	5.0E+03	5.0E+05

[1] Source Definition (TtEMI 2002)

a - Ambient Metal Background Concentration (95th percentile) in shallow groundwater at Mare Island Naval Shipyard
b - Ambient Metal Concentrations in Artificial Fill Material - Mare Island
c - Ambient Metal Concentrations in Original Island Soil - Mare Island
d - At the request of the regulatory agencies, the ambient level was set to the detection limit

Data from the following types of samples were excluded from this statistical summary query table: 1) duplicate or other quality control samples results; 2) split samples results; 3) removed samples results; and 4) samples analyzed using the toxicity characteristic leaching procedure (TCLP) or by the waste extraction test (WET) data; and 5) . In addition, rejected data was excluded from this query.

Data are rounded to two significant figures for presentation.
To calculate the average concentration, one-half the detection limit was used for U-qualified data.

the northwest corner of Building 108, in the vicinity of elevated TPH-diesel concentrations in soil, had TPH-diesel concentrations between 210 and 580 µg/L.

TPH-motor-oil. TPH-motor-oil was detected at concentrations ranging from 50 to 1,400 µg/L in 14 of the 29 samples for which it was analyzed. Eight of these detected results were below the analytical reporting limit. Similar to TPH-diesel, TPH-motor-oil was found in groundwater collected from five separate wells across the Building 108 Area, well as from six borings outside Building 108 to the north, east and west. The sample with the maximum TPH-motor-oil concentration (1,400 µg/L) was collected in May 1998 from boring B108GB008, located near the northwest corner of Building 108. This sample was collected at approximately 6 feet bgs. Elevated levels of TPH-motor-oil (1,300 to 27,000 mg/kg) were also detected in soil collected from this boring at 2 and 4 feet bgs.

TPH-gasoline. As indicated in Table 5.3-2, TPH-gasoline was detected in four of the 21 groundwater samples for which it was analyzed. Detected concentrations of TPH-gasoline ranged from 30 to 140 µg/L. Of the four detected TPH-gasoline concentrations in groundwater, two were below the analytical reporting limit. The maximum concentration of TPH-gasoline was found in a sample collected in July 1999 from B108W02 located within the Building 108 footprint. Two samples collected from this well subsequent to the July 1999 sampling event had substantially lower TPH-gasoline concentrations (54 µg/L and less than 50 µg/L). B108W02 was the only location with a concentration of TPH-gasoline detected in groundwater above the analytical reporting limit at the Building 108 Area. To provide a basis for comparison, the maximum concentration of TPH-gasoline found in groundwater at the Building 108 Area is less than the RWQCB ESL of 500 µg/L for groundwater where a drinking water resource is not threatened.

5.3.2.2 VOC Compounds

As shown in Table 5.3-2, VOCs were not detected frequently in groundwater samples collected from the Building 108 Area. The only VOCs detected in groundwater in the Building 108 Area were 1,2,4-trichlorobenzene and 1,3-dichlorobenzene, which were each detected in only one of the 20 samples groundwater samples for which it was analyzed. 1,2,4-trichlorobenzene and 1,3-dichlorobenzene were detected at concentrations of 0.93 and 0.14 µg/L, respectively, in a sample collected in October 1999 from B108W02. This well is located in the footprint of Building 108. These compounds were not detected in three other monitoring events at this well. The detected concentrations of 1,2,4-trichlorobenzene and 1,3-dichlorobenzene were quantified an order of magnitude lower than the analytical reporting limit.

To provide a basis for comparison, the maximum concentrations of 1,2,4-trichlorobenzene and 1,3-dichlorobenzene found in groundwater at B108W02 are two orders of magnitude less than the respective RWQCB ESL of 25 and 65 µg/L for groundwater where a drinking water resource is not threatened. Further, the maximum concentration of 1,3-dichlorobenzene found in groundwater at B108W02 was less than the numeric water quality criteria of 400 µg/L for priority toxic pollutants for human health consumption of water and organisms in 40 CFR 131.38.

5.3.2.3 SVOC Compounds

Twenty groundwater samples collected from throughout the Building 108 Area were analyzed for SVOCs. As shown in Table 5.3-2, most SVOC compounds were not detected in groundwater samples from the Building 108 Area. However, 21 separate SVOC compounds were detected in one or two of the 20 groundwater samples collected from the site. Similar to soil, the discussion is broken out between PAHs and other SVOC compounds.

Polynuclear Aromatic Hydrocarbons. Several PAH compounds were detected in groundwater samples collected from the Building 108 Area. The PAH compounds 2-methylnapthalene, acenaphthene, anthracene, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene were detected in a groundwater sample collected from monitoring well B108W02 in October 1999. This well is located within the footprint of Building 108, and detected PAH compounds in this well may be associated with past industrial activities in Building 108. These PAH compounds were not detected in groundwater samples from other locations at the Building 108 Area or in any other monitoring events from B108W02. The other location where groundwater samples with detected concentrations of PAHs were collected was monitoring well B108W05, located south of the site near Dry Dock No. 2. Benzo(a)anthracene and chrysene were found in this well in October 1999. Benzo(a)anthracene and chrysene were not detected in groundwater samples from other locations at the Building 108 Area or in any other monitoring events from B108W05.

The concentration of detected PAH compounds in groundwater samples are identified in Table 5.3-2. Detected concentrations ranged from 0.3 µg/L (pyrene) to 67 µg/L (naphthalene). Eight of the 10 detected PAH results were quantified at a concentration below the analytical reporting limit.

Other SVOC Compounds. The SVOCs 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dichlorophenol, 2,4-dimethylphenol, 2-methylphenol, 4-methylphenol, carbazole, and dibenzofuran were each detected once or twice in groundwater samples collected from monitoring well B108W02 in July and October 1999. This well is located within the footprint of Building 108. These SVOC compounds were not detected in other locations at the Building 108 Area.

The concentration of detected SVOC compounds in groundwater samples are identified in Table 5.3-2. Detected concentrations ranged from 0.24 µg/L (isophorone) to 63.0 µg/L (4-methylphenol). Approximately 50 percent of the detected results in groundwater were quantified at a concentration less than the analytical reporting limit.

Other than B108W02, groundwater samples with detected concentrations of SVOCs were collected from monitoring well B108W03 and boring B108GB020. Diethylphthalate and isophorone were detected in monitoring well B108W03, located to the west of the site, at a monitoring event in October 1999. Phenol was detected at B108GB020, located in the area of the former waterfront central dumpsters, in April 1998.

The maximum detected SVOC concentrations in groundwater at the Building 108 Area are below the RWQCB ESLs for groundwater where a drinking water resource is not threatened, and below the numeric water quality criteria for priority toxic pollutants for human health consumption of water and organisms (40 CFR 131.38) for those compounds for which values have been established. The SVOC concentrations shown in Table 5.3-2 are

less than the respective ESLs for 1,2-dichlorobenzene (14 µg/L), 1,4-dichlorobenzene (15 µg/L), 2,4-dichlorophenol (3 µg/L), 2,4-dimethylphenol (110 µg/L), diethylphthalate (1.5 µg/L), and phenol (1,300 µg/L). Further, the SVOC concentrations shown in Table 5.3-2 are less than numeric water quality criteria for 1,2-dichlorobenzene (2,700 µg/L), 1,4-dichlorobenzene (400 µg/L), 2,4-dichlorophenol (93 µg/L), 2,4-dimethylphenol (540 µg/L), diethylphthalate (23,000 µg/L), and phenol (21,000 µg/L) for priority toxic pollutants for human health consumption of water and organisms.

5.3.2.4 Metals

Table 5.3-2 provides a summary of metals results in groundwater samples collected from the Building 108 Area and distinguishes the results between filtered samples (dissolved metals results) and unfiltered samples (total metals results). Three filtered and 14 non-filtered groundwater samples collected from the Building 108 Area were analyzed for metals. All three filtered samples were collected from monitoring well B108W03. Seven additional filtered samples were collected from monitoring well B108W01 and analyzed for zinc during the 2002-2004 field investigation in IA C3.

As discussed in Section 2.3, ambient values for 24 metals in shallow groundwater at Mare Island have been established. Table 5.3-2 shows the ambient concentration for shallow groundwater at Mare Island based on filtered results (see also Table 2.3-2) and identifies the number of samples with metal results greater than the respective ambient concentration. The only metal without an established ambient value is hexavalent chromium, which was not detected in 16 groundwater samples collected from the Building 108 Area.

As identified in Table 5.3-2, zinc and thallium were the only metals detected at concentrations greater than the respective ambient value. Lead and other metals found in soil at concentrations higher than ambient levels were not found above ambient levels in groundwater. One of 14 unfiltered groundwater samples had a detected thallium concentration of 2 µg/L. The ambient value for thallium is the detection limit; however, given the range of detection limits (1.4 to 94.4 µg/L) in the ambient data set, the thallium concentrations found in groundwater at the Building 108 Area are considered to be within the range of ambient.

Zinc was detected in 17 of the 24 groundwater samples for which it was analyzed. Figure 5.3-4 presents the zinc concentrations detected in groundwater at the Building 108 Area site. The highest concentrations of zinc were detected in monitoring well B108W01, which is located near the eastern boundary of the Building 108 Area adjacent to Mare Island Strait. Unfiltered samples collected from B108W01 in April 1999, July 1999, October 1999, and January 2000 contained zinc at concentrations ranging from 53 to 890 µg/L. The samples collected between August 2002 and June 2004 were filtered with a 0.45 µm filter prior to analysis and contained zinc at concentrations ranging from 12 to 920 µg/L. Samples that were filtered prior to analysis may still contain colloids, which generally range in size from 0.001 µm to greater than 1 µm, suggesting that these concentrations are not representative of dissolved zinc concentrations. Zinc was not detected above the ambient value from other locations at the Building 108 Area, suggesting that elevated levels of zinc in groundwater are limited to the area in the immediate vicinity of B108W01.

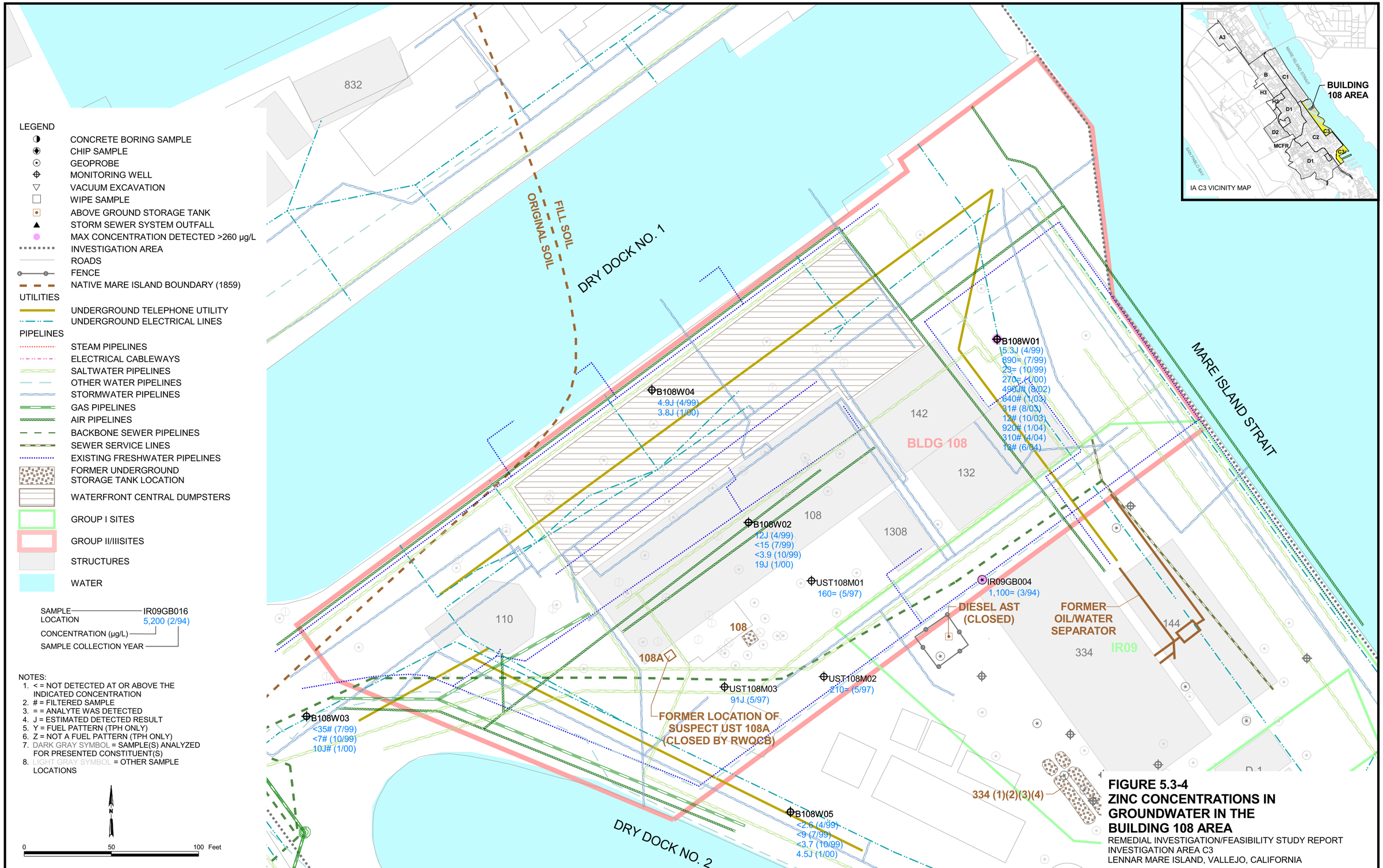

FIGURE 5.3-4
ZINC CONCENTRATIONS IN GROUNDWATER IN THE BUILDING 108 AREA
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

CH2MHILL

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5.3.3 Summary of the Nature and Extent of Contamination

The nature and extent of contamination at the Building 108 Area has been defined through the analysis of soil and groundwater samples collected during multiple investigations over 10 years. The sampling strategy was judgmental, with the objective to characterize the nature and extent of contamination, building on results of previous investigations and knowledge of site history. Over 250 soil and groundwater samples have been collected from approximately 75 separate locations throughout the site. Samples collected from the Building 108 Area have been analyzed for a wide variety of chemical constituents.

The analytical data collected from the Building 108 Area show that, by far, the petroleum hydrocarbon compound analysis (particularly TPH-diesel-range organics and TPH-motor-oil-range organics) yielded the highest frequency in detected results in soil samples collected from the Building 108 Area. The highest TPH-diesel-range organics and TPH-motor-oil-range organics results were located within Building 108 and select areas surrounding Building 108. The highest concentrations of TPH-diesel-range organics, TPH-motor-oil range organics, and select PAH compounds were found in surface and near surface soil outside the northwest corner of Building 108. The highest TPH-diesel-range organics, TPH-motor-oil-range organics, and PAH concentrations in soil were found in surface soil in this area, and the highest TPH-motor-oil-range organics concentration in groundwater were found in this area. Contamination in this area may be associated with the historical machine shop operations or the waterfront central dumpsters.

Detected concentrations of TPH-gasoline-range organics and BTEX compounds in soil were located in the vicinity of the former UST 108. This likely represents residual contamination from the UST and/or piping that was not removed when the UST, piping, and surrounding soil were removed in 1992. The concentrations of TPH-gasoline-range organics and BTEX compounds in soil in this area are low based on comparison to detection limits, PRGs, and ESLs. TPH-gasoline-range organics and BTEX compounds were not detected in groundwater near the former UST 108.

Other organic compounds including TCE, PCE, dibenzofuran, phenol, Aroclor-1260, and select PAH and pesticide compounds were found in soil samples at isolated locations at varying depths, mostly beneath Building 108, and in the vicinity of the historical central dumpsters (between Building 108 and Dry Dock No. 1). The concentrations of these compounds were low based on comparison to analytical detection limits, PRGs, and ESLs. The frequency of detection and the concentrations found suggest that the presence of these compounds in soil samples collected from the Building 108 Area represents isolated occurrences associated with past industrial operations or anomalous levels associated with the fill materials.

Similarly, organic compounds including TPH-gasoline-range organics, 1,2,4-trichlorobenzene, 1,3-dichlorobenzene, and select SVOC compounds were found in groundwater samples at low frequencies of occurrence and were limited typically to two of four sampling events in one well (B108W02 located within the footprint of Building 108). With the exception of PAHs, the concentrations of these compounds in groundwater were low based on comparison to analytical detection limits, ESLs, and numeric water quality criteria. These compounds were not detected in other groundwater monitoring events at this well or in groundwater wells downgradient from building 108 (e.g., B108W01).

Several different metals were found in soil samples at concentrations exceeding the established ambient levels. Lead was the most frequently detected metal at concentrations higher than the established ambient concentration. Lead and other metals, including zinc, manganese, chromium, copper, nickel, beryllium, and thallium, were found at concentrations exceeding ambient levels within the footprint of, and immediately surrounding, Building 108. The location, frequency of detection, and concentrations suggest that the presence of these metals in soil samples collected from within Building 108 is associated with past machine shop operations. These metals were not found in groundwater beneath Building 108 at concentrations exceeding ambient levels.

Lead was also found at concentrations greater than the established ambient concentration in surface and near surface soil in the area outside the northwest corner of Building 108 at some of the same locations with the highest concentrations of TPH and PAHs found in site soils.

Several metals including chromium, manganese, and nickel, were found at elevated concentrations in soil samples collected from the area near the former UST 108. It is likely the source of elevated metals concentrations in this area is ABM found during removal of the UST. These metals were not found in groundwater at concentrations exceeding ambient levels.

Zinc was the only metal found above the established ambient level in groundwater samples collected from the Building 108 Area. Zinc concentrations above the established ambient level were found in groundwater samples collected from B108W01, the well located nearest to Mare Island Strait. Several soil samples collected in this part of the site were also found to contain elevated zinc concentrations.

5.4 Contaminant Fate and Transport

This section presents an evaluation of the physical and chemical characteristics that may influence the mobility and behavior of contaminants in the Building 108 Area. Based on the evaluation presented in the previous section, TPH-diesel, TPH-motor-oil, benzo(a)pyrene, and lead were selected for inclusion in this fate and transport evaluation. These analytes represent the groups of contaminants (i.e., petroleum hydrocarbons, PAHs, and metals) that potentially contribute to soil and/or groundwater contamination in the Building 108 Area. Although the fate and transport evaluation is streamlined to include only these analytes, all analytical data historically collected at the site are included in the human health and ecological risk assessment evaluations (summarized in Sections 5.5 and 5.6, respectively).

The most probable fate and transport of contaminants in the Building 108 Area and potential pathways for on- and off-site migration are identified in this section. The probable migration pathways presented in the conceptual site model (Figure 5.4-1) are based on the results of the fate and transport evaluation presented in this section.

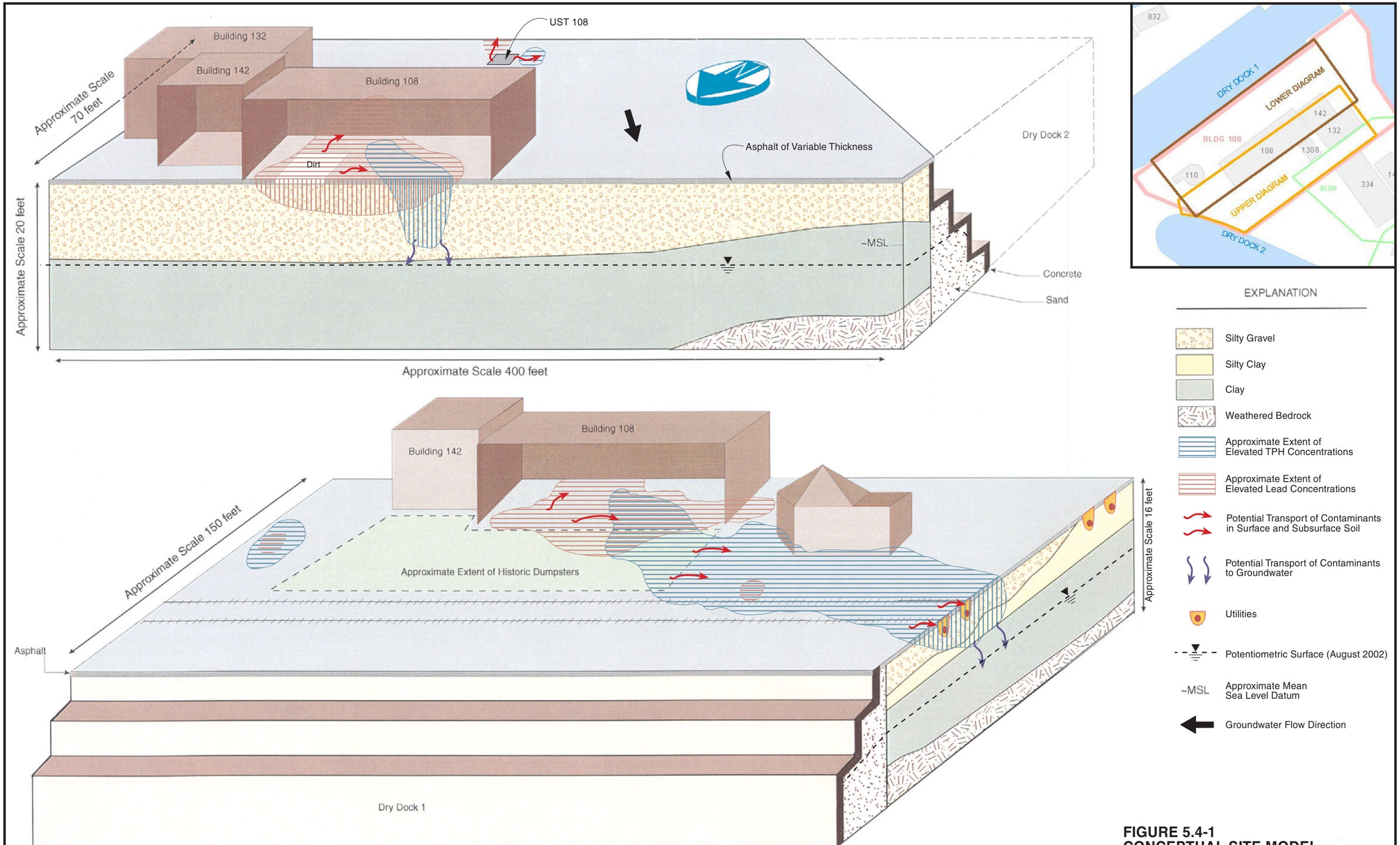

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FIGURE 5.4-1
CONCEPTUAL SITE MODEL
BUILDING 108 AREA
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

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5.4.1 Conceptual Site Model

5.4.1.1 Potential Sources

Potential sources of contamination in the Building 108 Area include:

- Former UST located near the southwestern corner of Building 108 (UST 108).
- Former waterfront dumpsters located between Building 108 and Dry Dock No. 1.
- Machine shop activities in Building 108, including ship repair activities and wastes associated with metal cleaning.
- Contaminant sources in IR09.

5.4.1.2 Potential Release Mechanisms

Potential release mechanisms that resulted from various operations performed in the Building 108 Area include:

- Releases of petroleum hydrocarbons to the adjacent subsurface at fracture points in former UST 108 and associated piping.
- Surface spills and leaks from the former waterfront dumpsters located between Building 108 and Dry Dock No. 1.
- Surface releases from machine shop activities in Building 108.
- Contaminant releases and subsequent migration from IR09.

5.4.1.3 Potential Contamination Migration Pathways

Potential migration pathways for contaminants in soil at the Building 108 Area include:

- Historical downward and lateral migration of separate-phase hydrocarbons from UST 108 and from surface releases north and west of Building 108 to the vadose zone.
- Dissolution of surface soil contaminants by infiltration of precipitation and other surface water sources though cracks in the pavement and migration into deeper subsurface soil and groundwater through advection and dispersion.
- Infiltration of surface contaminant releases in the former machine shop through the dirt floor surface in Building 108 and migration to subsurface soil through advection and dispersion.
- Lateral migration consistent with groundwater flow direction (Figures 1.5-1 and 1.5-2).
- Transport through utility lines or more permeable utility line backfill.

5.4.2 Fate and Transport Evaluation

This section presents an evaluation of the physical and chemical characteristics that may influence the mobility and behavior of contaminants identified in the previous section. The most probable fate and transport of contaminants in the Building 108 Area and potential pathways for on- and off-site migration are identified. A more detailed discussion of the fate

and transport processes and physical and chemical properties of specific constituents is presented in Appendix K.

The potential migration pathways for soil contaminants in the Building 108 Area include the following:

- Historical downward and lateral migration of separate-phase hydrocarbons
- Downward migration with the infiltration of rainwater
- Volatilization to air

The entire Building 108 Area is paved. Downward migration with infiltration and volatilization to air are considered migration pathways even in paved areas due to cracks and joints in the pavement. However, the ability of constituents to migrate via these pathways is greatly reduced compared to unpaved areas. Pathways that are considered unlikely in paved areas include (1) surface erosion by wind or water and (2) surface runoff to Mare Island Strait, due to lack of contact with contaminated media. Although separate-phase hydrocarbons have not been observed in borings advanced in the Building 108 Area, historical leaks from the UST and from surface sources may have resulted in the release of separate-phase hydrocarbons to subsurface soil in the past. Analytical data collected in the vicinity of the UST (Figures 5.3-1 and 5.3-2) suggest that separate-phase hydrocarbons did not migrate over significant distances and/or have biodegraded over time. The affinity for petroleum hydrocarbons to adsorb to soil and the high retention capacity of separate-phase hydrocarbons in a fine-grained soil matrix reduces the distance over which the separate-phase hydrocarbons can migrate in the subsurface. Because separate-phase hydrocarbons have not been observed in borings during recent investigations at the site, separate-phase hydrocarbons are no longer considered to be present in the subsurface. Consequently, the migration of separate-phase hydrocarbons is not evaluated as a potential future migration pathway in the following paragraphs.

There are two potential migration pathways for the groundwater contamination present within the Building 108 Area to reach potential receptors. These migration pathways include:

- Migration along relatively permeable utility line backfill.
- Migration to Mare Island Strait as shallow groundwater discharges to the east of the Building 108 Area.

One other potential transport pathway, volatilization to the atmosphere, is considered to be very minor at the Building 108 Area, since the constituents identified above are non-volatile and semivolatile compounds.

To estimate the potential travel times for groundwater contamination at the Building 108 Area to reach Mare Island Strait, a simple set of calculations based on Darcy's Law and fundamental adsorption chemistry were performed consistent with the equations and methodology provided in Section 3.4 for IR09. For the Building 108 Area, a representative hydraulic conductivity for the shallow aquifer based on numerical modeling studies is approximately 1 foot/day (CH2M HILL 2002i). The horizontal hydraulic gradient between the Building 108 Area and Mare Island Strait is 0.05 foot/foot (Figure 1.5-1). The transport porosity of the aquifer at the site is assumed to be 0.15. Based on these assumed hydraulic properties and the equation presented above, the bulk groundwater velocity at Building 108

Area is approximately 0.33 foot/day or 120 feet/year. As presented in Section 3.4, constituent concentrations in groundwater will be reduced by a factor of at least 1,000, as groundwater mixes with surface water upon entering Mare Island Strait.

Due to the interaction between contaminants and the aquifer solids through which they move, contaminants typically travel at velocities less than native groundwater. The degree to which the velocity of contaminant movement is reduced is typically expressed as a retardation factor. The retardation factor of a contaminant can be calculated based on the value of the distribution coefficient for that contaminant (see Section 3.0 for details).

Relatively permeable utility line backfill may act as preferential pathways for contaminant transport when the water table rises into the backfill. If contaminated groundwater reaches the backfill, transport times could be reduced by one or more orders of magnitude. Assuming a backfill with a hydraulic conductivity of 10 feet/day, groundwater transport to Mare Island Strait would occur approximately 10 times faster (based on the increased hydraulic conductivity) through the utility line backfill. This travel time is approximate due to uncertainty in K_D values, backfill composition, groundwater levels, and hydraulic gradient within the backfill.

The chemical characteristics controlling the fate of soil and groundwater contaminants in the Building 108 Area are discussed in the following sections. Based on the characteristics detailed below, the most likely migration pathways for specific contaminants can be determined.

5.4.2.1 Petroleum Hydrocarbons

The fate of the petroleum hydrocarbons detected in soil is expected to be controlled by (1) adsorption reactions between contaminants and soil mineral surfaces or soil organic matter of the soil material in the Building 108 Area, and (2) by biodegradation via the microbial community present in the subsurface. Volatilization and diffusion to the atmosphere or groundwater is not a likely pathway for the components of TPH-diesel and TPH-motor-oil.

In comparison with TPH-gasoline, TPH-diesel, and TPH-motor-oil are less volatile, less soluble, and less mobile in soils and groundwater. Transport velocities and biodegradation rates affect the dimension of groundwater plumes when TPH-motor-oil and TPH-diesel reach groundwater. TPH-motor-oil typically strongly adsorbs to fine-grained soil and soil organic matter and is not expected to migrate significant distances. When TPH-motor-oil reaches groundwater, it generally produces low-concentration, localized groundwater contamination of the sort currently observed at the Building 108 Area. A TPH-diesel groundwater plume will typically have a greater extent than a TPH-motor-oil plume with a similar source, due to the greater affinity of the TPH-motor-oil components to adsorb to soil organic matter. Concentrations of TPH constituents in soils and groundwater are expected to diminish over time as a result of natural attenuation processes such as chemical and biological degradation and diffusion.

In 1998, boring B108GB011 was installed approximately 25 feet from Mare Island Strait. A groundwater sample collected from the boring contained TPH-diesel at a concentration of 940 µg/L. Although concentrations at that location have likely declined through biodegradation, it is also possible that similar concentrations have migrated to Mare Island

Strait (no samples have been collected in the vicinity of this boring since 1998). However, concentrations of these constituents in Mare Island Strait would be significantly lower due to a mixing factor of more than 1,000. Boring B108GB021 was also installed in 1998, approximately 30 feet from Dry Dock No. 1. A groundwater sample collected from this boring contained TPH-motor-oil at a concentration of 860 µg/L. Concentrations at that location have also likely declined through biodegradation; however, it is possible that similar concentrations have migrated to Dry Dock No. 1 (no samples have been collected in the vicinity of this boring since 1998). Groundwater that migrates toward Dry Dock No. 1 will be collected in the sanitary wastewater system.

5.4.2.2 Metals

The fate of metals will likely be controlled by reactions, such as cation exchange, which results in adsorption of constituents to soil mineral surfaces or soil organic matter. Their fate will also likely be controlled by precipitation reactions leading to the formation of secondary mineral phases.

Lead was the primary risk-generating metal detected at the Building 108 Area. The high distribution coefficient of lead ($K_d \approx 100$ cc/g; Dragun 1988) indicates a very strong affinity for soil. Analytical data in the Building 108 Area (Appendix F) indicate that neutral-to-alkaline conditions prevail in the areas of exposed soil, making inorganic compounds less soluble, with lesser tendency to migrate with infiltrating precipitation. Lead is not expected to migrate significant distances in soil at the Building 108 Area, due to its high distribution coefficient.

The distribution coefficients for metals in groundwater are dependent not only on the particular metal present, but also the pH of the groundwater. The distribution coefficient for lead is typically around 100 cc/g (Dragun 1988). Using the equation presented in Section 3.4, and assuming a total aquifer porosity of 0.35 and a bulk density of 1.8 g/cc, these values imply retardation factors of over 500. In other words, due to the affinity of the metals present for the aquifer solids, the metals will travel more than 500 times more slowly than the native groundwater, or less than 0.24 foot/year.

Lead has not been detected in groundwater above ambient (10 µg/L) concentrations at the Building 108 Area in samples collected since 1998. However, in order to thoroughly present the fate and transport of lead, it is assumed that lead becomes dissolved at the location of the historic maximum detection of lead in groundwater (UST108M03) (31 µg/L). This boring is located approximately 80 feet from Dry Dock No. 2. Using the bulk groundwater velocity calculated above (120 feet/year), the shortest distance to Dry Dock No. 2 (80 feet), and the retardation factor (R=500), these calculations suggest that it will take centuries (over 300 years) for lead present in groundwater at location UST108M03 to reach Dry Dock No. 2 through the aquifer. However, there is substantial uncertainty associated with this travel time, as the downgradient edge of lead concentrations that exceed ambient concentrations is unbound in the direction of Dry Dock No. 2.

It should be noted that the influence of dispersion during transport may reduce the arrival time of the leading edge of the contaminant plume; however, given the long travel times computed here, any reduction due to dispersion would be relatively insignificant. In addition, the assumptions made above about flow and transport parameters at the

Building 108 Area are estimates based on current knowledge of site conditions. Any change from the assumptions above may affect the calculation of travel times.

5.4.2.3 Polynuclear Aromatic Hydrocarbons

PAHs, specifically benzo(a)pyrene, have extremely low solubility in water, extremely low vapor pressures, and do not readily volatilize. PAHs strongly adsorb to soil and soil organic matter and are not expected to migrate significantly through infiltration of precipitation. The organic carbon partitioning coefficient (K_{oc}) of benzo(a)pyrene is on the order of 90,000 cc/g (Reinbold et al. 1979), indicating a very strong affinity for soil. PAHs detected in subsurface soil are not expected to volatilize into the atmosphere. In groundwater, PAHs will experience very slow transport due to retardation. Groundwater concentrations will tend to attenuate rapidly during transport as the PAHs preferentially bind to the surrounding soil.

PAHs travel more slowly in groundwater than metals, with retardation factors of over 1,000, resulting in transport velocities of less than 0.009 foot/year. Although benzo(a)pyrene has not been detected in groundwater at the Building 108 Area at concentrations exceeding laboratory reporting limits, its potential transport in groundwater is discussed here. Assuming that benzo(a)pyrene had dissolved into groundwater at detectable concentrations at the soil sampling location closest to surface water (B108SS0101), the initial groundwater plume would be located 30 feet from Dry Dock No. 1. Using the same calculation described above, it would take several centuries (over 1,000 years) for benzo(a)pyrene contamination in groundwater to reach Dry Dock No. 1.

5.4.2.4 Conclusions

The most likely migration pathways for constituents in the soil at the Building 108 Area are dissolution of soil contaminants by infiltration, followed by migration through the vadose zone through advection and dispersion and subsurface lateral migration via groundwater transport through the aquifer to Mare Island Strait or the Dry Docks. While it is possible that petroleum hydrocarbons have migrated to the Strait, the concentrations of petroleum hydrocarbons detected at the site are low, and biodegradation likely has resulted in a reduction in petroleum hydrocarbon concentrations over time through natural attenuation. Further, a factor of over 1,000 applies for mixing between groundwater in IA C3 and Mare Island Strait. Lead has been detected in groundwater at the Building 108 Area, although concentrations above ambient levels are not likely to reach surface water for decades or centuries. Benzo(a)pyrene has not been detected in groundwater at the Building 108 Area, and would likely take centuries to reach surface water even if traveling through relatively permeable utility backfill.

5.5 Human Health Risk Assessment Summary

This section summarizes the HHRA conducted for the Building 108 Area. The complete HHRA is presented in Appendix G. The results of the HHRA are based on the following key assumptions and approaches:

- Domestic uses of groundwater are not evaluated because the groundwater at Mare Island is not considered a municipal and domestic water supply (Section 1.6.2).

- Human health exposures for current or future standard commercial/industrial worker and construction worker scenarios were evaluated using concentrations of COPCs in the top 2 feet of soil (0 to 2 bgs). In addition, exposures for future construction worker scenarios were evaluated using concentrations of COPCs in the top 10 feet of soil (0 to 10 feet bgs).
- The HHRA provides estimates of potential excess lifetime cancer risks and non-cancer adverse health impacts to humans under RME conditions. RME conditions represent upper-bound estimates of exposure that are within the range of plausible exposures.

The results of the HHRA are described below and include:

- Exposure pathways, receptors, and environmental media.
- HHRA constituents of potential concern.
- Risk characterization results.

5.5.1 Exposure Pathways and Environmental Media

The Building 108 Area is located in an area that is designated for industrial reuse. Therefore, future commercial/industrial workers and construction workers are evaluated for this site. To provide for the possibility of changes in the reuse planning, a residential receptor was also evaluated, and the results are presented in an attachment to Appendix G.

Exposure pathways evaluated for these receptors include:

- Incidental ingestion of soil.
- Dermal contact with soil.
- Inhalation of vapors from soil in outdoor air.
- Inhalation of chemicals sorbed to soil suspended in air as dust.
- Dermal contact with groundwater (construction workers only).
- Inhalation of volatiles from groundwater in outdoor air (construction workers only).
- Inhalation of volatiles from groundwater and subsurface soil in indoor air (commercial/industrial workers only).

The HHRA estimated potential risk based on analytical data for soil collected from the 0 to 2 feet bgs depth interval for commercial/industrial and construction workers and from the 0 to 10 feet bgs depth interval (i.e., mixed-zone soil) for construction workers. Analytical data from groundwater collected between April 1998 and June 2004 were also used to estimate risk.

EPCs associated with direct contact (dermal contact or incidental ingestion of soil) were based directly on measured concentrations. Chemical concentrations in air (vapors), however, were not measured directly. As a result, vapor concentrations from groundwater and soil are estimated using appropriate fate and transport models. Dust-in-air concentrations were estimated using a particulate emission factor.

5.5.2 HHRA Constituents of Potential Concern

COPCs for human health risk assessment were identified by including each detected constituent as a COPC, except for metals in soil. Metals were eliminated as COPCs in soil if the site concentrations were not significantly different than ambient concentrations for fill materials. COPCs for soils include metals, PCBs, organochlorine pesticides, SVOCs, and VOCs. COPCs for groundwater include metals, SVOCs, and VOCs. The COPCs selected for human health risk assessment for the Building 108 Area are shown in Table G.2-5.

5.5.3 Risk Characterization Results

A discussion of the RME scenario risks is provided below; a summary of the risks estimated for all scenarios is presented in Table 5.5-1. Risk characterization results indicate that future site conditions at the Building 108 Area pose potential excess lifetime cancer risks that are within the risk-management range (10^{-4} x 10^{-6}) for carcinogens. The estimated potential cancer risk for an industrial worker exposed to surface soil is 1×10^{-5}. The main contributors to the potential cancer risk are PAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and benzo(k)fluoranthene). The estimated potential cancer risk for construction workers exposed to surface soil is 4 x 10^{-7}. The estimated potential cancer risk for a construction worker exposed to mixed-zone soil is 3 x 10^{-7}. The estimated potential cancer risk for a construction worker exposed to groundwater through dermal contact is 3 x 10^{-8}. The estimated potential cancer risk for a construction worker exposed to groundwater through inhalation of volatiles is 8 x 10^{-13}.

TABLE 5.5-1
Summary of Estimated Risks at Building 108
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Site	Exposure Scenario/Receptor	Cancer	Non-cancer	Greatest Chemical Contributors
Building 108	Surface Soil/Industrial Worker	1 x 10^{-5}	0.2	PAHs (cancer)
	Surface Soil/Construction Worker	4 x 10^{-7}	0.2	
	Subsurface Soil/Construction Worker	3 x 10^{-7}	0.1	
	Groundwater/Construction Worker – Inhalation	8 x 10^{-13}	0.000003	
	Groundwater/Construction Worker – Dermal	3 x 10^{-8}	0.002	

Non-cancer adverse health effects (HI) were estimated to be below the threshold of 1 for all of the receptors potentially exposed to soil or groundwater. No COPC or group of COPCs contributes significantly to the total estimated HI.

Neither the USEPA nor the Cal/EPA publishes RfDs for lead, a COPC known to cause adverse health effects. Based on current guidance from DTSC, the potential for health effects from exposure to lead for commercial/industrial and construction workers was addressed by comparing EPCs for lead to a risk-based level (i.e., the USEPA Region 9 PRG for an industrial scenario, 750 mg/kg). Soil concentrations below the lead risk-based level are not

considered to represent a potential health risk in an industrial scenario. Both of the EPCs for surface and mixed-zone soil exceed the risk-based level of 750 mg/kg. The EPC calculated for lead in surface soil is the maximum detected value, 2,830 mg/kg (three of 14 surface soil sample results exceed 750 mg/kg). The EPC calculated for lead in mixed-zone soil is the UCL95 based on a lognormal distribution, 1,576 mg/kg, and only six of 35 mixed-zone soil sample results exceed 750 mg/kg. It is important to note that the elevated concentrations of lead are limited to a few locations in the Building 108 Area; 16 of the 35 mixed-zone soil samples have lead concentrations below the ambient level of 59 mg/kg.

As several VOCs were detected in groundwater and soil in IA C3, a screening-level evaluation was performed to determine if the indoor air pathway (i.e., volatilization of VOCs from groundwater or soil to indoor air) might be a significant exposure pathway for future receptors. As a conservative first step in this evaluation, maximum detected concentrations of VOCs in groundwater and soil for IA C3 were compared to RBCs based on potential exposure to VOCs in indoor air for an industrial scenario. All of the groundwater and soil data collected within IA C3 were used for this first step of the evaluation. These risk-based concentrations were developed using the screening level version of the Johnson and Ettinger model. As a second step in the screening-level evaluation, the EPCs for the IRP sites were compared to the RBCs for the constituents that had maximum detected concentrations greater than the RBCs, because EPCs are more representative of overall soil and groundwater conditions at an IRP site. No constituents in groundwater had concentrations in IA C3 that exceeded the RBCs.

Thirteen constituents in soil had maximum detected concentrations in IA C3 that exceeded the Tier 1 RBCs. The Building 108 Area EPCs for tetrachloroethene and trichloroethene exceed their Tier 1 RBCs. Since the infinite source (Tier 1) model indicated an exceedance of the RBCs for VOCs, a more rigorous estimate was obtained using additional site-specific data and the finite-source model for soil contamination. The Building 108 Area EPCs do not exceed their Tier 2 RBCs, indicating that the indoor air exposure pathway is not expected to be significant for VOCs volatilizing from soil to indoor air at this site. Based on this evaluation, no significant exposure is likely for the indoor air pathway for the Building 108 Area.

The HHRA developed four different sets of risk estimates for each soil exposure scenario evaluated. The definitions of the four sets of risk estimate are provided in Section 3.5.3. The approach for calculating these different risk estimates is described in Appendix G.

Table 5.5-2 summarizes the results for the four types of risk estimates for the Building 108 Area. As shown in Table 5.5-2, the total, ambient, site, and incremental risks are within the risk-management range.

TABLE 5.5-2
Summary of Estimated Risks at the Building 108 Area
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Exposure Scenario/Receptor	Mixed-zone Soil							
	Ambient		Total		Site		Incremental	
	Cancer	Non-cancer	Cancer	Non-cancer	Cancer	Non-cancer	Cancer	Non-cancer
Future Industrial Worker								
Surface Soil	7×10^{-6}	0.4	2×10^{-5}	0.5	1×10^{-5}	0.2	1×10^{-5}	0.07
Future Construction Worker								
Surface Soil	2×10^{-7}	0.4	7×10^{-7}	0.4	4×10^{-7}	0.2	4×10^{-7}	0.06
Mixed-zone Soil (0 to 10 feet bgs)	3×10^{-7}	0.3	6×10^{-7}	0.4	3×10^{-7}	0.1	3×10^{-7}	0.05

5.6 Ecological Risk Assessment Summary

A Baseline ERA was performed for the Building 108 Area to assess potential for risk to ecological receptors from site-related contaminants. The approach used for the Baseline ERA is described in Section 2.5, and the complete Baseline ERA is presented in Appendix H. The approach for the ERA is modeled after that developed by DTSC (1996) and USEPA (1997, 1998) and was used to assess ecological risks presented by COPECs.

A Baseline ERA includes the collection and interpretation of biological or abiotic media data to further refine the conclusions of a screening-level ERA. TtEMI performed the screening-level ERA for IA C3 (2002a).

5.6.1 Problem Formulation

The Building 108 Area is industrial, and most of the area is covered with buildings and pavement. Consequently, this site supports no viable habitat. The only potentially-complete ecological exposure pathway is groundwater from the Building 108 Area discharging to the Mare Island Strait. Therefore, risks to aquatic organisms in the offshore habitat of the Strait were evaluated on the basis of analyte concentrations in the groundwater.

Representative ecological receptors were identified for characterization of ecological risk in this offshore habitat; they include aquatic organisms such as fish, non-rooted aquatic plants, and aquatic invertebrates.

COPECs at the Building 108 Area were identified through evaluation of available groundwater data. Groundwater was analyzed for total and dissolved metals using unfiltered and filtered (45 microns) samples, respectively. Organics were analyzed using unfiltered samples. Inorganic COPECs were selected by screening maximum detected concentrations against ambient values. The screening-level evaluation considered the ambient concentration in shallow groundwater as established for Mare Island

(TtEMI 2002c). An inorganic chemical detected in groundwater was not considered a COPEC, and was ultimately omitted from the risk assessment if its maximum detected concentration was below the respective ambient value. If an analyte was detected but did not have a ambient value for comparison, it was retained for evaluation. Most inorganic analytes in groundwater at the Building 108 Area for which ambient values were available were within the ambient concentration in shallow groundwater (UCL95). All organic compounds were assumed to be site-related and were retained as COPECs, without comparison to ambient values. Based on this screening-level evaluation, zinc and 26 organics were retained as COPECs.

5.6.2 Analysis

Groundwater from within IA C3 was assumed to be representative of water in Mare Island Strait because of its potential to discharge to the Strait. Because aquatic organisms in surface water (i.e., non-rooted plants, invertebrates, and fish) are mobile and the medium they reside in is spatially variable, EPCs are best represented by the 95-percent UCL of the mean. However, the maximum detected concentration was used as the EPC for many COPECs at this site because of the statistical distribution of the data. Groundwater on site may have much higher contamination levels than the water that may eventually discharge to the Strait. Consequently, estimates of effects on aquatic organisms based on groundwater data are very conservative.

Ecological risk was evaluated by comparing site-related concentrations (EPCs) to TRVs. For this evaluation, ESLs published by the RWQCB (2003a) were selected as TRVs. The ESLs present the more conservative of saltwater and freshwater benchmarks. Because the Strait has varying salinity levels due to varying freshwater flow from the Napa River, the Strait may be considered freshwater or estuarine depending on season. As a result, the ESLs serve as conservative benchmarks for evaluating risk to aquatic organisms in the Strait. In addition, acute TRVs from the RWQCB (2003b) were used to refine the estimate of potential risk for those analytes that exceeded the ESLs.

5.6.3 Risk Characterization

For aquatic organisms, the EPC for each analyte in groundwater was divided by the respective TRV resulting in a quantitative estimation of risk known as a hazard quotient. HQs greater than 1 were further analyzed qualitatively. Cumulative risks (HIs) were not estimated for aquatic organisms because of the limited toxicity information available for evaluation of cumulative effects.

All chemicals with HQs greater than 1 were considered to pose some potential risk and were qualitatively evaluated further for the representative species. Qualitative evaluations assessed chemical information (magnitude of HQ and frequency of detection), incremental risk, potential dilution, and confidence in the benchmark using less conservative assumptions to predict a more reasonable potential for exposure and effects.

Zinc was the only inorganic detected in filtered samples that had a maximum concentration in excess of the ambient value. Of the retained COPECs, zinc, 2-methylnaphthalene, anthracene, benzo(a)anthracene, fluorene, naphthalene, and phenanthrene were the only analytes that posed potential risk to aquatic organisms based on comparison with ESLs.

HQs for these analyses ranged from 1.04 to 14.1. All organics with HQs greater than 1 were detected in only one of 20 samples. Anthracene and benzo(a)anthracene had EPCs based on maximum concentrations and were, therefore, also compared to acute TRVs. Both of these analytes had HQs less than 1 when compared to acute TRVs.

Realistically, groundwater concentrations will be reduced as groundwater mixes with surface water upon entering the Mare Island Strait. During the initial evaluation, ecological risks were estimated for direct exposures to groundwater that may discharge to the surface without taking into account reduction in constituent concentrations as groundwater mixes with surface water in the Mare Island Strait. A second evaluation, both quantitative and qualitative, was performed for analytes with potential risk (as determined in the first evaluation) to account for mixing of groundwater with surface water in the Strait. As groundwater enters Mare Island Strait, it is reasonable to expect that COPEC concentrations will be reduced by a factor of at least 1,000 (Section 3.4). If a mixing factor of that magnitude is applied to estimate potential concentrations in Mare Island Strait to which potential receptors might be exposed, risk is reduced to a negligible level. While localized impacts to sedentary invertebrates may occur near the discharge if mixing is not considered, community- and population-level impacts are unlikely to be significant. As a result, risk from groundwater to aquatic organisms in the Mare Island Strait is considered low.

5.7 Degradation of Groundwater Assessment

Analytical data for groundwater samples collected from monitoring well B108W01 were used to assess the quality of groundwater entering Mare Island Strait adjacent to the Building 108 Area. This well is approximately 75 feet away from Mare Island Strait (Figure 5.1-1). All analytes detected in samples collected from this well were screened against the chemical-specific ARARs for groundwater and surface water identified by the RWQCB (Appendix I). Select analytes were detected at concentrations exceeding the groundwater criteria. (Comparisons of criteria to metals concentrations were performed using analytical results for both filtered and unfiltered groundwater samples collected from B108W01.) A potential source of groundwater contamination at the site (UST 108) was removed in 1992 and 1993. Remaining potential sources of groundwater contamination (contaminated soil) will be addressed during implementation of one of the remedial alternatives identified and evaluated in the feasibility study, which is presented in Section 7.0.

The analytes that have been detected in groundwater at B108W01 at concentrations that exceed the chemical-specific ARARs identified by the RWQCB for groundwater and surface water (copper, manganese, mercury, thallium, and zinc) are presented in Table 5.7-1. With exception to the Basin Plan water quality objectives for agricultural supply, which apply to groundwater, each of the criteria identified in Table 5.7-1 apply to surface water. Because groundwater in IA C3 mixes with surface water upon entering Mare Island Strait, comparison of constituent concentrations in groundwater to surface water criteria results in a conservative determination of analytes that potentially impact surface water in the Strait. Further, this assessment is conservative because it compares the lowest of the criteria presented in Table 5.7-1 to the maximum detected concentration of each analyte.

TABLE 5.7-1
Chemical-specific ARARs Identified by the Regional Water Quality Control Board for Select Constituents in Groundwater and Surface Water at the Building 108 Area
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

	Chemical-specific ARARs in Groundwater	**Chemical-specific ARARs in Surface Water**												**Most Conservative Criteria (µg/L)**	**Maximum Detected Concentrations (µg/L)**
	San Francisco Bay Basin Plan [a]	**San Francisco Bay Basin Plan [a]**		**California Toxics Rule Criteria for Enclosed Bays and Estuaries [b]**					**National Ambient Water Quality Criteria [c]**						
Parameter	**Water Quality Objectives for Agricultural Supply (µg/L)**	**Water Quality Objective for Surface Waters with Salinity Greater than 5 ppt (µg/L)**	**Water Quality Objective for Surface Waters with Salinity Less than 5 ppt (µg/L)**	**Freshwater CMC [d] (µg/L)**	**Freshwater CCC [e] (µg/L)**	**Saltwater CMC [d] (µg/L)**	**Saltwater CCC [e] (µg/L)**	**Human Health (Aquatic Organisms Consumption Only (µg/L)**	**Freshwater CMC [d] (µg/L)**	**Freshwater CCC [e] (µg/L)**	**Saltwater CMC [d] (µg/L)**	**Saltwater CCC [e] (µg/L)**	**Human Health (Aquatic Organisms Consumption Only (µg/L)**		
Copper	200 (threshold) 5,000 (limit)	4.9 (1-hour average)	30.2 [f] (4-day average) 49.9 [f] (1-hour average)	38 [7, h]	23 [7, h]	4.8 [h]	3.1 [h]	--	38 [g, h, i]	23 [g, h, i]	4.8 [h, i]	3.1 [h, i]	--	3.1	14.3
Manganese	200 (threshold) 10,000 (limit)	--	--	--	--	--	--	--	--	--	--	--	--	200	290
Mercury	--	0.025 (4-day average) 2.1 (1-hour average)	0.025 (4-day average) 2.4 (1-hour average)	--	--	--	--	0.051	1.4 [h]	0.77 [h]	1.8 [h]	0.94 [h]	--	0.025	0.12
Thallium	--	--	--	--	--	--	--	6.3	--	--	--	--	0.47	0.47	2
Zinc	2,000 (threshold) 10,000 (limit)	58 (24-hour average) 170 (instantaneous maximum)	59 [f] (4-day average) 53 [f] (1-hour average) 58 (24-hour average) 170 (instantaneous maximum)	297 [g, h]	300 [g, h]	90 [h]	81 [h]	--	297 [g, h]	300 [g, h]	90 [h]	81 [h]	26,000	53	920

Notes:

[a] Water Quality Control Plan, San Francisco Bay Basin (Region 2). June 2, 1995.
[b] 40 CFR Part 131.38.
[c] USEPA. Office of Science and Technology. National Recommended Water Quality Criteria: 2002, EPA-822-R-02-047. November 2002.
[d] Criteria Maximum Concentration (CMC) = the highest concentration of a pollutant to which aquatic life can be exposed for a short period of time (1-hour average) without deleterious effects.
[e] Criteria Continuous Concentration (CCC) = the highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4 days) without deleterious effects.
[f] Hardness dependent. The limit shown is based on hardness of 300 mg/L.
[g] Criteria dependent upon hardness. Values shown are based on a hardness of 100 mg/L.
[h] Based on dissolved concentrations.
[i] Copper is substantially less toxic when the concentration of dissolved organic carbon is elevated.
-- No criteria.

Table 5.7-2 compares the maximum detected concentration for each of the metals presented in Table 5.7-1 to the ambient concentration of metals in groundwater at Mare Island. With exception to zinc, all metals are present at concentrations that are within the range of ambient concentrations at the site. The ambient value for thallium is the detection limit; however, given the range of detection limits (1.4 to 94.4 µg/L) in the ambient data set, the thallium concentrations detected in groundwater at the Building 108 Area are considered within the range of ambient. These metals are therefore present at concentrations that meet the standards of State anti-degradation and cleanup policies (SWRCB 1992, 1995).

TABLE 5.7-2
Ambient Groundwater Concentrations for Select Constituents at the Building 108 Area
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Analyte	Maximum Concentration (µg/L)	Ambient Concentration in Shallow Groundwater (TtEMI 2002c) (µg/L)	Detected Concentrations Within Ambient Range?
Copper	14.3	33	Yes
Manganese	290	5,400	Yes
Mercury	0.12	0.22	Yes
Thallium	2	DL[a]	Yes
Zinc	920	260	No

[a] The ambient value for thallium is the detection limit; however, given the range of detection limits (1.4 to 94.4 µg/L) in the ambient data set, the thallium concentrations detected in groundwater at the Building 108 Area are considered within the range of ambient.

Zinc is present in groundwater at the Building 108 Area at concentrations that exceed numeric water quality criteria for surface water and the ambient background concentration for this metal (zinc concentrations at B108W01 are less than the numeric water quality criteria for groundwater). Zinc has been detected at concentrations exceeding ambient concentrations in groundwater samples collected from monitoring well B108W01 since 1999. It is believed that these zinc concentrations are a result of fine colloidal material present in the samples and are not representative of dissolved metal concentrations. Dissolved zinc concentrations are likely significantly lower than those detected and are likely below the ambient concentration (260 µg/L). While groundwater samples collected since 2002 have been field filtered prior to analysis, the elevated zinc concentrations detected since 2002 may be attributed to the presence of fine colloidal material. Metals such as zinc can adsorb to iron or aluminum oxide colloids, which may have passed through the 0.45 µm filter used during sampling. Analytical results for samples filtered with a 0.45 µm filter may therefore not be representative of dissolved zinc concentrations in groundwater. The presence of colloids, which generally range in size from 0.001 µm to greater than 1 µm in diameter, can result in significant differences in metals concentrations between samples filtered with a 0.45 µm filter and those filtered with a filter of smaller pore size (CH2M HILL 2004; Kimball et. al. 1997). Based on this information, it is believed that dissolved zinc concentrations at B108W01 are likely below the ambient concentration and that zinc is not present at concentrations that are degrading the waters of the State.

To confirm that zinc is present in groundwater at the Building 108 Area at concentrations that are below the ambient concentration, groundwater samples will be collected from B108W01 and filtered with a 0.1 μm filter prior to analysis for zinc. The results of this monitoring will be documented in the implementation report for IA C3.

5.8 Conclusions of the Remedial Investigation at the Building 108 Area

The nature and extent of soil and groundwater contamination in the Building 108 Area has been defined by data collected during the 2002-2004 field investigation as well as data collected during previous investigations. The analytical data collected at the Building 108 Area indicate that impacted areas of the site primarily are located immediately surrounding Building 108 near the identified sources of contamination: former UST 108, the former waterfront dumpsters, and historical machine shop activities in Building 108.

The highest concentrations of TPH-diesel-range organics, TPH-motor-oil range organics, lead, and select PAH compounds were found in surface and near surface soil outside the northwest corner of Building 108. Contamination in this area may be associated with the historical machine shop operations or the waterfront central dumpsters.

In the vicinity of the former UST 108, low concentrations of TPH-gasoline-range organics and BTEX compounds were detected in soil that likely represent residual contamination that was not removed when the UST, piping, and surrounding soil were removed in 1992. These compounds were not detected in groundwater near the former UST, however. Several metals were also found at elevated concentrations in soil samples collected from the area near the former UST 108 that likely are associated with ABM that was found during removal of the UST.

Several different metals, including lead, were also found in soil samples at concentrations exceeding the established ambient levels within the footprint of, and immediately surrounding, Building 108. The presence of these metals is likely associated with past machine shop operations. Zinc was the only metal found above the established ambient level in groundwater samples collected from the Building 108 Area since 1998. Zinc concentrations above the established ambient level were found in groundwater samples collected from B108W01, the well located nearest to Mare Island Strait.

The most likely migration pathways for contaminants in the soil at the Building 108 Area are dissolution of soil contaminants by infiltration, followed by migration through the vadose zone through advection and dispersion and subsurface lateral migration via groundwater transport through the aquifer to Mare Island Strait or the dry docks. The concentrations of petroleum hydrocarbons detected in groundwater at the site are low, and biodegradation has likely resulted in a reduction in petroleum hydrocarbon concentrations over time through natural attenuation. Further, mixing between groundwater and surface water as groundwater entering the Strait results in a significant reduction in contaminant concentrations in the Strait. Lead has been detected in groundwater at the Building 108 Area, although concentrations above ambient levels are not likely to reach surface water for decades or centuries. Benzo(a)pyrene has not been detected in groundwater at the

Building 108 Area and would likely take centuries to reach surface water, even if traveling through permeable utility backfill.

The HHRA concluded that the EPCs for lead in surface soil (2,830 mg/kg) and mixed-zone soil (1,692 mg/kg) exceed the risk-based level of 750 mg/kg. Lead in soil presents a potential risk to human health. Remedial alternatives will be evaluated in the feasibility study (presented in Section 7.0) to determine the remedial measure that will most cost-effectively reduce the risk created by elevated levels of lead in surface and subsurface soil in the Building 108 Area.

The results of the HHRA indicate that future site conditions at the Building 108 Area pose potential excess lifetime cancer risks that are within the risk-management range (10^{-4} x 10^{-6}) for carcinogens. In addition, non-cancer adverse health effects (HIs) were estimated to be below 1 for all of the receptors potentially exposed to soil or groundwater. Because these calculated carcinogenic and non-carcinogenic risks are within or below the risk-management range, lead is the only chemical that presents a potential significant risk to human receptors in the Building 108 Area.

The results of the ERA indicate that zinc and six organic analytes had HQs greater than 1 when compared to their respective ESLs. HQs for these analytes ranged from 1.04 to 14.1. However, groundwater concentrations will likely be reduced as groundwater mixes with surface water upon entering the Mare Island Strait. As groundwater enters Mare Island Strait, it is reasonable to expect that COPEC concentrations will be reduced by at least a thousand-fold. If a factor of that magnitude is applied to estimate potential concentrations in Mare Island Strait to which potential receptors might be exposed, risk is reduced to a negligible level. While localized impacts may occur near the discharge if mixing is not considered, population-level impacts are unlikely to be significant. As a result, risk from groundwater to aquatic organisms in the Mare Island Strait is considered low.

The results of the degradation of groundwater assessment indicate that, while copper, manganese, mercury, and thallium are present in groundwater at the Building 108 Area at concentrations that exceed chemical-specific ARARs identified by the RWQCB for groundwater and surface water, these metals are present at concentrations that are within the range of concentrations that are considered ambient. Zinc was detected in groundwater at concentrations that exceed both the chemical-specific ARARs identified by the RWQCB for groundwater and surface water and ambient concentrations for this metal. However, detected concentrations are believed to be elevated due to the presence of colloidal material in groundwater samples and it is expected that dissolved zinc concentrations are within the range of ambient concentrations. Constituents in groundwater at the Building 108 Area are therefore not present at concentrations that are degrading the waters of the State.

Based on guidance provided in *Screening For Environmental Concerns at Sites With Impacted Soil and Groundwater* (RWQCB 2003b) and based on RWQCB comments on Tier 2 screening levels at petroleum hydrocarbon sites at Lennar Mare Island (RWQCB 2004b), petroleum hydrocarbons are present in soil at the Building 108 Area at concentrations that potentially pose an odor/nuisance condition. Consequently, the need to perform a remedial action in areas of the Building 108 Area that contain elevated levels of petroleum hydrocarbons will be evaluated in the feasibility study presented in Section 7.0 of this report.

Based on the results of the HHRA, ERA, and degradation of groundwater assessment, constituents in groundwater do not pose a risk to human or ecological receptors and are not degrading waters of the State. Therefore, remedial alternatives are not be developed in the feasibility study to address constituents in groundwater at the Building 108 Area.

6.0 IR14

6.1 Site Background

6.1.1 Site Description

IR14 is the IWTP collection system underground piping and pump stations, designed to collect, pretreat, and convey wastewater from various sources to the IWTP. The entire Mare Island IWTP collection system comprises 26,000 linear feet of underground pipeline (diameter ranging from 4 to 11 inches), 11 pump stations, and three pretreatment facilities. The pipeline is constructed of cement, mortar-lined, ductile iron pipe buried at 2.5 to 4 feet bgs in fill material consisting commonly of gravel and silt-sand-gravel mix with some debris (PRC 1996a). Approximately 550 feet of the IR14 pipeline is located within IA C3, as shown in Figure 6.1-1. There are no industrial wastewater pump stations or pretreatment facilities located in IA C3.

6.1.2 Site History

The IWTP and associated piping and pump stations was constructed in 1972 and operated until base closure in 1996. Removal of sludge and residue and flushing of the entire IWTP collection system was performed in 1996 by the Navy. The environmental concerns associated with the IWTP collection system include soil and groundwater contamination that may have resulted from piping system leakage, artificial fill contamination, and/or backfill debris disposal. ABM that may have been used for pipeline bedding material may also be associated with the IWTP collection system.

6.1.3 Chronology of Investigations

The following summarizes the chronology of investigations performed under the IRP at IR14 in IA C3. The Navy's IRP work at this site began in the early 1980s. the Navy transitioned environmental investigation and cleanup responsibilities to LMI in 2001.

6.1.3.1 Initial Assessment Study

In 1983, an IAS was completed that assessed potential soil and groundwater contaminants from past hazardous materials operations at the former MINS (Ecology and Environment 1983). The study consisted of a record review and site reconnaissance. No environmental samples were collected as part of the IAS. Fourteen Group I IRP sites were identified through the IAS as potentially-contaminated sites, including the IWTP collection system.

6.1.3.2 Corrosion Investigation and Pretreatment Study

In 1986, Harris and Associates conducted a corrosion investigation and concluded that the majority of the soil surrounding the force mains of the IWTP system is corrosive and that internal and external corrosion of the force mains had occurred in some of the line sections. Line J, within IA C3, was identified as requiring cathodic protection and inspection in 10

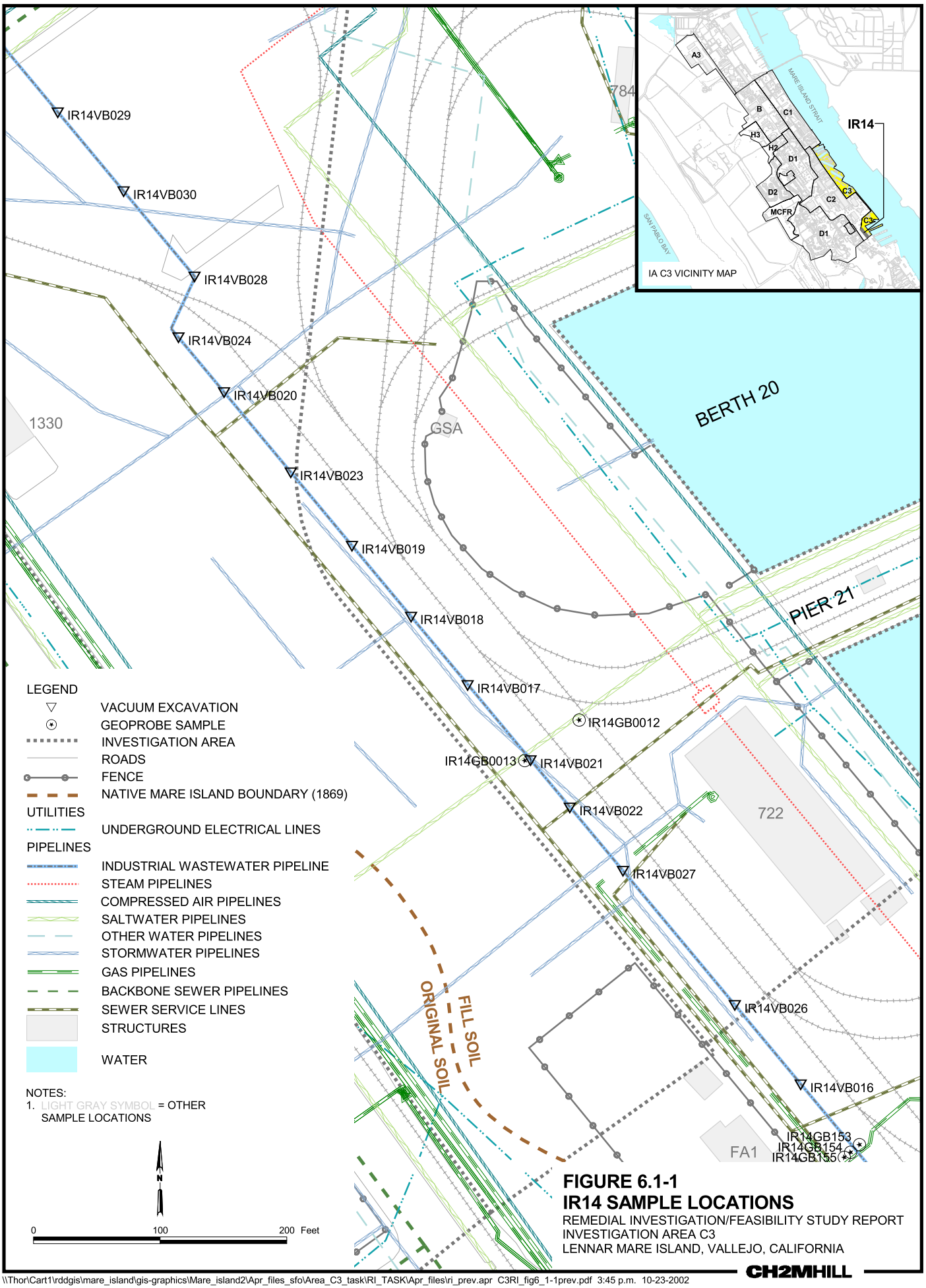

FIGURE 6.1-1
IR14 SAMPLE LOCATIONS
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

CH2MHILL

\\Thor\Cart1\rddgis\mare_island\gis-graphics\Mare_island2\Apr_files_sfo\Area_C3_task\RI_TASK\Apr_files\ri_prev.apr C3RI_fig6_1-1prev.pdf 3:45 p.m. 10-23-2002

years, but was not a line that was identified as impacted at that time (Harris and Associates 1986). A 1987 study identified 120 sources at 25 buildings and facilities that were discharged to the IWTP collection system, as documented in the *Industrial Waste System Pretreatment Study, Baseline Monitoring Report, Mare Island Naval Shipyard* (Harris and Associates 1987). The report also listed typical wastewater pollutant concentrations, volumetric flow, and system sources.

6.1.3.3 Phase I Remedial Investigation

Between 1990 and 1992, Phase I of the remedial investigation was conducted system-wide at IR14 to evaluate whether the IWTP collection system had leaked and whether ABM was in the backfill of the IWTP collection system. The results of the Phase I remedial investigation were documented in the *Site Characterization Summary for Phase I Remedial Investigation NSY Mare Island* (IT 1992). Findings across the IWTP system indicated additional assessment of the extent of contamination was needed. There were no data collected in IA C3 during this investigation.

6.1.3.4 Phase II Remedial Investigation

A Phase II remedial investigation was conducted between April 1993 and July 1994 to evaluate the extent of soil and groundwater chemicals along IWTP pipelines system-wide, including the lines located within IA C3. Results of the Phase II remedial investigation at IR14 were documented in the *Remedial Investigation Report, Operable Unit 3, Mare Island* (PRC 1996a). During the Phase II remedial investigation, vacuum excavations occurred approximately every 75 feet, and direct-push borings were installed based on locations of the highest contamination detected in the vacuum excavation samples (PRC 1996a). Soil samples were submitted for BTEX, TPH, PCB, and metal analysis. Fifteen percent of these samples were submitted for VOC analysis. Seven vacuum excavations (IR14VB017, IR14VB018, IR14VB019, IR14VB021, IR14VB022, IR14VB026, and IR14VB027) were advanced in IA C3. Groundwater samples were not collected within the IA C3 boundary during this investigation. ABM was documented in the boring logs along the IWTP pipeline in IA C3.

The Phase II remedial investigation included the preparation of a baseline human health risk assessment. The *Baseline Human Health Risk Assessment Addendum to the Remedial Investigation Report, Operable Unit 3, Mare Island* presented an evaluation of the potential risks associated with environmental contamination at IR14 in the absence of remedial action (PRC 1997d). The preliminary risk calculations indicated that human health risks from contaminants at the IWTP pipelines within the IA C3 boundaries are within the risk management range and the evaluation of remedial alternatives is not warranted.

6.1.3.5 Offshore Ecological Risk Assessment

An offshore ecological risk assessment was conducted to evaluate risks to ecological receptors from site-specific stressors present in offshore areas. Results of the Offshore ERA were documents in the *Revised Final Offshore Areas Ecological Risk Assessment, Mare Island* (TtEMI 2002b). The Offshore ERA evaluated impacts from contaminated sediments in the Mare Island Strait and performed both clam and amphipod bioassays using sediment and pore water collected from the Strait. Amphipod bioassay tests were performed using sediments collected near Pier 21, offshore of IR14 in IA C3; results indicated potential toxicity. However, overall conclusions stated that chemicals in offshore sediments do not

pose an unacceptable risk to populations of benthic invertebrates. Additionally, food-chain modeling suggested that population-level risks to birds and mammals were negligible.

6.1.3.6 Implementation of the LMI IA C3 SAP

Field activities at IR14 in IA C3 in July 2002 consisted of soil and groundwater sampling and analysis for chromium at two different locations. The soil sample (location IR14GB0013) was collected near former sample IR14VB021 within the pipeline backfill to further evaluate historical elevated chromium concentrations as analyzed by the XRF method. A groundwater sample was collected from a boring (IR14GB0012) located along the saltwater pipeline which is perpendicular to, and downgradient of, the IWTP pipeline. The field activities were performed consistent with the *IA C3 Sampling and Analysis Plan* (CH2M HILL 2002e).

6.2 Physical and Ecological Characteristics

6.2.1 Surface Features

IR14 in IA C3 consists of the underground IWTP pipeline, a buried utility. No surface structures are present, and the ground surface above the IWTP pipeline is paved with asphalt.

6.2.2 Surface Water

No surface water bodies are present at IR14. Surface water runoff from the area discharges into the stormwater system. Mare Island Strait is located approximately 225 feet to the northeast of IR14 in IA C3.

6.2.3 Geology

Three of the Mare Island geologic units were identified at IR14 across Mare Island. The units, from top to bottom, include: (1) fill material, (2) unconsolidated natural deposits, and (3) bedrock. The fill material in IR14 consists of clay, silt, and sand occurring from the surface to approximately 7 feet bgs. Brick, concrete, asphalt debris, and traces of burned wood fragments were frequently encountered and most likely were mixed with fill materials that were placed in the area during site development and backfill material placed around underground utilities. The unconsolidated natural deposits at IR14 within IA C3 were typically logged as silty clays and were found at depths of approximately 4 to 7 feet bgs. The bedrock formation is composed of sandstone, siltstone, and shale. The contact between unconsolidated material and bedrock varies from approximately 12 feet bgs to greater than 16 feet bgs.

The subsurface components of the IWTP collection system primarily were constructed within heterogeneous fill material. However, in some areas, IWTP pipelines were constructed by excavating into underlying fine-grained homogeneous fill material (such as dredge spoils), unconsolidated natural deposits, and bedrock units. The depth to the top of the IWTP pipelines varies from about 2.5 to 4 feet bgs within IA C3. The backfill material used immediately adjacent to the IWTP collection system, specifically the industrial wastewater pipeline, generally consisted of sand and gravel. Spent ABM was sometimes

used as backfill along the IWTP system following repairs. ABM was observed in a portion of the industrial wastewater line within IA C3.

6.2.4 Hydrogeology

Groundwater is generally encountered between 3.5 and 6 feet bgs at IR14 within IA C3. The groundwater table is typically within the bottom portion of the IWTP pipeline backfill. The groundwater flow near the section of the IWTP in IA C3 is primarily to the northeast, toward Mare Island Strait (Figure 1.5-1). However, groundwater flow through the IWTP collection system may be influenced by permeability variations between coarser-grained fill materials around pump station subsurface structures and within IWTP pipeline trenches, and surrounding finer-grained or less permeable material. A preferential groundwater flow path may exist through the more permeable backfill of the IWTP collection system.

6.2.5 Ecology

No viable habitat exists at IR14 within IA C3 because the underground IWTP line is overlain at the surface with asphalt pavement. Mare Island Strait is located directly northeast of IR14. A brief description of this offshore habitat can be found in Section 1.5.6.

6.3 Nature and Extent of Contamination

This section summarizes the nature and extent of soil and groundwater contamination at IR14 in IA C3. Figure 6.1-1 presents the locations of samples collected during investigations performed at IR 14 within and near IA C3. Only IR14 data for samples collected within the IA C3 boundaries are summarized in this section. Analytical soil and groundwater data for samples collected at IR14 during the investigations presented in Section 6.1.3 are provided in Appendices F8 and F9.

6.3.1 Soil

Soil samples collected from IR14 in IA C3 have been analyzed for petroleum hydrocarbons, VOCs, and metals. A summary of soil data for IR14 is provided in Table 6.3-1. For each compound, Table 6.3-1 shows the number of samples analyzed, the number of detected results of that compound,[14] the average result, the maximum result, and the frequency of detection. For metals analysis, the table shows the ambient concentration for Mare Island fill material (see also Table 2.3-1) and identifies the number of samples with metal results greater than the respective ambient concentration. The following is a discussion of the analytical results for each of the analytical categories in Table 6.3-1 (petroleum hydrocarbons, VOCs, and metals).

[14] Includes those samples for which a compound was quantified at a concentration below the analytical reporting limit.

Table 6.3-1

Investigation Area C3, IR14 Statistical Summary Table of Analytical Soil Data

Future Land Use: Industrial

Land Type: Fill Material

Analyte	CAS Number	Analysis Type	Background Concentration for Metals (mg/kg)	Source of Background Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Background Concentration for Metals	Average Result (mg/kg)	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)
SOIL - IR14																	
Petroleum Hydrocarbon Compounds																	
DIESEL	DRO	Laboratory			7	0		2.7E+01							0%	1.2E+01	6.9E+01
GASOLINE	GRO	Laboratory			9	0		5.9E+00							0%	6.0E+00	1.3E+01
MOTOR OIL	MRO	Laboratory			7	1		5.3E+01	2.1E+02	2.1E+02	4/7/1993	IR14VB026	3.8	4.3	14%	2.4E+01	6.9E+01
Volatile Organic Compounds																	
1,1,1-TRICHLOROETHANE	71-55-6	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
1,1,2,2-TETRACHLOROETHANE	79-34-5	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
1,1,2-TRICHLOROETHANE	79-00-5	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
1,1-DICHLOROETHANE	75-34-3	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
1,1-DICHLOROETHENE	75-35-4	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
1,2-DICHLOROETHANE	107-06-2	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
1,2-DICHLOROETHENE (TOTAL)	540-59-0	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
1,2-DICHLOROPROPANE	78-87-5	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
2-BUTANONE	78-93-3	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
2-HEXANONE	591-78-6	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
4-METHYL-2-PENTANONE	108-10-1	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
ACETONE	67-64-1	Laboratory			1	1		6.3E-02	6.3E-02	6.3E-02	4/6/1993	IR14VB022	3.8	4.3	100%	1.2E-02	1.2E-02
BENZENE	71-43-2	Laboratory			9	0		2.8E-02							0%	1.2E-02	7.0E-02
BROMODICHLOROMETHANE	75-27-4	Laboratory			1	1		4.0E-03	4.0E-03	4.0E-03	4/6/1993	IR14VB022	3.8	4.3	100%	1.2E-02	1.2E-02
BROMOFORM	75-25-2	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
BROMOMETHANE	74-83-9	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
CARBON DISULFIDE	75-15-0	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
CARBON TETRACHLORIDE	56-23-5	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
CHLOROBENZENE	108-90-7	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
CHLOROETHANE	75-00-3	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
CHLOROFORM	67-66-3	Laboratory			1	1		1.5E-02	1.5E-02	1.5E-02	4/6/1993	IR14VB022	3.8	4.3	100%	1.2E-02	1.2E-02
CHLOROMETHANE	74-87-3	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
CIS-1,3-DICHLOROPROPENE	10061-01-5	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
DIBROMOCHLOROMETHANE	124-48-1	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
ETHYLBENZENE	100-41-4	Laboratory			9	0		2.8E-02							0%	1.2E-02	7.0E-02
METHYLENE CHLORIDE	75-09-2	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
STYRENE	100-42-5	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
TETRACHLOROETHENE	127-18-4	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
TOLUENE	108-88-3	Laboratory			9	0		2.8E-02							0%	1.2E-02	7.0E-02
TRANS-1,3-DICHLOROPROPENE	10061-02-6	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
TRICHLOROETHENE	79-01-6	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
VINYL CHLORIDE	75-01-4	Laboratory			1	0		6.0E-03							0%	1.2E-02	1.2E-02
XYLENE (TOTAL)	1330-20-7	Laboratory			9	0		8.4E-02							0%	1.2E-02	2.0E-01
Metals																	
ALUMINUM	7429-90-5	Laboratory	3.5E+04	b	1	1	0	6.6E+03	6.6E+03	6.6E+03	4/6/1993	IR14VB022	3.8	4.3	100%	4.8E+00	4.8E+00
ANTIMONY	7440-36-0	XRF	8.5E+00	b	10	4	0	4.5E+00	2.6E+00	5.1E+00	4/2/1993	IR14VB018	3.6	3.9	40%	1.0E+01	1.0E+01
ANTIMONY	7440-36-0	Laboratory	8.5E+00	b	1	1	0	4.5E+00	4.5E+00	4.5E+00	4/6/1993	IR14VB022	3.8	4.3	100%	3.6E+00	3.6E+00
ARSENIC	7440-38-2	XRF	3.6E+01	b	3	3	0	1.5E+01	1.2E+01	1.6E+01	4/6/1993	IR14VB021	4.6	4.8	100%	1.0E+01	1.0E+01
ARSENIC	7440-38-2	Laboratory	3.6E+01	b	1	1	0	7.8E+00	7.8E+00	7.8E+00	4/6/1993	IR14VB022	3.8	4.3	100%	1.2E+00	1.2E+00
BARIUM	7440-39-3	Laboratory			1	1	0	1.3E+02	1.3E+02	1.3E+02	4/6/1993	IR14VB022	3.8	4.3	100%	2.4E-01	2.4E-01

Table 6.3-1

Investigation Area C3, IR14 Statistical Summary Table of Analytical Soil Data

Future Land Use: Industrial

Land Type: Fill Material

Analyte	CAS Number	Analysis Type	Background Concentration for Metals (mg/kg)	Source of Background Concentration [1]	Number of Samples	Number of Detections	Number of Detections Equal to or Above Background Concentration for Metals	Average Result (mg/kg)	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Sample Date of Maximum Detection	Location of Maximum Detection	Beginning Depth (ft BGS)	Ending Depth (ft BGS)	Frequency of Detection	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)
SOIL - IR14																	
BERYLLIUM	7440-41-7	Laboratory	9.0E-01	b	1	1	0	4.0E-01	4.0E-01	4.0E-01	4/6/1993	IR14VB022	3.8	4.3	100%	1.2E-01	1.2E-01
CADMIUM	7440-43-9	XRF	5.2E+00	b	10	3	1	5.2E+00	3.3E+00	9.0E+00	4/6/1993	IR14VB022	6.1	6.3	30%	1.0E+01	1.0E+01
CADMIUM	7440-43-9	Laboratory	5.2E+00	b	1	0	0	3.0E-01							0%	6.0E-01	6.0E-01
CALCIUM	7440-70-2	XRF			10	10	0	3.2E+04	5.2E+03	1.5E+05	4/1/1993	IR14VB016	4.3	4.6	100%	1.0E+01	1.0E+01
CALCIUM	7440-70-2	Laboratory			1	1	0	1.5E+03	1.5E+03	1.5E+03	4/6/1993	IR14VB022	3.8	4.3	100%	3.6E+00	3.6E+00
CHROMIUM	7440-47-3	XRF	1.4E+02	b	10	10	8	8.4E+02	4.8E+01	4.7E+03	4/6/1993	IR14VB021	3.8	4.1	100%	1.0E+01	1.0E+01
CHROMIUM	7440-47-3	Laboratory	1.4E+02	b	2	2	0	2.6E+01	1.2E+01	4.0E+01	7/25/2002	IR14GB0013	3.8	4.3	100%	1.2E+00	1.1E+01
COBALT	7440-48-4	XRF			10	0	0	5.3E+00							0%	1.0E+01	1.6E+01
COBALT	7440-48-4	Laboratory			1	1	0	8.6E+00	8.6E+00	8.6E+00	4/6/1993	IR14VB022	3.8	4.3	100%	2.4E+00	2.4E+00
COPPER	7440-50-8	XRF	1.2E+02	b	10	10	1	7.5E+01	2.4E+01	2.2E+02	4/6/1993	IR14VB021	3.8	4.1	100%	1.0E+01	1.0E+01
COPPER	7440-50-8	Laboratory	1.2E+02	b	1	1	0	1.3E+01	1.3E+01	1.3E+01	4/6/1993	IR14VB022	3.8	4.3	100%	1.2E+00	1.2E+00
IRON	7439-89-6	XRF	6.2E+04	b	10	10	2	5.4E+04	2.4E+04	9.4E+04	4/6/1993	IR14VB021	3.8	4.1	100%	1.0E+01	1.0E+01
IRON	7439-89-6	Laboratory	6.2E+04	b	1	1	0	2.0E+04	2.0E+04	2.0E+04	4/6/1993	IR14VB022	3.8	4.3	100%	1.2E+00	1.2E+00
LEAD	7439-92-1	XRF	5.9E+01	b	10	10	3	6.4E+01	7.4E+00	2.7E+02	4/6/1993	IR14VB022	6.1	6.3	100%	1.0E+01	1.0E+01
LEAD	7439-92-1	Laboratory	5.9E+01	b	1	1	0	9.8E+00	9.8E+00	9.8E+00	4/6/1993	IR14VB022	3.8	4.3	100%	2.4E+00	2.4E+00
MAGNESIUM	7439-95-4	Laboratory			1	1	0	3.6E+03	3.6E+03	3.6E+03	4/6/1993	IR14VB022	3.8	4.3	100%	3.6E+00	3.6E+00
MANGANESE	7439-96-5	XRF	1.6E+03	b	10	10	2	9.6E+02	1.9E+02	2.1E+03	4/2/1993	IR14VB019	3.8	4.0	100%	1.0E+01	1.0E+01
MANGANESE	7439-96-5	Laboratory	1.6E+03	b	1	1	0	1.7E+02	1.7E+02	1.7E+02	4/6/1993	IR14VB022	3.8	4.3	100%	2.4E-01	2.4E-01
MERCURY	7439-97-6	Laboratory	2.0E+00	b	1	1	0	2.0E-02	2.0E-02	2.0E-02	4/6/1993	IR14VB022	3.8	4.3	100%	2.0E-02	2.0E-02
MOLYBDENUM	7439-98-7	Laboratory			1	0	0	6.0E-01							0%	1.2E+00	1.2E+00
NICKEL	7440-02-0	XRF	1.3E+02	b	10	10	3	1.7E+02	2.3E+01	7.9E+02	4/6/1993	IR14VB021	3.8	4.1	100%	1.0E+01	1.0E+01
NICKEL	7440-02-0	Laboratory	1.3E+02	b	1	1	0	2.0E+01	2.0E+01	2.0E+01	4/6/1993	IR14VB022	3.8	4.3	100%	2.4E+00	2.4E+00
POTASSIUM	7440-09-7	XRF			10	10	0	1.1E+04	2.5E+03	1.8E+04	4/2/1993	IR14VB017	4.2	4.7	100%	1.0E+01	1.0E+01
POTASSIUM	7440-09-7	Laboratory			1	1	0	1.7E+03	1.7E+03	1.7E+03	4/6/1993	IR14VB022	3.8	4.3	100%	1.2E+02	1.2E+02
SELENIUM	7782-49-2	Laboratory			1	1	0	3.7E-01	3.7E-01	3.7E-01	4/6/1993	IR14VB022	3.8	4.3	100%	2.4E-01	2.4E-01
SILVER	7440-22-4	XRF			10	0	0	5.0E+00							0%	1.0E+01	1.0E+01
SILVER	7440-22-4	Laboratory			1	0	0	3.0E-01							0%	6.0E-01	6.0E-01
SODIUM	7440-23-5	Laboratory			1	1	0	7.8E+02	7.8E+02	7.8E+02	4/6/1993	IR14VB022	3.8	4.3	100%	2.4E+01	2.4E+01
THALLIUM	7440-28-0	Laboratory		d	1	0	0	1.2E-01							0%	2.4E-01	2.4E-01
TIN	7440-31-5	XRF			11	11	0	1.1E+01	7.2E+00	1.8E+01	4/6/1993	IR14VB022	6.1	6.3	100%	1.0E+01	1.0E+01
TITANIUM	7440-32-6	XRF			11	11	0	4.0E+03	1.1E+03	6.3E+03	4/2/1993	IR14VB019	3.8	4.0	100%	1.0E+01	1.0E+01
VANADIUM	7440-62-2	XRF	1.9E+02	b	10	10	2	1.3E+02	4.2E+01	2.5E+02	4/2/1993	IR14VB019	3.8	4.0	100%	1.0E+01	1.0E+01
VANADIUM	7440-62-2	Laboratory	1.9E+02	b	1	1	0	2.6E+01	2.6E+01	2.6E+01	4/6/1993	IR14VB022	3.8	4.3	100%	1.2E+00	1.2E+00
ZINC	7440-66-6	XRF	2.3E+02	b	10	10	3	3.8E+02	6.1E+01	1.3E+03	4/6/1993	IR14VB022	6.1	6.3	100%	1.0E+01	1.0E+01
ZINC	7440-66-6	Laboratory	2.3E+02	b	1	1	0	5.5E+01	5.5E+01	5.5E+01	4/6/1993	IR14VB022	3.8	4.3	100%	6.0E-01	6.0E-01

[1] - Source Definition

a - Ambient Background Concentration (95th percentile) at Mare Island Naval Shipyard
b - Ambient Metal Concentrations in Artificial Fill - Mare Island
c - Ambient Metal Concentrations in Original Island Soil - Mare Island
d - At the request of the regulatory agencies, the ambient limit was set to the detection limit.

6.3.1.1 Petroleum Hydrocarbons

Seven samples were analyzed for TPH-diesel and TPH-motor-oil in soil at IR14 in IA C3. One soil sample collected at location IR14VB026 contained TPH-motor-oil at a concentration of 210 mg/kg. The remaining samples contained TPH-diesel and TPH-motor-oil at concentrations below laboratory detection limits. Nine soil samples were analyzed for TPH-gasoline; no results were above laboratory detection limits.

6.3.1.2 VOCs

As shown in Table 6.3-1, VOCs were not detected frequently in soil samples collected from IR14. Low levels of acetone (0.063 mg/kg), bromodichloromethane (0.004 mg/kg), and chloroform (0.015 mg/kg) were detected in one soil sample collected at IR14VB022. To provide a basis for comparison, these concentrations are several orders of magnitude lower than the USEPA Region 9 PRGs for the direct-contact exposure pathway in an industrial setting (6,000, 1.8, and 12 mg/kg for acetone, bromodichloromethane, and chloroform, respectively). No other VOCs were detected in any of the soil samples collected from IR14. These results indicate that significant levels of VOCs are not present in soil in the vadose zone.

6.3.1.3 Metals

Soil samples collected from IR14 in IA C3 were analyzed for metals in an off-site laboratory by CLP methods and using XRF methodology in the Navy's Mare Island on-site laboratory. Table 6.3-1 provides statistics for soil samples analyzed using these two methodologies. "Laboratory" analysis means analysis of soil samples by an off-site laboratory using CLP methods. "XRF" analysis means analysis of soil samples by a fixed laboratory using XRF methodology. Approximately 10 soil samples were analyzed for metals using XRF, and two samples were analyzed by CLP methods.

Metal concentrations detected in soil at IR14 are compared to ambient concentrations for Mare Island fill material in the following paragraphs. Ambient values were established for selected metals at Mare Island to establish naturally-occurring conditions against which site concentrations are compared to identify conditions that may be attributable to site activities. Of the 25 metals analyzed for in soil samples collected from IR14, ambient levels have been established for 14.

As indicated in Table 6.3-1, nine metals analyzed by XRF were detected at concentrations exceeding the ambient concentration. (No metals were detected at concentrations exceeding the ambient concentration in soil samples analyzed by CLP methods. Of these, seven were detected at concentrations exceeding the upper range of the ambient data set and at a frequency that indicates an association with site activities. The metal most frequently found at concentrations exceeding the ambient level in soil samples collected from IR14 was chromium; the distribution of chromium is soil is presented in Figure 6.3-1.

Other metals detected at elevated concentrations in soil samples collected at IR14 were cadmium, copper, lead, nickel, vanadium, and zinc. These compounds are discussed below. Aluminum, antimony, arsenic, beryllium, magnesium, and mercury were detected at concentrations below the ambient concentration for fill material in all soil samples for which they were analyzed.

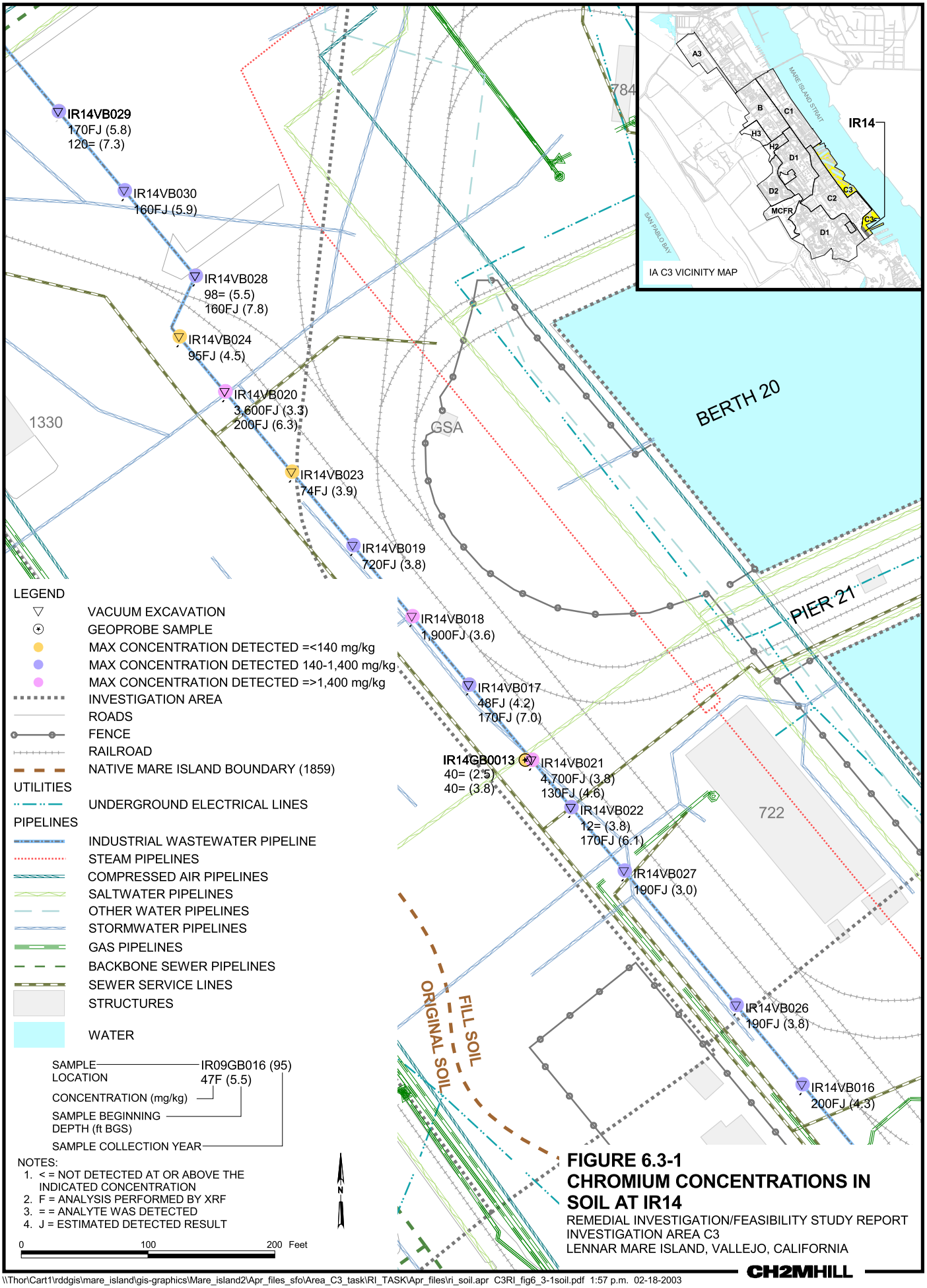

FIGURE 6.3-1
CHROMIUM CONCENTRATIONS IN SOIL AT IR14
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

CH2MHILL

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Chromium. Eight out of 10 samples analyzed by XRF methodology, and zero out of two samples analyzed by CLP methods, contained chromium above the ambient concentration for fill material (140 mg/kg). The presence of elevated levels of chromium in soil at IR14 may be attributed to the composition of the backfill material, a portion of which may consist of ABM around the IWTP pipeline.

The maximum chromium concentration detected in soil at IR14 is 4,700 mg/kg (Figure 6.3-1). This result was detected in a sample collected at a depth of 3.8 to 4.1 feet bgs at IR14VB021 and was analyzed using XRF methodology. A soil sample collected in 2002 from IR14GB0013, which is located within 5 feet of former location IR14VB021, contained a significantly lower chromium concentration (40 mg/kg at 3.8 to 4.3 feet bgs). Because this sample was analyzed by CLP methods, this result is more representative than the concentration detected using XRF methodology. Further evidence of the erroneously high concentrations detected by XRF is found in the results of a split sample collected from IR14VB022 at 3.8 feet bgs (analyzed by both CLP and by XRF methods). The results of these analyses indicate that the concentration detected by XRF (190 mg/kg) is an order of magnitude greater than that detected by CLP methods (12 mg/kg).

Cadmium. Cadmium was found above the ambient level in one out of the 11 samples for which it was analyzed. This sample (collected at IR14VB022) contained cadmium at a concentration of 9.0 mg/kg, which exceeds the ambient concentration of cadmium in fill material of 5.2 mg/kg. However, this result is below the reporting limit (10 mg/kg). Due to the uncertainty associated with concentrations detected below the reporting limit and the fact that other data indicate that cadmium is present at only low concentrations (below 5 mg/kg), a concentration below the reporting limit may be anomalous.

Copper. Copper was detected in all 11 samples for which it was analyzed at concentrations ranging from 13 to 220 mg/kg. Only the maximum concentration contained copper at a concentration greater than the ambient concentration of copper in fill material (120 mg/kg). This sample was collected from IR14VB021 at 3.8 feet bgs and is bound vertically and linearly along the pipeline by samples containing lower concentrations of copper (13 to 31 mg/kg).

Lead. Three of 11 soil samples contained lead at concentrations greater than the ambient concentration for lead in fill material (59 mg/kg). These samples were collected at IR14VB018, IR14VB021, and IR14VB022 and contained lead at concentrations of 86, 140, and 270 mg/kg, respectively. The lateral extent of elevated levels of lead along the IWTP piping is defined by concentrations below the ambient concentration.

Nickel. Three of 11 soil samples contained nickel at concentrations greater than the ambient concentration of nickel in fill material (130 mg/kg). These samples were collected at IR14VB019, IR14VB018, and IR14VB021 and contained nickel at concentrations of 160, 290, and 790 mg/kg, respectively. The lateral extent of elevated levels of nickel along the IWTP piping is defined by concentrations below the ambient concentration.

Vanadium. Two of 11 soil samples contained vanadium at concentrations greater than the ambient concentration of vanadium in fill material (190 mg/kg). These two samples were collected from IR14VB022 and IR14VB019 and contained vanadium at concentrations of 210 and 250 mg/kg, respectively. The lateral extent of elevated levels of vanadium along the

IWTP piping is defined by concentrations below the ambient concentration. In addition, analytical data from the spilt sample (which was analyzed by both CLP and XRF methods) suggests that vanadium concentrations analyzed by XRF are an order of magnitude greater than those analyzed by CLP methods. Therefore, vanadium concentrations detected using XRF at the site may be biased high.

Zinc. Three of 11 soil samples contained zinc at concentrations greater than the ambient concentration for zinc in fill material (230 mg/kg). These samples were collected at IR14VB018, IR14VB021, and IR14VB022 and contained zinc at concentrations of 450, 1,300, and 1,300 mg/kg, respectively. The lateral extent of elevated levels of zinc along the IWTP piping is defined by concentrations below the ambient concentration.

6.3.2 Groundwater

No groundwater samples were collected in IA C3 along IR14 prior to the 2002 field investigation. The collection of a groundwater sample was proposed in the *Investigation Area C3 Sampling and Analysis Plan* (CH2M HILL 2002e) to evaluate the potential for migration of elevated chromium concentrations toward Mare Island Strait. A groundwater sample (IR14GB0012) was collected downgradient of IR14 along the saltwater pipeline, which runs perpendicular to the industrial wastewater pipeline. The purpose of this sample was to evaluate the concentrations of chromium downgradient of IR14VB021, which contained the maximum concentration of chromium historically detected in soil. Chromium was not detected above the reporting limit (5 µg/L) in the groundwater sample collected along the saltwater pipeline.

6.3.3 Summary of the Nature and Extent of Contamination

The evaluation of analytical data collected at IR14 indicates that metals may contribute to contamination in soil at IR14 in IA C3. Seven metals (cadmium, chromium, copper, lead, nickel, vanadium, and zinc) were detected at concentrations exceeding the upper range of the ambient data set for fill material. However, a comparison of XRF analyzed data to CLP-analyzed data suggests that, in many cases, XRF-analyzed data are one to two orders of magnitude greater than CLP-analyzed data. Therefore, concentrations detected using XRF methodology are biased high at IR14 in IA C3, and *in-situ* metal concentrations may actually be less than the ambient concentrations.

Although chromium was not detected in laboratory-analyzed samples (suggesting that chromium is present at only low concentrations in soil at IR14), it is the metal most frequently detected at concentrations exceeding the ambient level in soil samples analyzed by XRF. The fate and transport of chromium is therefore evaluated in Section 6.4 to represent the partitioning and migration characteristics of metals in soil and groundwater at the site.

6.4 Contaminant Fate and Transport

This section presents an evaluation of the physical and chemical characteristics that may influence the mobility and behavior of contaminants at IR14. Based on the evaluation presented in the previous section, chromium was selected for inclusion in this fate and transport evaluation to represent the partitioning and migration characteristics of metals

that potentially contribute to soil and/or groundwater contamination at IR14. The probable migration pathways presented in the conceptual site model (Figure 6.4-1) are based on the results of the fate and transport evaluation presented in this section. The CSM is also based on the physical characteristics observed during a site walk and review of historical information.

6.4.1 Conceptual Site Model

The IWTP pipeline runs southeast to northwest at the southern end of IA C3 (Figure 1.3-3). Most of the pipeline within IA C3 is beneath asphalt and installed in fill material. Potential sources of contamination, potential release mechanisms, and potential contamination migration pathways at IR14 are presented below.

6.4.1.1 Potential Sources

Potential sources of contamination identified at IR14 include: (1) leaks from the IWTP pipeline and (2) debris disposal and/or ABM in the trench backfill material.

6.4.1.2 Potential Release Mechanisms

Potential release mechanisms that resulted from various operations performed at IR14 include leaks and releases from IWTP piping.

6.4.1.3 Potential Contamination Migration Pathways

Potential contaminant migration pathways include: (1) preferential migration of contaminants in groundwater within the IWTP pipeline backfill; (2) migration within backfill of a 4-inch ductile iron saltwater pipeline at a depth of approximately 2.5 feet beneath the asphalt, oriented perpendicular to the IWTP pipeline, and intersecting with the IWTP pipeline near sample location IR14VB021; and (3) groundwater migration in the aquifer underlying IA C3 towards Mare Island Strait and the dry docks.

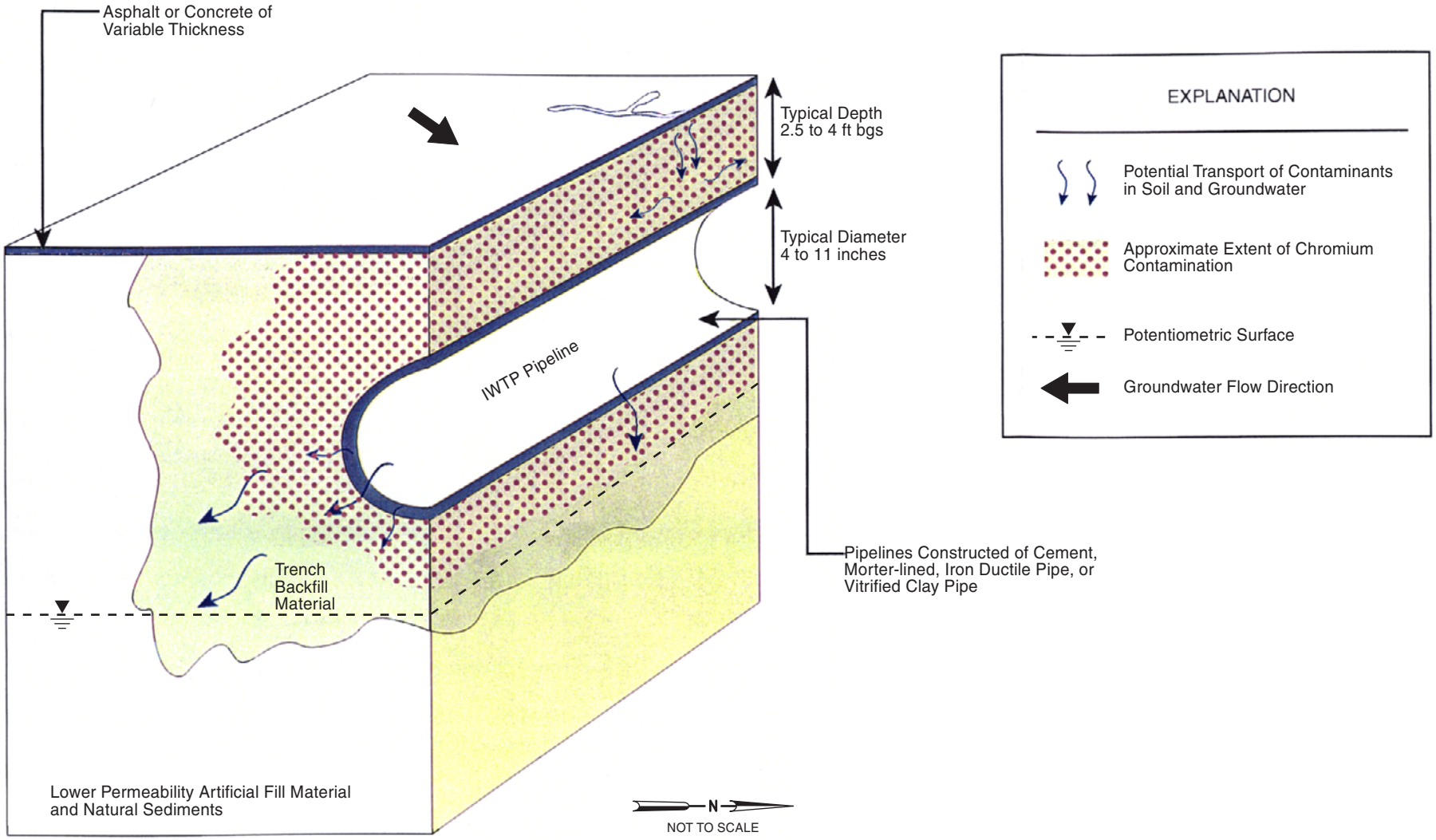
These potential pathways for chromium in soil and groundwater are evaluated in the following section.

6.4.2 Fate and Transport Evaluation

The most probable fate and transport and potential pathways for on- and off-site migration of chromium in soil and groundwater at IR14 are identified in this section. A more detailed discussion of the fate and transport processes and physical and chemical properties of specific chemicals is presented in Appendix K.

The potential migration pathways for soil contaminants in IR14 include:

- Downward migration with the infiltration of rainwater.
- Volatilization to air.
- Subsurface lateral migration via groundwater transport through the aquifer or preferential migration along permeable utility line backfill.



MODIFIED FROM TETRA TECH 2000

FIGURE 6.4-1
IR14 CONCEPTUAL SITE MODEL
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

E052003008RDD_03 (5/29/03)

CH2MHILL

The entire IR14 area is paved. Downward migration with infiltration and volatilization to air are considered migration pathways even in paved areas due to cracks and joints in the pavement. However, the ability of contaminants to migrate via these pathways is greatly reduced compared to unpaved areas. Pathways that are considered unlikely in paved areas include: (1) surface erosion by wind or water and (2) surface runoff to Mare Island Strait due to lack of contact with contaminated media.

Although chromium has not been detected in groundwater at the site, the fate and transport of chromium in groundwater is also evaluated for completeness. The migration pathways for groundwater at IR14 include:

- Migration along permeable utility line backfill.
- Migration to surface water bodies as shallow groundwater discharges to Mare Island Strait to the northeast of IR14.

One other potential transport pathway, volatilization to the atmosphere, is not of concern at IR14, as chromium is a non-volatile compound.

To estimate the potential travel times for groundwater contamination at IR14 to reach Mare Island Strait, a simple set of calculations based on Darcy's Law and fundamental adsorption chemistry were performed consistent with the equations and methodology provided in Section 3.4 for IR09. For IR14, a representative hydraulic conductivity for the shallow aquifer based on numerical modeling studies is approximately 1 foot/day (CH2M HILL 2002i). The horizontal hydraulic gradient between IR14 and the nearby Strait is 0.004 foot/foot (Figure 1.5-1). The transport porosity of the aquifer at the site is assumed to be 0.15. Based on these assumed hydraulic properties and the equation presented in Section 3.4, the bulk groundwater velocity at IR14 is approximately 0.03 foot/day or 9.7 feet/year. However, due to the interaction between contaminants and the aquifer solids through which they move, contaminants typically travel at velocities less than native groundwater. The degree to which the velocity of contaminant movement is reduced is typically expressed as a retardation factor. The retardation factor of a contaminant can be calculated based on the value of the distribution coefficient for that contaminant. As presented in Section 3.4, constituent concentrations in groundwater will be reduced by a factor of at least 1,000, as groundwater mixes with surface water upon entering Mare Island Strait.

The chemical characteristics controlling the fate of chromium in soil and groundwater in IR14 are discussed in the following sections. Based on the characteristics detailed below, the most likely migration pathways for specific contaminants can be determined.

6.4.2.1 Metals

The fate of metals will likely be controlled by reactions such as cation exchange, which results in adsorption of contaminants to soil mineral surfaces or soil organic matter. Their fate will also likely be controlled by precipitation reactions leading to the formation of secondary mineral phases.

Chromium is typically found in two valence states in soil: trivalent and hexavalent. Samples collected at IR14 in IA C3 were analyzed for total chromium. Although hexavalent chromium was not specifically analyzed in samples collected from IR14 in IA C3, hexavalent chromium was only detected in five out of 96 samples for which it was analyzed (at concen-

trations of 0.06 to 0.09 mg/kg) across Mare Island; the presence of hexavalent chromium is not expected at IR14. Trivalent chromium has an extremely high distribution coefficient ($K_d \approx 990{,}000$ cc/g) (USEPA 2001), indicating a very strong affinity for soil. Analytical data from IA C3 (Appendix F) indicates that neutral to alkaline conditions prevail in soil, making inorganic compounds less soluble, with lesser tendency to migrate with infiltrating precipitation. Chromium is not expected to migrate significant distances in soil at IR14, due to its high distribution coefficient.

Chromium transport in shallow groundwater beneath IA C3 or through permeable utility line backfill would be expected to proceed slowly, if at all. A sample was collected and analyzed for chromium from the most likely preferential flow pathway, the backfill along the saltwater pipeline. The sample was collected between the highest detected chromium soil concentration and Mare Island Strait (Figure 6.3-1). Chromium was not detected in the groundwater sample, suggesting that chromium transport in groundwater is either not occurring, or is proceeding so slowly that chromium contamination has traveled less than 50 feet.

Assuming a groundwater pH in the range of 6.5 to 7.0, the distribution coefficient of chromium (assuming the relatively mobile hexavalent chromium) ranges from 18 to 20 (USEPA 2001). Using the equation provided in Section 3.0, and assuming a total aquifer porosity of 0.35 and a bulk density of 1.8 g/cc, these values imply a range of retardation factors between about 90 and 105. In other words, due to the affinity of the metals present for the aquifer solids, the metals will travel between 90 and 105 times more slowly than the native groundwater, or between 0.09 feet/year and 0.11 feet/year.

Mare Island Strait is approximately 220 feet northeast of IR14. Using the bulk groundwater velocity calculated above (9.7 feet/year), the distance to the strait (220 feet), and the lowest retardation factor calculated above (R=90), these calculations suggest that it will take many centuries (over 2,000 years) for the contaminants present in groundwater at the site to reach Mare Island Strait through the aquifer. It should be noted that the influence of dispersion during transport may reduce the arrival time of the leading edge of the contaminant plume; however, given the extremely long travel times computed here, any reduction due to dispersion would be relatively insignificant. In addition, the assumptions made above about flow and transport parameters at IR14 are estimates based on current knowledge of site conditions. Any change from the assumptions above may affect the calculation of travel times.

Permeable utility line backfill may act as preferential pathways for contaminant transport when the water table rises into the backfill. If contaminated groundwater reaches the backfill, transport times could be reduced by one or more orders of magnitude. Assuming a backfill with a hydraulic conductivity of 10 feet/day, groundwater transport to Mare Island Strait would occur approximately 10 times faster (based on the increased hydraulic conductivity) through the utility line backfill, or in 200 years. This travel time is approximate due to uncertainty in K_D values, backfill composition, groundwater levels, and hydraulic gradient within the backfill.

Although the above discussion indicates travel times for chromium in groundwater, it should be noted that there is currently no evidence to indicate chromium contamination in groundwater in the portion of IR14 within IA C3.

6.4.3 Conclusions

The most likely migration pathways for contaminants in the soil at IR14 are subsurface lateral migration via groundwater transport through the aquifer, or preferential migration along permeable utility line backfill. However, due to the low mobility of the detected contaminants, this scenario is not likely to take place to a significant degree.

Dissolution or volatilization of contaminants from the soil are not likely due to the chemical nature of contamination at the site. The evaluation of the fate of chromium at IR14 suggests the soil contaminants will remain adsorbed to the soil, will not migrate to groundwater and, therefore, not impact Mare Island Strait to the northeast of IR14.

If contaminants were present in groundwater at IR14, the most likely migration pathways involve lateral migration through the aquifer and through preferential pathways along permeable utility corridors. The approximate transport time for chromium traveling in groundwater along the utility corridors is 200 years, while constituents traveling through the aquifer would take 2,000 years to reach Mare Island Strait. While migration pathways have the potential to transport contaminants via groundwater, these contaminants would not be expected to reach Mare Island Strait for centuries, if at all. In fact, chromium contamination in groundwater has not been detected in groundwater collected along the most likely preferential pathway at IR14, permeable utility line backfill.

6.5 Human Health Risk Assessment Summary

This section summarizes the HHRA conducted for the portion of the IR14 pipeline within IA C3. The complete HHRA is presented in Appendix G. The results of the HHRA are based on the following key assumptions and approaches:

- Any releases and associated soil contamination related to IR14 are assumed to be in the subsurface soil since IR14 is an underground system, and there are no surface features associated with the site.
- Domestic uses of groundwater are not evaluated because the groundwater in IA C3 is not considered a municipal and domestic water supply (see Section 1.2.4).
- Human health exposures for future construction worker scenarios are represented by concentrations of COPCs for human health risk assessment in the top 10 feet of soil (0 to 10 feet bgs).
- The HHRA provides estimates of cancer risks and non-cancer adverse health impacts to humans under an RME. RME scenarios represent a plausible “worst-case” scenario and account for potential impacts to extremely sensitive individuals within a population.

The following sections summarize the HHRA and are discussed in detail in the following text:

- Exposure pathways, receptors, and environmental media
- HHRA COPCs
- Risk characterization

6.5.1 Exposure Pathways and Environmental Media

IR14 is located in an area planned for industrial use. IR14 was previously used to collect, pretreat, and convey wastewater from various sources to the IWTP. Removal of sludge and residue and flushing of the entire IWTP collection system was performed in 1996 by the Navy. Based on the future reuse of the area, a construction worker is evaluated at the IR14 pipeline in IA C3. To provide for the possibility of changes in the reuse planning, a residential receptor was evaluated and the results are presented in Appendix G.

Exposure pathways evaluated for these receptors include:

- Ingestion of soil.
- Dermal contact with soil.
- Inhalation of vapors from soil in outdoor air.
- Inhalation of chemicals sorbed to soil suspended in air as dust.

The indoor air pathways (inhalation of VOCs volatilizing from groundwater or subsurface soil) were not evaluated for IR 14. There are no buildings in this area currently and there are no plans to construct buildings in this area in the future.

Because IR14 is an underground system, the HHRA estimated risk based on analytical data for soil collected from the 0 to 10 feet bgs depth interval. Surface soil samples were not collected at this site. Activities involved in the construction of industrial buildings have the potential to result in exposure to subsurface soil. The soil data from the mixed-zone depth interval (i.e., 0 to 10 feet bgs) were used to calculate human health risk from contaminants at IR14. It is anticipated that construction activities at Lennar Mare Island will last from approximately 3 to 6 months depending on the area and size of the project. For this HHRA, it was conservatively assumed that construction activities would last for the 6-month period; therefore, 180 days per year was used as the exposure frequency.

EPCs associated with direct contact (dermal contact or incidental ingestion of soil) were based directly on measured concentrations. However, chemical concentrations in air (vapors) were not measured directly. Therefore, vapor concentrations from groundwater were estimated using appropriate fate and transport models. Dust-in-air concentrations were estimated using a particulate emission factor.

6.5.2 HHRA Constituents of Potential Concern

COPCs for human health risk assessment were identified by including each detected constituent as a COPC except for metals in soil. Metals were eliminated as a COPCs in soil if the site concentrations were not significantly different than ambient concentrations for fill materials. COPCs for human health risk assessment in soils from the 0 to 10-foot bgs soil depth interval at IR14 include metals and VOCs. The selection of COPCs for human health risk assessment for IR14 is shown in Table G.2-5.

6.5.3 Risk Characterization Results

A discussion of the RME scenario risks for the construction worker is provided below. Risk characterization results indicate that future site conditions at IR14 pose potential lifetime excess cancer risks that are below the risk-management range (10^{-4} to 10^{-6}) for carcinogens.

The estimated potential cancer risk for the RME construction worker receptor for exposure to soil is 4×10^{-7}.

Non-cancer adverse health effects (HIs) were estimated to be less than the threshold of 1 for all COPCs. No COPC or group of COPCs contributes significantly to the total estimated HI. In addition, when HQs are segregated by body organ, the HIs are at least an order of magnitude below the threshold value of 1.

The HHRA developed four different sets of risk estimates (ambient, total, site, and incremental risk) for the construction worker exposure scenario. The definitions of the four sets of risk estimates are provided in Section 3.5.3. The approach for calculating these different risk estimates is described in Appendix G. Table 6.5-1 presents a summary of the estimated risks calculated for the construction worker exposure scenario.

TABLE 6.5-1
Summary of Estimated Risks at IR14
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

		Mixed-zone Soil							
		Ambient		Total		Site		Incremental	
Site	Exposure Scenario/Receptor	Cancer	Non-cancer	Cancer	Non-cancer	Cancer	Non-cancer	Cancer	Non-cancer
IR14	Construction Worker	4×10^{-7}	0.4	5×10^{-7}	0.5	1×10^{-7}	0.3	1×10^{-7}	0.06

6.6 Ecological Risk Assessment Summary

A Baseline ERA was performed for IR14 in IA C3 to assess potential for risk to ecological receptors from site-related contaminants. The approach used for the Baseline ERA is described in Section 2.5, and the complete Baseline ERA is presented in Appendix H. The approach for this Baseline ERA is modeled after that developed by DTSC (1996) and USEPA (1997, 1998) and was used to assess ecological risks presented by COPECs.

A Baseline ERA includes the collection and interpretation of biological or abiotic media data to further refine the conclusions of a screening-level ERA. TtEMI performed the screening-level ERA for IA C3 (TtEMI 2000a, 2002b).

Ecological receptors are not present at IR14 in IA C3. The site consists of a subsurface utility pipeline, the ground surface above which is paved with asphalt. However, ecological receptors are present at Mare Island Strait, which is located approximately 225 feet to the northeast from IR14. The Strait supports diverse communities of algal, invertebrate, fish, bird, and mammal species, as discussed in Section 1.5.5. Representative ecological receptors were identified for characterization of ecological risk in this offshore habitat and include aquatic organisms such as fish, non-rooted aquatic plants, and aquatic invertebrates.

Analysis of soil samples collected at IR14 in IA C3 prior to the 2002-2004 field investigation indicated that elevated concentrations of chromium are present in soil at IR14. Concern that elevated levels of chromium in soil may enter groundwater and migrate to Mare Island Strait led to additional sampling of groundwater during 2002, as presented in the IA C3 SAP

(CH2M HILL 2002e). Because the backfill along utility corridors may serve as a preferential pathway for groundwater to migrate to the Strait, one groundwater sample was collected from along the saltwater pipeline between the previous maximum chromium concentration (IR14VB021, which was collected from backfill material along IR14) and the Strait and was analyzed for chromium. Chromium was not detected in the grab sample, and the detection limit (5 µg/L) was below the chronic saltwater National Ambient Water Quality Criteria of 50 µg/L (USEPA 1999). Consequently, chromium was not retained as a COPEC, and risk posed by IR14 groundwater to aquatic organisms in the Mare Island Strait is considered negligible.

6.7 Degradation of Groundwater Assessment

The groundwater sample collected from IR14GB0012 in 2002 was used to determine whether previous releases from IR14 had degraded the waters of the State. This sample was analyzed for chromium. Chromium was not detected above the analytical reporting limit (5 µg/L), which itself is an order of magnitude lower than the chronic saltwater National Ambient Water Quality Criteria (50 µg/L) (USEPA 2002). Based on this information, constituents in groundwater at IR14 in IA C3 meet standards of the State anti-degradation and cleanup policies (SWRCB 1992, 1995).

6.8 Conclusions of the Remedial Investigation at IR14

Chromium was detected in soil above the ambient concentration for fill materials and was presented in the IA C3 SAP as the only compound for which additional data collection was required. The low level of chromium detected in soil during 2002 and the non-detect result recorded for chromium in groundwater along the preferential migration pathway to the Strait indicate that the objectives of the IA C3 SAP have been satisfied. Significant concentrations of other metals, petroleum hydrocarbons, and VOCs were not detected in soil samples collected at IR14. The nature and extent of soil and groundwater contamination around IR14 within IA C3 has therefore been characterized.

The most likely migration pathways for contaminants in the soil at IR14 are subsurface lateral migration via groundwater transport through the aquifer or preferential migration along permeable utility line backfill. However, due to the low mobility of the detected contaminants, this scenario is not likely to take place to a significant degree. Volatilization of contaminants from the soil are not likely due to the chemical nature of contamination at the site. If contaminants were present in groundwater at IR14, the most likely migration pathways involve lateral migration through the aquifer and through preferential pathways along permeable utility corridors. The approximate transport time for chromium traveling in groundwater along the utility corridors is 200 years, while constituents traveling through the aquifer would take 2,000 years to reach Mare Island Strait. Therefore, the conclusions of the fate and transport evaluation suggest that, while migration pathways have the potential to transport contaminants via groundwater, these contaminants would not be expected to reach Mare Island Strait for centuries, if at all. Since chromium was not detected in the groundwater sample collected from the most likely preferential migration pathway (permeable utility backfill), it is expected that significant concentrations of metals are not migrating from IR14 towards the Strait via groundwater.

The results of the HHRA indicate that future site conditions at IR14 pose potential lifetime excess cancer risks (4×10^{-7}) that are below the risk-management range (10^{-4} to 10^{-6}) for carcinogens. The non-cancer adverse health effects were estimated to be 1 for all COPCs at IR14 within IA C3, which is equal to the threshold of 1 for non-carcinogens. The evaluation of potential ecological risk posed by IR14 groundwater to aquatic organisms in the Mare Island Strait concluded that the risks are considered negligible.

The results of the degradation of groundwater assessment indicate that chromium, the only constituent that was analyzed in the groundwater sample collected along IR14 in IA C3, is not present at concentrations exceeding chemical-specific ARARs identified by the RWQCB for groundwater and surface water. Constituents in groundwater at IR14 in IA C3 are therefore not present at concentrations that are degrading the waters of the State.

No unacceptable risk to human or ecological receptors is posed by contaminants at IR14 in IA C3. Therefore, a feasibility study is not required for the portion of IR14 within IA C3. This site is not carried forward in the feasibility study presented in Section 7.0 of this report.

7.0 Feasibility Study

As concluded in Sections 3.7, 4.7, and 5.7, contaminants in soil at IR09, IR12, and the Building 108 Area are present at concentrations that potentially pose significant risks to human health or the environment. Accordingly, remedial alternatives are developed and evaluated in this feasibility study to determine the remedial measure that will most cost-effectively reduce the risk created by elevated levels of contaminants in surface and subsurface soil at these sites while maintaining compliance with state and federal ARARs. As concluded in Section 6.7, contaminants at IR14 in IA C3 do not pose a potential significant risk to human or ecological health receptors. Therefore, IR14 is not included in the evaluation of alternatives in this FS. Contaminants are not present in groundwater in IA C3 at concentrations that pose potential significant risks to human or ecological receptors. In addition, constituent concentrations in groundwater in IAC3 meet State anti-degradation and cleanup policies for groundwater and surface water. Consequently, groundwater is not included in the evaluation of alternatives in this feasibility study. Remediation of PCB-contaminated surface material at IR12 is not addressed in this feasibility study and will be addressed in accordance with the *Final PCB Work Plan* (CH2M HILL 2003a).

This FS will be followed by a Remedial Action Plan (RAP), which is subject to public review and will select a preferred alternative from the alternatives presented in this section.

7.1 Remedial Action Objectives

Remedial Action Objectives (RAOs) are narrative statements that define the extent to which sites require cleanup to meet the underlying objectives of protecting human health and the environment. RAOs are based on the specific contaminants and potential exposure routes and receptors for soil at IR09, IR12, and the Building 108 Area. RAOs are classified as either general or specific. General RAOs can be applied to all CERCLA sites; specific RAOs reflect site-specific conditions. The general and site-specific RAOs for IR09, IR12, and the Building 108 Area are presented in Sections 7.1.1 and 7.1.2, respectively.

Once RAOs have been developed, they can be numerically expressed as preliminary cleanup goals. Preliminary cleanup goals are chemical concentrations in soil that achieve the levels of protection specified by the RAOs. The preliminary cleanup goals consider the exposure pathways and scenarios that are pertinent to the IRP sites, as described in the HHRA presented in Appendix G, the ERA presented in Appendix H, and the ARARs presented in Appendix I. Preliminary cleanup goals for IR09, IR12, and the Building 108 Area are presented in Section 7.1.3.

7.1.1 General RAOs

The general RAOs for IR09, IR12, and the Building 108 Area include:

- Protecting human health and the environment by reducing the risk of potential exposure to contaminants.
- Expediting site cleanup and restoration.
- Restoring contaminated sites to the extent necessary to support existing and proposed land uses.
- Achieving compliance with ARARs.

7.1.2 Site-specific RAOs

7.1.2.1 IR09

The specific RAOs for soil in IR09 include:

- Protecting human health from exposure to lead in soil. This is achieved if estimated blood-lead concentrations fall below 10 µg/dL. This blood-lead concentration is not exceeded if EPCs are below the risk-based level of 750 mg/kg.
- Reducing or eliminating concentrations of petroleum hydrocarbons (TPH-gasoline, TPH-diesel, and TPH-motor-oil) in soil that present a potential significant risk to public welfare and the environment, in accordance with RWQCB guidance.
- Restoring soils to a condition compatible with planned industrial land use.
- Reducing or preventing migration of soil contamination that would result in degradation of groundwater quality.

7.1.2.2 IR12

The specific RAOs for soil in IR12 include:

- Protecting human health from exposure to Aroclor-1260 and lead in soil that presents a potential risk greater than the risk-management range through ingestion of soil, dermal contact with soil, inhalation of vapors from soil in outdoor air, and/or inhalation of constituents sorbed to soil suspended in air as dust. This is achieved if: (1) potential site risks fall within a range of excess lifetime cancer risk of 10^{-4} to 10^{-6}, below a non-cancer hazard quotient of 1.0, and (2) estimated blood-lead concentrations fall below 10 µg/dL. This blood-lead concentration is not exceeded if EPCs are below the risk-based level of 750 mg/kg.
- Achieving concentrations of Aroclor-1260 in soil that comply with TSCA requirements for risk-based cleanup and disposal of PCB remediation waste in accordance with 40 CFR 761.61(c).
- Restoring soils to a condition compatible with planned industrial land use.
- Reducing or preventing migration of soil contamination that would result in degradation of groundwater quality.

7.1.2.3 Building 108 Area

The specific RAOs for the soil in the Building 108 Area include:

- Protecting human health from exposure to lead in soil. This is achieved if estimated blood-lead concentrations fall below 10 µg/dL. This blood-lead concentration is not exceeded if EPCs are below the risk-based level of 750 mg/kg.
- Reducing or eliminating concentrations of petroleum hydrocarbons (TPH-diesel and TPH-motor-oil) in soil that present a potential significant risk to public welfare and the environment, in accordance with RWQCB guidance.
- Restoring soils to a condition compatible with planned industrial land use.
- Reducing or preventing migration of soil contamination that would result in degradation of groundwater quality.

7.1.3 Development of Preliminary Cleanup Goals

Preliminary cleanup goals are developed on the basis of chemical-specific ARARs and site-specific, risk-based factors and are designed to facilitate the development and evaluation of the remedial technologies and remedial alternatives. Preliminary cleanup goals are chemical concentrations that have been defined as protective of human health and the environment. RAOs need to be translated into numerical preliminary cleanup goals to evaluate the effectiveness of an alternative in reducing risk or meeting an ARAR and to compare the costs of different alternatives. In addition, the preliminary cleanup goals provide the basis for defining areas and volumes of contaminated media for which remedial alternatives are developed. Preliminary cleanup goals should not be considered final remediation goals or cleanup levels to be achieved by remedial action. Cleanup levels to be achieved through remedial action will be defined later in the IA C3 RAP.

Preliminary cleanup goals have been identified for the following analytes in soil at IR09, IR12, and the Building 108 Area:

- Lead – 750 mg/kg
- Aroclor-1260 – 14 mg/kg
- TPH-gasoline (0 to 3 feet bgs) – 500 mg/kg
- TPH-gasoline (3 to 10 feet bgs) – 4,172 mg/kg
- TPH-diesel (0 to 3 feet bgs) – 1,000 mg/kg
- TPH-diesel (3 to 10 feet bgs) – 4,172 mg/kg
- TPH-motor-oil (0 to 3 feet bgs) – 2,500 mg/kg
- TPH-motor-oil (3 to 10 feet bgs) – 5,000 mg/kg

The preliminary cleanup goal for lead is a risk-based number developed using the DTSC LeadSpread 7 model for industrial worker and construction worker exposure scenarios. Currently DSTC recommends using the USEPA Region 9 PRG of 750 mg/kg as a risk-based level for lead for commercial/industrial and construction worker scenarios (Wade 2002a).

The risk-based preliminary cleanup goal for Aroclor-1260 in subsurface soil at IR12 is based on the exposure assumptions for a construction worker. The construction worker is the only receptor identified in Section 4.5 as being exposed to Aroclor-1260 in soil at concentrations that pose a potential significant human health risk. It is assumed that the construction worker may be exposed to soil 65 days during one year (i.e., 3-month construction project). Using these assumptions, the preliminary cleanup goal based on carcinogenic effects (target risk of 1×10^{-6}) would be 14 mg/kg, and the preliminary cleanup goal based on

non-carcinogenic effects (HQ of 1) would be 24 mg/kg. The most conservative of these two values (14 mg/kg) was selected as the preliminary cleanup goal for Aroclor-1260 in soil at IR12.

The preliminary cleanup goals for petroleum hydrocarbons are based on *Screening For Environmental Concerns at Sites With Impacted Soil and Groundwater* (RWQCB 2003b) and RWQCB comments on Tier 2 screening levels and cleanup goals at other petroleum hydrocarbon sites at Lennar Mare Island (RWQCB 2004b). The preliminary cleanup goals were developed by accounting for the following exposure scenarios and migration pathways:

- Odor/nuisance Conditions
- Indoor Air Impacts
- Human Health Direct Exposure
- Soil Leaching to Groundwater
- Ceiling Limit

The preliminary cleanup goals are also based on the planned industrial future land use of the site and the depth of contamination. The preliminary cleanup goals for petroleum hydrocarbons in soil at the 0- to 3-foot-bgs depth interval are driven by odor-nuisance concerns. The preliminary cleanup goals for TPH-gasoline and TPH-diesel in soil at the 3- to 10-foot-bgs depth interval are driven by the need to protect groundwater from constituents leaching from soil. The preliminary cleanup goal for TPH-motor-oil in soil at the 3- to 10-foot-bgs depth interval is driven by the ceiling value for this constituent.

The preliminary cleanup goals for petroleum hydrocarbons were compared to the EPC for each petroleum hydrocarbon range and for each depth interval to determine areas where remedial action are warranted to address the potential risk and/nuisance created by petroleum hydrocarbons in soil at the site. In addition, the maximum detected concentration of each petroleum hydrocarbon range was compared to the ceiling value (5,000 mg/kg) to ensure that contaminants exceeding the ceiling value are addressed in the feasibility study. Table 7.1-1 presents the EPC, the maximum detected concentration, and the preliminary cleanup goal for each petroleum hydrocarbon range and for each depth interval. As indicated in the table, the EPCs and maximum concentrations for petroleum hydrocarbons at IR09 and the Building 108 Area exceed the corresponding preliminary cleanup goals and/or ceiling values. Consequently, RAOs for petroleum hydrocarbons were developed to address petroleum hydrocarbon contamination at these sites, as presented in Section 7.1.2.

7.1.4 Development of Target Volumes

Target volumes are the areas and corresponding thicknesses of contaminated media that need to be addressed by each remedial alternative. Target volumes are developed based on the preliminary cleanup goals presented in the previous section. The preliminary cleanup goals were compared to the analytical data for the relevant contaminants (i.e., lead, Aroclor-1260, TPH-gasoline, TPH-diesel, and TPH-motor-oil) to identify the estimated volumes of soil in which the preliminary cleanup goals are exceeded. Figures 7.1-1, 7.1-2, and 7.1-3 present planar and cross-section views of the target volumes at IR09, IR12, and the Building 108 Area, respectively.

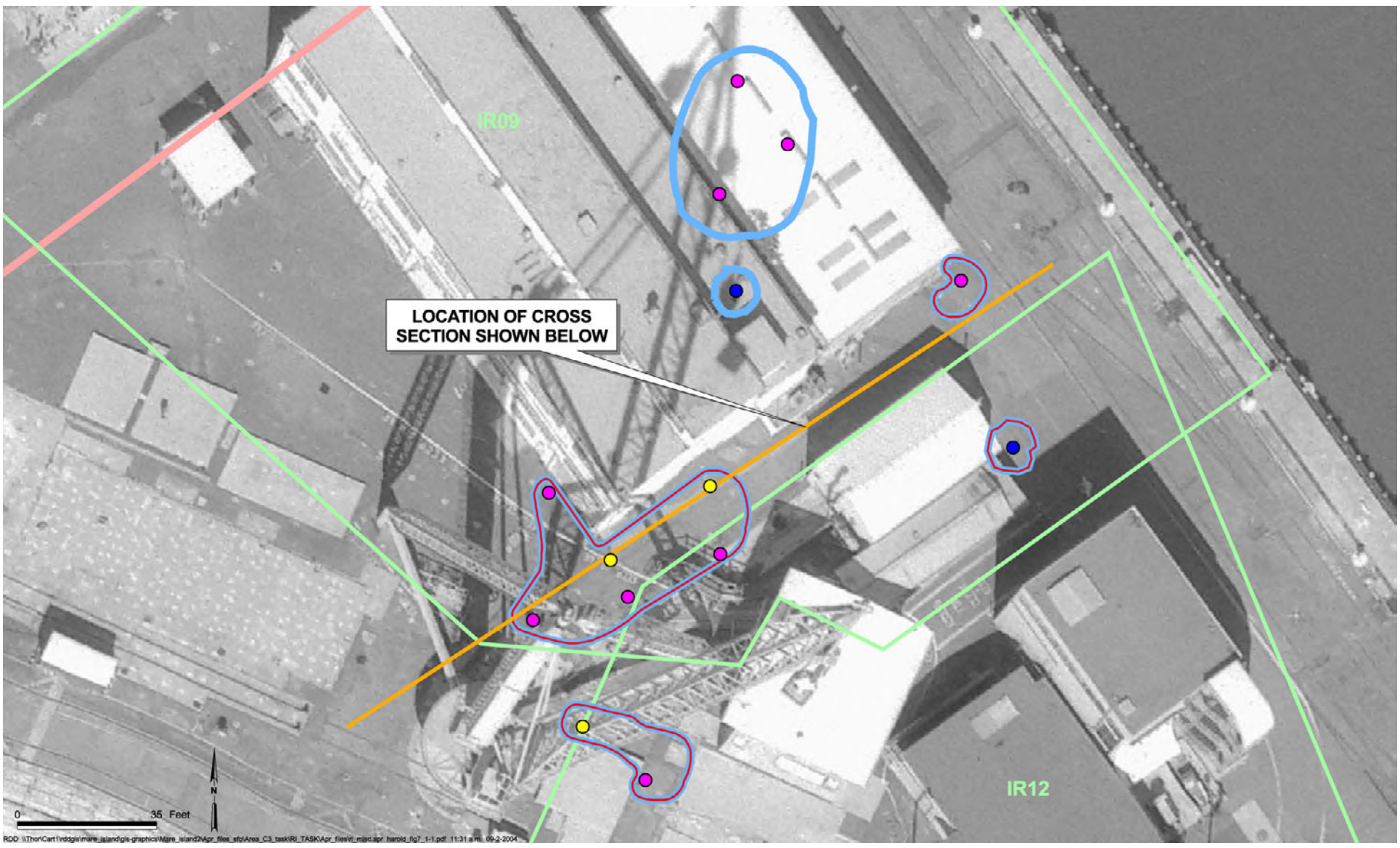
TABLE 7.1-1
Comparison of Preliminary Cleanup Goals for Petroleum Hydrocarbons to Exposure Point Concentrations
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

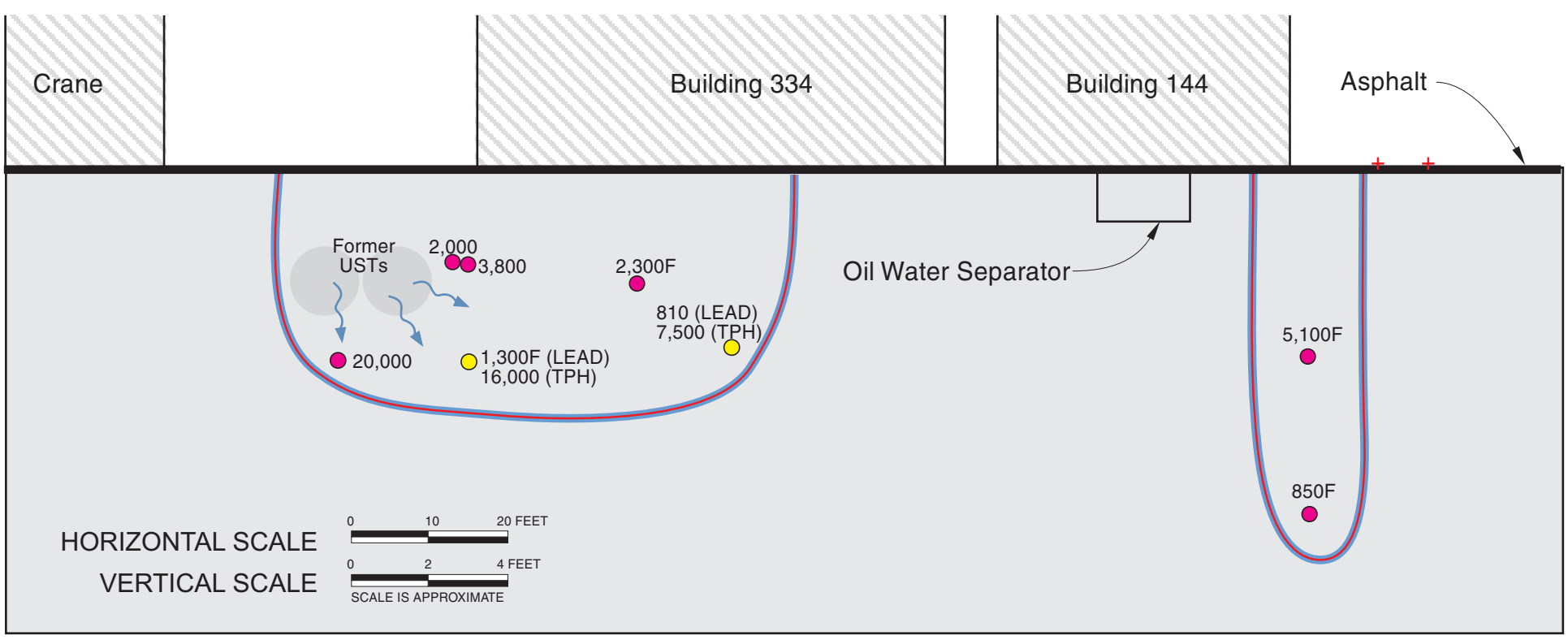
Site	Petroleum Hydrocarbon Range	Depth Interval (feet bgs)	Preliminary Cleanup Goal (mg/kg)	Exposure Point Concentration (mg/kg)	Basis	EPC exceeds Preliminary Cleanup Goal?	Maximum Result (mg/kg)	Maximum Result exceeds Ceiling Value (5,000 mg/kg)?	Remedial Action Required?
IR09	TPH-gasoline	0 - 3	500	2,500	Maximum	Yes	2,500	No	**Yes**
	TPH-gasoline	3 - 10	4,172	990	Bootstrap-t UCL	No	16,000	Yes	**Yes**
	TPH-diesel	0 - 3	1,000	2,600	Bootstrap-t UCL	Yes	1,100	Yes	**Yes**
	TPH-diesel	3 - 10	4,172	610	Bootstrap-t UCL	No	7,500	Yes	**Yes**
	TPH-motor-oil	0 - 3	2,500	3,000	Bootstrap-t UCL	Yes	5,900	Yes	**Yes**
	TPH-motor-oil	3 - 10	5,000	480	Bootstrap-t UCL	No	2,000	No	No
IR12	TPH-gasoline	0 - 3	500	38	Bootstrap-t UCL	No	82	No	No
	TPH-gasoline	3 - 10	4,172	520	Bootstrap-t UCL	No	4,400	No	No
	TPH-diesel	0 - 3	1,000	42	Bootstrap-t UCL	No	110	No	No
	TPH-diesel	3 - 10	4,172	100	Bootstrap-t UCL	No	930	No	No
	TPH-motor-oil	0 - 3	2,500	520	Bootstrap-t UCL	No	1,200	No	No
	TPH-motor-oil	3 - 10	5,000	150	Bootstrap-t UCL	No	430	No	No
Building 108 Area	TPH-gasoline	0 - 3	500	1.7	Bootstrap-t UCL	No	4.0	No	No
	TPH-gasoline	3 - 10	4,172	1.0	Maximum	No	1.0	No	No
	TPH-diesel	0 - 3	1,000	110,000	Maximum	Yes	110,000	Yes	**Yes**
	TPH-diesel	3 - 10	4,172	100	Bootstrap-t UCL	No	620	No	No
	TPH-motor-oil	0 - 3	2,500	15,000	Lognormal distribution	Yes	43,000	Yes	**Yes**
	TPH-motor-oil	3 - 10	5,000	830	Bootstrap-t UCL	No	3,800	No	No

IR09

Contaminants Dictating RAOs	Depth Interval	Baseline Exposure Point Concentration	Maximum Concentration	Preliminary Cleanup Goal	Ceiling Value
LEAD	0-2 feet 0-10 feet	1,800 mg/kg 1,300 mg/kg	1,800 mg/kg 20,000 mg/kg	750 mg/kg 750 mg/kg	N/A N/A
TPH - GASOLINE	0-3 feet 3-10 feet	2,500 mg/kg 990 mg/kg	2,500 mg/kg 16,000 mg/kg	500 mg/kg 4,172 mg/kg	5,000 mg/kg 5,000 mg/kg
TPH - DIESEL	0-3 feet 3-10 feet	2,600 mg/kg 610 mg/kg	1,100 mg/kg 1,500 mg/kg	1,000 mg/kg 4,172 mg/kg	5,000 mg/kg 5,000 mg/kg
TPH - MOTOR OIL	0-3 feet 3-10 feet	3,000 mg/kg 480 mg/kg	5,900 mg/kg 2,000 mg/kg	2,500 mg/kg 5,000 mg/kg	5,000 mg/kg 5,000 mg/kg

Target Volume: 960 cubic yards (Planar Area = 3,700 ft^2)
Limited Excavation Target Volume: 590 cubic yards (Planar Area = 2,300 ft^2)





LEGEND

- TARGET VOLUME BOUNDARIES
- LIMITED EXCAVATION TARGET VOLUME BOUNDARIES
- LEAD DETECTED ABOVE PRELIMINARY CLEAN UP GOAL (mg/kg)
- TPH DETECTED ABOVE PRELIMINARY CLEANUP GOALS (mg/kg)
- LEAD AND TPH DETECTED ABOVE PRELIMINARY CLEANUP GOALS (mg/kg)
- + + RAILROAD TRACKS
- F ANALYSIS BY XRF
- N/A NOT APPLICABLE

FIGURE 7.1-1
CONCEPTUAL DESIGN FOR SOIL IN IR09
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

E092004001RDD_04 (9/7/04)

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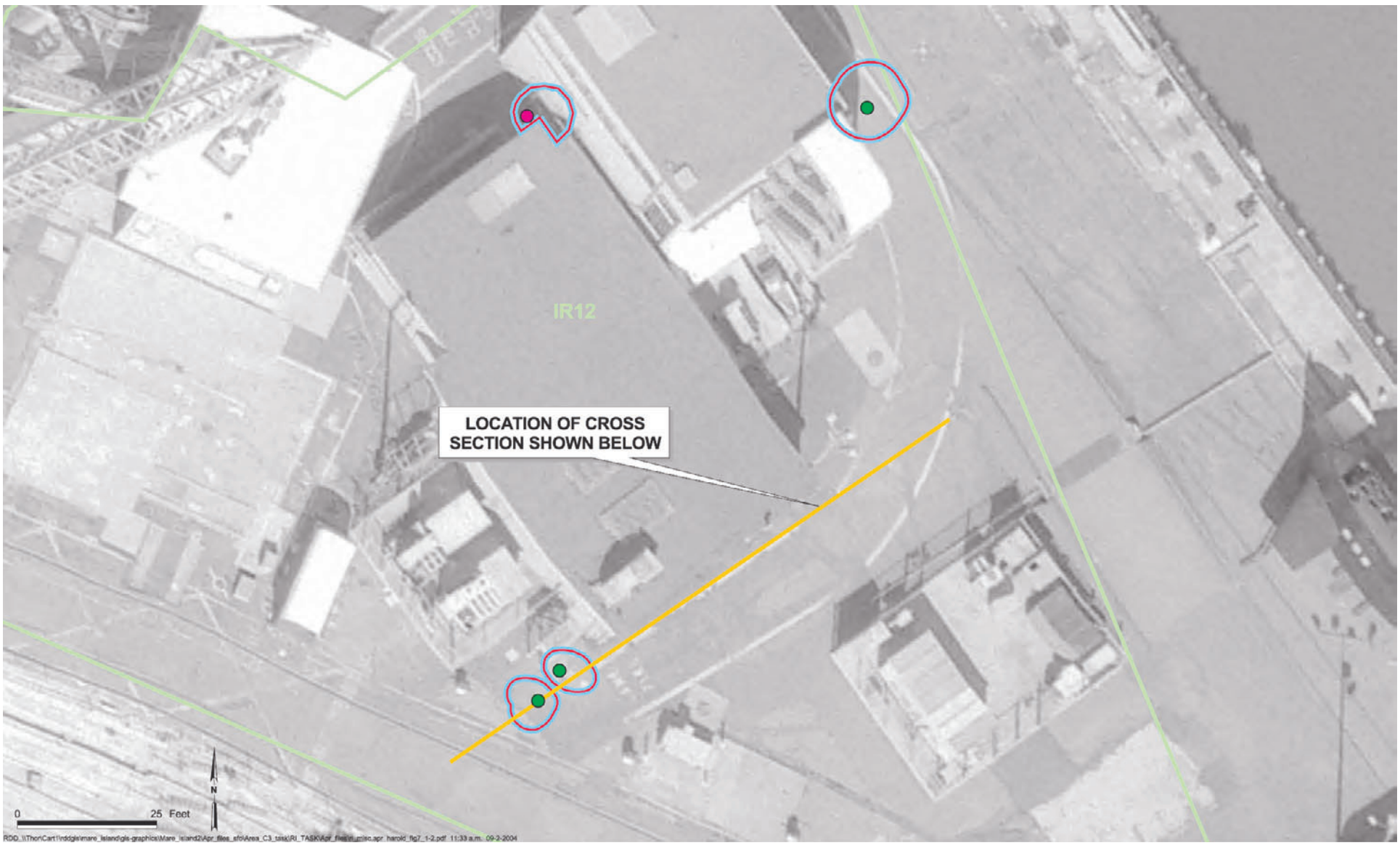
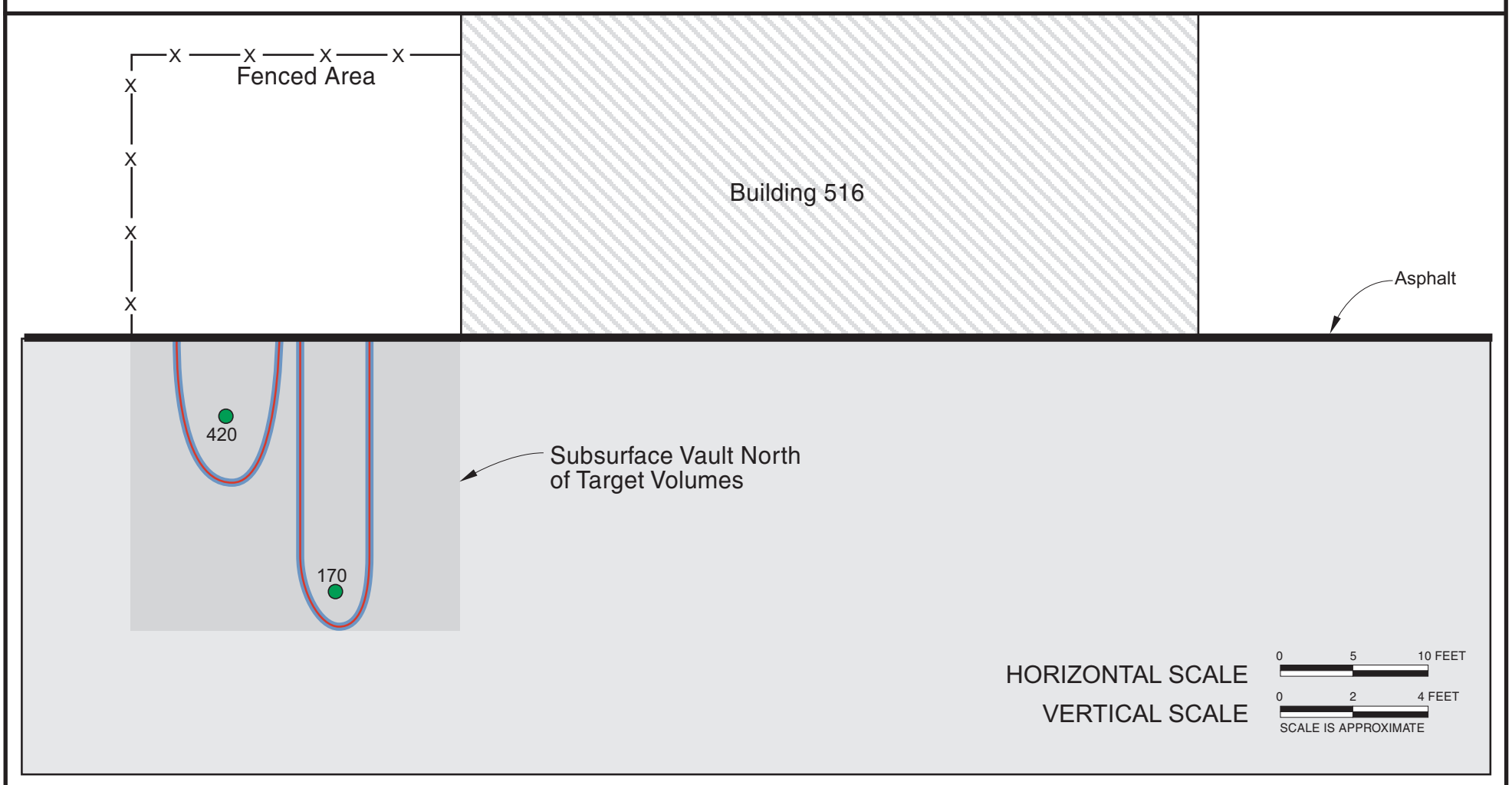
IR12

Contaminants Dictating RAOs	Depth Interval	Baseline Exposure Point Concentration	Maximum Concentration	Preliminary Cleanup Goal
LEAD	0-2 feet 0-10 feet	1,300 mg/kg 560 mg/kg	1,300 mg/kg 1,300 mg/kg	750 mg/kg 750 mg/kg
AROCLOR–1260	0-2 feet 0-10 feet	0.16 mg/kg 119 mg/kg	0.46 mg/kg 420 mg/kg	14 mg/kg 14 mg/kg

Target Volume: 80 cubic yards (Planar Area = 330 ft^2)
Limited Excavation Target Volume: 80 cubic yards (Planar Area = 330 ft^2)





LEGEND

- TARGET VOLUME BOUNDARIES
- LIMITED EXCAVATION TARGET VOLUME BOUNDARIES
- LEAD DETECTED ABOVE PRELIMINARY CLEAN UP GOAL
- AROCLOR-1260 DETECTED ABOVE PRELIMINARY CLEAN UP GOALS (mg/kg)

FIGURE 7.1-2
CONCEPTUAL DESIGN FOR SOIL IN IR12
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

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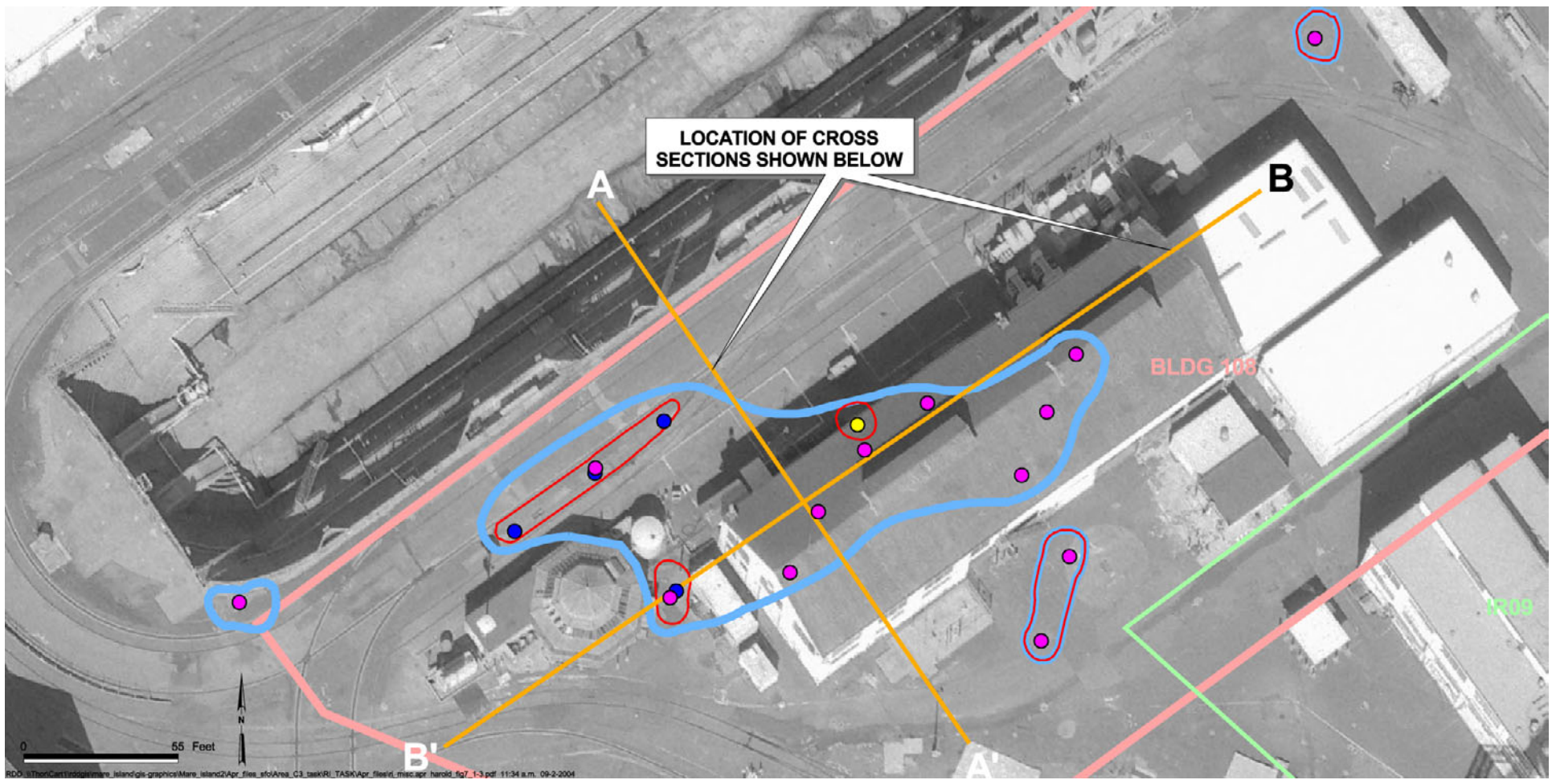
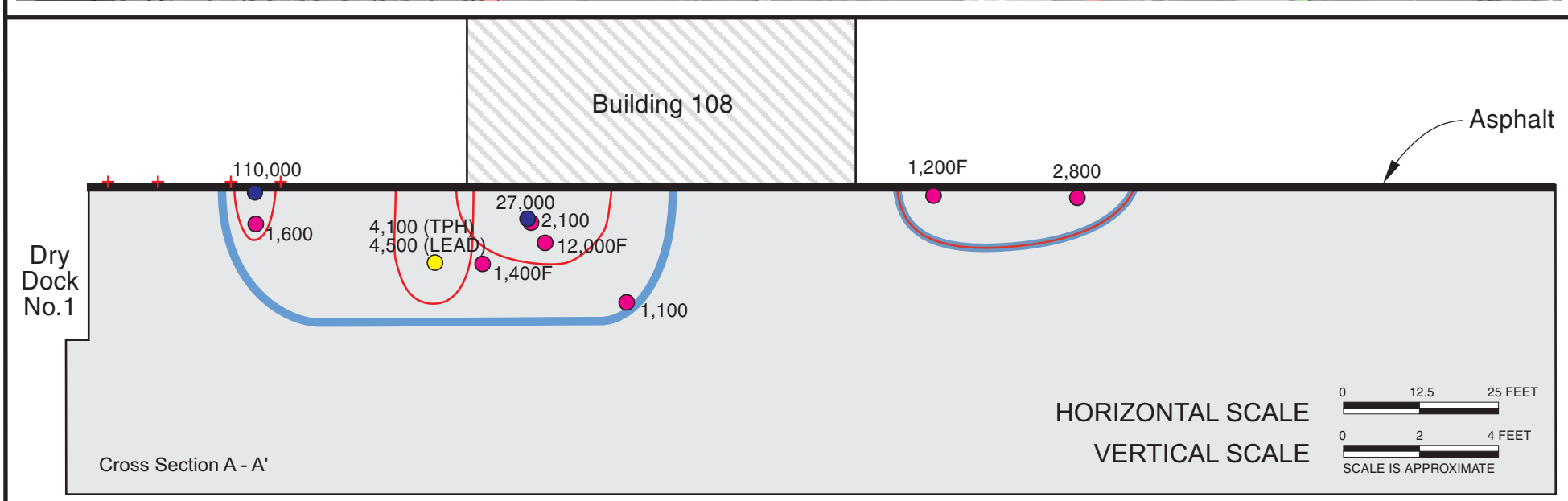
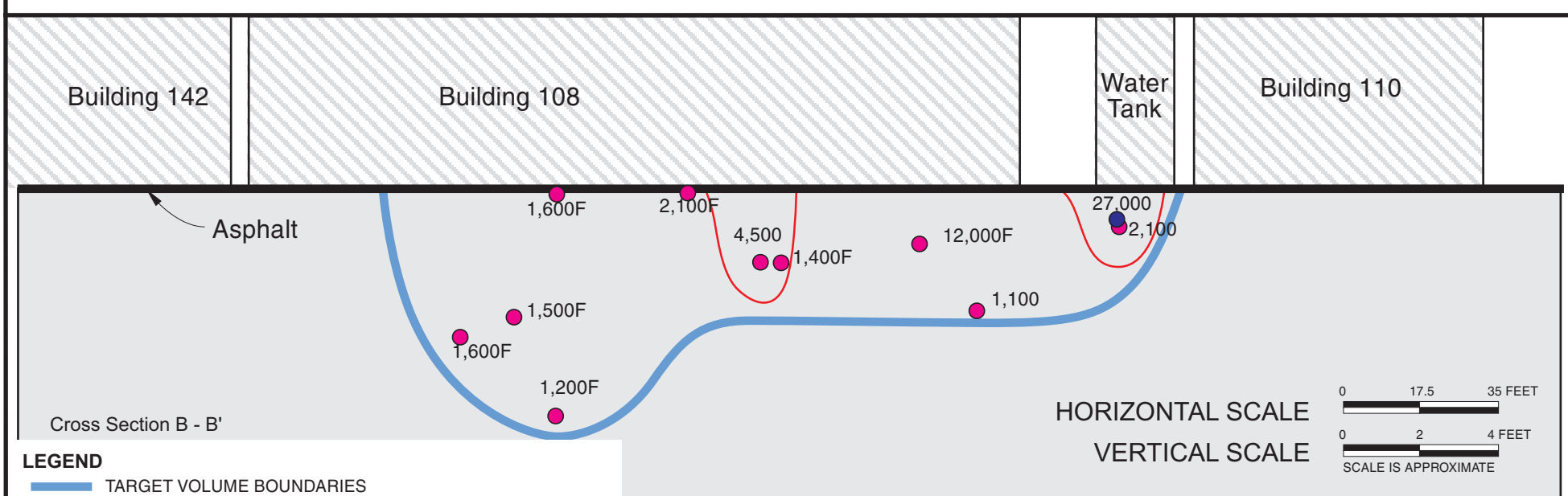
BUILDING 108 AREA

Contaminants Dictating RAOs	Depth Interval	Baseline Exposure Point Concentration	Maximum Concentration	Preliminary Cleanup Goal	Ceiling Value
LEAD	0-2 feet 0-10 feet	2,800 mg/kg 1,700 mg/kg	2,800 mg/kg 4,500 mg/kg	750 mg/kg 750 mg/kg	N/A N/A
TPH - DIESEL	0-3 feet 3-10 feet	110,000 mg/kg 100 mg/kg	110,000 mg/kg 620 mg/kg	1,000 mg/kg 4,172 mg/kg	5,000 mg/kg 5,000 mg/kg
TPH - MOTOR-OIL	0-3 feet 3-10 feet	15,000 mg/kg 830 mg/kg	43,000 mg/kg 3,700 mg/kg	2,500 mg/kg 5,000 mg/kg	5,000 mg/kg 5,000 mg/kg

Target Volume: 1,800 cubic yards (Planar Area = 12,300 ft^2)
Limited Excavation Target Volume: 160 cubic yards (Planar Area = 1,800 ft^2)







LEGEND

- TARGET VOLUME BOUNDARIES
- LIMITED EXCAVATION TARGET VOLUME BOUNDARIES
- LEAD DETECTED ABOVE PRELIMINARY CLEAN UP GOAL (mg/kg)
- TPH DETECTED ABOVE PRELIMINARY CLEAN UP GOAL (mg/kg)
- LEAD AND TPH DETECTED ABOVE PRELIMINARY CLEANUP GOALS (mg/kg)
- + + RAILROAD TRACKS
- F ANALYSIS PERFORMED BY XRF
- N/A NOT APPLICABLE

E092004001RDD_02 (9/8/04)

FIGURE 7.1-3
CONCEPTUAL DESIGN FOR SOIL IN THE BUILDING 108 AREA
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

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Target volumes were calculated by multiplying the estimated aerial extent of contamination by the thickness of the contaminated media determined through evaluation of the existing data. The following target volumes for soil at each IRP site are summarized in Figures 7.1-1 through 7.1-3:

- Soil at IR09 – 960 cubic yards
- Soil at IR12 – 80 cubic yards
- Soil at the Building 108 Area – 1,800 cubic yards

Target volumes were also identified for a "limited excavation" alternative. A description of this alternative is presented in Section 7.2. Figures 7.1-1 through 7.1-3 also present the planar and cross-section views of the target volumes under the limited excavation alternative at IR09, IR12, and the Building 108 Area. These target volumes are summarized as follows:

- Soil at IR09 under limited excavation alternative – 590 cubic yards
- Soil at IR12 under limited excavation alternative – 80 cubic yards
- Soil at the Building 108 Area under limited excavation alternative – 160 cubic yards

Due to the proximity of these three sites to one another and the similar types of contaminants present at each site, alternatives were developed by evaluating the three sites collectively. Figure 7.1-4 presents a planar view of the target volumes identified for the "site" that comprises IR09, IR12, and the Building 108 Area. These target volumes were used to support the development and evaluation of alternatives discussed in the following sections.

7.2 Development and Screening of Alternatives

Remedial technologies and process options were identified and screened against the criteria of effectiveness, implementability, and relative cost to support the development of remedial alternatives. The results of this process, including the development of general response actions, the screening of remedial technologies and process options, the evaluation of process options, and the eventual selection of representative process options, are presented in Appendix J of this report. The representative process options identified in Appendix J were used to assemble the remedial alternatives presented in this section. This section also presents a screening of each remedial alternative using the criteria of effectiveness, implementability, and cost. Alternatives with the most favorable composite evaluation of all factors were retained for detailed evaluation against CERCLA criteria in Sections 7.3 and 7.4.

The alternatives presented in this section are assembled from *representative* technologies and process options. However, the specific processes actually used to implement a remedial action may not be selected until the remedial design phase.

7.2.1 Development of Soil Alternatives

The development of representative process options into soil remediation alternatives is presented in Table 7.2-1. The following section describes each of the alternatives for the area composed of IR09, IR12, and the Building 108 Area in IA C3.

IRP Site	Contaminant Dictating RAOs	Preliminary Cleanup Goal (mg/kg)	Target Volume (cu. yards)	Maximum depth of Target Volume (feet)	Limited Excavation Targe Volume (cu. yards)
Building 108 Area			**1,800**	**8**	**160**
	Lead	750			
	TPH-Diesel (0-3 ft bgs)	1,000			
	TPH-Motor-oil (0-3 ft bgs)	2,500			
IR09			**960**	**10**	**590**
	Lead	750			
	TPH-Gasoline (0-3 ft bgs)	500			
	TPH-Gasoline (3-10 ft bgs)	4,172			
	TPH-Diesel (0-3 ft bgs)	1,000			
	TPH-Diesel (3-10 ft bgs)	4,172			
	TPH-Motor-oil (0-3 ft bgs)	2,500			
IR12			**80**	**9**	**80**
	Lead	750			
	Aroclor-1260	14			
TOTAL			**2,840**		**830**

LEGEND

- LEAD DETECTED AT CONCENTRATIONS EXCEEDING PRELIMINARY CLEANUP GOALS
- AROCLOR-1260 DETECTED AT CONCENTRATIONS EXCEEDING PRELIMINARY CLEANUP GOALS
- PETROLEUM HYDROCARBONS DETECTED AT CONCENTRATIONS EXCEEDING PRELIMINARY CLEANUP GOALS
- LEAD AND PETROLEUM HYDROCARBONS DETECTED AT CONCENTRATIONS EXCEEDING PRELIMINARY CLEANUP GOALS
- TARGET VOLUME PLANAR AREA
- PLANAR AREA FOR LIMITED EXCAVATION
- GROUP I SITES
- GROUP II/III SITES

N

0 70 140 Feet

FIGURE 7.1-4
PLAN VIEW OF TARGET VOLUMES FOR SOIL AT IR09, IR12, AND THE BUILDING 108 AREA

REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
INVESTIGATION AREA C3
LENNAR MARE ISLAND, VALLEJO, CALIFORNIA

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TABLE 7.2-1
Assembly of Soil Remediation Alternatives
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

			Remedial Alternatives				
General Response Action	**Remedial Technology**	**Representative Process Option**	**Alternative S1**	**Alternative S2**	**Alternative S3**	**Alternative S4**	**Alternative S5**
No Action	None	None	●				
Institutional Actions	Administrative restrictions	Deed Restrictions		●	●	●	●
		Land Use Covenant		●	●	●	●
Containment	Engineered Cap	Asphalt Cap			●		
		Concrete Cap			●		
Removal	Excavation	Shallow Excavation				●	●
		Subsurface Excavation				●	●
Ex-situ Treatment	Physical Treatment	Solidification/Stabilization				●	●
	Thermal Treatment	Off-site Incineration				●	●
Disposal	Landfill	RCRA Class I Hazardous Waste Landfill				●	●
		TSCA Waste Landfill				●	●
		Class II/III Nonhazardous Waste Landfill			●		

Summary of assembled soil alternatives:

Alternative S1 – No Action.
Alternative S2 – Institutional Controls: Land Use Covenant and Deed Restrictions.
Alternative S3 – Containment: Capping and Institutional Controls.
Alternative S4 – Excavation/Off-site Disposal and Institutional Controls.
Alternative S5 – Limited Excavation/Off-site Disposal and Institutional Controls.

7.2.1.1 Alternative S1 – No Action

The No Action Alternative provides a baseline for comparing other alternatives. No remedial actions are implemented under this alternative. The existing asphalt cover at the site serves to prevent exposure to subsurface soil contamination by human receptors under the No Action Alternative; however, there would be no provisions made to maintain the asphalt pavement and no restrictions on development. The NCP requires that this alternative be evaluated in the FS.

7.2.1.2 Alternative S2 – Institutional Controls: Land Use Covenant and Deed Restrictions

Alternative S2 implements a land use covenant and deed restrictions to limit exposure pathways between human and ecological receptors and contamination present at the site. Contaminated soil is left in place under the existing asphalt cover at the site to prevent exposure to subsurface soil contamination by human and ecological receptors. However, no provisions are made under this alternative for maintenance of the asphalt pavement. In addition, an unpaved area in Building 108 remains uncovered under this alternative.

The land-use covenant would prohibit future use of the property for residential purposes; commercial and industrial uses could be applied to the area. In addition, the land-use covenant would prohibit disturbance of contaminated soil through uncontrolled excavation or subsurface construction. Excavation and other subsurface work could only be executed if environmental and worker safety control measures are implemented as specified in the land-use covenant. State land-use covenants will be established between DTSC and the County of Solano and will include provisions for enforcement.

The deed restriction would be included in the alternative to prevent potable use of ground-water at IA C3.

7.2.1.3 Alternative S3 – Containment: Capping and Institutional Controls

All areas within the target volumes presented in Figure 7.1-4 are presently covered by asphalt or concrete, with exception of one area inside Building 108, which has a dirt floor surface. Under Alternative S3, Containment: Capping and Institutional Controls, the existing asphalt cover at the site is maintained in areas with soil contaminants greater than the preliminary cleanup goals currently covered by asphalt. For those areas inside Building 108 without an existing asphalt surface (with soil contaminants greater than the preliminary cleanup goals), concrete would be placed over the soil surface under this alternative. The cap would serve to eliminate the exposure pathway of direct-contact exposure to soils. Land-use covenant and deed restrictions described under Alternative S2 would be included under Alternative S3 to further reduce exposure pathways between human receptors and contamination present at the site. In addition, the condition of the cap is maintained through implementation of an O&M manual to prevent uncontrolled excavation or other activities that could damage the cap and create exposure pathways to human receptors. Surface controls for drainage of surface runoff are incorporated into the cap. Long-term monitoring would be used to verify the continued effectiveness of the cap at containing the contamination.

Alternative S3 is based on the following assumptions:

- Contaminated soil is and will continue to be covered by 6 inches of asphalt.
- Twenty-five percent of the existing asphalt cover is of poor quality and requires renovation (a capital cost).
- Asphalt will require replacing or repaving approximately every 10 years.
- Concrete surfaces inside buildings within the target volume will not degrade and will not be replaced.

Alternative S3 includes removing, transporting, and disposing of cracked and weathered asphalt on a routine basis and applying new 6-inch-thick asphalt to the area. It is assumed that the asphalt will be disposed of at a Class III non-hazardous waste landfill facility.

The total surface area included in the evaluation of O&M under this alternative is 9,600 square feet. This number represents the difference between the planar area of the target volume presented in Figure 7.1-4 and the areas inside Buildings 108 and 144 (also within the target volumes) that are covered by concrete and do not require maintenance. An additional 1,520 square feet is evaluated under this alternative for placement of concrete over the dirt floor surface in Building 108.

As presented in Appendix J, other cap types that may be employed at the site include a clay, geomembrane, multimedia RCRA-type, and native soil. However, these other process options were not retained for inclusion in the alternative because they do not meet the RAOs (i.e., they do not support existing and future land uses).

7.2.1.4 Alternative S4 - Excavation/Off-site Disposal and Institutional Controls

Under Alternative S4, soil within the target volume presented in Figure 7.1-4 is excavated and disposed of off site. The major components of Alternative S4 are institutional controls, site preparation, excavation of contaminated soil, confirmation soil sampling, backfill, and transportation, treatment, and disposal of the soil at an off-site landfill.

Institutional Controls. The institutional controls described for Alternative S2 are generally appropriate for Alternative S4. However, a restriction is not needed to prohibit uncontrolled subsurface excavation, as constituents of concern under the construction worker exposure scenario are excavated under this alternative.

Site Preparation. Sites will be prepared for excavation activities by performing ground utility surveys and identifying soil stockpile and parking areas. Buried utilities will be identified and marked to avoid damage to these structures during excavation. If the utilities or piping are located within the excavation area, relocation may be necessary. Equipment and personnel decontamination areas will be constructed near each site.

Surface and subsurface obstructions in addition to utilities require removal to facilitate the excavation of soil in certain areas of the site. Obstructions requiring removal or deconstruction under Alternative S4 include:

- Building 108.
- Trailer located west of Building 108.
- Tanks and associated piping north and west of Building 108.
- Building 144.
- Concrete slab and piping in the vicinity of the blue crane at IR09.
- Railroad and crane tracks north of Building 108, east of Building 516, and southwest of Building 516 (totaling approximately 150 feet in track length).

Excavation. Excavation is a commonly understood and well-proven method of removing contaminated surface and subsurface materials from contaminated sites. Equipment and construction methods appropriate to the excavation and handling of contaminated materials are readily available. Typical excavation equipment includes bulldozers, scrapers, excavators, backhoes, track loaders, and wheel loaders, all of which are available in a wide variety of sizes. The size and type of equipment chosen depends on such site-specific factors as site and material characteristics, excavation dimensions, desired project duration, degree of excavation accuracy required, and haul distance. Either side slope or shoring is normally required for excavations greater than 5 feet bgs. Excavations can vary in size from small trenches to large pits. A backhoe or tracked excavator is the representative process option, but other standard excavation equipment can also be employed. Selection of the appropriate equipment will depend largely on the depth and areal extent of contamination.

Groundwater that enters the excavation trench through lateral migration in the aquifer will be removed from the void as it seeps into the trench. The trench may be dewatered using a generator or vacuum truck. Groundwater will undergo waste characterization following removal to determine if the groundwater may be disposed of into the sanitary sewer system at Mare Island or if off-site disposal is required. Limited quantities of groundwater are expected to enter the excavation due to the low permeability of the surrounding formation.

Potential obstructions that may be encountered during the excavation process include subsurface utilities and overhead obstructions. While care will be taken to locate utilities prior to excavation, all utilities may not be located during this process. Utility pipelines encountered during drilling excavation activities may be cut and removed, if possible. Overhead obstructions associated with the blue crane located near IR09 (specifically, in the excavation area located east of the crane) may limit the accessibility and the type of excavation equipment that may be used in the area. Excavation must be executed in a manner that does not adversely impact the foundation of structures located adjacent to excavation boundaries (i.e., Building 334, Building 110, Building 516, Dry Dock No. 1, and the blue crane). These structures limit the lateral and vertical extent of excavation operations in some cases.

If required, workers will wear respiratory protection against fugitive dust and/or vapors. Dust suppression measures will be employed as needed to prevent the spread of airborne contaminants.

Excavation of soil under this alternative will include the excavation of five groundwater monitoring wells. A permit to remove these monitoring wells will be filed with the County

of Solano prior to excavation. It is assumed that two of these monitoring wells will be replaced following excavation, backfill, and surface restoration activities.

Backfill. Following the removal of contaminated soil, the excavation void will be backfilled with imported, compacted, clean soil to return the site to existing surface contours. Virgin-core basaltic soil equal to or less than 3 inches in diameter will be used as backfill. The soil will be compacted using nuclear-density gauge compaction to 90 percent of the maximum dry density. The surface of the site will be restored with approximately 6 inches of asphalt on the ground surface. Additional surface restoration measures such as replacing railroad and crane tracks and tanks removed prior to excavation will be implemented to restore site to existing conditions. In addition, sample locations, excavation boundaries, and new monitoring well locations will be surveyed.

Confirmation Soil Sampling. Following excavation of the target volumes presented in Figures 7.1-1 through 7.1-3, confirmation soil samples will be collected from the base and sidewalls of the excavation to verify that the remaining concentrations of contaminants in soil meet the RAOs. If RAOs are achieved, excavation activities will terminate and backfilling operations will commence. However, if RAOs are not achieved excavation activities will continue laterally and/or vertically. In some cases, excavation trenches may not be extended laterally and/or vertically due to physical constraints at the site.

Transportation, Treatment, and Disposal of Contaminated Soil. Excavated soil is transported by truck to a permitted landfill for burial. Prior to loading for transport, the soil is stockpiled and chemically analyzed to determine treatment requirements. Due to concentrations present in soil at the site, a Class I hazardous waste landfill is the representative disposal option for Alternative S4. Costs for this alternative are based on disposal of soil to Kettleman Hills Class I Facility, located in Kettleman City, California. This facility will accept soil that contains RCRA hazardous waste as well as TSCA-regulated waste.

If contaminated soil is considered a RCRA hazardous waste by toxicity characteristic leaching procedures (TCLPs), the soil may be subject to land disposal restrictions if placed on land in a waste-management unit following excavation. For toxicity characteristic waste, the waste would need to be treated to prescribed levels prior to land disposal. Hazardous soil would need to be treated so that it (1) no longer exhibited the characteristic of toxicity, and (2) is treated to 10 times the Universal Treatment Standard (as listed in 22 CCR 66268.48) or achieves 90 percent reduction, whichever is higher. *Ex-situ* solidification/ stabilization (S/S) is a means by which these land disposal restrictions can be met and can be performed at Kettleman Hills Facility prior to land disposal.

Due to the concentrations of metals (particularly lead) present in soil within the target volume, it is assumed that lead-contaminated soil is a RCRA hazardous waste and will require treatment through a solidification/stabilization process prior to disposal at the RCRA facility at Kettleman Hills. Because lead contamination is commingled with petroleum hydrocarbon contamination, petroleum hydrocarbon contamination will also go through a solidification/stabilization treatment process prior to disposal.

TSCA-regulated waste (e.g., waste derived from excavation of PCB-contaminated soil at IR12) does not require treatment prior to disposal if TCLP criteria are satisfied. Although off-site incineration was selected as a representative process option for this alternative,

incineration of PCB-contaminated waste may not be necessary. Based on *in-situ* metals concentrations in soil in the vicinity of elevated Aroclor-1260 concentrations at IR12, it is unlikely that TCLP criteria would be exceeded during waste characterization analysis. Therefore, it is assumed that PCB-contaminated soil will not require treatment through incineration. Alternative S4 is based on the assumption that PCB-contaminated soil can be disposed of at the TSCA-regulated facility at Kettleman Hills. However, if TCLP criteria are exceeded during waste characterization, incineration would have to be performed at an off-site thermal treatment facility, and the soil would subsequently be disposed of at a RCRA hazardous waste landfill.

Due to the different treatment requirements for the various contaminants, lead-/petroleum hydrocarbon-contaminated waste and PCB-contaminated waste must be segregated during excavation, temporary stockpiling, and transport to the landfill. These two waste streams must be monitored and characterized separately.

The soil volume requiring transport and disposal is greater than the *in-situ* target volume of contaminated soil presented in Section 7.1.4 because of the bulking effects of excavation. It is expected that the volume of soil will increase by approximately 20 percent over the *in-situ* target volumes provided in Section 7.1.4. The total volume of soil requiring transportation, treatment, and disposal is therefore approximately 3,400 cubic yards.

Ex-situ *Solidification/Stabilization (S/S) for RCRA Hazardous Waste.* *Ex-situ* S/S will be performed at Kettleman Hills Class I Facility if contaminated soil is considered a RCRA hazardous waste by TCLP. *Ex-situ* S/S treatment is a process that reduces the mobility of a contaminant, either by chemically altering or binding it to reduce mobility (stabilization), or by physically restricting its contact with a mobile phase (solidification). Similar to capping, *ex-situ* S/S functions by limiting the mobility of a contaminant through environmental media, usually without toxicity reduction. *Ex-situ* S/S treatment is implemented by mixing chemical reagents with contaminated soil using conventional earthmoving and mobile batch-mixing equipment. Solidification is a physical treatment. A reagent is added to encapsulate the hazardous waste into a solid material of high structural integrity. Solidification may immobilize the contaminants within the crystalline structure of the solidified material thus reducing the contaminant leaching potential, although this varies depending upon waste, soil, and reagent characteristics. Stabilization is a chemical treatment. A reagent is added to transform the material so that the hazardous constituents are in their least soluble, mobile, or toxic form.

S/S is generally most effective for inorganic, SVOC, and/or non-VOC compounds, and radionuclides. Successful treatability tests have been completed to demonstrate stabilization effectiveness for soils contaminated with metals and radioactive materials (USEPA 1993). Recent studies indicate that addition of silicates or modified clays to the binder system may improve S/S performance with organics (USEPA 1995).

7.2.1.5 Alternative S5 - Limited Excavation/Off-site Disposal and Institutional Controls

Limited excavation is performed under Alternative S5 to reduce risk to human and ecological receptors at the site in areas that require minimal pre-excavation deconstruction and post-excavation restoration. Alternative S5 consists of the same principle components as those that comprise Alternative S4. However, because access constraints may make

execution of Alternative S4 very difficult in some portions of the site, Alternative S5 was developed by considering areas of the site that are easily accessible and that pose the greatest potential risk to human and/or ecological receptors. Smaller target volumes were developed based on these considerations, and are presented in Figures 7.1-1 through 7.1-4.

The description presented for Alternative S4 is generally relevant to Alternative S5. Exceptions to this statement are presented below.

Institutional Controls. While the restriction to prohibit uncontrolled subsurface excavation was not necessary under Alternative S4, it is required under Alternative S5. Because the excavation is limited, not all soil containing lead at concentrations exceeding the preliminary cleanup goal is excavated under this alternative. Future subsurface excavation must be performed in a controlled manner (i.e., by implementing health and safety measures) to mitigate risks to construction and industrial workers.

Site Preparation. The removal or deconstruction of most of the obstructions identified under Alternative S4 is not necessary under Alternative S5. Obstructions that may require removal under this alternative include the concrete slab and piping in the vicinity of the blue crane and miscellaneous utilities through the site. Buried utilities will be identified and marked to avoid damage to these structures during excavation. If the utilities or piping are located within the excavation area, relocation may be necessary.

Excavation. While most excavation measures described for Alternative S4 also apply to Alternative S5, four, rather than five, monitoring wells are removed under Alternative S5. This alternative assumes that two of the four wells will be replaced following excavation, backfill, and surface restoration activities.

Transportation, Treatment, and Disposal of Contaminated Soil. The total volume of soil requiring transportation, treatment, and disposal under Alternative S5 is approximately 1,000 cubic yards.

7.2.2 Screening of Soil Remediation Alternatives

Alternatives S1 through S5 were screened against the criteria of effectiveness, implementability, and cost. Following are descriptions of each of these criteria:

Effectiveness — A key aspect of the alternative screening evaluation is the effectiveness of each alternative in protecting human health and the environment. Each alternative is evaluated in terms of its effectiveness in providing protection and the reductions in toxicity, mobility, or volume that it will achieve. Short-term and long-term effectiveness are evaluated. In this context, short-term refers to the construction and implementation period for the alternative. Long-term refers to the period after remedial action is completed.

Implementability — Implementability is evaluated in terms of both the technical and administrative feasibility of constructing, operating, and maintaining a remedial action alternative. Technical feasibility refers to the ability to construct, reliably operate, and comply with regulatory requirements during implementation of an alternative. Technical feasibility also refers to the future operation, maintenance, and monitoring of an alternative after the remedial action has been completed. Administrative feasibility refers to the ability to obtain approvals and permits from regulatory agencies; the availability and capacity of

treatment, storage, and disposal services; and the requirements for and availability of specialized equipment and technicians.

Cost — The primary purpose of the cost screening criterion is to permit comparative estimates between alternatives.

The screening of soil remediation alternatives using the criteria of effectiveness, implementability, and cost is summarized in Table 7.2-2. The screening process concluded that all of the alternatives, except the No Action Alternative, were protective of human health and the environment. The following four alternatives survived the screening process:

- Alternative S1—No Action. The No Action Alternative is required to be carried through the entire screening process.
- Alternative S2—Institutional Controls: Land-use Covenant and Deed Restrictions.
- Alternative S3—Containment: Capping and Institutional Controls.
- Alternative S5—Limited Excavation/Off-site Disposal and Institutional Controls.

As presented in Table 7.2-2, Alternative S4 is difficult to implement and is only implementable at a great cost (over four times as costly as other alternatives). The actions inherent to Alternative S4 that are most difficult to implement include the deconstruction of Buildings 108 and 144, the removal and restoration of approximately 150 feet of rail and crane track (including subsurface piles and supports), and excavation adjacent to Dry Dock No. 1. In addition, Alternative S4 is not expected to greatly reduce risks to human and ecological receptors beyond levels attainable through implementation of other alternatives. Consequently, this alternative was screened out of the feasibility study for the site.

Alternatives S1, S2, S3, and S5 are evaluated in further detail in Section 7.3.

7.3 Detailed Analysis of Alternatives

In this section, the soil remedial alternatives developed in the previous section are subjected to more detailed evaluation. This phase of evaluation provides support for the selection of the preferred alternatives for the IRP sites with soil contamination. Following the detailed analysis of alternatives, a comparative analysis of alternatives is performed. The final selection of the preferred alternative for soil remedial actions will be presented in the IA C3 RAP.

As discussed in Section 2.8, the detailed analysis of alternatives considers the nine CERCLA evaluation criteria as follows:

- Overall Protection of Human Health and the Environment
- Compliance with ARARs
- Long-term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume through Treatment
- Short-term Effectiveness
- Implementability
- Cost
- State Acceptance
- Community Acceptance

TABLE 7.2-2
Screening of Soil Remediation Alternatives
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Alternative	Effectiveness	Implementability	Cost	Comment
S1 — No Action	Ineffective; no reduction of toxicity, mobility, or volume of contaminants. Petroleum hydrocarbon contaminants can biodegrade naturally over time.	No implementation required.	None	Retained. Required by NCP to be retained for detailed analysis.
S2 — Institutional Controls: Land Use Covenant and Deed Restrictions	Effective for human receptors; provides short- and long-term protectiveness by limiting exposure pathways. Not effective for some ecological receptors. Existing asphalt surface will likely degrade over time, creating exposure pathways. Ineffective in reducing toxicity, mobility, or volume of contaminants. Petroleum hydrocarbon contaminants can biodegrade naturally over time.	Implementable. Requires coordination with agencies, attorneys, and title owner. Institutional controls must be maintained over a long period of time.	Very low capital; low annual maintenance (approximately $1,000). Present worth over 50-year period of performance ≈ $30,000.	Retained for detailed analysis.
S3 — Containment: Capping and Institutional Controls	Effective in eliminating short- and long-term exposure pathway between humans and terrestrial ecological species and surface and subsurface soil contamination. Effectively reduces adverse impacts to groundwater quality by reducing infiltration of precipitation and leaching of contaminants. Land use covenant and deed restrictions are enforced to further reduce exposure pathways between human and ecological receptors and contamination present at the site. Does not reduce the toxicity, mobility, or volume of contaminants through treatment. Ineffective in eliminating exposure pathway to aquatic organisms.	Implementable. Future land use must be restricted to activities that will not damage the cap. Future use of the land could make implementation of cap O&M manual (i.e., repaving or replacing asphalt cap) difficult. Cap and institutional controls must be maintained over a long period.	Low capital (approximately $60,000); low annual maintenance (approximately $1,000); moderate cap maintenance (approximately $80,000 every 10 years). Present worth over 50-year period of performance ≈ $300,000.	Retained for detailed analysis.
S4 — Excavation/Off-site Disposal and Institutional Controls	Effective in reducing exposure to human and ecological receptors. Provides short- and long-term protectiveness by eliminating direct exposure to contaminated soil. Land use covenant and deed restrictions are enforced to further reduce exposure pathways between human and ecological receptors and contamination present at the site. Effectively reduces adverse impacts to groundwater quality because contamination is removed. Excavation reduces the volume of contaminants on site. Off-site treatment (S/S) reduces mobility of contamination at off-site disposal facility.	Difficult to implement. The presence of structures (i.e., Building 108 and Building 144), rail and tracks (including subsurface piles and supports), tanks and associated piping, utilities, and overhead obstructions (associated with the blue crane) within the target volume make the implementation of this alternative technically difficult. Deconstruction of Building 144 is not consistent with developer's planned future use of the area. Also, may be difficult to obtain approval to excavate along the perimeter of Dry Dock No. 1, a historical structure.	Very high capital (approximately $2,000,000); low annual maintenance (approximately $1,000). Present worth over 50-year period of performance ≈ $2,000,000.	Alternative not retained for analysis. Relative high cost and implementation difficulty make this alternative uneconomical and technically infeasible.
S5 — Limited Excavation/Off-site Disposal and Institutional Controls	Effective in reducing exposure to human and ecological receptors. Provides short- and long-term protectiveness by eliminating direct exposure to contaminated soil. Land use covenant and deed restrictions are enforced to further reduce exposure pathways between human and ecological receptors and contamination present at the site. Effectively reduces adverse impacts to groundwater quality because contamination is removed. Excavation reduces the volume of contaminants on site. Off-site treatment (S/S) reduces mobility of contamination at off-site disposal facility.	Implementable. Construction equipment readily available. Dust controls and air monitoring during excavation may be required. Excavation void must be backfilled with clean soil. Permits required for contaminant transport, off-site disposal, and excavation/ abandonment of groundwater monitoring wells. Treatment of soil to achieve regulatory requirements may be required depending on contaminant and soil characteristics. Treatment through S/S is a viable and sufficiently demonstrated technology. Receiving landfill must have permits to treat and/or dispose of contaminant types. Excavation may be difficult in some areas (next to structures and in areas of subsurface utilities and overhead crane structure).	Moderate capital (approximately $500,000); low annual maintenance (approximately $1,000). Present worth over 50-year period of performance ≈ $500,000.	Retained for detailed analysis.

The modifying criteria (state and community acceptance) are generally evaluated after public comment on the proposed RAP. Accordingly, only the seven threshold and primary balancing criteria are evaluated in the detailed analysis phase. Alternative descriptions are described above in Section 7.2.1, and the detailed analysis of the alternatives is provided in Table 7.3-1. A description of the cost-estimating methodology, as well as the cost estimates for each alternative, are presented in Appendix L.

7.4 Comparative Analysis of Alternatives

In this section, the soil alternatives are subjected to comparative analysis. The relative performance of the four alternatives is evaluated in relation to each evaluation criterion. The comparative analysis identifies the advantages and disadvantages of each alternative to assist the decisionmaking process and selection of a preferred remedial alternative in the RAP. The discussions are organized from the better-performing alternatives to the poorly-performing alternatives within each criterion.

7.4.1 Overall Protection of Human Health and the Environment

All of the soil alternatives are protective of human health and the environment to varying degrees. Alternative S5 — Limited Excavation/Off-site Disposal and Institutional Controls provides the highest level of protection because contaminated soil is excavated and removed from IA C3. Under this excavation alternative, future risks to human health and ecological receptors are greatly reduced because no significant contamination remains at the site. In addition, the potential for migration of soil contamination into groundwater is minimized. Under Alternative S1 — No Action, Alternative S2 — Institutional Controls: Land Use Covenant and Deed Restrictions, and Alternative S3 — Containment: Capping and Institutional Controls, soil with contaminant concentrations greater than the preliminary cleanup goals remains on site.

Alternative S5 provides additional protection of human health through the S/S treatment, which will be performed at the off-site disposal facility prior to disposition of the excavated soil. Because the mobility of the inorganic contaminants in soil will be reduced, future releases to the environment from the off-site disposal facility are minimized.

Alternative S3 — Containment: Capping and Institutional Controls provides protection over Alternatives S1 and S2 through the measures taken to upgrade the existing quality of the asphalt surface that currently covers the majority of the site. Furthermore, Alternative S3 provides additional protection through the construction of a concrete cap in one area inside Building 108 and the implementation of an O&M manual, which provides instructions for maintenance of the cap in the future. Assuming that the cap is maintained in accordance with the O&M manual in the future, the presence of the fortified cap will effectively eliminate exposure pathways to human and ecological receptors and will greatly reduce the leaching potential of contaminants to groundwater over present conditions. Although contaminated soil is capped under Alternative S3, it is not treated. Alternative S5 does not include such provisions for an O&M plan for the asphalt cap; however, the risk from contamination remaining in soil at the site following excavation is within the risk-management range. Long-term maintenance of the asphalt would therefore not be necessary under Alternative S5.

TABLE 7.3-1
Detailed Evaluation of Soil Remedial Alternatives
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Evaluation Criterion	S1 – No Action	S2 – Institutional Controls: Land Use Covenant and Deed Restrictions	S3 – Containment: Capping and Institutional Controls	S5 – Limited Excavation/Off-site Disposal and Institutional Controls
Overall Protection of Human Health and the Environment				
Human Health Protection	This alternative would not include restrictions on development; therefore, the property could potentially be used for residential purposes that would result in elevated risks to future human receptors. Existing asphalt pavement provides control of exposure to contaminants in soil and groundwater. However, no controls are in place to prevent excavation into the pavement which may lead to exposure of human receptors to contaminated soil in the future. Further, the condition of the asphalt cap is not maintained, which may create exposure pathways between human receptors and contamination in the future.	Existing asphalt pavement provides control of exposure to contaminants in soil. Institutional controls further reduce the potential for exposure to contamination by receptors. The land use covenant prohibits use of the site for residential purposes and disturbance of contaminated soil through uncontrolled excavation or subsurface construction. Deed restrictions prevent the potable use of groundwater to control exposure to human receptors.	Existing asphalt pavement provides control of exposure to contaminants in soil. Concrete cap to be added to the exposed soil area in Building 108 provides additional control. The initial upgrades to the existing pavement, as well as the O&M plan for the cap, ensure the existence of an effective barrier to prevent exposure of human receptors to soil contamination. Land use covenant and deed restriction function as in Alternative S2.	Protection of human health is provided because contaminants are physically removed. The excavated soil will be placed in an appropriate off-site disposal facility where measures are taken to protect human health, by treatment before disposal and by placement of soil within a unit where the possibility of future releases are minimized through engineering controls. No O&M of the asphalt pavement is included after soil excavation, however, the risk from soil remaining at the site is within the risk management range. Land use covenant and deed restriction function as in Alternative S2.
Environmental Protection	As concluded in the ERA, no wildlife habitat exists within IA C3, and risks to ecological receptors in Mare Island Strait from the groundwater transport pathway is low. This alternative would not limit future development to industrial or commercial uses so future upland habitat could emerge.	As concluded in the ERA, no wildlife habitat exists within IA C3, and existing risks to ecological receptors in Mare Island Strait from the groundwater transport pathway is low. Implementation of this alternative would not alter those conclusions.	As concluded in the ERA, no wildlife habitat exists within IA C3, and existing risks to ecological receptors in Mare Island Strait from the groundwater transport pathway is low. Implementation of this alternative would not alter those conclusions.	As concluded in the ERA, no wildlife habitat exists within IA C3, and existing risks to ecological receptors in Mare Island Strait from the groundwater transport pathway is low. Implementation of this alternative would not alter those conclusions.

TABLE 7.3-1
Detailed Evaluation of Soil Remedial Alternatives
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Evaluation Criterion	S1 – No Action	S2 – Institutional Controls: Land Use Covenant and Deed Restrictions	S3 – Containment: Capping and Institutional Controls	S5 – Limited Excavation/Off-site Disposal and Institutional Controls
Compliance with ARARs				
Chemical-specific ARARs	This alternative would not meet the numeric cleanup levels for PCBs at IR12 required by 40 CFR 761.61. Bulk PCB remediation waste from the spill of transformer oil in Building 516 would not be cleaned up in this alternative. This alternative would meet numerical water quality objectives for groundwater with beneficial uses of agricultural supply, as concentrations of parameters in groundwater in IA C3 are either less than these numeric criteria, or are believed to be within the range of ambient concentrations. In addition, the standards of the State anti-degradation and cleanup policies (SWRCB 1992, 1995) for surface water quality in Mare Island Strait are met because concentrations of parameters in groundwater in IA C3 are less than surface water criteria, or are believed to be within the range of ambient concentrations.	This alternative would not meet the numeric cleanup levels for PCBs at IR12 required by 40 CFR 761.61. Bulk PCB remediation waste from the spill of transformer oil in Building 516 would not be cleaned up in this alternative. This alternative would meet numerical water quality objectives for groundwater with beneficial uses of agricultural supply, as concentrations of parameters in groundwater in IA C3 are either less than these numeric criteria, or are believed to be within the range of ambient concentrations. In addition, the standards of the State anti-degradation and cleanup policies (SWRCB 1992, 1995) for surface water quality in Mare Island Strait are met because concentrations of parameters in groundwater in IA C3 are less than surface water criteria, or are believed to be within the range of ambient concentrations.	This alternative would not comply with TSCA requirements at IR12 for on-site cleanup and disposal requirements for PCB remediation waste. PCBs are present in soil at concentrations that exceed the maximum concentration of 100 mg/kg allowed under 40 CFR 761.61(a). A risk-based concentration has not been derived for this exposure pathway. This alternative would meet numerical water quality objectives for groundwater with beneficial uses of agricultural supply, as concentrations of parameters in groundwater in IA C3 are either less than these numeric criteria, or are believed to be within the range of ambient concentrations. In addition, the standards of the State anti-degradation and cleanup policies (SWRCB 1992, 1995) for surface water quality in Mare island Strait are met because concentrations of parameters in groundwater in IA C3 are less than surface water criteria, or are believed to be within the range of ambient concentrations.	This alternative would comply with TSCA requirements at IR12 for on-site cleanup and disposal requirements for PCB remediation waste by removing soil with concentrations greater than the risk-based concentration in accordance with 40 CFR 761.61(c). This alternative would meet numerical water quality objectives for groundwater with beneficial uses of agricultural supply, as concentrations of parameters in groundwater in IA C3 are either less than these numeric criteria, or are believed to be within the range of ambient concentrations. . In addition, the standards of the State anti-degradation and cleanup policies (SWRCB 1992, 1995) for surface water quality in Mare island Strait are met because concentrations of parameters in groundwater in IA C3 are less than surface water criteria, or are believed to be within the range of ambient concentrations.
Location-specific ARARs	Meets location-specific ARARs since no historical landmarks, wildlife, or state waters are affected.	Meets location-specific ARARs since no historical landmarks, wildlife, or state waters are affected.	Construction and maintenance of the cap are not anticipated to significantly affect the historical structures in the area, even though	Excavation of soil in the vicinity of historical structures (Pump House 1) and an archaeological site (former marine railway and wet

TABLE 7.3-1
Detailed Evaluation of Soil Remedial Alternatives
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Evaluation Criterion	S1 – No Action	S2 – Institutional Controls: Land Use Covenant and Deed Restrictions	S3 – Containment: Capping and Institutional Controls	S5 – Limited Excavation/Off-site Disposal and Institutional Controls
			the cap would extend to Pump House 1 and Dry Dock No. 1. Wildlife or state waters would not be affected by this alternative.	basin) would likely require coordination with the State Historical Preservation Officer and City of Vallejo to ensure that integrity of these structures is not compromised. Wildlife or state waters would not be affected by this alternative.
Action-specific ARARs	This alternative does not include construction activities and no wastes would be generated. This alternative would not meet relevant and appropriate requirements for closure and post-closure care requirements for contaminated soil that would remain in place, including a cover system, post-closure care, and security and deed restriction requirements. This alternative would not meet requirements for remediation of PCBs at IR12 as required by 40 CFR Part 761.61. The groundwater data collection activities conducted subsequent to the release in IA C3 to evaluate the nature and extent of contamination satisfy groundwater monitoring ARARs identified by the RWQCB.	This alternative does not include construction activities and no wastes would be generated. This alternative would not meet relevant and appropriate closure and post-closure care requirements for contaminated soil that would remain in place. While this alternative includes post-closure care of administrative controls, it does not include post-closure care of a cover system to prevent disturbance of contaminated materials. This alternative would not meet requirements for remediation of PCBs at IR12 as required by 40 CFR Part 761.61 because the existing asphalt surface without provisions for maintenance and repair does not meet the TSCA requirements for a cap. The groundwater data collection activities conducted subsequent to the release in IA C3 to evaluate the nature and extent of contamination	Construction of the cap is anticipated to generate waste asphalt and shallow soils that would be managed, characterized, and disposed off site in accordance with action-specific ARARs for RCRA and TSCA waste. This alternative would meet relevant and appropriate closure and post-closure care requirements for contaminated soil that would remain in place, including a cover system, post-closure care, and security and deed restriction requirements. Measures would be included in the implementation of this alternative to comply with action-specific requirements pertaining to emission-and erosion control during demolition and earthwork activities. The groundwater data collection activities conducted subsequent to the release in IA C3 to evaluate the nature and extent of contamination satisfy groundwater monitoring ARARs identified by the RWQCB.	This alternative would generate solid wastes (soils, surface materials) that would be managed, characterized and disposed off site in accordance with action-specific ARARs for RCRA and TSCA waste. Measures would be included in the implementation of this alternative to comply with action-specific requirements pertaining to emission-and erosion control during demolition and earthwork activities. The groundwater data collection activities conducted subsequent to the release in IA C3 to evaluate the nature and extent of contamination satisfy groundwater monitoring ARARs identified by the RWQCB. This alternative would comply with the requirements for self-implementing the on-site cleanup and disposal of PCB remediation waste at IR12, which would

TABLE 7.3-1
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		satisfy groundwater monitoring ARARs identified by the RWQCB.	This alternative would comply with the requirements for self-implementing the on-site cleanup and disposal of PCB remediation waste at IR12, which would include a 6-inch asphalt or concrete cap, maintenance of the cap in perpetuity, and a deed restriction. Wastewater generated from the construction activities (primarily from decontamination activities) is anticipated to be discharged to the sanitary sewer system and would not be directly discharged to Mare Island Strait without treatment.	include sampling to verify cleanup. Wastewater generated from the construction activities (primarily from dewatering and decontam-ination activities) is anticipated to be discharged to the sanitary sewer system and would not be directly discharged to Mare Island Strait without treatment.
Long-term Effectiveness and Permanence				
Magnitude of Residual Risks	Soil with contaminant levels greater than preliminary cleanup goals remains on site. Existing asphalt pavement provides mitigation of risks. In the future, degradation of the asphalt cap and potential subsurface excavation may establish exposure pathways. The mobility of contaminants may increase over time due to infiltration. The long-term residual risk will be similar to the baseline risk presented in Appendix G, as lead concentrations are not expected to decline through degradation. Hydrocarbon compound concentrations are expected to	Soil with contaminant levels greater than preliminary cleanup goals remains on site. Existing asphalt pavement provides mitigation of risks. Land use covenant provides control over future excavation that would increase risks. In the future, degradation of the asphalt cap may establish exposure pathways. The mobility of contaminants may increase over time due to infiltration. Lead concentrations are not expected to decline through degradation. Hydrocarbon compound concentrations are expected to decline through biodegradation, particularly in	Soil with contaminant levels greater than preliminary cleanup goals remains on site. Existing asphalt pavement provides mitigation of risks. Maintenance of cap ensures residual risks are managed. Mobility of contaminants is low and the volume of contamination decreases due to natural biodegradation of hydrocarbon compounds. Land use covenant functions as in Alternative S2.	Soil with contaminant levels greater than preliminary cleanup goals is excavated, thereby reducing residual risk caused by soil under asphalt pavement. Exposure point concentrations for lead and Aroclor-1260 in soil at the site decrease to less than 750 and 14 mg/kg, respectively, as a result of the limited excavation, indicating that minimal potential risk to human receptors will exist under this alternative. Environmental and health risks from hydrocarbon compounds are also reduced. Land use covenant functions as in Alternative S2.

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	decline through biodegradation, particularly in shallow soil.	shallow soil.		
Adequacy and Reliability of Controls	Does not include any controls for exposures or long-term management measures. There would be no restrictions on future land use, and residential use of the property could occur under this alternative. Existing asphalt pavement provides control at present, but no controls are enforced to maintain the condition of the asphalt cap in the future, which creates an exposure pathway.	Provides continued protection of human health and the environment as long as land use covenant and deed restriction are enforced. Existing asphalt pavement provides control at present, but no controls are enforced to maintain the condition of the asphalt cap in the future, which creates an exposure pathway. Long-term annual monitoring is performed to enforce institutional controls.	Long-term management of the cap and performance specifications are provided by the O&M plan. Monitor-ing will be performed on a bi-annual basis to determine when the asphalt cap must be replaced or repaved. The cap will likely need to be replaced or undergo significant upgrades approximately every 10 years. The renovation of the asphalt surface can be performed without exposing receptors to contaminated soil. Land use covenant and deed restrictions will function as in Alternative S2.	Provides adequate control because contaminants are removed. S/S has proven effectiveness for inorganic contaminants such as metals. The technology's effectiveness on TPH contamination is less certain. The disposal facility provides adequate long-term controls for the excavated soil. PCB contam-inated waste may require incineration prior to disposal if metals concentrations exceed TCLP criteria, which has proven reliability. Land use covenant and deed restrictions will function as in Alternative S2.
Reduction of Toxicity, Mobility, or Volume				
Treatment Process and Remedy	No treatment process is included.	No treatment process is included.	No treatment process is included.	S/S has proven effectiveness for the reduction of mobility of inorganic contaminants such as metals. The effectiveness on TPH is less certain. The need for incineration is unlikely but may be required if PCB contaminated waste is classified as a RCRA hazardous waste.
Amount of Hazardous Material Destroyed or Treated	None. Soil with contaminant levels greater than preliminary cleanup goals remains on site.	None. Soil with contaminant levels greater than preliminary cleanup goals remains on site.	None. Soil with contaminant levels greater than preliminary cleanup goals remains on site.	Approximately 1,000 cubic yards of soil will be treated to reduce mobility of contamination in the off-site disposal facility.

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Reduction in Toxicity, Mobility, or Volume	Provides no reduction in toxicity, mobility, or volume of contaminants in soil through treatment. The toxicity and volume may decrease as natural biological or chemical degradation occurs. The soil contaminants within IA C3 are relatively immobile and the majority of the site is covered with asphalt pavement. Therefore, migration of contaminants would be limited.	Reduction in toxicity, mobility, or volume of contaminants is the same as Alternative S1 In addition, the mobility of soil contaminants is indirectly addressed by prohibiting excavation and the creation of migration pathways (e.g., fugitive dust or direct contact).	Reduction in toxicity, mobility, or volume of contaminants is the same as Alternative S2. Maintenance of the cap ensures the mobility of soil contaminants continues to be minimal in the future. Leaching of contaminants through infiltrating precipitation is very unlikely.	The volume of contaminants in IA C3 is effectively eliminated at the void and reduced in the site as a whole through excavation. Following S/S treatment, the mobility of contaminants is greatly reduced. However, the intrinsic toxicity of the chemicals that are physically and chemically bound in the treated soil is not changed. The volume of contaminated soil treated by S/S agents is typically greater than the *in-situ* volume. Given that the appropriate S/S reagents are used for the site contaminants and that the S/S reagents are completely mixed into the soil, S/S treatment will effectively reduce contaminant mobility for metals. The effectiveness for reducing mobility on TPH contamination is less certain. PCB waste incineration will reduce the toxicity and volume of waste.
Irreversibility of Treatment	No treatment process is included.	No treatment process is included.	No treatment process is included.	The addition of S/S reagents to contaminated soil to reduce contaminant mobility is an irreversible process. The incineration of PCB waste is a irreversible process.

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Type and Quantity of Treatment Residual	Not applicable.	Not applicable.	Not applicable.	After the addition of S/S reagents, the total volume of soil disposed will be greater than 1,000 cubic yards. The treatment residuals will consist of soil with greatly reduced contaminant mobility, which would reduce the potential for impacting the environment from a release from the disposal facility. If PCB waste incineration is required, the treatment residual will be ash, which will be disposed.
Statutory Preference for Treatment as a Principal Element	Does not satisfy statutory preference.	Does not satisfy statutory preference.	Does not satisfy statutory preference.	Satisfies statutory preference.
Short-term Effectiveness				
Protection of the Community During the Remedial Action	No construction activities were performed; therefore, there is no risk to community.	No construction activities were performed; therefore, no risk to community	This alternative creates minimal risk to the community. Upgrades to the existing asphalt pavement and the construction of the new concrete cap in Building 108 will be performed in a manner protective of the community.	Excavation into the pavement and of contaminated soil increases the chance for exposure through inhalation or dermal contact. The community will be prohibited from entering the construction site to provide adequate protection.
Protection of Workers During Remedial Actions	No construction activities were performed; therefore, there is no risk to workers.	No construction activities were performed; therefore, there is no risk to workers.	Upgrades to the existing asphalt pavement and the construction of the new concrete cap in Building 108 will be performed using adequate personal protective equipment and safe construction practices. Only minor exposure risks to workers.	Excavation of contaminated soil increases the chance for exposure through inhalation or dermal contact to workers. Appropriate personal protective equipment and safe construction practices will be used to minimize exposure.

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Environmental Impacts	No construction activities were performed; therefore, no adverse environmental impacts are anticipated.	No construction activities were performed; therefore, no adverse environmental impacts are anticipated.	Construction traffic will increase during upgrades to existing asphalt and construction of new concrete cap in Building 108.	Construction traffic will increase during excavation and disposal activities. Dust may be created from excavation activities which must be controlled. Erosion control plan must be developed for handling of stockpiled soil. Plastic sheeting and/or covered bins will be used to mitigate environmental impact.
Time Until RAOs are Achieved	RAOs are not achieved under Alternative S1.	Land use covenant and deed restrictions can be implemented in the Implementation Report for IA C3, scheduled for 2006. However, all RAOs are not achieved; therefore, the time to address the site threats and to achieve RAOs is indefinite.	Upgrades to the existing asphalt pavement and construction of the new concrete cap can be achieved in less than 2 weeks of field time. This does not include the mobilization time prior to field work. Concrete and asphalt caps can be upgraded during 2005. Institutional controls can be implemented in 2006. However, not all RAOs are achieved because this alternative is not compliant with TSCA. Therefore, the time to address the site threats and to achieve RAOs is indefinite.	Demolition of the existing asphalt pavement, excavation of soil, and construction of the new asphalt cap can be achieved in approximately 3 weeks of field time. This does not include the mobilization time prior to field work. S/S and disposal of the excavated soil will likely take an additional month prior to final disposition of the soil. Excavation activities can be occur during 2005. Institutional controls can be implemented in 2006.

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Implementability				
Ability to Construct and Operate the Technology	Easily implementable. No construction required.	Easily implementable. No construction required.	Upgrades to existing asphalt and the creation of a concrete cap are standard construction practices.	Demolition of pavement and excavation of soil are standard construction practices. Excavation near buildings and the existence of many overhead hazards and underground utilities at IA C3 will make the maneuvering of construction equipment more difficult. The presence of four monitoring wells within excavation trench establish further difficulty to implement alternative. Schedule delays may occur due to subsurface and overhead obstructions.
Reliability of the Technology	Not applicable.	Institutional controls are reliable if implemented correctly.	Containment is a reliable technology to minimize exposure to soil and infiltration of groundwater. Schedule delays are unlikely.	Demolition, excavation, and disposal are reliable technologies. The reliability of S/S on the contaminants in soil from IA C3 is less certain. Adequate mixing of the S/S fixation agents must be achieved through removal of debris and demolition rubble. PCB contaminated soil will need to be segregated as a separate waste stream, for possible incineration, which is a reliable technology.

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Evaluation Criterion	S1 – No Action	S2 – Institutional Controls: Land Use Covenant and Deed Restrictions	S3 – Containment: Capping and Institutional Controls	S5 – Limited Excavation/Off-site Disposal and Institutional Controls
Ease of Undertaking Additional Remedial Action	Future remedial actions may be necessary to achieve RAOs. Additional action is easily implemented. Additional action such as excavation and treatment is implementable.	Future remedial actions may be necessary to achieve RAOs. Additional action is easily implemented provided it is consistent with the institutional controls. Additional action such as excavation and treatment is implementable.	Additional action such as excavation and treatment is implementable upon demolition of the cap.	Additional action is implementable, but materials placed in site restoration (clean backfill, new pavement) may need to be removed.
Monitoring Considerations	Not applicable.	Annual monitoring of the enforcement of institutional controls will be required.	Monitoring of the condition of the cap will be performed on a bi-annual basis. Monitoring of the institutional controls as described in Alternative S2.	Confirmation soil sampling after excavation will be performed to monitor effectiveness of the removal action. Monitoring of the institutional controls as described in Alternative S2.
Coordination with Other Agencies	Easily implementable.	Coordination required during implementation of the RAP. DTSC and County of Solano will be involved with the implementation and monitoring of institutional controls, as well as review of annual letter reports.	O&M plan to be reviewed by agencies to ensure adequate future monitoring and controls. Coordination for the institutional controls as described in Alternative S2.	Remedial design for excavation to be reviewed by agencies. Permit required for transport and disposal of excavated soil. Permits will required for the abandonment/ excavation of groundwater monitoring wells. Waste profiling required prior to waste manifests. Coordination for the institutional controls as described in Alternative S2.
Availability of Treatment, Storage Capacity, and Disposal Services	Not applicable.	Not applicable.	Storage and disposal services are easily arranged through an on-going contract.	Storage and disposal services are easily arranged through an on-going contract. S/S is readily performed at Kettleman Hills Class I Facility. Adequate capacity exists at this facility to accept soil from IA C3.

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Availability of Necessary Equipment and Specialists	Not applicable.	Not applicable.	Construction equipment is readily available for upgrades to asphalt pavement and construction of concrete cap.	Construction equipment for demolition of pavement, excavation, and transport and disposal of soil is readily available. The capacity of the landfill to perform S/S may prolong the ultimate disposition of excavated soil.
Availability of Prospective Technologies	Not applicable.	Institutional controls are a viable and sufficiently demonstrated technology.	Construction of capping is sufficiently demonstrated and can be performed by multiple contractors.	Demolition of pavement, excavation, and construction of capping are sufficiently demonstrated and can be performed by multiple contractors. S/S and disposal will be limited to Kettleman Hills Class I Facility. If necessary, incineration can be performed at the Port Arthur facility.
Cost				
Capital cost	$0	$0	$58,000	$460,000
Annual O&M Cost	$0	$1,300	$1,400	$1,300
Maintenance Costs at Years 10, 20, 30, 40, and 50	--	--	$76,000	
Present-worth (50 Year Period of Performance)	$0	$33,000	$260,000	$500,000

Alternatives S1 and S2 provide some degree of protection to human health and the environment because currently the majority of the site is covered with approximately 6 inches of asphalt pavement. The presence of this cap minimizes exposure pathways to human and ecological receptors and greatly reduces the leaching potential of soil contaminants to groundwater. However, Alternative S1 does not restrict development and does not provide controls to prevent excavation into the pavement in the future, which may lead to future exposure to human and environmental receptors. Alternatives S2, S3, and S5 include such controls as provided by the land-use covenant. Additionally, Alternatives S2, S3, and S5 include a deed restriction to prohibit potable use of the groundwater beneath IA C3.

7.4.2 Compliance with ARARs

Alternative S5 is the only alternative that would comply with numeric cleanup requirements of TSCA for on-site cleanup and disposal at IR12. 40 CFR Part 761.61(c) allows determination of risk-based cleanup levels in lieu of the prescriptive cleanup levels. In Alternative S5, soil with concentrations greater than the risk-based cleanup goals are removed from the site. Alternative S3 includes a cap to address the PCB-contaminated soil at IR12, but the PCB concentrations would be greater than 100 mg/kg, which is the maximum concentration that can be left in place under 40 CFR 761.61(a). Risk-based disposal approval for in-place PCB concentrations greater than 100 mg/kg may be applied for under 40 CFR 761.61(c); however a risk-based concentration has not been derived for this exposure pathway.

Alternatives S1 and S2 would not comply with the numeric cleanup levels for PCBs at IR12 required by 40 CFR 761.61. Bulk PCB remediation waste from the spill of transformer oil in Building 516 would not be cleaned up in this alternative.

All alternatives would equally meet numerical water quality objectives for groundwater with beneficial uses of agricultural supply, and numerical water quality objectives for surface water in Mare Island Strait.

As Alternatives S1 and S2 would not include construction activities, no historic structures or archaeological sites would be affected. Alternatives S3 and S5 would involve construction activities in the vicinity of historical structures, and Alternative S5 would involve excavation near an archaeological site. Provisions would be made, including consultation with the City of Vallejo and the State Historic Preservation Office, as needed, to comply with the requirements of the Vallejo Municipal Code, the National Historic Preservation Act, Archaeological and Historic Preservation Act, and the Archaeological Resources Protection Act.

Alternatives S1, S2, and S3 would leave contaminated soil in place. The closure of soil in place would trigger relevant and appropriate state requirements for closure and post-closure care. Alternative S3 would comply with relevant and appropriate requirements by including a cover system to prohibit direct contact exposure with contaminated materials and a post-closure care program to monitor and maintain the effectiveness of the containment system. Alternative S2 would comply with some but not all relevant and appropriate closure and post-closure care requirements, while Alternative S1 would not comply with most relevant and appropriate closure and post-closure care requirements.

Alternative S5 would not leave contaminated soil in place, and therefore the closure and post-closure care requirements are not ARAR to this alternative.

Both Alternative S3 and S5 would comply with the action-specific requirements for self-implementing the on-site cleanup and disposal of PCB remediation waste at IR12 which, for Alternative S3, would include a 6-inch asphalt or concrete cap, maintenance of the cap in perpetuity, and a deed restriction. For Alternative S5, action-specific requirements would include sampling to verify cleanup and disposal of wastes in authorized off-site disposal facilities. Alternatives S1 and S2 would not comply with action-specific requirements for remediation of PCBs at IR12 as required by 40 CFR Part 761.61.

Alternatives S1 and S2 would not include construction activities, and would not generate wastes for off-site disposal. Alternatives S3 and S5 would generate both solid and liquid wastes. These alternatives would comply with ARARs associated with the characterization, storage, management, and off-site disposal of wastes. Wastewater generated from dewatering or decontamination is anticipated to be discharged to the sanitary sewer system and would not be discharged directly to Mare Island Strait. In addition, Alternatives S3 and S5 would comply with action-specific requirements pertaining to emission and erosion control during demolition and earthwork activities through engineering measures.

7.4.3 Long-term Effectiveness and Permanence

All of the soil alternatives achieve varying degrees of long-term effectiveness and permanence. Alternative S5 — Limited Excavation/Off-site Disposal and Institutional Controls provides the highest level of long-term effectiveness and permanence because soil with contaminant levels greater than the preliminary cleanup goals is excavated and removed from IA C3. As a result of the limited excavation, the EPCs for lead and Aroclor-1260 in soil at each IRP site decrease to less than 750 and 14 mg/kg, respectively, indicating that these contaminants will pose minimal future risk to human receptors under this alternative. In addition, off-site S/S and possible off-site incineration prior to soil disposal are reliable technologies for reducing the mobility, toxicity, and volume of metal and PCB contamination. Following soil excavation under Alternative S5, no long-term O&M functions are required because the residual risk at the site is within the risk-management range.

Under Alternative S1 — No Action, Alternative S2 — Institutional Controls: Land Use Covenant and Deed Restrictions, and Alternative S3 — Containment: Capping and Institutional Controls, soil contamination remains on site and, in varying degrees, the existing asphalt pavement at the site reduces the identified risks.

Alternative S3 — Containment: Capping and Institutional Controls is moderately less effective and permanent in the long term than Alternative S5. Although capping is an effective and accepted approach for reducing risk from direct contact with contaminants, it is considered less reliable than the removal and treatment included in Alternative S5. The long-term effectiveness of Alternative S3 depends on continued maintenance of the cap and enforcement of institutional controls to protect the integrity of the cap. If the integrity of the cap is maintained, this alternative would be effective over the long term to eliminate the direct-contact exposure pathway.

Alternative S2 — Institutional Controls would provide a lesser degree of long-term effectiveness and permanence than Alternatives S3 and S5. Under Alternative S2, contaminants are left in place and a land-use covenant and deed restriction are maintained to prevent excavation into the cap and minimize exposure pathways, including the potable use of groundwater. For protection of human health and the environment at IA C3, these actions are potentially effective and permanent, as long as the restrictions are maintained. However, in the future, degradation of the asphalt cap may establish exposure pathways and the mobility of contaminants may increase over time due to infiltration.

Alternative S1 — No Action provides some control at present due to the existing asphalt pavement. However, this alternative provides the least degree of long-term effectiveness and permanence because no institutional controls are in effect to limit development to those consistent with commercial/industrial purposes or to prevent future excavation into the cap. In addition, no controls are enforced to prevent degradation of the asphalt cap, which may establish exposure pathways and increase the mobility of constituents over time due to infiltration.

7.4.4 Reduction of Toxicity, Mobility, and Volume through Treatment

All of the soil alternatives achieve varying degrees of reductions in contaminant toxicity, mobility, or volume. Alternative S5 — Limited Excavation/Off-site Disposal and Institutional Controls provides the greatest reduction in volume of contaminated soil at the site because soil with constituent concentrations posing human health risk, or with potential for constituent migration into groundwater, is excavated and removed from IA C3. Alternative S5 is the only alternative that includes treatment. Following S/S treatment, the mobility of metal constituents is greatly reduced, which reduces the potential for impacting the environment from a release from the disposal facility. However, the intrinsic toxicity of the chemicals that are physically and chemically bound in the treated soil is not changed. The volume of contaminated soil treated by S/S agents is typically greater than the *in-situ* volume. PCB waste incineration, if required, will reduce the toxicity and volume of waste. In addition, only Alternative S5 satisfies the statutory preference for treatment to be included as a principal element of the remedial action.

Neither Alternative S3 — Containment: Capping and Institutional Controls, Alternative S2— Institutional Controls, nor Alternative S1 — No Action include treatment of constituents. Alternative S3 provides no significant reductions in the volume or toxicity of constituents achieved under Alternatives S1 and S2. Alternative S3 does provide an increased degree of mobility reduction over Alternatives S1 and S2 because of the maintenance of the integrity of the cap. Capping reduces the risk posed by contamination by placing a physical barrier (i.e., the cap) between the constituents and potential receptors. However, the intrinsic toxicity and volume of contamination is unaffected by this action. Groundwater quality is protected by reducing the infiltration of precipitation and the subsequent leaching of soil constituents to the water table.

Alternative S2 — Institutional Controls: Land-use Covenant and Deed Restrictions is a less positive action than Alternatives S3 and S5 and will provide only moderate reductions in the mobility of contamination indirectly by prohibiting excavation and the creation of migration pathways (e.g., fugitive dust or direct contact). The toxicity and volume of contamination is unaffected by this alternative. Under Alternative S2, constituents are left in

place, and a land-use covenant is maintained to prevent disturbances that might mobilize the constituents. No active measures are taken to control constituent mobility beyond avoiding disturbances of the sites.

Alternative S1 — No Action does not provide any reductions in constituent toxicity, mobility, or volume. Reduction of current risks to human and ecological receptors is achieved only through the existing asphalt pavement which covers the majority of the site.

7.4.5 Short-term Effectiveness

All of the soil alternatives achieve varying degrees of short-term effectiveness. The more aggressive alternative (Alternative S5), that necessarily involves disturbance of the contaminated soil, will entail more potential short-term risks to the community and workers during remedial action. Correspondingly, the more passive alternatives (Alternatives S1, S2, and S3) will have fewer potential impacts because less disruption of the sites is required to implement these actions.

Alternative S2 — Institutional Controls: Land-use Covenant and Deed Restrictions is a less positive action than Alternatives S3 and S5 but will create no significant risks to the community or workers because no remedial action is performed. Under Alternative S2, constituents are left in place, and a land-use covenant and deed restriction are maintained to prevent exposures to human receptors. These actions, by themselves, will entail no significant adverse environmental impacts at the site. However, these actions will not ensure maintenance of the cap and mitigation of potential future risks to receptors. Alternative S2 can be implemented in the implementation report for IA C3, scheduled for 2006. However, all RAOs are not achieved, so the time to address the site threats and to achieve RAOs is indefinite.

Alternative S3 — Containment: Capping and Institutional Controls creates more exposure to workers than Alternatives S1 and S2 because of the construction of the new concrete cap and the upgrades to the existing asphalt pavement. These activities will be performed using adequate personal protective equipment and safe construction practices; therefore, only minor exposure risks to workers are expected. Alternative S3 activities can be achieved in approximately 2 weeks of field time, during which time construction traffic will increase. The renovation to the existing cap would occur in 2005 under this alternative.

Alternative S5 — Limited Excavation/Off-site Disposal and Institutional Controls involves the physical removal of contaminated soil; therefore, excavation activities conducted under this alternative have the potential to expose workers and the community to constituents in fugitive dust and through direct contact. Because excavation is inherently more intrusive than the other soil alternatives, the short-term risks are greater. Dust controls, air monitoring, and construction site access restrictions will be implemented to minimize these risks. Alternative S5 also involves the hauling of excavated soil to an off-site landfill. Spillage prevention measures such as tarps, liners, and covers will be implemented during transportation to protect the community. In addition, excavation and backfilling activities will involve earthmoving equipment, and construction traffic will increase during the remedial action. The time frame to implement Alternative S5, including field work and soil treatment and disposal, is approximately 2 months. Excavation activities would occur in 2005 under this alternative.

Alternative S1 — No Action poses no additional risk to workers or the community and no additional adverse environmental impacts because no actions are taken. However, remedial action objectives are not achieved with this alternative; therefore, its short-term effectiveness is considered negligible.

7.4.6 Implementability

All of the soil alternatives are technically and administratively feasible to implement to varying degrees. On a technical basis, Alternative S1 — No Action is easily implementable, as no remedial actions are taken.

Alternative S2 — Institutional Controls: Land-use Covenant and Deed Restrictions will be the most simple of the alternatives to implement on a technical basis. No significant difficulties are associated with the technical feasibility aspects of implementing this alternative. No construction equipment, specialized materials, or technical services are required. Potential future remedial actions will not be precluded if Alternative S2 is implemented. Additional action is easily implemented provided it is consistent with the institutional controls. Institutional controls are a viable and sufficiently demonstrated technology. DTSC and County of Solano will be involved with the implementation and annual monitoring of institutional controls, as well as review of annual letter reports.

Alternative S3 — Containment: Capping and Institutional Controls is similar to Alternatives S2 in terms of implementability, although, with more complexity due to the remedial action. Capping and upgrades to existing asphalt pavement can be implemented with commonly used construction techniques and equipment. Installation of the concrete cap in Building 108 may require specialized, but readily available, technical services and equipment. Containment is a reliable technology to minimize exposure to soil and infiltration of groundwater. Because containment is a standard practice, schedule delays are unlikely. Construction of capping is sufficiently demonstrated and can be performed by multiple contractors. Additional action such as excavation and treatment is implementable upon demolition of the cap. Implementability depends of the coordination with agencies for review and approval of the O&M manual and annual monitoring to ensure implementation of institutional controls.

Alternative S5 — Limited Excavation/Off-site Disposal and Institutional Controls is generally the most complex alternative to implement. Potential difficulties are associated with the technical aspects of excavation around existing structures, around underground utilities, overhead restrictions, and existing monitoring wells. Excavation at sites with surface soil or shallow subsurface soil (less than 20 feet bgs) contamination can be excavated with little difficulty using conventional equipment and techniques; however, excavation becomes more difficult to implement around pre-existing structures, near buildings, and at greater depths. Schedule delays may occur due to subsurface and overhead obstructions. Deep excavations or excavations below the groundwater table can pose additional difficulties and may require specialized equipment or methods (e.g., sheet piling, dewatering, benched excavation, etc.). Under these conditions, the excavation alternative is more difficult and complex but is still considered implementable.

The demolition of pavement, excavation, and construction of capping included in Alternative S5 are sufficiently demonstrated and can be performed by multiple contractors.

Construction equipment for these activities and for the transport and disposal of soil is readily available. Additional action such as excavation and treatment is implementable in the future upon demolition of the cap.

The treatment aspects of Alternative S5 are complex yet implementable. The reliability of S/S on the constituents in soil from IA C3 needs to be confirmed. An additional complexity is that PCB-contaminated soil will need to be segregated as a separate waste stream for possible incineration, which is also a reliable technology.

7.4.7 Cost

Summaries of soil alternative costs are presented in Table 7.4-1. The costs reflected in these figures include the costs of each component that comprise each alternative. More detailed cost information and cost estimating methodology is provided in Appendix L.

TABLE 7.4-1
Summary of Costs for Soil Alternatives
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

Alternative	Capital Cost ($)	Annual O&M Cost for 50 Years ($)	Maintenance Costs at Years 10, 20, 30, 40, and 50 (Associated with Alternative S3 Only) ($)	Total Costs Over 50 Years ($)
Alternative S1 – No Action	0	0	--	0
Alternative S2 – Institutional Controls	0	1,300	--	33,000
Alternative S3 – Containment	58,000	1,400	76,000	260,000
Alternative S5 – Limited Excavation	460,000	1,300	--	500,000

7.4.8 Summary of Comparative Analysis

This section summarizes the results of the comparative analysis by describing the overall performance and cost of each soil alternative at IA C3. The discussions are organized from the best overall performing alternative to the worst-performing alternative. The relative performance of each soil alternative is summarized in Table 7.4-2.

Alternative S5 — Limited Excavation/Off-site Disposal and Institutional Controls has the highest degree of overall performance among the soil alternatives for IA C3. This alternative provides a high degree of protection to human health and the environment, reduces the mobility and volume of the contaminated soil, achieves compliance with ARARs, and provides a high degree of long-term effectiveness. However, the cost for Alternative S5 is nearly twice that of Alternative S3. The major issues affecting the performance of Alternative S5 are the complexity of the remedial action, the potential for delays in schedule, and the effectiveness of soil treatment prior to disposal in an off-site landfill.

TABLE 7.4-2
Summary of Comparative Analysis of Soil Alternatives
IA C3 Remedial Investigation/Feasibility Study Report, Lennar Mare Island, Vallejo, California

	Soil Alternative			
Criterion	**S1**	**S2**	**S3**	**S5**
Overall Protection of Human Health and the Environment	O	O	●	●
Compliance with ARARs	O	O	O	●
Long-term Effectiveness and Permanence	O	⊗	⊗	●
Reduction of Toxicity, Mobility, or Volume	O	O	⊗	●
Short-term Effectiveness	O	⊗	●	●
Implementability	⊗	●	●	⊗
Cost[a]	$0	$33,000	$260,000	$500,000

[a] Present Worth – 50-year Period of Performance (I = 3.2 percent)

Legend: Relative performance of the alternative at IA C3.

● Better satisfies criterion.
⊗ Moderately satisfies criterion.
O Poorly satisfies criterion.

Alternative S1 — No Action.
Alternative S2 — Institutional Controls: Land Use Covenant and Deed Restrictions.
Alternative S3 — Containment: Capping and Institutional Controls.
Alternative S5 — Limited Excavation/Off-site Disposal and Institutional Controls.

Alternative S3 — Containment: Capping and Institutional Controls provides a similar level of overall performance to Alternative S5. This alternative provides a high degree of protection of human health and the environment, provides adequate long-term effectiveness and costs significantly less than Alternative S5. However, there is no reduction in toxicity or volume and no treatment included. In addition, Alternative S3 is not compliant with TSCA at IR12, and therefore does not achieve the RAOs for the site. This alternative also requires long-term monitoring to ensure continued protectiveness.

Except for Alternative S1 — No Action, Alternative S2 — Institutional Controls provides the lowest level of overall performance compared to Alternatives S3 and S5. Under Alternative S2, contaminated soil is allowed to remain in place, and no future maintenance of the cap is provided to ensure its integrity. Alternative S2 does not comply with ARARs for closure of waste in place. Although adequate protection of human health and the environment exists

at present due to the existing asphalt pavement, no provisions would be made to maintain the asphalt pavement over time. However, the cost of implementing Alternative S2 is the lowest of any of the alternatives for IA C3.

Alternative S1 poorly satisfies the criterion in the comparative analysis and does not achieve RAOs.

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