N00236.002042
ALAMEDA POINT
SSIC NO. 5090.3

Final

OU-2B Remedial Investigation Report
Sites 3, 4, 11, and 21
Volume I of IV
Sections 1.0 through 6.0

Alameda Point
Alameda, California

August 5, 2005

Prepared for:
Base Realignment and Closure
Program Management Office West
San Diego, California

Prepared by:
SulTech, A Joint Venture of Sullivan Consulting Group
and Tetra Tech EM Inc.
1230 Columbia Street, Suite 1000
San Diego, California 92101

Prepared under:
Naval Facilities Engineering Command
Contract Number N687-1103-D-5104
Contract Task Order 0102

DS.B102.20060

Final

OU-2B Remedial Investigation Report
Sites 3, 4, 11, and 21
Alameda Point
Alameda, California

Contract Task Order 0102
DS.B102.20060

PREPARED FOR:

DEPARTMENT OF THE NAVY

REVIEW AND APPROVAL

Project Manager: ______________________ Date: 4 August 2005
Craig Hunter, Ph.D., SulTech

DEPARTMENT OF THE NAVY
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5090
Ser BPMOW.GC\0711
May 16, 2005

Ms. Anna-Marie Cook
Project Manager
U.S. Environmental Protection Agency
Region IX
75 Hawthorne Street, (SFD-8-2)
San Francisco, CA 94105-3901

Dear Ms. Cook:

Subj: DRAFT FINAL OU-2B REMEDIAL INVESTIGATION REPORT, SITES 3, 4, 11, AND 21, ALAMEDA POINT, ALAMEDA, CALIFORNIA

Enclosure (1) is forwarded for your information. As with all Draft Final primary documents created in accordance with the Federal Facilities Agreement for the Alameda Naval Air Station, this Draft Final document will become Final 30 days after issuance, unless a dispute is invoked.

Please call Ms. Glenna Clark at (619) 532-0951, if you have any questions.

Sincerely,

THOMAS L. MACCHIARELLA
BRAC Environmental Coordinator
By direction of the Director

Encl: (1) Draft Final OU-2B Remedial Investigation Report, Sites 3, 4, 11, And 21, Alameda Point, Alameda, California

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TRANSMITTAL/DELIVERABLE RECEIPT

Contract No. N68711-03-D-5104 Document Control No. DS. B102.20060

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Steven Bradley, Contract Manager

DOCUMENT TITLE AND DATE:

Final OU-2B Remedial Investigation Report, Sites 3, 4, 11, and 21 Alameda Point, Alameda, California – Appendix L

TYPE: ☐ Contractual Deliverable ☒ Technical Deliverable (DS) ☐ Other (TC)

VERSION: Final (e.g., Draft, Draft Final, Final) REVISION #: NA

ADMIN RECORD: Yes ☒ No ☐ CATEGORY: Confidential ☐

SCHEDULED DELIVERY DATE: 09/30/05 ACTUAL DELIVERY DATE: 09/30/05

NUMBER OF COPIES SUBMITTED TO NAVY: 3C/3E

O = original transmittal form
C = copy of transmittal form
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September 30, 2005

Ms. Anna-Marie Cook
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Subject: Final Remedial Investigation Report for Operable Unit 2B, Appendix L, Alameda Point, Alameda, California

Dear Ms. Cook:

Please insert the attached comments from the U.S. Environmental Protection Agency (EPA), dated June 20, 2005, on the *Draft Final Remedial Investigation Report, Operable Unit 2B, Sites 3, 4, 11, and 21, Alameda Point, Alameda, California* into Appendix L of your copy of the *Final Remedial Investigation Report for Operable Unit 2B, Sites 3, 4, 11, and 21, Alameda Point, Alameda, California*. The comments were inadvertently left out of Appendix L, which was sent to you on September 28, 2005.

If you have any questions, please call me at (415) 222-8306.

Sincerely,

Kevin Bricknell

Kevin Bricknell, P.E.
Project Manager

Enclosure: EPA Comments on Draft Final Remedial Investigation, dated June 20, 2005

Distribution:
(distribution list + Thomas Macchiarella & Glenna Clark)

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ALAMEDA POINT
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May 16, 2005

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Revisions to Draft Final OU-2B RI

The enclosed replacement pages include administrative and or editorial changes which are not substantial changes to the technical adequacy of the report. The replacement pages and the changes for the final report are as follows:

1. Revised cover page, title page and bindings for the Final OU-2B Remedial Investigation Report, Sites 3, 4, 11, and 21, Alameda Point, Alameda, California, of June 18, 2005.
2. Page ES-11, OU-wide Groundwater: removed benzene and tetrachloroethene (PCE) as primary chemicals of concern (COC) for OU-wide groundwater. Added 1,1-dichloroethane (DCA), 1,1-dichloroethene (DCE), benzene, PCE, and naphthalene as secondary COCs.
3. Page ES-11, OU-wide Groundwater: changed 1,1-DCE to a risk driver in the OU-wide Groundwater Nature and Extent table.
4. Page ES-13, OU-wide Groundwater: added 1,1-DCE to human health risk assessment table.
5. Page 9-10, Section 9.1.4.1: units for metals and polynuclear aromatic hydrocarbons (PAH) were revised to microgram per liter (μg/L).
6. Page 9-14, Section 9.1.4.2: In the last sentence of the first full paragraph, the capital "W" in the word "waste" was revised to lowercase.
7. Page 9-31 and 9-32, Section 9.1.6.2: added 1,1-DCA, 1,1-DCE, antimony, bis(2-ethylhexyl)phthalate cadmium, chloroethane, iron, and naphthalene as residential risk drivers for groundwater, and removed chloromethane.
8. Page 9-32, Section 9.1.6.2: added cadmium to the sentence, "Based on the background comparison, arsenic, <u>cadmium</u>, manganese, and thallium are attributed to background."
9. Page 9-38, Section 9.2.2: added 1,1-DCA, 1,1-DCE as risk drivers.
10. Page 9-39, Section 9.2.2.1: added 1,1-DCA, 1,1-DCE, antimony, bis(2-ethylhexyl)phthalate cadmium, chloroethane, iron, and naphthalene as residential risk drivers for groundwater, and removed chloromethane. Added cadmium to the sentence, "Based on the background comparison, arsenic, <u>cadmium</u>, manganese, and thallium are attributed to background."
11. Page 9-39 and 9-40, Section 9.2.3: removed benzene and PCE as primary COCs. (PCE was already listed as a secondary COC.) Added 1,1-DCA, !,1-DCE, benzene and naphthalene as secondary COCs.
12. Page 10-18, Section 10.5.2: added 1,1-DCA and naphthalene as risk drivers for groundwater, and removed chloromethane as a driver.
13. Page 10-19, Section 10.5.2.1: added 1,1-DCA and naphthalene as residential risk drivers for groundwater, and removed chloromethane as a driver.
14. Page 10-20, Section 10.5.3: Removed benzene and PCE as primary COCs (PCE was already listed as a secondary COC). Added 1,1-DCA, 1,1-DCE, benzene and naphthalene as secondary COCs.
15. Figure 9-6: Removed duplicate sample labels.

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TRANSMITTAL/DELIVERABLE RECEIPT

Contract No. N68711-03-D-5104 Document Control No. DS. B102.20060

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DOCUMENT TITLE AND DATE:

Final OU-2B Remedial Investigation Report, Sites 3, 4, 11, and 21 Alameda Point, Alameda, California

June 2005

TYPE: ☐ Contractual Deliverable ☒ Technical Deliverable (DS) ☐ Other (TC)

VERSION: Final (e.g., Draft, Draft Final, Final) REVISION #: NA

ADMIN RECORD: Yes ☒ No ☐ CATEGORY: Confidential ☐

SCHEDULED DELIVERY DATE: 06/18/05 ACTUAL DELIVERY DATE: 08/05/05

NUMBER OF COPIES SUBMITTED TO NAVY: O/6C/5E

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CTO: 0102
LOCATION:
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FROM: [signature]

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DOCUMENT TITLE AND DATE:

Draft Final OU-2B Remedial Investigation Report, Sites 3, 4, 11, and 21 Alameda Point, Alameda, California

May 2005

TYPE: ☐ Contractual Deliverable ☒ Technical Deliverable (DS) ☐ Other (TC)

VERSION: Draft Final (e.g., Draft, Draft Final, Final) REVISION #: NA

ADMIN RECORD: Yes ☒ No ☐ CATEGORY: Confidential ☐

SCHEDULED DELIVERY DATE: 05/18/05 ACTUAL DELIVERY DATE: 05/18/05

NUMBER OF COPIES SUBMITTED TO NAVY: O/5C/5E

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Appendix

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FIGURES

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ACRONYMS AND ABBREVIATIONS

µg/dL	Microgram per deciliter
µg/kg	Microgram per kilogram
µg/L	Microgram per liter
AOC	Area of concern
Army	U.S. Department of the Army
ARRA	Alameda Reuse and Redevelopment Authority
AST	Aboveground storage tank
ATSDR	Agency for Toxic Substances and Disease Registry
AVGAS	Aviation gas
B(a)P	Benzo(a)pyrene
BCF	Bioconcentration factor
BCT	Base Realignment and Closure Cleanup Team
Bechtel	Bechtel Corporation, Inc.
bgs	Below ground surface
BRAC	Base Realignment and Closure
BSU	Bay sediment unit
BTEX	Benzene, toluene, ethylbenzene, and xylene
BW	Body weight
CAA	Corrective Action Area
Cal/EPA	California Environmental Protection Agency
Canonie	Canonie Environmental
CCC	Criteria continuous concentration
CDI	Chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERFA	Community Environmental Response Facilitation Act
CLP	Contract Laboratory Program
CMC	Criteria maximum concentration
COC	Chemical of concern
COD	Chemical oxygen demand
COPC	Chemical of potential concern
COPEC	Chemical of potential ecological concern
CPT	Cone penetrometer testing
CSF	Cancer slope factor
CSM	Conceptual site model
CTE	Central tendency exposure

DCA	Dichloroethane
DCE	Dichloroethene
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethene
DDT	Dichlorodiphenyltrichloroethane
DNAPL	Dense nonaqueous-phase liquid
DoD	Department of Defense
DQO	Data quality objective
DTSC	California Environmental Protection Agency Department of Toxic Substances Control
DVE	Dual-vapor extraction
EBMUD	East Bay Municipal Utilities District
EBS	Environmental baseline survey
EDAW	EDAW, Inc.
EDB	Ethylene dibromide
EFA WEST	Naval Facilities Engineering Command, Engineering Field Activity West
EPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
ERA	Ecological risk assessment
ERM-West	ERM-West, Inc.
ERV	Ecological reference value
FS	Feasibility study
FSP	Field sampling plan
ft^2	Square foot
FWBZ	First water-bearing zone
FWBZL	First water-bearing zone lower
FWBZU	First water-bearing zone upper
GAP	Generator accumulation point
GT	Gehan-Wilcoxon Test
HEAST	Health Effects Assessment Summary Tables
HHRA	Human health risk assessment
HI	Hazard index
HMW	High-molecular weight
HQ	Hazard quotient
HSI	Hydro-Search, Inc.

IAS	Initial assessment study
IR	Installation Restoration
IRIS	Integrated Risk Information System
ISCO	In situ chemical oxidation
IT	International Technology Corporation
IWTP	Industrial waste treatment plant
JMM	James M. Montgomery, Consulting Engineers, Inc.
K_{ow}	Octanol-water partition coefficient
LMW	Low-molecular weight
LOAEL	Lowest observed adverse effect level
MCL	Maximum contaminant level
mg/kg	Milligram per kilogram
mg/kg-day	Milligram per kilogram per day
mg/dL	Milligram per deciliter
mg/L	Milligram per liter
MOGAS	Motor gasoline
Moju	Moju Environmental, Inc.
MW	Montgomery Watson
NACIP	Navy Assessment and Control of Installation Pollutants
NADEP	Naval Aviation Depot
NARF	Navy Aircraft Rework Refit Facility
NAS	Naval Air Station
Navy	U.S. Department of the Navy
NCEA	National Center for Environmental Assessment
NFA	No further action
NOAA	National Oceanographic and Atmospheric Administration
NOAEL	No observed adverse effect level
NPL	National Priorities List
OEHHA	California Office of Environmental Health Hazard Assessment
OU	Operable unit
OWS	Oil-water separator
PA/SI	Preliminary assessment and site inspection
PAH	Polynuclear aromatic hydrocarbon
PCB	Polychlorinated biphenyl

PCE	Tetrachloroethene
PRC	PRC Environmental Management, Inc.
PRG	Preliminary remediation goal
PWC	Public Works Center
RAB	Restoration advisory board
RAO	Remedial action objective
RCRA	Resource Conservation and Recovery Act
REL	Reference exposure level
RFA	Resource Conservation and Recovery Act facility assessment
RfC	Reference concentration
RfD	Reference dose
RFI	Resource Conservation and Recovery Act facility investigation
RI	Remedial investigation
RME	Reasonable maximum exposure
ROD	Record of decision
RV	Recreational vehicle
RWQCB	San Francisco Bay Regional Water Quality Control Board
SIMA	Ship Intermediate Maintenance Activity
SQL	Sample quantitation limit
SUF	Site use factor
SVOC	Semivolatile organic compound
SWBZ	Second water-bearing zone
SWMU	Solid waste management unit
TCA	Trichloroethane
TCE	Trichloroethene
TDS	Total dissolved solids
Tetra Tech	Tetra Tech EM Inc.
TOC	Total organic carbon
TP	Tiered permit
TPH	Total petroleum hydrocarbons
TRV	Toxicity reference value
UCL_{95}	95th percentile upper confidence limit on the arithmetic mean
URF	Inhalation unit risk factors
UST	Underground storage tank
VOC	Volatile organic compound

EXECUTIVE SUMMARY

In July 1999, Alameda Point was identified as a National Priorities List (NPL) site (U.S. Environmental Protection Agency [EPA] 1999a), and the U.S. Department of the Navy (Navy) is conducting investigations in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (Title 42 *United States Code* 9601-9675) at a number of sites at Alameda Point (formerly Naval Air Station [NAS] Alameda), located in Alameda, California. EPA Region 9, the California Environmental Protection Agency Department of Toxic Substances Control, and the San Francisco Bay Regional Water Quality Control Board are providing regulatory oversight of these investigations.

This report presents the approach, results, conclusions, and recommendations of the remedial investigation (RI) conducted for CERCLA Sites 3, 4, 11, and 21, which comprise Operable Unit (OU)-2B at Alameda Point (see Figure ES-1). Based on this RI, the following site-specific recommendations were made for soil at Sites 3, 4, 11, and 21; one discreet lead groundwater plume located in the northern portion of Site 3; and a large, commingled plume covering multiple sites, (OU-wide groundwater plume):

Site	Media	Further Evaluation in FS?	Chemicals of Concern	Further Action for TPH?	Data Gaps?
3	Soil	Yes	Aroclor-1260, benzene, lead, and PAHs	No	Yes
	Groundwater (Lead Plume)	Yes	Lead	Yes	Yes
4	Soil	Yes	N-nitroso-di-n-propylamine, 3,3'-dichlorobenzidine, Aroclor-1254, cadmium, TCE, and PAHs	No	Yes
11	Soil	Yes	Aroclor-1260 and PAHs	No	Yes
21	Soil	Yes	Arsenic, carbazole, and iron	No	Yes
OU-wide	Groundwater	Yes	Benzene, PCE, TCE, vinyl chloride, 1,2-DCA, 1,2-DCE (total), 1,4-dichlorobenzene, 1,1,2-TCA, benzo(a)anthracene, B(a)P, hexavalent chromium, iron, manganese	Yes	Yes

Notes:
B(a)P Benzo(a)pyrene
DCA Dichloroethane
DCE Dichloroethene
FS Feasibility Study
PAH Polynuclear Aromatic Hydrocarbon
PCE Tetrachloroethene
TCE Trichloroethene
TPH Total petroleum hydrocarbons

Because Alameda Point is listed as a NPL site, CERCLA provides the framework for the RI approach. The approach used to conduct the RI includes the following steps: (1) scoping the RI,

(2) conducting environmental investigations, (3) conducting data evaluations, and (4) making conclusions. During the initial scoping stage of the RI, site histories and available data were used to identify potential sources of contamination, potentially affected media, and data needs at each site. Field investigation methods were selected to meet the data needs established in the scoping process of the RI. Overall, the data for Sites 3, 4, 11, and 21 were collected using a biased and phased sampling approach. With the phased approach, stakeholders were afforded opportunities to provide feedback on the suitability or adequacy of the collected data and the need to collect additional data to identify releases and complete this RI report.

The process used to evaluate the data for each site in support of the CERCLA risk management process included (1) a site-specific CSM, (2) data quality assessment, (3) background comparison, 4) nature and extent evaluation, (5) fate and transport evaluation, (6) human health risk assessment (HHRA), and (7) ecological risk assessment (ERA). Site-specific CSMs were prepared by refining the initial CSM through an iterative process that involved identifying areas of known or potential releases of chemicals to the environment and conducting environmental investigations. The site-specific CSM is a flow chart that presents the primary sources of contamination, release mechanisms, exposure pathways, and current and potential future receptors. The data quality assessment was used to summarize the objective and results of the environmental investigations, define the most appropriate use for data, and establish the quantity and quality of data needed to support decision-making. The background comparison used a statistical process to determine which metals in soil and groundwater are present at naturally occurring concentrations. The nature and extent evaluation characterized each site by presenting the types and concentrations of chemicals that were detected in soil and groundwater, evaluating the data against selected parameters, and assessing the nature and extent of contamination as defined by the risk assessments (risk drivers). The fate and transport evaluation identified if chemicals driving risk at each site have migrated or degraded, if there is a continuing source of contamination, and if groundwater or other potential pathways will distribute contaminants. The fate and transport evaluation also focused on the risk drivers.

The HHRA (see Appendix F) and ERA (see Appendix G) estimated potential risks to human health and the environment associated with exposure to chemicals at OU-2B sites and identified those chemicals associated with the risk. Human health risk was evaluated for residential, commercial/industrial, and construction worker exposures. In cases where the residential exposure scenario was not considered a primary exposure scenario, it was evaluated anyway to allow for flexibility in implementing the reuse plan (or modifications thereto) at Alameda Point, and because EPA risk assessment guidance (1989) includes a strong preference for evaluation of the residential pathway.

Currently, ecological habitat capable of supporting significant wildlife is not present at the OU-2B sites; however, exposure pathways for terrestrial receptors were considered potentially complete to provide a conservative estimate of risk. An exposure pathway for aquatic receptors was considered complete for sites with groundwater plumes that could potentially migrate toward or discharge to the Seaplane Lagoon through broken storm-sewer lines. The aquatic receptor pathway was considered complete for OU-2B groundwater. Because these sites have limited habitat, site-specific ecological sampling to support a baseline ERA is not feasible; therefore, a modified ERA was conducted for the sites. This modified ERA is intended to be a conservative estimate using more realistic exposure parameters for the ecological receptors than would typically be used for a screening ERA. This modified ERA methodology is consistent with EPA guidance for screening-level and baseline ERAs as well as Navy ERA guidance (EPA 1999d, Navy 1999b). Assessment endpoints included small mammals, passerines, raptors and marine receptors. Although chemicals were identified that could pose a risk to terrestrial ecological receptors, ecological habitat capable of supporting significant wildlife is not present. Therefore, there is little likelihood the site will be used for ecological habitat. Consequently, the risks identified for ecological receptors are overestimated.

The following sections in this executive summary summarize the RI results for soil at Sites 3, 4, 11, and 21, one discreet lead groundwater plume located in the northern portion of Site 3, and the OU-wide groundwater plume.

SITE 3 – *(ABANDONED FUEL STORAGE AREA)*

Site 3 is located at the eastern entrance to Alameda Point along West Atlantic Avenue and West Seaplane Lagoon Street and is bordered to the south by Site 4. Site 3 measures about 50 acres; is roughly rectangular; and consists of Parcels 116A, 116B, 116C, 117, 118A, 118B, 120, 122, 128, 129, 131, and 209 (see Figure ES-2). Site 3 is known as the Abandoned Fuel Storage Area. In 1943 four concrete aviation gas (AVGAS) underground storage tanks (UST) (USTs 97A, 97B, 97C, 97D) were constructed in the center island along West Atlantic Avenue at the eastern entrance to Alameda Point. A fifth 10,000-gallon UST (UST 97E), constructed of steel, was built in 1962. Three of the five USTs were cleaned and closed in place in 1987 after leaks were detected in one of the USTs (UST 97A). The other two USTs (USTs 97B and 97E) were closed in place but were not cleaned. Supply Fuels Branch personnel estimate that as much as 365,000 gallons of AVGAS may have leaked into the surrounding soil and groundwater in the 1960s and early 1970s (International Technology Corporation [IT] 2001a). In addition, a nearby fuel line burst in 1972 releasing an unknown amount of AVGAS into the surrounding soil (Kennedy Engineers 1979). AVGAS has been found in utility ducts, storm drains and soil samples in and around Site 3. The southern half of Site 3 includes corrective action area (CAA)-3A, CAA-3B, and CAA 3C (Figure 5-1).

Additional features at the site include Buildings 112, 119, 337, 222, (also known as Building 512B), 512B, 517, 517A (also known as Building 220), and 527, Naval Air Station (NAS) generator accumulation point (GAP) 10; Structures 71 and 175; former bunkers; former Buildings 119-1, 120-1, 121-1, 121-1 Partial, 122-1, 123-2, and 394; former Buildings 109, 264, 295, and 548; and former Structures 222-1 and 430. Sitewide features include underground fuel lines, storm sewers, and open space.

Site 3 Chemicals of Concern for Soil: Aroclor-1260, Benzene, Lead, and Polynuclear Aromatic Hydrocarbons (PAH)

Site 3 Chemicals of Concern for Groundwater: Lead and total petroleum hydrocarbons (TPH)

Site 3 Potential Sources: Former Structure 430, use of pesticide and polychlorinated biphenyl (PCB)-containing oils for dust and weed control, and underground storage tanks (UST) 97-A through 97-E and associated fuel lines

Site 3 Nature and Extent:

Chemical	Exceeds Screening Levels?	Used by the Navy at the Site?	Risk Driver?	Background Metal?[1]	Related to Site Activity?	Data Gap?
Volatile Organic Compounds						
Benzene	Yes	Yes	No	--	Yes	No
Ethylbenzene	Yes	Yes	No	--	Yes	No
Metals						
Arsenic	Yes	No	Yes	Yes	No	No
Iron	Yes	No	Yes	No	No	No
Lead	Yes	No	Yes	No	Yes	Yes
Mercury	Yes	No	No	Yes	No	No
Polychlorinated Biphenyls						
Aroclor-1260	Yes		Yes	--	Yes	No
Polynuclear Aromatic Hydrocarbons						
Benzo(a)anthracene	Yes	No	Yes	--	Yes	No
Benzo(a)pyrene	Yes	No	Yes	--	Yes	No
Benzo(b)fluoranthene	Yes	No	Yes	--	Yes	No
Dibenzo(a,h)anthracene	Yes	No	Yes	--	Yes	No

Notes:

-- Does not apply to these chemicals

1 Based on the background comparison

Site 3 Human Health Risk Assessment:

Exposure Scenario	RME Carcinogenic Risk		RME HI		Risk Driver	
	Surface Soil (0-2 feet bgs)	Subsurface Soil (0-8 feet bgs)	Surface Soil	Subsurface Soil	Surface Soil	Subsurface Soil
Residential	7E-05	1E-04	5	6	Arsenic, Aroclor-1260, Benzo(a)anthracene, Dibenzo(a,h)anthracene, Benzo(a)pyrene	Aroclor-1260, Arsenic, Benzene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Dibenzo(a,h)anthracene, Iron
Commercial/ Industrial	1E-05	2E-05	Below 1	Below 1		
Construction Worker	1E-06	2E-06	1	1		

Notes:

bgs Below ground surface

HI Hazard index

RME Reasonable maximum exposure

Based on LeadSpread results, there is potential risk to human health from ingestion of lead in Site 3 soil and groundwater.

Site 3 Ecological Risk Assessment: Lead in soil was identified as posing potential risk to small mammals, passerines and raptors. PAHs in soil were identified as posing potential risk to passerines and raptors. These risks for ecological receptors are overestimated because ecological habitat is not present. No action is recommended for chemicals based on potential risk posed to ecological receptors.

Site 3 Data Gaps: The following data gaps for soil were identified:

- Further delineation of lead in soil east and west of sampling locations 129-001-002 and M03-07 and groundwater near well M04-03 is recommended.
- Further delineation of soil below former Building 109 is recommended based on staining that appeared in aerial photographs and that a large plume of petroleum hydrocarbons commingled with volatile organic compounds (VOC) is located below the area of former staining.
- Further sampling and analysis of soil may be necessary to confirm semivolatile organic compounds (SVOC) are not present in soil at Site 3.

SITE 4 – *(AIRCRAFT ENGINE FACILITY)*

Site 4 is in the eastern portion of Alameda Point between OU-2A to the north, Main Street to the east, West Atlantic Avenue to the south, and Viking Street to the west. Site 4 measures about 14 acres, is rectangular, and consists of EBS Parcels 133, 143, and 144, and Subparcels 134A and 164A (see Figure ES-3). Site 4 is approximately 65 percent open space consisting of paved vehicle parking areas, storage areas, and a large landscaped sports field along the eastern border. Site 4 is known as Building 360, the Aircraft Engine Facility. Building 360 was constructed in 1953 and operated as an aircraft engine and air frame overhaul facility. Operations ceased in April 1997 (International Technology [IT] 2001a). Additional features associated with Building 360 include aboveground storage tanks (AST) 360A through E; tiered permit (TP)-06 and TP-09; non-permitted Resource Conservation and Recovery Act (RCRA) unit M-06; industrial waste treatment plant (IWTP) 360; non-permitted RCRA unit Naval Aviation Depot (NADEP) generator accumulation points (GAP) 01, 49A, 50 through 52, 55 and 56, 57A, 58, and 80; and oil-water separator (OWS)-360.

Other site features include Buildings 163A, 372, 170 (Partial), 372, 414, and 610; Structure 552 and former Structure 587; and former Buildings 107, 201 through 223, 226, 227, 230 through 232, 236, 237, 240 through 260, and 360A through D. Additional features associated with Building 163A include UST 163-1, NADEP GAP 59, and OWS-163. Additional features associated with Building 372 include former AST 372, former USTs 372-1 and 372-2, non-permitted RCRA unit NADEP GAP 61, solid waste management unit (SWMU) 372, and OWS-372A and OWS-372B. OWS-414 was identified in error as being associated with

Building 414. Sitewide features include underground fuel lines, storm sewers, open space, and an old railroad track that ran through Site 4. Site 4 also includes portions of corrective action area (CAA) 3C, CAA 4A, CAA 4B, CAA 4C, and CAA 13 because petroleum hydrocarbons were detected in groundwater at these locations.

Site 4 Chemicals of Concern for Soil: N-Nitroso-di-n-propylamine, 3,3'-dichlorobenzidine, Aroclor-1254, cadmium, TCE, and PAHs

Site 4 Potential Sources: Buildings 163A, 170, 360, 372, and 414; NADEP GAP 59; ASTs 360A, B, and C, and AST 372; UST 163 and UST 372-1; OWS-163, OWS-360, and OWS-372A; and routine weed control

Site 4 Nature and Extent:

Chemical	Exceeds Screening Levels?	Used by the Navy at the Site?	Risk Driver?	Background Metal?[1]	Related to Site Activity?	Data Gap?
Semivolatile Organic Compounds						
N-Nitroso-di-n-propylamine	Yes	No	Yes	--	No	No
2,4-Dinitrotoluene	No	No	Yes	--	No	No
3,3'-Dichlorobenzidine	No	No	Yes	--	Yes	No
Volatile Organic Compounds						
Benzene	Yes	Yes	No	--	Yes	No
Ethylbenzene	Yes	Yes	No	--	Yes	No
Trichloroethene	Yes	Yes	Yes	--	Yes	No
Vinyl Chloride	Yes	Yes	No	--	Yes	No
1,1,2,2-Tetrachloroethane	Yes	Yes	No	--	Yes	No
Metals						
Antimony	Yes	No	No	Yes	No	No
Arsenic	Yes	No	Yes	Yes	No	No
Cadmium	Yes	Yes	Yes	No	Yes	No
Chromium	Yes	Yes	No	No	No	No
Copper	No	No	Yes	No	Yes	No
Iron	Yes	No	No	Yes	No	No
Lead	Yes	No	No	No	No	No
Silver	No	No	Yes	No	Yes	No
Polychlorinated Biphenyls						
Aroclor-1254	Yes	Yes	Yes	--	Yes	No
Polynuclear Aromatic Hydrocarbons						
Benzo(a)pyrene	Yes	No	Yes	--	No	No

Chemical	Exceeds Screening Levels?	Used by the Navy at the Site?	Risk Driver?	Background Metal?[1]	Related to Site Activity?	Data Gap?
Total Petroleum Hydrocarbons						
Diesel	--	Yes	No	--	Yes	No
Gasoline	--	Yes	No	--	Yes	No
Motor Oil	--	Yes	No	--	Yes	No

Notes:

-- Does not apply to these chemicals

1 Based on the background comparison

Site 4 Human Health Risk Assessment:

Exposure Scenario	RME Carcinogenic Risk		RME HI		Risk Driver	
	Surface Soil	Subsurface Soil	Surface Soil	Subsurface Soil	Surface Soil	Subsurface Soil
Residential	1E-04	2E-04	4	4	Arsenic, Benzo(a)pyrene, n-Nitroso-di-n-propylamine, Cadmium	2,4-Dinitrotoluene, 3,3-Dichlorobenzidine, Aroclor-1254, Arsenic, Benzo(a)pyrene, n-Nitroso-di-n-propylamine, Cadmium
Commercial/ Industrial	4E-06	8E-06	0.2	0.2		
Construction Worker	4E-07	7E-07	0.5	0.6		

Notes:
bgs Below ground surface
HI Hazard index
RME Reasonable maximum exposure

Site 4 Ecological Risk Assessment: Cadmium, copper, and silver in soil were identified as posing potential risk to small mammals. Silver and PAHs in soil were identified as posing potential risk to passerines and raptors. These risks for ecological receptors are overestimated because ecological habitat is not present. No action is recommended for chemicals based on potential risk posed to ecological receptors.

Site 4 Data Gaps: The following data gaps were identified:

- Further investigation of OWS-360 is recommended.
- Because detection limits for nondetected SVOCs in soil were elevated, further sampling and analysis of soil may be necessary to confirm these chemicals are not present in soil at Site 4.

SITE 11 – *(ENGINE TEST CELL)*

Site 11 is located in the eastern portion of Alameda Point south of Ingersol Street, west of Viking Street, north of corrective action area (CAA)-11B, and east of Ferry Point Road. Site 11 measures about 5.3 acres, is triangular, and consists of Parcel 137 and Subparcels 138A and 140A (see ES-4). Approximately 95 percent of Site 11 consists of buildings, roads, and parking lots covered with asphalt and concrete. Site 11 contains Building 14, an engine test cell. Building 14 was constructed in 1940 and operated as an aircraft testing and repair facility. Operations ceased in April 1997 (IT 2001a). NADEP GAP 47, NADEP GAP 48, and OWSs 14A through E are associated with Building 14. Additional physical features at Site 11 include Building 627; former Buildings 118, 180, 265, and 587; ASTs 14A through D and 37A through D; USTs 14-1 through 14-6 (collectively referred to as UST(R)-06) and 37-1 through 37-4; fuel lines; storm sewers; and open space covered by asphalt and concrete. Site 11 also contains CAAs 11A and 11B because of petroleum hydrocarbon contamination in groundwater at these locations.

Site 11 Chemicals of Concern for Soil: Aroclor-1260 and PAHs

Site 11 Potential Sources: Building 14, OWSs 14A and D, USTs 14-1 through 14-6, ASTs 37A through D, and USTs 37-1 through 37-4 and associated fuel lines and storm sewers

Site 11 Nature and Extent:

Chemical	Exceeds Screening Levels?	Used by the Navy at the Site?	Risk Driver?	Background Metal?[1]	Related to Site Activity?	Data Gap?
Metals						
Arsenic	Yes	No	No	Yes	No	No
Chromium	Yes	No	No	Yes	No	No
Copper	No	Yes	Yes	No	Yes	No
Iron	Yes	No	No	No	No	No
Lead	Yes	Yes	No	Yes	Yes	Yes
Polychlorinated Biphenyls						
Aroclor-1260	Yes	Yes	Yes	--	Yes	No
Polynuclear Aromatic Hydrocarbons						
Benzo(a)pyrene	Yes	No	Yes	--	No	No
Total Petroleum Hydrocarbons						
Diesel	--	Yes	No	--	Yes	No
Gasoline	--	Yes	No	--	Yes	No
Motor Oil	--	Yes	No	--	Yes	No

Notes:

-- Does not apply to these chemicals
1 Based on the background comparison

Site 11 Human Health Risk Assessment:

Exposure Scenario	RME Carcinogenic Risk		RME HI		Risk Driver	
	Surface Soil	Subsurface Soil	Surface Soil	Subsurface Soil	*Surface Soil*	*Subsurface Soil*
Residential	4E-05	4E-05	2	2	Aroclor-1260, Arsenic, Benzo(a)anthracene, Benzo(a)pyrene, Dibenzo(a,h)anthracene	Arsenic, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Dibenzo(a,h)anthracene
Commercial/ Industrial	1E-05	8E-06	0.2	0.1		
Construction Worker	1E-06	8E-07	0.5	0.4		

Notes:
bgs *Below ground surface*
HI Hazard index
RME Reasonable maximum exposure

Site 11 Ecological Risk Assessment: Copper in soil was identified as posing potential risk to small mammals. PAHs in soil were also identified as posing potential risk to passerines and raptors. These risks for ecological receptors are overestimated because ecological habitat is not present. No action is recommended for chemicals based on potential risk posed to ecological receptors.

Site 11 Data Gaps: The following data gaps were identified:

- Further delineation of lead in surface soil near sampling location M11-03 is also recommended.
- Because detection limits for non-detected SVOCs in soil were elevated, the need for further sampling and analysis of soil may be necessary to confirm these chemicals are not present in site soil.

SITE 21 – *(SHIP FITTING AND ENGINE REPAIR)*

Site 21 is located in the eastern portion of Alameda Point south of West Seaplane Lagoon Street, west of Viking Street, north of corrective action area (CAA)-11A, and east of Seaplane Lagoon Road. Site 21 measures about 7 acres, is irregularly shaped, and consists of Parcels 127, 135, 136, and 200, and Subparcel 155A (see Figure ES-5). Approximately 50 percent of Site 21 is covered with asphalt and concrete, and the rest of the site consists of buildings, roads, and parking lots. The northern portion of Site 21 is designated as part of CAA-3A and the southwestern corner as part of CAA-11A because of petroleum hydrocarbon contamination in groundwater at these locations. The main feature of Site 21 is Building 162, which was constructed in 1945 and operated as a ship and aircraft maintenance shop. Operations ceased in April 1997 (IT 2001a). Associated with Building 162 are OWSs-162, NAS GAP 11, NADEP GAP 46, SWMU 162, and USTs 162-1 and 162-2. Additional site features include Buildings 113 and 398, and former Building 349. Associated with Building 113 are NADEP GAP 76, NADEP GAP 77, and AST 113. Associated with Building 398 are Structure 470, NADEP GAP 44, NADEP GAP 45, RCRA Site M-07, and USTs 398-1 and 398-2. Sitewide features include underground fuel lines, storm sewers, and open space.

Site 21 Chemicals of Concern for Soil: Arsenic, Carbazole, and Iron

Site 21 Potential Sources: Buildings 162, 398, and 113 and their associated sanitary sewer and fuel lines; NADEP GAP 44, and USTs 162-1, 162-2, 398-1, and 398-2

Site 21 Nature and Extent:

Chemical	Exceeds Screening Levels?	Used by the Navy at the Site?	Risk Driver?	Background Metal?[1]	Related to Site Activity?	Data Gap?
Volatile Organic Compounds						
Benzene	Yes	Yes	No	--	Yes	No
Carbazole	No	No	Yes	--	Yes	No
Metals						
Arsenic	Yes	No	Yes	No	Yes	No
Cadmium	No	No	Yes	Yes	No	No
Chromium	Yes	No	No	Yes	No	No
Copper	No	No	Yes	No	Yes	No
Iron	Yes	No	Yes	No	Yes	No
Lead	Yes	Yes	Yes	No	Yes	No
Polynuclear Aromatic Hydrocarbons						
Benzo(a)pyrene	Yes	No	Yes	--	No	No
Total Petroleum Hydrocarbons						
Diesel	--	Yes	No	--	Yes	No
Gasoline	--	Yes	No	--	Yes	No
Motor Oil	--	Yes	No	--	Yes	No

Notes:

-- Does not apply to these chemicals

1 Based on the background comparison

Site 21 Human Health Risk Assessment:

Exposure Scenario	RME Carcinogenic Risk		RME HI		Risk Driver	
	Surface Soil	Subsurface Soil	Surface Soil	Subsurface Soil	Surface Soil	Subsurface Soil
Residential	1E-04	4E-05	5	3	Arsenic, Cadmium, Iron	Arsenic, Carbazole
Commercial/Industrial	1E-05	4E-06	0.3	0.2		
Construction Worker	2E-06	5E-07	1	1		

Notes:
bgs Below ground surface
HI Hazard index
RME Reasonable maximum exposure

Site 21 Ecological Risk Assessment: Copper and lead in soil were identified as posing potential risk to small mammals. PAHs in soil were identified as posing potential risk to passerines and raptors and lead was identified as posing a potential risk to raptors. These risks for ecological receptors are overestimated because ecological habitat is not present. No action is recommended for chemicals based on potential risk posed to ecological receptors.

Site 21 Data Gaps: No Data gaps were identified at Site 21

OU-WIDE GROUNDWATER

Groundwater was evaluated on a OU-wide basis, this evaluation encompasses the groundwater beneath OU-2B Sites 3, 4, 11, and 21.

Chemicals of Concern for OU-wide Groundwater: Primary (exceed the risk management range) - TCE, and vinyl chloride
Secondary (within the risk management range) – 1,1-Dichloroethane; 1,2-Dichloroethane; 1,1-Dichloroethene; 1,2-Dichloroethene (total); 1,4-Dichlorobenzene; 1,1,2-Trichloroethane; Benzene; Hexavalent Chromium; Iron; Manganese; PAHs; PCE, Naphthalene

OU-wide Groundwater Potential Sources: Buildings 162, 360, 372, 398, and 113 and their associated sanitary sewer and fuel lines; NADEP GAP 44; and USTs 162-1, 162-2, 398-1, and 398-2

OU-wide Groundwater Nature and Extent:

Chemical	Exceeds Screening Level?	Used by the Navy at the Site?	Risk Driver?	Background Metal?[1]	Related to Site Activity?	Data Gap?
Volatile Organic Compounds						
1,1,1-Trichloroethane	Yes	Yes	No	--	Yes	Yes
1,1,2-Trichloroethane	Yes	Yes	Yes	--	Yes	Yes
1,1-Dichloroethane	Yes	Yes	Yes	--	Yes	No
1,1-Dichloroethene	Yes	Yes	Yes	--	Yes	No
1,2,4-Trimethylbenzene	Yes	Yes	No	--	Yes	No
1,2-Dichloroethane	Yes	Yes	Yes	--	Yes	No
1,2-Dichloroethene (total)	Yes	Yes	Yes	--	Yes	No
1,2-Dichloropropane	Yes	No	No	--	No	No
1,3,5-Trimethylbenzene	Yes	Yes	No	--	Yes	No
1,4-Dichlorobenzene	Yes	Yes	Yes	--	Yes	No
Acetone	Yes	Yes	No	--	Yes	No
Benzene	Yes	Yes	Yes	--	Yes	No
Bromodichloromethane	Yes	No	Yes	--	Yes	No
Carbon tetrachloride	Yes	No	No	--	No	No
Chlorobenzene	Yes	No	No	--	No	No
Chloroethane[2]	Yes	No	Yes	--	Yes	No
Chloroform[2]	Yes	No	Yes	--	No	No
Chloromethane	Yes	No	No	--	No	No
Cis-1,2-dichloroethene	Yes	No	No	--	No	No
Dibromochloromethane	Yes	No	No	--	No	No
Ethylbenzene	Yes	Yes	No	--	Yes	No
M,P-xylene	Yes	No	No	--	No	No

Chemical	Exceeds Screening Level?	Used by the Navy at the Site?	Risk Driver?	Background Metal?[1]	Related to Site Activity?	Data Gap?
Methyl-T-butyl ether	Yes	No	No	--	No	No
Methylene chloride	Yes	Yes	Yes	--	No	No
Naphthalene	Yes	No	Yes	--	No	No
O-xylene	Yes	No	No	--	No	No
Tetrachloroethene	Yes	Yes	Yes	--	Yes	No
Toluene	Yes	Yes	No	--	Yes	No
Trans-1,2-dichloroethene	Yes	No	No	--	No	No
Trichloroethene	Yes	Yes	Yes	--	Yes	No
Vinyl Chloride	Yes	Yes	Yes	--	Yes	Yes
Semivolatile Organic Compounds						
1,4-Dichlorobenzene	Yes	No	No	--	No	Yes
Benzo(a)anthracene	Yes	No	No	--	No	No
Benzo(a)pyrene	Yes	No	No	--	No	No
Benzo(b)fluoranthene	Yes	No	No	--	No	No
Bis(2-chloroethyl)ether	Yes	No	No	--	No	No
Bis(2-ethylhexyl)phthalate[2]	Yes	No	Yes	--	No	No
Carbazole	Yes	No	No	--	No	No
Chrysene	Yes	No	No	--	No	No
Dibenzofuran	Yes	No	No	--	No	No
Fluorene	Yes	No	No	--	No	No
Indeno(1,2,3-cd)pyrene	Yes	No	No	--	No	No
Naphthalene	Yes	No	No	--	No	No
Pentachlorophenol	Yes	No	No	--	No	No
Metals						
Aluminum	Yes	Yes	No	No	Yes	No
Antimony	Yes	No	Yes	Yes	No	No
Arsenic	Yes	No	Yes	Yes	No	No
Cadmium	Yes	Yes	Yes	Yes	Yes	No
Chromium (hexavalent)	No	Yes	Yes	Yes	Yes	No
Iron	Yes	No	Yes	No	No	No
Manganese	Yes	No	Yes	No	No	No
Molybdenum	Yes	No	No	No	No	No
Nickel	Yes	No	No	No	No	No
Thallium	Yes	No	Yes	Yes	No	No
Vanadium	Yes	No	No	No	No	No
Polychlorinated Aromatic Hydrocarbons						
Benzo(a)anthracene	Yes	No	Yes	--	No	No
Benzo(a)pyrene	Yes	No	Yes	--	No	No
Total Petroleum Hydrocarbons						
Diesel	--	Yes	No	--	Yes	No
Gasoline	--	Yes	No	--	Yes	No
Motor Oil	--	Yes	No	--	Yes	No

Notes:

-- Does not apply to these chemicals
1 Based on the background comparison
2 Chloroethane, chloroform, and bis(2-ethylhexyl)phthalate were identified as risk drivers, but it was determined that they are not a significant concern

Human Health Risk Assessment:

Exposure Scenario	RME Carcinogenic Risk	RME HI	Risk Driver
Residential	4E-03	310	1,1,2-Trichloroethane, 1,1-Dichlorethane, 1,2-Dichlorethane, 1,1-Dichloroethene, 1,2-Dichloroethene (total), 1,4-Dichlorobenzene, Antimony, Arsenic, Benzene, Benzo(a)anthracene, Benzo(a)pyrene, Bromodichloromethane, Cadmium, Hexavalent Chromium, Iron, Manganese, Methylene chloride, Naphthalene, Tetrachloroethene, Thallium, Trichloroethene, Vinyl chloride
Commercial/Industrial	1E-04	0.2	
Construction Worker	6E-05	0.9	

Notes:
HI Hazard index
RME Reasonable maximum exposure

OU-wide Groundwater Ecological Risk Assessment: Because the OU-wide groundwater plume intersects the Seaplane Lagoon, the exposure pathways for marine receptors were considered complete, and a site-specific ERA was conducted for the OU-wide groundwater plume to estimate potential risks to marine receptors. Significant risk to ecological receptors is potentially posed by manganese; however, elevated manganese is likely from saline conditions.

OU-wide Groundwater Data Gaps: The following data gaps were identified:

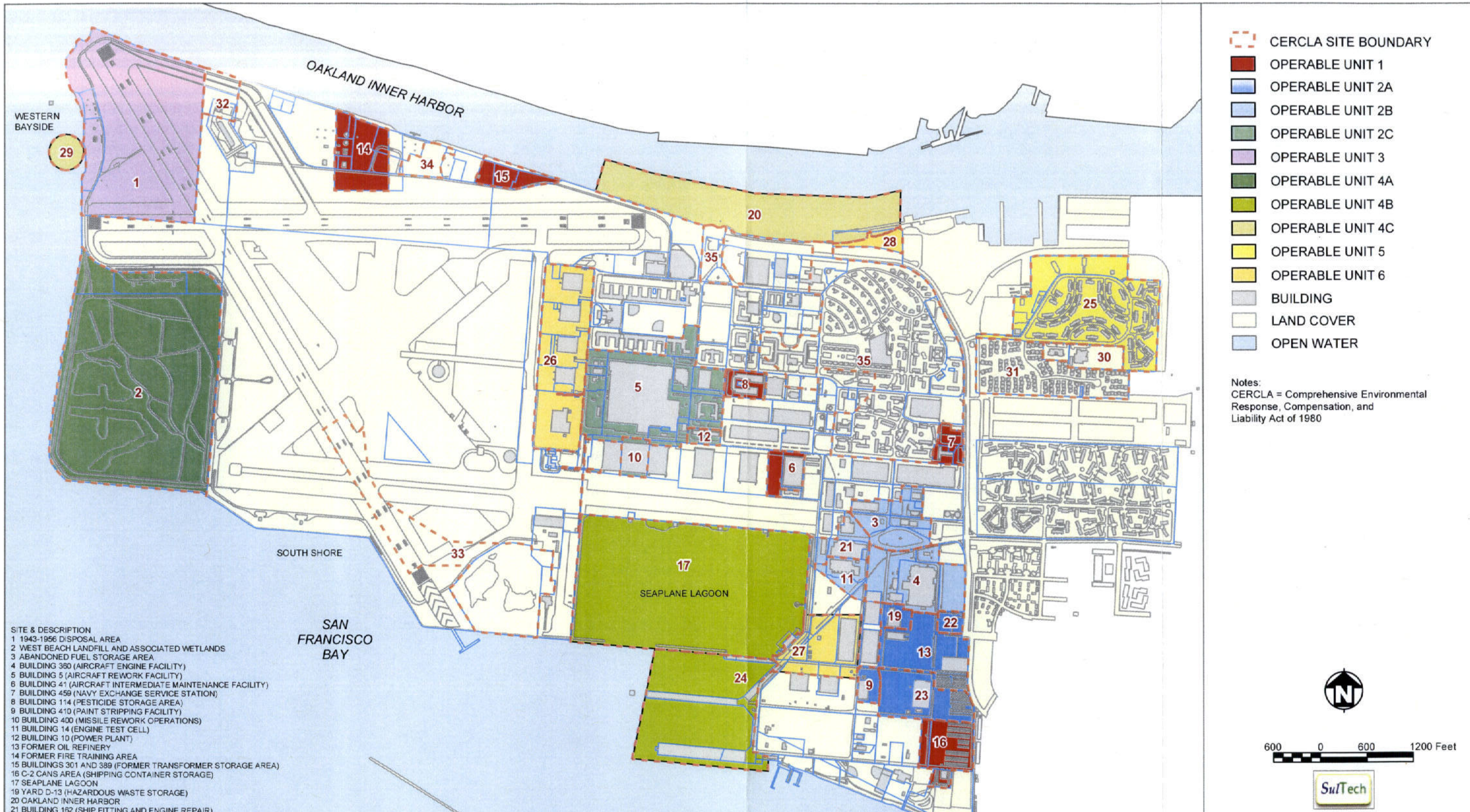
- Because detection limits for non-detected SVOCs and the VOCs 1,1,1-TCA, 1,1,2-TCA, and vinyl chloride in groundwater were elevated, the need for further sampling and analysis of groundwater may be necessary to confirm these chemicals are not present in OU-wide groundwater.
- Based on quarterly sampling in 2001 and 2002, concentrations of 1,4-dichlorobenzene appear to be increasing over time in the vicinity of MW360-1. The source of this increase in 1,4-dichlorobenzene concentrations is identified as a data gap.

N00236.002042
ALAMEDA POINT
SSIC NO. 5090.3

FIGURES

FINAL OPERABLE UNIT 2B
REMEDIAL INVESTIGATION REPORT
SITES 3, 4, 11, AND 21

DATED 05 AUGUST 2005

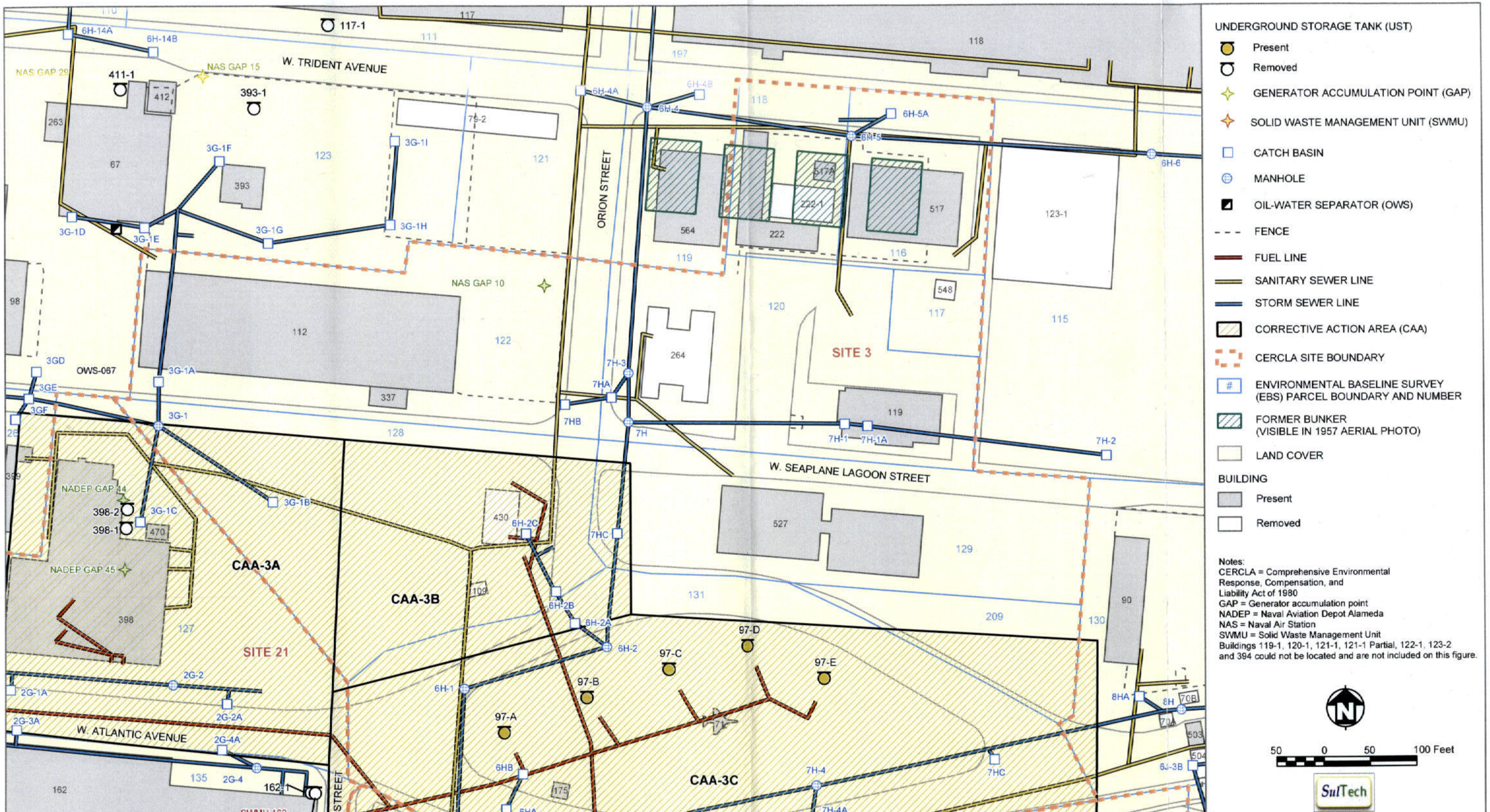


Alameda Point
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE ES-1
CERCLA SITES AND OPERABLE UNITS

Operable Unit 2B
Remedial Investigation Report

2004-03-27 U:\almda_sa\do030\ou2b_ri\mxd\figES-01_cercla_ou.mxd TtEMI-SA K. Johnson



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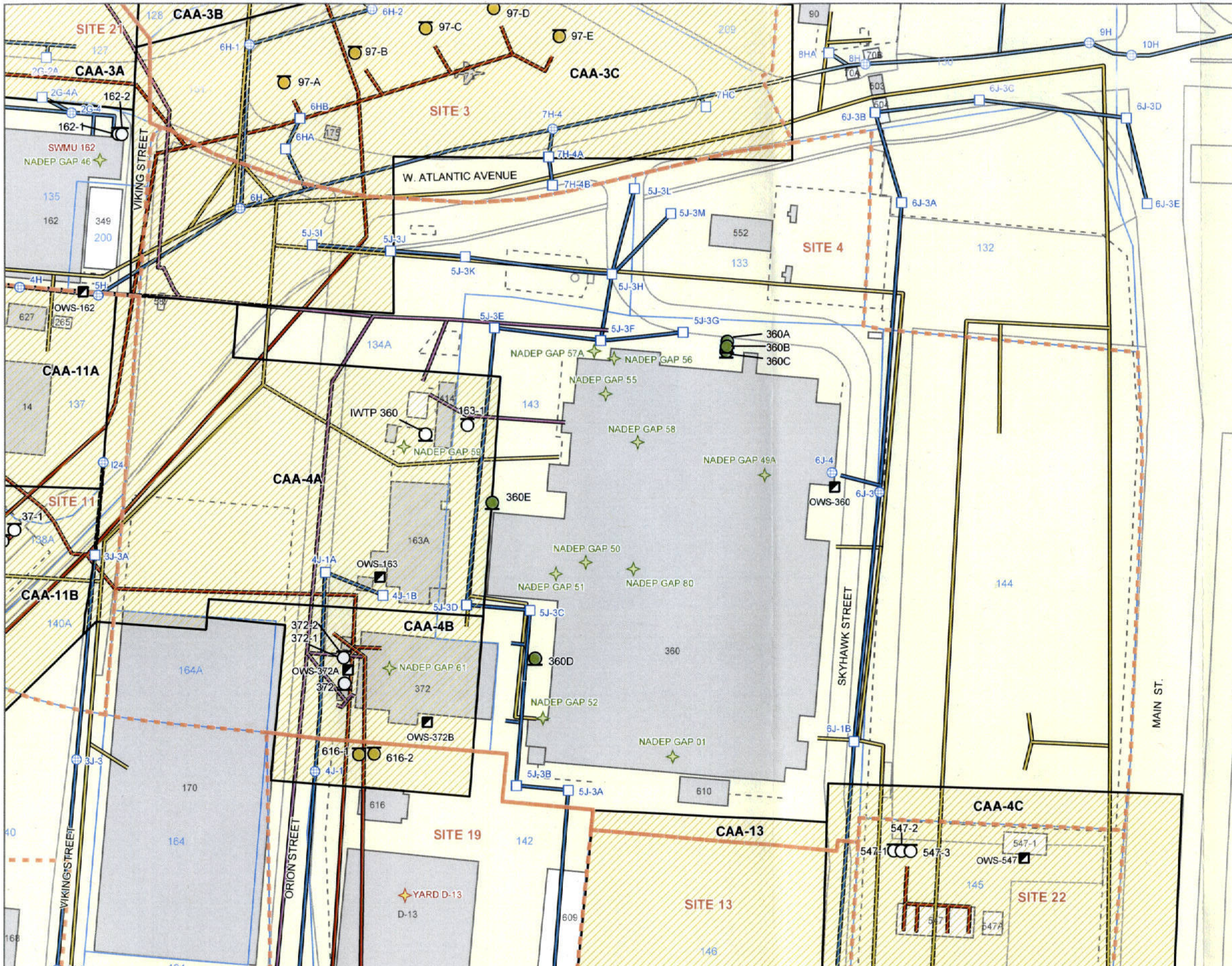
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE ES-2
SITE 3 FEATURES

Operable Unit 2B
Remedial Investigation Report

2004-03-27 U:\almda_sa\do030\OU2B_RI\mxd\figES-02_s03_features.mxd TtEMI-SA K. Johnson



ABOVEGROUND STORAGE TANK (AST)
- Present
- Removed

UNDERGROUND STORAGE TANK (UST)
- Present
- Removed

GENERATOR ACCUMULATION POINT (GAP)
SOLID WASTE MANAGEMENT UNIT (SWMU)
CATCH BASIN
MANHOLE
OIL WATER SEPARATOR (OWS)
FENCE
FUEL LINE
SANITARY SEWER LINE
STORM SEWER LINE
INDUSTRIAL WASTE LINE
CORRECTIVE ACTION AREA (CAA)
CERCLA SITE BOUNDARY
ENVIRONMENTAL BASELINE SURVEY (EBS) PARCEL BOUNDARY AND NUMBER
LAND COVER

BUILDING
- Present
- Removed

Notes:
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
GAP = Generator accumulation point
NADEP = Naval Aviation Depot Alameda
NAS = Naval Air Station

60 0 60 120 Feet

SulTech

Alameda Point
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FIGURE ES-3
SITE 4 FEATURES

Operable Unit 2B
Remedial Investigation Report

2004-03-27 U:\almda_sa\do030\OU2B_RI\mxd\figES-03_s04_features.mxd TtEMI-SA K. Johnson

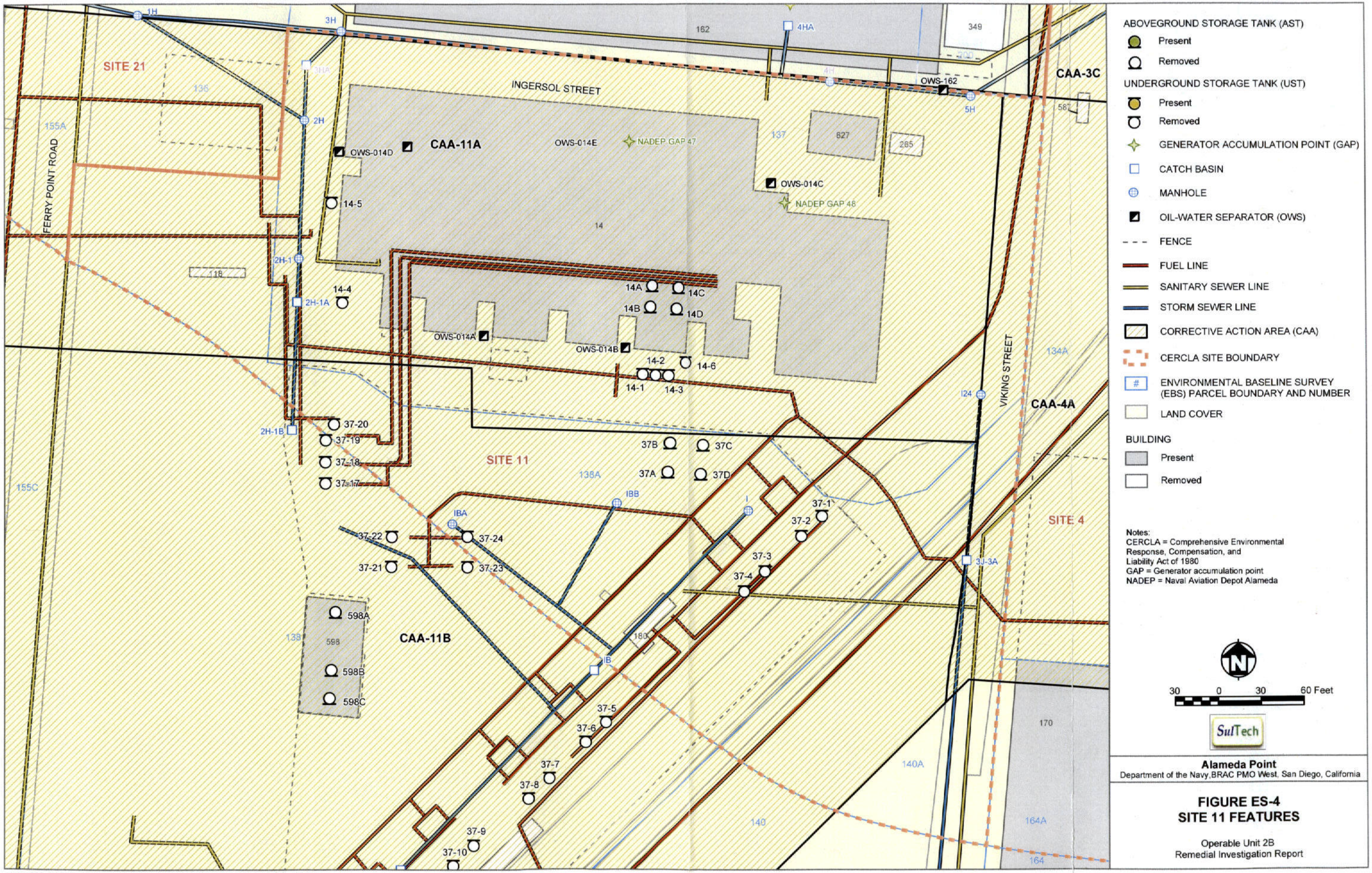

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FIGURE ES-4
SITE 11 FEATURES

Operable Unit 2B
Remedial Investigation Report

2004-03-27 U:\almda_sa\do030\OU2B_RI\mxd\figES-04_s11_features.mxd TtEMI-SA K. Johnson

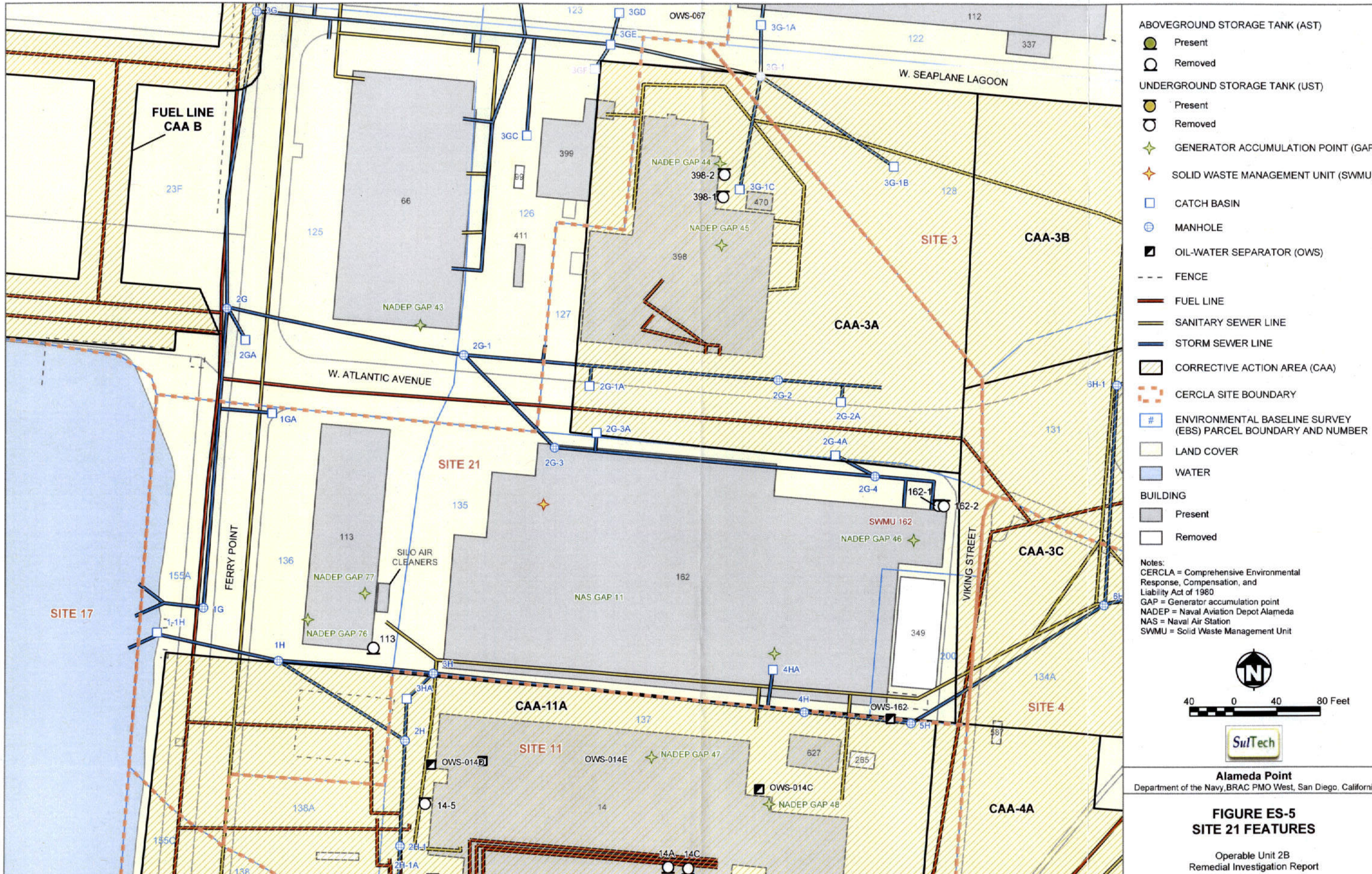

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FIGURE ES-5
SITE 21 FEATURES

Operable Unit 2B
Remedial Investigation Report

2004-03-27 U:\almda_sa\do030\OU2B_RI\mxd\figES-05_s21_features.mxd TtEMI-SA K. Johnson

1.0 INTRODUCTION

In July 1999, Alameda Point was identified by U.S. Environmental Protection Agency (EPA) as a National Priorities List (NPL) site (EPA 1999b). The U.S. Department of the Navy is conducting investigations in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (Title 42 *United States Code* 9601-9675) at various sites at Alameda Point (formerly Naval Air Station [NAS] Alameda) in Alameda, California (see Figure 1-1). As a management tool to accelerate site investigation, cleanup, and reuse, a comprehensive operable unit (OU) strategy was developed, which separates 35 CERCLA sites into a total of 10 OUs (OU-1, OU-2A, OU-2B, OU-2C, OU-3, OU-4A, OU-4B, OU-4C, OU-5, and OU-6). Figure 1-2 shows the sites within each OU. Site 18, the storm sewer system, was previously considered a separate site. The site was reconfigured, and the storm sewer system is now being addressed within the individual sites in which it is located. EPA Region 9, the California Department of Toxic Substances Control (DTSC), and the San Francisco Bay Regional Water Quality Control Board (RWQCB) provide regulatory oversight.

This remedial investigation (RI) report presents the results, conclusions, and recommendations of the RI conducted for the northeastern area of OU-2, referred to as "OU-2B," at Alameda Point (see Figure 1-2). The CERCLA sites that comprise OU-2B and are included in this report are Site 3 – the Abandoned Fuel Storage Area, Site 4 – Building 360 (Aircraft Engine Facility), Site 11 –Building 14 (Engine Test Cell), and Site 21 – Building 162 (Ship Fitting and Engine Repair).

1.1 PURPOSE AND OBJECTIVES

Because Alameda Point is listed as an NPL site, CERCLA sites are evaluated using the following steps of the Superfund cleanup process: (1) preliminary assessment and site inspection (PA/SI), (2) RI and feasibility study (FS), and (3) record of decision (ROD). The PA collects readily available information about a site and is designed to distinguish between sites that pose little or no threat to human health and the environment and sites that may pose a threat and require further investigation. The SI identifies CERCLA sites and typically collects environmental samples to assess what hazardous substances are present at a site. The RI is the mechanism for collecting data to accomplish the following objectives:

- Characterize site conditions
- Determine the nature and extent of contamination
- Assess risk to human health and the environment
- Conduct treatability testing to evaluate potential performance and cost of treatment technologies that are being considered

The FS is the mechanism for developing, screening, and evaluating remedial alternatives to address adverse risk identified during the RI. The ROD explains which remedial alternatives will be used.

The purpose of this report is to (1) document the approach used to conduct the RI for Sites 3, 4, 11, and 21; (2) document results of field investigations and risk assessments; and (3) recommend further assessment in an FS, if necessary, so an informed risk management decision can be made about the need for remedial action (EPA 1988b). The list below identifies the specific RI objectives for Sites 3, 4, 11, and 21.

- Collect soil and groundwater data for characterization of Sites 3, 4, 11, and 21 and in support of an FS, if necessary
- Evaluate each site's physical setting, geology, hydrogeology, and ecology
- Assess the nature and extent and fate and transport of those chemicals at each site demonstrating significant risk to human health or the environment
- Conduct background comparisons for soil and groundwater
- Conduct a human health risk assessment (HHRA) and ecological risk assessment (ERA) for each site

1.2 REPORT ORGANIZATION

This RI report is divided into 11 sections and 8 appendices and is provided in four volumes as listed below.

- Volume I: Executive Summary, Sections 1.0 through 6.0, and associated figures and tables
- Volume II: Sections 7.0 through 11.0, and associated figures and tables
- Volume III: Appendices A through K, excluding F and G
- Volume IV: Appendices F (HHRA) and G (ERA)

Volumes I and II of the report include Sections 1.0 through 11.0 and are organized as follows. Section 2.0 describes the history of Alameda Point, physical setting, geology, hydrogeology, and ecology of Alameda Point. Section 3.0 presents the approach to the RI, which includes the regulatory status, scoping of the RI, environmental investigations, data evaluation methods, and the approach to making conclusions. Data evaluation methods include site-specific conceptual site models, data quality objectives (DQO), and the approach for the background comparison, nature and extent evaluation, fate and transport evaluation, HHRA, and ERA. Section 4.0 describes the OU-wide geology and hydrogeology. Sections 5.0 through 8.0 present the histories and RI results for soils at each site and for one discrete plume of groundwater contamination in the northern portion of Site 3. Section 9.0 presents the RI results for all of OU-2B groundwater (OU-wide plume). Groundwater is being treated on an OU basis because historical releases from the sites within OU-2B have resulted in a large commingled plume covering multiple sites that cannot be effectively addressed on a site-by-site basis. Section 10.0 summarizes the RI conclusions and recommendations. Section 11.0 lists the references used to prepare this RI report.

All tables and figures are presented at the end of the section in which they are referred to in text and are numbered consecutively in the order in which they are mentioned in text.

Appendices A through K provide supporting documentation and calculations for the RI report and are included in Volumes III and IV.

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ALAMEDA POINT
SSIC NO. 5090.3

FIGURES

FINAL OPERABLE UNIT 2B
REMEDIAL INVESTIGATION REPORT
SITES 3, 4, 11, AND 21

DATED 05 AUGUST 2005

SulTech

CITY

HIGHWAY

COUNTY BORDER

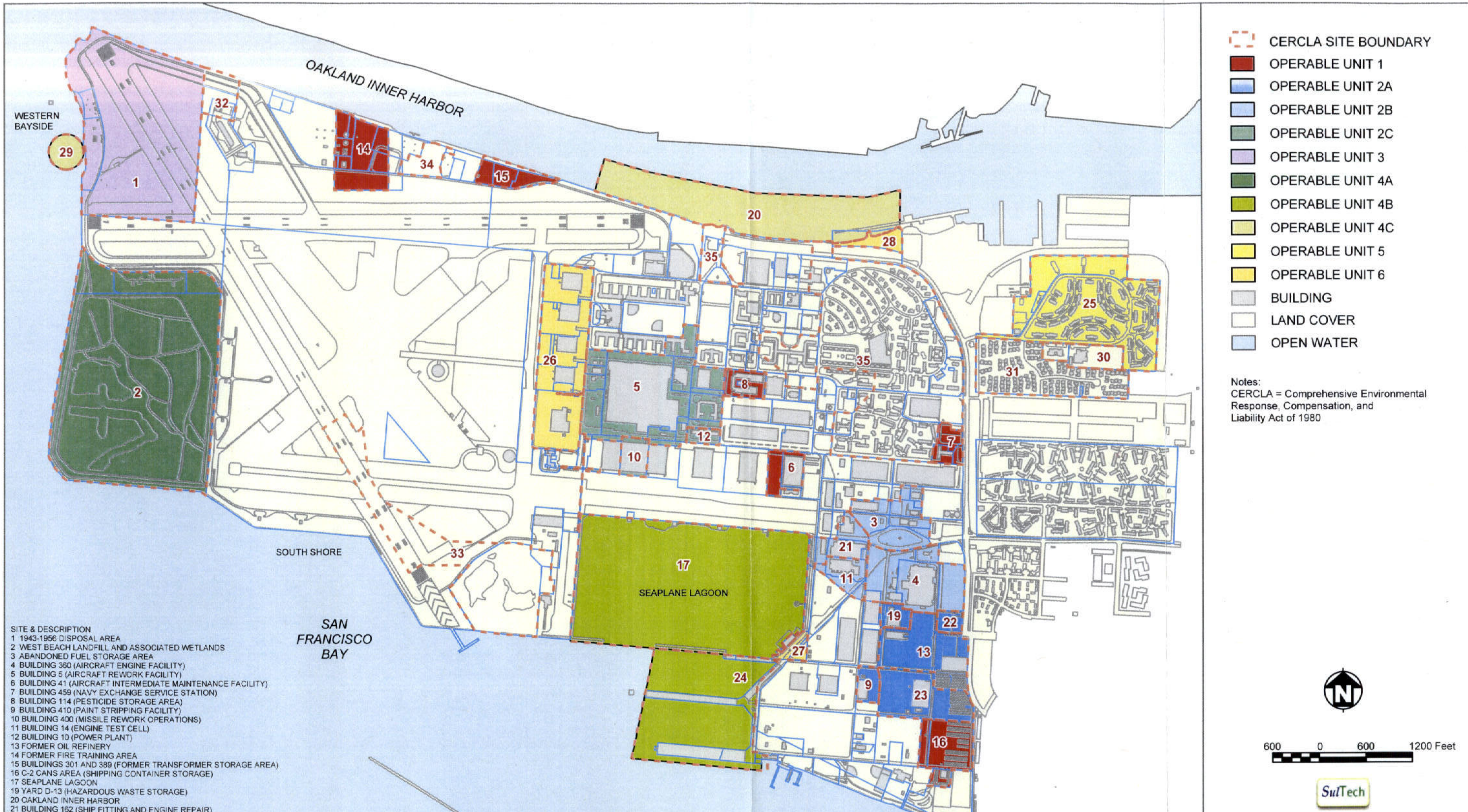
Alameda Point

Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 1-1
ALAMEDA POINT LOCATION MAP

Operable Unit 2B
Remedial Investigation Report

2005-03-15 U:\almda_sa\do030\ou2b_ri\mxd\fig01-01_location_map.mxd TtEMI-SA K. Johnson



SulTech

Alameda Point

Department of the Navy BRAC PMO West, San Diego, California

FIGURE 1-2
CERCLA SITES AND OPERABLE UNITS

Operable Unit 2B
Remedial Investigation Report

2005-03-15 U:\almda_sa\do030\ou2b_ri\mxd\fig01-02_cercla_ou.mxd TtEMI-SA K. Johnson

2.0 ALAMEDA POINT HISTORY AND SETTING

The following section provides a brief summary of the history, physical setting, and geological, hydrogeological, and ecological features of the installation.

2.1 ALAMEDA POINT HISTORY

This section summarizes the history of the land now known as Alameda Point and describes future uses planned at Alameda Point as presented in the "Naval Air Station Alameda Community Reuse Plan" (EDAW, Inc. 1996). Potential risks to human health and the environment are based on the future uses of each site.

2.1.1 Installation History

Originally a peninsula, Alameda Island was detached from the mainland in 1876, when a channel was cut to link San Leandro Bay with the San Francisco Bay. The area encompassed by Alameda Point was historically a combination of submerged lands, tideland, and dry land. The site is relatively flat, with elevations ranging from sea level to 30 feet above sea level. The property occupies the flattest portion of Alameda, reflecting its origins as diked bay lands and mud flats. Much of the land now occupied by Alameda Point was once covered by the waters of the San Francisco Bay or was tidal flats. Much of the base was gradually filled using hydraulically placed dredge spoils from the surrounding San Francisco Bay, Seaplane Lagoon, and Oakland Channel. The first documented filling of tidal and submerged land began sometime during the 1890s. By 1927, the northern part of what later became Alameda Point had been filled, chiefly with dredge materials from U.S. Army Corps of Engineers projects associated with the Oakland Harbor and other harbors throughout the East Bay (see Figure 2-1).

Before 1930, at least two large industrial sites, a borax processing plant and an oil refinery, were located on the island near what is now the eastern end of Alameda Point. The borax plant operated in the late 1800s to 1903. The refinery was constructed in 1879 and also ceased operations in 1903. Both of these facilities were located near the present-day Site 13 (see Figure 1-2).

The filled land was partially occupied by the Alameda Airport, a City-owned facility, and Benton Field, a minor U.S. Army Air Corps facility. The U.S. Department of the Army (Army) acquired Alameda Point from the City of Alameda in 1930 and began construction activities in 1931. The U.S. Department of the Navy (Navy) acquired title to the land from the Army in 1936 and began building the air station called Naval Air Station (NAS) Alameda in response to the military buildup in Europe before World War II. NAS Alameda was commissioned on November 1, 1940. After the 1941 entry of the United States into the war, more land was acquired adjacent to the air station. Following the end of the war, NAS Alameda returned to its original primary mission of providing facilities and support for fleet aviation activities. Following World War II, NAS Alameda supported Navy activities during the Korean War, the Vietnam War, and Operation Desert Storm (Kuwait). During its history, NAS Alameda housed approximately

60 military tenant commands for a combined military and civilian work force of over 18,000 personnel.

NAS Alameda was identified for closure in 1993. In April 1994, the City and County of Alameda signed a Joint Powers Agreement and established the Alameda Reuse and Redevelopment Authority (ARRA). The ARRA was recognized by the U.S. Department of Defense as the responsible entity for submitting and completing the community reuse plan for NAS Alameda. In 1997, the base closed, and the Navy began the process of property transfer to the City of Alameda.

2.1.2 Future Land Use

This section identifies future land use categories and land use areas for Alameda Point. Land use categories define the types of activities anticipated to be carried out in a specific geographical area (defined as "land use area" in the reuse plan) at Alameda Point. The following 10 land use categories have been identified in the NAS Alameda community reuse plan (EDAW, Inc. 1996):

- Residential
- Business Park/Light Industry
- Office
- Research and Development/Industrial Flex
- Civic/Institutional
- Commercial
- Mixed-use
- Parks
- Open Space/Habitat
- Commercial Recreation/Marina

Under the land use plan (EDAW, Inc. 1996), Alameda Point was divided into the following 7 geographical land use areas, which are expected to be associated with one or more of the 10 land use categories described previously:

- Civic Core
- Main Street Neighborhoods
- Inner Harbor
- North Waterfront
- Marina District
- Northwest Territories
- Wildlife Refug

According to the reuse plan (EDAW, Inc. 1996), Site 3 is partially located in the Civic Core Area and the Marina District Area, and Site 4 is located partially in the Civic Core Area and the Inner Harbor Area. Sites 11 and 21 are located in the Marina District Area (see Figure 2-2).

The Civic Core is planned to consist of approximately a 334-acre reuse area, located in the central part of Alameda Point. It currently contains a wide range of land use patterns, including the central open space mall, the shoreline along Oakland Inner Harbor, and the East Gate entrance station. Residential, recreational, administrative, warehouse, and industrial structures also are located in this reuse area. The Civic Core reuse area would be developed as a mixed-use "flex zone" to accommodate a range of uses, which is based on the near-term reuse of existing facilities with redevelopment and in-fill changes, additions, and demolition occurring over time. Development in the mixed-use core would emphasize international business and commerce, research and development facilities, and support commercial uses. Potential civic uses include public recreation facilities, a museum, a library, a teen activity center, a civic auditorium, civic office space, a place of worship, and meeting spaces (Navy 1999c).

The Marina District is planned to be about 126 acres, surrounding the entire shoreline of the Seaplane Lagoon. The Navy used this reuse area primarily for deepwater ship and seaplane berthing, and equipment storage and repair. A proposed open space promenade, extending from the Civic Core, would open into a civic plaza as it meets the water's edge in the Marina reuse area. A hotel and conference center would be built on 4 acres. Civic uses, such as office space, a cultural arts center or theater, and recreation, could front the plaza. Housing in the Marina reuse area would be limited to the eastern shores and provide opportunities for a mix of housing types and income levels. Housing could include artist lofts, apartments for low- to moderate-income families, and townhouses consistent with Measure A, which is a 1973 amendment of the Alameda City Charter prohibiting construction of multifamily dwelling units, except replacement of low-cost housing units by the Alameda Housing Authority (Navy 1999c).

The Inner Harbor area is planned to be approximately 120 acres in the southeastern corner of Alameda Point. This reuse area is characterized as a combination of industrial, open space, and community support uses. The most prominent land use features are large-scale industrial buildings and shoreline recreational areas (Navy 1999c). The southern shoreline in the Inner Harbor area would be developed as a 36-acre regional park. The East Bay Regional Park District would develop and manage the regional park, which would include opportunities for shoreline access and recreation, beach uses, a dog run, and other forms of developed recreation. The existing marina, recreation center, breakwater, boathouse, and cafe would be considered for rehabilitation for public use. The existing recreational vehicle (RV) park would be expanded to 13 acres and would accommodate about 135 RVs for short-term RV camping. The intent of the regional park would be to develop a program of public service facilities that would serve international tourists, visitors, and residents. The regional park would be included in the Bay Trail System (Navy 1999c).

2.2 PHYSICAL SETTING

Alameda Point is located at the west end of Alameda Island, which lies at the base of a gently westward-sloping plain extending from the Oakland-Berkeley hills on the east to the shore of the San Francisco Bay on the west (see Figure 1-1). San Francisco Bay borders Alameda Island to the south and the Oakland Inner Harbor borders the island to the north (Tetra Tech EM Inc. [Tetra Tech] 1998c).

The San Francisco Bay area experiences a maritime climate with mild summer and winter temperatures. Prevailing winds in the San Francisco Bay area are from the west. Due to the varied topography of the San Francisco Bay area, climatic conditions vary considerably throughout the region. Heavy fogs occur on an average of 21 days per year. Rainfall occurs primarily during the months of October through April. Alameda Point averages approximately 18 inches of rainfall a year (Air Traffic Control, NAS Alameda 1992). No naturally occurring surface streams or ponds are at Alameda Point, so precipitation either returns to the atmosphere by evapotranspiration, runs off in the storm drain system that discharges to the San Francisco Bay, or infiltrates to groundwater (Tetra Tech 1998c).

Physical features at Alameda Point include runways, streets, buildings, fuel lines, underground storage tanks (UST), aboveground storage tanks (AST), and utility lines (sanitary sewer, storm sewer, water, and power lines). Some fuel lines, USTs, and ASTs have been removed and others have been closed in place.

2.3 GEOLOGY

This section provides an overview of regional and Alameda Point geology. Geologic and cone penetrometer testing logs, in situ permeability results, and geotechnical data are presented in Appendices A, B, and C, respectively.

2.3.1 Regional Geology

Alameda Point is located along the eastern shore of the central San Francisco Bay, directly west of the city of Oakland (see Figure 1-1). The San Francisco Bay and the area surrounding it occupy a large regional trough that extends northwest to southeast across the California Coast Ranges. In the subsurface, the San Francisco Bay is approximately coincident with the axis of the bedrock trough, which was formed 1 million to 500,000 years ago by crustal movements associated with two active faults, the Hayward Fault to the east and the San Andreas Fault west of San Francisco (Figuers 1998). The trough was filled with a sequence of coalescing alluvial fans consisting of lenses of sand, silt, and gravel eroded from the surrounding hills. During interglacial periods, the Pacific Ocean entered the basin, which resulted in wide deposition of estuarine muds (Figuers 1998).

Today, regional geologic conditions in the San Francisco Bay area reflect this depositional history and consist of up to approximately 1,000 feet of interbedded and alternating alluvial and estuarine deposits overlying crystalline bedrock of the Franciscan Complex. The major formations underlying the San Francisco Bay area from oldest to youngest are (1) Franciscan Complex, (2) Alameda Formation, (3) Yerba Buena Mud, (4) San Antonio Formation, (5) Merritt Sand Formation, (6) Young Bay Mud, and (7) Artificial Fill. The stratigraphy of the San Francisco Bay area has been interpreted by several authors; these interpretations are presented as stratigraphic columns in Figure 2-3.

2.3.2 Installation Geology

This section describes the geology of Alameda Point based on interpretation of the occurrence of unconsolidated, Quaternary-aged units encountered in subsurface investigations completed to date. The Alameda Point geology is described beginning with the uppermost units encountered at the surface down to bedrock.

Artificial Fill. The artificial fill is the upper-most unit and underlies most of Alameda Point. It ranges in thickness from 0 to 30 feet. The artificial fill is thickest in the western portion and generally decreases in thickness eastward across Alameda Point. The varying thickness of the artificial fill results from natural variations in the surface topography of the estuary before artificial filling activities began in the late 1800s. Due to the fill process, artificial fill is thinnest in the tidal flats and thickens westward toward areas where the San Francisco Bay was filled.

The artificial fill consists of sediments that were dredged from the surrounding San Francisco Bay and the Oakland Inner Harbor. Although composition of the artificial fill varies, it generally consists of silty sand or sand with minor inclusions of clay or gravel or both. Sediments comprising the artificial fill are similar to Merritt Sand deposits, which comprise sediments of the San Francisco Bay and the Oakland Inner Harbor.

Bay Sediment Unit (BSU). The BSU, which consists of Holocene-aged estuarine (tidal flat) deposits, is the youngest naturally occurring unit in the vicinity of Alameda Point. The BSU is equivalent to the Young Bay Mud (Figuers 1998). The BSU is about 40 feet thick in the western portion of Alameda Point, thinning and pinching out in the southeastern region at the former shoreline of Alameda Island (see Figure 2-4). The BSU is encountered at a depth of about 25 feet below ground surface (bgs) in the western portion of Alameda Point and at a depth of about 5 feet bgs in the eastern portion of the installation. The BSU is made up of tidal flat deposits consisting of varying degrees of fine- and coarse-grained material that grade westward, away from the former shoreline and into finer-grained subtidal deposits. The BSU consists of gray to black silt and clay with discontinuous, poorly graded silty and clayey sand layers. In some parts of the western region of Alameda Point, the lower portion of the BSU is predominantly gray to black sand.

A layer with high organic content, called the "marsh crust" typically marks the top of the BSU throughout the eastern portion of Alameda Point. The marsh crust is a layer of contaminated sediment that was formed by the discharge of petroleum waste from two gas plants and an oil refinery. This waste migrated over most of the surface of the surrounding marshlands and was deposited through tidal actions under what would later become the Alameda Annex and the eastern portion of Alameda Point. Further west at Alameda Point, waste was deposited on tidal flats now known as the former subtidal area. Fill material dredged from the Oakland Inner Harbor and surrounding the San Francisco Bay was placed on these areas from as early as 1887 to as late as 1975, encapsulating the former subtidal area and marsh crust under the fill. Areas where the marsh crust is known to exist are subject to excavation restrictions known as the Marsh Crust Ordinance that limits the extent of excavations to designated threshold depths (City of Alameda 2000).

Merritt Sand. Over most of the installation, the Merritt Sand underlies the BSU. The Merritt Sand is encountered at depths ranging from 40 feet bgs in the western portion of Alameda Point to surface outcrops in the southeastern portion of the installation. At Alameda Point, the Merritt Sand is made of brown, fine- to medium-grained poorly graded sand. Bivalve shells and shell hash are observed in parts of the Merritt Sand, indicating some marine reworking during the most recent sea level rise. The thickness of the Merritt Sand ranges from 8 feet to 60 feet across Alameda Point.

San Antonio Formation (upper member). At Alameda Point, the upper member of the San Antonio Formation generally uncomformably underlies the Merritt Sand and consists of interbedded layers of gray sand and clay, ranging in thickness from 10 to 40 feet in the eastern portion and from 7 to 70 feet in the central portion of the installation. A persistent layer containing shells and sand is present near the top of the formation. The San Antonio Formation is present over most of Alameda Point but is absent where a paleochannel crosses the northern half of the central and western portions of the installation. Greenish-gray clay layers within the upper member of the San Antonio Formation may not be regionally continuous. An organic-rich layer containing plant debris or peat is occasionally present at the base of the formation.

A paleochannel (former stream channel cut through existing sediments then filled with younger sediments) underlying Alameda Point is located along an east-west trending axis through the middle of Alameda Point. The paleochannel was cut through the Merritt Sand and into the upper unit of the San Antonio Formation. It was then filled with the encroaching BSU, which consisted of low-permeability silts and clays with discontinuous layers of poorly graded sands. Those poorly graded sands become continuous and thicker in the western region of the Alameda Point.

Yerba Buena Mud (Lower San Antonio). Yerba Buena Mud at Alameda Point reaches a maximum thickness of 50 feet at the west end and thins to the east but does not pinch out. The top of the Yerba Buena Mud occurs at elevations of 50 to 100 feet below mean sea level. The top of the Yerba Buena Mud dips approximately 2 degrees to the southwest under Alameda Point (Rogers and Figuers 1991).

Alameda Formation. The Alameda Formation underlying Alameda Point ranges in thickness from approximately 250 feet at the western edge of the installation to approximately 850 feet at the east end of the installation. In the central portion of Alameda Point, the formation is about 600 feet thick; the upper layers of estuarine clays and silts are similar to those deposited in the San Francisco Bay (Rogers and Figuers 1991).

Franciscan Complex. Most of Alameda Point overlies the western side of the bedrock trough discussed in Section 2.3.1. Bedrock of the Franciscan Complex underlies Alameda Point at elevations ranging from approximately 400 to 950 feet below mean sea level. The bedrock surface under Alameda Point dips to the east-southeast at an angle of approximately 1 degree (Rogers and Figuers 1991). The axis of the bedrock depression in the San Francisco Bay area is oriented northwest to southeast and is coincident with the eastern part of Alameda Point.

2.4 HYDROGEOLOGY

This section describes the regional hydrogeology and hydrogeology of Alameda Point.

2.4.1 Regional Hydrogeology

Alameda Point is near the center of the San Francisco Basin, one of three groundwater basins beneath the greater San Francisco Bay area. The groundwater basins are elongated, sediment-filled troughs oriented in a northwest-southeast direction, parallel to the trend of regional geologic structural features. The lower half of the San Francisco Basin is filled with continental units; the upper part of the San Francisco Basin is filled with an alternating sequence of marine and continental units.

Generally, regional aquifers identified in the San Francisco Basin correspond with the continental and alluvial fan deposits and regional aquitards correspond with estuarine mud deposits such as the Young Bay Mud and the Yerba Buena Mud. Aquifers in east San Francisco Bay extend east to the Hayward Fault, where they merge into a vertically continuous, coarse-grained alluvial fan sequence. The aquifers are nonhomogeneous, with the particle size of materials generally becoming smaller from east to west. The aquifers can exhibit significant lateral and vertical variations, which reflect changes in the natural localized depositional environments.

Three primary aquifers in the east San Francisco Bay area consist of (from upper to lower) the Newark, Centerville, and Fremont Aquifers. The Newark Aquifer is contained within sediments of the San Antonio and Merritt Sand Formations and is generally 100 to 150 feet thick in the region. It is confined in the areas where the Merritt Sand is overlain by the Young Bay Mud, which is called the Newark Aquitard in these areas. The Newark Aquifer is unconfined in areas where the Young Bay Mud is absent.

The Newark Aquifer is confined below by the Irvington Aquitard. The Irvington Aquitard is contained in fine-grained sediments of the Yerba Buena Mud. The Irvington Aquitard acts as a confining unit for the Centerville Aquifer, which underlies the Irvington Aquitard and is contained in the upper part of the Alameda Formation.

Below the Centerville Aquifer is the Fremont Aquifer, which corresponds with continental sediments deposited at an earlier time period. This deeper aquifer is confined by estuarine sediments in the upper portion of the Alameda Formation (Figuers 1998).

2.4.2 Installation Hydrogeology

Groundwater occurs as an unconfined aquifer within artificial and natural unconsolidated deposits underlying Alameda Point, at depths ranging from approximately 6 feet bgs in the southeastern portion of the installation to approximately 10 feet bgs in the central and western portions. Groundwater also occurs under semiconfined and confined conditions at Alameda Point, in areas where the BSU functions as an aquitard.

Section 2.4.2.1 describes the hydrostratigraphy or system of aquifers and intervening aquitards underlying Alameda Point. The water-bearing units encountered at Alameda Point have been named based on their sequence in the subsurface; the aquitards are named based on the formation they are in (see Figure 2-3). The local hydrostratigraphic units at Alameda Point correlate with regional hydrostratigraphic units described in Section 2.3.1. Section 2.4.2.2 describes the regional subdivisions of Alameda Point, and Section 2.4.2.3 describes groundwater flow at Alameda Point.

2.4.2.1 Hydrostratigraphy

Five local hydrostratigraphic units are identified at Alameda Point. Water-bearing units include the first water-bearing zone (FWBZ) (Newark Aquifer) and the second water-bearing zone (SWBZ) (confined Newark Aquifer). The FWBZ and the SWBZ are separated by the BSU (Newark Aquitard). The occurrence of the SWBZ depends on the presence of the BSU, which acts as an aquitard separating the FWBZ and the SWBZ. The water-bearing units are underlain by the Yerba Buena Aquitard (Irvington Aquitard). The text below describes the hydrostratigraphic units (beginning at the top) at Alameda Point.

First Water-Bearing Zone

The FWBZ is an unconfined aquifer that occurs within the uppermost permeable units at Alameda Point, primarily the artificial fill materials (if present) or the Merritt Sand and the Upper San Antonio Formation in areas where the artificial fill and BSU are absent. Groundwater in most of the FWBZ at Alameda Point is fresh, but may be brackish (slightly saline) in areas near the San Francisco Bay shoreline.

The FWBZ in the artificial fill occurs mainly in the western and central parts of Alameda Point and in a portion of the southeastern area of Alameda Point. The FWBZ in the artificial fill extends vertically to the base of the fill except in localized zones, where more permeable materials occur in the upper part of the underlying BSU. In that case, the permeable part of the BSU functions as part of the FWBZ. In other areas where the BSU consists of low permeability materials, it acts as a confining layer below the FWBZ in the artificial fill.

The FWBZ is subdivided into upper and lower units in areas where the BSU functions as part of the FWBZ. The portion of the FWBZ in the artificial fill is referred to as the first-water bearing zone upper (FWBZU), and the portion in the BSU is referred to as the first water-bearing zone lower (FWBZL). The FWBZU consists of a thin layer of artificial fill and the upper portion of the Merritt Sand, and the FWBZL consists of the lower portion of the Merritt Sand and the upper San Antonio Formation.

In portions of the southeastern part of Alameda Point, where the BSU does not occur in a continuous layer, the FWBZ occurs primarily in the artificial fill (where present), the Merritt Sand Formation, and the underlying Upper San Antonio Formation. In those areas, the FWBZ extends vertically to the top of the Yerba Buena Mud (Lower San Antonio Formation), which acts as a confining layer below the FWBZ.

There is no connection between the shallow aquifer systems in artificial fill materials on Alameda Island and the Oakland mainland because Oakland Inner Harbor bisects the Merritt Sand unit. The Merritt Sand unit on Alameda Island is hydraulically isolated from mainland aquifers.

Bay Sediment Unit Aquitard

The BSU functions as an aquitard in areas where it is present and consists of fine-grained, low-permeability materials. In other areas, where it consists of higher permeability materials, the BSU forms the lower portion of the FWBZ.

Second Water-Bearing Zone

The SWBZ is a semiconfined and confined aquifer that occurs within the Merritt Sand and the Upper San Antonio Formation. The SWBZ is found only in portions of Alameda Point where the overlying BSU is both present and consists of low-permeability materials, so it acts as a confining unit for the SWBZ. The SWBZ extends to the top of the Yerba Buena Mud, which functions as a confining unit below the SWBZ. The SWBZ is present near the shoreline in the southeastern portion of Alameda Point. Groundwater in SWBZ at Alameda Point is brackish to saline.

Yerba Buena Mud Aquitard

The Yerba Buena Mud functions as an aquitard that underlies Alameda Point. The top of the Yerba Buena Mud has been encountered in some borings drilled at Alameda Point, but no borings advanced during the remedial investigation have drilled through the entire unit. Based on available data, the thickness of the Yerba Buena Mud Aquitard underlying Alameda Point is approximately 50 to 90 feet. As such, the Yerba Buena Mud Aquitard most likely is continuous beneath Alameda Point, which limits or prevents hydraulic communication between the FWBZ and SWBZ and the underlying Alameda Aquifer.

The thickness of the Yerba Buena Mud Aquitard underlying the Oakland Inner Harbor is approximately 50 to 110 feet. The presence of the aquitard prevents mixing of fresh water in the

Alameda Formation with saline water in the more shallow aquifers (Subsurface Consultants, Inc. 1998).

Alameda Aquifer

The Alameda Aquifer is a confined, regional drinking water aquifer that occurs in the Alameda Formation (Tetra Tech 2000c). This aquifer is the installation equivalent of the regional Centerville Aquifer (see Section 2.4.1). The Alameda Aquifer is confined by the overlying Yerba Buena Mud Aquitard. The Alameda Formation yields fresh water (Hickenbottom and Muir 1998) and most likely is isolated hydraulically from overlying saline aquifers based on pumping tests conducted in the Alameda Formation, during which no response was measured in overlying units (Hydro-Search, Inc. [HSI] 1977).

2.4.2.2 Installation Regional Subdivisions

Alameda Point has been divided into three regions based on geologic and hydrogeologic similarities: the southeastern, western, and central regions (see Figure 2-5). The hydrostratigraphy of each of these regions is described below.

Southeastern Region Hydrostratigraphy

In the southeastern region of Alameda Point, the BSU is discontinuous, thin, or is absent. The BSU does not occur east of the former shoreline. Where the Bay Sediment Aquitard occurs, the FWBZ is within a thin layer of artificial fill, and the SWBZ is in the Merritt Sand and the Upper San Antonio Formation. Where the Bay Sediment Aquitard does not occur, the FWBZ is within a thin layer of artificial fill, but primarily in the Merritt Sand and the Upper San Antonio Formation, which together are approximately 65 to 80 feet thick. The correlations of Alameda Point geologic and hydrogeologic units are illustrated on Figure 2-3.

Western and Central Region Hydrostratigraphy

In the western and central region of Alameda Point, the FWBZ occurs primarily in the artificial fill materials. The saturated thickness of the FWBZ ranges from less than 10 feet in the central region to over 30 feet in the western region. In the western region, the upper portion of the BSU consists entirely of silt and clay. However, in the southern part of the central region, the upper portion of the BSU contains interbedded silt and sand allowing that portion of the BSU to be included in the FWBZ.

The SWBZ occurs within the Merritt Sand and the Upper San Antonio Formation in the western region and the central region. The SWBZ in these regions are confined locally and contained in the lower portion of the BSU, the Merritt Sand Formation (where present), and the Upper San Antonio Formation.

The SWBZ is underlain by the Yerba Buena Mud aquitard, which is approximately 60 feet thick in the western region and the central region of Alameda Point.

2.4.2.3 Groundwater Flow

Shallow groundwater at Alameda Point flows in a radial pattern toward San Francisco Bay, Oakland Inner Harbor, or Seaplane Lagoon in the FWBZ. Groundwater flow directions vary locally as a result of seasonal changes in precipitation rates and diurnal variations related to tidal cycles. Groundwater in the southeast region of the base generally flows from the east or northeast inland areas to the west toward the Seaplane Lagoon and the San Francisco Bay. A sheet-pile wall located along the eastern edge of the Seaplane Lagoon has resulted in mounding of groundwater to the east of the Seaplane Lagoon. Groundwater is recharged by vertical infiltration of precipitation, horticultural irrigation, leaking water supplies, and from sanitary or storm sewer pipes. Tidal inundation of storm water conveyance lines also may contribute to recharge of the FWBZ.

Groundwater in the FWBZ within the central and western regions of Alameda Point generally flows in a radial pattern toward the San Francisco Bay, the Oakland Inner Harbor, and the Seaplane Lagoon. A sheet-pile wall located along the northern edge of the Seaplane Lagoon has resulted in mounding of groundwater to the north of the Seaplane Lagoon. Groundwater flow is affected locally near industrial buildings by preferential flow paths such as storm water drains and underground utility conveyance structures. The FWBZ is tidally influenced on the northern, western, and southern sides of Alameda Point. Tidal influence studies indicated the region of influence extends about 250 to 300 feet inland on the northern and southern sides of Alameda Island and about 1,000 to 1,500 feet inland on the west side. Diurnal tidal fluctuations measured in the FWBZ range from 0.1 to 4 feet (Tetra Tech 1997b).

The SWBZ appears to be a semiconfined aquifer and is made of the silty sands within the lower portion of the BSU, the Merritt Sand Unit, and the upper unit of the San Antonio formation. The potentiometric elevations of the SWBZ range from 3 to 9 feet above mean low low water.

The upper and lower units of the San Antonio Formation underlie the Merritt Sand. The lower unit, the Yerba Buena Mud, is believed to be both locally and regionally continuous and a significant barrier to potential contaminant migration. This observation is supported by (1) numerous local and regional boring logs showing an extensive, coherent stratigraphic unit; (2) the fact that the underlying Alameda Formation yields fresh water while the overlying Merritt Sand and upper unit of the San Antonio Formation yield saline to hypersaline water (Hickenbottom and Muir 1988); and (3) pumping tests performed in the Alameda Formation during which no drawdown was observed in the overlying Merritt Sand or upper unit of the San Antonio Formation (HSI 1977).

The SWBZ is recharged mainly by lateral flow (through the Merritt Sand) from upgradient areas on Alameda Island. Another source of recharge may be the upper unit of the San Antonio Formation, although the small thickness and discontinuity of the water-bearing zones within the upper unit of the San Antonio Formation would preclude a significant contribution. The sources of recharge for the Merritt Sand unit are precipitation; irrigation; and pipe leakages from water supply, sanitary sewer, and storm sewer systems. The SWBZ is believed to discharge through lateral groundwater flow to the San Francisco Bay, the Oakland Inner Harbor, and the Seaplane Lagoon.

2.4.3 Existing Uses of Groundwater

Groundwater beneath Alameda Point was evaluated for potential beneficial uses in 2000 (Tetra Tech 2000c). U.S. Environmental Protection Agency's (EPA) "Guidelines for Groundwater Classification Under the EPA Groundwater Protection Strategy" were used to classify groundwater as Class I, II, or III (EPA 1988a). Class I groundwater is an irreplaceable source of drinking water or is ecologically vital. Class II groundwater is a current or potential source of drinking water that has other beneficial uses. Class III groundwater is not a potential source of drinking water and is of limited beneficial use. EPA classifies groundwater having an existing or potential use as a drinking water supply (Class I or II) using the following criteria: a total dissolved solids (TDS) concentration less than 10,000 milligrams per liter (mg/L) and a minimum well yield of 150 gallons per day. Under Resolution No. 88-63 (California State Water Resources Control Board 1988), all groundwater is considered potentially suitable for municipal or domestic supply, unless the TDS content exceeds 3,000 mg/L or a well cannot provide a sustainable yield of 200 gallons per day. The state identifies other potential beneficial uses of groundwater, including industrial service and industrial supply, agricultural supply, and freshwater replenishment (California Regional Water Quality Control Board 1995). For the purposes of Comprehensive Environmental Response, Compensation, and Liability Act response actions, EPA's guidelines are used to classify groundwater, because (1) EPA guidelines for TDS and well yield are more conservative than state criteria and (2) the State of California does not have an EPA-approved comprehensive state groundwater protection plan.

Based on federal TDS and yield criteria, the FWBZ in the southeastern portion of Alameda Point beneath Sites 3, 4, 11, and 21 is a Class II aquifer. The FWBZ in the southeastern region of Alameda Point is connected to another Class II groundwater (Merritt Sand) that is a drinking water source for off-base wells. Sixty upgradient wells are screened in the Merritt Sand immediately east (up to 1 mile) of Alameda Point, and an additional 113 upgradient wells are screened in the Merritt Sand, between 1 and 2 miles east-southeast of Alameda Point. Most wells were installed during the 1970s to provide a supplemental source of irrigation water for homeowners on Alameda Island. During a recent backflow prevention device field survey, East Bay Municipal Utilities District found that many of the wells are no longer in use; however, some of the wells are still used for backyard irrigation. No restrictions exist on the type of well use (domestic supply, industrial supply, or irrigation) (Tetra Tech 2000c).

The EPA Well Head Protection Area model was used to assess whether an off-base well could capture a groundwater contaminant plume from the southeastern region of Alameda Point. The model indicated that plume capture was possible at pumping rates of 3 gallons per minute (Tetra Tech 2000c).

The existence of these wells, as well as the classification of the aquifer as Class II, indicates that groundwater in this area is a potential and possibly current drinking water source. Other possible uses for groundwater would be for watering livestock and crop irrigation. Industrial uses would require pretreatment for TDS. It is highly unlikely that water below Alameda Point will be used for watering livestock based on the proposed land uses.

2.5 ECOLOGY

This section summarizes the ecology of the San Francisco Bay area and Alameda Point. It describes the ecological regions, soil types, habitats, and dominant species, including special-status species found in the San Francisco Bay area and at Alameda Point.

2.5.1 Regional Ecology

The San Francisco Bay area is situated in the California coastal chaparral forest and scrub province of the Mediterranean division and includes the discontinuous coastal plains. The coastal province has a more moderate climate than the interior and receives some moisture from fog in the summer. These coastal plains are characterized by sagebrush and grassland communities. Exposed coastal areas support desert-like shrub communities called coastal scrub, dominated by coyote bush (*Baccaris pitularis*), California sagebrush (*Artemisia californica*), and bush lupine (*Lupinus arboreus*). Most of the coastal plains in the San Francisco Bay area have been converted to urban use; however, the area continues to be a major resource and migration route for both aquatic and terrestrial birds (Bailey 1995).

2.5.2 Habitat Types and Dominant Species

Through literature sources, the following six major terrestrial and aquatic wildlife habitats were identified at Alameda Point (Navy 1999c):

- Open Water Area
- Grassland Area
- Landscaped or Developed Area
- Intensively Developed Area
- Airfield (Paved) Area
- Rock Breakwaters and Riprap Area

Sites 3, 4, 11, and 21 are considered Intensively Developed areas and are bordered by Intensively Developed or Landscaped areas (see Figure 2-6). The Intensively Developed areas consist primarily of buildings, roads, and parking lots and have little vegetation (Navy 1999c). These areas are primarily in the eastern end of Alameda Point. Typical urban wildlife, such as California ground squirrel (*Spermophilus beecheyi*), scrub jays (*Aphelocoma inularis*), and American robins (*Turdus migratorius*), may be observed in the intensively developed areas, but to a lesser extent than in the landscaped or developed areas because less foraging habitat is available in these areas. Feral cats also are found in the intensively developed area.

2.5.3 Special-Status Species

Special-status species that occur or are expected to occur at Alameda Point were identified by the U.S. Fish and Wildlife Service in 1993, and a search of the California Department of Fish and Game Natural Diversity Database also was conducted in October 2003. Table 2-1 summarizes special-status species identified within the vicinity of Alameda Point. The species are federal- or state-designated threatened or endangered species. Some species do not receive legal status under federal or state endangered species acts, but are identified by the state as "Species of Special Concern."

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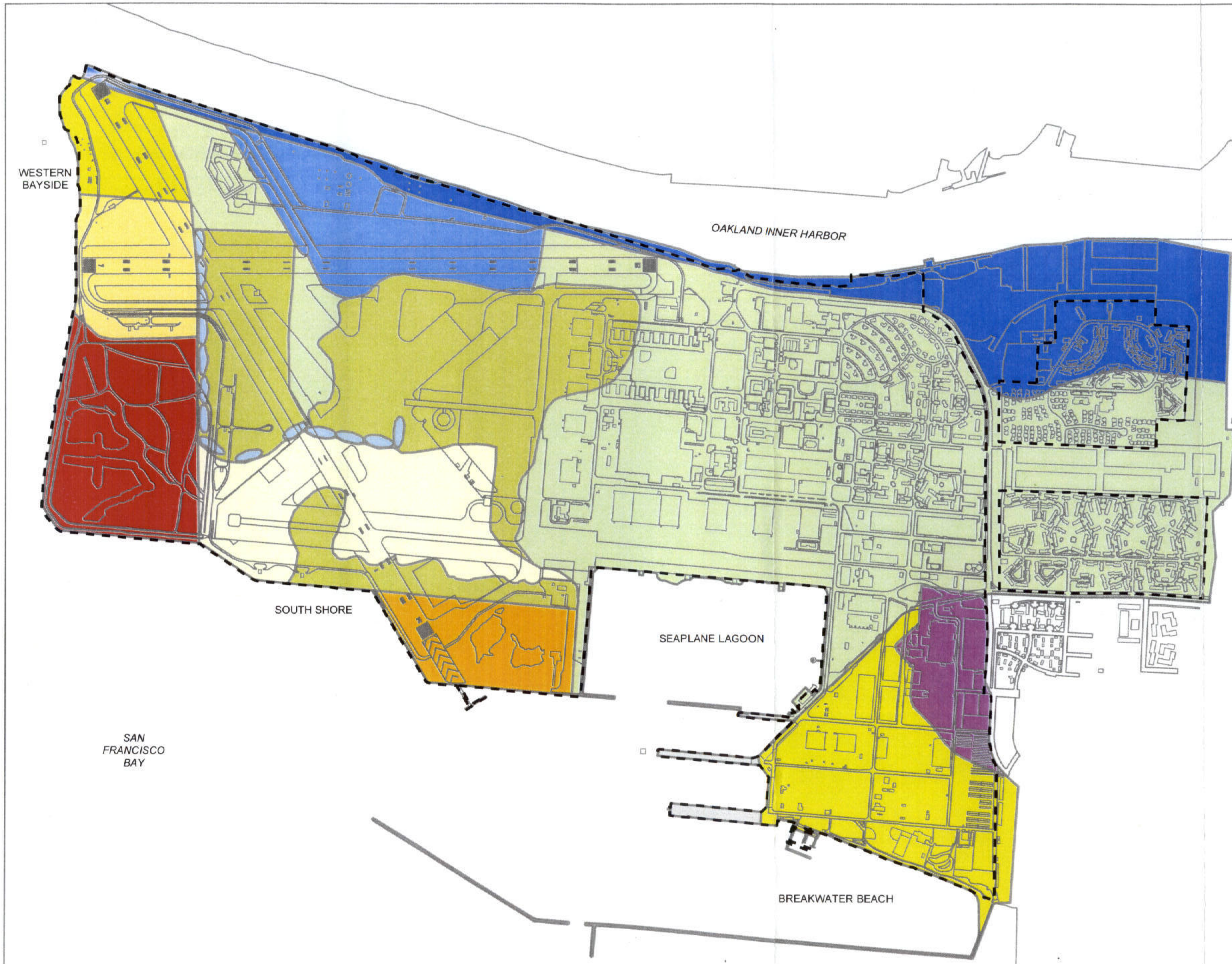
FIGURES

FINAL OPERABLE UNIT 2B REMEDIAL INVESTIGATION REPORT SITES 3, 4, 11, AND 21

DATED 05 AUGUST 2005



SulTech

Alameda Point
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-1
FILL HISTORY

Operable Unit 2B
Remedial Investigation Report

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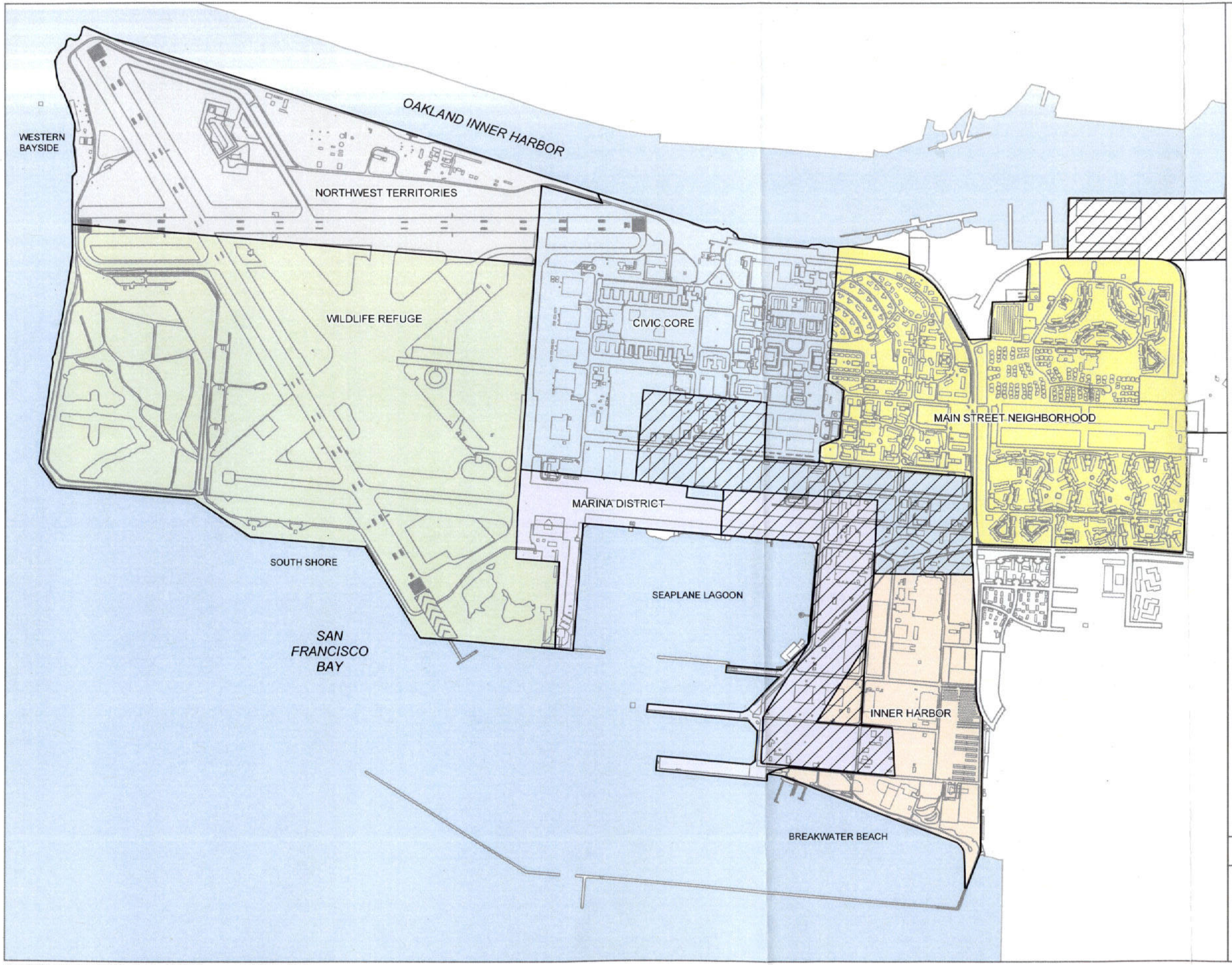

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Alameda Point
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-2
PLANNED REUSE AREAS

Operable Unit 2B
Remedial Investigation Report

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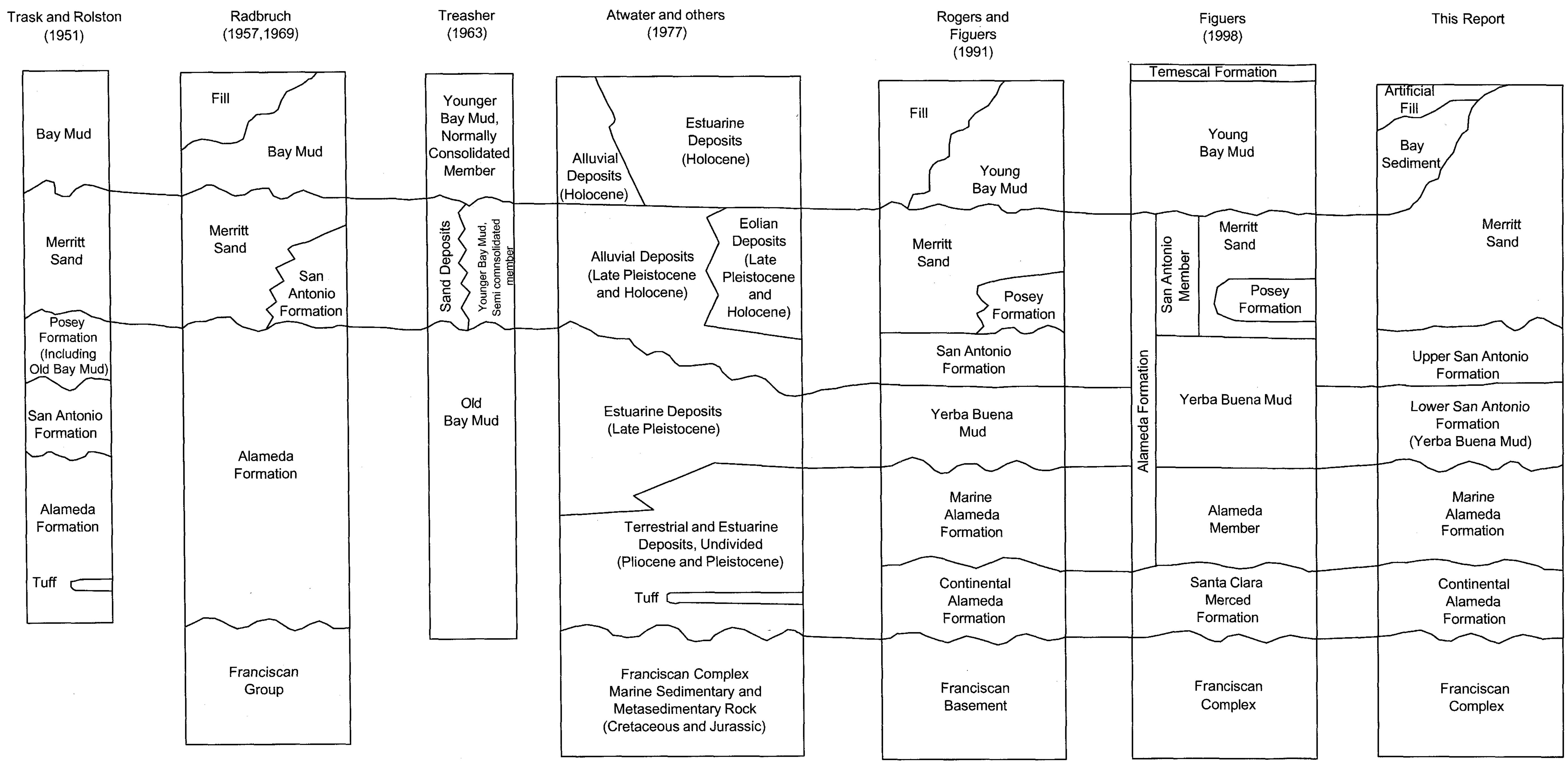
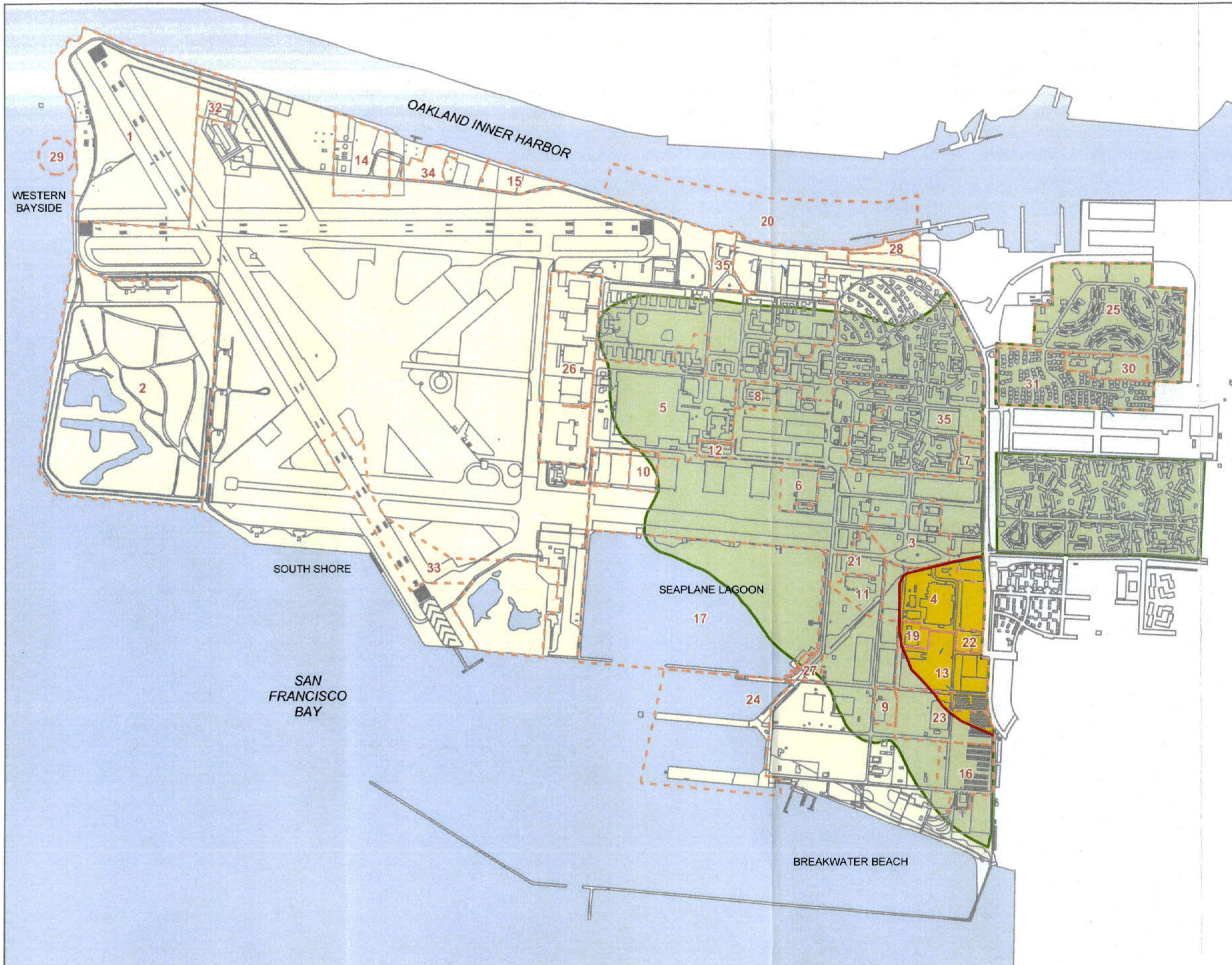


Notes:
1. Zig-Zag lines indicate inter-fingering of time equivalent units
2. Wavy lines indicate unconformaties

Tetra Tech EM Inc.

Alameda Point
U.S. Navy Southwest Division, NAVFAC, San Diego

FIGURE 2-3
CORRELATION OF STRATIGRAPHIC INTERPRETATIONS OF PREVIOUS INVESTIGATIONS
Operable Unit 2B
Remedial Investigation Report



EXTENT OF BAY SEDIMENT UNIT

AREA SUBJECT TO MARSH CRUST RESTRICTIONS

EXTENT OF FORMER ISLAND 1865 (RADBRUCH 1957)

CERCLA SITE BOUNDARY

LAND COVER

WATER

Notes:
Source: City of Alameda, California. 2000. "Excavation into the Marsh Crust/Subtidal Zone at the Former Naval Air Station Alameda and Fleet and Industrial Supply Center (FISC), Alameda Annex and Facility." Ordinance No. 2824
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980

600 0 600 1200 Feet

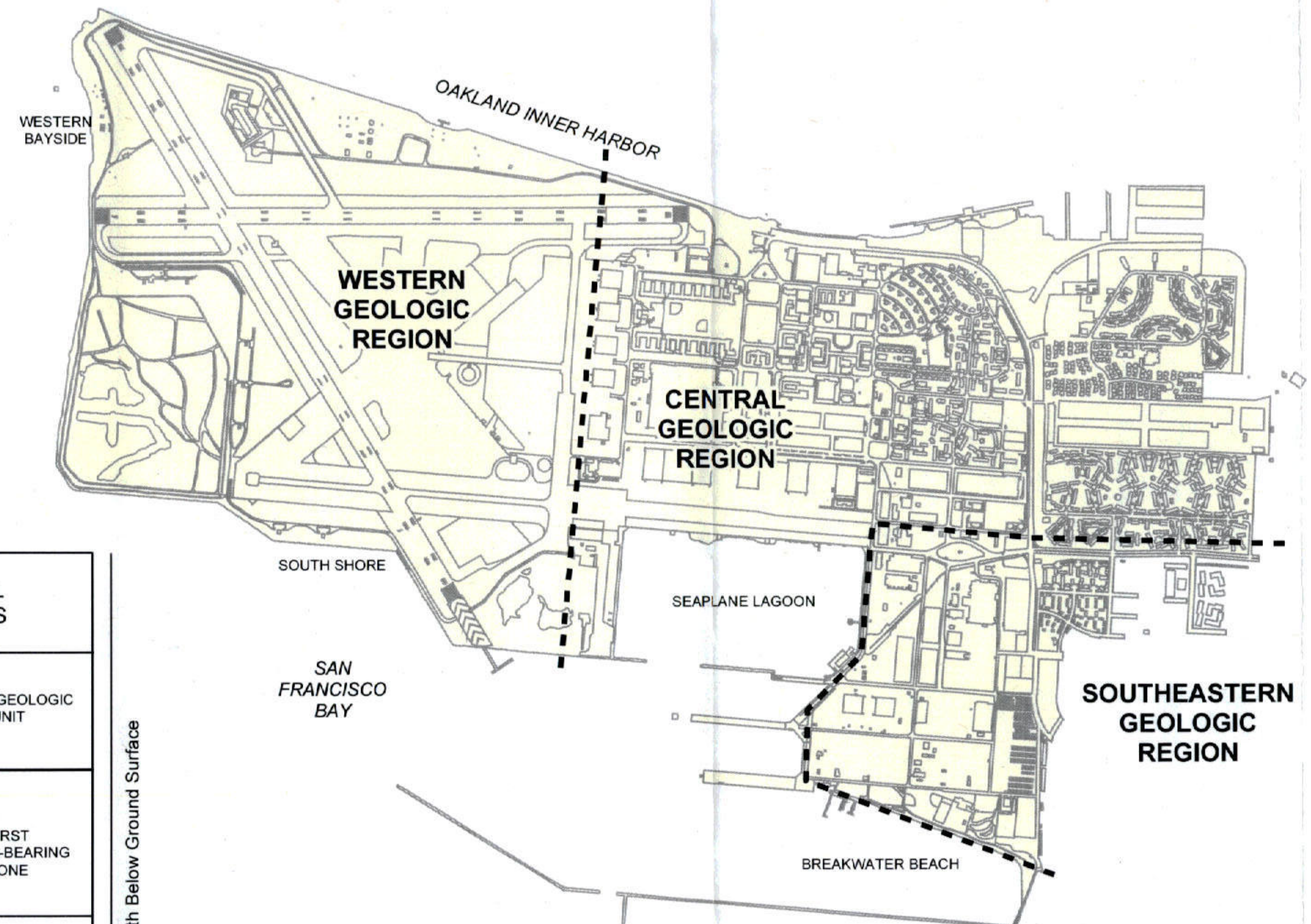
SulTech

Alameda Point
Department of the Navy, BRAC PMO West, San Diego, California

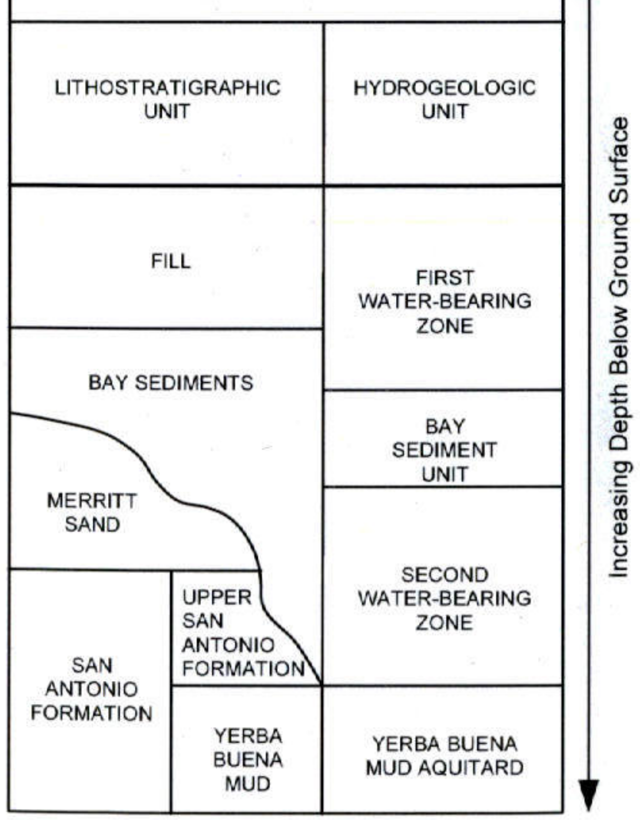
FIGURE 2-4
EXTENT OF BAY SEDIMENT UNIT AND MARSH CRUST AREA

Operable Unit 2B
Remedial Investigation Report

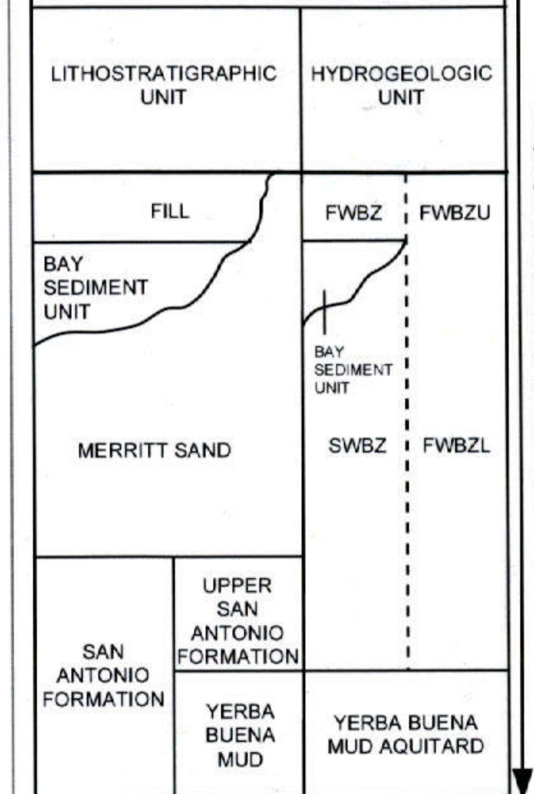
2005-03-15 U:\almda_sa\do30\ou2b_ri\mxd\fig02-04_marsh_crust.mxd TtEMI-SA K. Johnson



WESTERN/CENTRAL GEOLOGIC REGIONS



SOUTHEASTERN GEOLOGIC REGIONS



Notes:

The FWBZU in the Southeastern Geologic Region communicates with the FWBZU in the Central Geologic Region where the Bay Sediment Unit pinches out near CERCLA Site 3. The FWBZL in the Southwestern Geologic Region becomes and communicates with the SWBZ in the Central Geologic Region north and west of CERCLA Site 3.

FWBZ = First Water-Bearing Zone
FWBZU = Upper First Water-Bearing Zone
FWBZL = Lower First Water-Bearing Zone
SWBZ = Second Water-Bearing Zone

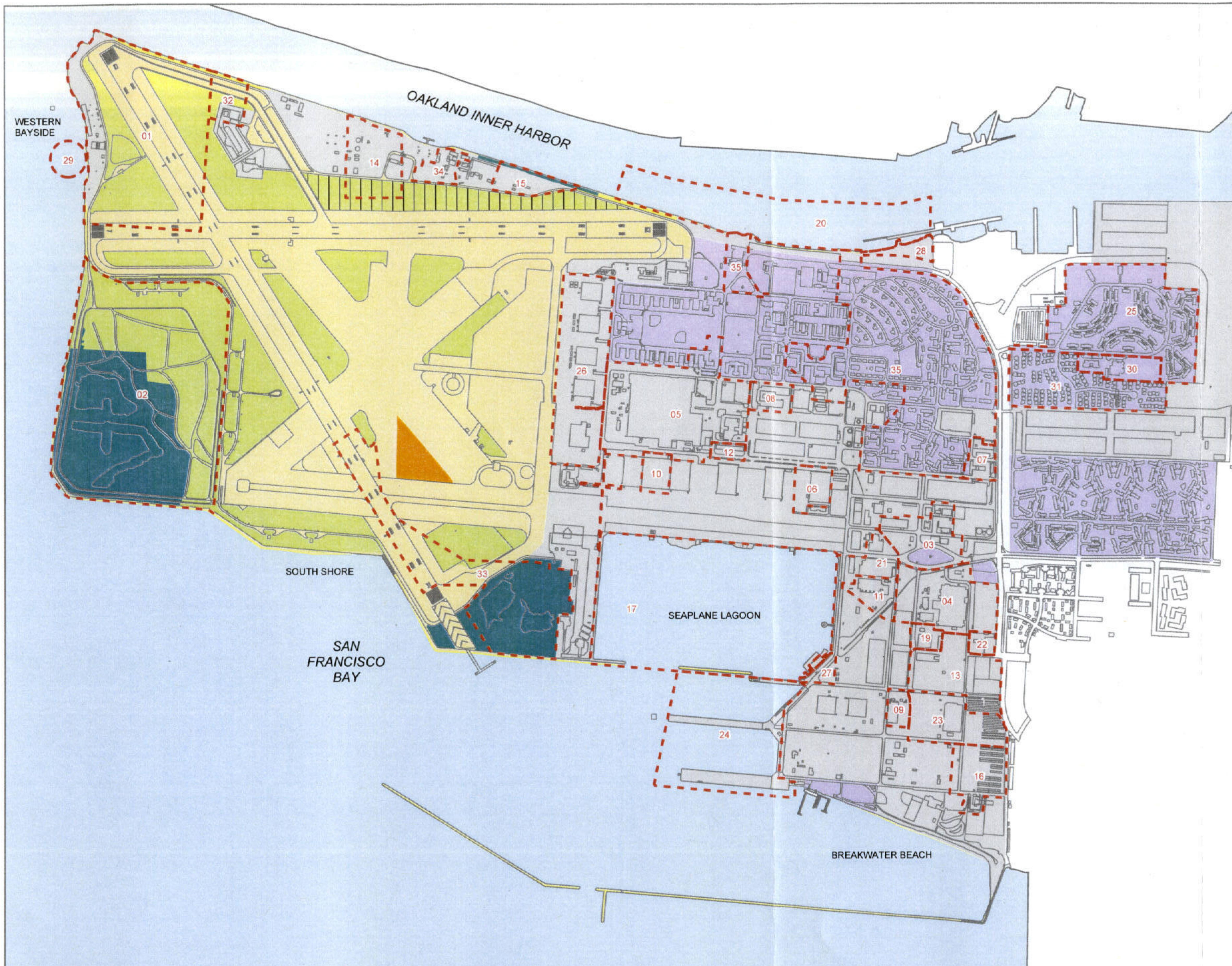
800 0 800 1600 Feet

SulTech

Alameda Point
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-5
INSTALLATION GEOLOGIC AND HYDROGEOLOGIC DIVISIONS

Operable Unit 2B
Remedial Investigation Report



HABITAT

- Airfield (Paved)
- California Least Tern Sanctuary
- Grassland
- Intensively Developed
- Landscaped/Developed
- Rock Breakwaters/Rip Rap
- Surveyed Grassland
- Wetland
- CERCLA SITE BOUNDARY
- LAND COVER
- WATER

Notes:

CERCLA = Comprehensive Environmental Response, Compensation and Liability Act of 1980

600 0 600 1200 Feet

SulTech

Alameda Point

Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-6
ECOLOGICAL HABITAT MAP

Operable Unit 2B
Remedial Investigation Report

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ALAMEDA POINT
SSIC NO. 5090.3

TABLES

FINAL OPERABLE UNIT 2B REMEDIAL INVESTIGATION REPORT SITES 3, 4, 11, AND 21

DATED 05 AUGUST 2005

TABLE 2-1: SPECIAL STATUS SPECIES
Remedial Investigation Report for CERCLA Sites 3, 4, 11, and 21, Alameda Point, Alameda, California

	COMMON NAME	SCIENTIFIC NAME	STATUS
PLANTS	Alkali milk-vetch	*Astragalus tener var. tener*	SC
	Beach layia	*Layia carnosa*	FE, SE
	Bent-flowered fiddleneck	*Amsinckia lunaris*	SC
	Knot grass (Kellogg's horkelia)	*Horkelia cuneata ssp. sericea*	SC
	Robust spinflower	*Chorizanthe robusta var. robusta*	FE
	Rose linanthus	*Linanthus rosaceus*	SC
	Round-leaved filaree	*Erodium macrophyllum*	Not listed
	Saline clover	*Trifolium depauperatum var. hydrophilum*	SC
	San Francisco Bay spineflower	*Chorizanthe cuspidate var. cuspidate*	SC
	Santa Cruz tarplant	*Holocarpha macradenia*	FT, SE
	Kellogg's horkelia	*Horkelia cuneata sericea*	SC
	Point Reyes bird's beak	*Cordylanthus maritimus palustris*	FE
BIRDS	California least tern[a]	*Sterna antillarum browni*	FE, SE
	White-tailed kite	*Elanus leucurus*	SC
	Double-crested cormorant, rookery sites	*Phalacrocorax auritus*	C
	California black rail	*Laterallus jamaicensis coturniculus*	SC
	California clapper rail	*Rallus longirostris obsoletus*	FE, SE
	Northern harrier	*Circus cyaneus*	C
REPTILE	California tiger salamander	*Ambystoma californiense*	FE
FISH	Tidewater goby	*Eucyclogobius newberryi*	FE, C
MAMMALS	Saltmarsh harvest mouse[b]	*Reithrodonomys raviventris*	FE, SE

Notes:
C State Species of Concern
FE Federally endangered
FT Federally threatened
SC Federal Species of concern
SE State endangered
[a] Nesting colonies within Alameda Point, west of the sites.
[b] In 1995, a survey for the saltmarsh harvest mouse was conducted in the West Beach Landfill and the Runway Area Wetlands to identify potential receptors for evaluation in ecological risk assessments being conducted by the Navy for the IR Program. No individuals were captured during these surveys of the West Beach Landfill and Runway Area Wetlands.

Source: California Department of Fish and Game Natural Diversity Data Base, Oakland West Quadrangle, October 21, 2003.

3.0 REMEDIAL INVESTIGATION APPROACH

This section describes the regulatory status and the general remedial investigation (RI) approach used at Sites 3, 4, 11, and 21. Section 3.1 describes the regulatory status of Alameda Point and specifically the regulation of Sites 3, 4, 11, and 21 under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which provide the framework for this RI approach. The approach used to conduct the RI includes the following steps: (1) scoping, (2) environmental investigations, (3) data evaluations, and (4) conclusions. Section 3.2 presents the approach used to scope the RI, including identification of potential sources at each site, media potentially affected, data needs, and development of an initial conceptual site model (CSM). Section 3.3 summarizes previous environmental investigations conducted at Alameda Point in support of the Installation Restoration (IR) Program (CERCLA, environmental baseline survey [EBS], Total Petroleum Hydrocarbon [TPH] Program, and Resource Conservation and Recovery Act [RCRA]) and to verify the initial CSM.

Section 3.4 presents the data evaluation methods. The purpose of this section is to present what is known about the sites and to identify the process used to evaluate the data in support of the CERCLA risk management process. Section 3.5 describes the procedures used to assess data quality for use in this RI; to develop site-specific CSMs; and to conduct background comparisons, nature and extent evaluations, fate and transport evaluations, a human health risk assessment (HHRA), and an ecological risk assessment (ERA). Section 3.5 presents the conclusions of the RI based on results of data evaluation.

Results of this approach are presented in a similar order in the site-specific sections (see Sections 5.0 through 9.0). Soil data and one discrete lead groundwater plume were evaluated by site (see Sections 5.0 through 8.0). Because a groundwater plume was formed by the convergence of groundwater plumes emanating from multiple operable unit (OU)-2B sites, this OU-wide groundwater plume was evaluated separately (see Section 9.0), so the cumulative effects of the OU-wide groundwater contaminants were addressed.

3.1 REGULATORY STATUS

One of the consequences of the operations that occurred at Alameda Point during its years of operation was the release of contamination to soil, sediments, and water. In 1982, the U.S. Department of the Navy (Navy) began investigations of contaminated sites under the Navy Assessment and Control of Installation Pollutants (NACIP) Program. Under the NACIP Program, 12 sites were evaluated during an initial assessment study (IAS) and based on results of the IAS, additional study was recommended at seven of these sites, including Sites 3 and 4 (Ecological & Environment [E&E] 1983). In 1988, the Navy received a Remedial Action Order from the California Department of Health Services (now known as the California Department of Toxic Substances Control [DTSC]) that identified an additional 16 sites for evaluation.

In 1986, the Superfund Amendment and Reauthorization Act (SARA) formally established authority and funding for the Defense Environmental Restoration Program (Title 10 *United States Code* [USC] 2701-2708 and 2810) to guide U.S. Department of Defense (DoD) cleanups.

Section 2701 of Title 10 USC codified the Defense Environmental Restoration Program. SARA also accomplished the following:

- Established CERCLA as a statutory requirement for DoD
- Modified terminology and procedures to match those provided in the National Oil and Hazardous Substances Contingency Plan (NCP)
- Gave U.S. Environmental Protection Agency (EPA) and states broad power to review, comment, and, in some instances, approve documents and decisions
- Established specific reporting requirements
- Made federal facilities subject to listing on the National Priorities List (NPL)
- Mandated interagency agreements between EPA and federal facilities on the NPL

In 1987, Executive Order 12580 delegated CERCLA authority to DoD. CERCLA, commonly known as Superfund, (1) established prohibitions and requirements concerning closed and abandoned hazardous waste sites, (2) provided for liability of persons responsible for releases of hazardous substances at these sites, and (3) established a trust fund to provide for cleanup when no responsible party could be identified.

Congress directed that DoD environmental cleanup efforts be consistent with CERCLA. Additionally, CERCLA itself requires that cleanup efforts at federal facilities be conducted under CERCLA. Due to these reasons, and in order to have a common framework for managing a national cleanup program, DoD uses CERCLA as the primary legislative authority for managing cleanup of DoD sites. As the lead agency for cleanup under CERCLA, DoD also can take advantage of existing CERCLA authorities (such as removal actions) to expedite cleanup. The Defense Environmental Restoration Program governs the IR Program at Alameda Point.

In 1988, Congress passed the Base Closure and Realignment Act. This act (together with subsequent base closure laws) established the basic requirements for identifying and implementing domestic military base closures and realignments, including the transfer of surplus property from DoD to other entities. One element of the act was to require that all property to be transferred must be done in accordance with Section 120(h) of CERCLA. In 1992, the Community Environmental Response Facilitation Act amended Section 120(h) of CERCLA. This amendment required that DoD identify and document all uncontaminated real property, or parcels thereof, at installations undergoing closure or realignment. The mechanism identified for this documentation was an EBS.

When Naval Air Station (NAS) Alameda was listed for closure in 1993, responsibility for the environmental cleanup program at Alameda Point passed to the Base Realignment and Closure (BRAC) Cleanup Team (BCT). At Alameda Point, the BCT comprises representatives from Navy, EPA, San Francisco Bay Regional Water Quality Control Board (RWQCB), and DTSC.

The BCT provides oversight of investigations. In addition to the BCT, a restoration advisory board (RAB) provides community involvement in the cleanup program.

After NAS Alameda was identified for closure, an EBS (ERM-West, Inc. 1994 and IT 2001a) was performed to identify the environmental condition of all property affected by base closure, a program began to decommission all underground storage tanks (UST), and ongoing environmental cleanup programs were coordinated with property conversion and reuse activities. As a part of the program to decommission all USTs, TPH contamination was evaluated under the TPH Program and corrective action areas (CAA) were developed. The corrective action program for these petroleum-impacted areas is overseen by RWQCB, in cooperation with DTSC and EPA.

In July 1999, EPA listed Alameda Point as an NPL site (EPA 1999b). This listing included all of Alameda Point except for those parcels that have received regulatory agency concurrence pursuant to Section 120(h) of CERCLA. The listing of Alameda Point on the NPL invokes the remedial requirements of the NCP (EPA 1994c) and requires EPA's concurrence with uncontaminated property designations. The Navy also is required to negotiate and sign an interagency agreement with EPA. Navy and EPA signed the Federal Facility Agreement in 2001.

In addition to CERCLA, Alameda Point also has been regulated under RCRA. RCRA regulations provide for the "cradle-to-grave" tracking of hazardous wastes by establishing recordkeeping requirements for hazardous waste generation, transportation, storage, and disposal. Alameda Point was listed in the May 1992 RCRA database as a large-quantity hazardous waste generator and a treatment, storage, and disposal facility.

At Alameda Point, DTSC regulated the storage and treatment of RCRA hazardous waste through two operating permits (RCRA Part A and RCRA Part B). In November 1980, the Navy originally applied to DTSC for a RCRA Part A permit (also known as an interim status document); the application covered four hazardous waste storage tanks (Tetra Tech EM Inc. [Tetra Tech] 2003b). In March 1981, an interim status document was issued by DTSC for the waste container storage facility at Alameda Point (DTSC 1992). Throughout the rest of the 1980s and into the early 1990s, several revisions to the RCRA Part A interim status permit were approved by DTSC (Tetra Tech 2003b). In 1992, DTSC conducted a RCRA facility assessment (RFA) at Alameda Point (DTSC 1992). Its primary purpose was to identify solid waste management units (SWMU) and areas of concern (AOC) and to collect preliminary information on all actual or potential contaminant releases to evaluate the need and scope of a RCRA facility investigation (RFI). The 1992 RFA identified certain RCRA facilities that were already being evaluated under the Navy's IR Program. DTSC recommended a low priority for these sites to avoid duplication with CERCLA investigations (DTSC 1992). In July 1993, DTSC issued a RCRA Part B permit for seven hazardous waste facilities at Alameda Point (Tetra Tech 2003b). DTSC has concurred with findings of no further action (NFA) for several of the facilities formerly operating under either the Part A or Part B permits.

Although CERCLA and RCRA are separate legislative authorities, each environmental cleanup program should operate consistently with the other and should yield similar environmental solutions when faced with similar circumstances. Any procedural differences between CERCLA and RCRA should not substantively affect the outcome of remediation.

3.2 SCOPING OF THE REMEDIAL INVESTIGATION

As presented in the previous section, the Navy began environmental investigations at Alameda Point under the NACIP Program in 1982. Under the NACIP Program, an IAS assessed the entire base for potential areas where chemicals may have affected soil or groundwater (E&E 1983). In 1985, a verification step and characterization study was performed at sites that were identified for further study in the IAS, which included Sites 3 and 4 (Wahler Associates 1985). Sites 11 and 21 were not investigated in the IAS. In 1988, the Navy converted its NACIP Program into the IR Program to be more consistent with CERCLA, and investigations were conducted at Sites 3, 4, 11, and 21 in a phased approach.

During the initial scoping stage of the RI, site histories and data collected were used to identify potential sources of contamination at each site, potentially affected media, and data needs. Field investigation methods were selected to meet the data needs established in the scoping process of the RI.

The following types of physical features and historical site activities were considered potential sources of contamination:

- Buildings associated with nonadministrative functions
- USTs and ASTs
- Generator accumulation points (GAP)
- Oil-water separators
- Washdown areas
- Disposal and storage practices associated with hazardous waste

The site-specific sections (see Sections 5.0 through 9.0) describe the physical features and historical activities conducted at each site and the types of chemicals (such as solvents, polychlorinated biphenyls [PCB], metals, and so forth) associated with the potential sources of contamination.

Media potentially affected by physical features and historical activities and possible exposure pathways and receptors identified during the scoping stage of the RI are presented in an initial CSM (see Figure 3-1). Soil and groundwater were expected to be the primary exposure media through ingestion, direct contact, and inhalation exposure routes. Both current and potential future receptors were identified, which include human receptors (residential, commercial/industrial, recreational, and construction workers) and ecological receptors.

The storm sewer system was not evaluated as a potential source of contamination; however, it was considered to be a possible preferential pathway for the discharge of contaminant plumes into the Oakland Inner Harbor, the San Francisco Bay, groundwater, or soil. The storm sewer system lies within the fill material and consists of storm sewer lines, accessways, manholes, catch basins, and outfalls on the base and in the outlying base housing area. Much of the system is below the water table. The storm sewer system was initially constructed by the Navy to collect basewide surface runoff from streets, runways, the tarmac, landscaped areas, and building roof drains. Before 1972, the Navy also used it for disposal of industrial waste. The storm sewer system conveys stormwater to the Oakland Inner Harbor, Seaplane Lagoon, or the San Francisco Bay through 36 outfalls (Tetra Tech 2000d).

The initial CSM was refined through an iterative process that involved identifying areas of known or potential releases of chemicals to the environment, conducting environmental investigations, and filling data gaps until the quality and quantity of data for characterization of the nature and extent of contamination and evaluating risk at each site was judged to be sufficient. Consequently, environmental investigations at Sites 3, 4, 11, and 21 focused mainly on known or potential releases and data gaps. Overall, data for Sites 3, 4, 11, and 21 were collected using a biased sampling approach that was phased. With the phased approach, stakeholders were afforded opportunities to provide feedback on the suitability or adequacy of the collected data and the need to collect additional data to identify releases and complete this RI report.

The environmental investigations conducted at Sites 3, 4, 11, and 21 to meet the data needs established in the scoping process of the RI and the data needs to address other regulatory requirements (base closure, TPH, and RCRA) are presented in the following section.

3.3 ENVIRONMENTAL INVESTIGATIONS CONDUCTED UNDER THE INSTALLATION RESTORATION PROGRAM

This section briefly describes each of the environmental investigations that were conducted at Alameda Point under the IR Program (see Table 3-1). The investigations are grouped according to the four types of investigations conducted in conformance with CERCLA, the EBS, the TPH Program, and RCRA, which are defined previously in Section 3.1. Activities specific to a site and results of the environmental investigations are presented in the site-specific sections (see Sections 5.0 through 8.0) and the groundwater section (see Section 9.0).

3.3.1 Comprehensive Environmental Response, Compensation, and Liability Act Investigations

Congress enacted CERCLA, commonly known as Superfund, on December 11, 1980. This law provided broad Federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. In 1987, Executive Order 12580 delegated CERCLA authority to DoD. The following environmental investigations and removal actions were conducted in accordance with CERCLA at Alameda Point from 1988 until the present.

Sites 3 and 4, along with Sites 1, 2 (partial), 9, 10B, 13, 16, and 19, were investigated in Phases 1 and 2A of the IR Program. Investigations at Sites 4, 11, 21 (known as 7B at the time) were conducted, along with Sites 5, 6, 7A, 8, 10A, 12, 14, and 15, during Phases 2B and 3. Investigations for Phases 1, 2A, 2B, and 3 were conducted initially to evaluate the potential impact of site operations to soil and groundwater. The investigations were performed as described in the work plans (Canonie 1989 and 1990) and addenda to these plans (PRC Environmental Management, Inc. [PRC] and James M. Montgomery, Consulting Engineers, Inc. [JMM] 1991). Results for Sites 3 and 4 from investigations conducted during Phase 1 and 2A were summarized in the Phases 1 and 2A report (PRC and Montgomery Watson 1993). Results for Sites 4, 11, and 21 from investigations conducted during Phase 2B and 3 were summarized in the Phases 2B and 3 report (PRC and JMM 1992).

During 1994 and 1995, two follow-on investigations were conducted to collect data to fill the gaps from the Phases 1 and 2A and Phases 2B and 3 investigations. The investigations were conducted under the follow-on field sampling plan (PRC and JMM 1994). Results for Site 4 were summarized in the data transmittal memorandum for Sites 4, 5, 8, 10A, 12, and 14 (PRC and JMM 1996), and results for Sites 3, 11, and 21 were summarized in the data transmittal memorandum for Sites 1, 2, 3, 6, 7A, 7B, 7C, 9, 10B, 11, 13, 15, 16, 19, and the Runway Area (PRC and JMM 1995).

Between 1995 and 1997, sampling and clean out of the storm sewer lines (formerly Site 18) and removal of sediment from manholes and catch basins was conducted. Phase 1 of this removal action was conducted by the Navy Public Works Center in 1995 as a CERCLA time-critical removal action (Tetra Tech 2000d). It entailed vacuum-cleaning sediment and debris from storm sewer catch basins and manholes associated with outfalls, H, I, and J which are associated with stroms drains in OU-2B. Phase 2 of the removal action was completed by 1997 and involved additional cleaning of all manholes and subsystems throughout the base including the outfalls G, H, I, and J which are located in OU-2B. The storm sewer bedding was also investigated as a preferential pathway in the "Draft Final Storm Sewer Study Report, Alameda Point" (Tetra Tech 2000d). The locations of these outfalls and the results of the storm sewer study are discussed later in the site specific sections (Section 4, 5, 6, and 7).

In 2001, supplemental RI data gaps sampling was conducted at Sites 3, 4, 11, and 21 under the "Final Field Sampling Plan Supplemental RI Data Gap Sampling for OU-1 and OU-2" (Tetra Tech 2001a). Results were summarized in the "Data Summary Report Supplemental RI Data Gap Sampling for OU-1 and OU-2" (Tetra Tech 2002). The overall objectives of the supplemental data gap sampling at Sites 3, 4, 11, and 21 were to (1) delineate contaminant plumes in groundwater, (2) investigate storm sewer pathways, and (3) characterize soil gas to evaluate risk from the vapor inhalation pathway (Tetra Tech 2002).

The Navy conducted a basewide investigation to identify transformers with PCB concentrations greater than 50 parts per million for replacement. Wipe samples were collected at stained transformers pads. If PCBs were detected, the pads were remediated (pressure washed). Results of the investigation were summarized in the "Final PCB Report, Alameda Point, Alameda, California" (Innovative Technical Solutions, Inc. 2002). The Navy did not find any PCB contamination that warranted further action.

In 2002 and 2003, a basewide groundwater monitoring investigation was conducted in accordance with the "Draft Final Work Plan for Basewide Groundwater Monitoring Program" (Shaw Environmental & Infrastructure, Inc. [Shaw] 2003a). The specific objectives of this investigation were to (1) monitor the status of contaminant plumes in groundwater, (2) evaluate the potential for natural degradation, (3) identify the groundwater flow direction and gradients, and (4) assess if additional wells required better delineation of plumes or if some wells could be abandoned. Select wells were identified for quarterly or semiannual monitoring. Groundwater monitoring was conducted in June, September, and December 2002 and March 2003. Results are summarized in individual groundwater monitoring report for each IR site (Shaw 2003b, 2003c, 2003d, 2003e)

In 2002, a PAH background investigation was conducted. The purpose of the background PAH investigation was to determine ambient concentrations of PAHs in soil. Results are summarized in the "Draft Technical Memorandum for the PAH Background Study for Alameda Point" (Bechtel Environmental, Inc. 2002).

In 2003, a basewide PAH investigation was conducted at the CERCLA sites in accordance with the "Draft Work Plan for Assessment of PAH Contamination at Selected CERCLA Sites and EBS Parcels" (Bechtel Environmental, Inc. 2003). The objective of the investigation was to obtain PAH analytical data for soil that are acceptable for risk assessment because detection limits for historical PAH data were elevated. Samples were collected between ground surface and 0.5 foot below ground surface (bgs), 0.5 and 2 feet bgs, 2 and 4 feet bgs, and 4 and 8 feet bgs. Each sample interval was homogenized and analyzed as a discrete sample.

CERCLA authorizes two kinds of response actions, short-term removals and long-term remedial response actions. Short-term removals are conducted where actions may be taken to address releases or threatened releases requiring prompt response. No removal actions have been conducted under CERCLA at Sites 3, 4, 11, and 21.

3.3.2 Environmental Baseline Survey Investigations

After Alameda Point was identified for closure in September 1993, ongoing environmental restoration and compliance programs were coordinated with property conversion and reuse activities. As mandated under the Base Closure and Realignment Act, an EBS was performed to identify the environmental condition of all property affected by base closure. As part of the EBS, all Alameda Point onshore property was divided into parcels and grouped into 23 zones based on geographic location and expected land use. Site-specific information gathered during the EBS was used to determine each parcel's suitability for leasing or transfer based on the intended use and the Defense Authorization Act of 1997 (enacted in September 1996).

The EBS process included a series of basewide investigations. The EBS Phase 1 investigation included site visits, employee interviews, and historical research (ERM-West, Inc. 1994). In addition, recommendations for additional investigations (EBS Phase 2A) were prepared and presented in the zone analysis plans and parcel evaluation plans (ERM-West, Inc. 1995a, 1995b). In conjunction with the EBS Phase 2A investigation, a basewide EBS sewer investigation was conducted in accordance with the work plan for storm, industrial, and sanitary sewer sampling (International Technology Corporation [IT] 1994). EBS Phases 2A and 2B and the sewer investigation results are presented in the final EBS data evaluation summaries (IT 2001a).

3.3.3 Total Petroleum Hydrocarbon Program Investigations

TPH contamination was evaluated as a part of a program to decommission all USTs, which began in August 1994. Under the TPH Program, 14 CAAs and 2 fuel-line specific CAAs were developed. The corrective action program for these petroleum-impacted areas is overseen by RWQCB, in cooperation with DTSC and the EPA. Under the TPH Program, sampling was conducted at Sites 3, 4, 11, and 21. Sampling was conducted at Site 3 within CAA 3A, CAA 3B, and CAA 3C. Sampling was conducted at Site 4 within CAA 4B. Sampling was conducted at Site 11 within CAA 11A and CAA 11B. Sampling was conducted at Site 21 within CAA 3A. Results of these samples were used to evaluate TPH as a potential contaminant for each site. The results of the TPH screening process are shown in Appendix H.

3.3.4 Resource Conservation Recovery Act Investigations

Alameda Point was listed in the May 1992 RCRA database as a large-quantity hazardous waste generator and a treatment, storage, and disposal facility. Storage and treatment of hazardous waste at Alameda Point was regulated through two operating permits issued by DTSC (RCRA Part A and RCRA Part B). DTSC has concurred with findings of NFA for several of the facilities formerly operating under either the Part A or Part B permits.

An RFA was conducted at Alameda Point in 1992 (DTSC 1992). Its primary purpose was to identify SWMUs and AOCs and to collect preliminary information on all actual or potential contaminant releases from these SWMUs and AOCs to evaluate the need and scope of an RFA (DTSC 1992). The 1992 RFA also identified certain RCRA facilities that were already being evaluated under the Navy's IR Program. DTSC recommended a low priority for these sites in the RFI to avoid duplication with CERCLA investigations (DTSC 1992).

A SWMU is defined as units at a hazardous waste facility from which hazardous chemicals might migrate, regardless of whether the units were intended for the management of wastes, including but not limited to containers, tanks, surface impoundments, waste piles, land treatment units, landfills, incinerators, and underground injection wells. The SWMUs and AOCs identified in the RFA were divided into the following six categories:

- GAP
- USTs

- CERCLA Program Sites
- Hazardous Waste Permit Facilities
- Miscellaneous Sites
- Tiered Permit Facilities

A RFI for Alameda Point was implemented through coordination of existing environmental programs, namely the CERCLA Program, the TPH Program, and the EBS Program. Functional equivalents of RFI documents (such as RFI work plans and RFI reports) have been and continue to be issued for various SWMUs and AOCs under each of these programs. These programs have and will continue to result in the full characterization of the nature, extent, and rate of migration of hazardous waste releases at all SWMUs and AOCs at Alameda Point. Many of the results of RFA- and RFI-related activities at Alameda Point are summarized in the 2001 EBS (IT 2001a).

The history of RCRA permitting activities and the status (as of July 2002) of RCRA-permitted units at Alameda Point are shown in the "Final Technical Memorandum: Evaluation of Issues Related to the RCRA Facility Permit EPA ID CA 2170023236, Tiered Permits, and the Nonpermitted Areas at Alameda Point" (Tetra Tech 2003d).

The DTSC and Alameda County Department of Public Health have been notified that the Tiered Permit Facilities have been closed. Therefore, no further action is required for these facilities. The only remaining RCRA-permitted facility within OU-2B is Industrial Wastewater Treatment Plant 360 in Site 4. This facility will remain under the RCRA Program and will be evaluated for closure under RCRA. Table 3-2 shows the remaining nonpermitted SWMUs identified within each OU-2B site. These SWMUs will be evaluated with each of the OU-2B sites in accordance with the CERCLA process.

3.4 DATA EVALUATION METHODS

This section presents what is known about the sites and identifies the process used to evaluate data in support of the CERCLA risk management process and to meet TPH and RCRA closure requirements. Soil data and one discrete lead groundwater plume at Site 3 were evaluated by site (see Sections 5.0 through 8.0). An OU-wide groundwater plume was formed by the convergence of groundwater plumes emanating from multiple OU-2B sites (Sites 3, 4, 11, and 21) and is evaluated separately (see Section 9.0) so the cumulative effects of the OU-wide groundwater contaminants are addressed. The lead groundwater plume at Site 3 is not commingled with this OU-wide groundwater plume; therefore, it was addressed in Section 5.0. Data generated during the environmental investigations are presented in Appendix D.

The process used to evaluate the data in support of the CERCLA risk management process included: (1) a site-specific CSM, (2) a data quality assessment, (3) a background comparison, (4) a nature and extent evaluation, (5) a fate and transport evaluation, (6) an HHRA, and (7) an ERA. The site-specific CSM is a result of refining the initial CSM through an iterative process that involved identifying areas of known or potential releases of chemicals to the environment, conducting environmental investigations, and filling data gaps. The site-specific CSM is a flow chart that presents the physical features and historical site activities considered the primary sources of contamination; primary, secondary, and tertiary release mechanisms; pathways; exposure pathways; and current and potential future receptors.

The data quality assessment summarizes the objective and results of the environmental investigations, defines the most appropriate use for data, and establishes the quantity and quality of data needed to support decision-making. Results of CERCLA, EBS, and TPH environmental investigations are summarized in tables for each media (soil, soil gas, and groundwater) in the site-specific sections (Sections 5.0 through 8.0). The tables are organized according to analytical group and include (1) the number and percent of detections of chemicals; (2) the average, minimum, and maximum detected concentrations; (3) minimum and maximum detection limits for nondetected samples; and (4) whether the maximum detected concentrations exceeded Region 9 residential preliminary remediation goals (PRG) or Cal-modified PRGs for soil and groundwater (EPA 2002). PRGs and MCLs are provided in the tables for comparison purposes only.

The background (or ambient) comparison is a statistical process used to determine which metals in soil and groundwater are present at naturally occurring concentrations. A data set representative of ambient concentrations is compared with the data sets for each site.

The nature and extent evaluation characterizes each site by presenting the types and concentrations of chemicals that were detected in soil and groundwater, evaluating the data against selected parameters, and assessing the nature and extent of contamination as defined by the risk assessments.

The fate and transport evaluation identifies if chemicals driving risk at each site have migrated or degraded, if there is a continuing source of contamination, and if groundwater or other potential pathways will distribute contaminants. The fate and transport evaluation also focuses on the risk drivers.

The HHRA and ERA estimate potential risks to human health and the environment associated with exposure to chemicals at each site and identify those chemicals associated with the risk. The HHRA and ERA identify chemicals of potential concern (COPC) and chemicals of potential ecological concern (COPEC), respectively, and evaluate the risk from these chemicals. COPCs are considered risk drivers if they pose a cancer risk above 1E-06 or a hazard index (HI) above 1. COPECs are considered risk drivers if they pose potential risk to ecological receptors. The HHRA and ERA are presented in Appendices F and G to this RI report.

Because TPH is not a CERCLA chemical, a separate evaluation was conducted for TPH in soil and groundwater that is not commingled with a plume containing CERCLA chemicals. This separate TPH evaluation was conducted using the "Preliminary Remediation Criteria and Closure Strategy for Petroleum-Contaminated Sites at Alameda Point" (hereinafter referred to as the Alameda Point TPH strategy) (Navy 2001a) and is presented in Appendix H to this RI report.

A RCRA evaluation of the SWMUs in Sites 3, 4, 11, and 21 is presented in Appendix I to this RI report. The SWMUs addressed in Appendix I were evaluated using requirements stipulated in the final hazardous waste facility permit for former NAS Alameda (EPA Identification

Number CA 2170023236) to support further corrective action decisions at Alameda Point. Recommendations for NFA or further action are based on the analytical results presented in Appendix I. Any corrective action required will be conducted under the CERCLA program as part of the remedial actions to be evaluated in the feasibility studies (FS).

3.4.1 Conceptual Site Model

The initial CSM was refined in an iterative process that involved conducting environmental investigations and identifying areas of known or potential releases of chemicals to the environment. This iterative process resulted in site-specific CSMs.

The site-specific CSMs include the following components: (1) primary source of contamination; (2) primary, secondary, and tertiary release mechanisms; (3) pathways; (4) exposure routes; and (5) current and future receptors. Physical features and site-related activities (former and remaining) at the sites are identified as likely primary sources of contamination. Release mechanisms include spills and leaks, suspension of air particles, plant uptake, infiltration to groundwater, and volatile emissions. Current and potential future receptors include human receptors (residential, recreational, commercial/industrial, and construction workers) and ecological receptors. The site-specific CSMs also indicate which exposure pathways are considered complete for each receptor. An exposure pathway for aquatic receptors was considered complete if a groundwater plume could potentially migrate toward the San Francisco Bay (including Oakland Inner Harbor and Seaplane Lagoon) or if broken storm sewer lines (sags) could potentially discharge to the San Francisco Bay.

According to EPA guidance (EPA 1989), an exposure pathway consists of four elements:

- A source and mechanism of chemical release
- A retention or transport medium (or media in cases involving transfer of chemicals)
- A point of potential contact with the contaminated medium (referred to as the "exposure point")
- An exposure route (such as ingestion) at the contact point

Eliminating any of these elements (except in a case where the source itself is the point of exposure) results in an incomplete exposure pathway. Therefore, if no receptors exist that would contact the source or transport medium, the exposure pathway is incomplete and is not evaluated. Similarly, if contact with a medium is not possible, the exposure pathway is considered incomplete.

The site-specific CSMs were used to support the risk assessment and nature and extent evaluations

3.4.2 Data Quality Objectives

This section presents the data quality objectives (DQO) for the RI for Sites 3, 4, 11, and 21. DQOs are qualitative and quantitative statements developed through a seven-step DQO process outlined in guidance documents (EPA 1993b, 1994b, 1999a). DQOs clarify objectives, define the most appropriate use for data, and specify tolerable limits on decision errors used as the basis for establishing the quantity and quality of data needed to support decision-making. The results of applying the DQOs for the RI to Sites 3, 4, 11, and 21 and a specific discussion of the quality and quantity of data collected at each site (data quality assessment) are presented in the site-specific sections (see Sections 5.0 through 8.0) and in the groundwater section (see Section 9.0).

3.4.2.1 State the Problem

Step 1 of the DQO process identifies the following specific problem to be solved. Past activities at Sites 3, 4, 11, and 21 were suspected of causing releases of volatile organic compounds (VOC), semivolatile organic compounds, pesticides and PCBs, TPH, and metals to soil and groundwater. These chemicals were suspected of posing a threat to human and ecological receptors.

3.4.2.2 Identify the Decision

Step 2 of the DQO process identifies three decisions that must be supported in the RI for Sites 3, 4, 11, and 21. These decisions were formulated based on the overall problem presented in Step 1.

The first decision is to determine whether there is sufficient quality and quantity of data available to characterize the site and conduct a risk assessment. Sufficient quality and quantity of data are necessary to ensure confidence in nature and extent and risk assessment conclusions.

The second decision is to determine whether site contamination is appropriately addressed under CERCLA or is best addressed by another Navy program, such as the petroleum corrective action program or RCRA Program. This is necessary to provide the appropriate regulatory context for corrective action.

The third decision is to determine whether any CERCLA chemicals present at the sites as a result of site-related activities pose a potential risk to human health or the environment, thus requiring an FS. An FS provides a regulatory context for corrective action under CERCLA.

3.4.2.3 Identify Inputs to the Decision

Step 3 of the DQO process describes the information needed to resolve the decision statements identified in Step 2. The decision to determine whether sufficient data have been collected during previous investigations to characterize the site and conduct a risk assessment was based on knowledge of the history of the sites, an initial CSM, the spatial distribution of samples collected, the quantity and quality of data for each analytical group, professional judgment, and consensus among stakeholders (Navy, regulatory agencies, and the RAB).

Both screening and definitive data were generated during the environmental investigations using a wide range of field and laboratory methodologies. For this report, screening data are defined as the results of sample analyses either (1) performed in the field (for example, mobile laboratories), not verified by a "fixed laboratory" and unvalidated or (2) samples analyzed in a "fixed laboratory" and unvalidated. Although the quality control requirements specified for the mobile laboratory analyses were less stringent than those that would be expected from a fixed laboratory, the resulting data underwent cursory validation to ensure that their quality was adequate for their intended purpose of characterizing the sites. Screening data were considered appropriate for use in nature and extent evaluations, fate and transport evaluations, evaluation of alternatives, and/or engineering design (see Figure 3-2). Definitive data are defined as the results of samples analyzed in a "fixed laboratory" and are also validated. Typically, definitive quality data could be used for risk assessment and background comparisons in addition to nature and extent evaluations, fate and transport evaluations, evaluation of alternatives, and/or engineering design. In 2001, some mobile laboratory data collected during the supplemental RI data gaps sampling investigation were also verified in a fixed laboratory and received a cursory validation (Level II). For this RI report, as directed by the regulatory agencies, these data also were considered adequate for use in risk assessment and background comparisons (EPA 2005).

In general, the definitive quality data were collected and analyzed in accordance with EPA's Contract Laboratory Program (CLP) procedures, and detection limits (sample quantitation limits [SQL]) were sufficiently low to permit identification of potential health risks. Samples in each sample delivery group received a cursory validation review, and a minimum of 10 percent of the samples for each of the analyses performed received a full validation review by independent validators. The majority of data was validated with respect to laboratory blanks, quality control samples, and qualifiers. In general, data quality is consistent with EPA Analytical Level III, as specified in EPA's "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (1988a). Data qualified "R" (rejected) were not used in this RI.

Detection limits for some of the data used in this RI are elevated over the current residential PRGs (EPA 2002); these elevated detection limits are the result of one or more of the following circumstances: (1) the evolution of lower detection limits as technology improves, (2) the revision of PRGs over time (which are not always technologically feasible), (3) and matrix interference. The first two circumstances are common whenever data are collected over a period of greater than 10 years and generally do not result in significantly elevated detection limits. However, matrix interferences sometimes cause significant elevations in the detection limits for a chemical, which leads to uncertainty about whether the undetected chemical could be present in significant concentrations at a site. During the more than 10 years of sampling at these sites, lower detection limits were established for a number of chemicals as technology improved and PRG concentrations for some of those chemicals were reduced based on new toxicological information. For example, reporting limits for groundwater data collected during the basewide groundwater monitoring investigations were compared against MCLs and reporting limits for soil gas samples were not compared against PRGs (Tetra Tech 2001c).

Matrix interference caused elevated detection limits for most of the historical soil data for PAHs at Alameda Point; therefore, additional PAH sampling of the CERCLA sites was conducted in 2003. These PAH data achieved detection limits below Region 9 PRGs, so the PAH data are of sufficient quality to characterize the sites and conduct risk assessments. Only PAH data from the 2003 sampling event, rather than historic data, are evaluated in the RI.

Risk from TPH was assessed separately for soil and groundwater using the Alameda Point TPH Strategy (Navy 2001a) and is presented in Appendix F.

To determine whether a site is eligible for closure under CERCLA or is best addressed by another Navy program, the following information was used: site activities, chemical data associated with soil and groundwater samples, results of a TPH screening, and regulatory guidance.

To determine whether CERCLA chemicals from site-related activities are present at concentrations posing a potential risk to human health or the environment, thus requiring an FS, the following information was used: background, HHRA and ERA results, site-specific CSMs, future land use, and professional judgment.

3.4.2.4 Define the Study Boundary

Step 4 of the DQO process describes the spatial boundaries of the sites. Site boundaries were used to evaluate soil and were based on physical features (such as roads and buildings), knowledge of site activities, and results of previous investigations. Contaminant plume boundaries were used to evaluate groundwater. Temporal boundaries were established to include all site activities and extend to the future based on anticipated uses of each site.

3.4.2.5 Develop Decision Rules

Step 5 delineates the effects of study results and provides direction for the next stage of problem resolution. The first decision, are sufficient data available to characterize the site and conduct a risk assessment, is a yes/no decision that is based on inputs identified in Step 2.

The second decision is to determine whether site contamination is appropriately addressed and eligible for closure under CERCLA or is best addressed by another Navy program. If NFA is required under CERCLA and it is necessary to further address site contamination under the TPH or RCRA programs, then the site will be recommended for transfer to another Navy program. If further action is required under CERCLA, then site contamination (including commingled CERCLA and TPH plumes) will be addressed under CERCLA. Further action for noncommingled TPH plumes and RCRA contamination will be recommended to another Navy program.

The third decision is to determine whether any chemicals present at the sites due to site-related activities pose a potential risk to human health or the environment, thus requiring an FS. Results of the HHRA and ERA and of a background comparison were used to evaluate if risk is posed by site activity-related chemicals at Sites 3, 4, 11, and 21. Potential risk is posed and an FS is necessary if (1) human health risk estimates for site activity-related chemicals exceed acceptable risk as defined in the NCP (EPA 1994c) or (2) site activity-related chemicals are present at concentrations that would pose risk to ecological receptors. Potential risk is not posed and an FS is not necessary if (1) human health risk estimates do not exceed acceptable risk identified in the NCP and (2) chemicals are not present at concentrations that would pose a risk to ecological receptors.

Acceptable human health risk, as defined in the NCP, is a carcinogenic risk below 1E-06 and a noncarcinogenic hazard quotient (HQ) below 1. Carcinogenic risk from 1E-04 to 1E-06 is considered within the risk management range.

Acceptable ecological risk from soil is defined as HQ values below 1 for chemicals in soil or a determination of no or limited potential risk after further evaluation of background and a chemical's frequency of detection and distribution at the site, the range of concentrations detected, and its absorption potential and toxicity. Acceptable ecological risk from groundwater is defined as no or limited potential risk indicated by the groundwater screening.

3.4.2.6 Specify Tolerable Decision Errors

The decision as to whether Sites 3, 4, 11, and 21 have been adequately characterized during this RI is a yes/no decision, which is based on a series of professional judgments and consensus among stakeholders. Data collection at the sites focused mainly on potential sources. Overall, the types and numbers of samples collected at the sites and the analyses conducted were based on a phased, biased sampling approach. The phased approach afforded stakeholders opportunities to provide feedback on the suitability or adequacy of the collected data and the need to collect additional data to identify releases and complete the RI report. Therefore, there is a low potential of any source at the sites not being adequately evaluated or of a NFA recommendation if contamination poses a potential risk to human health or the environment.

The decision to address contamination at Sites 3, 4, 11, and 21 under CERCLA or to transfer the sites to another Navy program is a yes/no decision, based upon the requirements of CERCLA-, TPH-, and RCRA-regulated chemicals and a series of professional judgments made by stakeholders. There is a low potential of a site not being addressed under the appropriate program.

The decision as to whether any chemicals present at Sites 3, 4, 11, and 21 pose a potential risk to human health or the environment, thus requiring an FS, is a "yes/no" decision, which is based on human health and ecological risks. Risk assessment methods were established by the regulatory agencies and adapted by the Navy to site-specific conditions, in cooperation with the regulatory agencies. The risk assessment defines the uncertainty in the risk characterization; however, EPA guidance and professional judgment determine the tolerable limits on decision error. Because risk assessment methods used are intentionally designed to be biased toward the overestimation of risks to account for unavoidable uncertainties inherent in any risk assessment process, the tolerance for this decision is low.

3.4.2.7 Optimize Sampling Design

Soil, groundwater, and soil gas samples were collected during previous investigations using a biased, phased sampling approach. The Navy and regulatory agencies reviewed the data from these investigations to identify data gaps before completion of the risk assessments and RI report. Additional data gaps sampling (Tetra Tech 2001a) was proposed and conducted in accordance with regulatory agency review and recommendations.

3.4.3 Background Comparison Approach

Data for soil and groundwater at Alameda Point that were considered to be naturally occurring and not related to historical site activities were compared with analytical results for samples representative of current conditions at Sites 3, 4, 11, and 21. This comparison identified which metals in soil or groundwater at the sites potentially resulted from historical site activities and which metals in soil or groundwater were naturally occurring (background).

This section briefly describes the methodology used to determine background metals in soil and groundwater at Alameda Point and summarizes the methodology used to compare the background data set with samples representative of current conditions at the sites. The complete background comparison is presented in Appendix E, and results are summarized in the site-specific and OU-wide groundwater sections (see Sections 5.0 through 9.0).

3.4.3.1 Selection of Background Data Sets

The data sets considered to represent naturally occurring metals or background conditions for Alameda Point were selected using a series of statistical tests conducted on data sets for each media. Details of the construction of the ambient or background soil and groundwater data sets are provided in "Samples for Use as Background" (Tetra Tech 1997a) and "Technical Memorandum for Estimation of Ambient Metal Concentrations in Shallow Groundwater" (Tetra Tech 1998b), respectively, which are provided in Appendix E of this RI report.

As presented in the background comparisons report for soil, areas of the installation with geologically similar soils that represent a single background data set were designated as pink, blue, or yellow areas (PRC 1997). These areas correspond with a particular fill event provided as follows and are shown on Figure 3-3.

- Pink Area: Runway area and central portion of the installation (Fill Area 1)
- Blue Area: Southeast portion of the installation (Fill Area 2)
- Yellow Area: Far west portion of the installation (Fill Area 3)

Sites 3, 11, and 21 are located in the pink area, and Site 4 is located mostly in the blue area. The statistical summary results for the pink and blue metals background data sets are provided in Appendix E of this RI report.

As presented in ambient metals technical memorandum, 35 wells were identified as being unaffected by site-related groundwater contamination and filtered metals data analyzed using CLP methodology comprise the ambient metals data set (Tetra Tech 1998b). Each of the 35 wells was sampled at least 4 times during quarterly sampling. The statistical summary results that define the groundwater metals background data set are provided in Appendix E of this RI report.

3.4.3.2 Background Soil and Groundwater Comparison

The background soil comparison consisted of comparing the soil background data set (pink or blue area) with analytical results representative of Sites 3, 4, 11, and 21. This comparison identified which metals in soil and groundwater are present at concentrations above naturally occurring levels (greater than background). The background metals data set for the blue area was compared with metals results for Site 4. The background metals data set for the pink area was compared with metals results for Sites 3, 11, and 21. The background groundwater comparison consisted of comparing the background groundwater data set for Alameda Point with analytical results representative of groundwater at Sites 3, 4, 11, and 21. The methodology for the background comparison is presented in Appendix E of this RI report and is summarized below.

Two-population statistical tests were used to compare metal concentrations in site data to ambient concentrations determined for Alameda Point. One or more of the following methods were used to conduct two-population tests, depending on the relative frequency of detection and sample size of each of the populations being compared:

- Wilcoxon rank sum (WRS) and Gehan-Wilcoxon (GT) tests
- Test of proportions
- Quantile test (QT)

One-sided statistical tests were used in all cases and employed a Type I error rate of 0.05. WRS and GT tests were used for metals with at least 60 percent detected data and single detection limits in both the site and ambient populations. Testing was performed using the nonparametric WRS test. For chemicals with fewer than 60 percent detected data, the detection frequencies in the site and ambient populations were compared using the test of proportions. The QT was conducted for all chemicals with less than 60 percent detected data and for all cases where either the WRS or GT test did not reject the null hypothesis (that is, when it was concluded that the median concentrations at the site and ambient concentrations were not significantly different) (Johnson and others 1987; EPA 1994a; Navy 1999a).

3.4.4 Nature and Extent Approach

The main objectives of the nature and extent evaluations at each OU-2B site are to (1) present the types and concentrations of detected chemicals exceeding screening levels, (2) characterize the types and concentrations of chemicals that were used by the Navy, and (3) describe the spatial distribution and concentration patterns of all chemicals that demonstrate significant risk to human health or the environment (also known as "risk drivers"). Risk drivers are defined by the risk assessments, which were conducted (see Appendices F and G) prior to this nature and extent evaluation, as those chemicals that pose a carcinogenic risk above 1E-06, an HI above 1, or pose potential risk to ecological receptors. These objectives, which focus on risk drivers, are consistent with the NCP (EPA 1994c) and EPA guidance (EPA 1988b), which state that the RI should discuss the nature and extent of risks posed by hazardous substances. According to the NCP, in characterizing the site, the lead agency shall characterize the nature and threat posed by the hazardous substances and hazardous materials and assess the extent to which the release poses a threat to human health and the environment (Title 40 *Code of Federal Regulation* 300.430 (d)(2)).

This section describes the approaches used to reach the objectives of the nature and extent evaluations at each OU-2B site.

3.4.4.1 Chemicals Exceeding Screening Levels

This evaluation is an initial screening of chemical concentrations detected in soil and groundwater at each site. Risks are quantified by the risk assessments. Concentrations of all chemicals, except PAHs, detected at each site were compared to screening levels, which consisted of Region 9 residential or California-modified (Cal-modified) PRGs for soil or tap water PRGs for groundwater (EPA 2002). PRGs are risk-based concentrations that are intended for use in initial screening-level evaluations of soil and groundwater and are calculated without site-specific information (EPA 2002).

Concentrations of PAHs at each site were converted to benzo(a)pyrene (B[a]P)-equivalent concentrations, summed, and then compared with a screening level of 0.62 milligram per kilogram (mg/kg) (Navy 2001b), which was established under agreements between the Navy and agencies. B(a)P equivalents are calculated by multiplying the detected concentrations of the carcinogenic PAHs by appropriate toxicity equivalency factors. The toxicity equivalency factors (TEF) are based on the carcinogenic potency of each compound relative to B(a)P (EPA 1993a). The table below lists the TEFs for the seven PAHs that are considered by EPA to be probable human carcinogens.

Chemical	TEF
B(a)P	1.0
Benz(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenzo(a,h)anthracene	1.0
Indeno(1,2,3-c,d)pyrene	0.1

Chemicals exceeding the screening levels are summarized in embedded tables for soil and groundwater in Sections 5.0 through 9.0. The summaries are organized according to analytical groups and include the maximum detected concentrations and the number of detected concentrations exceeding the screening levels.

Figures are provided for chemicals with concentrations exceeding screening levels. Chemicals are presented by analytical group, and sampling locations with concentrations exceeding the screening levels are identified.

3.4.4.2 Characterizing Chemicals Used by the Navy

This evaluation provides additional information to assess whether contamination hot spots or data gaps are present at each site. Chemicals used during operations or activities conducted by the Navy at each site were identified by reviewing all available records and interviews with past workers at each site. Next, this initial list of chemicals was compared to analytical data to identify all chemicals that were detected in soil or groundwater at the site and that most likely resulted from Navy activities, based on professional judgment. The few chemicals that were not attributed to Navy activities included PAHs attributed to historical dredging operations used to construct Alameda Point, common analytical reagents that were attributed to laboratory contamination (when Navy use of the chemical appeared to be highly unlikely and the detected concentrations were extremely low), and chemicals that could be attributed only to operations and processes that were never used by the Navy.

Once the list of chemicals used by the Navy was completed, tables were prepared to summarize the characteristics of those chemicals that were detected in soil and groundwater. The tables include each chemical's (1) detection frequency, (2) range of detected concentrations, (3) location of maximum detection, and (4) sampling interval. In addition, a figure with the maximum detected concentrations of chemicals consistent with Navy use was prepared for each site. Although TPH is not a CERCLA contaminant, it was addressed because it was used at various locations across the sites and an objective of this RI is to meet TPH closure requirements. The site-specific tables and figures are presented and briefly discussed in their respective section (see Sections 5.0 through 9.0).

3.4.4.3 Characterizing Risk Drivers

A more detailed evaluation is conducted for those chemicals that are considered risk drivers, which is based on the results of the risk assessments. Risk drivers are defined as those chemicals that pose a carcinogenic risk above 1E-06, an HI above 1, or pose potential risk to ecological receptors. The approach to characterizing risk drivers at each site was not limited to those chemicals used by the Navy, rather it began by using the HHRA and ERA results (see Sections 3.4.6 and 3.4.7, respectively) to identify every chemical at the site that is a risk driver. Next, the background comparison results (see Section 3.4.3) were used to identify every risk driver that is attributed to background. Finally, it involved describing the spatial distribution and concentration patterns of every risk driver that is not attributed to background at each site (since it is unlikely that background chemicals would exhibit any distinct concentration patterns).

Results of these efforts included:

- Site-specific figures showing the spatial distribution and concentration patterns of risk drivers, including sampling locations with concentrations exceeding the screening levels described above in Section 3.4.4.1 or the maximum background concentration detected in soil or groundwater for metals

- Descriptions of the boundaries of the contamination, the volume of the affected media, and identification, if possible, of the suspected source of these chemicals, based on reviewing the figures, data, and site hydrology

3.4.5 Fate and Transport Approach

This evaluation identifies whether the chemicals driving risk at each site have migrated or degraded, are being released from a continuing source of contamination, and are likely to be distributed by groundwater or other potential pathways. This evaluation used geological and hydrogeological properties in combination with chemical data and primarily included the following:

- Identifying soil and groundwater sampling locations with the maximum concentrations of chemicals driving risk

- Identifying the presence of breakdown or parent products for chemicals driving risk

- Evaluating the effect of groundwater flow or other potential pathways on the distribution of chemicals driving risk

Because the sites are currently paved, it is unlikely that sufficient soil would be exposed to transport chemicals in soil via wind. Therefore, this pathway is not evaluated.

3.4.6 Baseline Human Health Risk Assessment Approach

A baseline HHRA was conducted as part of the RI for Sites 3, 4, 11, and 21, to estimate human health risks associated with possible exposure to site-related chemicals. Risk estimates presented in the HHRA will be used to support informed risk management decisions regarding the need for remedial action and selection of the most appropriate remedial alternative, if necessary.

The methods and assumptions used to evaluate human health risks were selected or developed to be consistent with the Navy, EPA, and DTSC guidelines for baseline risk assessments and agreements made during meetings with EPA and DTSC. The Navy is a federal agency, and as such, primarily followed federal guidance regarding risk assessment, as required by Section 120 of CERCLA. Additional information was obtained from the primary literature or developed from key EPA and DTSC reference documents, including published reports or unpublished memoranda. The primary risk assessment guidance documents upon which the HHRAs are based include the Navy "Human Health Risk Assessment Guidance" (Pioneer Technologies

Corporation 2001); "Risk Assessment Guidance for Superfund [RAGS], Volume I: Human Health Evaluation Manual (Part A), Interim Final" (EPA 1989); and the "Preliminary Endangerment Assessment Guidance Manual" (DTSC 1994).

Lead was evaluated using the DTSC lead risk model, LeadSpread 7 (DTSC 2003), instead of the EPA method. Therefore, the DTSC lead risk model, LeadSpread 7 (DTSC 2003), was used to assess lead health risks for children.

Following the risk assessment model in EPA (EPA 1989), the HHRA is composed of the following four components:

- **Data Evaluation and Selection of COPCs.** This step consists of evaluating data and selecting COPCs in site media.
- **Exposure Assessment.** This step involves evaluating potential exposure pathways to the COPCs and human populations.
- **Toxicity Assessment.** This step consists of compiling toxicity values that characterize potential adverse health effects of exposure to COPCs.
- **Risk Characterization.** This step quantitatively characterizes potential human health risks associated with exposure to COPCs.

These components along with general uncertainty factors are summarized in the following text. Greater detail is provided in Appendix F, and summaries of the site-specific results are provided in Sections 5.0 through 9.0 of this report.

3.4.6.1 Data Evaluation

The first step of the HHRA process consisted of reviewing and evaluating available data and identifying COPCs in the environmental media (such as groundwater and soil). Soil and groundwater data were collected within and near Sites 3, 4, 11, and 21 through several sampling efforts, and the data were considered to be appropriate for use in the HHRA if they (1) were validated, (2) were not qualified "R", and (3) reflected current site conditions.

Soil Data

For the purposes of the HHRA for Sites 3, 4, 11, and 21, the site boundaries were used to define the soil exposure area. Soil data for each site were aggregated in depth intervals of 0 to 2 feet bgs and 0 to 8 feet bgs. The depth intervals were used to evaluate potential exposures associated with site use. The 0–to-2-feet bgs depth interval (surface soil) assumes little or no disturbance of deeper soils, and the 0-to-8-feet bgs depth interval (subsurface soils) assumes disturbance of deeper soils, which may be associated with future regrading or excavation activities. While the DTSC standard depth interval of 0 to 10 feet bgs is typically evaluated for residential and construction worker receptors, the groundwater table exists at about 8 feet bgs throughout Alameda Point; therefore, subsurface soils were characterized and evaluated only to a depth of 8 feet bgs.

Soil data considered to be inappropriate for use in the HHRA included screening level data, data for soils that are no longer present at the sites, and some historical soil data for PAHs. Mobile laboratory data collected during the supplemental RI data gap sampling investigation in 2001 (Tetra Tech 2002) were also considered adequate for use in the HHRA, as directed by the regulatory agencies (EPA 2005). These data were also verified in a fixed laboratory and received a cursory validation (Level II). Data for soils that are no longer present at the sites because of removal actions were not included because they do not reflect current conditions at the sites.

Because some historical soil data for PAHs at Alameda Point have elevated detection limits, additional PAH sampling of the CERCLA sites was conducted in 2003. These PAH data achieved detection limits that meet the DQOs for the RI (that is, detection limits below EPA Region 9 residential PRGs [EPA 2002]), so the HHRA includes only the PAH data from the 2003 sampling event, rather than historic data.

Chromium speciation also was performed, and results indicated that hexavalent chromium was present at Site 4.

Groundwater Data

Groundwater data were aggregated by contaminant plume rather than site. Two individual groundwater contaminant plumes were identified, an OU-wide groundwater plume and a lead groundwater plume located in the northern portion of Site 3.

The groundwater data set for the HHRA only included direct-push and groundwater monitoring well data from within the plume boundaries because data concentrated within the plume boundaries provide a more conservative estimate of risk under potential future scenarios in which a well or a residence could be placed at the center of a plume. The last four quarters of groundwater monitoring data were used because these data are more reflective of current site conditions. Samples collected from the second water bearing zone (SWBZ) were excluded from the risk assessment because it is considered Class III groundwater, which is not a potential source of drinking water.

Soil Gas Data

Soil gas data were used in the evaluation of subsurface vapor migration to indoor air. As a result, soil gas data are used to complement groundwater and soil data and to provide a "weight of evidence" basis for risks calculated for pathways related to subsurface vapor intrusion. All available soil gas data were used.

3.4.6.2 Identification of Chemicals of Potential Concern

Following the data evaluation, chemicals were identified as COPCs. COPCs are chemicals that are carried through the quantitative exposure and risk analysis portions of the HHRA. Only chemicals in soil or groundwater considered to be essential human nutrients (calcium, magnesium, potassium, and sodium) were excluded as COPCs. All other chemicals detected in soil or groundwater were retained for evaluation in the HHRA.

Soil gas data were evaluated for potential vapor intrusion because vapors can emanate from the subsurface, where there is the potential for migration upward into indoor air. All detected volatile chemicals were retained as COPCs.

3.4.6.3 Exposure Assessment

An exposure assessment identifies potential human receptors that could be exposed to site-related chemicals, as well as the routes, magnitude, frequency, and duration of the potential exposures. An evaluation of all possible human exposures is necessary to identify receptors in current contact with or that could contact environmental media in the future. The principal objective of this evaluation is to identify reasonable maximum exposure, which is the maximum exposure that is reasonably expected to occur at a site.

The exposure assessment involves the following steps:

- Characterization of the exposure setting(s) and identification of potential future human receptors
- Identification of exposure pathways and exposure routes
- Estimation of exposure point concentrations (EPC)
- Quantification of chemical intake for pathway specific exposures for each potential receptor

Exposure Scenarios and Receptor Populations

To estimate human exposure to chemicals, assumptions must be made regarding how and with what frequency an individual will contact the subject chemicals. These exposure patterns are collectively referred to as an "exposure scenario." Exposure scenarios depend on whether a child or adult receptor is exposed and on the current and future uses of the property (residential, commercial/industrial, recreational, or construction worker). All four uses might be applicable at a single site.

According to reuse plans for Alameda Point (EDAW 1996), residential and commercial/industrial exposures are the most likely future exposures at Sites 3, 4, 11, and 21.

Residential and commercial/industrial along with construction worker exposure scenarios were evaluated for each site. Both an adult and child are considered potential future residential receptors. The recreational exposure scenario was not evaluated because each site was evaluated for exposure scenarios that were more protective to human health.

Exposure Pathways and Exposure Routes

All relevant exposure pathways were evaluated for future residential, commercial/industrial, and construction worker exposure scenarios. According to EPA guidance (EPA 1989), an exposure pathway consists of the following four elements:

- A source and mechanism of chemical release
- A retention or transport medium (or media in cases involving transfer of chemicals)
- A point of potential human contact with the contaminated medium (referred to as the exposure point)
- An exposure route (such as ingestion) at the contact point

Eliminating any of these elements (except in a case where the source itself is the point of exposure) results in an incomplete exposure pathway. Therefore, if no receptors exist that would contact the source or transport medium, the exposure pathway is incomplete and is not evaluated. Similarly, if human contact with a medium is not possible, the exposure pathway is considered incomplete and is not evaluated.

The exposure scenarios were evaluated for the following pathways:

- **Residential:** Incidental ingestion of soil, dermal contact with soil, inhalation of particulates from soil (nonvolatile), ingestion of homegrown produce, inhalation of vapors in ambient air, inhalation of vapors in indoor air, and domestic use of groundwater (ingestion, dermal contact, and inhalation of vapors)
- **Commercial/Industrial:** Ingestion of soil, dermal contact with soil, inhalation of particulates from soil (nonvolatile), inhalation of vapors in ambient air, and inhalation of vapors in indoor air
- **Construction Worker:** Ingestion of soil, dermal contact with soil, inhalation of particulates from soil (nonvolatile), and inhalation of vapors in ambient air

Because these pathways are based on future exposures, they are considered potentially complete and are evaluated to provide a conservative estimate of risk.

Groundwater was evaluated for domestic use (ingestion, dermal contact, and inhalation of vapors during whole-house use) because it has been established as a potential drinking source using "Guidelines for Groundwater Classification under the EPA Groundwater Protection Strategy" (EPA 1988a). Although construction workers may have transient dermal contact with groundwater, this exposure was considered insignificant because of the very short duration and limited extent expected, and it is not assessed. However, inhalation of volatile chemicals from groundwater to outdoor air was evaluated for the construction worker.

It is unlikely that residential gardening would occur at Alameda Point in existing (unamended) in situ soils, which largely consist of dredge material from San Francisco Bay that are highly unsuitable for crop production in their native state. In addition, exposures from future, hypothetical homegrown produce ingestion are highly variable, and a long list of exposure assumptions and extrapolations are necessary to predict risk. Because of the pathway's inherent uncertainty, it can result in unrealistic elevated risk estimates or insignificant exposures compared with other pathways, such as incidental ingestion of soil.

Volatilization of chemicals (vapors) to ambient or indoor air was included in the HHRA when volatile chemicals were detected in soil, soil gas, or groundwater.

Exposure Point Concentrations

An EPC is the concentration of a chemical in a medium (soil, water, or air) that a human receptor may be exposed to. EPCs were calculated for surface soils (0 to 2 feet bgs), subsurface soils (0 to 8 feet bgs), groundwater, and soil gas.

Based on guidance (EPA 1989, 1992b), the EPC for a chemical has generally been the lesser of the 95th percentile upper confidence limit on the arithmetic mean (UCL_{95}) or the maximum concentration of a data set (EPA 1989). The UCL_{95} is defined as a value that, when calculated repeatedly for randomly drawn subsets of site data, equals or exceeds the true mean 95 percent of the time (EPA 1992b). The UCL_{95} is a better predictor of actual chronic exposure conditions because it is based on the probability of long-term random contact with contaminated areas. See Appendix E for a complete description of how the EPCs were calculated.

Estimating Chemical Intake

Chemical intake rates were estimated for all complete exposure pathways based on the EPCs and on the estimated magnitude of exposure to contaminated media. Exposure is based on "intake," which is defined as the mass of a substance taken into the body per unit body weight per unit time. Intake from a contaminated medium is determined by the amount of the chemical in the medium, the frequency and duration of exposure, body weight, the contact rate, and the averaging time. The following is a generic algorithm that is used to calculate chemical intake:

$$I = \frac{C \times CR \times EF \times ED}{BW \times AT}$$

where

I	=	Intake (mg/kg body weight-day [mg/kg-day])
C	=	Chemical concentration in contaminated medium (mg/kg or milligrams per liter)
CR	=	Contact or ingestion rate (milligrams soil per day or liters per day)
EF	=	Exposure frequency; how often exposure occurs (days per year)
ED	=	Exposure duration; how long exposure occurs (years)
BW	=	Body weight (kilogram)
AT	=	Averaging time; period over which exposure is averaged (days)

Site-specific and default values for exposure parameters were used in the HHRA. Default hypothetical exposure parameters recommended by EPA Region 9 and DTSC were used, as referenced in detail for each parameter and scenario, in the HHRA.

3.4.6.4 Toxicity Assessment

Standard toxicological methodologies for assessing the toxicity of chemicals involve quantifying the dose-response relationships for adverse human health effects associated with exposure to specific chemicals. There are two categories of toxic chemicals, noncarcinogenic and carcinogenic. While not all chemicals have carcinogenic potential, all are assumed to have some noncarcinogenic effect at a high dose. Carcinogenic chemicals' potency was evaluated and presented separately from noncarcinogenic chemical potency.

The toxicity assessment identifies the reference doses (RfD) and cancer slope factors (CSF) used to evaluate adverse noncarcinogenic health effects and carcinogenic risks. The major toxicological effects associated with the COPCs also are presented. The following sources of toxicity values are used for the HHRA, in order of preference:

- Integrated Risk Information System (IRIS), which is summarized in the EPA Region 9 table of PRGs (EPA 2004). IRIS is an online database that contains EPA-approved RfDs and oral CSFs as well as inhalation reference concentrations (RfC) and inhalation unit risk factors (URF) (EPA 2003). The RfDs/RfCs and CSFs/URFs have undergone extensive review and are recognized as high-quality, agencywide consensus information.

- Provisional Peer Reviewed Toxicity Values (PPRTV), as listed in the Region 9 table of PRGs (EPA 2004). PPRTVs are developed by EPA's Office of Research and Development, the National Center for Environmental Assessment (NCEA), and Superfund Health Risk Technical Support Center on a chemical-specific basis as requested by EPA's Superfund program.

- Other toxicity values, such as values recommended by NCEA, Health Effects Assessment Summary Tables (HEAST) (EPA 1997b), and non-EPA sources of toxicity information (such as California Environmental Protection Agency toxicity values).

3.4.6.5 Risk Characterization

The final step in the HHRA is the characterization of potential risks associated with exposure to detected chemicals. Risk characterization combines the exposure and toxicity assessment to produce quantitative estimates of health effects from COPCs. Chemicals might present noncancer health effects in addition to cancer risks; therefore, the potential for both types of effects will be evaluated. Noncancer health hazards and cancer risks are characterized separately.

Characterization of Noncancer Hazards

The potential for exposure to result in adverse health effects other than cancer is evaluated by comparing the chronic daily intake with an RfD. When calculated for a single chemical, the comparison yields a ratio termed the HQ, as shown in the following equation:

$$HQ = \frac{CDI}{RfD}$$

where

CDI	=	Chronic daily intake
RfD	=	Reference dose

To evaluate the potential for adverse health effects from simultaneous exposure to multiple chemicals, the HQs for all chemicals are summed, yielding an HI. Pathway-specific HIs are then summed to estimate a total HI for each receptor. If the resulting HI is less than 1, it is assumed that there is no significant potential for noncarcinogenic health effects due to cumulative effects. If the total HI exceeds 1, a more refined analysis is required. This analysis is referred to by EPA as "segregation of hazard indices" (EPA 1989). In this procedure, chemicals that have similar mechanisms of toxic action, or more conservatively, similar target organs, are grouped together, and an HI is calculated for each group.

It is important to note that the noncancer HI is estimated differently than lifetime cancer risk; specifically, a child's exposure is not cumulatively additive to the projected adult exposure. Noncancer effects manifest over a specific time period, and once the exposure period is over, the hazard has also passed (that is, no latency is assumed). Therefore, because a child's exposure is much larger compared to its body weight, risk management decisions for chemicals with noncancer health effects are based on the HI for a child (the receptor with the highest potential risk) for the residential scenario. The total HI is presented for all scenarios.

Characterization of Cancer Risks

Unlike noncancer health effects, which assume that there is no significant potential for noncarcinogenic health effects if the HI is below 1, carcinogenic risks associated with exposure to chemicals classified as carcinogens are estimated as the incremental probability that an individual will develop cancer over a lifetime as a direct result of an exposure. The estimated risk is expressed as a unitless probability. To aid in the interpretation of HHRA results, EPA guidance presents a range of goals for residual carcinogenic risk, which is "an excess upper-bound lifetime cancer risk to an individual of between 1 in 1,000,000 to 1 in 10,000" or between 1E-06 and 1E-04. The range between 1E-06 and 1E-04 is referred to as the "risk management range" in the HHRA results.

Three steps are used in estimating cancer risks. First, to derive a cancer risk estimate for a single chemical and pathway, the chronic daily intake is multiplied by the chemical-specific cancer slope factor, as follows:

$$\text{Cancer Risk} = \text{CDI} \times \text{CSF}$$

where

CSF = Cancer slope factor

CDI = Chronic daily intake

Second, to estimate the carcinogenic risk associated with exposure to multiple carcinogens for a single exposure pathway, the individual chemical carcinogenic risks are assumed to be additive. Third, pathway-specific risks are summed to estimate the total cancer risk for a receptor. The total carcinogenic risk is presented for all scenarios. Risk management decisions for chemicals with carcinogenic effects are based on lifetime or total risk; therefore, risks for adult and child receptors are summed to obtain a total carcinogenic risk.

Health Effects Associated with Exposure to Lead

Lead is not evaluated in the same manner as other human health COPCs because the nature of the toxicological data for lead differs for assessment of health effects; therefore, lead is not included in the noncancer HI or cancer risk. Where lead EPCs exceed the Cal-modified PRG, lead health risks were measured based on the expected blood lead concentration that will result from exposure. DTSC has developed a special model called "LeadSpread" to predict blood lead concentrations and to assess health risks associated with them. LeadSpread 7 (DTSC 2003) was used to assess lead health risks to a child. The 95th percentile was used as the cutoff for acceptable lead risks. That is, acceptable lead levels are defined as those that produce a blood lead concentration greater than 10 micrograms per deciliter in no more than 5 percent of the exposed child population. LeadSpread was used to assess risk from ingestion of site soil and groundwater and risk from ingestion of site soil and East Bay Municipal Utility District drinking water, which has a lead concentration of 0.15 microgram per liter.

3.4.6.6 Uncertainty Discussion

Uncertainty can be introduced into each stage of the HHRA because of the assumptions made in the risk assessment and limitations of the data used to calculate risk estimates. Uncertainty and variability are inherent in the exposure assessment, toxicity assessment, and risk characterization.

EPA categorizes uncertainty into three types: (1) parameter uncertainty, (2) model uncertainty, and (3) scenario (or decision) uncertainty (EPA 1997a). Variability is often used synonymously with uncertainty. However, uncertainty is a description of imperfect knowledge and can usually be reduced through additional data collection. Variability is defined as "observed differences attributable to true heterogeneity or diversity in a population or exposure parameter" (EPA 1997a). Unlike uncertainty, variability cannot be reduced with additional data collection, although it may be known more accurately.

Parameter uncertainty includes the measurement errors, sampling errors, and systematic errors. This type of uncertainty occurs when variables that appear in equations cannot be measured precisely or accurately. Reasons can include equipment limitations or spatial or temporal variances between the quantities measured. Parameter uncertainty can either be random (sampling errors) or systemic (experimental design).

Model uncertainty is associated with all models used during all phases of the risk assessment, including the animal models used as surrogates for testing chemical carcinogenicity, dose-response models used to extrapolate the level of adverse effects, and the analytical models used predict the fate and transport of chemicals in the environment. The uncertainty arises because of the necessary simplification of real-world processes, misspecification of the model structure, model misuse, and use of inappropriate surrogate variables.

Scenario uncertainty describes the uncertainty that occurs because of incomplete analysis, errors in problem description, aggregation errors, and errors in professional judgment. The impacts of scenario uncertainty can have the biggest impact on the risk managers' decision-making role because it directly relates to the balance among societal concerns when determining acceptable levels of risk. Chemicals identified for evaluation in the HHRA are identified using a process that involves professional judgment and regulatory guidance. This process could exclude some chemicals that might contribute to risk. The calculation of risk in the HHRA involves the use of default values typically defined by regulatory guidance. These defaults do not necessarily reflect site-specific conditions and thus risk estimates may not reflect actual conditions. Consequently, the HHRA process uses many conservative factors to generate risk estimates that likely overstate actual risk (Hattis and Burmaster 1994)

The HHRA calculated for OU-2B was based on a series of assumptions, most intended to be conservative, that are expected to yield an estimation of risks that is biased toward protecting exposed populations. The following text identifies potential sources of uncertainty for the HHRA.

Parameter Uncertainty

- Measurement of chemical concentrations – historical sampling events commonly had elevated detection limits due to numerous reasons, including investigation objectives, interferences, or technology. For a number of chemicals, although not detected, the detection limits were greater than concentrations that would equate to a minimal risk level of 1E-06. Potential uncertainty was accounted for by using a robust approach to calculating EPCs where the chemical was detected. In addition, there was a bias to using more recent data (especially groundwater) to better present current conditions in the HHRA. The impact on the overall uncertainty due to measurement errors on the HHRA was probably neutral.

- Sampling and sampling design errors – Samples were collected in areas suspected or known to be a source of contamination. Samples were not collected systematically or randomly across a site. Therefore, there are areas within a site where no samples were collected. However, the impact of either sampling or sampling design errors is likely biased toward the overestimation of risk because of the bias toward areas of known or potential releases.

Model Uncertainty

- Animal models and dose-response models – The uncertainty related to the choice of animal models for evaluating carcinogenicity or the dose-response model is common to many if not all HHRAs conducted for hazardous wastes sites in the United States. The desire to be protective of potentially exposed individuals has lead to a conservative bias in the evaluation of potential effects from chemical exposure. The overall effect on the HHRA is to bias the risk estimates high for any identified potential exposure.

- Exposure models – The HHRA for OU-2B used three models to evaluate potential exposure to chemicals present in soil or groundwater. The Johnson-Ettinger and ASTM International models were used for estimating indoor and outdoor air concentrations for an inhalation exposure pathway due to vapor intrusion from volatile chemicals in groundwater. A soil-uptake model also was used to evaluate plant uptake of soil contaminants to evaluate a homegrown produce consumption exposure pathway. These models should be considered screening models that likely overestimate exposure and consequently risk. The conservative nature of the model likely balances potential issues with sample design for soil gas, resulting in a neutral impact on the HHRA risk estimates for indoor air inhalation. However, the input parameters for the garden produce pathway likely lead to an overestimation of risk for this pathway.

Scenario Uncertainty

- Default exposure parameters – These factors were not adjusted to relate to site-specific conditions. Because of the bias to protect potentially exposed individuals, the effect of using the default exposure parameters is to bias the risk estimate to higher values.

Although there are aspects of the HHRA for OU-2B that were not always the most conservative, the overall effect on the HHRA was likely neutral. It is expected that nonconservative assumptions were balanced by using other more conservative elements, and resulting risk estimates adequately reflect the risk to potentially exposed individuals.

3.4.7 Ecological Risk Assessment Approach

This section summarizes the methodology used in the ERA conducted for Sites 3, 4, 11, and 21, which is presented in Appendix G. Results and conclusions are summarized in the site-specific and groundwater sections (see Sections 5.0 through 9.0). Residual chemicals at Sites 3, 4, 11, and 21 may pose a risk to ecological receptors; however, site-specific ecological sampling has not been conducted for these sites. Because these sites have limited habitat, site-specific ecological sampling to support a baseline ERA is not feasible; therefore, a modified ERA was conducted for the sites. This ERA is intended to be a conservative estimate using more realistic exposure parameters for the ecological endpoints defined than would typically be used for a screening ERA. In addition, because habitat is limited at Sites 3, 4, 11, and 21 and future land use would not result in additional habitat, it is unlikely that ecological receptors would use the sites in any significant manner. This modified ERA methodology is consistent with EPA guidance for screening-level and baseline ERAs as well as Navy ERA guidance (EPA 1997b; Navy 1999c).

Current and reasonable future uses of the sites were evaluated to determine the presence and potential future formation of habitat in these areas and to identify complete exposure pathways that might exist at each site. Ecological habitat at Sites 3, 4, 11, and 21 is not currently capable of supporting significant wildlife; therefore, exposure pathways for terrestrial receptors were considered potentially complete and provide a conservative estimate of risk. (A complete exposure pathway is one in which the chemical can be traced or expected to travel from the source to a receptor.) An exposure pathway for aquatic receptors was considered complete if a groundwater plume could potentially migrate toward the San Francisco Bay (including Oakland Inner Harbor and Seaplane Lagoon) or if broken storm sewer lines could potentially discharge to the San Francisco Bay. The aquatic receptor pathway was considered complete for the OU-wide groundwater plume.

The process used to conduct the ERA comprises the following components:

- Screening for COPECs
- Problem formulation

- Exposure estimates and risk evaluation
- Evaluation of ERA results

These components, along with uncertainty factors, are summarized in the following subsections.

3.4.7.1 Screening for Chemicals of Potential Ecological Concern

COPECs are organic and inorganic chemicals that are defined as potentially related to site activity and potentially causing adverse effects to ecological receptors. Evaluating site-specific data is the first step in quantifying risks and identifying potential hazards at each site.

Soil and groundwater sampling data were collected within and near Sites 3, 4, 11, and 21 through several sampling efforts, and these data were used to characterize the sites. In general, the data were collected and analyzed in accordance with EPA's CLP procedures and were validated. Detection limits were sufficiently low to permit identification of potential ecological risks, and data quality is consistent with EPA Analytical Level III (EPA 1988b). Only data collected under the IR Program with the objective of characterizing CERCLA activities and that reflect the current conditions at the sites were used in the ERA. Groundwater data collected from 1998 through 2002 were used. Data for soil that is no longer present at the sites because of removal actions were not included because they do not reflect the current conditions at the sites. Only the PAH data from the 2003 sampling event, rather than historic PAH data, were included in the ERA. See Section 3.4.3 for more information on data quality.

Soil data for each site were aggregated at a depth interval of 0 to 4 feet bgs, and groundwater data were aggregated by plume rather than site. Chromium speciation also was performed; results indicated that hexavalent chromium was present at Site 4. The soil and groundwater data summaries for each site are presented in Appendix D. These data were used to develop COPECs for Sites 3, 4, 11, and 21.

Identification of Chemicals of Potential Ecological Concern in Soil

Chemicals detected in soil were subjected to a screening process to focus the ERA on chemicals that are related to site activity and that pose the greatest potential risk to ecological receptors. The screening was a sequential process that considered factors such as frequency of detection, spatial distribution of detected chemicals, statistical comparison to background concentrations for inorganic chemicals, and chemical properties such as bioaccumulation and toxicity. The following steps are involved in the chemical screening process.

Step 1: The first step in the COPEC screening process was to calculate the frequency of detection for all detected chemicals. Chemicals with a frequency of detection of greater than 5 percent were further screened in Step 3. Chemicals with a frequency of detection of 5 percent or less were further screened in Step 2.

Step 2: Chemicals that did not have a 5 percent frequency of detection were then screened based on their bioaccumulation potential and toxicity. Octanol-water partition coefficient (K_{ow}) values for a chemical are correlated with the bioaccumulation potential because K_{ow} values measure the tendency of a chemical to partition into lipids (fat tissues). Chemicals detected in soils with K_{ow} values greater than 3.0 were considered to have significant bioaccumulation potential. Chemical toxicity was evaluated by literature review. If the chemical was associated with significant bioaccumulation or high toxicity (to a specific receptor), it was retained as a COPEC.

Step 3: Certain inorganic chemicals are essential nutrients that may be eliminated as COPECs, according to guidance documents issued by EPA and the DTSC. These chemicals, calcium, iron, magnesium, potassium, and sodium, were excluded as COPECs. If the chemical was not an essential nutrient, it was further screened by the criteria in Step 4.

Step 4: If the frequency of detection was greater than 5 percent and the chemical was inorganic but not an essential nutrient, the concentration was statistically compared with background concentrations established for Alameda Point, consistent with the methodology identified in the document "Procedural Guidance for Statistically Analyzing Environmental Background Data" (Navy 1998a). Any inorganic chemical attributed to background was removed from consideration as a COPEC.

Identification of Chemicals of Potential Ecological Concern in Groundwater

As in the soil COPEC screening process described above, the screening of groundwater was a sequential process. The following steps were used in the COPEC screening for groundwater.

Steps 1 through 4: COPEC screening for groundwater was conducted as described previously for soil. Chemicals retained from these steps proceeded to Step 5.

Step 5: Water quality criteria issued pursuant to the Clean Water Act (CWA) Section 304(a) were used to identify groundwater COPECs based on the groundwater to surface water exposure pathway. According to the CWA, water quality criteria are intended to accurately reflect the latest scientific knowledge of the effects of many chemicals on aquatic and marine life. EPA, states, and other organizations use water quality criteria to determine acceptable concentrations of chemicals introduced into freshwater and marine ecosystems. The concentration of each chemical detected in groundwater at Sites 11 and 21, which were considered to have complete pathways for groundwater, was compared to the "California Toxic Rule Criteria for Enclosed Bays and Estuaries, Saltwater Aquatic Life Protection" (California Environmental Protection Agency 2000). If these values were unavailable, the comparison was made to the "National Ambient Water Quality Criteria for Saltwater Aquatic Life Protection" (EPA 1999c).

Chemicals exceeding the criteria continuous concentration (CCC) or 1/10 the criteria maximum concentration (CMC) for saltwater (when no CCC was available) were retained as COPECs and screened further in Step 6. The CCC is an estimate of the highest concentration of a chemical in surface water to which an aquatic community can be exposed indefinitely without resulting in unacceptable effects, which is synonymous with a chronic effect. The CMC is a single maximum dose that produces adverse effects, which is synonymous with an acute effect. Precedence was given to the CCC when available because chronic effects are more applicable at Alameda Point. When a CCC was not available, the CMC, divided by a dilution factor of 10, was used to estimate chronic effects. Those chemicals for which the maximum concentration detected was less than the CCC or 1/10 of the CMC, whichever was applicable, were not retained as COPECs. Those chemical concentrations that were above the CCC or CMC were further screened in Step 6.

Step 6: The National Oceanographic and Atmospheric Administration (NOAA) applies a dilution factor of 10 to compare chemical concentrations in groundwater to water quality criteria (NOAA 1999). Based on NOAA's practice, chemicals with maximum groundwater concentrations exceeding water quality criteria were divided by a factor of 10 to account for dilution that occurs as groundwater mixes with surface water in the San Francisco Bay. This diluted value was then compared to the CCC or 1/10 of the CMC. Chemicals for which the diluted maximum concentration was less than the CCC or 1/10 of the CMC for saltwater were not retained as COPECs. Those chemicals for which the diluted maximum concentration exceeded the CCC or 1/10 of the CMC were selected as COPECs.

A quantitative fate and transport model that could forecast exposure concentrations for aquatic receptors in surface water bodies has not been developed for Alameda Point. Consequently, the NOAA dilution factor is considered a surrogate in the absence of such a model. This factor was judged suitable for this modified ERA because the actual dilution of groundwater entering the San Francisco Bay is expected to exceed this factor by a large magnitude. It should be noted that maximum concentrations for many of the COPECs are found in groundwater monitoring wells located more than 100 feet from the San Francisco Bay.

3.4.7.2 Problem Formulation

Problem formulation represents the stage of the ERA process where the goals, breadth, and focus of the assessment are determined. The major goal of the problem formulation component is to develop an ecological CSM that addresses the following five issues:

- Environmental setting and chemicals known or suspected to exist at the site
- Chemical fate and transport mechanisms that might exist at the site
- Mechanisms of ecotoxicity associated with chemicals and likely categories of receptors that could be affected
- Complete exposure pathways that might exist at the site (a complete exposure pathway is one in which the chemical can be traced or expected to travel from the source to a receptor)
- Selection of assessment and measurement endpoints to screen for ecological risk

To begin the problem formulation stage, information on the environmental setting and a list of chemicals known to exist at the site was obtained. For these chemicals, physical and chemical characteristics were obtained. The first step to compiling environmental setting information was to obtain the following information about each site: (1) history, (2) habitats, and (3) animal and plant species, including special-status species. Sites 3, 4, 11, and 21 are located in industrial areas with limited habitat for ecological receptors. Ecological habitat capable of supporting significant wildlife is neither present nor expected based on future reuse; therefore, inclusion of exposure pathways for terrestrial receptors provides a conservative estimate of risk.

Using a fully exposed soil scenario, the following complete exposure pathways for Sites 3, 4, 11, and 21 were selected:

- Direct exposure to soil
- Food chain exposure

Potential exposure of marine and estuarine organisms to VOCs transported to surface water from groundwater also was assumed for Sites 11 and 21 because of their proximity to the Seaplane Lagoon and the San Francisco Bay, respectively.

An assessment endpoint is defined by EPA as an "explicit expression of an environmental value to be protected" (EPA 1997a). Ecological resources may be considered to be valuable when (1) their absence would significantly impair ecosystem function; (2) they provide critical resources, such as habitat or fisheries; and (3) they are perceived as being valuable, such as endangered species. Useful assessment endpoints define both the valuable ecological entities at the site and a characteristic of the entity to protect such as reproductive success or production per unit area. Unlike HHRAs, which evaluate only one species, the ERA involves multiple species with different degrees of exposure and toxicological responses.

Assessment endpoints are usually not amenable to direct measurement. Instead, endpoints that are measurable and related to assessment endpoints must be developed. Selected assessment and measurement endpoints are presented in Table 3-3. EPA defines measurement endpoints as "a measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint and is a measure of biological effects (e.g., mortality, reproduction, growth)" (EPA 1997a). Measurement endpoints can include measures of exposure or effect. They are frequently numerical expressions of observations that can be compared statistically to a control or reference site or scientific study to detect adverse responses to a site-specific COPEC. Each measurement endpoint correlates directly with one of the defined assessment endpoints and was based on available literature mechanisms of toxicity.

3.4.7.3 Exposure Estimates and Risk Evaluation

The exposure estimate and risk calculation step results in a conservative estimate of potential risk to the selected measurement endpoints. For each measurement endpoint and COPEC, a conservative estimate of the dose to an organism was developed using soil concentrations and either site-specific or literature-derived exposure parameters. The urban nature of the sites precluded the collection of site-specific tissue samples that could be used to reduce uncertainty and conduct a baseline ERA. Therefore, in the absence of site- or species-specific tissue data, the use of more average exposure parameters was deemed appropriate. These average exposure parameters were used to provide a more realistic estimate of potential risk to ecological receptors. The following equations were used to estimate daily doses to various receptors in the ERA. Values for the exposure factors for each vertebrate receptor are presented in Appendix G.

California ground squirrel dose (mg/kg-day) =

$$(SUF)\ \frac{\left[(C_{soil})(IR_{soil}) + (C_{invert})(IR_{invert}) + (C_{plant})(IR_{plant})\right]}{BW}$$

Alameda song sparrow dose (mg/kg-day) =

$$(SUF)\ \frac{\left[(C_{soil})(IR_{soil}) + (C_{invert})(IR_{invert}) + (C_{plant})(IR_{plant})\right]}{BW}$$

American robin dose (mg/kg-day) =

$$(SUF)\ \frac{\left[(C_{soil})(IR_{soil}) + (C_{invert})(IR_{invert}) + (C_{plant})(IR_{plant})\right]}{BW}$$

Red-tailed hawk dose (mg/kg-day) =

$$(SUF)\ \frac{\left[(C_{ground\ squirrel})(IR_{ground\ squirrel}) + (C_{soil})(IR_{soil})\right]}{BW}$$

where

BW	=	Body weight
C_{soil}	=	EPC of chemical in soil (mg/kg)
C_{invert}	=	$(C_{soil})(BCF_{soil\text{-}to\text{-}invert})$ (mg/kg-fresh weight) (EPA 1999a)
C_{plant}	=	$(C_{soil})(BCF_{soil\text{-}to\text{-}plant})$ (0.12) (mg/kg-fresh weight) (EPA 1999a)
		(0.12 is a default value to convert the plant concentration from dry weight to fresh weight and is presented in Appendix B of EPA 1999a. This value is an average based on 80 to 95 percent water content in herbaceous plants and non-woody plant parts.)
$BCF_{soil\text{-}to\text{-}invertebrate}$	=	Bioconcentration factor for uptake of constituent from soil to invertebrate tissue
$BCF_{soil\text{-}to\text{-}plant}$	=	Bioconcentration factor for uptake of constituent from soil to plant tissue

$C_{ground\ squirrel}$	=	$[(C_{invert})(FCM^3/FCM^2)(F_i) + (C_{plant})(BCF_{plant\text{-}to\text{-}mammals})(F_p)(0.12) + (C_{soil})(BCF_{soil\text{-}to\text{-}mammal})](mg/kg)]$ (EPA 1999a)
$BCF_{soil\text{-}to\ mammal}$	=	Bioconcentration factor for uptake of constituent from soil to mammal tissue (based on mg/kg dry weight soil to mg/kg fresh weight mammal tissue (unitless) (EPA 1999a)
$BCF_{plant\text{-}to\text{-}mammals}$	=	Bioconcentration factor for uptake of constituent from plant tissues to mammal tissues (based on mg/kg dry weight soil to mg/kg dry weight plant tissue (unitless)
FCM^3/FCM^2	=	Food chain multiplier, which models a COPC concentration in a predator item (FCM^3), such as the California ground squirrel, from the ingestion of a prey item (FCM^2), such as a soil invertebrate (unitless). Table G-15 (Appendix G) presents the FCMs as presented in EPA 1999a.
Fi	=	The fraction of the ground squirrel diet that consists of invertebrates
F_p	=	The fraction of the ground squirrel diet that consists of plants
IR	=	Ingestion rate (the amount of prey items and soil ingested per day) (mg/kg-day)
SUF	=	Site use factor

Using risk calculations, doses were then compared to toxicity reference values (TRV) or ecological reference values (ERV) to evaluate potential risks to each ecological receptor. A TRV or ERV is a concentration or daily dose at which a particular biological effect may occur in an organism, based on laboratory toxicological investigations. TRVs were developed as a result of an ecological effect evaluation for mammalian and avian receptors that was conducted by the Navy, the EPA Region 9 Biological Technical Advisory Group, and Tetra Tech (Navy 1998b). If a Navy TRV was not available for a COPEC or endpoint, ERVs previously developed for other Navy facilities in California were used, if available. If no ERVs for Navy facilities were available, other sources of conservative ERVs, such as Toxicological Benchmarks for Wildlife (Sample, Opresko, and Suter 1996), were used. The entire exposure estimate and risk calculations are presented in Appendix G.

Chemicals detected in groundwater and retained as COPECs were further compared to valid saltwater screening values that have been published for the COPECs (see Section 3.4.7.1). HQs were calculated by dividing the EPC by a factor of 10, to account for mixing of groundwater and surface water, and then dividing the resulting concentration by the saltwater screening criteria. If no saltwater screening values have been published for the retained COPECs, impacts of these chemicals to marine receptors were qualitatively assessed.

3.4.7.4 *Evaluation of Assessment Results*

Using the high and low TRVs to evaluate ecological endpoints provides a bounding estimate of risk to each endpoint. The high TRV represents an upper bounding limit, which is the lowest concentration at which adverse effects are known to occur. The low TRV represents the lower bounding limit, which is the highest concentration an endpoint can be exposed to at which adverse effects are known not to occur. Based on this, HQ results for soil using the high and low TRVs were evaluated. If both HQ values for a chemical were below 1.0, then no potential risk to the ecological endpoint from soil was considered likely. However, if one or both bounding limit HQs for metals exceeded 1.0, then the chemical was further compared to calculated background HQs for metals in soil. Additionally, chemical with HQs above 1.0 and above background concentrations were further evaluated based on each chemical's frequency of detection and distribution at the site, the range of concentrations detected, and its absorption potential and toxicity to each ecological receptor. This type of analysis provides additional weight-of-evidence data to support risk management decisions for the sites.

3.4.7.5 *Uncertainty*

The ERA process involves a large number of uncertainties and extrapolations to evaluate potential risk to ecological receptors. Uncertainties associated with the modified ERA conducted for Sites 3, 4, 11, and 21 are identified as follows:

- **Site Use Factors:** The risk calculations assumed that all receptors lived and fed in the area of the site at all times.

- **Dietary Composition:** The percent composition and type of prey ingested by various receptors were based on literature studies that were not site-specific. Additionally, the models were simplified to assume a limited diet, consistent with the literature data.

- **Bioavailability:** All COPECs were assumed to be 100 percent bioavailable to all receptors.

- **Development of TRVs:** TRVs and ERVs used in risk calculations were derived from literature studies. These studies were not conducted on the receptors used in this assessment. TRVs and ERVs were extrapolated using uncertainty factors to account for differences between species.

- **Qualitative Evaluations of COPECs:** Studies were not available to develop TRVs for a number of the measurement endpoints. The potential effects of these ecological COPECs were evaluated on a qualitative basis, relying heavily on professional judgment.

- **Surrogate TRVs:** Surrogate TRV values were used for some compounds, such as the use of the 4,4'-dichlorodiphenyltrichloroethane TRV for other chlorinated pesticides.

- **Bioconcentration Factors (BCF):** The use of the K_{ow} to calculate the biotransfer factor of chemicals into mammal tissue and the BCFs for receptors and food items can overestimate the uptake of organic chemicals into the tissues of organisms and plants.

- **Background Levels of Metals:** To place site-specific risks in the proper context, the risks associated with background concentrations of metals were considered.

Overall, many of the assumptions in the ERA process are conservative and result in overestimates of site-specific parameters. For further discussion on uncertainty refer to the ERA in Appendix H.

3.5 CONCLUSIONS APPROACH

The decision as to whether an FS is required at any of the OU-2B sites is based primarily on a determination as to whether any CERCLA chemicals are present at concentrations that pose a potential risk to human health or the environment. That determination is based on the following information:

- Site-specific CSM
- Background comparison results
- HHRA results
- ERA results
- Future land use
- Professional judgment

Potential risk is posed and an FS is necessary if: (1) human health risk estimates for chemicals related to site activity exceed acceptable risk as defined in the NCP (EPA 1994c) or (2) chemicals related to site activity are present at levels that would pose risk to ecological receptors. EPA guidance presents a range of goals for residual carcinogenic risk, which is "an excess upper-bound lifetime cancer risk to an individual of between 1E-06 and 1E-04." The range between 1E-06 and 1E-04 is referred to as the "risk management range." EPA (1991) recommends the following (parenthetical notes added):

> Where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 1E-04 and the non-carcinogenic hazard index is less than 1, action generally is not warranted unless there are adverse environmental impacts. However, if MCLs [maximum contaminant levels] or non-zero MCLGs [maximum contaminant level goals, which are used to evaluated drinking water] are exceeded, action generally is warranted.

If total carcinogenic risk (including risk from background metals) exceeds 1E-06, risk is posed and an FS is necessary. If risk is within the risk management range, risk managers will assess whether site risks are great enough to warrant remedial action or whether there is justification for taking no action. If the HI for a child (the receptor with the highest potential risk) exceeds 1, further evaluation in the form of a segregation of HIs may be performed to determine whether the noncancer HI is a concern. If the HI for a target organ exceeds 1, risk is posed, and an FS is necessary.

Acceptable ecological risk from soil is defined as HQ values below 1 for chemicals in soil. If HQ values exceed 1, further evaluation of background and a chemical's frequency of detection and distribution at the site, the range of concentrations detected, and its absorption potential and toxicity may be performed to make a determination of no or limited potential risk. Acceptable ecological risk from groundwater is defined as the groundwater screening indicating no or limited potential risk.

Chemicals that demonstrate significant risk to human health or the environment (risk drivers), as defined by the risk assessments, with a few exceptions, are identified as chemicals of concern (COC) requiring further evaluation in an FS. Chemicals that are not from Navy operations or are naturally occurring will not be recommended for evaluation in the FS. In addition, recommendations for further evaluation in an FS are not based on risk from historical detections that are nondetect in more recent data or on risk from PAHs attributed to the Marsh Crust or subtidal area. The Marsh Crust ROD is applicable to PAHs attributed to the Marsh Crust or subtidal area (Tetra Tech 2001e). Conclusions and recommendations regarding further action are provided in the site-specific and groundwater sections (see Sections 5.0 through 9.0). Section 10.0 summarizes all of the conclusions and recommendations from Sections 5.0 through 9.0 for all the sites in OU-2B.

N00236.002042
ALAMEDA POINT
SSIC NO. 5090.3

FIGURES

FINAL OPERABLE UNIT 2B REMEDIAL INVESTIGATION REPORT SITES 3, 4, 11, AND 21

DATED 05 AUGUST 2005

PRIMARY EXPOSURE MEDIA	EXPOSURE PATHWAY		EXPOSURE ROUTE		CURRENT AND POTENTIAL RECEPTORS				
					Future Resident	Construction Worker	Future On-site Worker (Commercial/ industrial)	Future Recreational User	Ecological
SOIL	Wind Erosion/ Resuspension of Soil Particles	Air/Fugitive Dust	Inhalation		☑	☑	☑	☑	☐
SOIL			Ingestion		☑	☑	☑	☑	☑
			Dermal Contact		☑	☑	☑	☑	☐
	Surface Runoff	Surface Water	Ingestion		☐	☐	☐	☐	☑
	Infiltration to Groundwater (FWBZ)	Groundwater	Dermal Contact		☑	☑	☐	☐	☐
			Ingestion		☑	☐	☐	☐	☐
		Surface Water	Ingestion		☐	☐	☐	☐	☑
		Volatile Emissions/ Air	Inhalation	Ambient	☑	☑	☑	☑	☐
				Indoor	☑	☐	☐	☐	☐
	Plant Uptake	Home-grown Produce	Ingestion		☑	☐	☐	☐	☐
		Food Chain	Ingestion		☐	☐	☐	☐	☑
GROUNDWATER			Dermal Contact		☑	☑	☐	☐	☐
			Ingestion		☑	☐	☐	☐	☐
		Surface Water	Ingestion		☐	☐	☐	☐	☑
		Volatile Emissions/Air	Inhalation	Ambient	☑	☑	☑	☑	☑
				Indoor	☑	☐	☐	☐	☐

☑ Potentially complete exposure pathway

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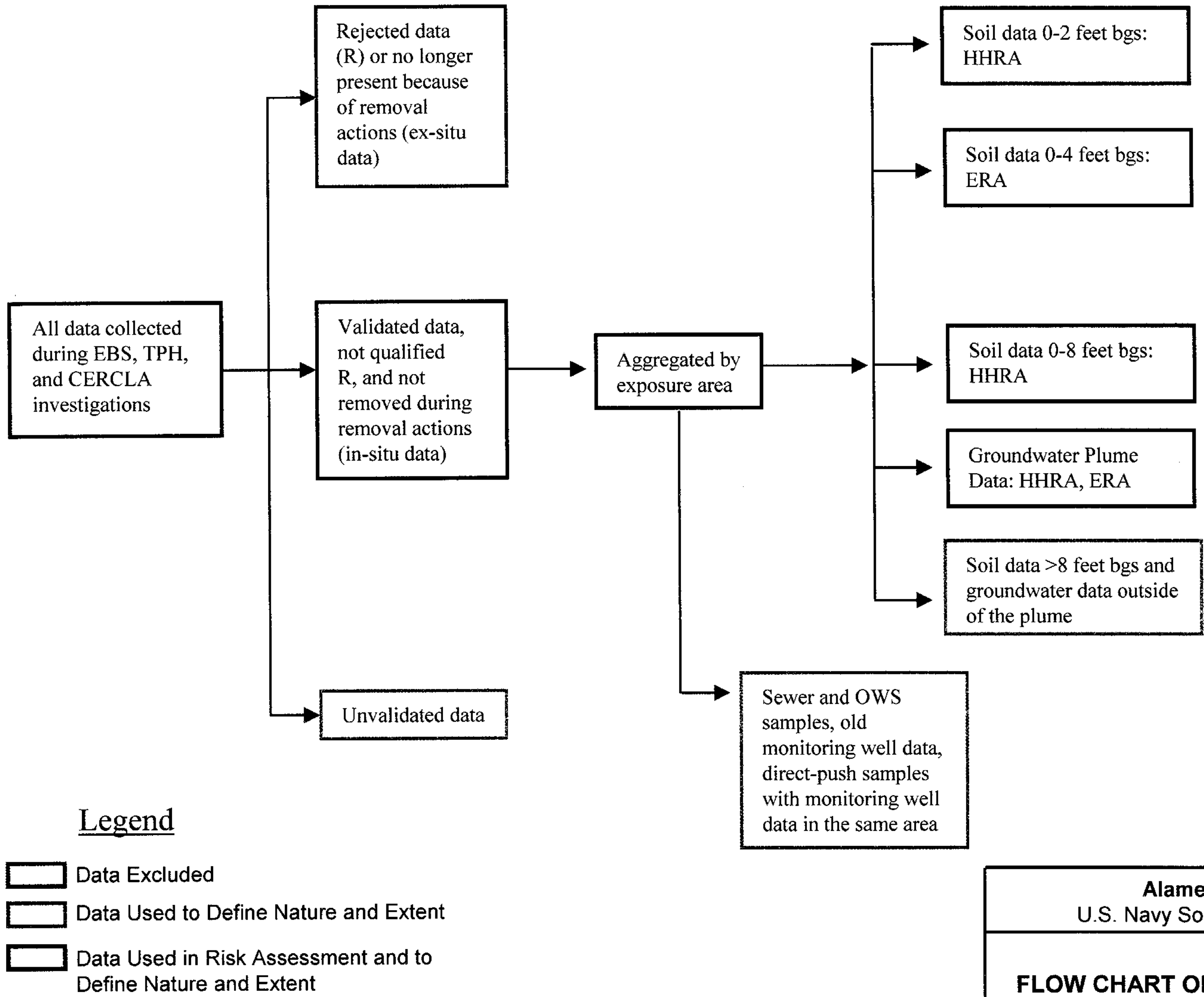
Alameda Point
U.S. Navy Southwest Division, NAVFAC, San Diego

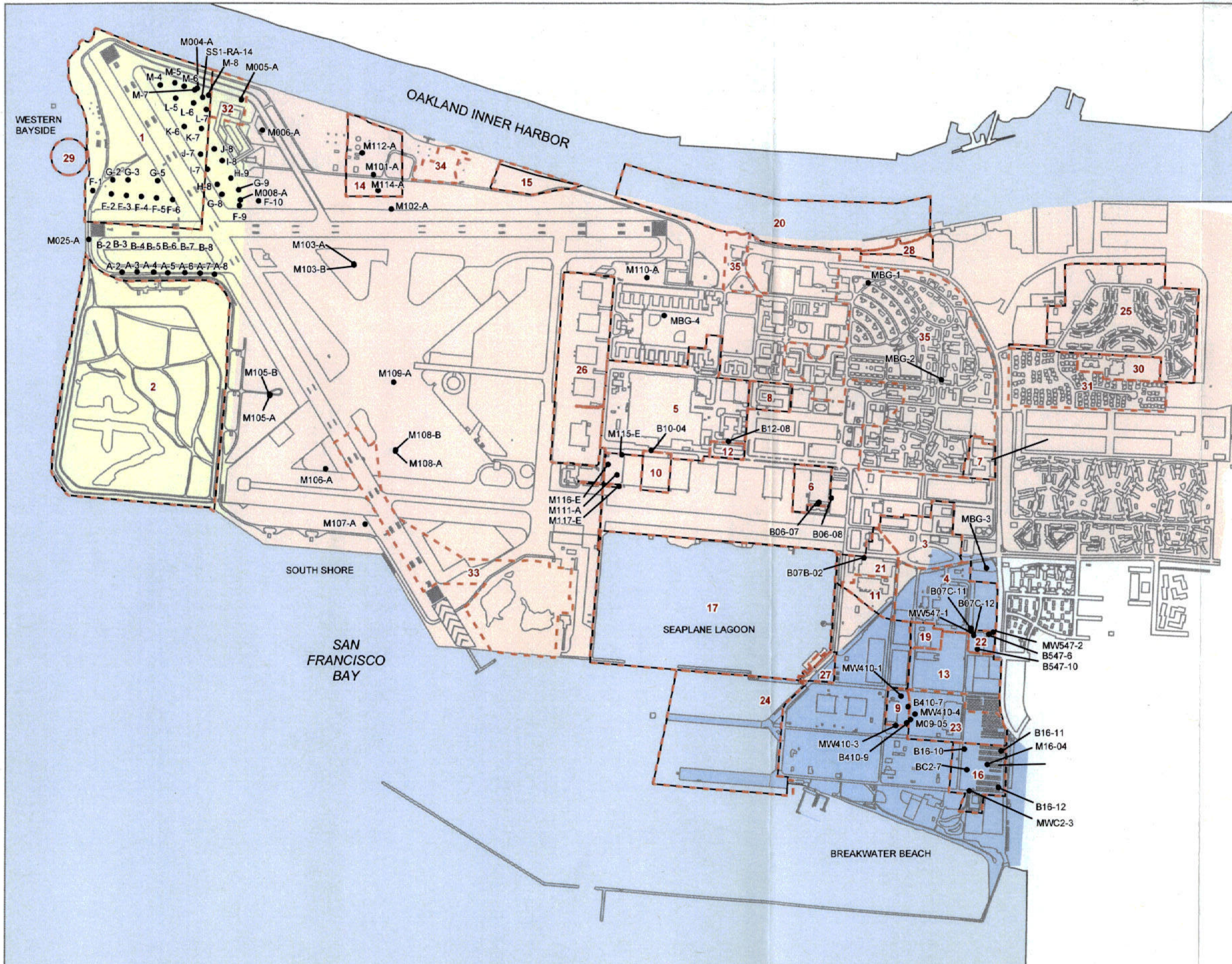
FIGURE 3-1
INITIAL CONCEPTUAL SITE MODEL
Operable Unit 2B
Remedial Investigation Report



SulTech

Alameda Point, Alameda, California
U.S. Navy Southwest Division, NAVFAC. San Diego

FIGURE 3-2
FLOW CHART OF DATA SELECTION FOR USE IN THE REMEDIAL INVESTIGATION REPORT
Operable Unit 2B
Remedial Investigation Report



- SAMPLE LOCATION
- CERCLA SITE BOUNDARY
- FILL AREA 1
- FILL AREA 2
- FILL AREA 3
- LAND COVER
- OPEN WATER

Notes:
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980

600 0 600 1200 Feet

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Alameda Point

Department of the Navy BRAC PMO West, San Diego, California

FIGURE 3-3
SOIL BACKGROUND AREAS - YELLOW, PINK AND BLUE

Operable Unit 2B
Remedial Investigation Report

2005-03-15 U:\almda_sa\do030\ou2b_ri\mxd\fig03-03_soil_background_areas.mxd TtEMI-SA K. Johnson

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SSIC NO. 5090.3

TABLES

FINAL OPERABLE UNIT 2B REMEDIAL INVESTIGATION REPORT SITES 3, 4, 11, AND 21

DATED 05 AUGUST 2005

TABLE 3-1: HISTORICAL SUMMARY OF ENVIRONMENTAL INVESTIGATIONS
Remedial Investigation Report for CERCLA Sites 3, 4, 11, and 21, Alameda Point, Alameda, California

Environmental Investigation		Reference	Site 3	Site 4	Site 11	Site 21
Prior to IR Program	Initial Assessment Study	E&E 1983	√	√		
RI	Phases 1 & 2A Investigation, 1991	Canonie 1989 and 1990, PRC and MW 1993	√	√		
	Phases 2B & 3 Investigation, 1991	PRC and MW 1992		√	√	√
	Additional Work at Sites 4 and 5, 1992	PRC and MW 1995		√		
	Follow-on Investigation, 1994	PRC and MW 1995, 1996a, 1996b	√	√	√	√
	Storm Sewer Removal, 1997	Tetra Tech, 2000b	√	√	√	√
	Geochemical Profiling to Define Chlorinated Solvent Plumes, 1997	OGISO Environmental 1997		√		
	Follow-on Investigation, 1998	Tetra Tech and Uribe 1998, Tetra Tech 1997a, 1997b, 1998	√	√	√	√
	Supplemental RI Data Gap Sampling, 2001	Tetra Tech 2002	√	√	√	√
	Basewide Investigation of Transformer Pads, 2001	Innovative Technical Solutions, Inc. 2002	√	√	√	√
	Basewide Groundwater Monitoring, 2002	Shaw Environmental 2003a	√	√	√	√
	Pilot Studies, 2002	IT 2002, Shaw 2003b		√		
	DNAPL Removal Action, 2002	IT 2002	√			
	Basewide PAH Investigation, 2003	Bechtel 2003	√	√	√	√
EBS	Phase 1	ERM West 1994	√	√	√	√
	Phase 2A EBS	IT 2001	√	√	√	√
	Phase 2B EBS	IT 2001	√	√	√	√
	Phase 2C EBS	IT 2001	√			
	Storm Sewer Investigation	Tetra Tech 2001a and 2000b	√	√	√	√
TPH	Treatability Study	BERC 1998	√			
	Fuel Lines and UST Investigations	PWC 1996, Moju 1998	√	√	√	√
	Data Gap Sampling Investigation for CAAs, 2000	Tetra Tech 2000a, 2001b	√	√	√	√

TABLE 3-1: HISTORICAL SUMMARY OF ENVIRONMENTAL INVESTIGATIONS

Remedial Investigation Report for CERCLA Sites 3, 4, 11, and 21, Alameda Point, Alameda, California

Environmental Investigation		Reference	Site 3	Site 4	Site 11	Site 21
RCRA	RFA, 1992	DTSC 1992	√	√	√	√

Notes:

AST	Aboveground storage tank
CAA	Corrective action areas
DNAPL	Dense non-aqueous phase liquid
EBS	Environmental baseline survey
IAS	Initial assessment study
IR	Installation restoration
MW	Montgomery Watson
PAH	Polynuclear aromatic hydrocarbons
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RI	Remedial Investigation
TPH	Total petroleum hydrocarbon
UST	Underground storage tank

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TABLE 3-2: NONPERMITTED SOLID WASTE MANAGEMENT UNITS WITHIN EACH OU-2B SITE
Remedial Investigation Report for CERCLA Sites 3, 4, 11, and 21, Alameda Point, Alameda, California

Identification	EBS Subparcel	Location
Site 3		
IR-3	NA	Abandoned Fuel Storage Area (refers to Area 97 in RFA)
NAS GAP 10	122	Building 112; outside of northeastern portion of building
UST-97A	131	UST97A
UST-97B	131	UST97B
UST-97C	131	UST97C
UST-97D	131	UST97D
UST-97E	131	UST97E
Site 4		
IR-4	NA	Building 360 (Aircraft Engine Facility) (same name in RFA)
AST 360A	143	Building 360 - 1 of 3 ASTs on northern side
AST 360B	143	Building 360 - 2 of 3 ASTs on northern side
AST 360C	143	Building 360 - 3 of 3 ASTs on northern side
AST 360D	143	Building 360 - western side
AST 360E	143	West of Building 360
AST 372	134A	West of Building 372 (small secondary containment area)
AOC 372/SWMU 372	134A	JP-5 fuel spill (SWMU 372), southwestern corner of Building 372; overflow from UST (AOC is UST 372-1 & UST 372-2)
M-06	143	Solvent distillation unit; Building 360, Cleaning and Blasting Shop
NADEP GAP 01	143	Building 360, Shop 96234
NADEP GAP 49A	143	Building 360, Shop 96212
NADEP GAP 50	143	Building 360, Shop 96223
NADEP GAP 51	143	Building 360, Shop 96225
NADEP GAP 52	143	Building 360, Shop 96231; outside of Building 360
NADEP GAP 55	143	Building 360, Shop 96215
NADEP GAP 56	143	Building 360, Shop 96215
NADEP GAP 57A	143	Building 360, Shop 96215; outside of northern wall of Building 360; area 20 feet by 30 feet
NADEP GAP 58	143	Building 360, Shop 96211
NADEP GAP 59	134A	Building 163, Shop 65132; outside, between Buildings 163 and 414
NADEP GAP 61	134A	Building 372, Shop 96232

TABLE 3-2: NONPERMITTED SOLID WASTE MANAGEMENT UNITS WITHIN EACH OU-2B SITE
Remedial Investigation Report for CERCLA Sites 3, 4, 11, and 21, Alameda Point, Alameda, California

Identification	EBS Subparcel	Location
NADEP GAP 80	143	Building 360, Shop 96223
OWS-163	134A	Southwestern portion of Building 163
OWS-360	143	Former OWS at Building 360
OWS-372A	134A	West of Building 372
OWS-372B	134A	Building 372 - OWS outside of main entrance to building that collects runoff/excess from adjacent ASTs
Site 11		
IR-11	NA	Building 14 (Engine Test Cell) (refers to Building 410 in RFA)
AST 014A	137	Inside of Building 14 in Test Cell 4
AST 014B	137	Inside of Building 14 in Test Cell 4
AST 014C	137	Inside of Building 14 in control room for Test Cells 3 and 4 (1 of 2)
AST 014D	137	Inside of Building 14 in control room for Test Cells 3 and 4 (2 of 2)
NADEP GAP 47	137	Building 14, Shop 96233; sump
NADEP GAP 48	137	Building 14, Shop 96233
OWS-014A	137	1 of 4 OWSs at Building 14 - located on southern side in 2nd bay from the western end
OWS-014B	137	2 of 4 OWSs at Building 14 - located on southern side in 4th bay from the western end
OWS-014C	137	3 of 4 OWSs at Building 14 - located at northeastern corner of building (aboveground)
OWS-014D	137	4 of 4 OWSs at Building 14 - located on western side of building
OWS-014E	137	Building 14 - OWS inside of building; Northern portion of building about 45 ft east of western wall in room's E-W center line (Engine Canning Area)
UST(R)-06	137	USTs 14-1 through 14-6
AOC 398	127	USTs 398-1 through 398-2
Site 21		
IR-21	NA	Building 162 (Ship Fitting and Engine Repair) (refers to the Station Sewer System in RFA)
M-07	127	Solvent distillation unit; Building 398, Drize Test Shop

TABLE 3-2: NONPERMITTED SOLID WASTE MANAGEMENT UNITS WITHIN EACH OU-2B SITE
Remedial Investigation Report for CERCLA Sites 3, 4, 11, and 21, Alameda Point, Alameda, California

Identification	EBS Subparcel	Location
NADEP GAP 44	127	Building 398, Shop 96327 (Turbine Accessory Shop); outside of building east of northern wing
NADEP GAP 45	127	Building 398, Shop 96327 (Turbine Accessory Shop); under a covered walkway outside of building
NADEP GAP 46	135	Building 162, Shop 96324
NADEP GAP 76	136	Building 113, Shop 96212
NADEP GAP 77	136	Building 113, Shop 96215, southeastern corner of Building 113
NAS GAP 11	135	Building 162; sump to collect waste oils inside of building; not in RFA
OWS-162	135	Southeastern corner of Building 162
SWMU 162	135	Building 162; Shop 0542; Laboratory; second floor

Notes:

AOC	Area of concern
AST	Aboveground storage tank
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
EBS	Environmental baseline survey
GAP	Generation accumulation point
IR	Installation restoration
M	Miscellaneous
NA	Not applicable
NADEP	Naval Aviation Depot
NAS	Naval Air Station
OWS	Oil-water separator
R	RCRA
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
SWMU	Solid waste management unit
UST	Underground storage tank

TABLE 3-3: ECOLOGICAL RISK ASSESSMENT AND MEASUREMENT ENDPOINTS
Remedial Investigation Report for CERCLA Sites 3, 4, 11, and 21, Alameda Point, Alameda, California

ASSESSMENT ENDPOINTS	MEASUREMENT ENDPOINTS
Sufficient rates of survival, growth, and reproduction to sustain small mammal populations typical to the area	Reproductive or physiological impacts to the California ground squirrel *(Citellus beecheyi)*, as indicated by HQs developed based on both high (LOAEL-based) and low (NOAEL-based) TRVs
Sufficient rates of survival, growth, and reproduction to sustain passerine populations typical to the area	Reproductive or physiological impacts to the Alameda song sparrow *(Melospiza melodia pusillula)* and American robin (*Turdus migratorius*), as indicated by HQs developed based on both high (LOAEL-based) and low (NOAEL-based) TRVs
Sufficient rates of survival, growth, and reproduction to sustain raptor populations typical to the area	Reproductive or physiological impacts to the red-tailed hawk *(Buteo jamaicensis)*, as indicated by HQs developed based on both high (LOAEL-based) and low (NOAEL-based) TRVs
Sufficient rates of survival, growth, and reproduction to sustain marine populations typical to the area	Direct comparison with published water quality criteria to assess risk to marine receptors(1)

Notes:

(1) Published criteria were obtained from either the California Toxics Rule Criteria (U.S. EPA) for Enclosed Bays and Estuaries, Saltwater Aquatic Life Protection, or if not available, the U.S. EPA National AWQC, Saltwater Aquatic Life Protection, as presented in the NOAA SQUIRT Tables. See full references below.

AWQC	Aquatic Water Quality Criteria
HQ	Hazard quotient
LOAEL	Lowest observed adverse effects level
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No observed adverse effects level
SQUIRT	Screening Quick Reference Tables
TRV	Toxicity reference value
U.S. EPA	U.S. Environmental Protection Agency

Source:
California Environmental Protection Agency, Regional Water Quality Control Board, Central Valley Region. 2000. A Compilation of Water Quality Goals. August.
U.S. Department of Commerce, NOAA. 1999. NOAA SQUIRT. Hazmat Report 99-1. Updated September.

4.0 RESULTS OF GEOLOGICAL AND HYDROGEOLOGICAL INVESTIGATIONS

This section describes the results of geologic and hydrogeologic investigation activities at operable unit (OU)-2B Sites 3, 4, 11, and 21. Because these four sites are contiguous, the geologic and hydrogeologic conditions at the sites are similar and interrelated; therefore, they are discussed together in the following sections. The site-specific geology of OU-2B is described in Section 4.1, followed by a discussion of the site-specific hydrogeology presented in Section 4.2.

4.1 OPERABLE UNIT 2B GEOLOGY

The OU-2B geology, investigated in the remedial investigation (RI), includes four upper units (as described in Section 2.3.2), plus a surficial layer of artificial fill material. The OU was characterized by reviewing logs of 175 soil and cone penetrometer test (CPT) borings that have been conducted at the sites (see Appendix A). Conceptual geologic cross sections showing the basic geology of OU-2B are presented as Figure 4-1. Detailed geologic cross sections, two per site (see Figures 4-2 through 4-9), were developed based on the following observations during exploration activities:

- Information from the boring logs
- Stratigraphic contacts that were determined using changes in lithology
- Color of the lithologic matrix
- Grain features (frosting, angular, subangular, rounded)
- Presence of debris, oxidized root channels, and oxide staining
- Presence of key shell marker beds, buried vegetative surfaces, roots, stems, leaves, old soil surfaces, peat layers, and shell hash
- Degree of consolidation
- Changes in CPT tip resistance and blow counts

Artificial Fill. The artificial fill is the uppermost unit that underlies most of OU-2B, ranging in thickness from 3 to 18 feet below ground surface (bgs). The artificial fill is thickest in the southern portion of Site 4 and is thinnest in the northern portion of Site 3 at approximately 3 feet thick, although thicknesses vary locally. The fill at OU-2B mainly comprises dense to medium dense, brown silty sand. Local variations in the fill include the presence of discontinuous clay and gravel lenses. Shell fragments, asphalt, and root debris have been encountered in borings at numerous locations in OU-2B.

Bay Sediment Unit (BSU) (Estuarine Deposits). At OU-2B, the BSU underlies the artificial fill material at all sites, although it is not present in the southeastern portion of Site 4, where it pinches out along the former shoreline of Alameda Island (see Figure 2-4). Southeast of the former shoreline, the BSU is not present. The BSU reaches a maximum thickness of 11 feet at Site 3. At OU-2B, the BSU consists of loose silt and soft gray to black clay with laterally discontinuous, poorly graded silty and clayey sand layers. Horizontal bedding in thin discrete clay layers has been seen in several borings. The marsh crust has been identified on top of the BSU at Sites 3, 4, 11, and 21 (see Section 2.3.2).

Merritt Sand (Eolian Deposits). At OU-2B, the Merritt Sand underlies the artificial fill in the southeastern portion of Site 4, as shown in Figures 4-4 and 4-5, and underlies the BSU across the rest of OU-2B, as shown in Figures 4-2, 4-3, and 4-6 through 4-9. The full thickness of the Merritt Sand is encountered in only three of the borings advanced at OU2B, in these borings the Merritt Sand ranged in thickness from 56 feet to 70, with the unit thickening to the north of Site 4 (Figure 4-5).

The upper ten feet of the Merritt Sand at OU-2B is composed of yellowish brown, dense to medium dense, fine- to medium-grained, poorly graded sand and clayey sand with occasional roots and other vegetative material. Below approximately the first ten feet, the Merritt Sand grades into silty sand. Further down it grades into very dense yellowish brown sand. Thin, continuous clayey or silty sand layers are common at lower depths.

Upper San Antonio Formation (Alluvial Deposits). At OU-2B, the upper unit of the San Antonio Formation was encountered in three borings. The depth of the top of the upper unit of the San Antonio Formation is between 68 feet bgs in the southern portion of Site 4 and 80 feet bgs at the northern portion of Site 4 as shown in Figure 4-5. The thickness of the upper unit of the San Antonio Formation, seen in all three borings, ranges from 14 to 28 feet in the northern and southern portions of Site 4, respectively. The Upper San Antonio Formation at OU-2B consists of loose greenish gray to gray silty clay with trace amounts of organic matter and roots, grading into sand and clayey sand.

Yerba Buena Mud (Estuarine Deposits). At OU-2B, the lower unit of the San Antonio Formation (Yerba Buena Mud) was encountered in three borings. The depth of the top of the Yerba Buena Mud occurs at approximately 95 feet bgs in all three borings. Borings advanced at OU-2B penetrated the unit a maximum of 8 feet; the total thickness of this unit was not explored during RI activities. The Yerba Buena Mud encountered at OU-2B is described as a dark greenish gray to gray, highly plastic stiff fat clay.

Alameda Formation/Franciscan Complex. Geologic units underlying the Yerba Buena Mud, the Alameda Formation and the Franciscan Complex, were not encountered in borings conducted during the RI program.

4.2 OPERABLE UNIT 2B HYDROGEOLOGY

This section describes the hydrogeology of OU-2B at Alameda Point.

4.2.1 Hydrostratigraphy

As discussed in Section 2.4.2.1, there are five hydrostratigraphic units at Alameda Point, each of which is represented in OU-2B. Hydrostratigraphic units occurring within OU-2B include the first water-bearing zone (FWBZ), the second water-bearing zone (SWBZ), the BSU Aquitard, the Yerba Buena Aquitard, and the Alameda Aquifer. The FWBZ occurs in all of OU-2B. The SWBZ occurs only at Sites 3, 11, 21, and the northern and western portion of Site 4, where the BSU Aquitard is present and separates the FWBZ from the SWBZ. The BSU Aquitard pinches out beneath OU-2B, approximately coincident with the former Alameda Point shoreline; the approximate eastern extent of the BSU in OU-2B is shown on Figure 2-4. The SWBZ does not occur in the southeastern portion of Site 4 at OU-2B, where the BSU Aquitard is absent.

The SWBZ in OU-2B is confined by the overlying BSU Aquitard. The regional aquitard (Yerba Buena Mud) separates the FWBZ and, where present, the SWBZ from the underlying Alameda Formation. Detailed descriptions of the hydrostratigraphic units are provided in Section 2.4.2; the occurrence of these hydrostratigraphic units within OU-2B is described as follows:

FWBZ. The FWBZ is the uppermost water-bearing zone at OU-2B and occurs throughout the OU as a water table aquifer. At OU-2B, the FWBZ occurs within both the artificial fill deposits in the western and northern portion of OU-2B and in the Merritt Sand in the southeastern portion of Site 4. Artificial fill was placed in most areas of OU-2B at thicknesses up to 18 feet. The artificial fill was placed on top of native materials including the Merritt Sand and the BSU. Where the BSU Aquitard is present, the FWBZ is approximately 10 feet thick and is comprised primarily of artificial fill.

Where the BSU Aquitard is absent, the FWBZ reaches a maximum thickness of at least 70 feet and is comprised of either artificial fill and the Merritt Sand or only the Merritt Sand in the southern part of OU-2B (Site 4). In this part of OU-2B, the FWBZ is subdivided vertically into the FWBZ upper (FWBZU) and the FWBZ lower (FWBZL). In general, the FWBZU is coincident with the artificial fill deposits where present and the upper part of the Merritt Sand. The FWBZL occurs only in the Merritt Sand in the southeastern portion of Site 4 at OU-2B.

BSU Aquitard. The BSU Aquitard occurs at Sites 3, 11, and 21 in the north and western portion of Site 4. Where present, the BSU Aquitard underlies the artificial fill material. The aquitard discontinues along a line curving from the southwestern corner of Site 4, up to the near Site 4 and 3 border and then east towards the edge of the installation, as determined from boring logs, and is illustrated Figure 2-4. The BSU Aquitard consists of loose silt and soft gray to black clay with laterally discontinuous, poorly graded, silty and clayey sand layers and reaches a maximum thickness of 11 feet at Site 3.

SWBZ. The SWBZ occurs in the northwestern portion of OU-2B in Sites 3, 11, 21, and in the north and western portion of Site 4, coincident with the occurrence of the BSU Aquitard. The SWBZ is in the Merritt Sand and the Upper San Antonio Formation. The maximum thickness of the SWBZ in OU-2B is estimated to be 90 feet thick in the northern portion of Site 3, based on trends seen at adjacent Site 4.

Yerba Buena Aquitard. The Yerba Buena Aquitard occurs at depths of approximately 95 feet bgs at OU-2B. No OU-2B monitoring wells are screened in or below this unit.

Alameda Aquifer. The Alameda Aquifer occurs below the Yerba Buena Aquitard at OU-2B. No OU-2B monitoring wells are screened in or below this unit.

4.2.2 Groundwater Flow

This section describes the groundwater flow in the FWBZ and the SWBZ at OU-2B.

4.2.2.1 Groundwater Flow in the FWBZ

In 2002 and 2003, groundwater elevations measured in the FWBZ in OU-2B ranged from approximately 4.5 to 9.94 feet above the mean lower low water (MLLW). Groundwater in the FWBZ at OU-2B generally flows from east to west.

Groundwater flow patterns in OU-2B were estimated using two rounds of groundwater elevation data collected in September 2002 and April 2003. In June 2002, the collection of groundwater elevation data was not synchronized.and was collected over an approximate 3-week period. The September data set, which contains a limited amount of data points, was collected over a 1.5-hour period. The April data set is fairly complete, comprising water levels collected at two-thirds of the monitoring wells in OU-2B in a 6-hour period. Contoured groundwater elevation data for September 2002 and April 2003 are shown on Figures 4-10 through 4-11. The September 2002 and April 2003 data were collected over a short time (within 1.5 and 6 hours, respectively), so tidal correction is not needed.

Groundwater elevation data collected in OU-2B in monitoring wells on September 3, 2002 (see Figure 4-10) are limited; however, groundwater elevation contours suggest that groundwater generally flowed from the east to the western portion of OU-2B, with the highest groundwater elevations occurring in wells in Site 4 and the lowest groundwater elevations occurring at Site 21.

Figure 4-11 presents groundwater elevation data from the FWBZ collected on April 7, 2002. Groundwater elevation contours using those data suggest that groundwater generally flowed from the east to the western portion of OU-2B, with a slight trend to the northwest in the eastern half of the OU. Groundwater elevations were highest at Site 4 and lowest at Site 21.

4.2.2.2 *Groundwater Flow in the SWBZ*

Groundwater elevations in the SWBZ at OU-2B ranged from approximately 5.2 to 6.4 feet above MLLW in June 2002 and from 5.5 to 6.8 feet above MLLW in April 2003. Based on limited data on groundwater elevations collected in June 2002, groundwater flow direction in the SWBZ at OU-2B is generally from east to west. Groundwater elevation contour maps generated from the June 2002 and April 2003 data are shown on Figures 4-12 and 4-13.

4.2.3 Aquifer Hydraulic Parameters

Table 4-1 presents estimates of aquifer hydraulic parameters for Sites 4, 11, and 21 based on data collected from geotechnical laboratory tests conducted in 1991 (PRC Environmental Management, Inc. 1992) and slug and pumping tests that were conducted in 2003 (Shaw Environmental & Infrastructure, Inc. 2003a). The hydraulic conductivity (K) of the FWBZ at Site 11, as determined from slug testing, is estimated at 2.1 feet per day. K values for Site 4 ranged from 2.2E-04 to 5.6 feet per day, as interpreted from geotechnical testing data.

The hydraulic conductivity of the SWBZ at Sites 11 and 21, as determined from pumping test data, is 4.4 feet per day. The estimated transmissivity and storativity of the SWBZ at Site 11 and 21, as determined from pumping test data, are 98 square feet (ft^2) per day and 0.0014 (dimensionless).

4.2.4 Hydraulic Gradients

This section describes the horizontal and vertical hydraulic gradients of the FWBZ and SWBZ at OU-2B.

4.2.4.1 *Horizontal Hydraulic Gradients*

The horizontal hydraulic gradient in the FWBZ, as estimated from groundwater elevation data collected in April 2003, was calculated at 0.005 with a northeast direction in the vicinity of Site 4 and 0.006 with a northwest direction at Site 11 in the western portion of OU2-B.

In April 2003, the horizontal hydraulic gradient in the SWBZ was calculated to have a magnitude of 0.002 in the northwest direction (324°) in the southeastern portion of OU-2B in the vicinity of Building 360.

4.2.4.2 *Vertical Hydraulic Gradients*

Vertical hydraulic gradients within the FWBZ and between the FWBZ and the SWBZ were estimated using groundwater elevation data from three monitoring well pairs. The well pairs consist of adjacent or closely spaced wells screened in multiple hydrostratigraphic zones.

Vertical hydraulic gradients in OU-2B were estimated using groundwater elevation data collected over 6 hours on April 7, 2003.

Vertical hydraulic gradients were calculated by dividing the difference in hydraulic heads between two adjacent wells by the difference in the midpoint elevations of the screened intervals. Vertical hydraulic gradients are indicative of the magnitude and direction of the vertical component of groundwater flow. Vertical hydraulic gradients calculated using the groundwater elevation data were generally downward, suggesting that although groundwater in the FWBZ moves horizontally toward the Seaplane Lagoon and the San Francisco Bay, there is some component of flow downward to recharge the lower FWBZ and the SWBZ. The BSU Aquitard functions as an aquitard, most likely limiting or slowing the downward flow of groundwater from the FWBZ to the SWBZ.

Based on data from three well pairs, one in the eastern portion of OU-2B where the BSU is not present and one each in the western and northern portions, the calculated vertical gradients were low: 0.028, 0.017, and 0.029, respectively.

4.2.5 Tidal Influence

Aquifers located adjacent to tidal water bodies are subject to short-term fluctuations in water levels in response to the tides. Water levels in monitoring wells near tidal bodies demonstrate fluctuations in hydraulic head that parallel the rise and fall of the tide. The amplitude of the fluctuation is generally greatest at the coast and diminishes inland. At Alameda Point, water level fluctuations in the San Francisco Bay cause groundwater levels near the coast to respond hydraulically, moving up and down according to the tidal cycle; groundwater affected in this way is said to be "tidally influenced." Groundwater levels in tidally influenced monitoring wells move up and down after the corresponding high and low tides occur. The length of time required for the water in a well to respond to the ocean tidal cycle is known as the "tidal time lag" (Fetter 1994). The ratio of the tidal amplitude in a well to that of the sea is termed the "tidal efficiency."

Groundwater that is tidally influenced in OU-2B occurs at the western edges in Sites 3, 4, 11, and 21, as determined during tidal studies performed at Alameda Point.

In the FWBZ, tidally influenced groundwater occurs at monitoring wells MW11-01, MW11-02, MW11-03, MW11-04, MW11-05, and MW11-06. Groundwater in the SWBZ along the western edge of OU-2B is tidally influenced, as indicated by data from monitoring well D03-01 (Tetra Tech EM Inc. [Tetra Tech] 1997b).

4.2.6 Seawater Intrusion

In aquifers near the coast, fresh water generally grades into saline water with a steady increase in the dissolved solids content. Because of the difference in the concentration of dissolved solids, the density of the saline water is greater than that of fresh water. As a result, along seacoasts there is a salt water-freshwater contact zone or interface in aquifers that extends under the sea. At coastal locations, the fresh groundwater beneath the ground surface is discharging across the freshwater-saltwater interface and mixing with saline groundwater under the sea floor (Fetter 1994).

Normally, freshwater moves seaward continuously at a rate that is related to the hydraulic head above mean sea level in a freshwater aquifer (Hem 1989); this natural flow of fresh water toward the sea limits the landward encroachment of sea water (Domenico and Schwartz 1990).

The shape and position of the interface between saline groundwater and fresh groundwater is a function of the volume of fresh water discharging from the aquifer. Any action that changes the volume of fresh water discharge results in a consequent change in the salt water-fresh water boundary. Minor fluctuations in the boundary position occur with tidal actions and seasonal and annual changes in the amount of fresh water discharge (Fetter 1994). With development of groundwater supplies and subsequent lowering of the water table or piezometric surface, the dynamic balance between freshwater and seawater is disturbed, permitting seawater to intrude into usable parts of the aquifer above the coastline (Domenico and Schwartz 1990). This phenomenon is referred to as "salt water intrusion" or "saline-water encroachment."

Specific conductance is a measure of the ability of a solution to carry an electric current and depends on the total concentration of ionized substances dissolved in the water. Although all ions contribute to conductivity, their valences and mobilities differ, so their actual and relative concentrations affect conductivity. When the concentration of ions is high, conductivity is elevated. The approximate specific conductance of seawater is 50,000 micromhos per centimeter (µmhos/cm) (Hem 1989). The California Secondary MCL recommended for the specific conductance of drinking water is 900 µmhos/cm.

At Alameda Point, fresh groundwater occurs in the FWBZ; the SWBZ primarily consists of water that is fresh to brackish, with specific conductance readings ranging from less than 500 µmhos/cm to greater than 3,000 µmhos/cm. Specific conductance values measured in monitoring wells in OU-2B were measured in 1990 and 1994. In 1990, specific conductance readings from seven monitoring wells screened in the FWBZ ranged from approximately 1,140 to 36,000 µmhos/cm. In 1994, specific conductance measured in 15 monitoring wells screened in the FWBZ ranged from 970 to 42,000 µmhos/cm, with five wells over 10,000 µmhos/cm.

In 1994, conductivity was measured in one monitoring well (D03-03) in the SWBZ at OU-2B at 45,000 µmhos/cm.

Overpumping of groundwater extraction wells drilled into the Merritt Sand on Alameda Island before the turn of the century resulted in saltwater intrusion and closure of many production wells. Only minor pumping of groundwater from the aquifer underlying Alameda Island has occurred since 1990 (Figuers 1998).

4.2.7 Existing Uses of Groundwater

A technical memorandum was prepared on the quality and beneficial uses of groundwater at Alameda Point (Tetra Tech 2000c). The memorandum focused on applicable water quality policies and regulations, the rationale for and assessment of groundwater quality, the feasibility of using the groundwater resource, and the determination of the probable beneficial use of the groundwater resource at Alameda Point. The document currently is being revised to reflect U.S. Environmental Protection Agency groundwater classification and use scenarios.

Nine state-registered wells are screened in the unconfined Merritt Sand unit east of Alameda Point. These wells are located in the neighborhood south of Atlantic Avenue and west of Webster Street. In addition, there are several unregistered, private irrigation wells screened in the unconfined Merritt Sand unit and the confined Alameda Formation. All the neighborhood wells are located upgradient of Alameda Point. Many of the unregistered wells screened in the Merritt Sand aquifer were installed by private landowners to obtain water for lawn and horticultural irrigation during periods of drought. The irrigation wells are currently used for lawn irrigation within the community. The irrigation wells were installed in accordance with historical well construction standards before the enactment of current Alameda County well construction standards. Current Alameda County standards prohibit screening of municipal or domestic water supply wells in the unconfined Merritt Sand unit.

Three wells on or near Alameda Point are screened in the confined Alameda Formation. Two of the wells are in operation, and one of the wells has been closed. Of the two operational wells, one is near the intersection of Pan Am Way and West Red Line Avenue on Alameda Point, and the other is near the intersection of 5th Street and Pacific Avenue east of Alameda Point. Both of these wells are used for irrigation.

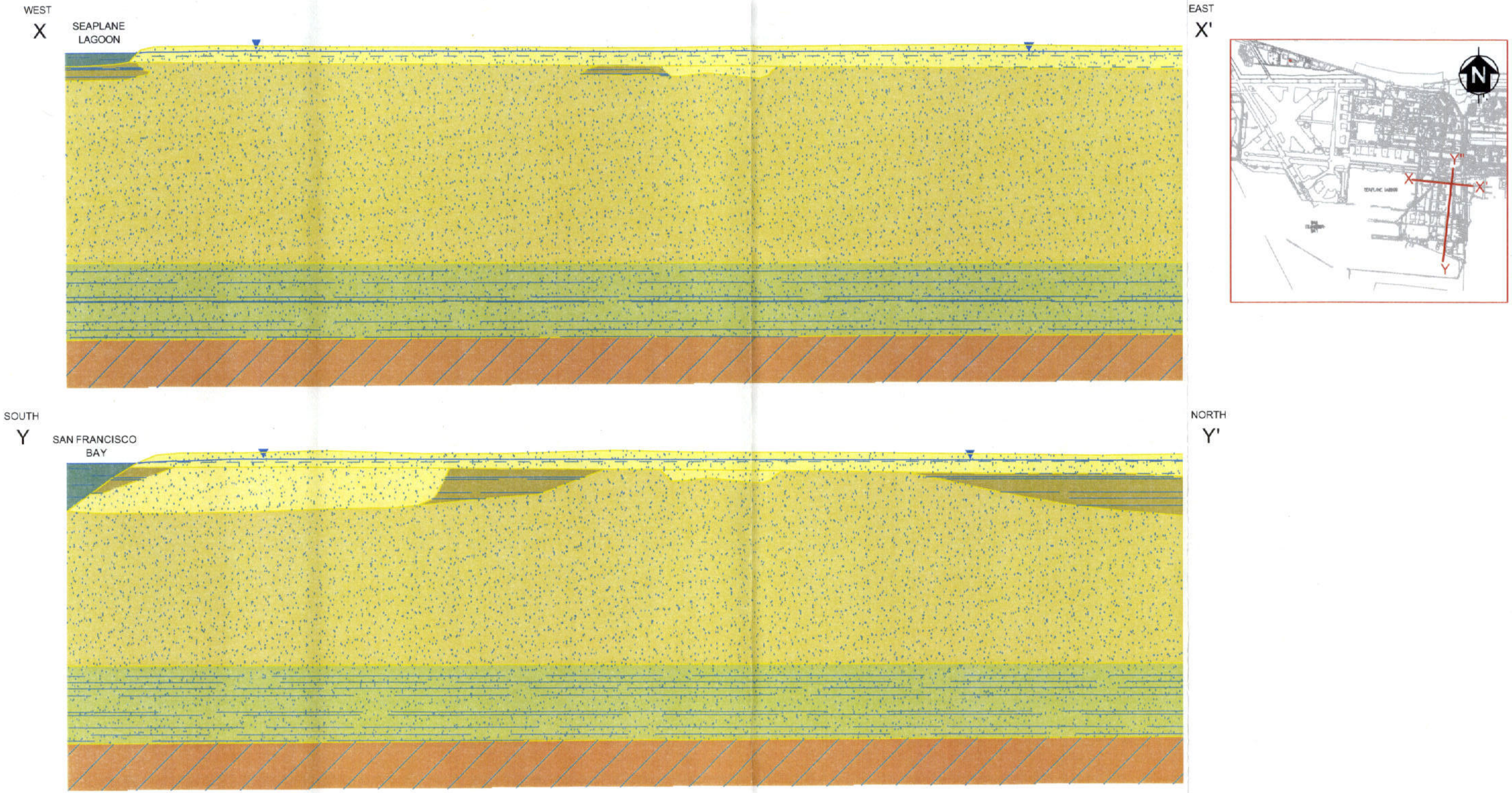
Groundwater wells to be used for domestic consumption could be installed in the Alameda Formation (a confined aquifer) because the regional aquitard protects the formation from contamination. However, pumping rates of any new wells in this aquifer must be controlled to prevent significant drawdown that would adversely affect the current domestic groundwater wells in the area.

N00236.002042
ALAMEDA POINT
SSIC NO. 5090.3

FIGURES

FINAL OPERABLE UNIT 2B REMEDIAL INVESTIGATION REPORT SITES 3, 4, 11, AND 21

DATED 05 AUGUST 2005



LEGEND

Symbol	Description
	WATER BODIES
	FILL
	BAY SEDIMENTS CLAY
	BAY SEDIMENTS SAND
	MERRITT SAND
	SAN ANTONIO INTERBEDDED SAND AND CLAY
	YERBA BUENA MUD
	CONTACT OF LITHOLOGIC UNITS
	CONTACT OF FINE AND COARSE MATERIAL WITHIN BAY SEDIMENTS
	SHALLOW WATER-BEARING ZONE WATER TABLE

NOT TO SCALE

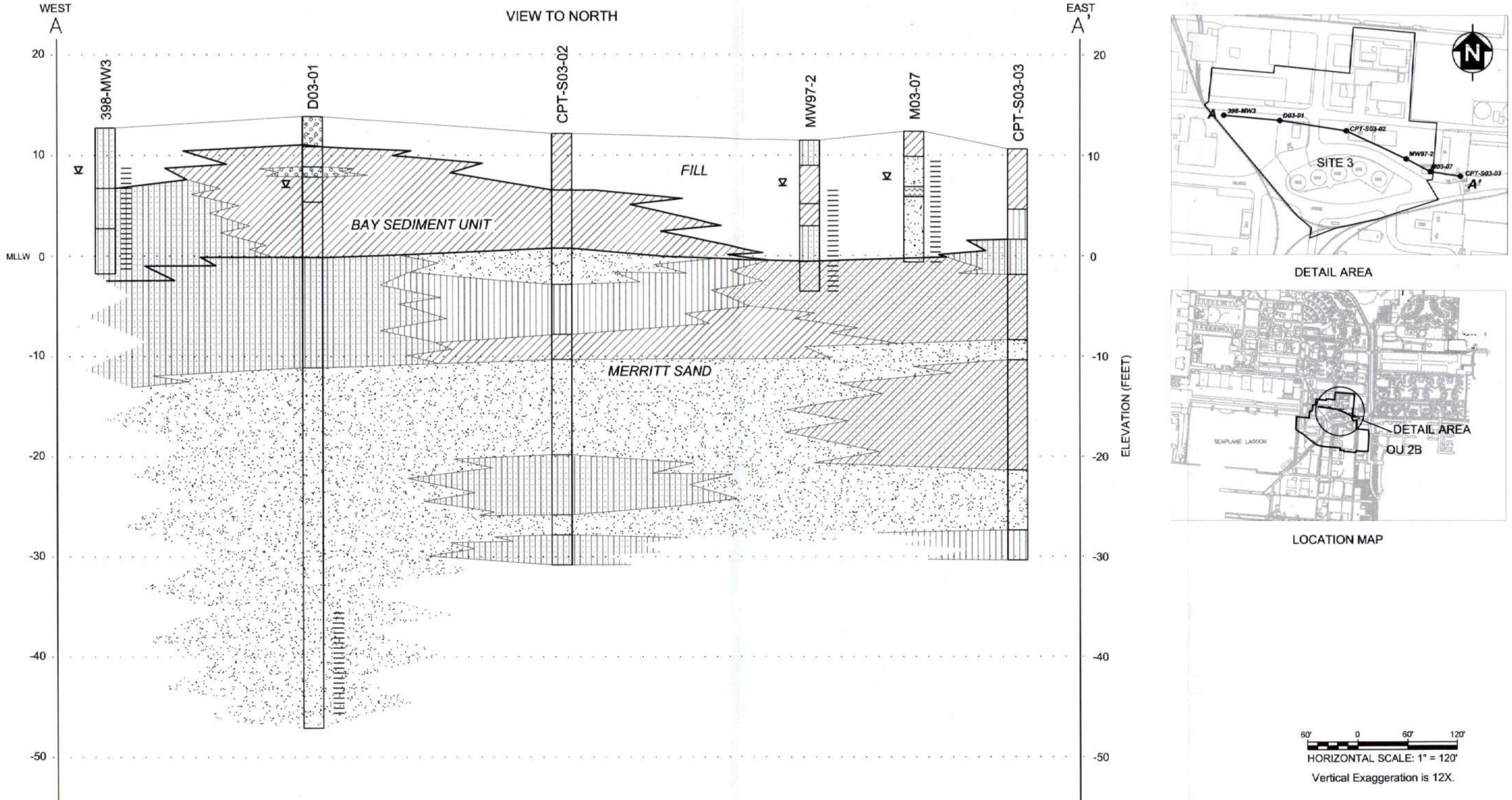
Alameda Point

Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 4-1
CONCEPTUAL GEOLOGIC CROSS SECTIONS

Operable Unit 2B

Remedial Investigation Report



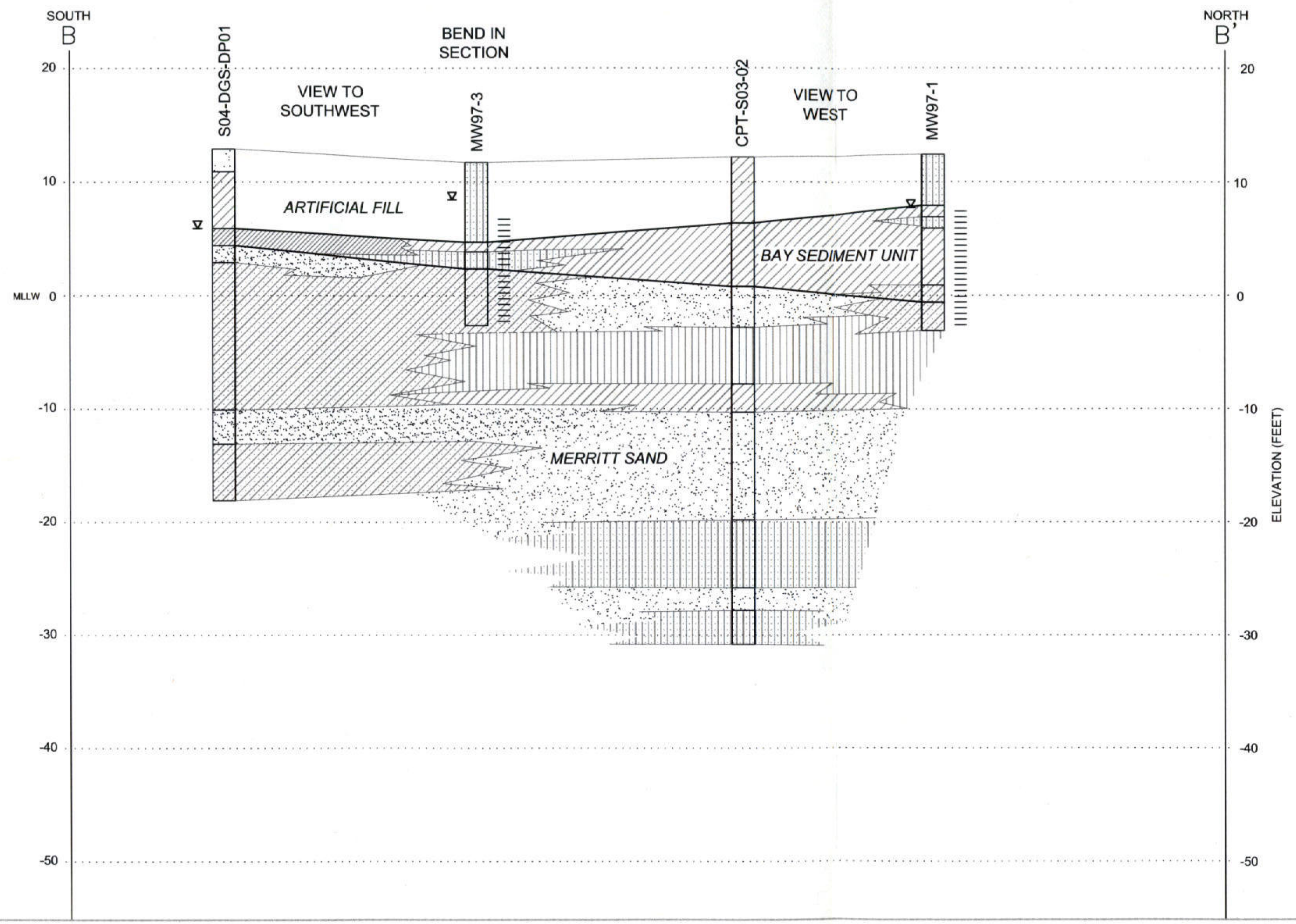
LEGEND

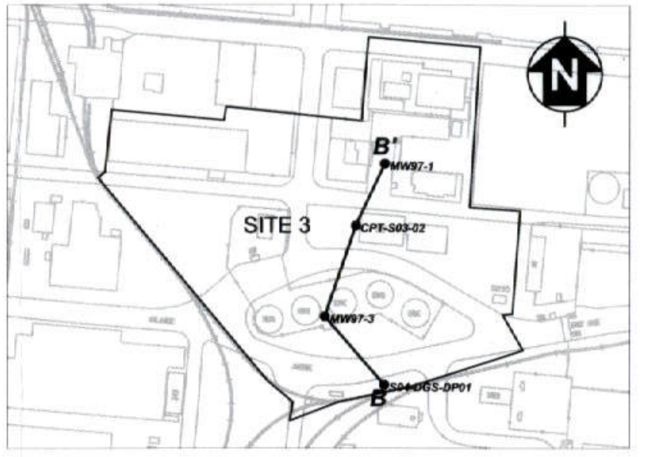
- SW - WELL GRADED SANDS
- SP - POORLY GRADED SANDS
- SM - SILTY SANDS
- SC - CLAYEY SANDS
- ML - SANDY SILTS
- CL - SANDY CLAYS
- PT - PEAT
- LITHOLOGIC CONTACT
- FORMATION CONTACT
- MONITORING WELL SCREENED INTERVAL
- MLLW MEAN LOWER LOW WATER
- WATER ENCOUNTERED DURING DRILLING

Tetra Tech EM Inc.

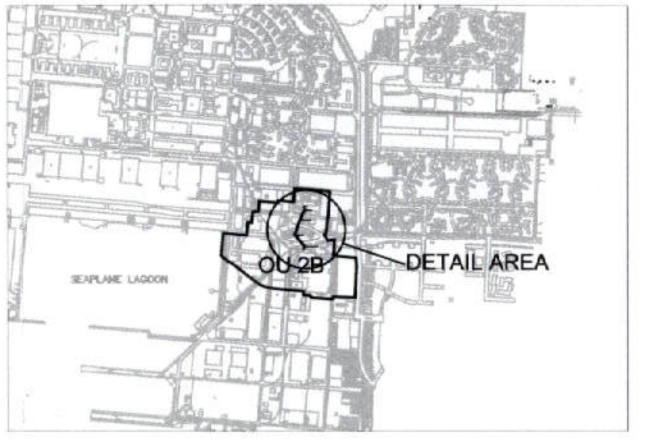
ALAMEDA POINT
U.S. Navy Southwest Division, NAVFAC, San Diego

FIGURE 4-2
GEOLOGICAL CROSS SECTION A-A'
SITE 3
Operable Unit 2B
Remedial Investigation Report





DETAIL AREA



LOCATION MAP

50' 0 50' 100

HORIZONTAL SCALE: 1" = 100'

Vertical Exaggeration is 10X.

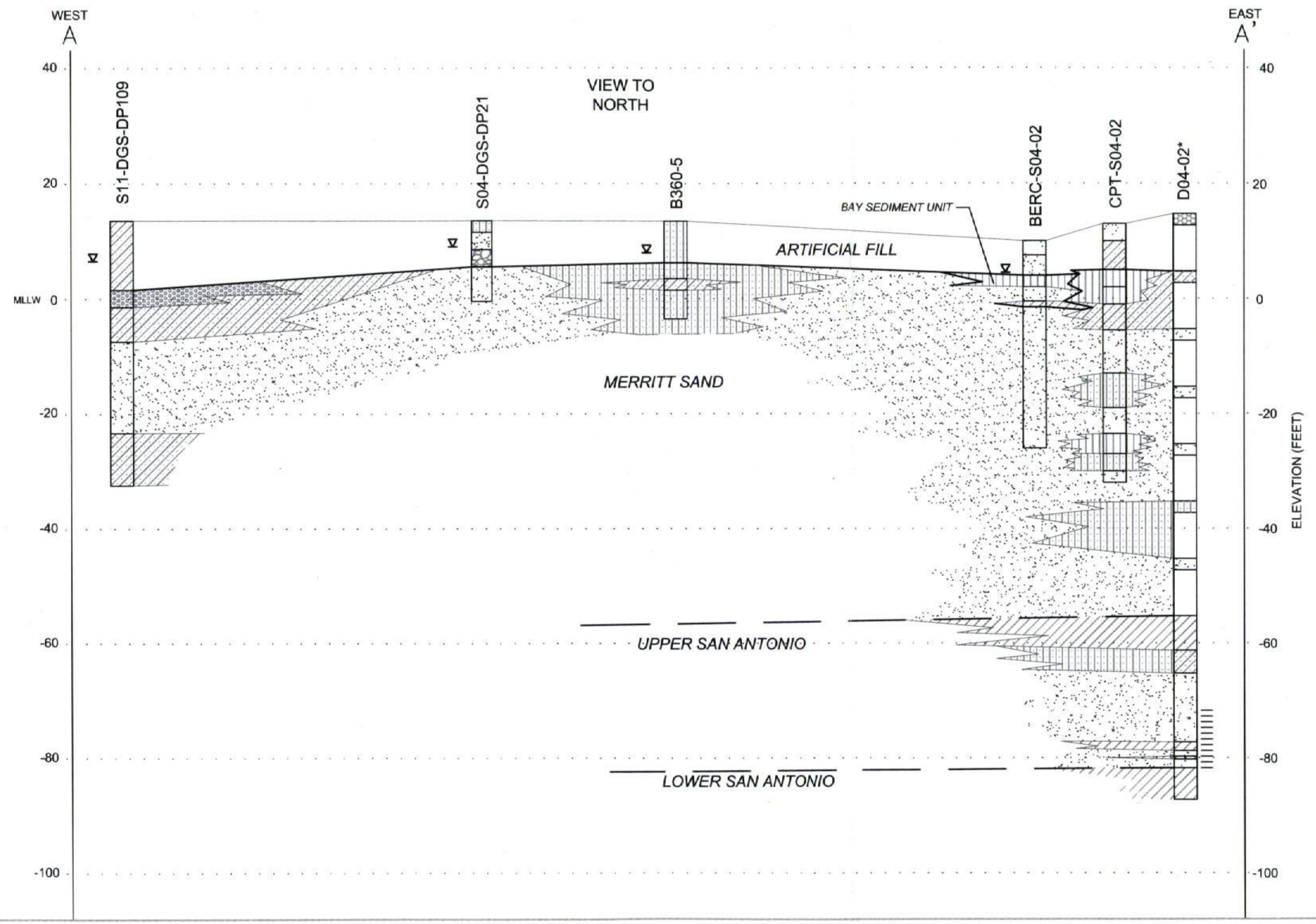
LEGEND

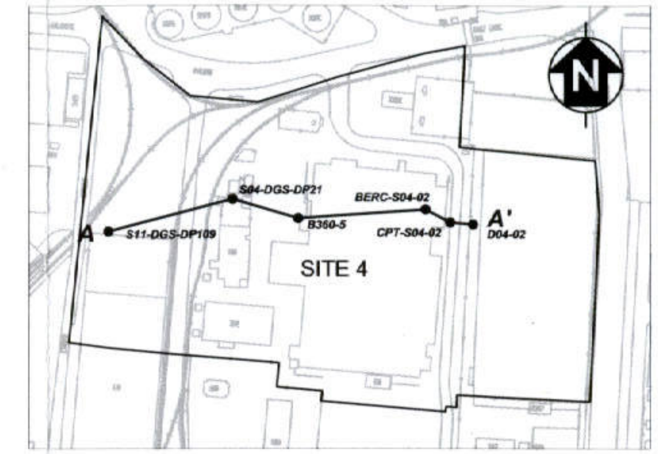
- SW - WELL GRADED SANDS
- SP - POORLY GRADED SANDS
- SM - SILTY SANDS
- SC - CLAYEY SANDS
- ML - SANDY SILTS
- CL - SANDY CLAYS
- CH - ORGANIC CLAYS, HIGH PLASTICITY
- LITHOLOGIC CONTACT
- FORMATION CONTACT
- MONITORING WELL SCREENED INTERVAL
- MLLW MEAN LOWER LOW WATER
- WATER ENCOUNTERED DURING DRILLING

Tetra Tech EM Inc.

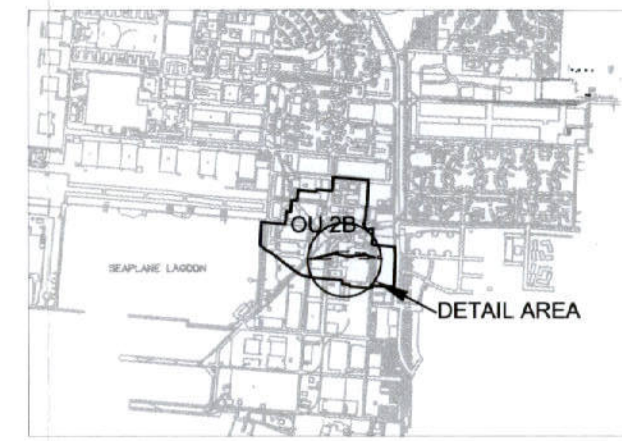
ALAMEDA POINT
U.S. Navy Southwest Division, NAVFAC, San Diego

FIGURE 4-3
GEOLOGICAL CROSS SECTION B-B'
SITE 3
Operable Unit 2B
Remedial Investigation Report





DETAIL AREA



LOCATION MAP

50' 0 50' 100

HORIZONTAL SCALE: 1" = 100'
Vertical Exaggeration is 5X.

LEGEND

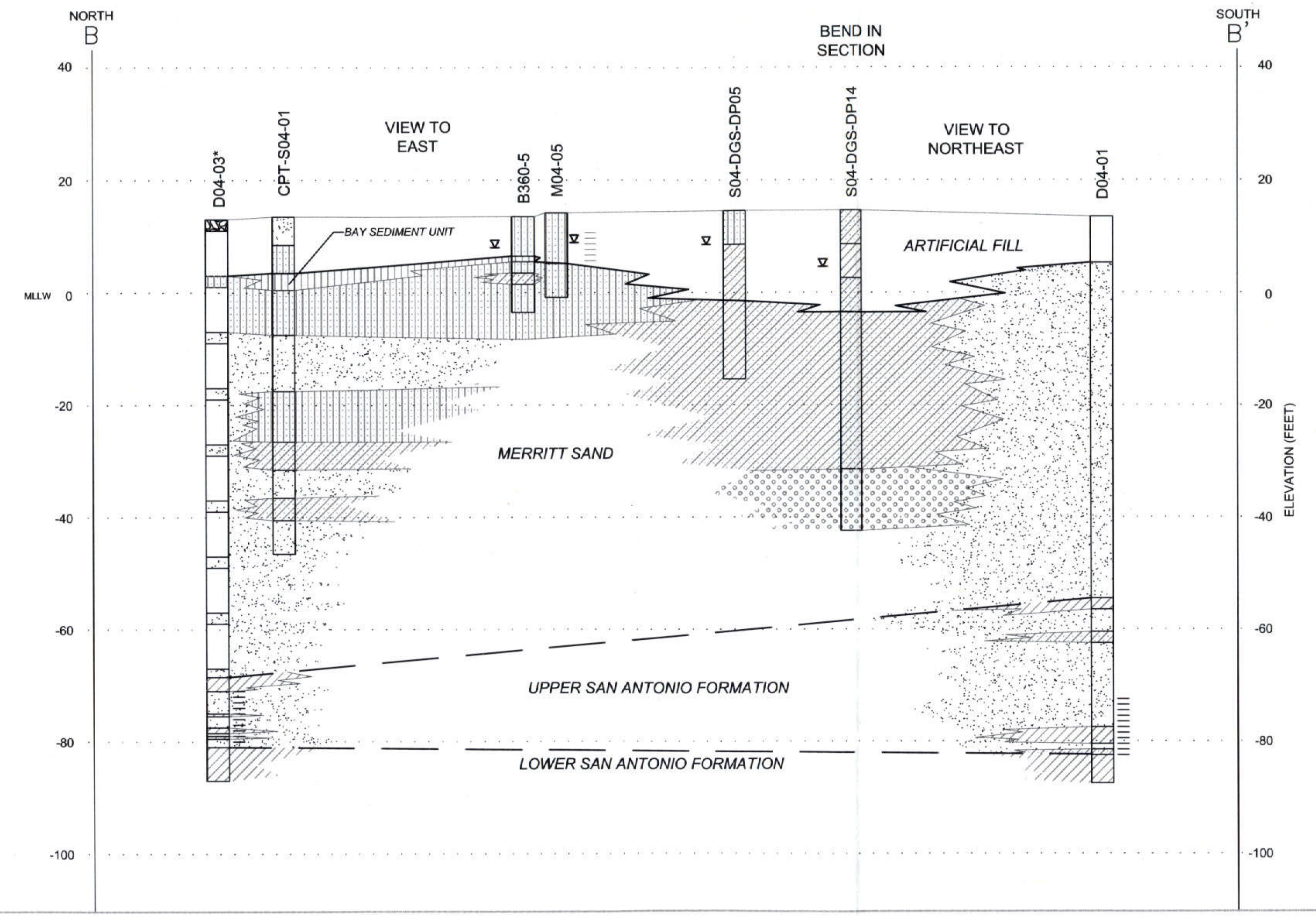
- GP - POORLY GRADED GRAVELS
- GW - WELL GRADED GRAVELS
- SW - WELL GRADED SANDS
- SP - POORLY GRADED SANDS
- SM - SILTY SANDS
- SC - CLAYEY SANDS
- ML - SANDY SILTS
- CL - SANDY CLAYS
- LITHOLOGIC CONTACT (DASHED WHERE INFERRED)
- FORMATION CONTACT (DASHED WHERE INFERRED)
- MONITORING WELL SCREENED INTERVAL
- MLLW MEAN LOWER LOW WATER
- ▽ WATER ENCOUNTERED DURING DRILLING

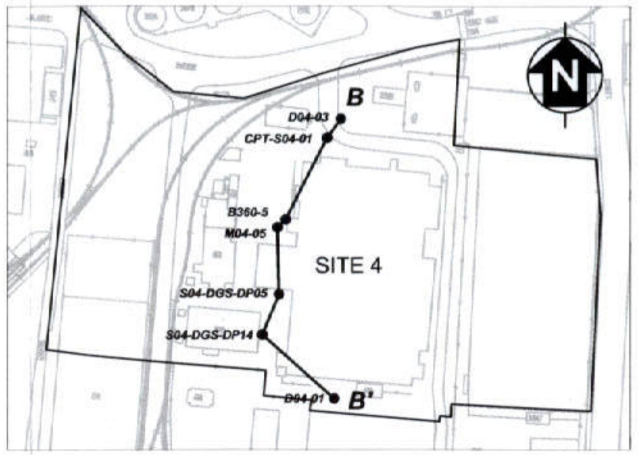
* TWO FEET OF SOILS WERE LOGGED EVERY TEN FEET UNTIL THE UPPER SAN ANTONIO FORMATION WAS ENCOUNTERED.

Tetra Tech EM Inc.

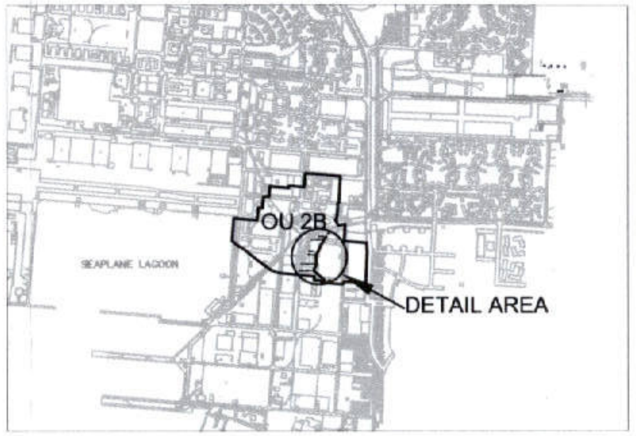
ALAMEDA POINT
U.S. Navy Southwest Division, NAVFAC, San Diego

FIGURE 4-4
GEOLOGICAL CROSS SECTION A-A'
SITE 4
Operable Unit 2B
Remedial Investigation Report





DETAIL AREA



LOCATION MAP

50' 0 50' 100

HORIZONTAL SCALE: 1" = 100'

Vertical Exaggeration is 5X.

LEGEND

- GP - POORLY GRADED GRAVELS
- SW - WELL GRADED SANDS
- SP - POORLY GRADED SANDS
- SM - SILTY SANDS
- SC - CLAYEY SANDS
- ML - SANDY SILTS
- CL - SANDY CLAYS
- LITHOLOGIC CONTACT
- FORMATION CONTACT (DASHED WHERE INFERRED)
- MONITORING WELL SCREENED INTERVAL
- MLLW MEAN LOWER LOW WATER
- WATER ENCOUNTERED DURING DRILLING

* TWO FEET OF SOILS WERE LOGGED EVERY TEN FEET UNTIL THE UPPER SAN ANTONIO FORMATION WAS ENCOUNTERED.

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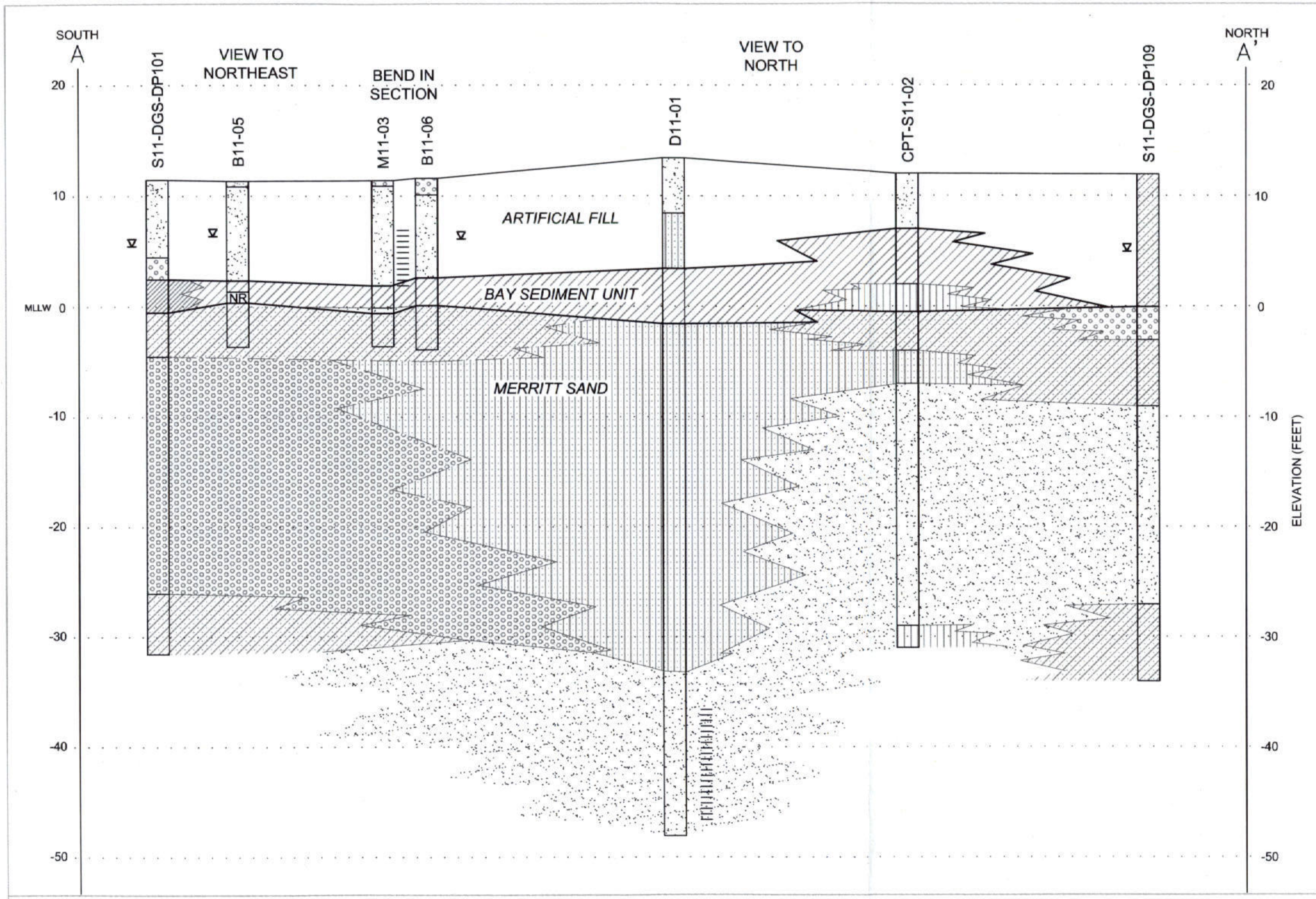
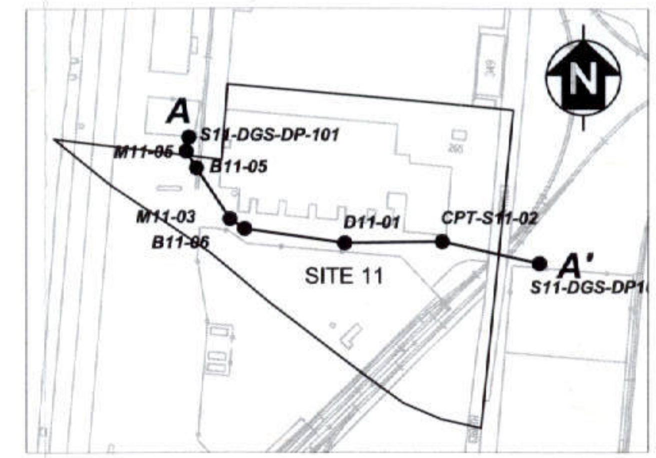
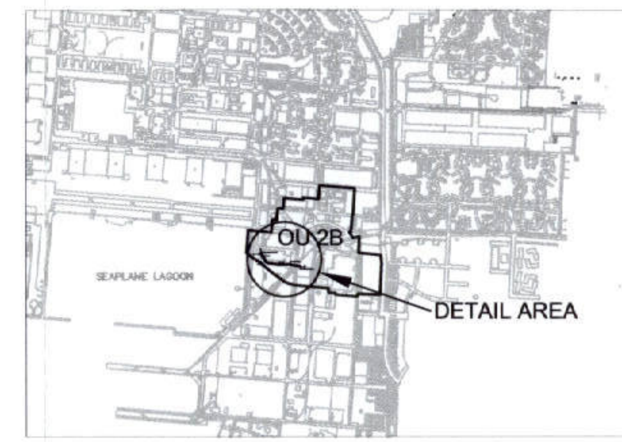
ALAMEDA POINT
U.S. Navy Southwest Division, NAVFAC, San Diego

FIGURE 4-5
GEOLOGICAL CROSS SECTION B-B'
SITE 4
Operable Unit 2B
Remedial Investigation Report





DETAIL AREA



LOCATION MAP

50' 0 50' 100

HORIZONTAL SCALE: 1" = 100'

Vertical Exaggeration is 7.5X.

LEGEND

- CN - CONCRETE
- SW - WELL GRADED SANDS
- SP - POORLY GRADED SANDS
- SM - SILTY SANDS
- SC - CLAYEY SANDS
- CL - SANDY CLAYS
- ML - SANDY SILTS
- CH - ORGANIC CLAYS, HIGH PLASTICITY
- LITHOLOGIC CONTACT (DASHED WHERE INFERRED)
- FORMATION CONTACT
- MONITORING WELL SCREENED INTERVAL
- MLLW MEAN LOWER LOW WATER
- ∇ WATER ENCOUNTERED DURING DRILLING
- NR NO RECOVERY

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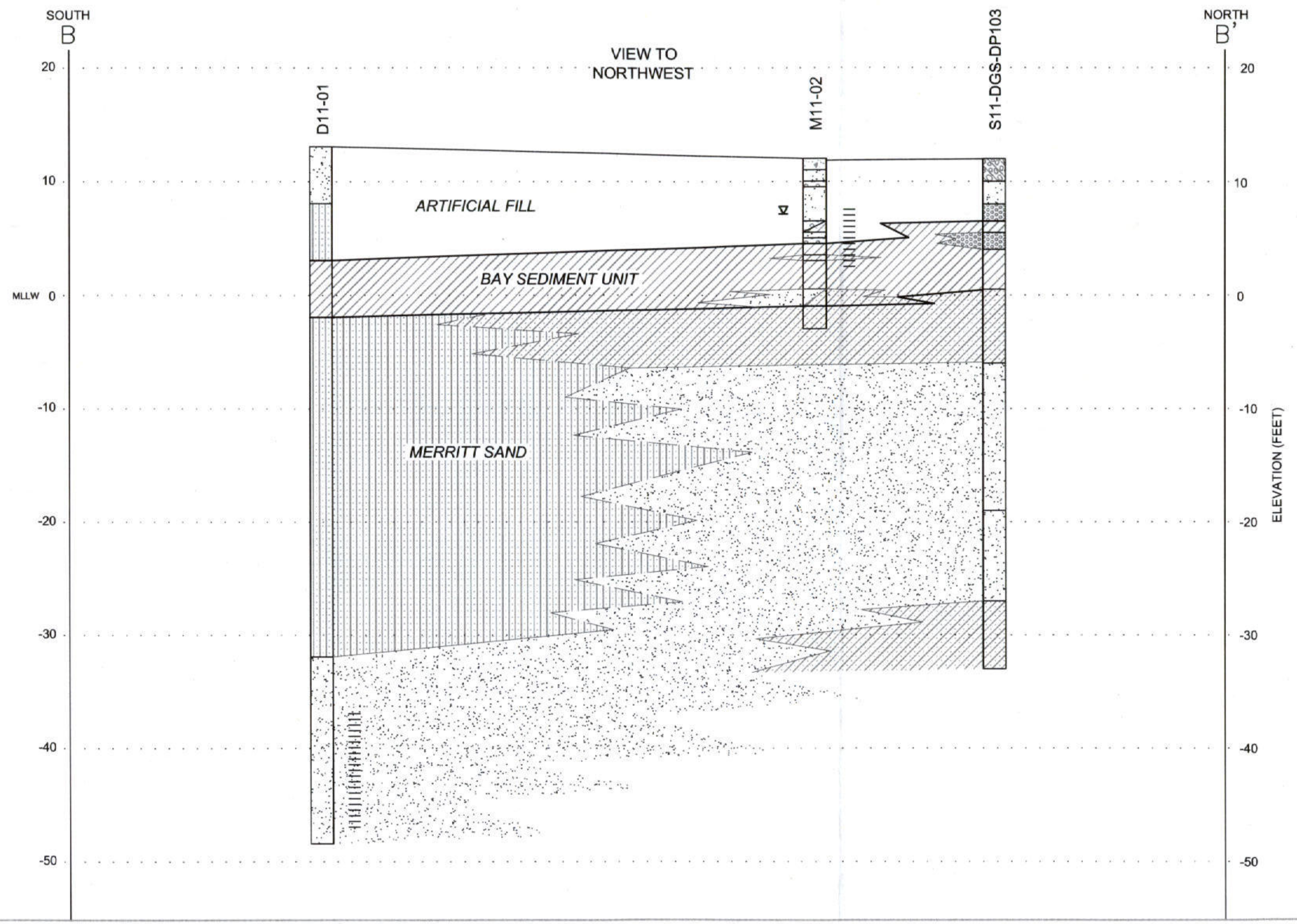
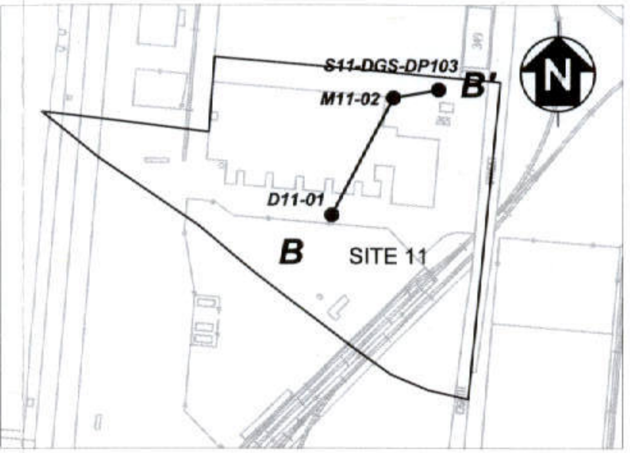
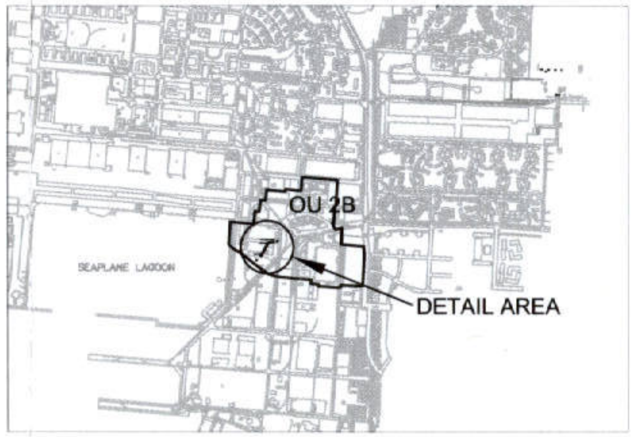
U.S. Navy Southwest Division, NAVFAC, San Diego

FIGURE 4-6
GEOLOGICAL CROSS SECTION A-A'
SITE 11
Operable Unit 2B
Remedial Investigation Report





DETAIL AREA



LOCATION MAP

50' 0 50' 100

HORIZONTAL SCALE: 1" = 100'

Vertical Exaggeration is 5X.

LEGEND

- CN - CONCRETE
- GC - CLAYEY GRAVELS
- SW - WELL GRADED SANDS
- SP - POORLY GRADED SANDS
- SM - SILTY SANDS
- SC - CLAYEY SANDS
- CL - SANDY CLAYS
- LITHOLOGIC CONTACT (DASHED WHERE INFERRED)
- FORMATION CONTACT
- MONITORING WELL SCREENED INTERVAL
- MLLW MEAN LOWER LOW WATER
- WATER ENCOUNTERED DURING DRILLING

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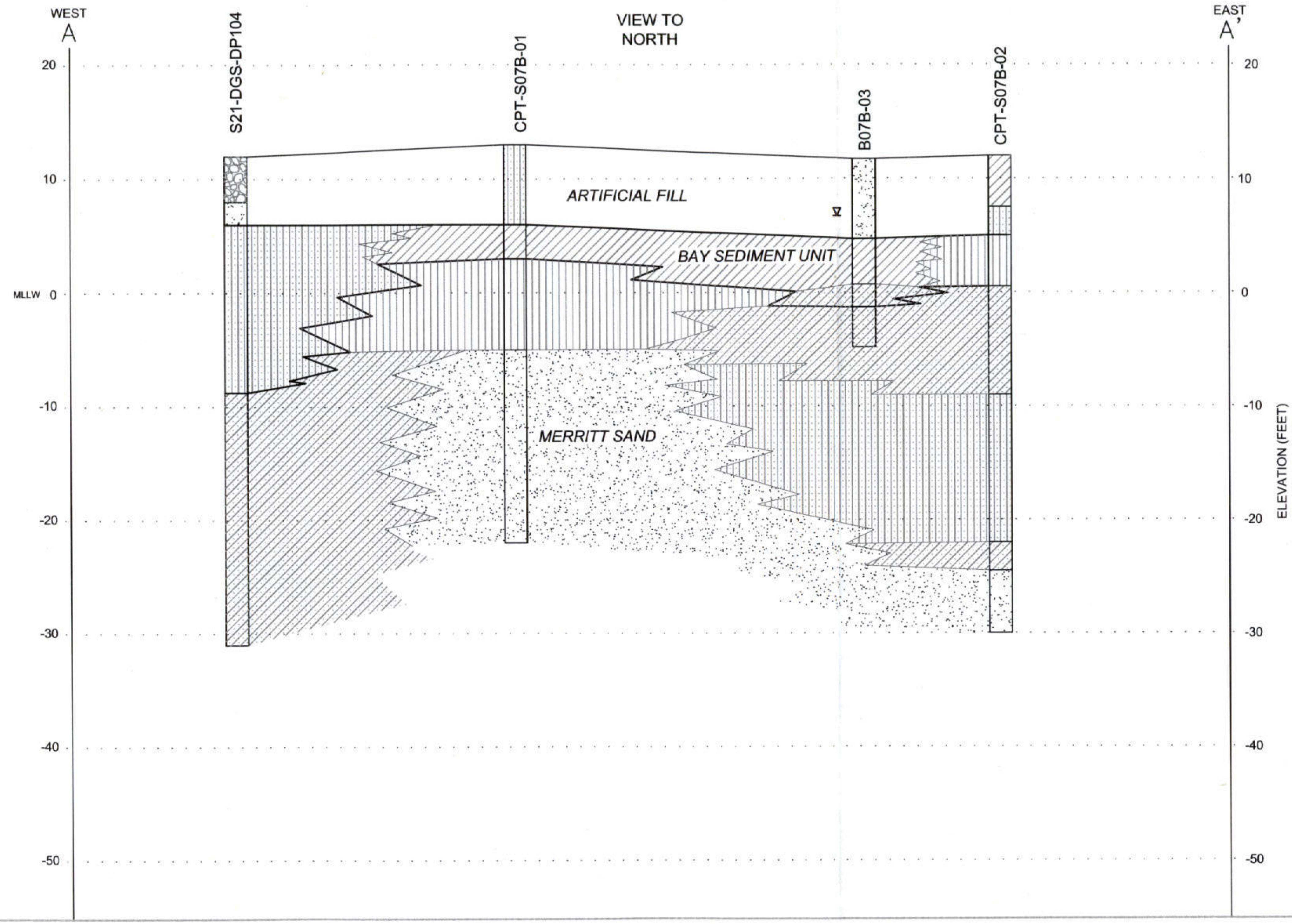
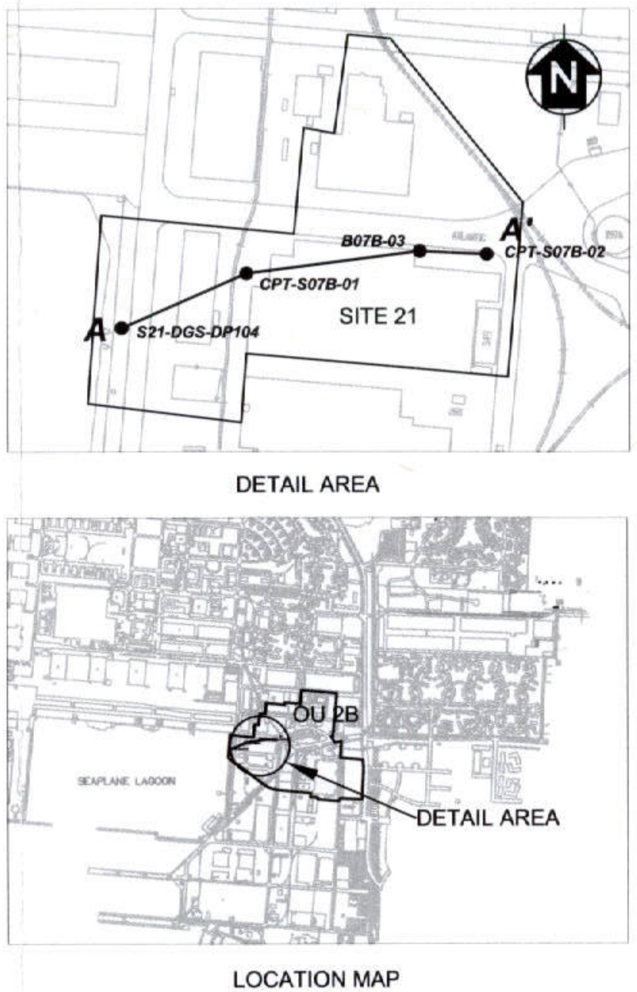
U.S. Navy Southwest Division, NAVFAC, San Diego

FIGURE 4-7
GEOLOGICAL CROSS SECTION B-B'
SITE 11
Operable Unit 2B
Remedial Investigation Report





50' 0 50' 100'
HORIZONTAL SCALE: 1" = 100'
Vertical Exaggeration is 10X.

LEGEND

- GW - WELL GRADED GRAVELS
- SP - POORLY GRADED SANDS
- SM - SILTY SANDS
- SC - CLAYEY SANDS
- ML - SANDY SILTS
- CL - SANDY CLAYS

- LITHOLOGIC CONTACT
- FORMATION CONTACT
- MONITORING WELL SCREENED INTERVAL
- MLLW MEAN LOWER LOW WATER
- ▽ WATER ENCOUNTERED DURING DRILLING

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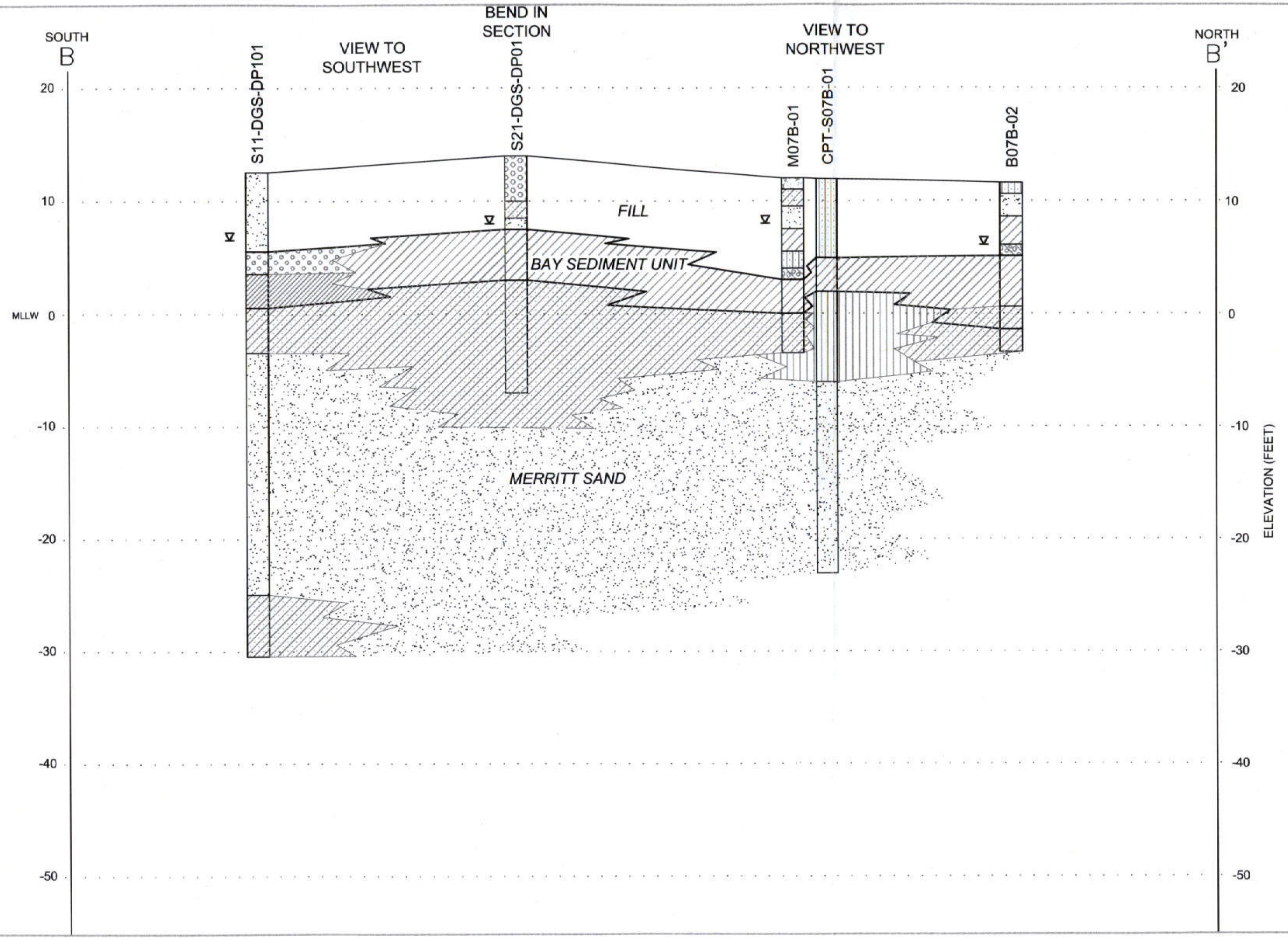
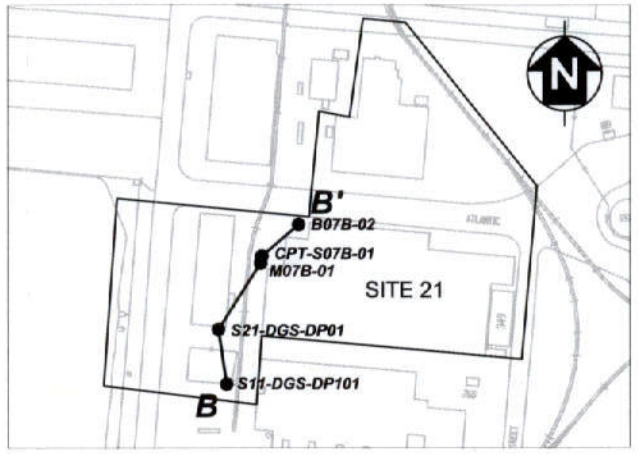
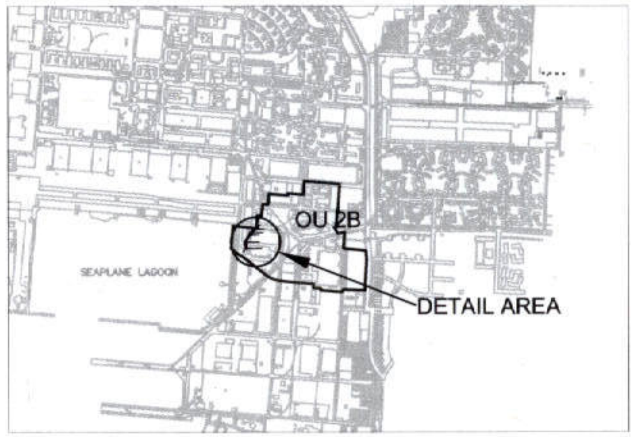
ALAMEDA POINT
U.S. Navy Southwest Division, NAVFAC, San Diego

FIGURE 4-8
GEOLOGICAL CROSS SECTION A-A'
SITE 21
Operable Unit 2B
Remedial Investigation Report





DETAIL AREA



LOCATION MAP

25' 0 25' 50'
HORIZONTAL SCALE: 1" = 50'
Vertical Exaggeration is 5X.

LEGEND

- CN - CONCRETE
- GC - CLAYEY GRAVELS
- SW - WELL GRADED SANDS
- SP - POORLY GRADED SANDS
- SM - SILTY SANDS
- SC - CLAYEY SANDS
- ML - SANDY SILTS
- CL - SANDY CLAYS
- CH - ORGANIC CLAYS, HIGH PLASTICITY
- LITHOLOGIC CONTACT (DASHED WHERE INFERRED)
- FORMATION CONTACT
- MONITORING WELL SCREENED INTERVAL
- MLLW MEAN LOWER LOW WATER
- ∇ WATER ENCOUNTERED DURING DRILLING

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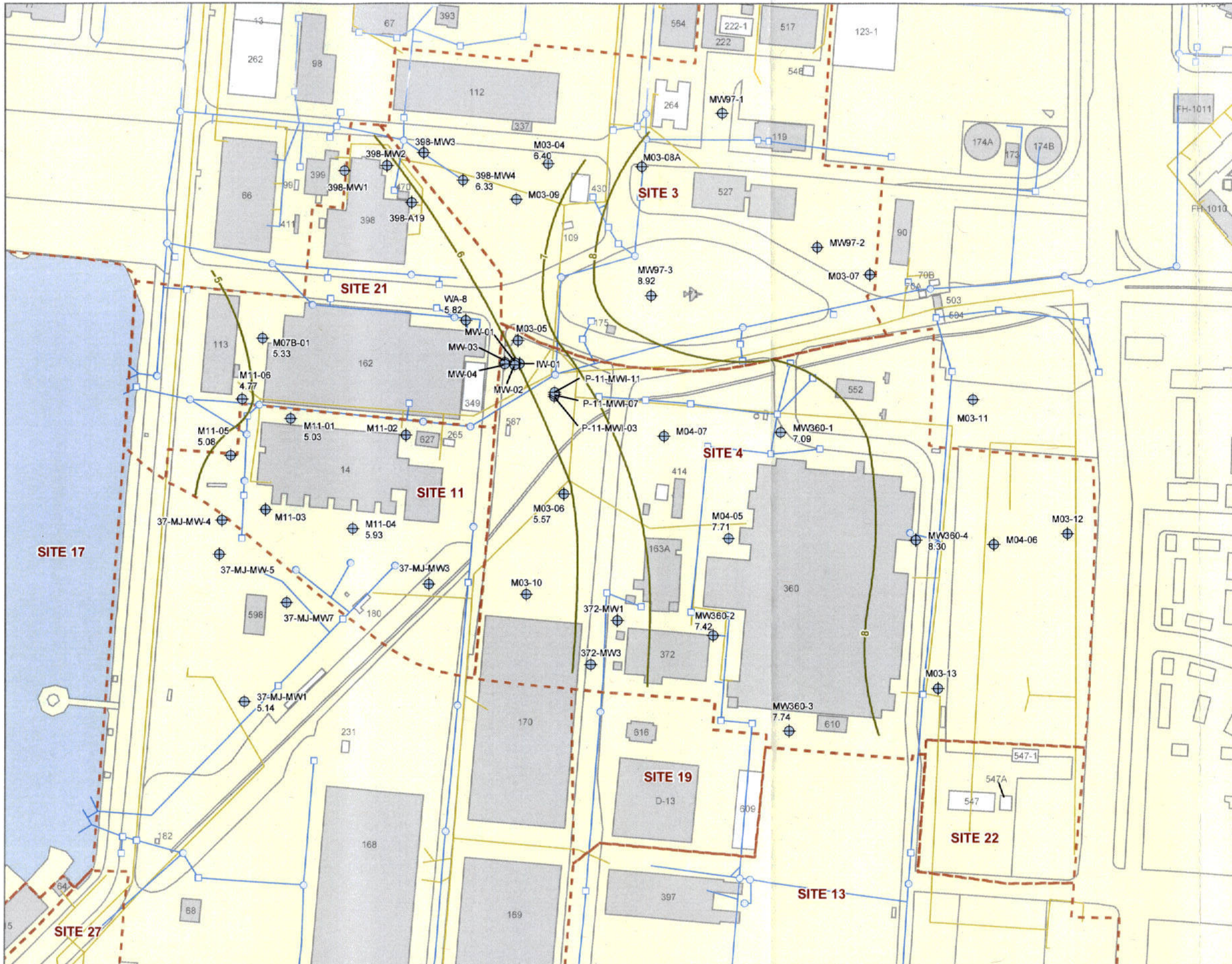
ALAMEDA POINT
U.S. Navy Southwest Division, NAVFAC, San Diego

FIGURE 4-9
GEOLOGICAL CROSS SECTION B-B'
SITE 21
Operable Unit 2B
Remedial Investigation Report



MONITORING WELL AND GROUNDWATER ELEVATION (FEET MLLW) SEPTEMBER 2002 (8.11)

GROUNDWATER ELEVATION CONTOUR LINE (FEET MLLW) (DASHED WHERE INFERRED) (-9-)

CATCH BASIN

MANHOLE

SANITARY SEWER LINE

STORM SEWER LINE

CERCLA SITE BOUNDARY

BUILDING

- Present
- Removed
- LAND COVER
- WATER

Note:

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980

MLLW = Mean Low Low Water

N

100 0 100 200 Feet

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Alameda Point

Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 4-10
GROUNDWATER LEVEL ELEVATIONS WITHOUT TIDAL CORRECTIONS, SEPTEMBER 2002

Operable Unit 2B
Remedial Investigation Report

2005-03-15 U:\almda_sa\do030\OU2B_RI\mxd\fig04-11_gw_levels_sept2002.mxd TtEMI-SA K. Johnson

⌖ 8.11 — MONITORING WELL AND GROUNDWATER ELEVATION (FEET MLLW) APRIL 2003

—9— GROUNDWATER ELEVATION CONTOUR LINE (FEET MLLW) (DASHED WHERE INFERRED)

CATCH BASIN

MANHOLE

SANITARY SEWER LINE

STORM SEWER LINE

CERCLA SITE BOUNDARY

BUILDING

- Present
- Removed

LAND COVER

WATER

Note:

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980

MLLW = Mean Low Low Water

100 0 100 200 Feet

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Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 4-11
GROUNDWATER LEVEL ELEVATIONS WITHOUT TIDAL CORRECTIONS APRIL 2003

Operable Unit 2B
Remedial Investigation Report

Note:

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980

MLLW = Mean Low Low Water

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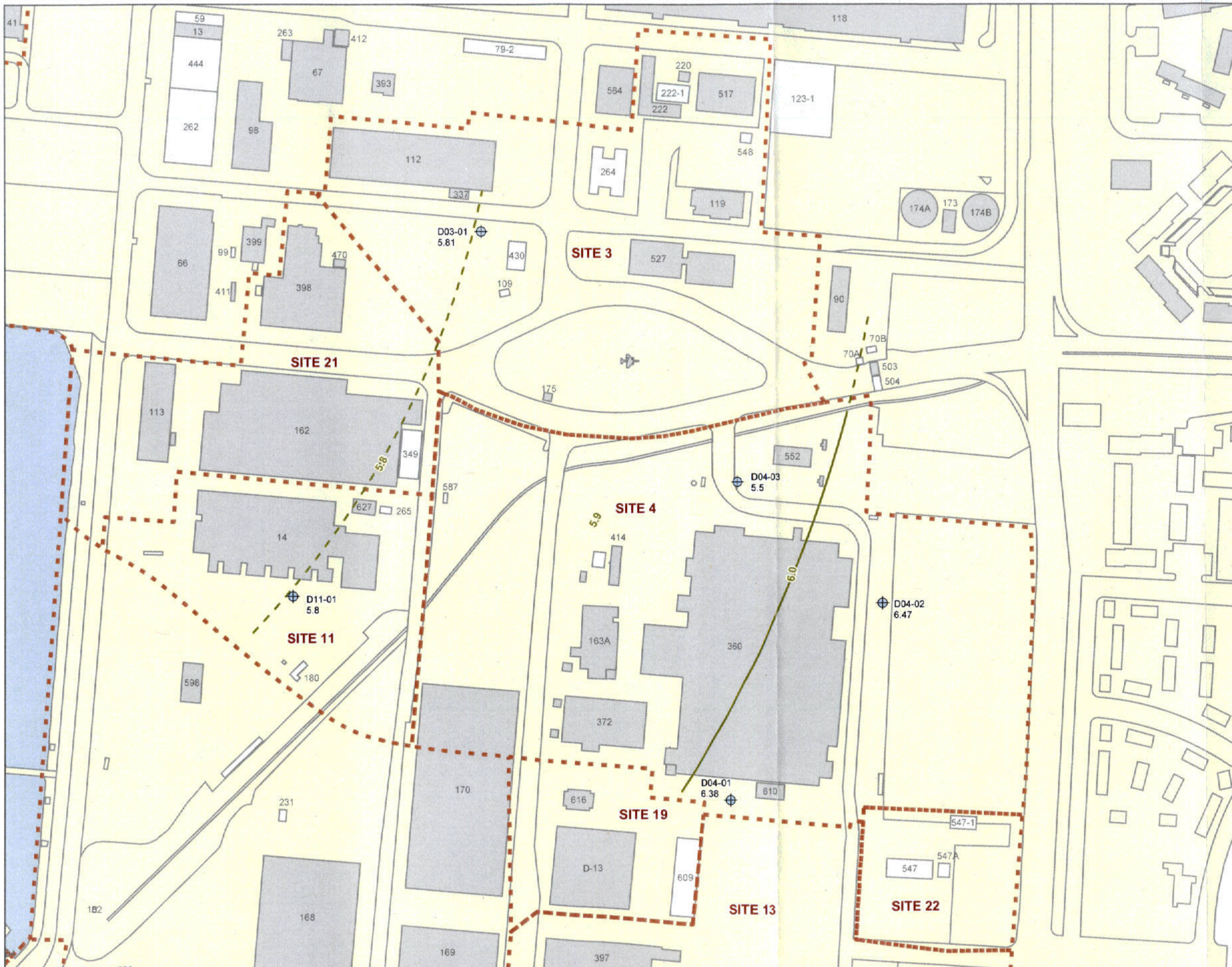
FIGURE 4-12
POTENTIOMETRIC SURFACE MAP: SECOND WATER BEARING ZONE, JUNE 2002

Operable Unit 2B
Remedial Investigation Report

2005-03-15 U:\almda_sa\do030\OU2B_RI\mxd\fig04-13_swbz_june2002.mxd TtEMI-SA K. Johnson

Continue



MONITORING WELL AND GROUNDWATER ELEVATION (FEET MLLW) JUNE 2002 (8.11)

GROUNDWATER ELEVATION CONTOUR LINE (FEET MLLW) (DASHED WHERE INFERRED) (–9–)

CATCH BASIN

MANHOLE

SANITARY SEWER LINE

STORM SEWER LINE

CERCLA SITE BOUNDARY

BUILDING

- Present
- Removed

LAND COVER

WATER

Note:

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980

MLLW = Mean Low Low Water

Groundwater elevation not used in estimation of contours.

N

100 0 100 200 Feet

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FIGURE 4-13
POTENTIOMETRIC SURFACE MAP
SECOND WATER BEARING ZONE
APRIL 2003

Operable Unit 2B
Remedial Investigation Report