RISK ASSESSMENT REPORT FOR THE FORMER PACIFIC DRY DOCK AND REPAIR COMPANY YARD II SITE IN OAKLAND, CALIFORNIA

PDD II.

Prepared For:

CROWLEY MARINE SERVICES, INC.
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Prepared By:

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May 16, 1997

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May 16, 1997

VIA OVERNIGHT MAIL

Mr. Barney Chan
Hazardous Materials Specialist
Division of Environmental Protection
Department of Environmental Health
Alameda County Health Care Services Agency
1131 Harbor Bay Parkway, 2nd Floor
Alameda, California 94502

Dear Mr. Chan:

On behalf of Crowley Marine Services, Inc., please find enclosed one copy of the Risk Assessment Report for the Former Pacific Dry Dock and Repair Company Yard II Site in Oakland, California dated May 16, 1997.

If you have any questions, please call me at (916) 395-4964.

Sincerely,

Risk-Based Decisions, Inc.

Ijaz S. Jamall, Ph.D., DABT
Principal Toxicologist

ISJ:fal
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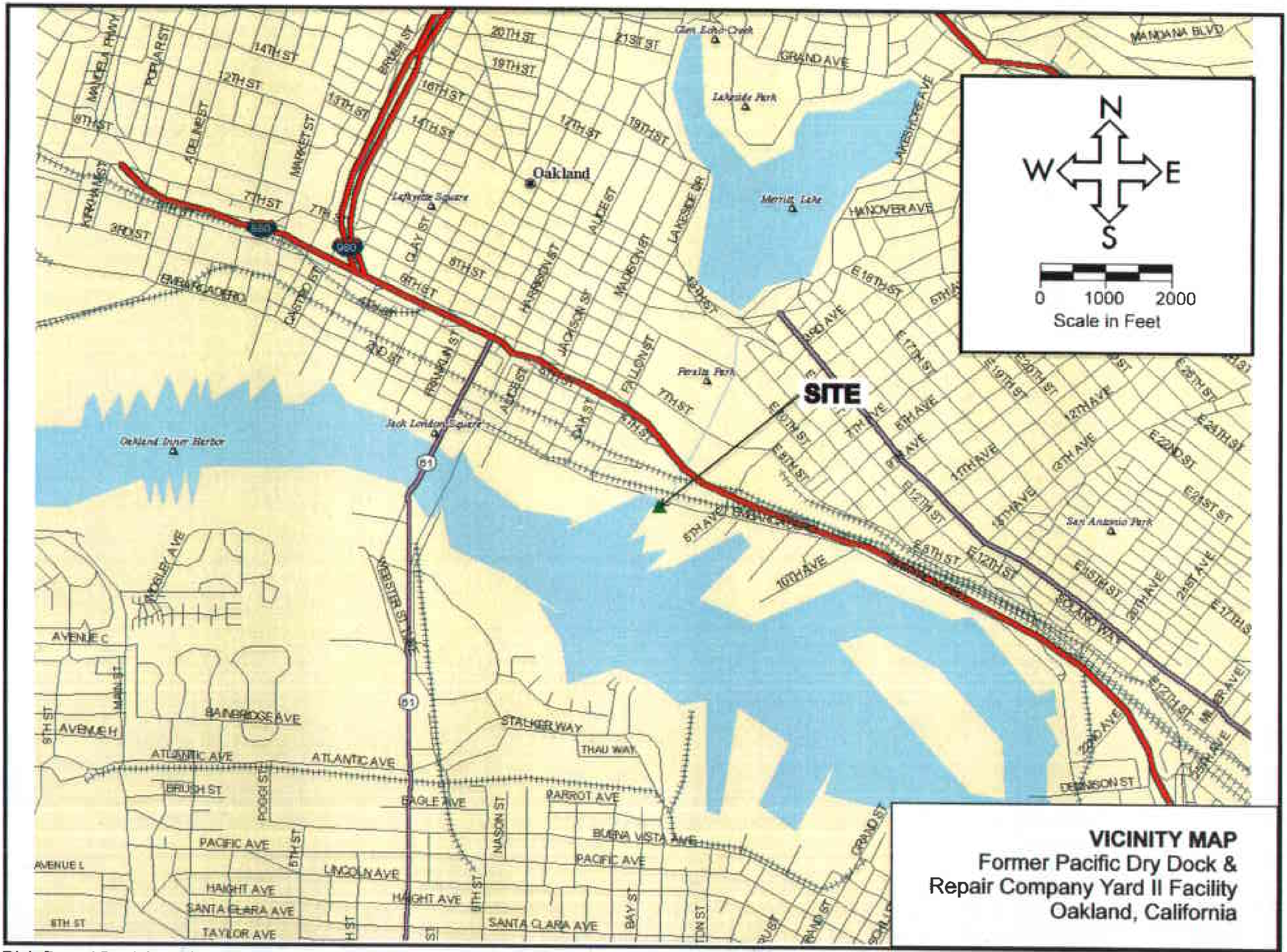
1.0 INTRODUCTION

This risk assessment report evaluates the human health and environmental significance of metals, petroleum hydrocarbon constituents, and chlorinated solvents in soils and groundwater at the former Pacific Dry Dock and Repair Company Yard II (the "Site") located at 321 Embarcadero, Oakland, California (Figure 1).

The risk assessment considers both current and potential future Site conditions, and all the existing data, to determine whether or not chemicals of potential concern (COCs) detected at the Site pose risks to human health or the environment above levels of regulatory concern as defined by the U.S. Environmental Protection Agency (USEPA) and the California Regional Water Quality Control Board (RWQCB). In preparing this risk assessment, the following guidance documents were followed:

- USEPA (1989a). Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). EPA/540-1-89/002, December.
- USEPA (1989b). Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual. EPA/540-1-89/001, March.
- USEPA (1994). Technical Background Document for Soil Screening Guidance. OSWER, EPA/540/R-94/106, November.
- USEPA (1995). Exposure Factors Handbook. Draft. EPA/600/P-95/002A, June.
- ASTM (1995). Standard Guide for Risk-Based Corrective Action at Petroleum Release Sites. Designation E 1739-95, November.
- SWRCB-San Francisco Bay Region (1996). Supplemental Instructions to State Water Board, December 8, 1995. Interim Guidance on Required Cleanup at Low Risk Fuel Leak Sites. January 12.



VICINITY MAP

Former Pacific Dry Dock &
Repair Company Yard II Facility
Oakland, California

Risk-Based Decisions, Inc.

Figure 1

The following site characterization and remediation reports were reviewed to obtain the data and information used in this risk assessment:

- Versar, Inc. (1990). Site Assessment Report for the Pacific Dry Dock and Repair Yard 1 and 2. October 2.
- PTI Environmental Services (1994). Supplemental Inshore Sediment Impairment Study. Crowley Marine Services, Inc., Pacific Dry Dock Yards I and II, Volume I. June.
- Versar, Inc. (1996a). Preliminary Investigation and Evaluation Report, Former Pacific Dry Dock and Repair Company Yard II Facility. Oakland, California. March 20.
- Versar, Inc. (1996b). Fourth Round Groundwater Monitoring Report, Pacific Dry Dock and Repair Company Yard II Facility. Oakland, California. March 21.
- Versar, Inc. (1996c). Letter Report of Quarterly Groundwater Monitoring, May 8, 1996, Former Pacific Dry Dock and Repair Company Yard II Facility. Oakland, California. June 21.
- EMCON Associates (1996). Yard II Soil and Groundwater Sampling Results, 321 Embarcadero, Oakland, California. December 4.
- The Gauntlett Group, LLC (1997a). Letter Report: Supplemental Arsenic Sampling at Yard II. March 20.
- The Gauntlett Group, LLC (1997b). Letter Report: Sandblast Grit Removal and Metal Analysis for the Grit Stockpiles. 321 Embarcadero, Oakland, California. March 26.

2.0 SITE BACKGROUND

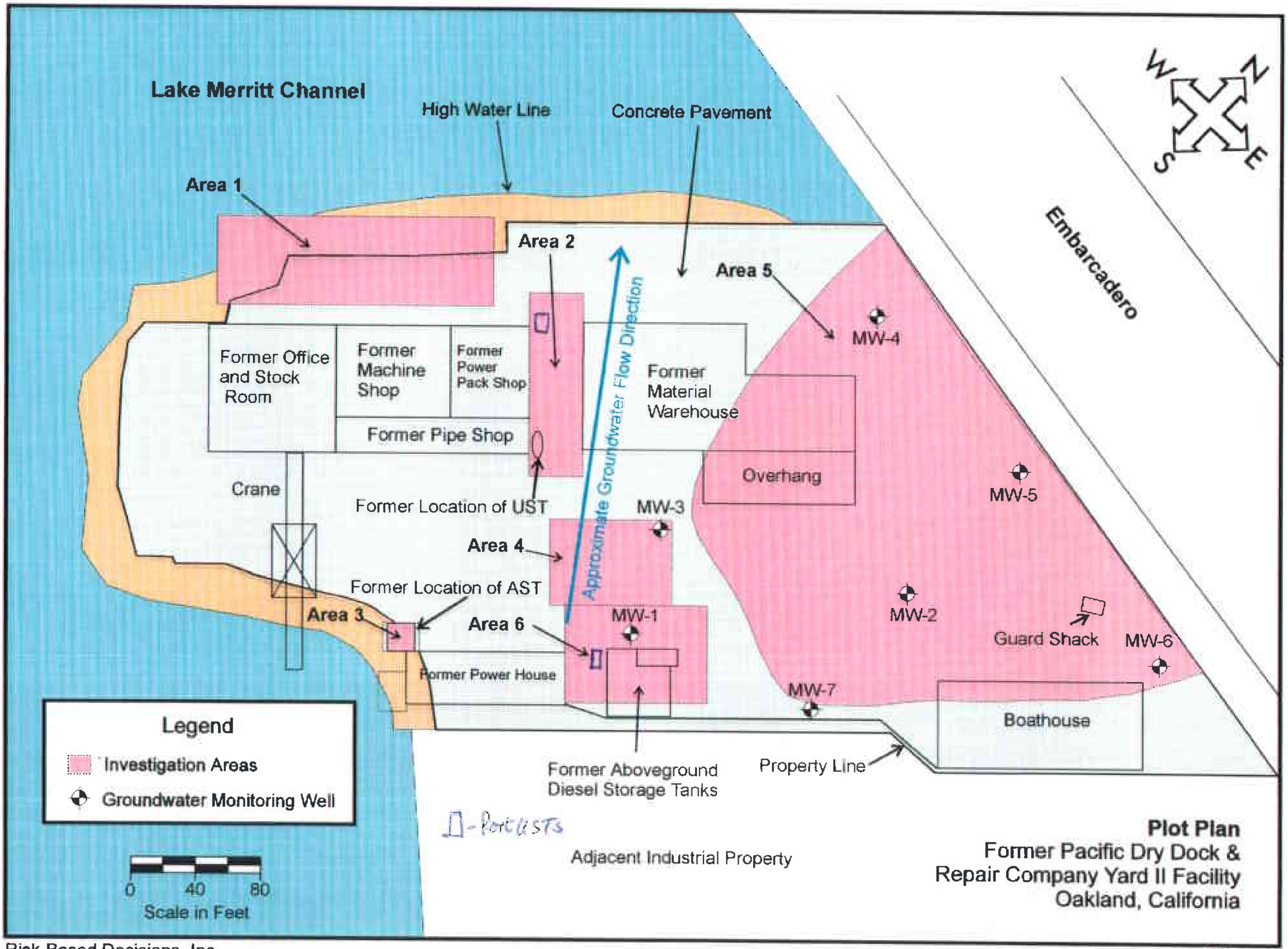
The Site is an approximately 3.5-acre vacant property bounded by Lake Merritt Channel on the west, Oakland Inner Harbor on the south and the west, the Embarcadero Freeway on the north, and an industrial property to the east (Figure 2).

2.1 Site History

The Site has been used as a ship repair and maintenance facility since 1942. The United States Navy leased the property from the City of Oakland and occupied it from 1942 to 1951. From 1951 to 1962, the Navy sub-leased the property to Martin Olich which became the direct lessee from the City of Oakland in 1962. Crowley Marine Services is Martin Olich's successor in interest.

In 1944, the Navy extended the land area of the Site substantially by filling in the western and southern boundaries along the water with imported fill material. The Navy also constructed the buildings on the Site. Since 1963, the Site has been operated by Crowley Marine Services. In the late 1980s all commercial activity at the Site ceased.

A series of phased investigation programs were conducted at Yard II between 1989 and 1997. Aerial photographs, site observations and site history information were used to select areas for the initial environmental investigations. Many of the initial soil and water samples collected from the site were tested for broad ranges of priority pollutants such as chlorinated and aromatic volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), metals (Title 22 metals), and petroleum hydrocarbons. The initial soil and water test results were used to focus areas for additional



Plot Plan
Former Pacific Dry Dock &
Repair Company Yard II Facility
Oakland, California

Risk-Based Decisions, Inc.

Figure 2

investigation and testing. The phased investigation approach that was used is consistent with the current ASTM standards for environmental investigations.

In December 1989, Crowley Marine Services conducted the first subsurface investigation to assess the impact of historical activities on Site soils. A total of 11 soil boreholes were hand-augured and 20 soil samples taken from these boreholes. In addition, several spent sandblast samples were collected and analyzed for petroleum hydrocarbons, chlorinated compounds, and metals (Versar, 1990 and 1991). During these early investigations, the Site was sub-divided into six investigation areas based on activities conducted in these areas of the Site. The six areas are shown on Figure 2.

In May 1994, Crowley expanded its characterization of the Site to include an additional 18 soil boreholes from which 30 soil samples and one grab water sample were collected and analyzed for petroleum, hydrocarbons, chlorinated solvents and metals (Versar, 1996).

In July 1994, three groundwater monitoring wells were installed and sampled for total petroleum hydrocarbons as diesel and gasoline, TPHd and TPHg, respectively, and for benzene, toluene, ethylbenzene and xylenes (BTEX), and chlorinated volatile organic compounds (VOCs) (Versar, 1996).

In September 1994, a 500-gallon underground storage tank (UST) was removed from the Site. Regulatory closure for the UST removal was obtained from the Alameda County Health Care Services Agency (Versar, 1996).

In April 1995. yet another 33 soil samples were collected and analyzed for TPHd, TPHg, BTEX, chlorinated hydrocarbons and metals (Versar, 1996).

In July 1995, four additional groundwater monitoring wells were installed at the Site. Soil and groundwater samples from the monitoring wells and grab groundwater samples from 10 temporary groundwater sampling points across the Site were collected and analyzed for TPHd, TPHg, BTEX, chlorinated hydrocarbons and metals (Versar, 1996).

In preparation for the removal of spent sandblast materials from the inter-tidal zone along Lake Merritt Channel and the Oakland Harbor sides of the Site in November 1996, 10 more soil samples were collected from Area 1 and analyzed for metals and pH (EMCON, 1996).

In March 1997, spent sandblast grit was removed from the Site. Based on the cleanup levels required by the RWQCB-San Francisco Region (RWQCB, August 3, 1992), four areas where the inter-tidal sediment contained 10% or more of the spent sandblast grit were selected for removal. At each location (Figure 3) grit and sediment were excavated to a depth of about 3.5 to 5 feet. Approximately 500 tons of spent sandblast grit and sediments were removed, and eight soil verification samples were collected (The Gauntlett Group, 1997).

The areas of sandblast grit removal are shown in dark green in Figure 3. A few, small pockets of spent sandblast grit could not be removed because of the presence of some wild geese nests with eggs. In consultation with the RWQCB and the Alameda County Health Care Services Agency (ACHCSA), these pockets of sandblast grit will be removed once the eggs have hatched and the birds have flown away (late May/early June, 1997). These areas of spent sandblast grit to be removed shortly are shown in Figure 3 in light green.

2.2 Site Geology and Hydrogeology

The Site has an elevation of between five and eight feet above mean sea level (MSL). Based on soil and groundwater boring logs and data from monitoring wells, the shallow soils at the Site are characterized as fill material mixed with gravel, sand, silt and clay from the ground surface to the Bay mud layer. The Bay mud layer is reported to be at between 15 and 20 feet, bgs. The Bay mud consists of silty clay and clay with shell fragments.

Groundwater beneath the Site is very shallow and has been reported at depths of two to five feet, bgs. The groundwater gradient is approximately 0.015 to the northwest toward the Lake Merritt Channel (Figure 2). Because the Site is located next to the Channel/Harbor, the groundwater is influenced by the tides.

3.0 DATA EVALUATION

This section summarizes the data previously collected at the Site. The purposes of the data evaluation are to discuss what the data mean with respect to how much chemical might occur in soil, air and groundwater, why it is where it was detected at the Site, where it might or might not migrate on or off the Site, and to set the stage for using the data to quantify potential impacts to human health and the environment.

There are three critical factors to be considered in evaluating the human health and environmental significance of these data, namely:

1. ***Frequency of detections:*** This parameter describes how often a chemical was detected. The more often it is detected, the more widespread it is likely to be.

2. ***Concentration of chemicals:*** This parameter describes how high the concentration of a chemical was in the sample analyzed, and is often used as a surrogate for risk or threat to groundwater. However, in order to be used in this manner, the concentration must be linked to frequency of detections to get an approximate estimation of the mass of the chemical present.

3. ***Mass of chemicals:*** The mass of a chemical refers to how much is present in a particular medium (*e.g.*, in soil or groundwater). If, for instance, a large mass of a chemical is present in soil, then this mass can serve as a continuing source of human exposure, and a source of possible leaching to groundwater and a long term impact on the environment. This large mass of chemical will likely take a longer time to degrade. On the other hand, if the mass is small, then even high concentrations might not present a significant threat to human health or to environment because it will tend to degrade more quickly, thus, affording less opportunity for exposure and a lesser threat to the environment.

3.1 Chemicals in Soil

Soil samples were collected from 85 locations at the Site between December 1989 and March 1997 (Figure 3). The samples were analyzed for a wide variety of chemicals such as total oil and grease, total petroleum hydrocarbons as gasoline (TPHg) and diesel (TPHd), benzene, toluene, ethylbenzene, xylenes (BTEX), chlorinated hydrocarbons, semi-volatile organic compounds (SVOCs), and metals.

The analytical results for metals detected in soils at the Site are shown in Tables 1 through 3, and illustrated in Figures 4 through 8. Figures 4 and 5 also indicate the year in which the sample was collected and analyzed. Sample points that have been excavated as part of the spent sandblast grit removal are shown in green and the pockets of sandblast grit to be removed shortly (because of the geese nests) are shown in light green in Figures 4, 6, 7 and 8). The excavated sample points are also shaded in Table 1.

Table 1 shows soil pH for several samples. The average pH is about 8.0 and all of the observed pH data are above pH 7.55. These pH data will be discussed later in the context of the potential for migration of these metals.

In accordance with risk assessment guidance (USEPA, 1989a) and in order to quantitatively assess the significance of these data, the following descriptive statistics were calculated for all chemicals that were positively detected in at least three samples:

- Maximum concentration detected;
- Arithmetic mean; and
- 95% Upper Confidence Limit on the mean (95% UCL).

TABLE 1
SOIL SAMPLING RESULTS
METALS (mg/kg)
Former Pacific Dry Dock and Repair Company Yard II
321 Embarcadero, Oakland, California

Sample ID	Date	Depth feet	Arsenic	Chromium	Cobalt	Copper	Lead	Mercury	Vanadium	Zinc	pH
2-1	Mar-97	0-0.5	ND	NA	NA	NA	NA	NA	NA	NA	NA
2-2	Mar-97	0-0.5	ND	NA	NA	NA	NA	NA	NA	NA	NA
BH10A	May-94	3.0	NA	NA	NA	28	8.1	0.56	NA	NA	NA
BH11	May-94	3.0	11	ND	ND	56	7.9	0.16	44	80	NA
BH17	May-94	2.5	15	3.8	ND	26	4	0.18	24	40	NA
BH19	May-94	6.0	9.5	16	14	26	ND	0.12	60	67	NA
BH22	May-94	9.0	11	10	ND	20	8.2	0.26	33	63	NA
BH6A	May-94	3.0	NA	NA	NA	58	100	ND	NA	NA	NA
CH10	Apr-95	2.5	NA	NA	NA	NA	5.4	NA	NA	NA	NA
CH10	Apr-95	5.0	NA	NA	NA	NA	7.2	NA	NA	NA	NA
CH11	Apr-95	2.5	NA	NA	NA	NA	17	NA	NA	NA	NA
CH11	Apr-95	5.5	NA	NA	NA	NA	7.4	NA	NA	NA	NA
CH12	Apr-95	2.5	NA	NA	NA	NA	38	NA	NA	NA	NA
CH12	Apr-95	5.5	NA	NA	NA	NA	4.5	NA	NA	NA	NA
CH14	Apr-95	2.5	NA	NA	NA	22	13	NA	NA	NA	NA
MW4	Sep-95	5.0	NA	NA	NA	150	30	ND	NA	180	NA
MW6	Sep-95	3.5	NA	NA	NA	200	39	1.3	NA	140	NA
MW6	Sep-95	6.0	NA	NA	NA	32	ND	ND	NA	69	NA
MW6	Sep-95	15.5	NA	NA	NA	360	5.8	ND	NA	87	NA
MW7	Sep-95	15.5	NA	NA	NA	32	5.9	ND	NA	40	NA
PDDII-3	Dec-89	2.5	5.5	27	9.5	140	220	0.38	ND	600	NA
PDDII-6	Dec-89	5.0	3.3	37	11	90	78	0.5	5.2	360	NA
B-10	Nov-96	3.5	51	70	22	84	9	ND	74	180	8.49
B-11	Mar-97	0-0.5	9.8	NA	NA	NA	NA	NA	NA	NA	NA
B-11	Mar-97	3.0-3.5	3.2	NA	NA	NA	NA	NA	NA	NA	NA
B-12	Mar-97	0-0.5	10	NA	NA	NA	NA	NA	NA	NA	NA
B-12	Mar-97	3.0-3.5	2.1	NA	NA	NA	NA	NA	NA	NA	NA
B-13	Mar-97	0-0.5	12	NA	NA	NA	NA	NA	NA	NA	NA
B-13	Mar-97	3.0-3.5	7.6	NA	NA	NA	NA	NA	NA	NA	NA
B-14	Mar-97	0-0.5	20	NA	NA	NA	NA	NA	NA	NA	NA
B-14	Mar-97	3.0-3.5	5.4	NA	NA	NA	NA	NA	NA	NA	NA
B-15	Mar-97	0-0.5	21	NA	NA	NA	NA	NA	NA	NA	NA
B-15	Mar-97	3.0-3.5	14	NA	NA	NA	NA	NA	NA	NA	NA
B-16	Mar-97	0-0.5	23	NA	NA	NA	NA	NA	NA	NA	NA
B-16	Mar-97	3.0-3.5	25	NA	NA	NA	NA	NA	NA	NA	NA
B-2	Nov-96	3.0-3.5	38	81	7	270	100	1.4	23	300	7.55
B-3	Nov-96	3.0-3.5	25	32	10	34	9	ND	40	120	8.00
B-4	Nov-96	3.5	ND	760	27	510	1100	3	34000	4500	7.97
B-5	Nov-96	3.5	46	51	16	45	13	ND	79	110	8.70
B-6	Nov-96	3.0-3.5	44	32	15	48	ND	ND	96	110	8.56
B-7	Nov-96	3.0-3.5	37	74	16	170	5.3	ND	51	83	8.20
B-8	Nov-96	3.0-3.5	15	34	6	12	7	ND	25	30	7.56
B-9	Nov-96	3.5	15	40	6	7	7	ND	29	23	7.97
BH1	May-94	3.0	14	12	ND	660	110	0.72	24	510	NA

Removed

TABLE 1
SOIL SAMPLING RESULTS
METALS (mg/kg)
Former Pacific Dry Dock and Repair Company Yard II
321 Embarcadero, Oakland, California

Sample ID	Date	Depth feet	Arsenic	Chromium	Cobalt	Copper	Lead	Mercury	Vanadium	Zinc	pH
BH20	May-94	6.0	NA	NA	NA	15	8.4	0.24	NA	NA	NA
BH21	May-94	9.0	NA	NA	NA	43	22	1.4	NA	NA	NA
BH4	May-94	6.0	NA	NA	NA	7.5	3.9	0.2	NA	NA	NA
CH13	Apr-95	2.5	NA	NA	NA	98	92	NA	NA	NA	NA
PDDII-1	Dec-89	2.5	25	61	5.8	1900	7500	26	20	550	NA
PDDII-10	Dec-89	2.5	NA	NA	NA	1800	650	NA	NA	NA	NA
PDDII-11	Dec-89	1.5	NA	NA	NA	770	290	NA	NA	NA	NA
PDDII-9	Dec-89	2.5	NA	NA	NA	1600	660	NA	NA	NA	NA
Max.			15	37	14	360	220	1	60	600	8.6
Mean			7	16	7	89	30	0.36	28	157	8.0
95%UCL			11	25	11	153	65	0.57	43	273	8.2

Note:

NA = Not Analyzed

ND = Less than Detection Limit. (see Versar reports in references for detection limits)

▨: Areas were excavated during the grit removal. Data collected at these points are not included in the calculations of means, and 95% Upper Confidence Level (95%UCL) except pH.

TABLE 2
COMPARISON OF ANALYTICAL DATA AND BACKGROUND CONCENTRATIONS OF METALS IN CALIFORNIA SOILS (mg/kg)
Former Pacific Dry Dock and Repair Company Yard II
321 Embarcadero, Oakland, California

Background Concentration of Metals in California					Metals detected in Site	
Chemicals	Number of Samples[1]	Mean Concentration[1] mg/kg	Range of Concentration[1] mg/kg	95% UCL of the Mean[2] mg/kg	Mean	UCL 95%
					mg/kg	
Arsenic	72	6.6	0.3 - 69	19.1	7	11
Chromium	75	118	10 - 1500	99.6	16	25
Cobalt	75	13.3	ND - 50		7	11
Copper	75	49	5.0 - 300	69.4	89	153
Lead	75	29	ND - 300	16.1	30	65
Mercury	73	0.154	0.01 - 1.5	0.4	0.36	0.57
Vanadium	75	125	30 - 500		28	43
Zinc	75	78	25 - 212	106.1	157	273

[1]: Dragun, J. and Chiasson, A. (1991), Elements in North American Soils. (Hazardous Materials Control Resources Institute, Greenbelt, Maryland)

[2]: Lawrence Berkeley National Laboratory (1995), Protocol for Determining Background Concentration of Metals in Soil at Lawrence Berkeley National Laboratory. Environment, Health and safety Division and Earth Sciences Division. August. Resources Institute, Greenbelt, Maryland)

Note: Non-detectable concentration were taken as zero in calculation of mean.

Concentration of <0.5 mg/kg were taken as 0.5 mg/kg in calculation of mean of Dragun and Chiasson.

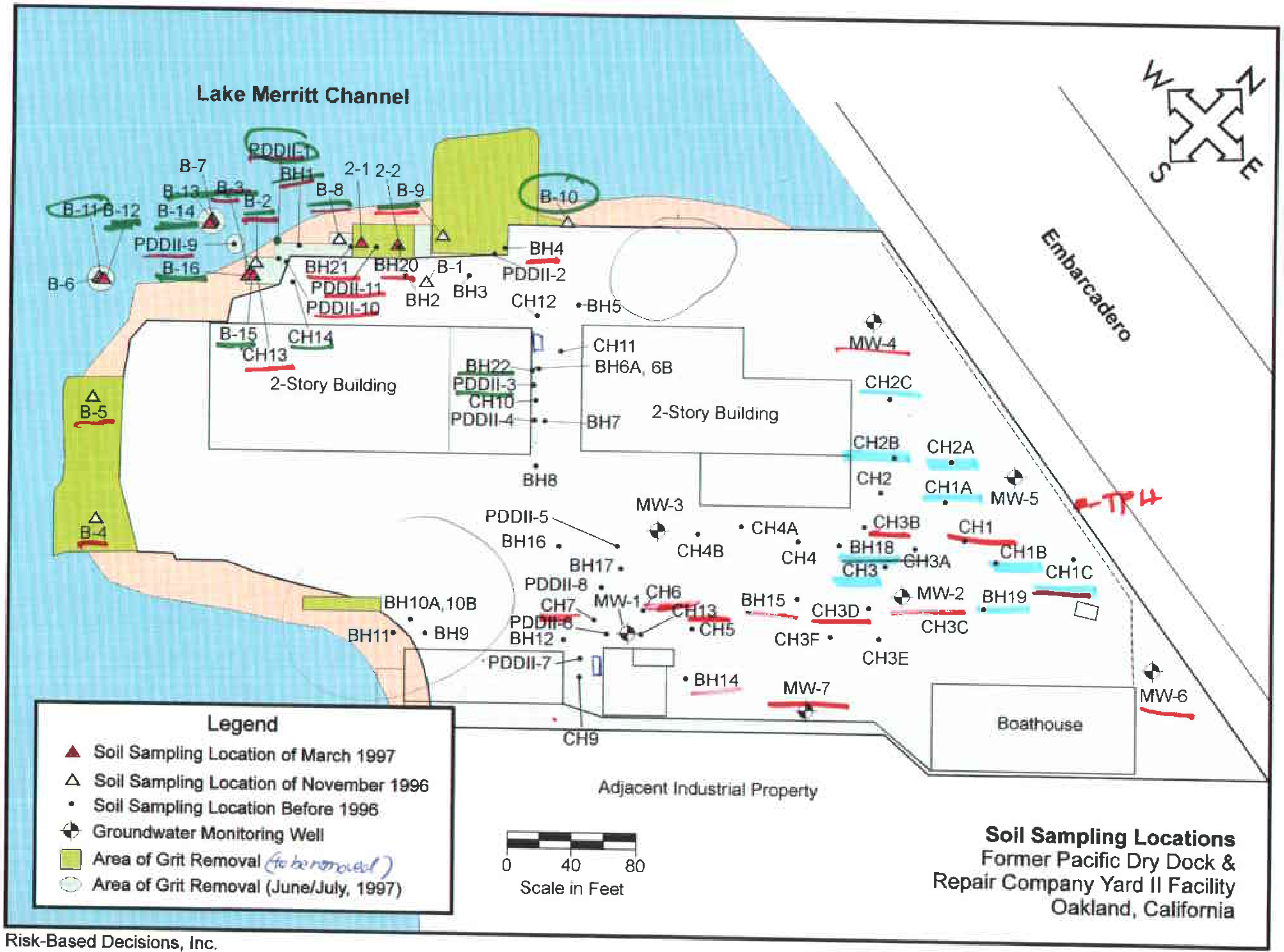
TABLE 3
SOIL SAMPLING RESULTS
PETROLEUM AND CHLORINATED HYDROCARBONS (mg/kg)
Former Pacific Dry Dock and Repair Company Yard II
321 Embarcadero, Oakland, California

Sample ID	Date	Depth feet	TPH-D	TPH-G	Benzene	Toluene	Ethylbenzene	Xylenes	Chlorobenzene	cis & trans 1,2-DCE	1,4-Dichlorobenzene	TCE	PCE
BH1	May-94	9.0	210	72	ND	ND	ND	0.44	NA	NA	NA	NA	NA
BH13	May-94	6.0	1700	25	ND	ND	ND	ND	ND	ND	ND	ND	ND
BH14	May-94	6.0	NA	5	ND	ND	ND	ND	NA	NA	NA	NA	NA
BH15	May-94	6.0	NA	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA
BH15	May-94	9.0	180	31	ND	ND	ND	ND	NA	NA	NA	NA	NA
BH18	May-94	8.0	NA	NA	NA	NA	NA	NA	0.61	ND	ND	ND	ND
BH19	May-94	6.0	NA	NA	NA	NA	NA	NA	1.7	ND	0.61	ND	ND
BH22	May-94	9.0	NA	NA	NA	NA	NA	NA	ND	ND	ND	ND	ND
BH5	May-94	8.0	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA
BH8	May-94	8.5	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA
BH9	May-94	3.0	190	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA
CH1	Apr-95	4.0	1300	73	0.58	0.088	ND	1.5	0.54	ND	0.19	ND	ND
CH13	Apr-95	2.5	59	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA
CH14	Apr-95	2.5	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA
CH1A	Apr-95	2.0	240	5.4	0.048	0.0069	ND	0.14	0.22	ND	ND	ND	ND
CH1B	Apr-95	3.0	1.4	ND	ND	ND	ND	ND	0.034	ND	ND	ND	ND
CH1C	Apr-95	2.0	ND	ND	ND	ND	0.0068	0.018	ND	ND	ND	ND	ND
CH1C	Apr-95	4.5	910	23	0.1	ND	ND	0.3	0.48	ND	0.41	ND	ND
CH2	Apr-95	1.0	18	4.5	ND	ND	ND	0.019	ND	ND	ND	0.023	ND
CH2A	Apr-95	2.5	8.7	16	2.1	ND	ND	0.66	0.063	ND	ND	ND	ND
CH2B	Apr-95	1.5	55	ND	ND	ND	0.0053	ND	ND	ND	ND	ND	ND
CH2C	Apr-95	2.5	44	ND	0.011	ND	ND	ND	ND	ND	ND	ND	ND
CH2C	Apr-95	4.5	8.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CH3	Apr-95	4.0	ND	ND	ND	ND	0.0092	0.022	ND	ND	ND	ND	ND
CH3A	Apr-95	1.5	26	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CH3B	Apr-95	2.5	240	1.8	0.15	0.017	0.012	0.096	0.89	0.031	ND	ND	ND
CH3C	Apr-95	2.0	ND	0.88	0.0054	ND	ND	0.07	0.079	ND	ND	ND	ND
CH3D	Apr-95	2.0	940	9.6	0.81	ND	ND	3.6	2.3	ND	1.2	ND	ND
CH3E	Apr-95	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CH3E	Apr-95	4.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CH3F	Apr-95	1.5	NA	NA	NA	NA	NA	NA	ND	ND	ND	ND	ND
CH3F	Apr-95	4.0	ND	0.8	ND	ND	ND	ND	0.027	ND	ND	ND	ND
CH4	Apr-95	3.0	1.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CH4A	Apr-95	2.5	26	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 3
SOIL SAMPLING RESULTS
PETROLEUM AND CHLORINATED HYDROCARBONS (mg/kg)
Former Pacific Dry Dock and Repair Company Yard II
321 Embarcadero, Oakland, California

Sample ID	Date	Depth feet	TPH-D	TPH-G	Benzene	Toluene	Ethylbenzene	Xylenes	Chlorobenzene	cis & trans 1,2-DCE	1,4-Dichlorobenzene	TCE	PCE
CH4A	Apr-95	4.5	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CH5	May-94	1.5	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA
CH6	May-94	2.5	5.3	ND	ND	ND	0.0052	0.043	NA	NA	NA	NA	NA
CH7	May-94	2.5	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA
CH8	May-94	3.5	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA
CH9	May-94	2.0	7	ND	ND	ND	ND	0.038	NA	NA	NA	NA	NA
X MW2	Jul-94	16.5	2700*	500	ND	1	8.3	7.4	9	ND	5.4	ND	ND
MW4	Sep-95	5.5	1600	58	ND	ND	ND	ND	0.22	ND	0.067	ND	ND
MW6	Sep-95	3.5	280	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW6	Sep-95	6.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW6	Sep-95	15.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW7	Sep-95	15.5	1.6	0.61	ND	ND	ND	ND	ND	ND	ND	ND	ND
PDDII-3	Dec-89	0.5	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	0.21
Max.			2700	500	2.10	1.00	8.30	7.40	9.00	0.03	5.40	0.02	0.21
Mean			277	21	0.07	0.03	0.20	0.34	0.48	0.01	0.24	0.01	0.01
95%UCL			460	45	0.17	0.07	0.59	0.72	0.97	0.01	0.54	0.01	0.02

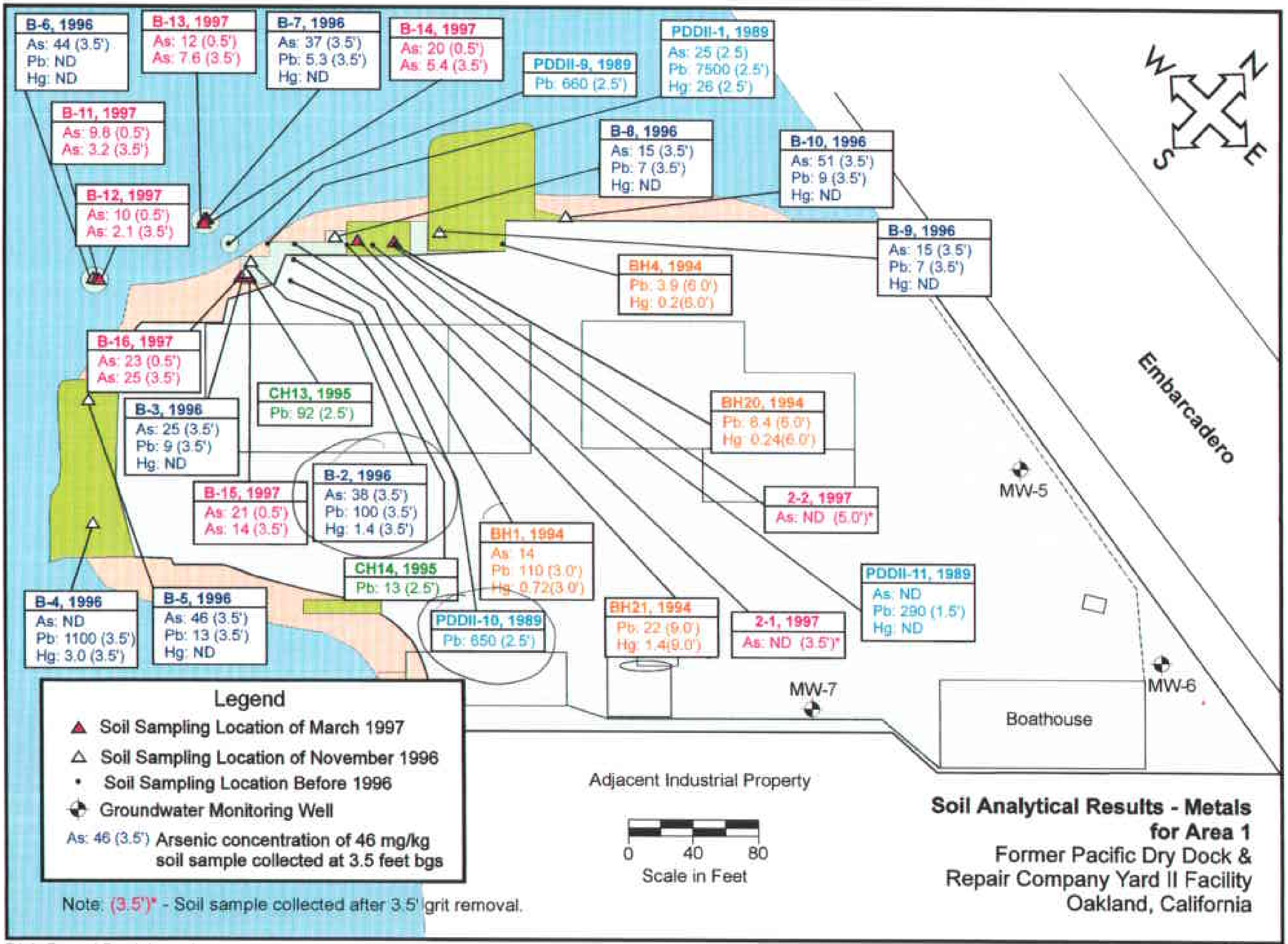
Note:
NA = Not Analyzed
ND = Less than Detection Limit. (see Versar reports in references for detection limits)



Soil Sampling Locations
Former Pacific Dry Dock &
Repair Company Yard II Facility
Oakland, California

Risk-Based Decisions, Inc.

Figure 3



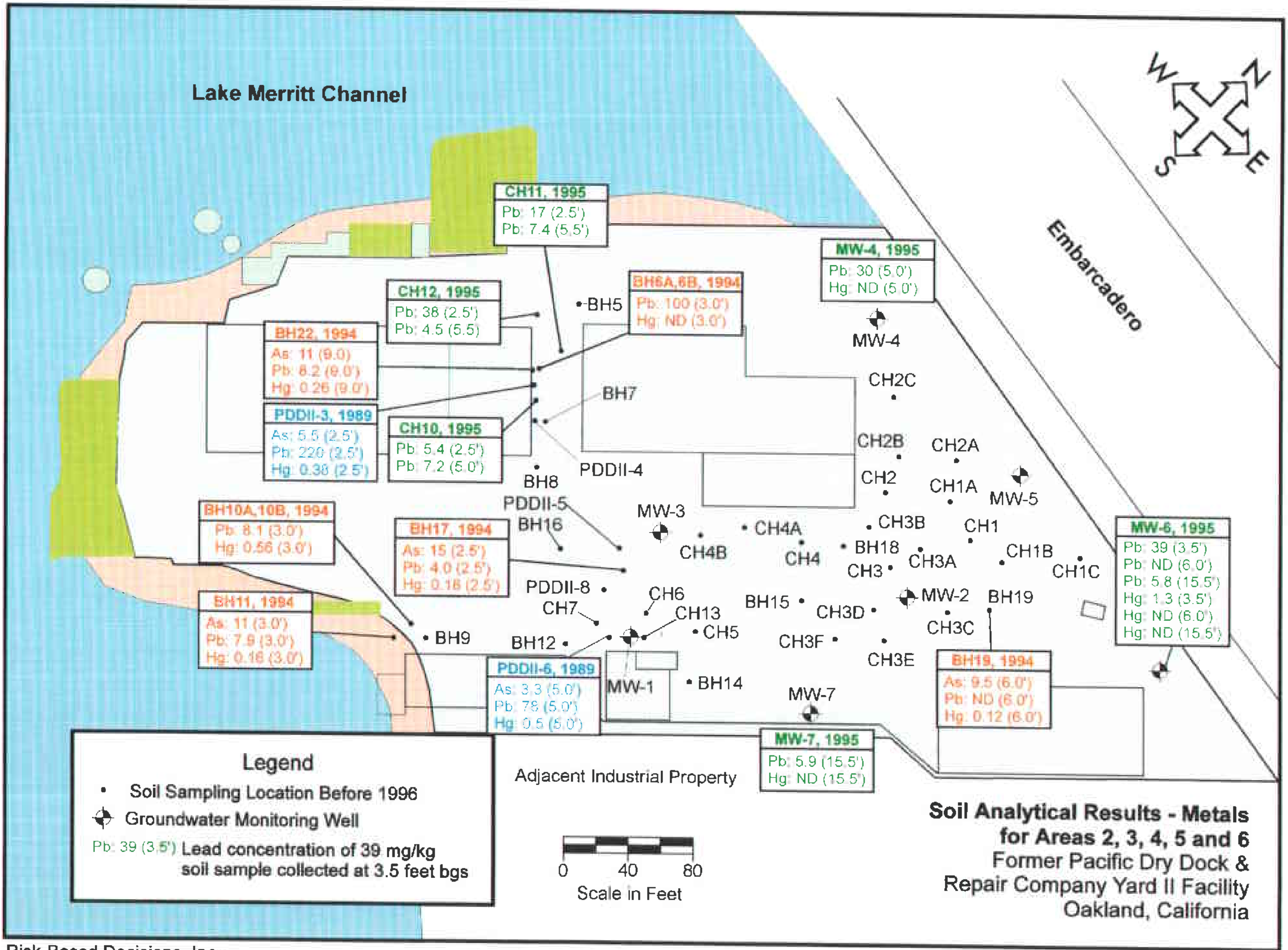
Note: (3.5')* - Soil sample collected after 3.5' grit removal.

Soil Analytical Results - Metals for Area 1

Former Pacific Dry Dock & Repair Company Yard II Facility
Oakland, California

Risk-Based Decisions, Inc.

Figure 4



Soil Analytical Results - Metals for Areas 2, 3, 4, 5 and 6
Former Pacific Dry Dock & Repair Company Yard II Facility
Oakland, California

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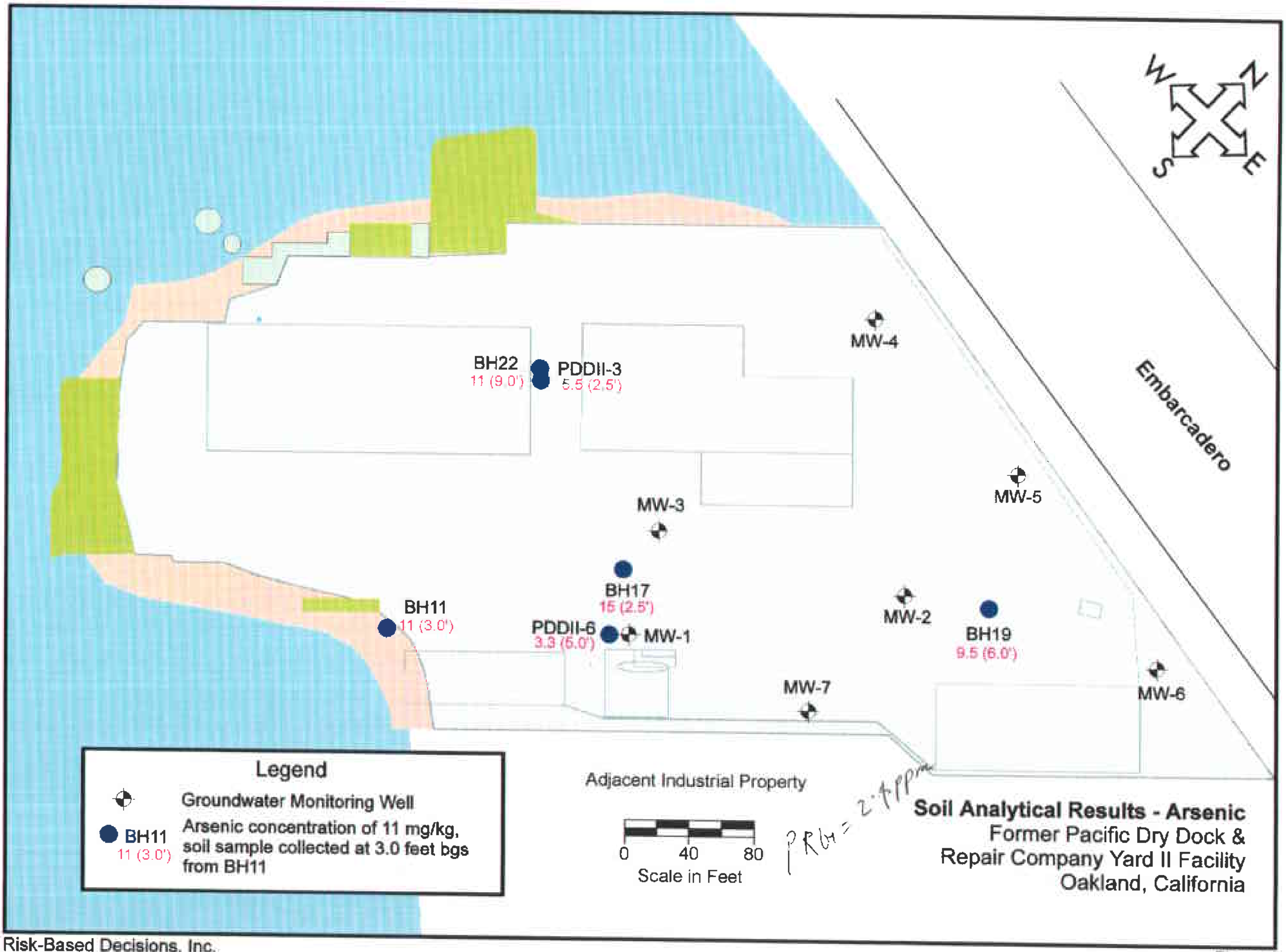
Figure 5

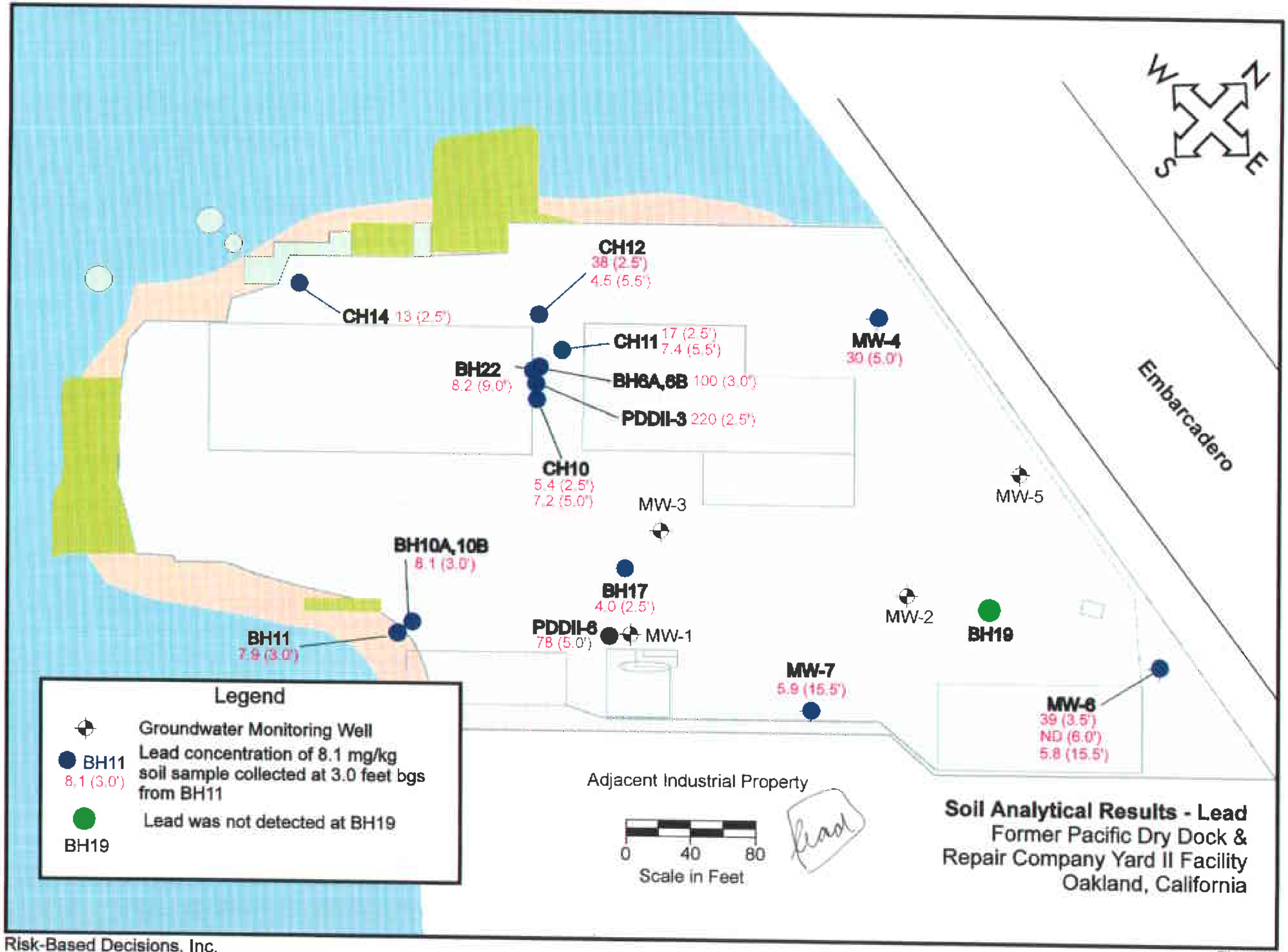


PRG = 2.4 ppm

Soil Analytical Results - Arsenic
Former Pacific Dry Dock &
Repair Company Yard II Facility
Oakland, California

Risk-Based Decisions, Inc.

Figure 6

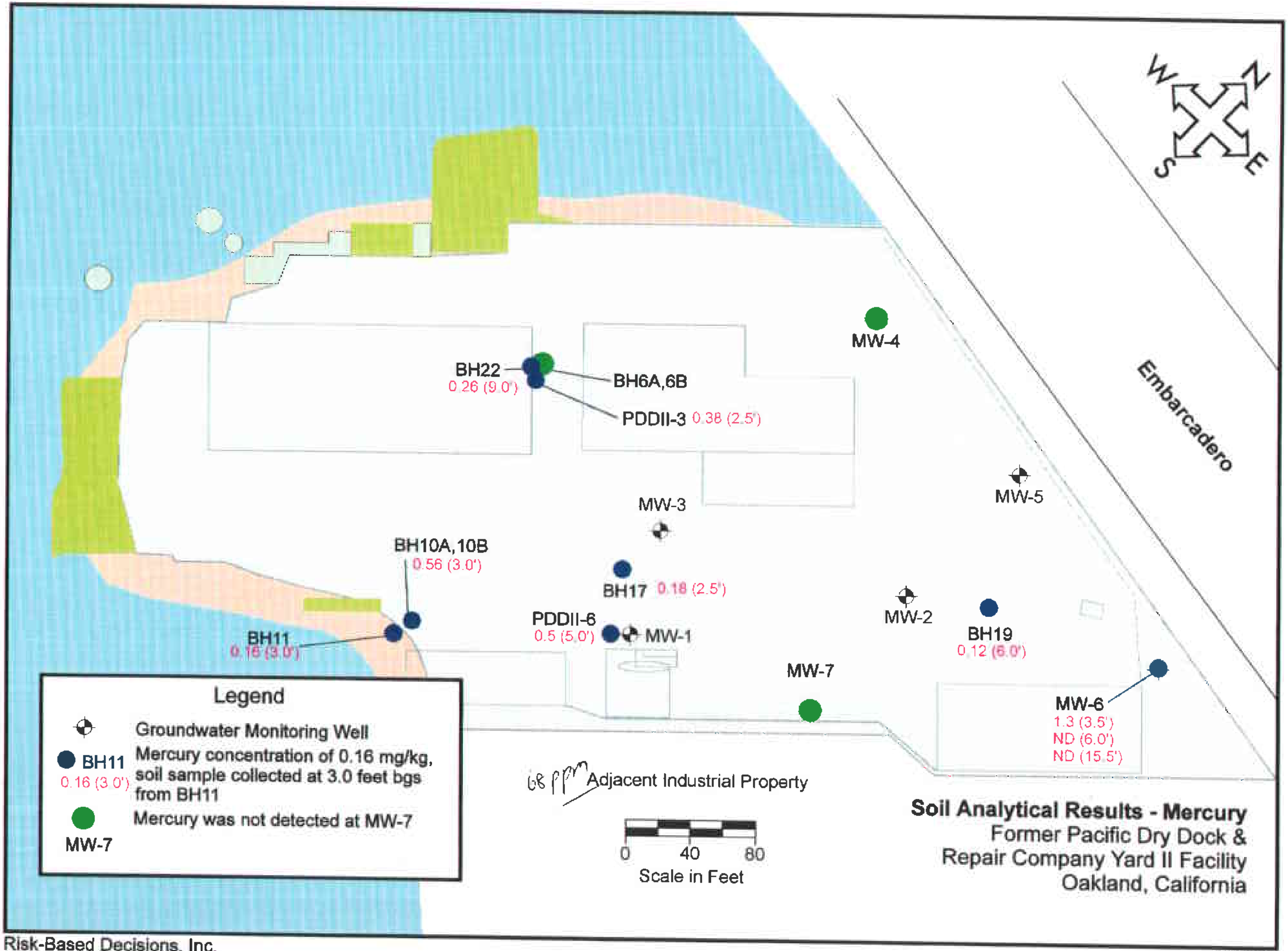


lead

Soil Analytical Results - Lead
Former Pacific Dry Dock &
Repair Company Yard II Facility
Oakland, California

Risk-Based Decisions, Inc.

Figure 7



Soil Analytical Results - Mercury
Former Pacific Dry Dock &
Repair Company Yard II Facility
Oakland, California

Risk-Based Decisions, Inc.

Figure 8

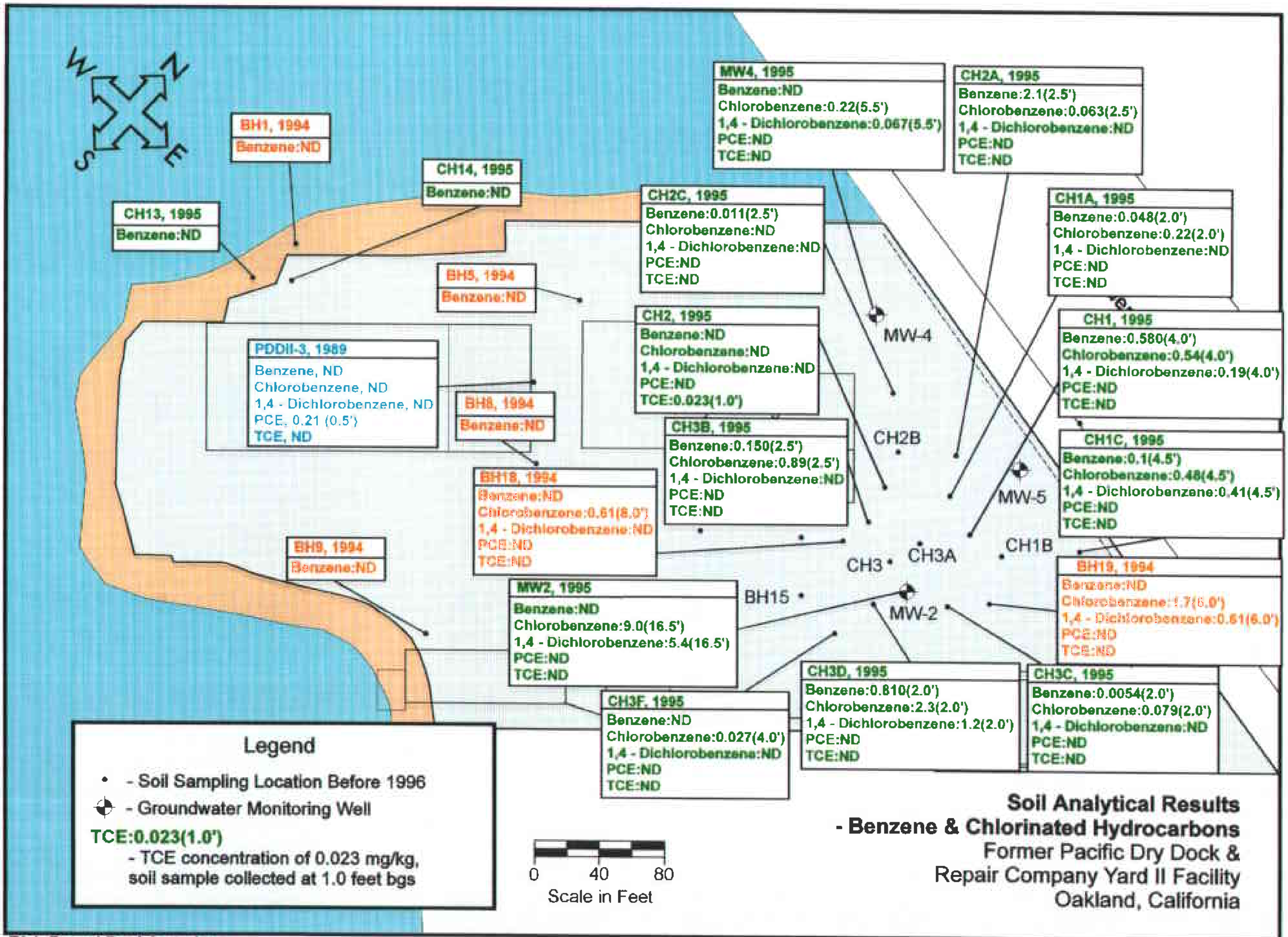
Table 2 is a comparison of naturally-occurring background concentrations of metals in California soils in comparison to metal concentrations detected in soils at the PDD Yard II Site. Based on a comparison of the means, only copper, lead, mercury and zinc at the Site exceed background concentrations. The mean of arsenic is 7 mg/kg whereas the background mean is 6.6 mg/kg, while the 95% UCL for naturally-occurring arsenic is 19.1 mg/kg *versus* an on-site arsenic 95% UCL is only 11 mg/kg. Therefore, statistically speaking the arsenic is not different from background. However, to be health protective, arsenic was retained as a chemical of concern for purposes of this risk assessment.

Figure 6 shows the distribution of residual arsenic in Site soils at the surface (0-0.5 feet) and at depth (2.5 feet and deeper as noted).

Figure 7 shows the distribution of lead in soils at the Site. As noted in the Figure, the green dots represent lead concentrations below detection limits. Concentrations of lead generally exceed background concentrations in the two to four feet bgs fill material. Samples collected from depths below the fill are well within naturally-occurring background concentrations.

Figure 8 shows the distribution of mercury in soils at the Site. As noted in the Figure, the green dots represent mercury concentrations below detection. A soil sample taken from MW-6 at 3.5 feet bgs showed 1.5 ppm mercury although samples taken from this same location at 6 and 15.5 feet bgs were non-detect.

Soil sampling analytical results for constituents of petroleum hydrocarbons and chlorinated hydrocarbons are summarized in Table 3 and illustrated in Figure 9. As shown in Table 3, even the maximum detected concentration for the organic



Soil Analytical Results
- Benzene & Chlorinated Hydrocarbons
Former Pacific Dry Dock &
Repair Company Yard II Facility
Oakland, California

Risk-Based Decisions, Inc.

Figure 9

compounds detected in soils at any depth are less than 10 mg/kg, and the means and 95% UCL are below 1.00 mg/kg. The maximum soil concentration of TPHd and TPHg were 2,700 and 500 mg/kg at 16.5 feet bgs in MW2 (in July 1994). The BTEX constituents in this same sample were ND, 1.0, 8.3 and 7.4 mg/kg, respectively. These data suggest that the fuel hydrocarbons are significantly degraded or weathered.

Benzene was detected in sample CH2A at 2.5 feet bgs at a concentration of 2.1 mg/kg in 1995. However, toluene was ND, ethylbenzene was 0.0053 and xylenes were ND in this same sample. Since the half-lives (a measure of the rate of breakdown of these fuel hydrocarbons) are considerably shorter than for benzene (Howard *et al.*, 1991), it is plausible that this benzene detection was anomalous. However, because benzene is a known human carcinogen, it was retained as a chemical of potential concern for further evaluation in this risk assessment.

The data for organic compounds detected in soils are consistent with known historical activities at the Site, and do not indicate the potential for a large mass of chemicals remaining in soils such that the soils could serve as a reservoir of ongoing contamination of the shallow groundwater. As discussed below, the data for chemicals detected in groundwater confirm this interpretation of the soils data.

3.2 Groundwater Sampling

Seven groundwater monitoring wells have been installed at the PDD Yard II Site and five rounds of quarterly groundwater sampling were conducted (three rounds for metals in groundwater). Groundwater samples from the monitoring wells and grab groundwater samples from soil boreholes and temporary sampling points were analyzed for the same constituents as the soil samples.

Table 4 shows the results of metals detected in groundwater and electrical conductivity as an indicator of groundwater quality. It should be noted that the electrical conductivity at the Site averages 5,002 μs/cm. This electrical conductivity is indicative of poor water quality. Furthermore, under the California State Water Resources Control Board (SWRCB) Resolution 88-63, in order for an aquifer to be a source of drinking water, it must have an electrical conductivity under 5,000 μs/cm.

Figure 10 shows the distribution of selected metals in groundwater at the Site. As indicated in Table 4, copper was detected at concentrations ranging from non-detect (ND) to 100 μg/l in October and December 1995, but has not been detected in any on-site well in the May 1996 quarter sampling event.

Lead was detected in three wells, MW1 (110 μg/l-December 1995), MW4 (210 μg/l-October 1995) and MW7 (310 μg/l-October 1995). Subsequent rounds of monitoring showed no detections of lead in any well (Table 4).

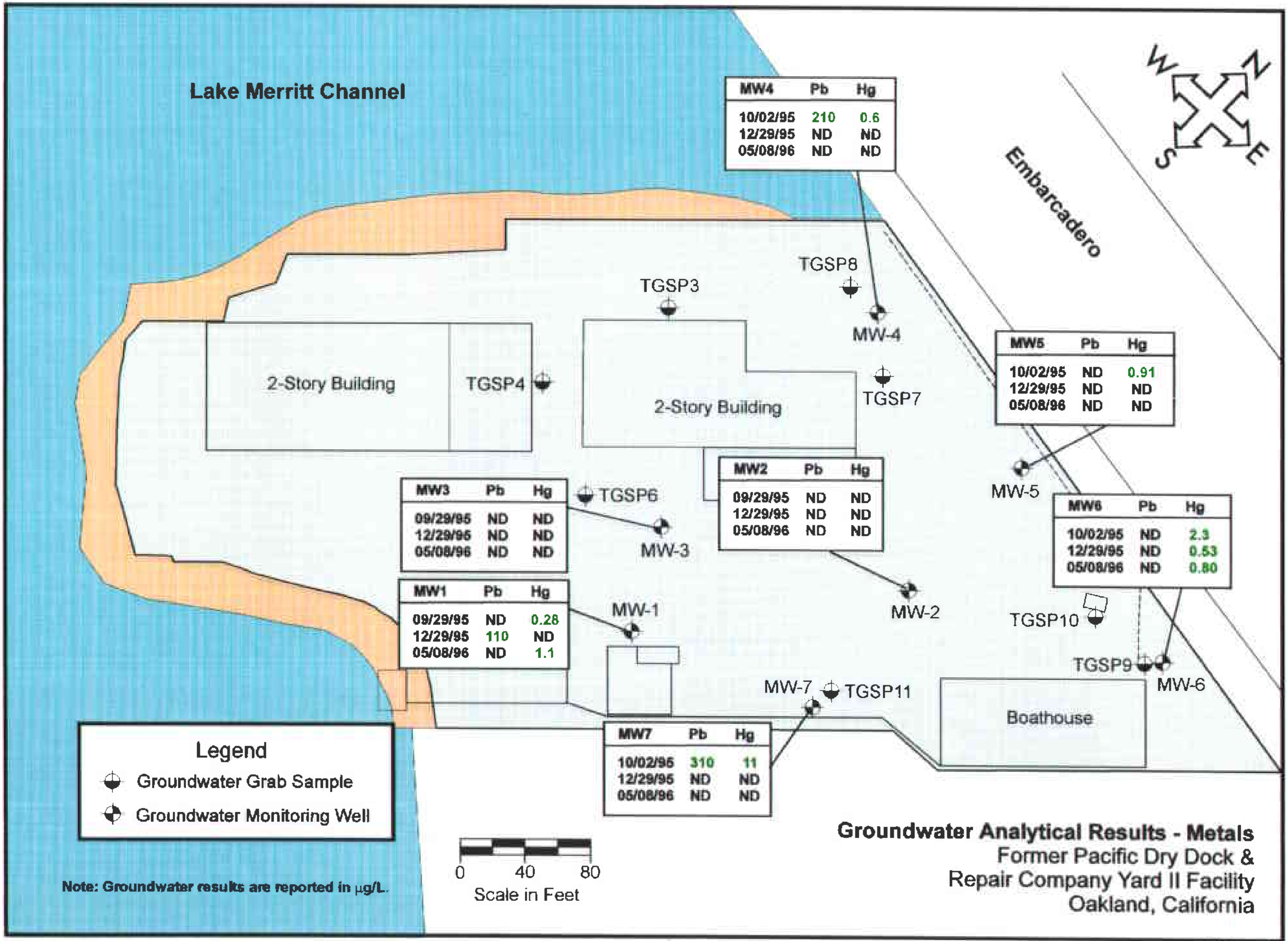
Mercury was detected in groundwater at concentrations ranging from 0.28 to 11 μg/l. Since December 1995, however, mercury has only been detected in well MW1 at 1.1 μg/l and in well MW6 at 0.8 μg/l. All other wells had no detectable concentrations of mercury (Table 4).

The analytical results for groundwater samples from the seven on-site monitoring wells sampled over five quarters for petroleum hydrocarbons, BTEX and chlorinated compounds are summarized in Table 5 and illustrated in Figure 11.

TABLE 4
GROUNDWATER SAMPLING RESULTS
METALS (μg/L)
Former Pacific Dry Dock and Repair Company Yard II
321 Embarcadero, Oakland, California

Sample ID Date	Copper	Lead	Mercury	Zinc	Electrical Conductivity umhos/cm
MW1					
9/29/95	ND	ND	0.28	56	
12/29/95	50	110	ND	24	6780
5/8/96	ND	ND	1.1	ND	4750
MW2					
9/29/95	ND	ND	ND	51	
12/29/95	55	ND	ND	38	6470
5/8/96	ND	ND	ND	ND	3230
MW3					
9/29/95	ND	ND	ND	60	
12/29/95	100	ND	ND	30	4420
5/8/96	ND	ND	ND	ND	7790
MW4					
10/2/95	20	210	0.6	440	
12/29/95	55	ND	ND	68	3780
5/8/96	ND	ND	ND	ND	6950
MW5					
10/2/95	ND	ND	0.91	240	
12/29/95	100	ND	ND	68	3550
5/8/96	ND	ND	ND	ND	3950
MW6					
10/2/95	ND	ND	2.3	140	
12/29/95	95	ND	0.53	110	6770
5/8/96	ND	ND	0.8	ND	1360
MW7					
10/2/95	20	310	11	380	
12/29/95	60	ND	ND	80	6930
5/8/96	ND	ND	ND	ND	3320

Note:
NA = Not Analyzed
ND = Less than Detection Limit. (see Versar reports in references for detection limits)



MW4	Pb	Hg
10/02/95	210	0.6
12/29/95	ND	ND
05/08/96	ND	ND

MW5	Pb	Hg
10/02/95	ND	0.91
12/29/95	ND	ND
05/08/96	ND	ND

MW3	Pb	Hg
09/29/95	ND	ND
12/29/95	ND	ND
05/08/96	ND	ND

MW2	Pb	Hg
09/29/95	ND	ND
12/29/95	ND	ND
05/08/96	ND	ND

MW6	Pb	Hg
10/02/95	ND	2.3
12/29/95	ND	0.53
05/08/96	ND	0.80

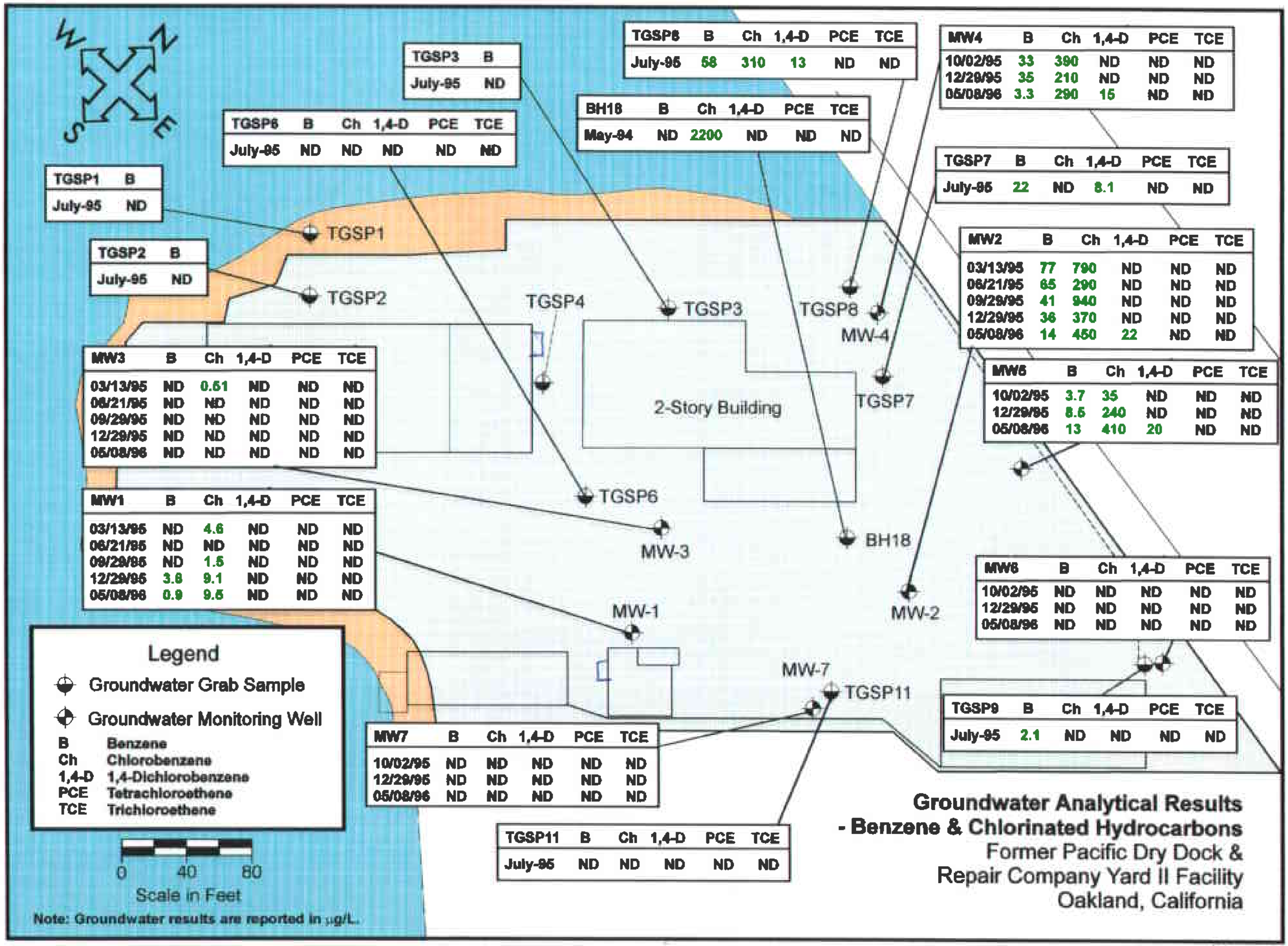
MW1	Pb	Hg
09/29/95	ND	0.28
12/29/95	110	ND
05/08/96	ND	1.1

MW7	Pb	Hg
10/02/95	310	11
12/29/95	ND	ND
05/08/96	ND	ND

Note: Groundwater results are reported in µg/L.

Groundwater Analytical Results - Metals
Former Pacific Dry Dock &
Repair Company Yard II Facility
Oakland, California

Figure 10



TGSP3	B
July-95	ND

TGSP8	B	Ch	1,4-D	PCE	TCE
July-95	58	310	13	ND	ND

MW4	B	Ch	1,4-D	PCE	TCE
10/02/95	33	390	ND	ND	ND
12/29/95	35	210	ND	ND	ND
05/08/96	3.3	290	15	ND	ND

BH18	B	Ch	1,4-D	PCE	TCE
May-94	ND	2200	ND	ND	ND

TGSP6	B	Ch	1,4-D	PCE	TCE
July-95	ND	ND	ND	ND	ND

TGSP7	B	Ch	1,4-D	PCE	TCE
July-95	22	ND	8.1	ND	ND

TGSP1	B
July-95	ND

TGSP2	B
July-95	ND

MW2	B	Ch	1,4-D	PCE	TCE
03/13/95	77	790	ND	ND	ND
06/21/95	65	290	ND	ND	ND
09/29/95	41	940	ND	ND	ND
12/29/95	36	370	ND	ND	ND
05/08/96	14	450	22	ND	ND

MW3	B	Ch	1,4-D	PCE	TCE
03/13/95	ND	0.61	ND	ND	ND
06/21/95	ND	ND	ND	ND	ND
09/29/95	ND	ND	ND	ND	ND
12/29/95	ND	ND	ND	ND	ND
05/08/96	ND	ND	ND	ND	ND

MW5	B	Ch	1,4-D	PCE	TCE
10/02/95	3.7	35	ND	ND	ND
12/29/95	8.5	240	ND	ND	ND
05/08/96	13	410	20	ND	ND

MW1	B	Ch	1,4-D	PCE	TCE
03/13/95	ND	4.6	ND	ND	ND
06/21/95	ND	ND	ND	ND	ND
09/29/95	ND	1.5	ND	ND	ND
12/29/95	3.6	9.1	ND	ND	ND
05/08/96	0.9	9.5	ND	ND	ND

MW6	B	Ch	1,4-D	PCE	TCE
10/02/95	ND	ND	ND	ND	ND
12/29/95	ND	ND	ND	ND	ND
05/08/96	ND	ND	ND	ND	ND

MW7	B	Ch	1,4-D	PCE	TCE
10/02/95	ND	ND	ND	ND	ND
12/29/95	ND	ND	ND	ND	ND
05/08/96	ND	ND	ND	ND	ND

TGSP9	B	Ch	1,4-D	PCE	TCE
July-95	2.1	ND	ND	ND	ND

TGSP11	B	Ch	1,4-D	PCE	TCE
July-95	ND	ND	ND	ND	ND

Legend

◒ Groundwater Grab Sample

⊕ Groundwater Monitoring Well

B	Benzene
Ch	Chlorobenzene
1,4-D	1,4-Dichlorobenzene
PCE	Tetrachloroethene
TCE	Trichloroethene

Note: Groundwater results are reported in µg/L.

Groundwater Analytical Results
- Benzene & Chlorinated Hydrocarbons
Former Pacific Dry Dock &
Repair Company Yard II Facility
Oakland, California

Risk-Based Decisions, Inc.

Figure 11

TPHd was detected in all wells at concentrations ranging from ND to 3,300 µg/l. MW2 has the highest detected concentrations of TPHd. However, the TPHd concentrations in this well have decreased from a high of 3,300 µg/l in June 1995 to 680 µg/l in May 1996, an attenuation of approximately 80%. In most of the other wells, the concentration of TPHd has decreased or remained unchanged.

The highest reported concentrations of TPHg also occurred in well MW2 and as with TPHd, the concentrations have attenuated in this well from a high of 2,300 µg/l in June 1995 to 640 µg/l in May 1996, a reduction of about 72%. The TPHg concentrations have been stable over time consistent with a hypothesis of release several years ago (as evidenced also by the weathered nature of the petroleum hydrocarbon constituents). These TPHg levels represent weathered gasoline as indicated by the consistently low BTEX values reported in groundwater across the Site and over time. For example, historical detections of benzene ranged from ND to 77 µg/l. In well MW2, benzene concentrations attenuated from a high of 77 µg/l in March 1995 to 14 µg/l in May 1996, an 82% reduction in concentration. The low BTEX concentrations are indicative of small residual concentrations of petroleum hydrocarbon constituents in groundwater. Given that the soil data also showed low concentrations of these hydrocarbons, the groundwater concentrations reported in groundwater in May 1996 are not likely to increase and, in fact, will biodegrade naturally even further over time.

With regard to chlorinated compounds, trichloroethylene (TCE) and perchloroethylene (PCE) were not detected in any of the groundwater monitoring wells at any time (Table 5). The primary daughter product of TCE, cis- and trans-1,2-dichloroethylene (DCE) was detected only once in well MW2 at 1.6 µg/l (June 1995) at approximately three times the detection limit. These data indicate the virtual absence of PCE, TCE and DCE in groundwater at the Site.

TABLE 5
GROUNDWATER SAMPLING RESULTS
PETROLEUM AND CHLORINATED HYDROCARBONS (μg/L)
Former Pacific Dry Dock and Repair Company Yard II
321 Embarcadero, Oakland, California

	TPH-D	TPH-G	Benzene	Toluene	Ethyl-benzene	Xylenes	Chloro-benzene	cis & trans-1,2-DCE	1,4-Dichloro-benzene	Phenanthrene	TCE	PCE
MW1												
3/13/95	220	ND	ND	ND	ND	ND	4.6	ND	ND	NA	ND	ND
6/21/95	160	ND	ND	ND	1	5.3	ND	ND	ND	NA	ND	ND
9/29/95	ND	ND	ND	ND	ND	ND	1.5	ND	ND	NA	ND	ND
12/29/95	ND	55	3.6	ND	1.4	ND	9.1	ND	ND	NA	ND	ND
5/8/96	330	240	0.9	2.6	5.7	58	9.5	ND	ND	NA	ND	ND
MW2												
3/13/95	2500	1600	77	ND	ND	850	790	ND	ND	NA	ND	ND
6/21/95	3300	2300	65	0.74	1.3	810	290	1.6	ND	NA	ND	ND
9/29/95	870	1400	41	ND	ND	ND	940	ND	ND	NA	ND	ND
12/29/95	2600	1600	36	ND	14	ND	370	ND	ND	NA	ND	ND
5/8/96	680	640	14	ND	0.53	59	450	ND	22	NA	ND	ND
MW3												
3/13/95	ND	ND	ND	ND	ND	ND	0.51	ND	ND	NA	ND	ND
6/21/95	140	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
9/29/95	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
12/29/95	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
5/8/96	140	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
MW4												
10/2/95	1900	1400	33	ND	3	ND	390	ND	ND	NA	ND	ND
12/29/95	800	960	35	5.5	13	ND	210	ND	ND	NA	ND	ND
5/8/96	2400	610	3.3	1.5	2.5	160	290	ND	15	NA	ND	ND
11/22/96	NA	NA	NA	NA	NA	NA	NA	NA	NA	100	NA	NA
MW5												
10/2/95	840	300	3.7	ND	ND	ND	35	ND	ND	NA	ND	ND
12/29/95	650	860	8.5	0.85	0.77	ND	240	ND	ND	NA	ND	ND
5/8/96	1100	830	13	ND	0.55	59	410	ND	20	NA	ND	ND
MW6												
10/2/95	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
12/29/95	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND

TABLE 5
GROUNDWATER SAMPLING RESULTS
PETROLEUM AND CHLORINATED HYDROCARBONS (μg/L)
Former Pacific Dry Dock and Repair Company Yard II
321 Embarcadero, Oakland, California

	TPH-D	TPH-G	Benzene	Toluene	Ethylbenzene	Xylenes	Chlorobenzene	cis & trans-1,2-DCE	1,4-Dichlorobenzene	Phenanthrene	TCE	PCE
5/8/96	220	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
MW7												
10/2/95	900	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
12/29/95	130	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
5/8/96	180	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND

Note:
NA = Not Analyzed
ND = Less than Detection Limit. (see Versar reports in references for detection limits)

As shown in Table 5, 1,4-dichlorobenzene (1,4-DCB) was detected in three out of 27 samples at a maximum reported concentration of 22 μg/l (MW2 in May 1996). It was also detected in well MW4 at 15 μg/l (May 1996) and at 20 μg/l in MW5 (also in May 1996). These wells previously had no detections of 1,4-DCB. The fact that these three wells had detections of 1,4-DCB in the same quarter suggests that the results could be a consequence of cross-contamination at the time of sampling or a laboratory artifact.

Chlorobenzene has been consistently detected in groundwater at the Site at concentrations ranging from ND to 940 μg/l. As with the TPHd, TPHg and BTEX data, MW2 exhibited the highest reported concentrations (also illustrated in Figure 11). The data shown in Table 5 suggest that the chlorobenzene detections in groundwater are stable aside from minor fluctuations normal for low detections of organic compounds in groundwater.

3.3 Data Summary

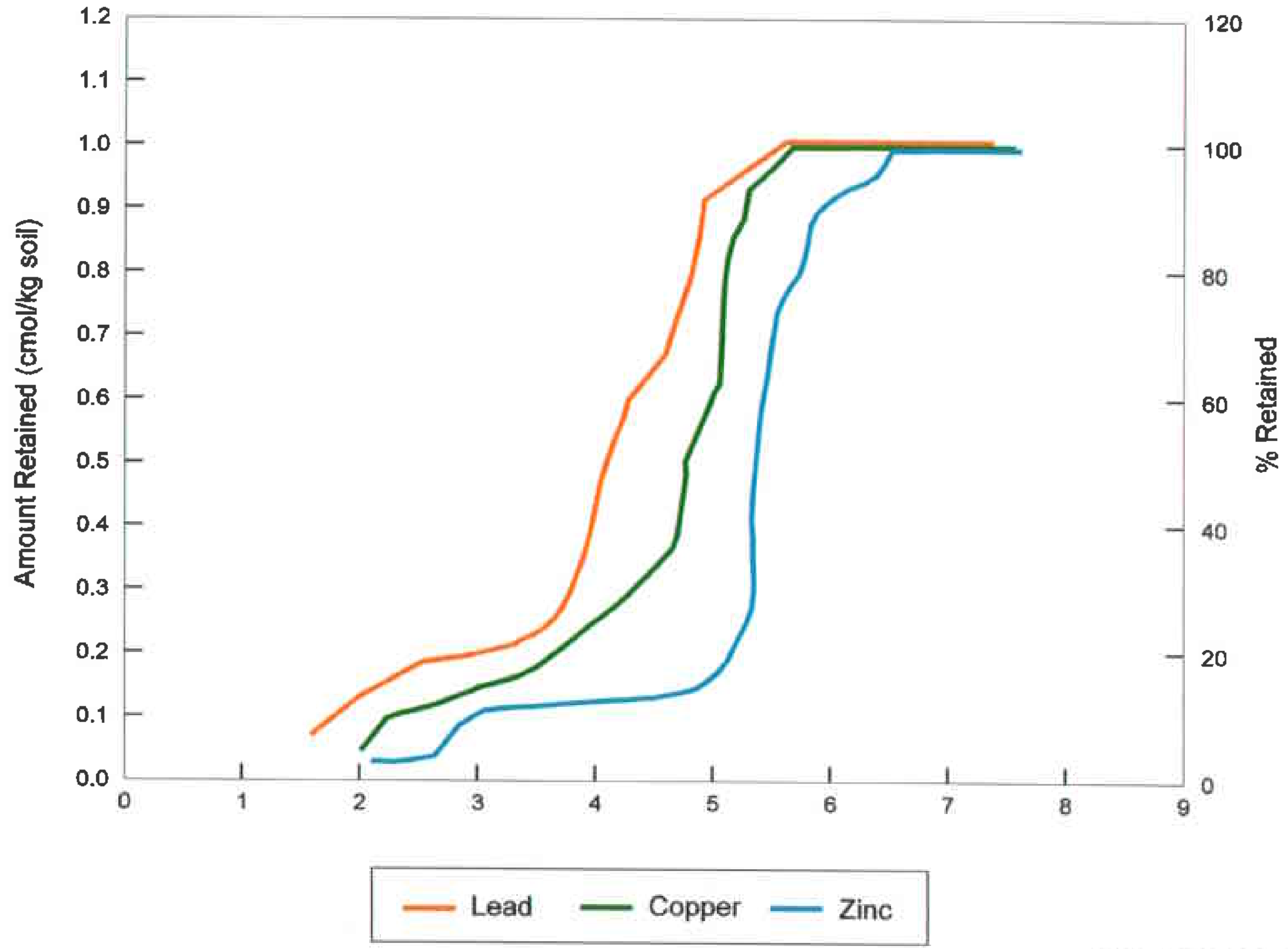
The soil data indicate that the concentrations of arsenic are virtually at (or slightly below if 95% UCLs are compared) regional background. The arithmetic means for copper, lead and mercury in soils were above naturally-occurring background concentrations and these metals were evaluated for potential risks in this report.

From a fate and transport perspective, metals with high partition coefficients tend to be adsorbed to soil surfaces and, thus, become less mobile. Soil conditions that are generally favorable for the retention of metals include:

- Small grain size (*i.e.*, clay or silty soils);
- Organic content (greater than 5%); and
- pH ranging between 6-8.

These soil conditions exist at the Site. Figure 12 shows the sorption of selected metals in soils as a function of pH. As can be seen from this Figure, at about pH 6, the metals are strongly retained by the clay. Lead and copper are retained better than zinc. At pH 7, nearly 100% of all the metals are retained. As noted in Table 1, the average pH value of Yard II soil is 8. Thus, any remaining metals in fill material or in soils are rendered virtually immobile.

The soil analytical data for VOCs show that the total mass of chemical remaining is small. This fact is further substantiated by the low concentration of organic compounds detected in groundwater.



SORPTION OF METALS
Former Pacific Dry Dock &
Repair Company Yard II Facility
Oakland, California

Note: Contaminants added separately at 1 cmol/kg soil (Yong et al., 1992).

Figure 12

4.0 EXPOSURE ASSESSMENT

An exposure assessment consists of identifying who might be exposed to chemicals at or from a site. In addition, the assessment seeks to quantitatively estimate how often such exposures could occur, for how long the exposure might continue, and how much total exposure could occur over a defined length of time. The exposure assessment also examines the route by which the chemicals travel from the site to receptors at or near the site.

An exposure pathway generally consists of four elements:

- A source and mechanism of chemical release;
- A retention or transport medium;
- A point of contact with the medium; and
- A route of exposure (*e.g.*, inhalation) at the contact point.

There must be a complete exposure pathway from the source of chemicals in the environment (*i.e.*, from groundwater, soil or air) to human or ecological receptors in order for chemical intake to occur.

Since, at the former Pacific Dry Dock Yard II Site, the metal concentrations are elevated generally in soils at depths of 3.0 to 3.5 feet, and these locations are submerged below the Bay/Channel water or near the water line, the soils are always wet. These physical conditions minimize or preclude the potential for human exposure via absorption through the skin or inhalation of dust. While not very likely because of location and depth, in order to provide a conservative estimate of risk, we have assumed potential on-site worker exposure to metals via incidental soil ingestion.

The shallow groundwater beneath the Site is not potable and is not used as a source of drinking water. Therefore, there is no complete pathway for direct human exposure to chemicals in groundwater. However, indirect human exposure may occur as a result of volatilization of the volatile organic compounds (VOCs) upward through the soil column and into outdoor or indoor air. Furthermore, the pathway for impacts to aquatic marine organisms living in the Bay is potentially complete via migration of groundwater to the Bay.

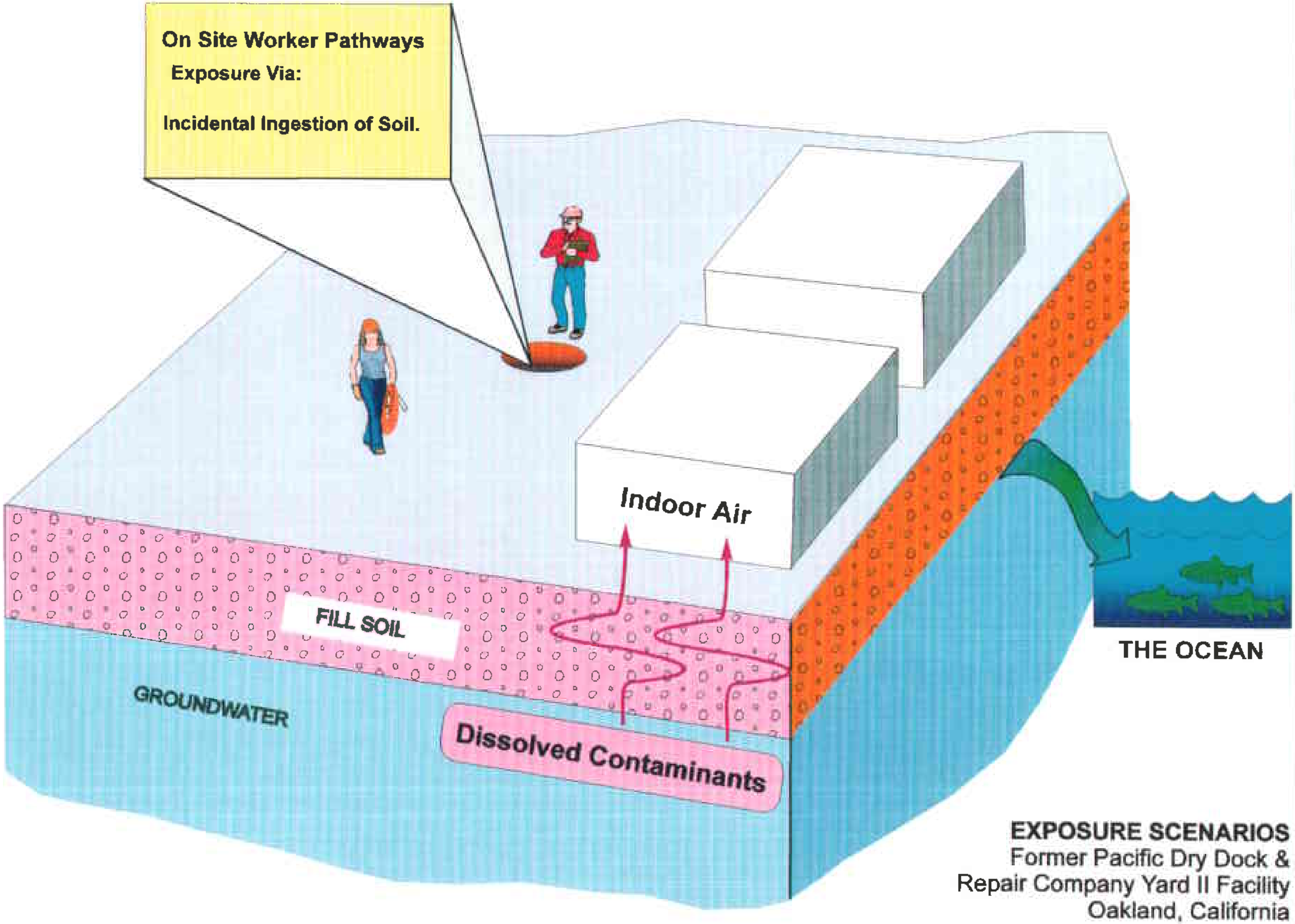
Based on the physical conditions at the Site, its location, the nature of the residual chemicals in soils and groundwater, and on the geology and hydrogeology of the Site and in its vicinity, three potentially complete pathways of exposure were identified (Figure 13). These include:

1. Upward migration of the volatile constituents of gasoline, primarily BTEX, and the chlorinated compounds through the soil column and into indoor air where on-site workers might be exposed to these chemicals via inhalation;

2. Direct on-site worker exposure to chemicals, primarily metals in surficial soils; and

3. Off-site migration of the impacted groundwater to the Bay with potential exposure of marine organisms.

The rationale for the selection and evaluation of the worker exposure pathway is discussed below while the groundwater fate and transport is presented in Section 6.0.



EXPOSURE SCENARIOS
Former Pacific Dry Dock &
Repair Company Yard II Facility
Oakland, California

Figure 13

4.1 Commercial/Industrial Workers

The Site is currently vacant and is zoned for industrial use. Therefore, risks for worker exposures were quantitatively evaluated. It should be noted, however, that the Port of Oakland and the City of Oakland have proposed a plan to redevelop the Site into a public access recreational area. Under Framework Plan 2 in the proposed *Draft Oakland Waterfront Initiatives: Estuary Plan* (Port of Oakland/City of Oakland, March 3, 1997), approximately half of the former Pacific Dry Dock Yard II Site, along a north-south axis, would be excavated and made into a public beach. The implementation of such a plan would require substantial amounts of clean sand to be brought in to create the proposed public access beach. Under these proposed redevelopment conditions, much of the residual chemicals in soil and groundwater would be removed and any potential exposure to the public would be precluded. ?

If the Site remained industrial or commercial, on-site workers could become exposed to metals in surficial soils and to vapors of volatile constituents of petroleum hydrocarbons originating from the subsurface. Such exposures could occur via outdoor or indoor air. In general, potential exposures via outdoor air are unlikely to be significant from a health perspective because any vapors emanating from the subsurface would be greatly diluted by ambient air in moving up from the ground surface to the breathing zone of the worker. In addition, it is unlikely that a worker would be working outdoors in one place for any extended length of time to enable such a worker to become significantly exposed. A more plausible, and perhaps even likely, exposure scenario would be for vapors to migrate up to the surface and accumulate in indoor air where an on-site worker would spend most of her or his work day. Thus, in this risk assessment report, the risks to outdoor workers were qualitatively evaluated, recognizing that outdoor air exposures would be orders of magnitude less than indoor air exposures (ASTM, 1995).

4.2 Exposure to Groundwater

Because the Site is located on the shoreline, the groundwater is saline and not potable. Therefore, ingestion of drinking water was not considered to be a complete exposure pathway. However, the potential for residual chemicals in groundwater to migrate towards the Bay/Channel and potentially impact marine organisms was considered plausible and is discussed further in the Groundwater Fate and Transport Section (Section 6.0).

Human exposure is expressed as the amount of a chemical taken into the body per unit body weight per unit time, and expressed as mg/kg/day. Calculations and input parameters used for estimating intake rates, through the direct contact with soils and the inhalation of vapor from chemicals in the subsurface soils and groundwater, were obtained from USEPA (USEPA, 1989 and 1994).

Intake (or exposure) was calculated as either the Average Daily Dose (ADD) or the Lifetime Average Daily Dose (LADD). The ADD was used in the evaluation of noncarcinogenic health effects, while the LADD was used to evaluate carcinogenic effects. The following general equation was used to calculate the intake associated with the inhalation of chemical vapor by exposed workers:

$$Intake = \frac{(Ca)\,(Br)\,(EF)\,(ED)}{(BW)\,(AT)\,(365)} \qquad (1)$$

Where:

Intake = ADD or LADD (mg/kg/day)
Ca = Concentration of Chemical in Air (mg/m^3)
Br = Breathing Rate (20 m^3/day)
EF = Exposure Frequency (250 days/year)
ED = Exposure Duration (25 years)
BW = Body Weight (70 kg)
AT = Averaging Time (70 years)
365 = Conversion Factor (days/year)

The exposure point concentrations in indoor air were computed using an emissions model as described in Section 5.0.

For direct exposure to chemicals in surface soils, the equation used is written as:

$$\textbf{Intake} = \frac{(Cs)\,(Ir)\,(FI)\,(EF)\,(ED)}{(BW)\,(AT)\,(365)} \qquad \textbf{(2)}$$

Where:

Intake = ADD or LADD (mg/kg/day)
Cs = Concentration of Chemical in Soil (mg/m^3)
Ir = Soil ingestion rate (50 mg/day)
FI = Fraction of contaminated soil surface (0.10)
EF = Exposure Frequency (250 days/year)
ED = Exposure Duration (25 years)
BW = Body Weight (70 kg)
AT = Averaging Time (70 years)
365 = Conversion Factor (days/year)

The parameters selected to quantify chemical intake (noted in parentheses above) represent default 95% upper bound estimates recommended by the USEPA (1989). The only site-specific parameter was the conservative estimate that approximately 10%

of the surface soils at the Site contained metal concentrations above background. As discussed in Section 3.0 (Data Evaluation) and illustrated in Figures 3 through 10, this is a health-protective assumption since the data indicate that less than approximately one percent of the surface area of the Site contain metal concentrations above background.

5.0 CHEMICAL FATE AND TRANSPORT MODELING

This section presents the modeling methodology used to predict the transport of chemicals from the subsurface soil up to the atmosphere.

The vapor transport process is influenced by several factors including the volatilization of chemicals by their vapor-phase diffusion through air-filled soil pores, liquid-phase diffusion of chemicals through soil moisture, and capillary forces due to upward soil moisture flow. The rates for each of these processes were determined from the physical properties of the chemical, the soil matrix and on-site features.

Vapor emissions of chemicals from subsurface soil and groundwater were evaluated under an indoor worker exposure setting. For this exposure scenario, the Heuristic Model (Johnson and Ettinger, 1991) recommended by the USEPA (USEPA, 1992 and 1994) and the ASTM Risk-Based Corrective Action Standard (ASTM, 1995), was used.

5.1 Estimation of Emissions From Soil and Groundwater into Indoor Air

This section describes the vapor transport from contaminated soil and groundwater into the on-site commercial building. The Heuristic model assumes that the soil is homogeneous within any horizontal plane with respect to effective diffusion coefficients and that convective vapor flow in the region near the foundation is uniform. The Heuristic model further assumes that the three phases of the chemical are in equilibrium, and that there are no interactions between the chemicals.

Tables 6 and 7 present the chemical-specific source concentrations in the subsurface soil and groundwater, building dimensions, soil type and chemical-specific properties used as inputs to the Heuristic Model. Chemical vapors enter structures primarily through cracks and openings in the walls and foundation (electrical outlets, wall-floor seams, cracks, *et cetera*). There are two primary pathways by which vapors from subsurface soils or groundwater can enter a building: by convection and diffusion. Convective transport is likely to be most significant in the region close to a basement or foundation, and vapor velocities decrease rapidly with increasing distance from a structure. Vapor-phase diffusion is the dominant mechanism for transporting vapors from chemical sources away from the foundation or slab to the soil region near the slab or foundation. The relative contributions of each of these transport mechanisms can be determined by calculating what is termed the Peclet Number (Johnson and Ettinger, 1991). If the equivalent Peclet number >>1, then convective transport dominates; if the value is <<1, then diffusion dominates. In the case of the former Pacific Dry Dock Yard II Site, both convective and diffusive transport were assumed to contribute to vapor migration from the subsurface soil into indoor air. Tables 6 and 7 also gives the resulting indoor air concentrations from the model which were used to estimate carcinogenic health risks and noncarcinogenic health effects for the potentially exposed on-site worker.

For the purposes of the model, it was assumed, based on existing site characterization reports, that the on-site commercial building on the Site was 200 feet long by 100 feet wide by 20 feet high (inside floor-to-ceiling). The building was further assumed to be constructed on an eight-inch (20 cm) concrete slab with a 0.1 percent crack ratio. The distance from the source was assumed to be either 1.0 feet to 16.5 feet depending on the depth at which the maximum detected soil or groundwater concentration was reported for the particular chemical of concern. This commercial building was

Table 6
Input Parameters for Heuristic Model and Resultant Indoor Air Concentrations for Carcinogens
Pacific Dry Dock and Repair Company Yard II
Oakland, California

Chemical	Benzene	1,4-DCB	PCE	TCE
Scenario	1	1	1	1
Chemical Sources				
Chemical in Soil (mg/kg)	2.1	5.4	0.21	0.023
Chemical in Groundwater (mg/L)	7.70E-02	2.20E-02	0.00E+00	0.00E+00
Chemical Specific Parameters				
Diffusivity in Air (cm^2/s) at 25 ^oC	8.70E-02	6.90E-02	7.20E-02	7.90E-02
Henry's Constant (Dimensionless)	2.20E-01	1.20E-01	7.10E-01	4.30E-01
Koc (ml/g)	57	516	300	94
Soil Specific Parameters				
Total Porosity	0.40	0.40	0.40	0.40
Air Filled Porosity	0.15	0.15	0.15	0.15
Water Filled Porosity	0.25	0.25	0.25	0.25
Foc	0.001	0.001	0.001	0.001
Bulk Density (g Dry Soil/cm^3)	1.6	1.6	1.6	1.6
Building Parameters				
Distance From Slab to Source (ft)	2.5	16.5	0.5	1
Building Length (ft)	200	200	200	200
Building Width (ft)	100	100	100	100
Building Height (ft)	20	20	20	20
Air Changes per Hour	1.5	1.5	1.5	1.5
Foundation Thickness (in)	8	8	8	8
Crack Ratio	0.001	0.001	0.001	0.001
Vapor Concentration From Soil				
Total Soil Concentration (mg/cm^3)	1.92E-04	4.46E-03	1.01E-04	3.46E-06
Source Vapor Concentration (mg/m^3)	1.13E+02	4.89E+02	8.56E+01	3.20E+00
Indoor Air Concentration (mg/m^3)	2.35E-05	8.25E-05	1.51E-05	6.13E-07
Vapor Concentration From Groundwater				
Source Vapor Concentration (mg/m^3)	1.69E+01	2.64E+00	0.00E+00	0.00E+00
Indoor Air Concentration (mg/m^3)	3.54E-06	4.45E-07	0.00E+00	0.00E+00

Table 7
Input Parameters for Heuristic Model and Resultant Indoor Air Concentrations for Noncarcinogens
Pacific Dry Dock and Repair Company Yard II
Oakland, California

Chemical	Chlorobenzene	Ethylbenzene	Toluene	Xylene
Scenario	1	1	1	1
Chemical Sources				
Chemical in Soil (mg/kg)	9	8.3	1	7.4
Chemical in Groundwater (mg/L)	9.40E-01	1.40E-02	5.50E-03	8.50E-01
	(940 ppb)			
Chemical Specific Parameters				
Diffusivity in Air (cm^2/s) at 25 °C	7.30E-02	7.50E-02	8.70E-02	7.20E-02
Henry's Constant (Dimensionless)	1.80E-01	3.20E-01	2.50E-01	2.50E-01
Koc (ml/g)	204	221	131	260
Soil Specific Parameters				
Total Porosity	0.40	0.40	0.40	0.40
Air Filled Porosity	0.15	0.15	0.15	0.15
Water Filled Porosity	0.25	0.25	0.25	0.25
Foc	0.001	0.001	0.001	0.001
Bulk Density (g Dry Soil/cm^3)	1.6	1.6	1.6	1.6
Building Parameters				
Distance From Slab to Source (ft)	16.5	16.5	16.5	16.5
Building Length (ft)	200	200	200	200
Building Width (ft)	100	100	100	100
Building Height (ft)	20	20	20	20
Air Changes per Hour	1.5	1.5	1.5	1.5
Foundation Thickness (in)	8	8	8	8
Crack Ratio	0.001	0.001	0.001	0.001
Vapor Concentration From Soil				
Total Soil Concentration (mg/cm^3)	2.94E-03	2.93E-03	2.10E-04	3.08E-03
Source Vapor Concentration (mg/m^3)	8.76E+02	1.44E+03	1.05E+02	1.09E+03
Indoor Air Concentration (mg/m^3)	1.55E-04	2.62E-04	2.19E-05	1.92E-04
Vapor Concentration From Groundwater				
Source Vapor Concentration (mg/m^3)	1.69E+02	4.48E+00	1.38E+00	2.13E+02
Indoor Air Concentration (mg/m^3)	3.00E-05	8.14E-07	2.86E-07	3.72E-05

conservatively assumed to have 1.5 air exchanges per hour (air exchanges in commercial buildings can range from 4 to 12 per hour (ASHRAE, 1993).

Soil parameters were conservatively estimated based on site-specific information from boring logs and from guidance provided by the USEPA's *Soil Screening Guidance* (USEPA, 1994). The total porosity of soils at the Site was estimated to be 40 percent (0.40), the air-filled porosity was taken to be 15 percent (0.15), the water-filled porosity was estimated to be 25 percent (0.25), the fractional organic carbon (F_{oc}) was assumed to be 0.006, and the bulk density was assumed to be 1.6. ?

↑

0.001
used in tables

6.0 GROUNDWATER FATE AND TRANSPORT

As illustrated in Figure 2, the groundwater flows toward the Bay which is typical for property located at the shoreline with a hydraulic gradient of 0.015. Considering that the fill materials were mixed with gravel, sand, silt and clay from the ground surface to the Bay mud layer, it was assumed that the porosity of the aquifer was 0.40 and hydraulic conductivity of 0.003 cm/sec. The total length of the Site from east to west is about 500 feet. It was further assumed, in order to be protective of human health, that half of the Site, about 250 feet, was contaminated by VOCs. Based on the observed depth to groundwater of between two to five feet bgs, and the depth of Bay mud of between 15 feet to 20 feet bgs, we assumed an average depth to groundwater was 15 feet. Using above assumptions, the volume of groundwater flow into the Lake Merritt Channel was estimated as follows:

Using Darcy's equation, the aquifer flow rate was calculated as:

$$Q_a = WdKi \qquad (3)$$

(Equation 2-35, EPA540/R-94/106, 1994)

Where:

W = Width of source perpendicular to flow
d = Depth of aquifer
K = Aquifer hydraulic conductivity
i = Aquifer gradient

And the total volume of groundwater flow into the Channel was estimated to be:

$$V_w = Q_a\, n \qquad (4)$$

Where:

n = Aquifer porosity

Using above-mentioned site-specific parameters, the total volume of groundwater flowing into the channel was estimated to be 63 ft^3/day. Near the Site, dimension of the Channel is about 1000 x 500 x 30 feet. If we assume only 1% of the sea water in the Channel will be mixed with the groundwater daily due to water movement in the Bay, the dilution factor would be:

$$D_f = 1\% \times 1000 \times 500 \times 30 / 63 \approx 2{,}380 \qquad (5)$$

This means that chlorobenzene detected in MW-4 at 290 ug/l would be 0.12 ug/l in the Channel which is lower than the detection limit of 0.5 ppb.

7.0 TOXICITY ASSESSMENT

The toxicity assessment examines what is known about the intrinsic ability of a chemical to cause disease and the nature of the disease. Special emphasis is paid to the relationship between exposure to a chemical and the resulting disease. In particular, to understanding how much exposure to a particular chemical can result in what kind of disease, or with what likelihood. As indicated earlier in the Data Evaluation Section, the low frequency of detections coupled with the very low concentrations detected indicate that the chemicals remaining in subsurface soils at the Site resulted from spillage of gasoline, diesel and small amounts of solvents in the distant past. The toxicity criteria used to evaluate risks to human health are considered in the following sections. Ecological criteria are discussed in Section 7.2.

7.1 Toxicity Criteria for Human Health

For purposes of the toxicity assessment for humans, the chemicals of potential concern have been classified into two broad categories: noncarcinogens and carcinogens. This classification is used because health risks are calculated differently for carcinogenic and noncarcinogenic effects. Toxicity studies with laboratory animals or epidemiological studies of human populations provide the data used to develop these toxicity criteria.

7.1.2 Noncarcinogenic Effects

Noncarcinogenic effects were evaluated using either *reference doses* (RfDs) or *reference concentrations* (RfCs), developed by the EPA. The RfD or RfC is a health-based criterion based on the assumption that thresholds exist for noncarcinogenic toxic effects (*e.g.*, liver or kidney damage), but do not exist for carcinogenic toxic effects. In general, the RfD is an estimate (with uncertainty spanning perhaps one to several order(s) of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime of exposure (USEPA, 1989). Similarly, RfCs are concentrations for which daily exposure is likely to be without an appreciable risk of deleterious effects during a lifetime of exposure to the human population (including sensitive subgroups) (USEPA, 1989). RfDs are expressed in units of mg/kg/day (intake) for oral routes of exposure, while RfCs are expressed in units of milligrams per cubic meter (mg/m^3) air concentration for inhalation exposure (RfCs converted to dose units are referred to as inhalation RfDs).

7.1.2 Carcinogenic Effects

Numerical estimates of cancer potency are presented as *slope factors* (SFs). Under an assumption of dose-response linearity at low doses, the SF defines the cancer risk due to constant lifetime exposure to one unit of carcinogen (in units of risk per mg/kg/day). Excess cancer risk was calculated as the product of exposure to an individual chemical (in mg/kg/day) and the SF for that chemical (per mg/kg/day).

The carcinogens at the Site include arsenic, benzene, 1,4-DCB, PCE and TCE. Toxicity criteria were combined with exposure estimates in the risk characterization process presented in Section 8.0 to estimate adverse effects from chemicals at the Site.

Toxicity criteria used in the risk assessment were obtained from the Integrated Risk Information System (IRIS), a database available through the USEPA Environmental Criteria and Assessments Office (ECAO) in Cincinnati, Ohio. IRIS, prepared and maintained by USEPA, is an electronic database containing health risk and USEPA regulatory information on specific chemicals (USEPA, 1996). Cancer slope factors were obtained from the California Cancer Potency Factors guidance (Cal-EPA, 1994). RfDs used to evaluate the noncancer health effects for the all noncarcinogens were obtained from the USEPA's IRIS database. There is no reference dose for lead and the potential health effects for worker exposure to this metal was evaluated using the California Department of Toxic Substances (DTSC) Lead Spread Model.

8.0 RISK CHARACTERIZATION

Risk characterization is the culmination of the health evaluation process and is where a quantitative interpretation of the assessment is provided. In the risk characterization, the information, results, conclusions and uncertainties from the data evaluation, exposure assessment, fate and transport modeling, and toxicity evaluation are integrated to provide a coherent picture of potential risks posed by the Site under current and future land use considerations.

For the human health evaluation, numerical risk estimates were provided for each exposure pathway to derive a cumulative risk for the individual, including both carcinogenic risk and noncarcinogenic hazards. These estimates are comparisons of exposure levels with appropriate toxicity criteria or estimates of the lifetime cancer risks associated with a particular intake. Risk characterization also considers the nature and weight of evidence supporting these risk estimates, as well as the magnitude of uncertainty surrounding such estimates.

8.1 Carcinogenic Health Risks

The following calculation was used to obtain numerical estimates of lifetime cancer risks for humans:

$$\textit{Risk} = \textit{Intake (or Exposure)} * \textit{SF} \qquad (6)$$

Where:

Risk = Potential excess cancer risk adjusted for a 70-year lifetime (unitless)
Intake = Chemical intake (LADD) (mg/kg/day)
SF = Slope factor $(\text{mg/kg/day})^{-1}$

The level of regulatory action for excess cancer risk estimates promulgated by the USEPA ranges from 1 in 1,000,000 or 1.0E-06 or $1{*}10^{-6}$ (*i.e.*, the probability that one individual out of one million exposed individuals will develop cancer from exposure to a particular chemical over and above the background cancer rates) to 1 in 10,000 (1.0E-04). In general, the cancer incidence in the United States, unrelated to any particular chemical exposure, is estimated to be between approximately 23 and 37 percent or put another way, between 230,000 and 370,000 cancers occur in every million people (National Cancer Institute, 1994).

8.2 Noncarcinogenic Human Health Effects

Health hazards associated with exposure to noncarcinogenic compounds were evaluated using Reference Doses (RfDs) and calculating hazard quotients. The hazard quotient is the ratio of the intake rate to the RfD (developed by the EPA), as follows:

$$HQ = Intake/RfD \qquad (7)$$

Where:

HQ = Hazard Quotient
Intake = Chemical intake (ADD) (mg/kg/day)
RfD = Reference dose (mg/kg/day)

Hazard quotients were summed for all noncarcinogenic chemicals to calculate a total hazard index. The USEPA has set a hazard index of 1.0 as the threshold for noncancer health effects (USEPA, 1989).

8.3 Results of the Human Health Evaluation

Table 8 presents the excess cancer risk and noncarcinogenic health effects for the on-site worker from the inhalation of chemical vapors in indoor air in an on-site industrial/commercial building. The excess cancer risk from the inhalation of benzene, 1,4-DCB PCE and TCE vapors emanating from the subsurface soils and groundwater up through the soils and into indoor air was estimated to be about three in ten million (3.3E-07). Table 9 shows the risks (carcinogenic and noncarcinogenic) from direct worker contact via ingestion of surficial soils/fill. This potential exposure to metals resulted in an excess cancer risk of 2.9E-07. Thus, if the same on-site worker were exposed to chemical vapors and come in regular contact with arsenic, the total excess cancer risk for such a worker would be 3.3E-07 + 2.9E-07 = 6.2E-07 (Tables 8 and 9). In spite of the conservative assumptions made in quantifying potential risks, this excess cancer risk is approximately 16 times lower than the risk ($1.0*10^{-5}$) considered acceptable by the RWQCB and USEPA for commercial/industrial workers.

For noncancer health effects, even summing up the hazard quotients for the BTEX, chlorobenzene, 1,4-DCB, and PCE constituents resulted in a hazard index of 0.011 (Table 8) while the noncancer effects from metals yielded a hazard index of 0.00034 (Table 9). Summing the noncancer hazard indexes for the two pathways results in a worker hazard index of 0.0119, more than 50 times lower than the regulatory threshold of 1.0 (Tables 8 and 9).

Table 8
Excess Cancer Risks (ECR) and Noncarcinogenic Health Hazards for Onsite Workers Via Inhalation of Soil and Groundwater Emissions in Indoor Air
Pacific Dry Dock and Repair Company Yard II
Oakland, California

Chemical	Ca (mg/m3)	Br (m3/hr)	Indoors (hrs/d)	EF (d/yr)	ED (yr)	CF (d/yr)	AT (yr)	BW (kg)	LADD (mg/kg/d)	SF mg/kg/d-1	ECR
Carcinogens											
Benzene	2.71E-05	2.5	8	250	25	365	70	70	1.9E-06	1.00E-01	1.9E-07
1,4-DCB	8.29E-05	2.5	8	250	25	365	70	70	5.8E-06	2.40E-02	1.4E-07
PCE	1.51E-05	2.5	8	250	25	365	70	70	1.1E-06	2.00E-03	2.1E-09
TCE	6.13E-07	2.5	8	250	25	365	70	70	4.3E-08	6.00E-03	2.6E-10
									Total ECR:		3.3E-07

Chemical	Ca (mg/m3)	Br (m3/hr)	Indoors (hrs/d)	EF (d/yr)	ED (yr)	CF (d/yr)	AT (yr)	BW (kg)	ADD (mg/kg/d)	RfD (mg/kg/d)	Hazard Quotient
Noncarcinogenic Effects											
Benzene	2.71E-05	2.5	8	250	25	365	25	70	5.3E-06	0.002	0.00311
1,4-DCB	8.29E-05	2.5	8	250	25	365	25	70	1.6E-05	0.230	0.00007
PCE	1.51E-05	2.5	8	250	25	365	25	70	3.0E-06	0.010	0.00030
TCE	6.13E-07	2.5	8	250	25	365	25	70	1.2E-07	0.006	0.00002
Chlorobenzene	1.85E-04	2.5	8	250	25	365	25	70	3.6E-05	0.006	0.00636
Ethylbenzene	2.63E-04	2.5	8	250	25	365	25	70	5.1E-05	0.057	0.00090
Toluene	2.22E-05	2.5	8	250	25	365	25	70	4.3E-06	0.010	0.00043
Xylene	2.29E-04	2.5	8	250	25	365	25	70	4.5E-05	0.110	0.00041
									Hazard Index:		0.01161

Table 9
Excess Cancer Risks (ECR) and Noncarcinogenic Health Hazards for Onsite Workers Via Direct Contact with Metals in Surface Soils
Pacific Dry Dock and Repair Company Yard II
Oakland, California

Chemical	Cs (mg/kg)	Ir (mg/d)	FI	EF (d/yr)	ED (yr)	CF (d/yr)	AT (yr)	BW (kg)	LADD (mg/kg/d)	SF mg/kg/d-1	ECR
Carcinogens											
Arsenic	1.10E+01	50	0.1	250	25	365	70	70	1.9E-07	1.50E+00	2.9E-07
									Total ECR:		2.9E-07

Chemical	Cs (mg/kg)	Ir (mg/d)	FI	EF (d/yr)	ED (yr)	CF (d/yr)	AT (yr)	BW (kg)	ADD (mg/kg/d)	RfD mg/kg	HQ
Noncarcinogenic Effects											
Copper	1.53E+02	50	0.1	250	25	365	25	70	7.5E-06	3.70E-02	0.00020
Mercury	5.70E-01	50	0.1	250	25	365	25	70	2.8E-08	3.00E-04	0.00009
Zinc	2.73E+02	50	0.1	250	25	365	25	70	1.3E-05	3.00E-01	0.00004
								Hazard Index:			0.00034

The potential health effects from direct ingestion of lead in fill/soils at the site was evaluated using DTSC' "Lead Spread Model." As shown in Table 10, default exposure assumptions recommended by the DTSC were used. The results show that the 95th percentile of blood lead in a potentially exposed worker would be 3.4 μg/l, well below the regulatory level of concern of 10 μg/l.

Thus, these estimates indicate that potential exposure to on-site workers at the former Pacific Dry Dock and Repair Company Yard II Site would not be expected to cause adverse health effects to such workers above levels of regulatory concern.

8.4 Results of the Ecological Evaluation

A comprehensive ecological risk evaluation was conducted for this Site (PTI, 1994). This ecological evaluation, approved by the RWQCB (RWQCB, March 22, 1996) showed that potential risks were below levels of regulatory concern to marine organisms from metals, sandblast grit and petroleum hydrocarbons in sediments.

For the chlorinated solvents, as indicated in Section 4.0, the most likely pathway of potential exposure for marine receptors is from chemicals in groundwater from the Site flowing into the Channel/Harbor. The groundwater fate and transport modeling estimated that the dilution factor is more than 2,000. Even under a worst case scenario, using the maximum concentration of each organic compound detected in groundwater beneath the Site, the impact of these chemicals to marine organisms would be insignificant. For example, the chemical detected at highest concentration in groundwater is chlorobenzene at 2,200 μg/l. The concentration of this chemical will attenuate approximately 2,000-fold by the time this groundwater reaches the Lake Merritt Channel with resultant concentration of chlorobenzene at about 1 μg/l, and all

Table 10
Lead Risk Assessment
Pacific Dry Dock and Repair Company Yard II
Oakland, California

INPUT		OUTPUT							
MEDIUM	LEVEL		percentiles					PRG-99	PRG-95
			50th	90th	95th	98th	99th	(ug/g)	(ug/g)
LEAD IN AIR (ug/m^3)	0.15								
LEAD IN SOIL (ug/g)	65.0	BLOOD Pb, ADULT (ug/dl)	2.0	3.2	3.6	4.1	4.6	3417.3	5102.9
LEAD IN WATER (ug/l)	15	BLOOD Pb, CHILD (ug/dl)	3.6	5.6	6.4	7.4	8.1	264.7	558.5
PLANT UPTAKE? 1=YES 0=NO	0	BLOOD Pb, PICA CHILD (ug/dl)	7.0	10.9	12.4	14.3	15.8	19.5	41.1
RESPIRABLE DUST (ug/m^3)	50	BLOOD Pb, INDUSTRIAL (ug/dl)	1.9	3.0	3.4	4.0	4.4	4262.5	6306.5

EXPOSURE PARAMETERS

		residential			industrial
	units	adults	children	children with pica	adults
General					
Days per week	days/wk	7	7	7	5
Dermal Contact					
Skin area	cm^2	3700	2800	2800	5800
Soil adherence	mg/cm^2	0.5	0.5	0.5	0.5
Route-specific constant	(ug/dl)/(ug/day)	0.00011	0.00011	0.00011	0.00011
Soil ingestion					
Soil ingestion	mg/day	25	55	790	25
Route-specific constant	(ug/dl)/(ug/day)	0.0176	0.0704	0.0704	0.0176
Inhalation					
Breathing rate	m^3/day	20	10	10	20
Route-specific constant	(ug/dl)/(ug/day)	0.082	0.192	0.192	0.082
Water ingestion					
Water ingestion	l/day	1.4	0.4	0.4	1.4
Route-specific constant	(ug/dl)/(ug/day)	0.04	0.16	0.16	0.04
Food ingestion					
Food ingestion	kg/day	2.2	1.3	1.3	2.2
Route-specific constant	(ug/dl)/(ug/day)	0.04	0.16	0.16	0.04
Dietary concentration	ug/kg	10.0	10.0	10.0	10.0
Lead in produce	ug/kg	10.0	10.0	10.0	

Table 10
Lead Risk Assessment
Pacific Dry Dock and Repair Company Yard II
Oakland, California

PATHWAYS, ADULTS

Pathway	Residential		Industrial		
	Blood Pb ug/dl	percent of total	Blood Pb ug/dl	percent of total	Concentration in medium
SOIL CONTACT:	0.01	1%	0.01	1%	65 ug/g
SOIL INGESTION:	0.03	1%	0.02	1%	65 ug/g
INHALATION:	0.25	12%	0.18	9%	0.15 ug/m^3
WATER INGESTION:	0.84	42%	0.84	43%	15 ug/l
FOOD INGESTION:	0.88	44%	0.88	45%	10.0 ug Pb/kg diet

PATHWAYS, CHILDREN

Pathway	Typical		with pica		
	Blood Pb ug/dl	percent of total	Blood Pb ug/dl	percent of total	concentration in medium
SOIL CONTACT:	0.01	0%	0.01	0%	65 ug/g
SOIL INGESTION:	0.25	7%	3.62	52%	65 ug/g
INHALATION:	0.29	8%	0.29	4%	0.15 ug/m^3
WATER INGESTION:	0.96	27%	0.96	14%	15 ug/l
FOOD INGESTION:	2.08	58%	2.08	30%	10.0 ug Pb/kg diet

other chemicals will be below their respective limits of detection. Thus, adverse impacts will not occur in marine receptors from migration of organic chemicals in groundwater.

8.5 Discussion of Uncertainty

In any risk assessment there are a number of uncertainties. Often, the emphasis in analyzing uncertainties in health risk estimates has been with the exposure assessment (*i.e.*, how much water an individual ingests, how much chemical volatilizes from water, how frequently an individual can come in contact with groundwater from a site, or how long an individual may live near a site). However, the uncertainty associated with the exposure assumptions typically ranges from one to two orders of magnitude (10- to 100-fold), whereas the assumptions used to evaluate the toxicity of chemicals, rather than exposure, may provide the greatest sources of uncertainty. Specifically, the extrapolation of cancer potency from laboratory animals to humans, which forms the basis for the cancer risk estimates, may be associated with uncertainties ranging from as much as three to five orders of magnitude (1,000- to 100,000-fold) for selected chemicals. Some of the more important ones are briefly summarized as follows:

- The maximum detected chemical concentrations in soils and groundwater were selected as the representative source concentration for emissions modeling. This selection is expected to over-estimate potential risks to human health because these concentrations have attenuated significantly through natural degradation and no longer exist.

- The vapor emissions calculation assumed that the concentrations of VOCs in the most contaminated soil and groundwater locations sampled occurred under the on-site building and was representative of the entire building area. The actual data as illustrated in the Figures show that the areal extent of VOCs in the subsurface soils and groundwater is a small fraction of what was assumed for purposes of this risk assessment. Therefore, this assumption is very protective of on-site worker health.

- The Heuristic model assumes a non-depleting chemical source over time and uniform distribution of chemicals within the specified depth. This, too, is very conservative since measured concentrations vary within each sample.

- The Heuristic model assumes uniform soil properties within the soil column; this assumption may increase or decrease the emission rate based on the different types of soil that may be found on-site.

9.0 CONCLUSIONS

Based on the findings of this risk assessment, the former Pacific Dry Dock and Repair Company Yard II Site does not present risks to human health or the environment above levels of regulatory concern. Based on these findings, the Site constitutes a low risk soil and groundwater site based on the criteria set forth in the Water Board guidance (SWRCB, 1996; RWQCB-San Francisco Bay Region, 1996).

As discussed in previous reports (Versar, 1996 and The Gauntlett Group, 1997), all aboveground storage tanks were removed from the Site. All sediments which contained >10% sandblast grit have been removed and verification sampling performed to the satisfaction of the RWQCB.

Since 1989, several phases of soil and groundwater investigations were conducted by Crowley Marine Services. During these investigations, 32 soil borings were conducted, 7 groundwater monitoring wells were installed, and a total of 85 soil samples, 10 grab groundwater samples, and 5 rounds of quarterly groundwater samples were collected and analyzed for VOCs and metals. This characterization effort was performed pursuant to oversight of the RWQCB-San Francisco Bay Region and the Alameda County Environmental Health Agency.

There are no drinking water wells screened in the shallow groundwater beneath the Site or in its vicinity. The soil testing conducted by Crowley, and the very low concentrations of remaining chemicals in soils and groundwater, along with the known occurrence of biodegradation and more than 2,000-fold dilution factor in transport of chemicals via groundwater to the Bay, indicate that site-related chemicals would be virtually non-detectable by the time they reached the Bay.

As shown in the risk evaluation, the chemicals of potential concern remaining at the Site present no health risks to future workers above levels of regulatory concern. In addition, the residual concentrations of chemicals are also well below criteria developed for protection of aquatic species.

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