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Public Works Agency
Environmental Services

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RO293

Alameda County
NOV 15 2002
Environmental Health

November 12, 2002

Mr. Barney Chan
Alameda County Environmental Health Services
1131 Harbor Bay Parkway
Alameda, California 94502-6577

Subject: **Results of Dual-Phase Extraction Pilot Test for Plumes A & B**
City of Oakland Municipal Service Center
7101 Edgewater Drive Oakland, California

Dear Mr. Chan:

Enclosed is a copy of the above referenced report prepared by our consultants, URS Corporation for the City of Oakland Municipal Service Center at 7101 Edgewater Drive.

Please call me at 238-6259, if you have any questions or require additional information.

Sincerely,

Joseph A. Cotton, R.G.
Environmental Program Specialist

cc: Diane Heinz, Port of Oakland, 530 Water St., Oakland, CA 94604

URS

August 29, 2002

Project No. 5100129010.00

Mr. Joseph Cotton
City of Oakland, Public Works Agency
Environmental Services Division
250 Frank H. Ogawa Plaza, Suite 5301
Oakland, CA 94612

Subject: Results of Dual-Phase Extraction Pilot Test for Plumes A & B,
City of Oakland Municipal Services Center
7101 Edgewater Drive, Oakland, California

Dear Mr. Cotton:

URS Corporation (URS) is pleased to submit this letter report presenting the results of a Dual-Phase Extraction (DPE) pilot test program for Plumes A and B at the City of Oakland Municipal Services Center. This report includes a brief introduction on site background, details of pilot program activities, results and discussions and recommendations.

1. Introduction

The City of Oakland Municipal Services Center (MSC) is located at 7101 Edgewater Drive, Oakland, CA (Figure 1). The site was originally part of a waterfront tidal marsh complex, which was filled between 1950 and 1971. The MSC occupies an area of approximately 17 acres. The City leased the land from the Port of Oakland for use as a corporation yard. Bordering the MSC site to the west and the north is the Martin Luther King Regional Shoreline Park. Damon Slough is located to the north, and commercial developments are located to the east and south.

Baseline Environmental Consulting of Emeryville, CA (Baseline) has summarized the site history and environmental investigation and remediation results through December 2000 in the report entitled *Site History and Characterization* (Baseline, January 2001). Readers are referred to this report for details. Continuing quarterly groundwater monitoring results are documented in quarterly monitoring reports.

Separate-phase petroleum hydrocarbon product (SPH) has been identified in shallow water-bearing zone at four separate locations at the MSC. They are labeled as Plumes A through D on Figure 2. The shallow water-bearing zone exists in artificial fill where water levels have historically ranged from 4 to 11 feet below ground surface (bgs). Wells in the SPH plume areas are identified on Figure 3.

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In the report entitled *Evaluation of Free-Phase Product Removal Alternatives for Petroleum Hydrocarbons* (June 2001) prepared by URS Corporation (URS), a dual-phase extraction (DPE) remediation system was recommended for the removal of the SPH plumes. This report presents the results of field pilot testing of a DPE system for Plumes A and B.

2. DPE Pilot Test Equipment

DPE is a technology that removes groundwater along with any free-phase product and soil vapor simultaneously from wells through the application of vacuum pressures. A trailer-mounted DPE unit, as shown in Photo 1, was used in the pilot test. The center piece of the DPE unit is a 10-HP liquid-ring positive displacement vacuum pump capable of achieving a vapor flow rate of 125 inlet cubic feet per minute (cfm) and a maximum applied vacuum of 28 inches of mercury. The unit has a complete water separation system and a control system. A schematic diagram of the DPE unit is shown on Figure 4.

Power supply to the DPE unit was provided by a portable electrical generation unit rented from Hertz Equipment Rental. Soil vapor was treated through two vapor-phase activated carbon units before been discharged to the atmosphere. The carbon units are model VSC-400 from US Filter. Each unit contains approximately 400 lbs of granular activated carbon. The electrical unit and the carbon units are shown in Photo 2. Bay Area Air Quality Management District was notified one week prior to the field pilot DPE test.

Extracted groundwater was stored on-site in a 21,000-gallon closed top tank rented from Rain-for-Rent Co. The water was later transported to an off-site treatment/recycling facility by Uribe and Associates under a direct contract with the City of Oakland.

3. DPE Pilot Test Activities

Field activities were performed over five-week period from April 29 through May 31, 2002. The DPE trailer was transported to the site and connected to the electrical power source and vapor-phase carbon unit in the first week of May. Trial runs and system tuning were performed in the second week. DPE pilot test was conducted in individual wells on Plumes A and B in the third and fourth week, and system removal and site cleanup in the last week.

Test procedures were as follows:

- For a test well, its water level was first measured. A schedule 40, 2"-diameter PVC pipe (1"-diameter pipe for 2" wells) was cut to appropriate length and was inserted into the well. The pipe, serving as vapor/liquid removal straw, was connected to the DPE unit's inlet through 2"-diameter flexible vacuum hose. Figure 5 illustrates the construction of a DPE well. Photo 3 shows the wellhead of a completed DPE well.
- After turning the DPE system on, the vacuum pressure at the DPE wellhead is adjusted to maximize both flows of groundwater and soil vapor. For wells located in very tight soil formation where soil vapor flow rate is too low, air is allowed to bleed into the well at a controlled rate in order to keep groundwater flow.

- Volume of groundwater extracted was accounted by a water totalizer. Vapor flowrate was measured by a Pitot tube at the DPE system discharge side (before the vapor-phase carbon units). The extracted vapor was monitored on-site for oxygen and carbon dioxide content using a GesTech gas analyzer and for total organic vapor using an organic vapor analyzer equipped with a photoionization detector (PID), which was calibrated with hexane gas. Vapor samples were also collected using 6-liter Summa canisters, which were delivered to Air Toxics Laboratory of Folsom, CA for the analysis of atmospheric gases using modified EPA Method 3C and TPHgas using modified CARB 419A method.
- Vacuum responses and water level changes at monitoring wells adjacent to the extraction well were measured periodically. A typical monitoring wellhead configuration is shown in Photo 4. A magnehelic differential pressure gauge was used to measure vacuum responses in inches of water column.
- RW-A1 was tested for DPE in Plume A area. RW-B3, RW-B4, MW-6, and MW-16 were tested for DPE in Plume B area. During the test of a DPE well, three nearby wells were monitored for vacuum responses, water levels and the thickness of SPH.

4. Results

Field measured parameters are summarized in Table 1 and laboratory analysis data are presented in Table 2. Laboratory analysis reports are included in Appendix A.

Plume A Test Area

Plume A is the smallest among the four plumes and has the size of only about 30 feet by 50 feet. As such, only one well (RW-A1) was tested for the feasibility of dual-phase extraction. The following observations were noted during the test:

- The DPE unit vapor flow instrument registered near zero flow rate even when the pump was operated at the maximum vacuum of 28"-Hg vacuum pressure. To keep groundwater moving through the system, air had to be bled into the well. The soil vapor flow rate did not increase throughout the test period.
- Depth to the water was initially at 2.26 feet below the top of the well casing (TOC), but was vacuumed to dry almost instantaneously when air was bled into the well and the straw was lowered to the bottom of the well. For 4.2 hours of DPE operation, only 16 gallons of groundwater was removed, which gave a yield of less than 0.1 gallon per minute (gpm).
- SPH was not observed on the extracted groundwater. However, the extracted soil vapor had strong petroleum odor and registered readings between 500 and 600 ppmv using a field PID.
- Vacuum responses at observation wells OB-A1, MW-6, and RW-A2 were no more than 0.02 inches of water column, which was less than 0.02% of the vacuum applied at RW-A1. The effective radius of vacuum influence from a DPE well is typically considered

at the distance where 1% of the applied vacuum is observed. OB-A1 and RW-A2 are located approximately 20 feet east and west, respectively, of RW-A1. The observed vacuum responses at these wells indicate that the effective radius of vacuum influence from RW-A1 is less than 20 feet.

- Based on the field recorded vapor flow rates and the organic vapor concentration (PID readings in ppmv), petroleum hydrocarbons removed by the vapor phase is estimated at 0.2 lbs (see Explanation notes in Table 1 for calculation formula). SPH was not observed on the extracted water.

Plume B Test Area

The following wells in Plume B area were tested individually for the dual-phase extraction: RW-B3, RW-B4, MW-6, and MW-16. Field monitoring results are summarized in Table 1 and laboratory analysis data are presented in Table 2. Field observations are discussed below.

For RW-B4:

- A two-hour step extraction test was first performed and followed by 27 hours of continuous DPE test. RW-B4 is a newly installed remediation well. During the initial step test, air had to be bled in to move groundwater through the DPE system. However, soil gas flow rate gradually increased as the test progressed and air bleeding-in was completely turned off after 20 hours of extraction. Soil gas flow rate increased to 63 scfm after 25 hours of extraction. Such gradual increase is expected due to continuous opening up of vapor pathways in the subsurface.
- Vacuum responses at RW-B3 were as high as 6.8 inches of water column. RW-B3 is also a newly installed remediation well and is located approximately 20 feet north of RW-B4. MW-16 recorded near 2% of the applied vacuum at RW-B4 at the end of the test (1.6 inches water column). MW-16 is located approximately 35 feet southeast of RW-B4 and near the downgradient edge of the SPH plume. However, negligible vacuum responses were observed at RW-B2, which is located upgradient and approximately 50 feet northeast of RW-B4. The effective radius of vacuum influence from RW-B4 is estimated to be approximately 40 feet.
- A total of 3,229 gallons of liquid was extracted during the 26.9-hour continuous extraction test, yielding a pumping rate of about 2 gallons per minute (gpm). The extracted liquid had strong petroleum odor. A layer of black, sticky, tar-like product was observed floating on the surface of the extracted water (Photos 6 and 7). This product was also observed in the extraction well RW-B3 and monitoring well MW-16. This product was so sticky that it coated the water/oil probes and made the measurement of water levels and product thickness in the wells extremely difficult. The volume of the floating product is estimated at approximately 1% of the total extracted liquid volume or 32 gallons, based on visual checks conducted during the extraction.
- Based on the field recorded vapor flow rates and the organic vapor concentration readings, petroleum hydrocarbons removed by the vapor phase alone is estimated to be

26.3 lbs. (16.3 lbs. from the initial step test and 10 lbs. from the 27-hour continuous test, see Explanation notes in Table 1 for calculation formula).

For RW-B3:

- A 3-hour step extraction test was performed on this remediation well. The soil gas flow rate was sufficiently high to move groundwater through the DPE system from the beginning (13 scfm) and increased rapidly toward the end of the test (>40 scfm). Air bleed-in was not needed.
- As high as 4.5" water column vacuum response was observed at RW-B4, 1" at MW-16, and less than 0.5" at RW-2. This is consistent with the observations from the RW-B4 test. Both RW-B3 and RW-B4 were newly installed 4"-diameter remediation wells near the southeast property boundary and are separated by approximately 20 feet. The effective radius of vacuum influence from RW-B3 is approximately 40 feet.
- A total of 419 gallons of liquid was extracted during the 3.3-hour extraction, yielding a pumping rate of about 2 gpm. The extracted liquid had strong petroleum odor. A layer of sticky, tar-like product was also observed floating on the surface of the extracted water and it amounted to approximately 1% of the extracted liquid or 4.2 gallons.
- 0.7 lbs. of petroleum hydrocarbons were removed by the vapor phase alone (see Explanation notes in Table 1 for calculation formula).

For MW-6:

- A 24-hour continuous extraction test was conducted. This well is a 2" monitoring well located near the upgradient edge of plume B. Air had to be bled in throughout the test period in order to move groundwater through the DPE system.
- Negligible vacuum responses (less than 0.1% of the applied vacuum) were observed in all of the three nearby monitoring wells (OB-A1, RW-A1, and RW-B1) throughout the test period. RW-B1 is located approximately 20 feet west of MW-6. The effective influence zone from MW-6 is less than 20 feet.
- A total of 243 gallons of liquid was extracted during the 24.3-hour continuous extraction, yielding a pumping rate of 0.17 gpm. The extracted liquid had strong petroleum odor. A layer of brown color SPH was noted on surface of the extracted water (approximately 1% of the total volume or 2.4 gallons) and in well MW-6, but not in RW-A1 and RW-B1. Only oily sheen was noted in OB-A1. The SPH observed in this upgradient area of plume B exhibits different physical characteristics. It is fluid like, brown colored, and can be easily wiped off water probes, as compared with the SPH observed in the downgradient area of plume B (RW-B3, RW-B4, and MW-16), which is very sticky, tar-like, and black colored.
- 5.8 lbs. of petroleum hydrocarbons were removed by the vapor phase alone (see Explanation notes in Table 1 for calculation formula).

For MW-16:

- A 21-hour continuous extraction test was conducted. This well is a 2" monitoring well located near the downgradient edge of plume B. Air had to be bled in throughout the test period in order to move groundwater through the DPE system. At the end of the test the well was checked with a flashlight. A layer of black oily material was seen covered most part of the well casing.
- Negligible vacuum responses (less than 0.5% of the applied vacuum) were observed in monitoring wells RW-B3, RW-B4, and MW-17. The radius of vacuum influence is less than 35 feet.
- A total of 421 gallons of liquid was extracted during the 21-hour continuous extraction, yielding a pumping rate of 0.33 gpm. The extracted liquid had strong petroleum odor. A layer of sticky, tar-like product was also observed floating on the surface of the extracted water and it amounted to approximately 1% of the extracted liquid or 4.2 gallons.
- 4.8 lbs. of petroleum hydrocarbons were removed by the vapor phase alone (see Explanation notes in Table 1 for calculation formula).

As summarized at the end of Table 1 (above the Explanation notes), a total of 4,629 gallons of groundwater was removed from five extraction wells in Plumes A and B during this DPE pilot test period. Petroleum hydrocarbons removed by the vapor phase is estimated at 37.8 lbs., or approximately 6 gallons. Free-phase product recovered from the extracted groundwater is approximately 43 gallons. Therefore, without counting hydrocarbons dissolved in the extracted water, this pilot program removed approximately 49 gallons of product from plume B and 0.03 gallons (0.2 lbs) from plume A.

5. Discussions and Recommendations

Subsurface soil in Plume A area appears to be fine grained, with low permeability in both the saturated and unsaturated zones. It presents challenges to both vapor extraction and groundwater extraction, as evidenced by very low recovery rates achieved at the test well RW-A1. Fortunately, the amount of SPH within plume A appears limited as only sheen was observed in well OB-A1.

In the *Evaluation of Free-Phase Product Removal Alternatives for Petroleum Hydrocarbons Report* (URS, June 2001), enhanced bioattenuation alternative had the same highest rank as the DPE alternative for plume A. It is recommended to enhance natural bioattenuation activities within plume A area by periodically introducing oxygen so that DPE effort can be focused on plume B. Because an adequate number of wells exist in plume A area, the most cost effective method for oxygen addition appears to be direct injection of hydrogen peroxide solution into the existing wells.

Results of pilot test conducted within plume B indicate that RW-B3 and RW-B4 are appropriate wells for the dual-phase extraction. DPE influence from these two wells reaches the downgradient edge of plume B. Long-term DPE is recommended for RW-B3 and RW-B4.

MW-6 is the only well tested in the upgradient portion of plume B. MW-6 is a 2" monitoring well and did not exhibit reasonable recovery rates for both soil vapor and groundwater. RW-B1 and RW-B2, both are newly installed remediation wells in the upgradient portion of plume B, should be tested for the DPE.

The SPH recovered from MW-6 has the physical characteristics of gasoline/diesel, i.e. not viscous, as compared with the SPH recovered from RW-B3, RW-B4, and MW-16 that is highly viscous (coal tar like) and has black color. Since the site is in an artificial fill area, the results suggest that coal tar, asphalt emulsion or like wastes may have been dumped in the area during the filling period. When gasoline and/or diesel is released into the subsurface, it dissolves and mobilizes the previously deposited coal tar/asphalt emulsion and transported it to the extraction wells. The existence of the tar-like waste made the extraction significantly more difficult.

We appreciate the opportunity to provide our professional services to the City of Oakland on this important project. Please contact Mr. Xinggang Tong at (510) 874-3060 if you have questions or comments.

Sincerely,

URS CORPORATION

Xinggang Tong, Ph.D., P.E.

Project Manager

Attachments:

Table 1	Summary of Dual-Phase Extraction Test Data, Plume A & B
Table 2	Laboratory Analytical Data of Extracted Soil Gas, Plume A & B
Figure 1	Site Location Map
Figure 2	Identification of Free-Phase Plumes and Site Features
Figure 3	Identification of Wells in the SPH Plume Areas
Figure 4	Schematic Diagram of the DPE Unit
Figure 5	Dual-Phase Extraction Well Detail
Photos 1 – 7	Documentation of DPE Pilot Test Field Activities
Appendix A	Laboratory Analysis Reports

TABLE 1
Summary of Dual-Phase Extraction Test Data
Plumes A and B
City of Oakland Municipal Service Center

DPE Well RW-B4															Monitoring Well RW-B2			Monitoring Well RW-B3				Monitoring Well MW-16			
Date & time	Elapsed time (hr)	Level of * straw tip (ft, TOC)	Vacuum at DPE (in. Hg)	Outlet Tempt (F)	Air Flow Rate (ft/min)**	Air Flow Rate (scfm)	Cumulative*** TPH removed (lbs.)	Water totalizer (gallons)	Cumulative groundwater extr (gallons)	Thickness of SPH (inch)	Field PID reading (ppmv)	Field GasTech O2%	Field GasTech CO2%	Notes	Wellhead vacuum (in. H2O)	Thickness of SPH (inch)	water level (ft, TOC)	Wellhead vacuum (in. H2O)	Thickness of SPH (inch)	water level (ft, TOC)	Notes	Wellhead vacuum (in. H2O)	Thickness of SPH (inch)	water level (ft, TOC)	Notes
5/15/02 11:00	0	10.25	0	77	0	0.0	0.0	280881	0	0				System started at 11:00	0	0	7.22	0	<1/8	10.29	black & thick SPH	0	0.1	13.1	black tar-like SPH
5/15/02 12:17	1.3	10.6	7	89	2500	52.4	10.5	281085	204		>9,999	17.8	2.3	Tight soil, with air bleeding at wellhead,	0			0.84				0.3		difficult to measure due to coating of the sticky SPH on probe	
5/15/02 13:00	2.0						16.3	281182	301					Stopped at 13:00 for DPE system tune											
5/16/02 9:40	0	10.37					0.0	281190	0	0.08				Restart DPE system low tide	0	0	7.28	0	0.27	10.58	black & thick SPH				
5/16/02 10:53	1.2	11.1	10	90	1000	20.9	0.6	281446	256		1400	17.4	5.4	Tar-like black oil floating on extracted water	0.08			0.75				0.3		difficult to measure due to coating of the sticky SPH on probe	
5/16/02 12:50	3.2	12.56	10	84	1200	25.4	1.2	281750	560	0.06	300	18.7	3.4	Incoming high tide	0.01			2	23 (?)	14.15	black tar-like SPH	0.5			
5/16/02 15:30	5.8	11.1	10	83	1800	38.2	1.6	282107	917		375	15.2	2.2	high tide	0	0	7.29	3.8				1			
5/16/02 18:07	8.4	11.1	9	82	1400	29.7	2.2	282461	1271		440	14.5	1.8	high tide	0			5.4				0.1			
5/16/02 20:15	10.6	11.1	9	70	2000	43.4	2.7	282753	1563		460	13.3	1.6		0	0	7.3	6	18 (?)	14.04		0.4			
5/17/02 6:45	21.1	11.1	7	66	2500	54.7	7.1	283970	2780		640	7.2	4.5	Outgoing high tide	0.06	0	7.31	6.8	24 (?)	13.98	black tar-like SPH	0.3			
5/17/02 9:09	23.5	11.1	7	84	2300	48.7	8.2	284178	2988		500	7.8	2.7		0.05			6.6				0.94			
5/17/02 10:35	24.9	11.1	7	88	3000	63.0	8.9	284287	3097		570	7.9	2.4	low tide	0			7				1			
5/17/02 11:54	26.2	11.1	7	88	3000	63.0	9.6	284374	3184		570	7.5	2.4	low tide	0			6.8				1.6			
5/17/02 12:35	26.9						10.0	284419	3229					End of test at RW-B4		0	7.31		24 (?)	13.94			0.75	14.9	

DPE Well RW-B3															Monitoring well RW-2			Monitoring Well RW-B4				Monitoring Well MW-16			
5/20/02 10:45	0	10.13	0	76	0	0.0	0.0	284421	0	0.06					0	0	7.28	0	0.03	10.4		0	0.11	12.61	
5/20/02 11:45	1.0	11.1	8	74	600	12.9	0.1	284537	116		600	10.2	9.2	outgoing low tide	0.16			0.35				0			
5/20/02 13:30	2.8	11.1	8	72	1900	41.1	0.5	284742	321		500	9.3	2.1	low tide	0.3			4.5				1	0.15	13.85	
5/20/02 14:05	3.3	11.45					0.7	284840	419	0.05				End of DPE test		0	7.28		0.05	11.79					

DPE Well RW-A1															Monitoring Well OB-A1			Monitoring Well MW-6				Monitoring Well RW-A2			
5/21/02 13:50		2.26	0				0.0	284850	0						0	0	3.5	0	0.28	7.14		0	0	1.71	
5/21/02 15:48	2.0	10	9	78	400	8.6	0.2	284857	7		600	20.9	0	Very tight soil, zero soil gas without air bleeding	0.02			0.015				0.02			
5/21/02 16:20	2.5	10	9	78	0	0.0	0.2	284857	7		500	20.9	0	Near zero soil gas and groundwater yield	0.01			0				0.02			
5/21/02 18:00	4.2	8.81					0.2	284866	16					End of DPE test		0	3.5	0	0.29	7.11			0	1.71	

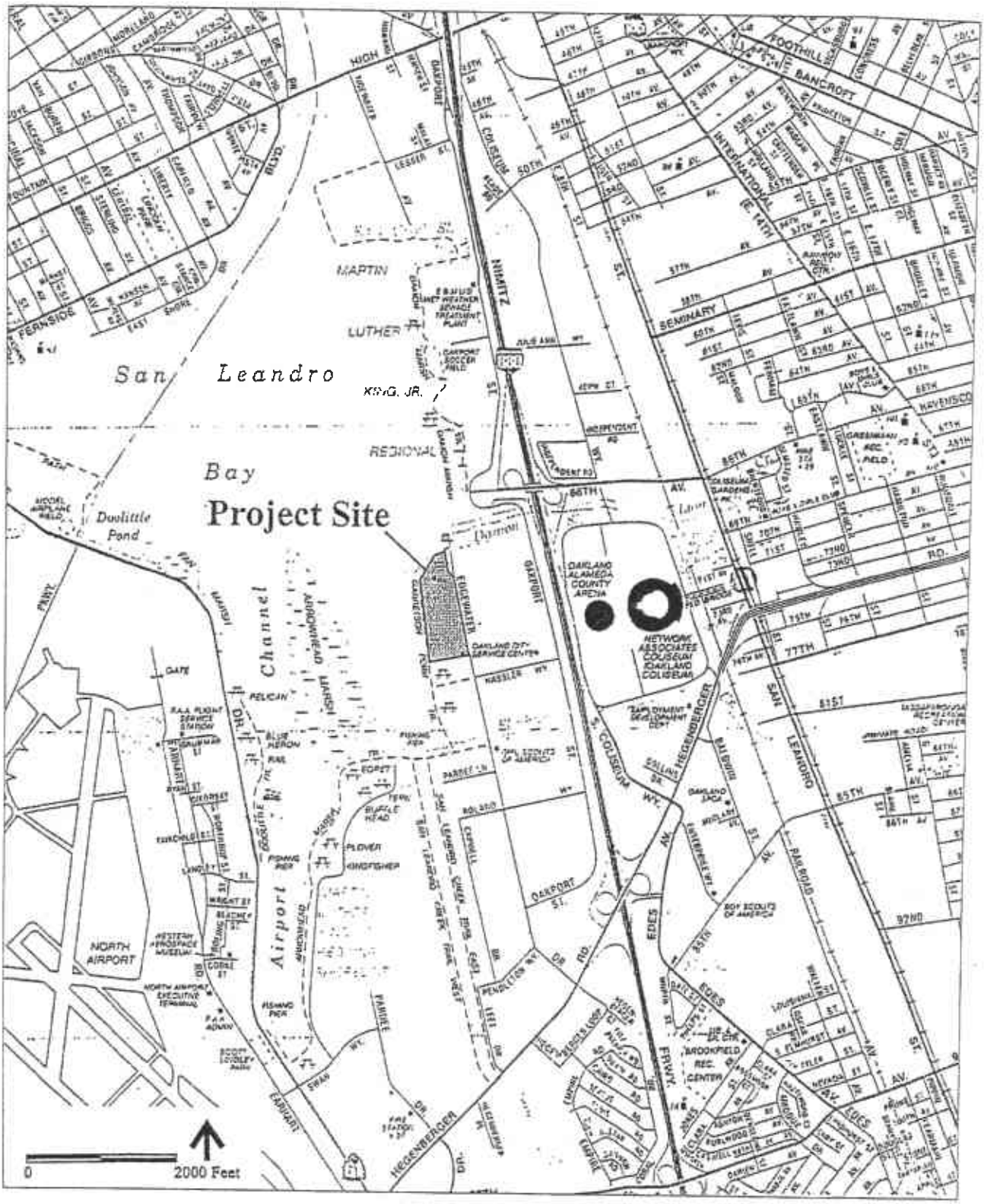
TABLE 1
Summary of Dual-Phase Extraction Test Data
Plumes A and B
City of Oakland Municipal Service Center

	DPE Well MW-6														Monitoring Well OB-A1			Monitoring Well RW-A1				Monitoring Well RW-B1			
Date & time	Elapsed time (hr)	Level of straw tip (ft, TOC)	Vacuum at DPE (in. Hg)	Outlet Tempt (F)	Air Flow Rate (ft/min)	(scfm)	Cumulative*** TPH removed (lbs.)	Water totalizer (gallons)	Cumulative groundwater extr (gallons)	Thickness of SPH (inch)	Field PID reading (ppm)	Field GasTech O2%	CO2%	Notes	Wellhead vacuum (in. H2O)	Thickness of SPH (inch)	water level (ft, TOC)	Wellhead vacuum (in. H2O)	Thickness of SPH (inch)	water level (ft, TOC)	Notes	Wellhead vacuum (in. H2O)	Thickness of SPH (inch)	water level (ft, TOC)	Notes
5/22/02 13:40	0	7.00	0			0.0		284867	0	0.26				Brown light SPH	0	0	3.47	0	0	3.26		0	0	7.36	
5/22/02 14:05	0.4	9.8	9	76		0.0		284867	0					Very tight soil, zero soil											
5/22/02 15:41	2.0	8.3	10	78	1500	32.1		284887	20					gas without air bleeding											
5/22/02 16:30	2.8	8.3	11	80	1600	34.1	0.8	284891	24		550	20.9	0		0.06			0.02				0			
5/22/02 18:23	4.7	8.3	10	78	1600	34.2	1.5	284916	49		700	20.9	0		0.02			0.02				0			
5/22/02 20:07	6.4	8.7	10	68	1700	37.1	2.0	284933	66		500	20.9	0	High tide	0.03	oily sheen	3.43	0	0	2.66		0	0	7.41	
5/23/02 6:20	16.7	8.7	11	62	1600	35.3	4.5	285039	172		350	20.9	0		0.04		3.48	0	0	2.35		0.06	0	7.47	
5/23/02 8:48	19.1	8.7	11	76	1700	36.5	5.0	285063	196			20.9	0		0.06			0				0.06			
5/23/02 10:40	21.0	9.8	11	80	1500	32.0	5.2	285079	212		400	20.9	0	High tide	0.02			0				0			
5/23/02 12:28	22.8	9.8	10	82	1200	25.5	5.5	285095	228		400	20.9	0		0.02			0.01				0			
5/23/02 14:00	24.3	9.8	11	88	1300	27.3	5.8	285110	243	0.01	500	20.9	0	Brown light SPH	0.03		3.49	0.03	0	2.34		0	0	7.45	
	DPE Well MW-16														Monitoring Well RW-B3			Monitoring Well RW-B4				Monitoring Well MW-17			
5/23/02 18:00	0	13.38					0.0	285110	0	0.09				Tar-like black SPH, very sticky & strg petro odor	0	0.1	10.5	0	0.02	10.51		0	0	10.03	
5/23/02 20:45	2.8	15	8	84	1200	25.4	0.7	285152	42		650	20.9	0.4	High tide	0	0.1	10.48	0	0.03	10.5		0	0	7.54	
5/24/02 6:30	12.5	15	8	66	1300	28.5	2.7	285410	300		300	20.4	0.4	Very little soil gas, the well screen may have been sealed by	0.09	0.1	10.45	0.08	0.04	10.49		0	0	10.14	
5/24/02 9:00	15.0	15	7	90	2200	46.1	2.9	285464	354		100	20.8	0.1	the sticky SPH	0.1			0.07				0			
5/24/02 10:15	16.3	14.5	6	92	1200	25.0	3.4				1100	20.4	0.4	High tide	0			0				0			
5/24/02 12:45	18.8	13.5	8	100	1100	22.6	4.2	285505	395		700	20.1	0.2		0			0				0.01			
5/24/02 15:15	21.2	13.15					4.8	285531	421	0.01				Tar-like black SPH, very sticky & strg petro odor		0.1	10.34	0	0.01	10.38		0	0	9.58	
Total gallons of groundwater extracted from all tested DPE wells:									**4629**																
Total pounds of hydrocarbons removed through soil vapor:							**37.8**																		

Explanation:
* the first and the last number (level of straw tip) for a DPE test well were measured groundwater levels.
**measured at the DPE discharge side before the vapor-phase carbon vessels with a 2-inch diameter Pitot tube.
***asssume that the vaporized petroleum hydrocarbons (TPH) has a molecular weight of 100. The formula for mass removal calculation is based on ideal gas law PV = nRT. The specific formula is as follows:
TPH mass removed = extraction time x air flow rate x field measured PID reading x TPH molecular weight /RT, where R is the universal gas constant and T is the temperature.
TOC = top of well casing
SPH = separate phase petroleum hydrocarbons
scfm = standard cubic feet per minute (68 deg. Fahrenheit and 14.7 psi)

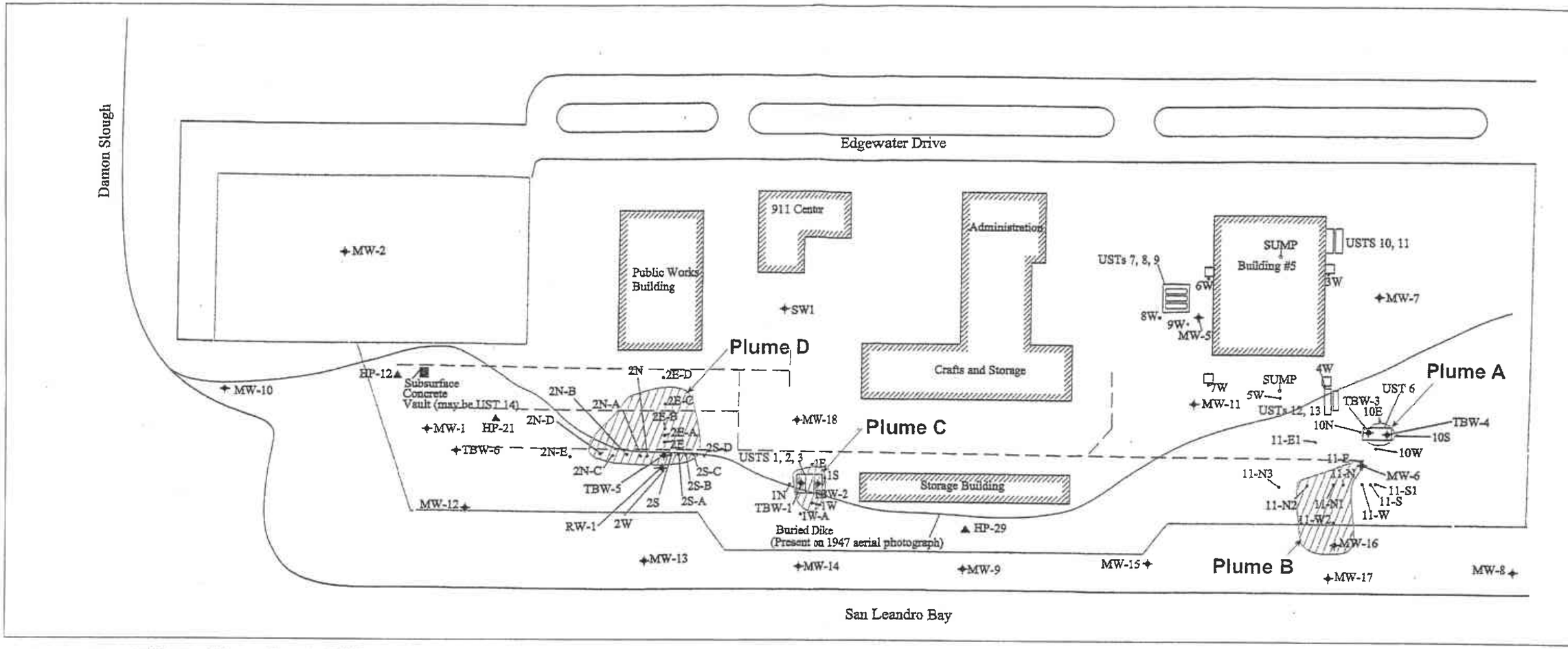
TABLE 2
Laboratory Analytical Results of Extracted Soil Gas
Plumes A and B
City of Oakland Municipal Service Center

BTEX and TPH analyses by Modified CARB 410A method (GC/PID/FID):													
Sample ID	Date & time of	Benzene	Benzene	Toluene	Toluene	Ethyl benzene		Total xylenes		TPH as gasoline		C2-C4 hydrocarbons	
	sample collected	ppmv	ug/L	ppmv	ug/L	ppmv	ug/L	ppmv	ug/L	ppmv	ug/L	ppmv	ug/L
RW-B4	5/16/02 18:45	900	2900	110	440	140	610	290	1300	71000	290000	ND	ND
MW-6	5/22/02 19:00	9.7	32	6.4	24	19	84	42	190	780	3200	ND	ND
MW-16	5/24/02 10:35	7.2	23	3.3	12	10	45	20	88	770	3200	ND	ND
Notes:													
TPH as gasoline - C5+ hydrocarbons referenced to gasoline (which is assumed to have the average molecular weight of 100)													
C2 - C4 hydrocarbons - referenced to gasoline in instrument calibration and concentration calculation													
Method 3C analysis (GC/TCD):													
Sample ID	Date & time of	O2	N2	CH4	CO2								
	sample collected	%	%	%	%								
RW-B4	5/16/02 18:45	2.9	57	22	12								
MW-6	5/22/02 19:00	19	82	ND	ND								
MW-16	5/24/02 10:35	18	83	ND	0.43								



URS	Project No. 51-00129010.00 Oakland MSC	SITE LOCATION MAP Municipal Service Center 7101 Edgewater Drive Oakland, California	Figure 1

51-00129010.00-00020/060601/gos,mci



Note: USTs 4 and 5 are not shown adjacent to UST 6 (as they are shown on Figure 13) because it is unclear whether they ever existed at the site.

0 150 Feet

Legend

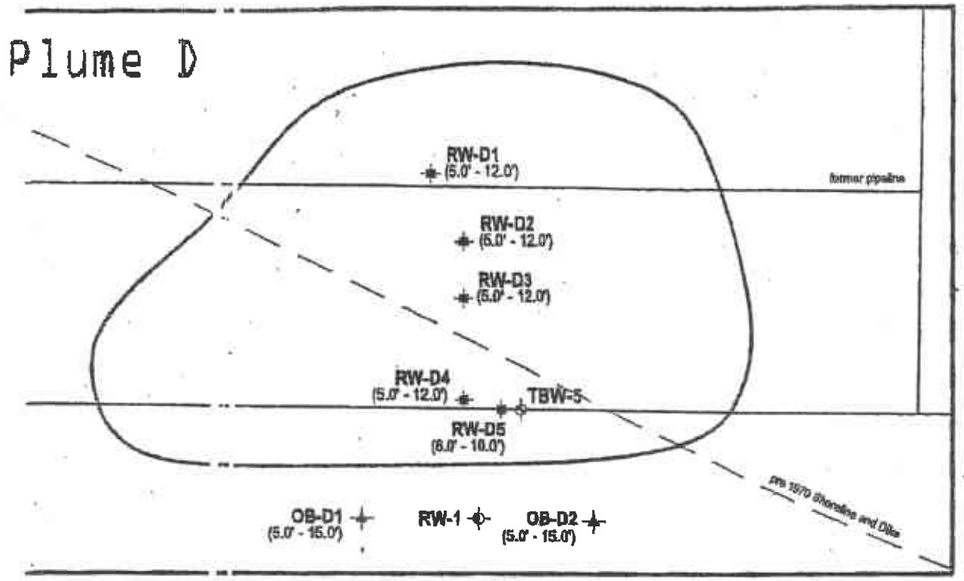
- Boring Location (Installed in July 2000 by BASELINE)
- Groundwater Well Location (Installed by others)
- Former Fuel Hydrant Line
- Area of Free Product on Groundwater
- Waste Collection Pit
- Underground Storage Tanks
- Temporary Well Point

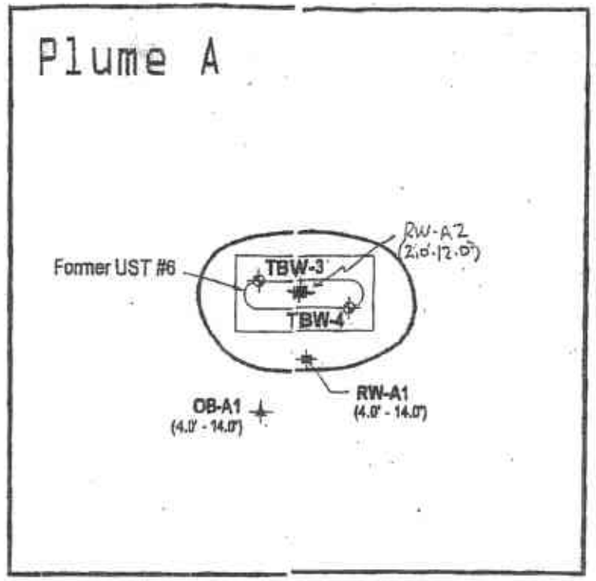
Municipal Service Center
7101 Edgewater Drive
Oakland, California

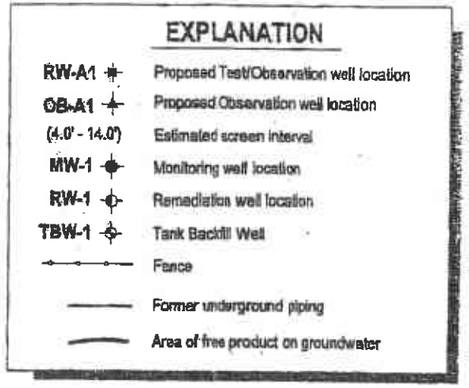
Base map from Figure 16 of Baseline January 2001 Report (Site History and Characterization)

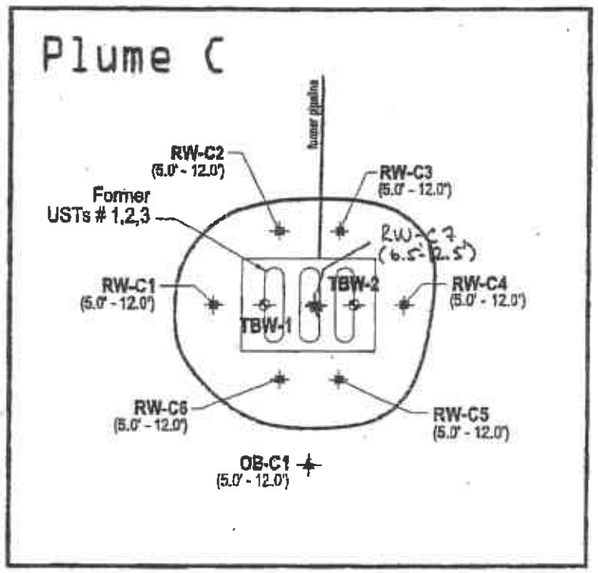
URS	Project No. 51-00129010.00	IDENTIFICATION OF FREE-PRODUCT PLUMES AND SITE FEATURES	Figure 2
	Oakland MSC		

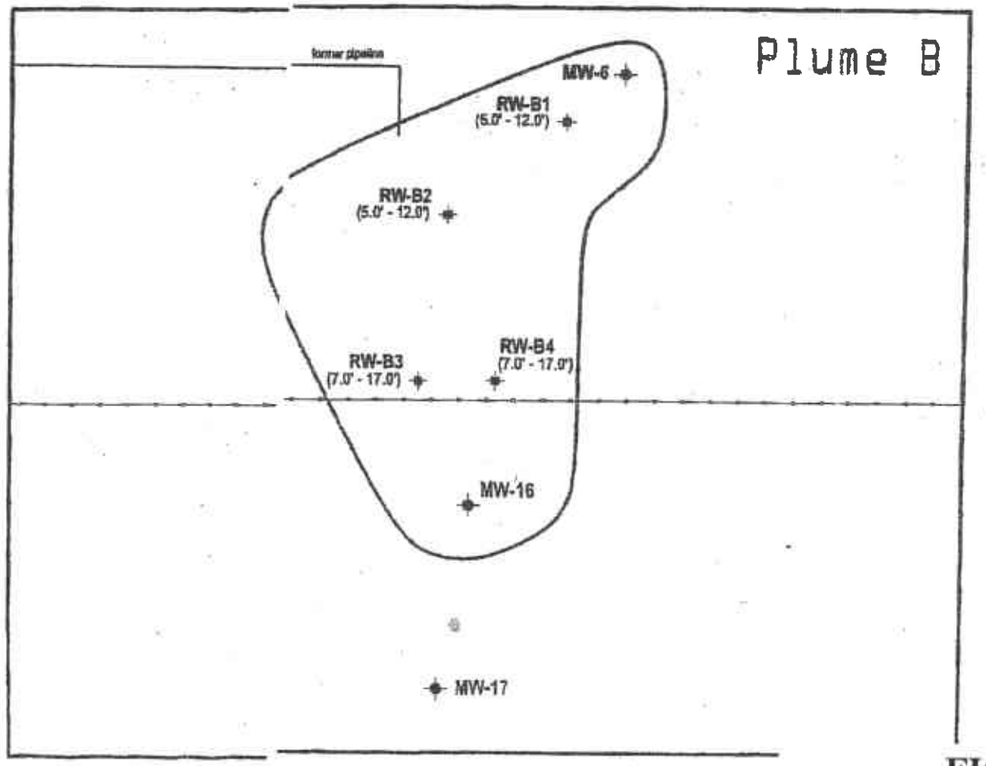
51-00129010.00-00020/060601/gos.mxd











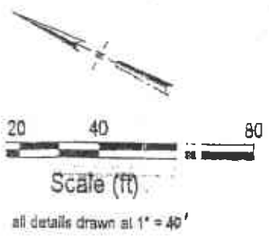
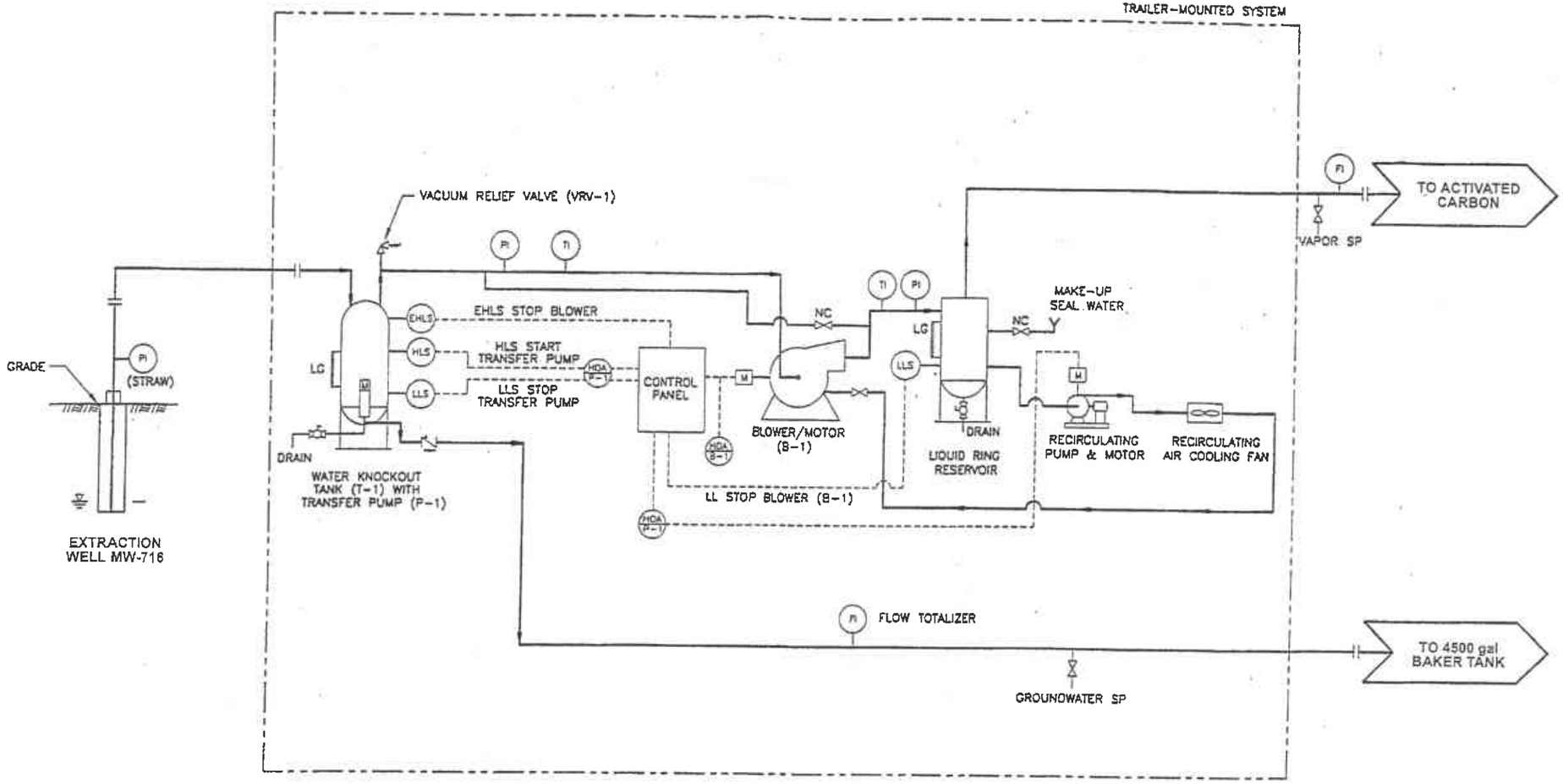


FIGURE 3

Identification of Wells in the Plume Areas
City of Oakland Municipal Services Center



LEGEND

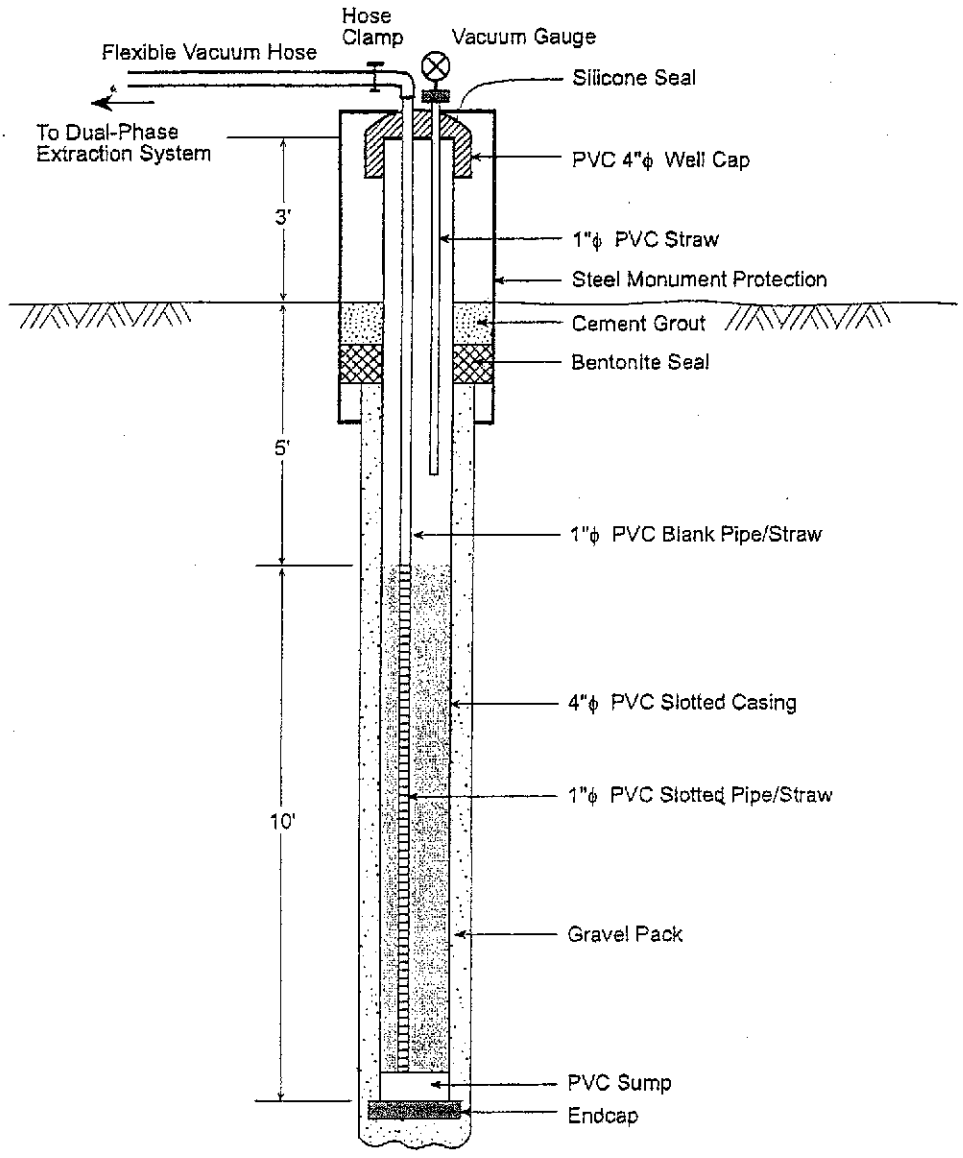
⊣⊢	= QUICK CONNECT FITTING	M	= MOTOR
	= VACUUM RELIEF VALVE	FI	= FLOW RATE INDICATOR
◯	= INSTRUMENT	———	= RIGID PIPE
	= CHECK VALVE	HLS	= HIGH LEVEL SWITCH
	= BALL VALVE	EHLS	= EMERGENCY HIGH LEVEL SWITCH
	= GATE VALVE	LLS	= LOW LEVEL SWITCH
HOA	= HAND-OFF-AUTO SWITCH	PI	= PRESSURE/VACUUM INDICATOR
LG	= SIGHT LEVEL GAGE	SP	= SAMPLE PORT
NC	= NORMALLY CLOSED	TI	= TEMPERATURE INDICATOR

URS

Project No.

SCHEMATIC DIAGRAM OF DUAL-PHASE EXTRACTION SYSTEM

Figure 4



NOT TO SCALE

FIGURE 5

Illustration of Dual-Phase Extraction Well
City of Oakland Municipal Services Center

Photo 1: Trailer mounted Dual-Phase Extraction (DPE) system

Photo 2: Activated carbon units for vapor control and electrical generator for the DPE system.

Photo 3: Dual-phase extraction from Well MW-6.

Photo 4: Monitor vacuum response from a monitoring well.

Photo 5: Dual-phase extraction from off-site Well MW-16.

Photo 6: Tar-like material floating on surface of extracted groundwater. The material is in a semi-solid state and very sticky.

Photo 7: Separate-phase hydrocarbons recovered from extraction wells.

APPENDIX A

Laboratory Analysis Reports

AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

Air Toxics Ltd. Introduces the Electronic Report

Thank you for choosing Air Toxics Ltd. To better serve our customers, we are providing your report by e-mail. This document is provided in Portable Document Format which can be viewed with Acrobat Reader by Adobe.

This electronic report includes the following:

- Work order Summary;
- Laboratory Narrative;
- Results; and
- Chain of Custody (copy).

180 BLUE RAVINE ROAD, SUITE B FOLSOM, CA - 95630

(916) 985-1000 .FAX (916) 985-1020
Hours 8:00 A.M to 6:00 P.M. Pacific
E-mail to:samplereceiving@airtoxics.com

@ AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

WORK ORDER #: 0205543A

Work Order Summary

CLIENT:	Dr. Xinggang Tong URS Corporation 500 12th Street Suite 200 Oakland, CA 94607-4014	**BILL TO:**	Dr. Xinggang Tong URS Corporation 500 12th Street Suite 200 Oakland, CA 94607-4014
PHONE:	510-893-3600	**P.O. #**	
FAX:	510-874-3268	**PROJECT #**	5/00/290/0.00 Oakland MSC
DATE RECEIVED:	5/28/02	**CONTACT:**	Karen Burden
DATE COMPLETED:	6/10/02		

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.
01A	RW-B4	CARB 410A	6.0 "Hg
02A	MW-6	CARB 410A	3.0 "Hg
03A	MW-16	CARB 410A	4.0 "Hg
04A	Lab Blank	CARB 410A	NA
05A	LCS	CARB 410A	NA

CERTIFIED BY: Linda D. Truman DATE: 06/11/02

Laboratory Director

Certfication numbers: CA ELAP - 1149, NY NELAP - 11291, UT ELAP - E-217, LA - AI 30763
Name of Accrediting Agency: NELAP/Florida Department of Health, Scope of Application: Clean Air Act,
Accreditation number: E87680, Effective date: 01/01/02, Expiration date: 06/30/02

Air Toxics Ltd. certifies that the test results contained in this report meet all requirements of the NELAC standards

180 BLUE RAVINE ROAD, SUITE B FOLSOM, CA - 95630
(916) 985-1000 , (800) 985-5955 , FAX (916) 985-1020

LABORATORY NARRATIVE
CARB 410A
URS Corporation
Workorder# 0205543A

Two 6 Liter Summa Canister and One 6 Liter Silonite Canister samples were received on May 28, 2002. The laboratory performed analysis via modified Method CARB 410A for Benzene, Toluene, Ethylbenzene, Xylenes and Total Petroleum Hydrocarbons (TPH). BTEX was analyzed via GC/PID and TPH via GC/FID. The TPH results are calculated using the response of Gasoline. A molecular weight of 100 is used to convert the TPH ppmv result to ug/L. The method involves concentrating up to 200 mL of sample. The concentrated aliquot is then dry purged to remove water vapor prior to entering the chromatographic system. See the data sheets for the reporting limits for each compound.

Receiving Notes

There were no receiving discrepancies.

Analytical Notes

The recovery of surrogate Fluorobenzene in sample RW-B4, MW-6 and MW-16 was outside control limits due to high level hydrocarbon matrix interference. Data is reported as qualified.

Definition of Data Qualifying Flags

Seven qualifiers may have been used on the data analysis sheets and indicate as follows:
B - Compound present in laboratory blank greater than reporting limit.
J - Estimated value.
E - Exceeds instrument calibration range.
S - Saturated peak.
Q - Exceeds quality control limits.
U - Compound analyzed for but not detected above the detection limit.
M - Reported value may be biased due to apparent matrix interferences.

File extensions may have been used on the data analysis sheets and indicates as follows:
a-File was requantified
b-File was quantified by a second column and detector
r1-File was requantified for the purpose of reissue

AIR TOXICS LTD.

SAMPLE NAME: RW-B4

ID#: 0205543A-01A

MODIFIED CARB 410A GC/PID/FID

File Name:	**d052911**	**Date of Collection: 5/16/02**	
Dil Factor:	**6720**	**Date of Analysis: 5/29/02**	

Compound	Rpt. Limit (ppmv)	Rpt. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	6.7	22	900	2900
Toluene	6.7	26	110	440
Ethyl Benzene	6.7	30	140	610
Total Xylenes	6.7	30	290	1300
TPH (C5+ Hydrocarbons) ref. to Gasoline	170	700	71000	290000
C2-C4 Hydrocarbons ref. to Gasoline	170	700	Not Detected	Not Detected

Q = Exceeds Quality Control limits, possibly due to matrix effects.

Container Type: 6 Liter Summa Canister

Surrogates	%Recovery	Method Limits
Fluorobenzene (PID)	141 Q	75-125
Fluorobenzene (FID)	146 Q	75-125

AIR TOXICS LTD.

SAMPLE NAME: MW-6

ID#: 0205543A-02A

MODIFIED CARB 410A GC/PID/FID

File Name:	d052912	Date of Collection:	5/22/02
Dil. Factor:	74.5	Date of Analysis:	5/29/02

Compound	Rpt. Limit (ppmv)	Rpt. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.074	0.24	9.7	32
Toluene	0.074	0.28	6.4	24
Ethyl Benzene	0.074	0.33	19	84
Total Xylenes	0.074	0.33	42	190
TPH (C5+ Hydrocarbons) ref. to Gasoline	1.9	7.7	780	3200
C2-C4 Hydrocarbons ref. to Gasoline	1.9	7.7	Not Detected	Not Detected

Q = Exceeds Quality Control limits, possibly due to matrix effects.

Container Type: 6 Liter Silonite Canister

Surrogates	%Recovery	Method Limits
Fluorobenzene (PID)	154 Q	75-125
Fluorobenzene (FID)	182 Q	75-125

AIR TOXICS LTD.

SAMPLE NAME: MW-16

ID#: 0205543A-03A

MODIFIED CARB 410A GC/PID/FID

File Name:	d052915	Date of Collection:	5/24/02
Dil. Factor:	77.5	Date of Analysis:	5/29/02

Compound	Rpt. Limit (ppmv)	Rpt. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.078	0.25	7.2	23
Toluene	0.078	0.30	3.3	12
Ethyl Benzene	0.078	0.34	10	45
Total Xylenes	0.078	0.34	20	88
TPH (C5+ Hydrocarbons) ref. to Gasoline	1.9	8.0	770	3200
C2-C4 Hydrocarbons ref. to Gasoline	1.9	8.0	Not Detected	Not Detected

Q = Exceeds Quality Control limits, possibly due to matrix effects.

Container Type: 6 Liter Summa Canister

Surrogates	%Recovery	Method Limits
Fluorobenzene (PID)	138 Q	75-125
Fluorobenzene (FID)	144 Q	75-125

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank

ID#: 0205543A-04A

MODIFIED CARB 410A GC/PID/FID

File Name:	d052904	Date of Collection: NA	
Dil. Factor:	1.00	Date of Analysis: 5/29/02	

Compound	Rpt. Limit (ppmv)	Rpt. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.0010	0.0032	Not Detected	Not Detected
Toluene	0.0010	0.0038	Not Detected	Not Detected
Ethyl Benzene	0.0010	0.0044	Not Detected	Not Detected
Total Xylenes	0.0010	0.0044	Not Detected	Not Detected
TPH (C5+ Hydrocarbons) ref. to Gasoline	0.025	0.10	Not Detected	Not Detected
C2-C4 Hydrocarbons ref. to Gasoline	0.025	0.10	Not Detected	Not Detected

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Fluorobenzene (PID)	90	75-125
Fluorobenzene (FID)	89	75-125

AIR TOXICS LTD.

SAMPLE NAME: LCS

ID#: 0205543A-05A

MODIFIED CARB 410A GC/PID/FID

File Name:	d052920b	Date of Collection: NA	
Dil. Factor:	1.00	Date of Analysis: 5/29/02	

Compound	Rpt. Limit (ppmv)	Rpt. Limit (uG/L)	%Recovery
Benzene	0.0010	0.0032	87
Toluene	0.0010	0.0038	88
Ethyl Benzene	0.0010	0.0044	93
Total Xylenes	0.0010	0.0044	89
TPH (C5+ Hydrocarbons) ref. to Gasoline	0.025	0.10	76
C2-C4 Hydrocarbons ref. to Gasoline	0.025	0.10	76

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Fluorobenzene (PID)	88	75-125
Fluorobenzene (FID)	103	75-125

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AN ENVIRONMENTAL ANALYTICAL LABORATORY

WORK ORDER #: 0205543B

Work Order Summary

CLIENT:	Dr. Xinggang Tong URS Corporation 500 12th Street Suite 200 Oakland, CA 94607-4014	**BILL TO:**	Dr. Xinggang Tong URS Corporation 500 12th Street Suite 200 Oakland, CA 94607-4014
PHONE:	510-893-3600	**P.O. #**	
FAX:	510-874-3268	**PROJECT #**	5/00/290/0.00 Oakland MSC
DATE RECEIVED:	5/28/02	**CONTACT:**	Karen Burden
DATE COMPLETED:	6/11/02		

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.
01A	RW-B4	Method 3C	6.0 "Hg
02A	MW-6	Method 3C	3.0 "Hg
03A	MW-16	Method 3C	4.0 "Hg
04A	Lab Blank	Method 3C	NA
05A	LCS	Method 3C	NA

CERTIFIED BY: Linda J. Fruman DATE: 06/11/02

Laboratory Director

Certfication numbers: CA ELAP - 1149, NY NELAP - 11291, UT ELAP - E-217, LA - AI 30763
Name of Accrediting Agency: NELAP/Florida Department of Health, Scope of Application: Clean Air Act,
Accreditation number: E87680, Effective date: 01/01/02, Expiration date: 06/30/02

Air Toxics Ltd. certifies that the test results contained in this report meet all requirements of the NELAC standards

180 BLUE RAVINE ROAD, SUITE B FOLSOM, CA - 95630
(916) 985-1000 . (800) 985-5955 . FAX (916) 985-1020

LABORATORY NARRATIVE
Method 3C
URS Corporation
Workorder# 0205543B

Two 6 Liter Summa Canister and one 6 Liter Silonite Canister samples were received on May 28, 2002. The laboratory performed analysis via Modified EPA Method 3C for Oxygen, Nitrogen, Carbon Dioxide and Methane using GC/TCD. The method involves direct injection of 1.0 mL of landfill gas. The analytical system consists of a multidimensional gas chromatograph equipped with a variety of gas switching valves and columns. See the data sheet for the reporting limits.

Receiving Notes

There were no receiving discrepancies.

Analytical Notes

There were no analytical discrepancies.

Definition of Data Qualifying Flags

Seven qualifiers may have been used on the data analysis sheets and indicate as follows:
B - Compound present in laboratory blank greater than reporting limit.
J - Estimated value.
E - Exceeds instrument calibration range.
S - Saturated peak.
Q - Exceeds quality control limits.
U - Compound analyzed for but not detected above the detection limit.
M - Reported value may be biased due to apparent matrix interferences.

File extensions may have been used on the data analysis sheets and indicates as follows:
a-File was requantified
b-File was quantified by a second column and detector
r1-File was requantified for the purpose of reissue

AIR TOXICS LTD.

ID#: 0205543B-01A

Modified EPA Method 3C
GC/TCD

Sample Name:	**RW-B4**	**Date of Collection: 5/16/02**	
Dil. Factor:	**1.68**	**Date of Analysis: 5/30/02**	

Compound	Rpt. Limit (%)	Amount (%)
Oxygen	0.17	2.9
Nitrogen	0.17	57
Methane	0.17	22
Carbon Dioxide	0.17	12

AIR TOXICS LTD.

ID#: 0205543B-02A

Modified EPA Method 3C
GC/TCD

Sample Name:	**MW-6**	**Date of Collection: 5/22/02**	
Dil. Factor:	**1.49**	**Date of Analysis: 5/30/02**	

Compound	Rpt. Limit (%)	Amount (%)
Oxygen	0.15	19
Nitrogen	0.15	82
Methane	0.15	Not Detected
Carbon Dioxide	0.15	Not Detected

AIR TOXICS LTD.

ID#: 0205543B-03A

Modified EPA Method 3C
GC/TCD

Sample Name:	**MW-16**	**Date of Collection:**	**5/24/02**
Dil. Factor:	**1.55**	**Date of Analysis:**	**5/30/02**

Compound	Rpt. Limit (%)	Amount (%)
Oxygen	0.16	18
Nitrogen	0.16	83
Methane	0.16	Not Detected
Carbon Dioxide	0.16	0.43

AIR TOXICS LTD.

ID#: 0205543B-04A

Modified EPA Method 3C
GC/TCD

Sample Name:	**Lab Blank**	**Date of Collection:**	**NA**
Dil. Factor:	**1.00**	**Date of Analysis:**	**5/30/02**

Compound	Rpt. Limit (%)	Amount (%)
Oxygen	0.10	Not Detected
Nitrogen	0.10	Not Detected
Methane	0.10	Not Detected
Carbon Dioxide	0.10	Not Detected

AIR TOXICS LTD.

ID#: 0205543B-05A

Modified EPA Method 3C
GC/TCD

Sample Name:	**LCS**	**Date of Collection: NA**	
Dil. Factor:	**1.00**	**Date of Analysis: 5/30/02**	

Compound	Rpt. Limit (%)	% Recovery
Oxygen	0.10	98
Nitrogen	0.10	104
Methane	0.10	99
Carbon Dioxide	0.10	102

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CHAIN-OF-CUSTODY RECORD

Sample Transportation Notice
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FOLSOM, CA 95630-4719
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Contact Person: Xinggang Tang
Company: URS Corporation
Address: 500 12th St, Suite 200 City: Oakland State: CA Zip: 94607
Phone: (510) 874-3060 FAX: (510) 874-3268
Collected By: (Signature) Xinggang Tang

Project Info:
P.O. #
Project #: 51001290/0.00
Project Name: Oakland MSC

Turn Around Time:
☒ Normal
☐ Rush _____ Specify

ML 5/29/02

Lab I.D.	Field Sample I.D.	Date & Time	Analyses Requested	Canister Pressure / Vacuum Initial	Final	Receipt
01A	RW-B4	5/16/02, 18:45	modified CARB 410A & EPA method 3C	29.8"	7"	6.0"Hg 25.7"
02A	MW-6	5/23/02, 19:00	" "	30"	4.5"	3.0"Hg 25.8"
03A	MW-16	5/24/02, 10:35 AM	" "	30"	5"	4.0"Hg 25.8"

Relinquished By: (Signature) Date/Time: 5/24/02 Via FedEx
Received By: (Signature) Date/Time
Relinquished By: (Signature) Date/Time
Received By: (Signature) Date/Time
Relinquished By: (Signature) Date/Time
Received By: (Signature) Date/Time: 0855 5/28/02

Notes:

Lab Use Only

Shipper Name	Air Bill #	Opened By	Temp. (°C)	Condition	Custody Seals Intact?	Work Order #
FedEx	843525697	KCB	—	Good	Yes No None	020554 BA

Form 1093 rev. 09