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Air Sparge/Soil Vapor Extraction Pilot Test Summary Report
Former BP Service Station #11132
3201 35th Avenue
Oakland, California
ACEH Case #RO0000014

ENVIRONMENT

"I declare that to the best of my knowledge at the present time, that the information and/or recommendations contained in the attached document are true and correct."

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February 28, 2011

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HEP
No. 6887
STATE OF CALIFORNIA

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Former BP Service Station # 11132

ACEH CASE Number: RO0000014

3201 35th Avenue
Oakland, California
28 February 2011

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Former BP Service Station #11132

3201 35th Avenue

Oakland, California

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Tables

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Figure 2 Site Map

1. Introduction

On behalf of British Petroleum (BP), ARCADIS has prepared the following summary report for former BP facility number 11132 located at 3201 35th Avenue, Oakland, California (the Site). The Site and surrounding area can be seen in **Figure 1**. This memorandum summarizes the Air Sparge and Soil Vapor Extraction Pilot system test performed at the Site on January 19th and 20th, 2011 and recommends a remedial path forward.

2. Site Conditions

2.1 Site History

The Site is an active 76-branded gas station located on the northeast corner of the intersection of 35th Avenue and Sutter Street, southwest of Interstate 580, in Oakland, California. Current facility operations consist of gasoline dispensing and retail sales by ConocoPhillips. The Site has operated as a gasoline service station since at least the early 1970's. It was acquired in 1989 from Mobil Oil Company by BP and operated under the BP brand. BP sold the station in 1994 to Tosco, which was acquired by Conoco Phillips who now operates the 76-branded station.

The leaking underground storage tanks (USTs) were removed and replaced in 1986. Product conveyance lines and fuel dispensing equipment was subsequently replaced in the 1990. Existing USTs consist of one 12,000-gallon and two 10,000-gallon double-wall fiberglass USTs. According to the station manager, these USTs contain regular unleaded, plus unleaded, and super unleaded gasoline and are equipped with an electronic leak detection system. In addition, the station personnel inventory the contents of the USTs by manually gauging the tanks. Existing and former Site features are shown on **Figure 2**.

2.2 Geology and Hydrology

Sediments encountered at the Site consist primarily of silty clays or clayey silts with varying amounts of sand and gravel, extending from the ground surface to the total depth investigated, approximately 45 ft below ground surface (bgs) (Broadbent and Associates, Inc. (BAI), 2008) Interbedded lenses of sandy gravelly silts and sandy gravelly clays have also been reported in subsurface soils.

Groundwater depth historically varies across the Site from approximately 11 to 24 ft bgs. Average seasonal fluctuations are approximately 10 ft. Historically, the ground-water gradient has ranged from 0.003 ft/ft to 0.01 ft/ft and ground-water flow direction has varied between southeast and southwest. Groundwater contour data from the most recent monitoring event conducted on September, 2010 is included on **Figure 3**.

2.3 Soil and Groundwater

A comprehensive summary of previous environmental investigations is presented in the report prepared by BAI titled *Site Conceptual Model with Feasibility Study Report, Former BP Station #11132*, dated July 21, 2008.

2.3.1 Soil

Soil impacts originate from historical operations relating to the former USTs. Laboratory analysis of soil samples collected from soil borings confirmed the presence of petroleum hydrocarbons in soils 20 -25 feet beneath the Site at concentrations exceeding San Francisco Bay Region- Regional Water Quality Control Board (SFR-RWQCB) Environmental Screening Levels (ESLs).

2.3.2 Groundwater

Groundwater has been sampled on a quarterly or semi-annual basis since the 1986 Site investigation following the originally reported UST release. No measurable separate phase hydrocarbons (SPH) was reported in Site wells during the first quarter 2010 monitoring event; however, sheen was observed during purging in monitoring wells MW-1, MW-2, MW-4, MW-10 and RW-1.

Historically, measurable quantities of SPH have been detected in wells MW-1, MW-2, MW-8, MW-9, MW-10 and RW-1. SPH was last seen at the site in September 2010 at MW-10 with a measured thickness of 0.02 feet. Observations of the free product encountered in the wells indicate a black, heavily-degraded, grease-like material, very aged and viscous (BAI, July 2008). The maximum historical thickness of SPH at the Site was observed in well MW-1 at a thickness of 1.80 feet, measured on April 20, 1994.

3. Well Installation

From September 7, 2010 to September 8, 2010, 5 wells including SVE-1, VM-1, VM-2, OW-1, and AS-1, were installed at the Site for air sparge (AS) and soil vapor extraction (SVE) pilot testing.

SVE-1 was installed using hollow stem auger (HSA) drilling to a total depth of 20 feet below ground surface. SVE-1 was constructed of 2-inch diameter Schedule 40 polyvinyl chloride (PVC) casing with 0.020-inch slotted screen installed from approximately 10 to 20 feet below ground surface (bgs). Well construction included neat cement grout from 0 to 8 ft bgs, #30 transition sand from 8 to 9 feet bgs, and 2/16 silica sand pack from 9 to 20 ft bgs. Vapor monitoring wells VM-1 and VM-2 were constructed identical to SVE-1 at distances of 10 and 15 feet from SVE-1, respectively. VM-1 and VM-2 were used as performance monitoring location during pilot testing to monitor for vacuum influence and determine a Site specific radius of influence for SVE-1.

OW-1 was completed to a total depth of 40 feet bgs. OW-1 was constructed of 2-inch diameter Schedule 40 PVC casing from ground surface to 20 ft bgs followed by 20 ft of 0.010-inch slotted screen from 20 to 40 feet bgs. Well construction included neat cement grout from 0 to 17 ft bgs, bentonite from 17 to 19 ft bgs, and 2/16 silica sand pack from 19 to 40 ft bgs. OW-1 was used as a performance monitoring location during AS pilot testing to evaluate influence of the air injections at AS-1.

AS-1 was installed to approximately 45 feet. AS-1 was constructed using 2-inch diameter Schedule 40 PVC casing from ground surface to 42 feet below ground surface followed by 3 feet of 0.020-inch slotted well screen from 42 to 45 feet below ground surface. This depth is approximately five feet below the deepest observed impacts which ensures complete coverage of the sparging system. Well construction included neat cement grout from 0 to 40 ft bgs, #30 transition sand from 40 to 42 ft bgs, and 2/16 silica sand pack from 42 to 45 ft bgs.

4. Evaluation of Air Sparge and Soil Vapor Extraction Pilot Test

An AS/SVE system pilot test was completed to confirm effectiveness of the remedial technology and obtain design parameters for full scale system design. Summarized below are a summary of the field implementation of the Site AS/SVE pilot test and evaluation of data collected during testing.

4.1 Soil Vapor Extraction Pilot Test

4.1.1 Field Implementation

A soil vapor extraction system pilot test was conducted on January 19, 2011 at the newly installed SVE well, SVE-1. A portable blower and thermal oxidizer were used to create the applied vacuum and treat extracted soil vapors. A step test was conducted by increasing the vacuum applied at the wellhead from 8 inches of water in increments of 10 to 40 inches of water up to 125 inches of water. The applied vacuum was allowed to stabilize and was then maintained at a stable flowrate for approximately 30-60 minutes. . Flow rates from the wellhead varied from 8 standard cubic feet per minute (scfm) to 36 scfm. Wellhead monitoring instrumentation included a digital vacuum gauge, digital thermometer, and digital anemometer to measure flow rate. A valved sample port, vacuum pump, tedlar bag and Photo Ionization Detector were used to measure VOC content of extracted vapor at the wellhead and atmospheric discharge at the thermal oxidizer effluent.

Vacuum influence was monitored at nearby wells MW-2, VM-1, and VM-2 at approximately 15 minute intervals. MW-2 is located 7 feet from SVE-1, VM-1 is located 10 feet from SVE-1, and VM-2 is located 14 feet from SVE-1.

A summary of field data is presented in **Table 1**. Field observations and an evaluation of collected data are discussed in the following section.

4.1.2 Data Evaluation and Recommendation

Although, no induced vacuum was observed at any of the adjacent monitoring locations, extraction flow rates at the wellhead was observed ranging from 8 scfm to 36 scfm while applied vacuum varied from 8 inches of water to 125 inches of water. At the higher flow rate and vacuum, mass removal reached approximately 2 lbs/day total hydrocarbons.

Additionally, historical groundwater elevation data at this Site indicate groundwater elevation fluctuates seasonally by as much as seven feet (BAI, October 2010). This pilot test was conducted when groundwater was at a seasonal high of approximately 16 feet bgs. From August to November, historical groundwater elevation data indicate water levels can fall as low as 21 feet bgs (BAI, October 2010). With groundwater elevation fluctuations up to five feet, SVE operation during the summer and fall months may be more effective with potentially higher extraction flow rates and mass removal rates. Based on field implementation data, SVE appears to be a viable technology to address vadose zone and smear zone impacts.

4.2 Air Sparge Pilot Test.

4.2.1 Field Implementation

An AS system pilot test was conducted on January 20, 2011 at the newly installed air sparge well, AS-1. A portable air compressor was used to conduct a step test by incrementally increasing injection pressure and measuring air flow rates, water level changes and physical evidence such as air bubbles at adjacent monitoring locations.

Field parameter measurements were collected at nearby performance monitoring wells OW-1, MW-2, and RW-1. Groundwater elevation was monitored using continuous down well water level loggers. Each location was monitored for pressure changes using a digital pressure gauge. Performance monitoring wells were also profiled for dissolved oxygen to monitor for potential air channels.

The system was started with an initial pressure of 15 pounds per square inch (PSI). The system was allowed to stabilize and then the injection pressure was slowly increased in increments of 5 to 10 psi to obtain an initial flow response. Pressure was increased to a maximum 30 psi over a 12 minute period and no breakthrough flowrate was observed. After maintaining a pressure of 30 psi for a 5 minute period the system was shutdown.

Although air bubbles were not observed at any monitoring locations, water level increase was observed at OW-1. So the system was restarted and injection pressure was set at 26 psi and allowed to stabilize. A pressure of 26 psi was maintained for 25 minutes but no injection flow rate or air bubbles and pressure change at monitoring locations were observed. The system was then shutdown and disassembled.

A summary of field data is presented in **Table 2**. These field observations along with depth to water measurements are discussed in the following section to assess sparge test subsurface air flow distribution and zone of influence.

4.2.2 Data Evaluation and Recommendations

Groundwater elevation data logged continuously at RW-1 and MW-2 indicate negligible change (less than 0.2 feet and 0.3 feet respectively) in water levels throughout the duration of the sparge tests. Groundwater elevation did increase at OW-1 by 1.4 feet.

The minimal vertical displacement of groundwater, or mounding, at the adjacent monitoring locations indicates a significant radius of influence (ROI) is not likely attainable. A small ROI is also expected based on the predominantly clayey content of the Site soil. The lack of air bubbles at all monitoring locations indicates that air channels likely do not intersect the well screens. Despite attempting injection at pressures significantly above the calculated allowable injection pressure of 17 psi, no injection flowrate was achieved. Based on the inability to achieve a flowrate at safe injection pressure at AS-1, AS is not a viable remedial technology to address saturated zone impacts at the Site.

5. Alternative Remedial Strategies

5.1 Dual Phase Extraction

Stratus conducted a DPE pilot test between May 11 and May 19, 2009 at MW-1, MW-2, MW-8, MW-9, MW-10 and RW-1. A stinger was inserted into each well on an individual basis allowing for simultaneous extraction of groundwater and soil vapor. Testing was also performed on a combined basis at MW-1, MW-2 and RW-1. The average observed extraction rate was approximately 26 scfm and the average observed applied vacuum was 26 inches of mercury (in of Hg) (BAI, August 2009).

It is unclear if DPE testing was effectively executed by Stratus based on the following:

- Groundwater drawdown was not maintained at the observation wells which prevented exposure of smear zone soils and additional influence of the vapor extraction system.
- Several observation wells had fully submerged screens, therefore preventing induced vacuum at those locations.

- The applied wellhead vacuum was not specified.
- Applied vacuum results did not specify if vacuum readings were collected at the blower manifold or at the wellhead indicating the possibility that sufficient vacuum may not have been applied to the extraction wells for vapor and groundwater extraction.

Based on the limited pilot test information and potential for improved field operations to optimize mass removal rates, it is unclear at this time if DPE is a viable technology at this Site.

5.2 In Situ Remedial Fluid Injection

Upon completion of the AS and SVE system pilot tests on January 20, 2011, a falling head test was performed to estimate injection pressures under gravity flow conditions for evaluation of the viability of a fluid injection based remedy at the Site.

A falling head test was completed at MW-2 and AS-1. Each well was completely filled with clean water and a down well continuous level logger was used to measure fluid acceptance. Test results indicated that MW-2 accepted fluid at approximately 0.91 gallons per minute (gpm) and AS-1 at approximately 0.16 gpm. When averaged across the screen interval, MW-2 accepted fluid at approximately 0.036 gpm/foot of screen and AS-1 at approximately 0.053 gpm/foot of screen.

Limited flow rates observed during the falling head test indicate fluid injection based remedy is not a viable technology at this Site.

6. Conclusions

Based on the above evaluation, ARCADIS does not recommend air sparge or a fluid injection based remedy for this Site. Based on the SVE pilot conducted, soil vapor extraction appears to be a viable technology to address vadose zone impact. Although Stratus conducted a DPE pilot test in 2009 with limited mass removal and induced vacuum, it is unclear whether or not an optimized DPE system could be a viable option. Prior to making a final recommendation on the proposed remedial path forward, ARCADIS proposes to conduct a dual phase extraction test to re-evaluate the viability of this technology for this site.

7. Schedule

ARCADIS will conduct the pilot test the week of April 4, 2011 and submit the results by May 6, 2011.

8. References

Broadbent & Associates, Inc., 2008. *Site Conceptual Model and Feasibility Study Report, Former BP Station No. 11132*, July 2008.

California Department of Water Resources. 2003. *California's Groundwater.* Sacramento. Bulletin 118, update 2003.

San Francisco Bay Water Board, 2008. *Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater, Volume 1: Summary Tier 1 Lookup Tables, Interim Final,* May 2008.

Broadbent & Associates, Inc., 2010 *Third Quarter 2010 Semi-Annual Ground-Water Monitoring Report, Former BP Station #11132,* October 2010.

Broadbent & Associates, Inc., 2009 *Vapor Intrusion Assessment & Dual-Phase Extraction Pilot Test Report, Former BP Service Station No. 11132,* August 2009

Table 1
BP Station #11132
AS/SVE Pilot Test January 19-20, 2011
SVE Field Results

	Extraction Well				Blower Effluent			Monitoring Well Response (Vacuum, inches H2O)		
System Run Time (min)	Vacuum (in H2O)	Flow (scfm)	VOCs (ppmv)	Total Hydrocarbon mass removal rate (lbs/day)	Pressure (in H2O)	Flow (scfm)	VOCs (ppmv)	MW-2	VM-1	VM-2
0	0.0	19.1	---	---	1.0	98.7	98.4	0.0	0.0	0.0
33	8.3	8.2	197	0.1	0.5	91.0	90.9	0.0	0.0	0.0
51	8.2	7.7	287	0.2	0.9	83.4	83.2	0.0	0.0	0.0
64	8.2	7.7	77.7	0.1	---	79.2	79.2	0.0	0.0	0.0
79	14.5	12.2	143	0.2	0.0	21.4	21.4	0.0	0.0	0.0
94	14.9	12.5	115	0.1	0.0	22.4	22.4	0.0	0.0	0.0
107	14.2	19.9	73.8	0.1	0.2	20.9	20.9	0.1	0.0	0.0
118	14.8	11.3	202	0.2	0.0	22.4	8.7	0.0	0.0	0.0
137	13.8	10.5	239	0.2	0.2	20.5	20.5	0.0	0.0	0.0
147	20.9	11.7	95.3	0.1	0.1	16.9	16.9	0.0	0.0	0.0
158	20.5	10.6	56.5	0.1	0.2	20.7	20.7	0.0	0.0	0.0
168	20.9	12.6	216	0.2	0.1	17.4	17.4	0.0	0.0	0.0
178	20.1	16.6	88.6	0.1	0.4	20.7	20.7	0.0	0.0	0.0
189	21.0	15.9	247	0.4	0.1	20.8	20.8	0.1	0.0	0.1
202	20.3	13.0	86.8	0.1	0.3	19.7	19.7	0.0	0.0	0.0
218	35.6	13.5	73.9	0.1	0.3	25.2	25.2	0.0	0.0	0.0
230	39.4	13.0	98.6	0.1	0.5	15.8	15.8	0.0	0.0	0.0
240	39.3	15.1	107	0.1	0.1	27.2	27.2	0.0	0.0	0.0
251	38.8	12.3	86.3	0.1	0.3	21.5	21.5	0.0	0.0	0.0
261	39.1	13.0	92.3	0.1	0.3	29.4	29.4	0.0	0.1	0.0
276	82.1	20.1	144	0.3	0.6	60.4	60.3	0.0	0.0	0.0
286	81.4	21.0	367	0.7	0.6	57.5	57.4	0.0	0.0	0.0
298	80.2	22.2	161	0.3	0.8	60.2	60.1	0.0	0.0	0.0
310	81.1	24.0	198	0.4	0.7	55.9	55.8	0.0	0.0	0.0
323	81.2	22.7	151	0.3	0.6	55.9	55.8	0.0	0.0	0.0
336	126	23.6	252	0.5	1.1	65.1	64.9	0.0	0.0	0.0
347	125	21.9	768	1.5	1.8	60.2	59.9	0.0	0.1	0.1
358	125	23.5	403	0.9	1.7	55.7	55.5	0.0	0.0	0.0
371	125	24.8	913	2.0	1.7	55.7	55.5	0.0	0.0	0.0
388	123	22.2	976	1.9	1.8	60.2	59.9	0.0	0.0	0.0

Notes
1. Blower Effluent Diameter: 3 inches
2. Bleed Control Diameter: 2 inches
3. Extraction Well Diameter: 2 inches
4. Monitoring Location Diameters: 2 inches
5. Distance between SVE-1 and MW-2: 7 feet
6. Distance between SVE-1 and VM-1: 10 feet
7. Distance between SVE-1 and VM-2: 14 feet

ABBREVIATIONS:
min=minutes
in H2O=inches of water
scfm=standard cubic feet per minute
ppmv=part per million by volume
GRO=Gasoline Range Organics
lbs/day=pounds per day

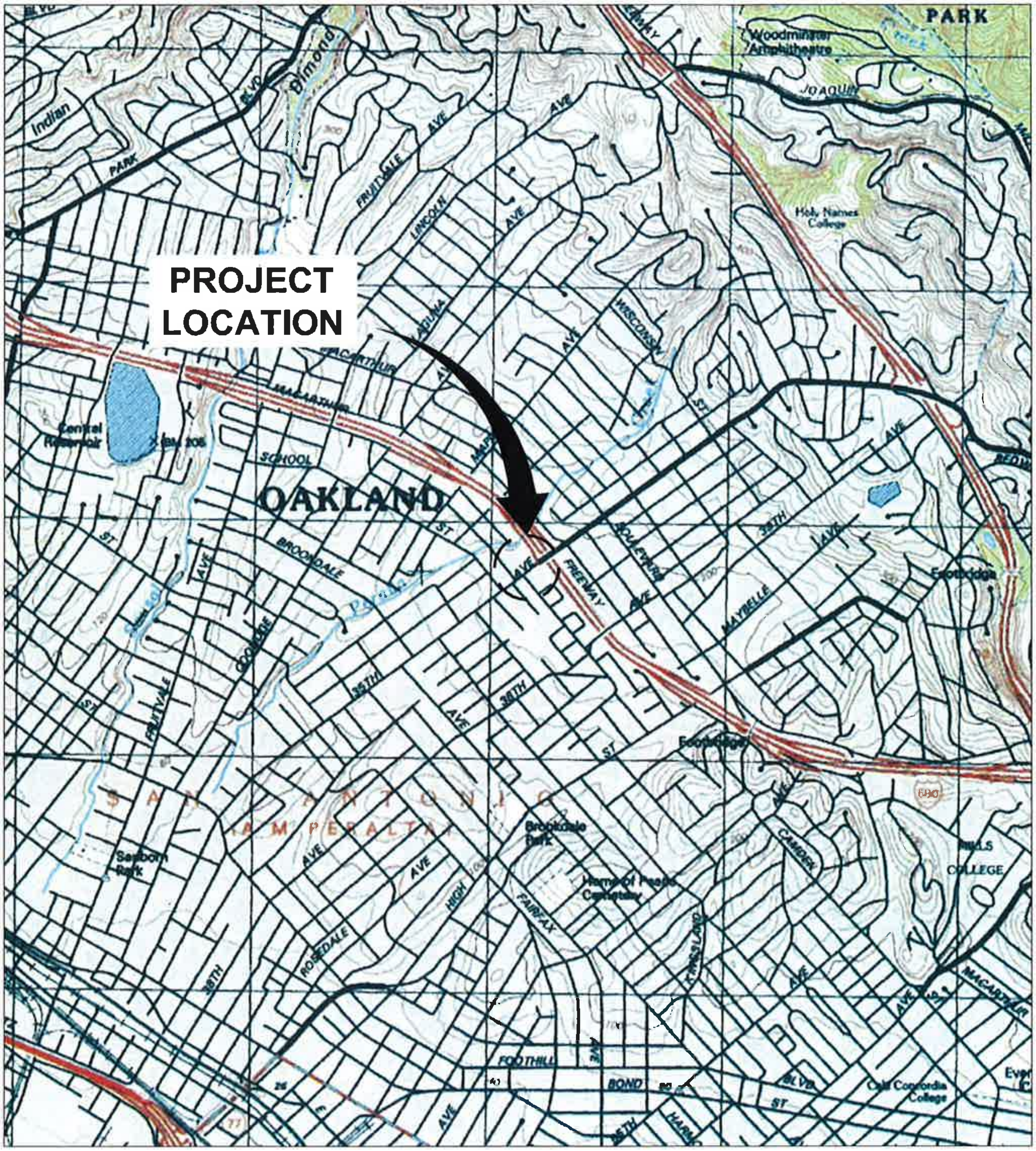
mass removal rate (lbs/day)= extraction flow rate (scfm)*VOC concentration (ppmv)*6.23*10^-8 ((lb/ft^3)/ppmv)*1440 (min/day)

Table 2
BP Station #11132
AS/SVE Pilot Test January 19-20, 2011
AS Field Results

Run Time (minutes)	Pressure (psi)	injection flow rate (scfm)
0	15	0
7	25	0
12	30	0
0	26	0
27	26	0

NOTES:
1. Air Sparge well Diameter: 2 inches
2. System stopped for 15 minutes then restarted

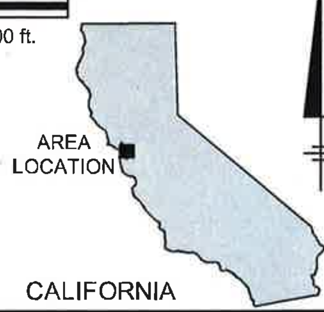
ABBREVIATIONS:
psi=pounds per square inch
SCFM=standard cubic feet per minute



REFERENCE: BASE MAP USGS 7.5. MIN. TOPO. QUAD., OAKLAND EAST, CALIFORNIA, 1997.

0 2000' 4000'

Approximate Scale: 1 in. = 2000 ft.



FORMER BP STATION NO. 11132
3201 35TH AVENUE, OAKLAND, CALIFORNIA
AIR SPARGE/SOIL VAPOR EXTRACTION SUMMARY REPORT

SITE LOCATION MAP

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FIGURE
1

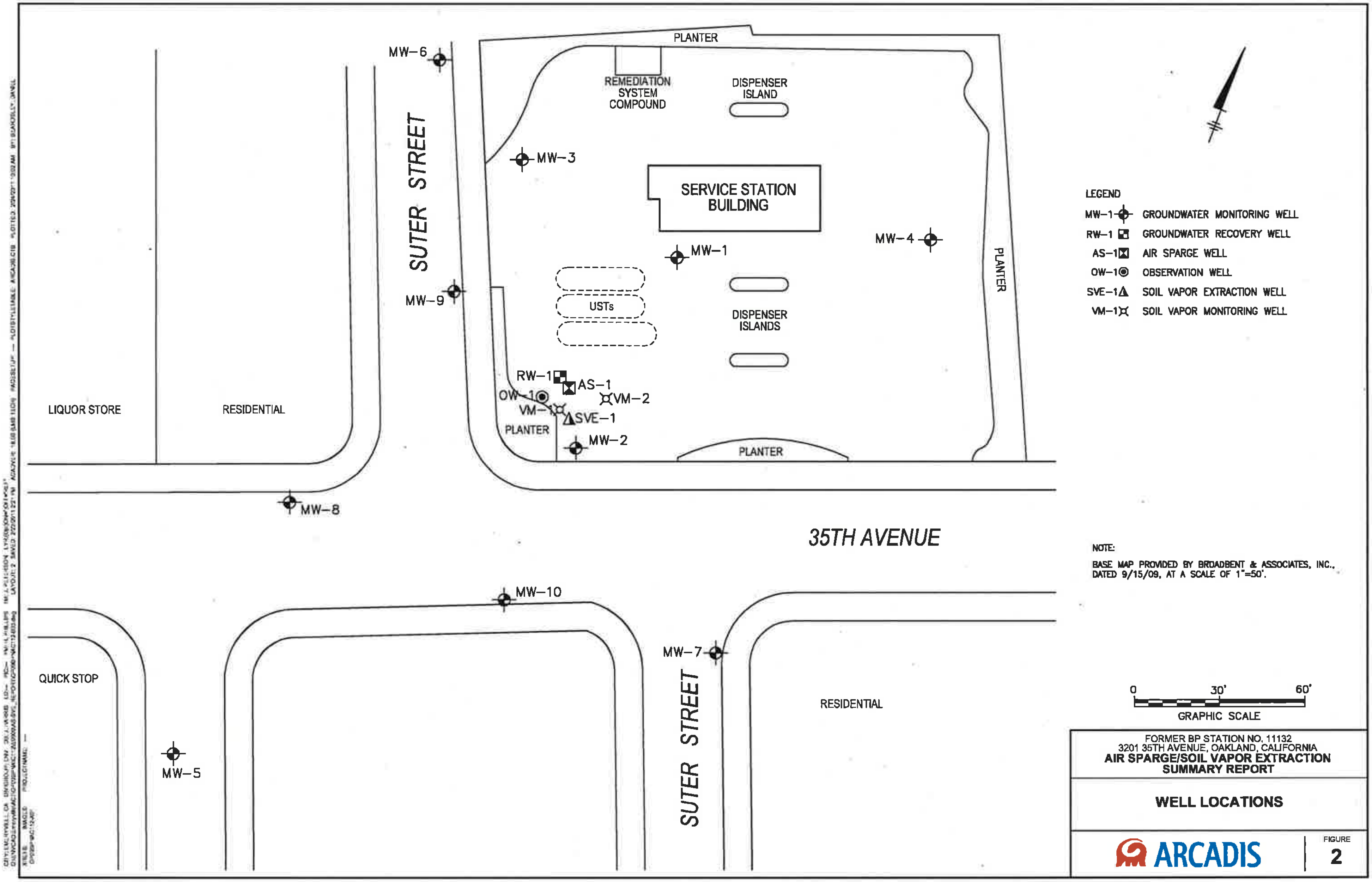
PLANTER
REMEDIATION SYSTEM COMPOUND
DISPENSER ISLAND
SERVICE STATION BUILDING
MW-1
MW-2
MW-3
MW-4
MW-5
MW-6
MW-7
MW-8
MW-9
MW-10
USTs
DISPENSER ISLANDS
RW-1
AS-1
OW-1
VM-1
VM-2
SVE-1
PLANTER
PLANTER
PLANTER
SUTER STREET
SUTER STREET
35TH AVENUE
LIQUOR STORE
RESIDENTIAL
QUICK STOP
RESIDENTIAL
LEGEND
MW-1 GROUNDWATER MONITORING WELL
RW-1 GROUNDWATER RECOVERY WELL
AS-1 AIR SPARGE WELL
OW-1 OBSERVATION WELL
SVE-1 SOIL VAPOR EXTRACTION WELL
VM-1 SOIL VAPOR MONITORING WELL
NOTE:
BASE MAP PROVIDED BY BROADBENT & ASSOCIATES, INC., DATED 9/15/09, AT A SCALE OF 1"=50'.
0 30' 60'
GRAPHIC SCALE
FORMER BP STATION NO. 11132
3201 35TH AVENUE, OAKLAND, CALIFORNIA
AIR SPARGE/SOIL VAPOR EXTRACTION SUMMARY REPORT
WELL LOCATIONS
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FIGURE
2

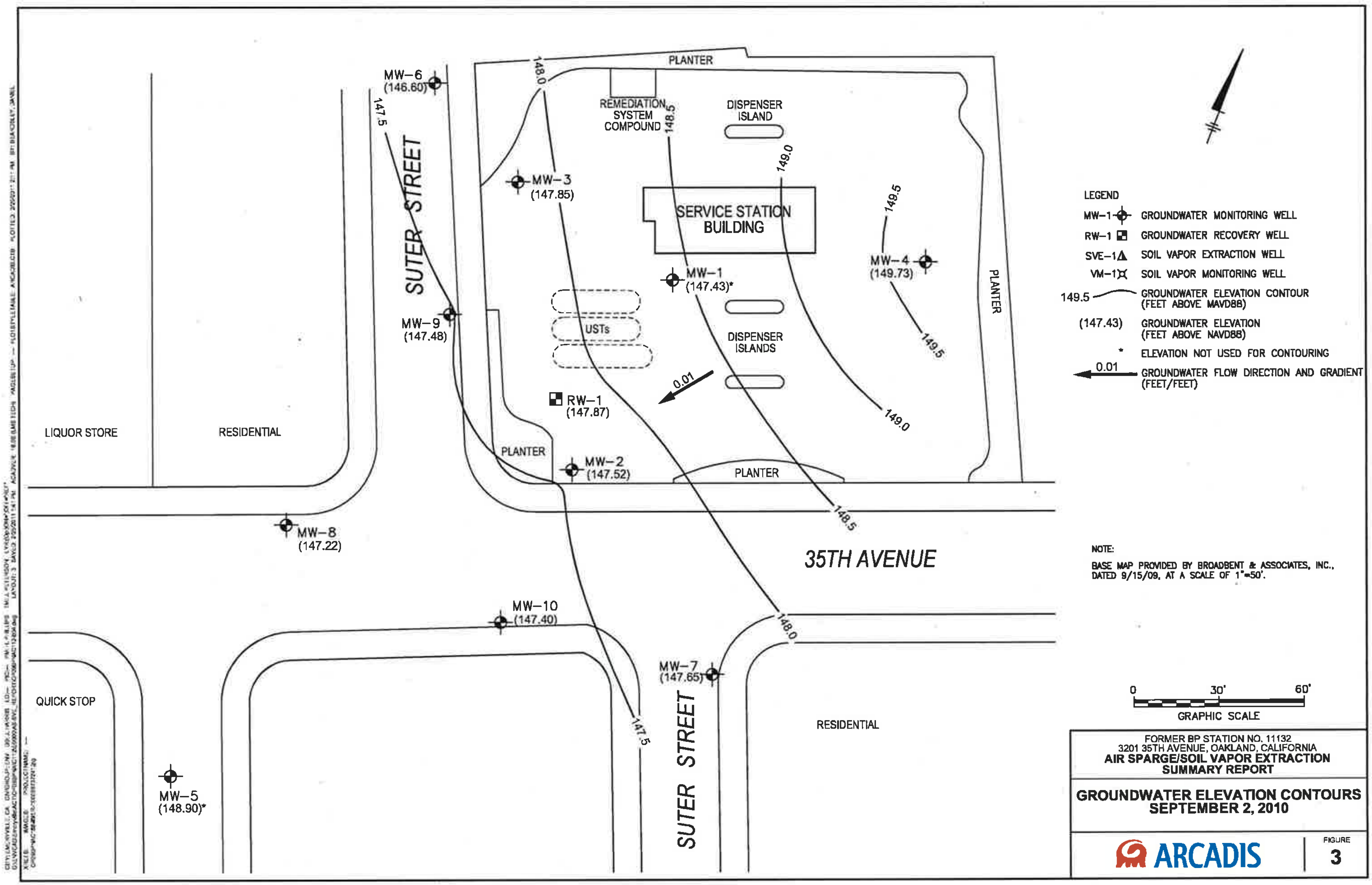
PLANTER
REMEDIATION SYSTEM COMPOUND
DISPENSER ISLAND
SERVICE STATION BUILDING
DISPENSER ISLANDS
USTs
PLANTER
PLANTER
PLANTER
SUTER STREET
35TH AVENUE
SUTER STREET
LIQUOR STORE
RESIDENTIAL
QUICK STOP
RESIDENTIAL
MW-6 (146.60)
MW-3 (147.85)
MW-1 (147.43)*
MW-4 (149.73)
MW-9 (147.48)
RW-1 (147.87)
MW-2 (147.52)
MW-8 (147.22)
MW-10 (147.40)
MW-7 (147.65)
MW-5 (148.90)*
148.0
148.5
149.0
149.5
147.5
0.01
LEGEND
MW-1 GROUNDWATER MONITORING WELL
RW-1 GROUNDWATER RECOVERY WELL
SVE-1 SOIL VAPOR EXTRACTION WELL
VM-1 SOIL VAPOR MONITORING WELL
149.5 GROUNDWATER ELEVATION CONTOUR (FEET ABOVE MAVD88)
(147.43) GROUNDWATER ELEVATION (FEET ABOVE NAVD88)
* ELEVATION NOT USED FOR CONTOURING
0.01 GROUNDWATER FLOW DIRECTION AND GRADIENT (FEET/FEET)
NOTE:
BASE MAP PROVIDED BY BROADBENT & ASSOCIATES, INC., DATED 9/15/09, AT A SCALE OF 1"=50'.
0 30' 60'
GRAPHIC SCALE
FORMER BP STATION NO. 11132
3201 35TH AVENUE, OAKLAND, CALIFORNIA
AIR SPARGE/SOIL VAPOR EXTRACTION SUMMARY REPORT
GROUNDWATER ELEVATION CONTOURS
SEPTEMBER 2, 2010
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FIGURE
3