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ENVIRONMENTAL PROTECTION

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September 15, 1997

PE

5510 3714

Jennifer Eberle
Alameda County Department of Environmental Health
1131 Harbor Bay Parkway, Suite 250
Alameda, California 94502-6577

Re: **MTBE Investigation Work Plan**
Shell Service Station
350 Grand Avenue
Oakland, California
WIC #204-5510-0204

Dear Ms. Eberle:

On behalf of Shell Oil Products Company (Shell), Cambria Environmental Technology, Inc. (Cambria) is submitting this *MTBE Investigation Work Plan* in response to a July 31, 1997 Alameda County Department of Environmental Health (ACDEH) request for additional information and investigation at the above-referenced site. To fulfill your request, summarized below are (1) Cambria's approach for investigating sites where methyl tert-butyl ether (MTBE) is a primary compound of concern, and (2) our proposed scope of work for additional investigation for this site. In addition, a revised Table 2 (Analytic Results for Ground Water) from the *Third Quarter 1996 Monitoring Report* including analytic results for total petroleum hydrocarbons as diesel (TPHd) from the April 2, 1996 sampling event is included as Attachment A, as requested in your July 31, 1997 letter.

BACKGROUND

The site is an active Shell Service Station, located at the intersection of Grand Avenue and Perkins Street in Oakland, California (Figure 1). At the time of the last monitoring event on October 2, 1996, the highest hydrocarbon concentrations were detected in well S-2 with 31 parts per million (ppm) TPHd, 28 ppm total petroleum hydrocarbons as gasoline (TPHg), 3.7 ppm benzene, 1.1 ppm ethylbenzene, 0.11 ppm toluene, 0.26 ppm total xylenes, and 20 ppm MTBE (Figure 2).

On January 27, 1993, GeoStrategies Inc. of Hayward, California installed three hydropunch borings in the site vicinity (Figure 2). Boring HP-1 was located cross gradient of the source area and borings HP-2 and HP-3 were located down gradient of the source area. The borings were drilled to depths of 10, 13, and 14 feet below grade, respectively. TPHg and benzene were not detected in ground water samples from borings located up to 160 feet down gradient of the site.

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MTBE INVESTIGATION AND REMEDIATION DECISION FLOW CHART

As you are aware, site assessment policy for sites where MTBE is a primary compound of concern is not well established. Because a majority of service station sites appear to contain MTBE in ground water and many of these sites may require additional investigation, Cambria developed a decision-making flow chart that will help establish consistent site assessment procedures based on site-specific conditions while ensuring the safety of community members and other sensitive receptors. The chart is included as Attachment B and is summarized below.

It is important to recognize that this decision chart is intended only to provide a consistent structure for MTBE assessment and remediation decision making. It is designed as a flexible process that needs to be tailored to individual site conditions. For instance, the 1 and 10 ppm threshold concentrations shown on the chart are proposed to establish categorization cutoffs only. Similarly, determining whether existing clean down gradient wells are appropriate to monitor MTBE migration will depend on site-specific conditions. In summary, the flow chart is intended to provide a framework for the MTBE investigation process. The "Stages" presented below correspond to box numbers on the flow chart.

Stages 1-3

If the site is located in a sensitive area and MTBE concentrations are over 1 ppm, or the site is not in a sensitive area and the MTBE concentrations are over 10 ppm; identify water wells and other human and environmental receptors within a one-half mile radius of the site. The 1 and 10 ppm thresholds are intended only to help categorize sites. They are not proposed as risk thresholds. Use of these log-based MTBE cutoff values allow us to focus our resources on the sites underlain by the highest MTBE concentrations or on the sites located closest to sensitive receptors.

Stage 4

Conduct appropriate MTBE fate and transport modeling to assess whether receptor(s) is/are at risk. This process is used to quantify the exposure potential for sensitive receptors. The sophistication of the modeling conducted under this stage ranges from simple calculation of the ground water velocity to comprehensive two or three dimensional fate and transport analysis. The sophistication of the of modeling required will be determined on a case by case basis.

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Stages 5-8

If receptor(s) is/are at risk, identify existing clean wells at down gradient sites that could be used to monitor MTBE migration. If such wells are not available, perform expedited site assessment to define MTBE using borings and/or wells. If clean wells have been installed at sites down gradient of the subject site, and if these wells are within a reasonable distance of the subject site, then these wells could be used to monitor MTBE migration. If no down gradient wells are available, then new wells may be required. The investigation of MTBE extent may need to follow expedited investigation procedures such as those outlined in ASTM Provisional Standard PS 3-95.

Stages 9-11

Using data from the investigation or existing down gradient wells, fine tune the MTBE fate and transport model. If the data suggests that receptors could be impacted, install a MTBE plume migration control system and monitor its effectiveness. The investigation should provide additional data to fine tune the fate and transport modeling. If the calibrated model continues to suggest that sensitive receptors are at risk, then a MTBE migration control system may be needed.

Stages 12-13

If necessary based on monitoring and modeling, enhance the performance of the migration control system. If monitoring or modeling indicates that MTBE could still pose a risk to receptors, expand the system as needed.

Not all sites will require all investigation/remediation stages. Many sites may require only a receptor survey and modeling to show that MTBE will not impact potential receptors. By applying this approach at sites where MTBE is the primary compound of concern, we will ensure a systematic and logical investigation and remediation approach.

PROPOSED SCOPE OF WORK

Overview

The MTBE concentration in well S-2 was 20 ppm during the fourth quarter 1996 ground water monitoring event. Because this concentration is above the secondary indication level of 10 ppm in Stage 2, it was not necessary to determine whether the site lies in a sensitive ground water recharge area as is described in Stage 1.

Receptor Identification

Stage 3: *Identify water wells and other human and environmental receptors within a one-half mile radius.*

Initial site review indicates that Lake Merritt lies approximately 660 feet south of the site (Figure 1).

Cambria prepared a preliminary fate and transport model based on the following:

- The January 7, 1991 boring logs indicate that the water-bearing zone is composed primarily of sand and sandy silt. An average hydraulic conductivity (k) for the water-bearing zone of $k=5x10^{-4}$ cm/s (silty sand) was used for this model;
- The *Third Quarter 1996 Monitoring Report* indicates a ground water flow gradient at the site of approximately 0.025 ft/ft toward the south;
- The effective porosity of a silty sand is approximately 20%;
- Hydrocarbons had at least two years from the beginning of the monitoring program in 1991 to migrate prior to the 1993 investigation, yet no hydrocarbons were detected in boring HP-3, located approximately 160 feet south of the source area; and
- The migration velocity of MTBE is roughly equivalent to that of ground water.

Cambria calculated an estimated migration rate of approximately 64 feet per year in a southward direction. Because MTBE was not widely used prior to 1992, the maximum MTBE travel distance is estimated to be 320 feet from the source area.

In order to complete Stages 3, Cambria will perform a complete sensitive receptor survey for a one-half mile radius of the site. Completion of Stage 4 may include revision of this fate and transport model in order to evaluate the risk to the identified potential receptors.

Down Gradient Well Identification

Stage 6: [redacted].

Following completion of the well survey, Cambria will review available data to find existing clean down gradient wells. If such wells are available, are a reasonable distance from the site, and screen the subject water-bearing zone, we will apply for permission to include them in our current monitoring program. The offsite investigation described below will be conducted only if suitable down gradient wells are not identified or if access is denied.

Offsite Investigation

Stage 8b: *Perform dynamic site assessment to define MTBE using borings and/or wells.*

Based on available files, there do not appear to be any existing down gradient wells. If no existing accessible down gradient wells are identified during Step 6, we will install two or three new borings down gradient of well S-2 (Figure 2) as detailed below:

Soil Borings: [redacted] The proposed borings shown on Figure 2 are subject to review for subsurface and overhead obstructions. Each of the proposed borings (B-1, B-2, and B-3) will be driven and sampled to a depth of 15 feet. Soil samples will be collected in each boring at 5 foot intervals and one grab ground water sample will be collected from each boring. Cambria's Standard Field Procedures for the Geoprobe® are included as Attachment C.

Well Installation: Using a Geoprobe®, Cambria will install pre-packed, one-inch diameter PVC ground water monitoring wells in two of the borings. If boring B-1 shows no field indications of hydrocarbons in soil or water, we will install monitoring wells in borings B-1 and B-2, and boring B-3 will not be installed. If boring B-1 does show field indications of hydrocarbons, we will install monitoring wells in borings B-2 and B-3. Following installation, we will develop and survey the top of casing elevation of the wells. Ground water samples will be collected during the next scheduled quarterly monitoring event.

SUMMARY

The specific tasks for this investigation will include:

- Surveying local and state agencies regarding water-producing wells;
- Reviewing topographic maps to identify surface water bodies;
- Applying for permission to include any existing down gradient wells in our monitoring program, and if permission is granted, preparing a report summarizing the results of the receptor survey and presenting the locations of additional monitoring wells;

If no existing down gradient wells are found or if access is denied, we will continue the investigation by:

- Preparing a site safety plan and coordinating field activities;
- Obtaining well/boring permits and an encroachment permit to work in the street;
- Notifying Underground Service Alert of our planned activities to locate underground utilities in the vicinity of the proposed boring locations;
- Driving two or three soil borings, depending on field conditions, to a depth of 15 ft, collecting soil samples for lithologic description, and collecting ground water samples;
- Analyzing selected samples for TPHg and TPHd by modified EPA Method 8015; and benzene, toluene, ethylbenzene, and xylenes (BTEX) and MTBE by EPA Method 8020;
- Installing two ground water monitoring wells in borings B-1 and B-2 or borings B-2 and B-3, depending on field conditions, and sealing the remaining boring to the surface with cement grout;
- Coordinating with Blaine Tech Services of San Jose, California to develop and sample the wells;
- Surveying the top of casing elevations of the two new wells;
- Collecting ground water samples from the wells semi-annually in the first and third quarters and analyzing the samples for TPHg and TPHd by modified EPA Method 8015, BTEX and MTBE by EPA Method 8020;
- Preparing a report that describes our activities and, at a minimum, contains:

  A summary of the site background and history;
  Results of our well survey;
  Descriptions of the drilling and soil sampling methods;
  Boring logs;
  Tabulated soil and ground water analytic results;
  Analytic reports and chain-of-custody forms; and
  A discussion of the analytic results.

SCHEDULE

Upon receiving written approval of this work plan, we will contact county and state agencies regarding wells located within a one-half mile radius of the site. If no wells are located down gradient of the site, Cambria will apply for the necessary permits and schedule offsite investigation activities. We will submit an offsite investigation report approximately four to six weeks following field activities.

CLOSING

We appreciate your continued assistance with this project. Please contact us if you have any questions or comments.

Sincerely,
Cambria Environmental Technology, Inc.

Maureen D. Feineman
Staff Geologist

Khaled B. Rahman, R.G., C.H.G.
Senior Geologist

REGISTERED GEOLOGIST
KHALED B. RAHMAN
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STATE OF CALIFORNIA

Attachments: A - Analytic Results for Ground Water
B - MTBE Investigation and Remediation Decision Flow Chart
C - Standard Field Procedures for Geoprobe® Sampling and Pre-packed Well Installation

cc: A.E. (Alex) Perez, Shell Oil Products Company, P.O. Box 4023, Concord, CA 94524

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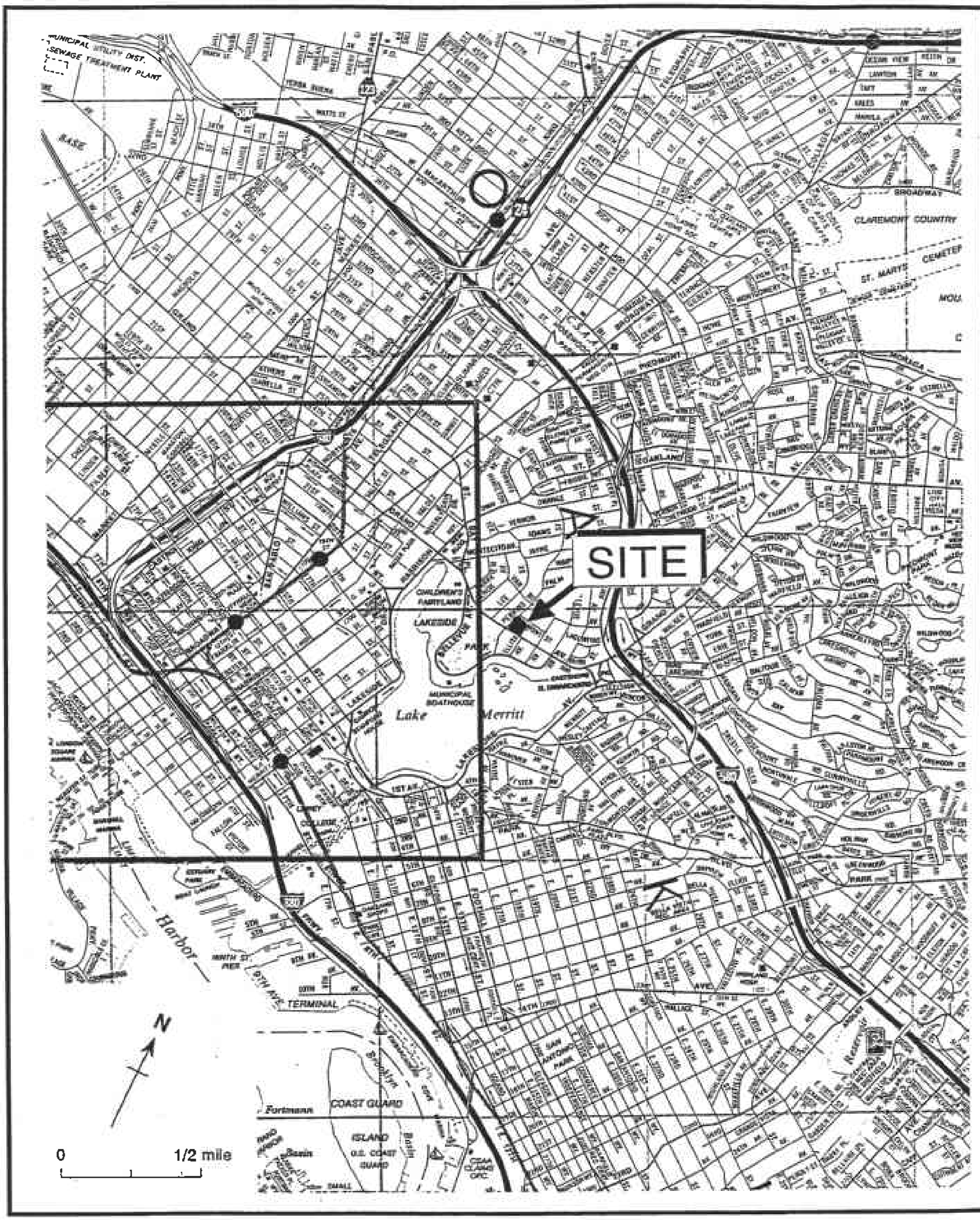

Figure 1. Site Location Map - Shell Service Station WIC #204-5510-0204, 350 Grand Avenue, Oakland, California

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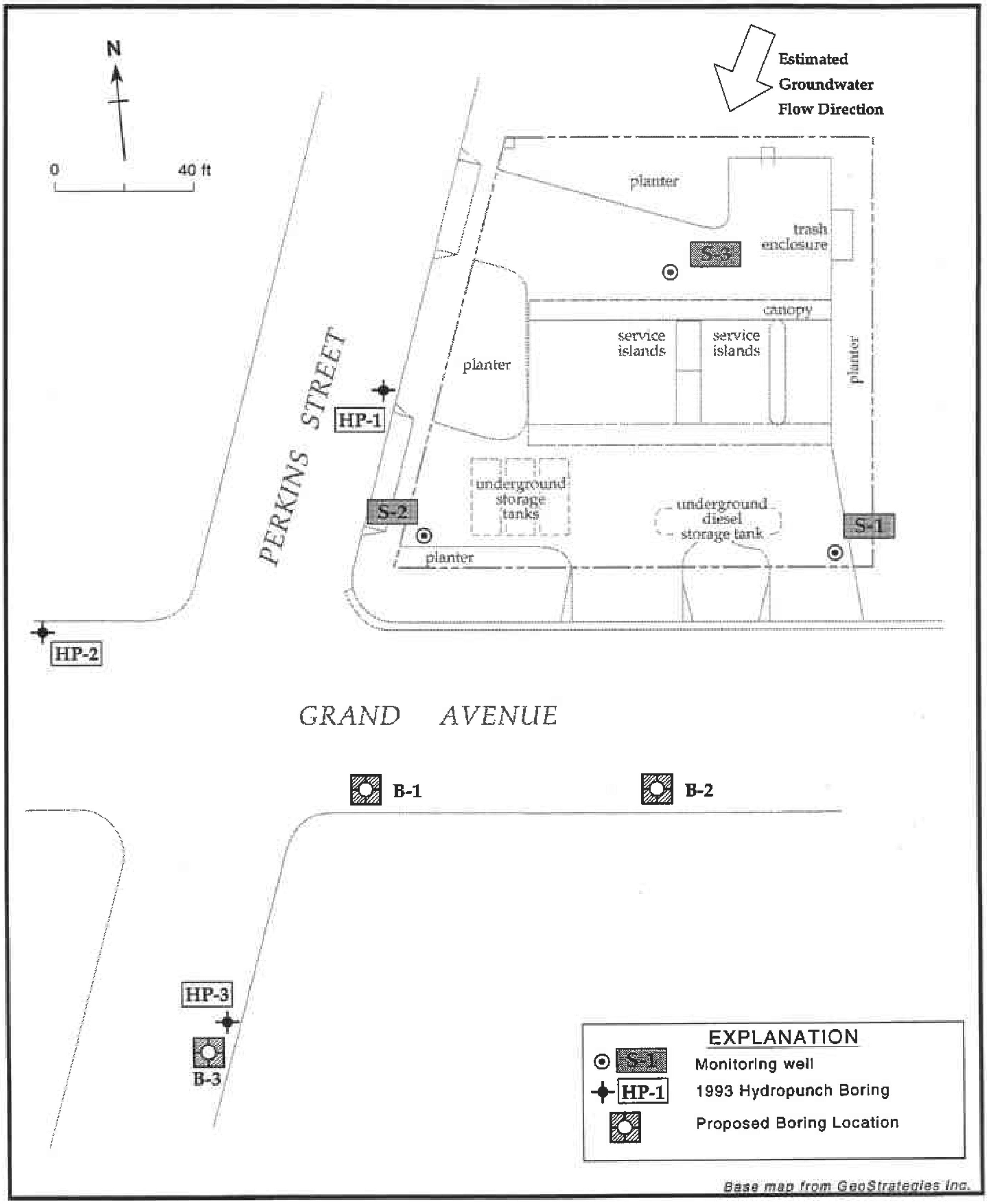

Figure 2. Proposed Boring Locations - Shell Service Station WIC #204-5510-0204, 350 Grand Avenue, Oakland, California

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ATTACHMENT A

Analytic Results for Ground Water

Table 2. **Analytic Results for Ground Water** - Shell Service Station, WIC #204-5510-0204, 350 Grand Avenue, Oakland, California

Sample ID	Date	Depth to Water (ft)	TPH-D	TPH-G	B	E	T	X	MTBE
			← parts per billion (µg/L) →						
S-1	01/23/91	9.73	<50	<50	<0.5	<0.5	<0.5	<0.5	---
	04/25/91	7.37	<50	<50	<0.5	<0.5	<0.5	<0.5	---
	07/19/91	8.92	<50	<50	6.8	<0.5	<0.5	<0.5	---
	10/09/91	9.62	260[a]	120	10	<0.5	<0.5	<0.5	---
	01/23/92	8.94	<50	<50	<0.5	<0.5	<0.5	<0.5	---
	04/27/92	7.06	70[b]	<50	1.2	<0.5	<0.5	<0.5	---
	07/10/92	8.31	930	<50	13	<0.5	<0.5	<0.5	---
	10/06/92	9.55	110	62	<0.5	<0.5	<0.5	<0.5	---
	01/06/93	9.86	81	85	1.1	<0.5	<0.5	<0.5	---
	04/26/93	6.30	53[c]	<50	<0.5	<0.5	<0.5	<0.5	---
	04/26/93[dup]	6.30	53[c]	<50	<0.5	<0.5	<0.5	<0.5	---
	07/20/93	8.78	140	<50	<0.5	<0.5	<0.5	<0.5	---
	10/18/93	9.20	210	<50	<0.5	<0.5	<0.5	<0.5	---
	01/07/94	9.53	<50	<50	1.4	0.55	1.5	2.8	---
	01/07/94[dup]	9.53	53	<50	1.2	<0.5	1.5	2.7	---
	04/11/94	8.50	320	<50	2.8	<0.5	<0.5	<0.5	---
	04/11/94[dup]	8.50	220	<50	2.6	<0.5	<0.5	<0.5	---
	07/19/94	9.07	110	<50	<0.5	<0.5	<0.5	<0.5	---
	10/06/94	11.68	370	110	1.4	<0.5	<0.5	<0.5	---
	01/04/95	8.51	1,000	120	2.5	1.5	<0.5	1.7	---
	04/12/95	6.66	290	<50	2.1	<0.5	<0.5	<0.5	---
	04/12/95[dup]	6.66	480	<50	<0.5	<0.5	<0.5	<0.5	---
	07/07/95	6.95	370	<50	5.5	<0.5	<0.5	<0.5	---
	07/07/95[dup]	6.95	450	<50	6.5	<0.5	<0.5	<0.5	---
	10/05/95	8.50	200	<50	3.9	<0.5	1.2	2.4	---
	01/12/96	8.02	1,500	230	2.5	0.9	<0.5	0.6	---
	04/02/96	4.98	2,000	95	0.91	<0.5	<0.5	<0.5	140
	07/30/96	6.40	510	<50	<0.5	<0.5	<0.5	<0.5	67
	07/30/96[dup]	6.40	380	<50	<0.5	<0.5	<0.5	<0.5	68
	10/02/96	7.53	250	<50	<0.5	<0.5	<0.5	<0.5	96

Table 2. **Analytic Results for Ground Water** - Shell Service Station, WIC #204-5510-0204, 350 Grand Avenue, Oakland, California (continued)

Sample ID	Date	Depth to Water (ft)	TPH-D	TPH-G	B	E	T	X	MTBE
			←			parts per billion (µg/L)			→
S-2	01/23/91	10.55	1,200	2,500	550	33	15	42	---
	04/25/91	8.24	20,000[b]	32,000	2,900	1,400	480	2,300	---
	07/19/91	9.55	30,000[b]	21,000	4,700	1,200	430	2,400	---
	10/09/91	10.26	32,000[b]	29,000	6,300	1,700	510	2,400	---
	01/23/92	9.51	36,000[b]	31,000	5,800	2,000	480	2,700	---
	04/27/92	7.83	12,000[b]	21,000[d]	4,800	1,600	320	1,400	---
	07/10/92	8.57	3,700[e]	31,000	7,500	3,400	940	3,500	---
	10/06/92	9.49	4,500[e]	57,000	9,300	4,000	1,200	4,900	---
	01/06/93	8.56	5,600	55,000	5,600	3,000	360	3,000	---
	04/26/93	6.84	9,400[e]	32,000	10,000	4,400	500	3,600	---
	07/20/93	8.52	8,400[e]	25,000	5,800	2,700	300	1,400	---
	07/20/93[dup]	8.52	8,900[e]	25,000	5,900	2,800	310	1,400	---
	10/18/93	9.36	18,000[e]	23,000	3,700	2,100	200	1,600	---
	10/18/93[dup]	9.36	14,000[e]	28,000	3,700	2,100	210	1,600	---
	01/07/94	8.37	22,000[e]	120,000	6,900	3,100	400	2,600	---
	04/11/94	6.96	17,000[e]	34,000	4,800	1,900	170	880	---
	07/19/94	8.02	---	23,000	4,300	1,100	210	1,000	---
	07/19/94[dup]	8.02	---	29,000	4,700	1,200	270	1,200	---
	10/06/94	11.00	---	61,000	4,600	1,900	290	1,900	---
	10/06/94[dup]	11.00	---	52,000	5,200	2,100	270	1,900	---
	01/04/95	8.07	---	23,000	4,500	1,300	49	500	---
	01/04/95[dup]	8.07	---	18,000	3,800	1,100	33	390	---
	04/12/95	6.12	---	29,000	4,300	990	210	700	---
	07/07/95	6.35	---	26,000	4,200	1,100	180	730	---
	10/05/95	7.36	10,000	26,000	3,500	1,100	150	640	---
	10/05/95[dup]	7.36	9,400	33,000	4,200	1,500	210	850	---
	01/12/96	7.64	13,000	36,000	4,100	1,400	240	790	---
	01/12/96[dup]	7.64	11,000	40,000	4,100	1,400	260	860	---
	04/02/96	6.18	7,300	12,000	1,300	460	120	150	4,000
	04/02/96[dup]	6.18	5,800	17,000	1,800	590	29	140	7,600
	07/30/96	7.22	13,000	18,000	3,000	1,200	100	420	17,000*

Table 2. **Analytic Results for Ground Water** - Shell Service Station, WIC #204-5510-0204, 350 Grand Avenue, Oakland, California (continued)

Sample ID	Date	Depth to Water (ft)	TPH-D	TPH-G	B	E	T	X	MTBE
			←			parts per billion (µg/L)			→
	10/02/96	7.60	18,000	28,000	3,700	1,100	110	260	20,000
	10/02/96[dup]	7.60	31,000	25,000	3,500	1,100	100	260	19,000
S-3	01/23/91	14.67	---	<50	<0.5	<0.5	<0.5	<0.5	---
	04/25/91	12.96	---	<50	<0.5	<0.5	<0.5	<0.5	---
	07/19/91	12.45	---	<50	<0.5	<0.5	<0.5	<0.5	---
	10/09/91	12.98	---	<50	<0.5	<0.5	<0.5	<0.5	---
	01/23/92	13.06	---	<50	<0.5	<0.5	<0.5	<0.5	---
	04/27/92	7.25	100	<50	<0.5	<0.5	<0.5	<0.5	---
	07/10/92	8.46	68	<50	<0.5	<0.5	<0.5	<0.5	---
	10/06/92	11.77	<10	<50	<0.5	<0.5	<0.5	<0.5	---
	01/06/93	12.53	<10	<50	<0.5	<0.5	<0.5	<0.5	---
	04/26/93	4.28	69	<50	<0.5	<0.5	<0.5	<0.5	---
	07/20/93	5.70	120	<50	<0.5	<0.5	0.6	<0.5	---
	10/18/93	10.30	160	<50	<0.5	<0.5	<0.5	<0.5	---
	01/07/94[f]	12.40	58	160	59	4.9	26	22	---
	04/11/94	10.94	<50	<50	<0.52	<0.5	<0.5	<0.5	---
	07/19/94	8.12	110[a]	<50	<0.5	<0.5	<0.5	<0.5	---
	10/06/94	12.15	<50	<50	<0.5	<0.5	<0.5	<0.5	---
	01/04/95	11.18	<50	<50	<0.5	<0.5	<0.5	<0.5	---
	04/12/95	3.76	110	<50	<0.5	<0.5	<0.5	<0.5	---
	07/07/95	4.72	410	<50	<0.5	<0.5	<0.5	<0.5	---
	10/05/95	5.80	160	<50	<0.5	<0.5	<0.5	<0.5	---
	01/12/96	7.00	<50	100	<0.5	<0.5	<0.5	<0.5	---
	04/02/96	3.42	170	<50	<0.5	<0.5	<0.5	<0.5	3.4
	07/30/96	5.89	92	<50	<0.5	<0.5	<0.5	<0.5	4.3
	10/02/96	7.20	160	<50	<0.5	<0.5	<0.5	<0.5	4.1
HP-1	01/27/93		14,000	22,000	2,500	1,400	130	140	---
HP-2	01/27/93		---	<50	<0.5	<0.5	4.4	<0.5	---

[illegible]

Table 2. Analytic Results for Ground Water - Shell Service Station, WIC #204-5510-0204, 350 Grand Avenue, Oakland, California (continued)

Sample ID	Date	Depth to Water (ft)	TPH-D	TPH-G	B	E	T	X	MTBE
			←			parts per billion (µg/L)			→
HP-3	01/27/93		---	<50	<0.5	<0.5	<0.5	<0.5	---
Trip Blank	01/23/91		---	<50	<0.5	<0.5	<0.5	<0.5	---
	04/25/91		---	---	---	---	---	---	---
	07/19/91		---	<50	<0.5	<0.5	<0.5	<0.5	---
	10/09/91		---	---	---	---	---	---	---
	01/23/92		<50	<50	<0.5	<0.5	<0.5	<0.5	---
	04/26/93		<50	<50	<0.5	<0.5	<0.5	<0.5	---
	07/20/93		---	<50	<0.5	<0.5	<0.5	<0.5	---
	10/18/93		<50	<50	<0.5	<0.5	<0.5	<0.5	---
	01/07/94		<50	<50	<0.5	<0.5	<0.5	<0.5	---
	04/11/94		<50	<50	<0.5	<0.5	<0.5	<0.5	---
	07/19/94		<50	<50	<0.5	<0.5	<0.5	<0.5	---
	10/06/94		---	<50	<0.5	<0.5	<0.5	<0.5	---
	01/04/95		---	<50	<0.5	<0.5	<0.5	<0.5	---
	04/12/95		---	<50	<0.5	<0.5	<0.5	<0.5	---
	07/07/95		---	<50	<0.5	<0.5	<0.5	<0.5	---
	10/05/95		---	<50	<0.5	<0.5	<0.5	<0.5	---
	01/12/96		---	<50	<0.5	<0.5	<0.5	<0.5	---
MCLs				NE	1	700	150	1,750	NE

Table 2. **Analytic Results for Ground Water -** Shell Service Station, WIC #204-5510-0204, 350 Grand, Oakland, California (continued)

Abbreviations:

TPH-G = Total petroleum hydrocarbons as gasoline by Modified EPA Method 8015
TPH-D = Total petroleum hydrocarbons as diesel by Modified EPA Method 8015
MTBE = Methyl t-butyl ether by EPA Method 8020
B = Benzene by EPA Method 8020
E = Ethylbenzene by EPA Method 8020
T = Toluene by EPA Method 8020
X = Xylenes by EPA Method 8020
--- = Not analyzed
MCLs = California Primary maximum contaminant levels for drinking water (22 CCR 64444)
NE = Not established
<n = Not detected at detection limits of n ppb
dup = Duplicate sample
HP = Hydropunch ground water sample

Notes:

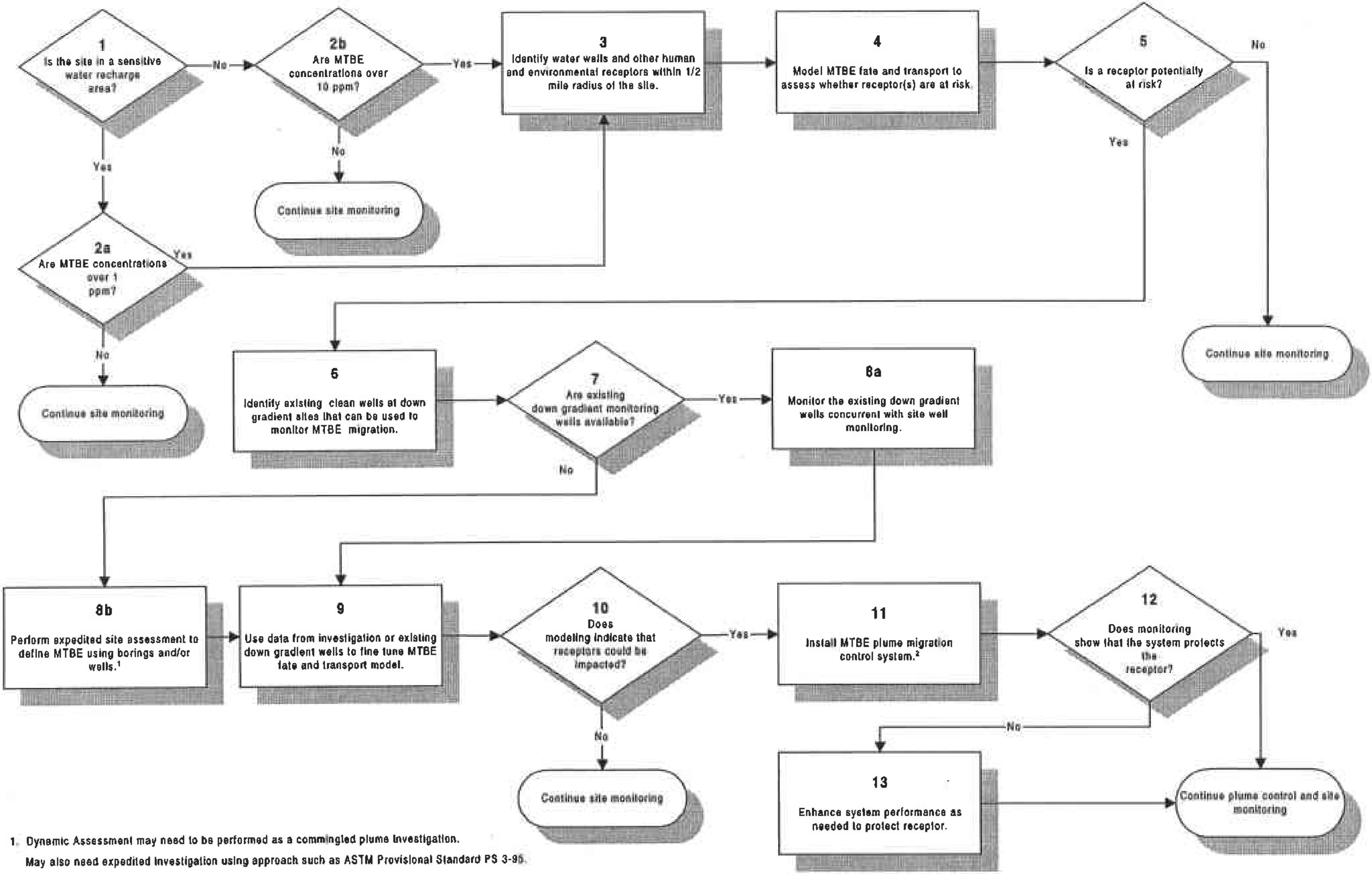
a = compounds detected and calculated as diesel are not characteristic of the standard diesel chromatographic pattern
b = Compounds detected and calculated as diesel appear to be the less volatile constituents of gasoline
c = Concentration reported as diesel primarily due to the presence of a heavier petroleum product, possibly motor oil
d = Compounds detected and calculated as gasoline are not characteristic of the standard gasoline chromatographic pattern
e = Concentration reported as diesel is primarily due to the presence of lighter petroleum product, possibly gasoline
f = TPH-G/BETX concentrations anomalous with historical data. Lab verified concentrations.
* = MTBE confirmed by EPA Method 8260

ATTACHMENT B

MTBE Investigation and Remediation Decision Flow Chart

MTBE Investigation and Remediation Decision Flow Chart

CAMBRIA



1. Dynamic Assessment may need to be performed as a commingled plume investigation. May also need expedited investigation using approach such as ASTM Provisional Standard PS 3-95.

2. Plume control systems may need to be installed as a commingled plume remediation.

ATTACHMENT C

Standard Field Procedures for Geoprobe® Sampling
and Pre-packed Well Installation

STANDARD FIELD PROCEDURES FOR GEOPROBE® SAMPLING AND PRE-PACKED WELL INSTALLATION

This document describes Cambria Environmental Technology's standard field methods for Geoprobe® soil and ground water sampling and pre-packed well installation. These procedures are designed to comply with Federal, State and local regulatory guidelines. Specific field procedures are summarized below.

Objectives

Soil samples are collected to characterize subsurface lithology, assess whether the soils exhibit obvious hydrocarbon or other compound vapor odor or staining, estimate ground water depth and quality, and to submit samples for chemical analysis.

Soil Classification/Logging

All soil samples are classified according to the Unified Soil Classification System by a trained geologist or engineer working under the supervision of a California Registered Geologist (RG), Certified Engineering Geologist (CEG), or Professional Engineer (PE). The following soil properties are noted for each soil sample:

- Principal and secondary grain size category (i.e., sand, silt, clay or gravel)
- Approximate percentage of each grain size category,
- Color,
- Approximate water or separate-phase hydrocarbon saturation percentage,
- Observed odor and/or discoloration,
- Other significant observations (i.e., cementation, presence of marker horizons, mineralogy), and
- Estimated permeability.

Soil Sampling

Geoprobe® soil samples are collected from borings using hydraulic push technologies. A minimum of one and one half ft of the soil column is collected for every five ft of drilled depth. Additional soil samples can be collected near the water table and at lithologic changes. Samples are collected using samplers lined with polyethylene or brass tubes driven into undisturbed sediments at the bottom of the borehole. The ground surface immediately adjacent to the boring is used as a datum to measure sample depth. The horizontal location of each boring is measured in the field relative to a permanent on-site reference using a measuring wheel or tape measure.

Drilling equipment is steam-cleaned or washed prior to drilling and between borings to prevent cross-contamination. Sampling equipment is washed between samples with trisodium phosphate or an equivalent EPA-approved detergent.

Sample Storage, Handling and Transport

Sampling tubes chosen for analysis are trimmed of excess soil and capped with Teflon® tape and plastic end caps and sealed in an individual zip-lock bag. Soil samples are labeled and stored at or below 4°C on either crushed or dry ice, depending upon local regulations. Samples are transported under chain-of-custody to a State-certified analytic laboratory.

Field Screening

After a soil sample has been collected, soil from the remaining tubing is placed inside a sealed plastic bag and set aside to allow hydrocarbons to volatilize from the soil. After ten to fifteen minutes, a photoionization detector measures volatile hydrocarbon vapor concentrations in the bag's headspace, extracting the vapor through a slit in the plastic bag. The measurements are used along with the field observations, odors, stratigraphy and ground water depth to select soil samples for laboratory analysis.

Grab Ground Water Sampling

Ground water samples are collected from the open borehole using bailers, by advancing disposable Tygon® tubing into the borehole and extracting ground water using a diaphragm pump, or by using a hydro-punch style sampler with a bailer or tubing. The ground water samples are decanted into the appropriate containers supplied by the analytic laboratory. Samples are labeled, placed in protective foam sleeves, stored on crushed ice at or below 4°C, and transported under chain-of-custody to the laboratory.

Duplicates and Blanks

Blind duplicate water samples are usually collected only for monitoring well sampling programs, at a rate of one blind sample for every 10 wells sampled. Laboratory-supplied trip blanks accompany samples collected for all sampling programs to check for cross-contamination caused by sample handling and transport. These trip blanks are analyzed if the internal laboratory quality assurance/quality control (QA/QC) blanks contain the suspected field contaminants. An equipment blank may also be analyzed if non-dedicated sampling equipment is used.

Grouting

If the borings are not completed as wells, the borings are filled to the ground surface with cement grout poured or pumped through a tremie pipe. When required by local regulations, the borings are abandoned using chipped or pellitized bentonite.

Pre-Packed Well Installation and Surveying

Ground water monitoring wells are installed in soil borings to monitor ground water quality and determine the ground water elevation, flow direction and gradient. Well depths and screen lengths are based on ground water depth, occurrence of hydrocarbons or other compounds in the borehole, stratigraphy, and State and local regulatory guidelines. Well screens typically extend 10 to 15 feet below and 5 feet above the static water level at the time of drilling. However, the well screen will generally not extend into or through a clay layer that is at least three feet thick.

Prior to well installation, a 2-inch rod casing with an expendable point is advanced to the desired depth. The 3-foot length pre-packed filter sections are then threaded together with the associated PVC riser and placed through the 2-inch rod casing. The pre-packed well is comprised of sand filter media housed by a stainless steel exterior and schedule-80 PVC screen inner core that is coupled together to create the desired filtered well length. Screen slot size varies according to the sediments screened, but slots are generally 0.010 or 0.020 inches wide. A rinsed and graded sand occupies the annular space between the boring and the well screen to about one to two ft above the well screen. A two feet thick hydrated bentonite seal separates the sand from the overlying sanitary surface seal composed of Portland type I, II cement.

Well-heads are secured by locking well-caps inside traffic-rated vaults finished flush with the ground surface using concrete. A stovepipe may be installed between the well-head and the vault cap for additional security. The well top-of-casing elevation is surveyed with respect to mean sea level and the well may be surveyed for horizontal location with respect to an onsite or nearby offsite landmark.

Well Development

Wells are generally developed using a combination of ground water surging and extraction. Surging agitates the ground water and dislodges fine sediments from the sand pack. After about ten minutes of surging, ground water is extracted from the well using bailing, pumping and/or reverse air-lifting through an eductor pipe to remove the sediments from the well. Surging and extraction continue until at least ten well-casing volumes of ground water are extracted and the sediment volume in the ground water is negligible. This process usually occurs prior to installing the sanitary surface seal to ensure sand pack stabilization. If development occurs after surface seal installation, then development occurs 24 to 72 hours after seal installation to ensure that the Portland cement has set up correctly.

All equipment is steam-cleaned prior to use and air used for air-lifting is filtered to prevent oil entrained in the compressed air from entering the well. Wells that are developed using air-lift evacuation are not sampled until at least 24 hours after they are developed.