Chevron

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RECEIVED

2:54 pm, Oct 23, 2007

Alameda County
Environmental Health

10-19-07
(date)

Alameda County Health Care Services
1131 Harbor Bay Parkway, Suite 250
Alameda, CA 94502-6577

Re: Chevron Facility # 9-7127

Address: I-580 and Grant Line Road, Tracy, CA Fuel Leak Case RO0000185

I have reviewed the attached report titled Additional Assessment and Revised Interim Remedial Action Plan and dated 10-19-07.

I agree with the conclusions and recommendations presented in the referenced report. The information in this report is accurate to the best of my knowledge and all local Agency/Regional Board guidelines have been followed. This report was prepared by Conestoga Rovers & Associates, upon whose assistance and advice I have relied.

This letter is submitted pursuant to the requirements of California Water Code Section 13267(b)(1) and the regulating implementation entitled Appendix A pertaining thereto.

I declare under penalty of perjury that the foregoing is true and correct.

Sincerely,

Thomas K. Bauhs
Project Manager

Enclosure: Report

CONESTOGA-ROVERS
& ASSOCIATES

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Telephone: 916·677·3407, ext. 100 Facsimile: 916·677·3687
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October 19, 2007

Ms. Donna Drogos
Alameda County Environmental Health Services
1131 Harbor Bay Parkway
Suite 250
Alameda, California 94502

Re: **Additional Assessment and Revised Interim Remedial Action Plan**
Former Chevron Station 9-7127
I-580 and Grant Line Road
Tracy, California
Fuel Leak Case RO0000185

Dear Ms. Drogos:

On behalf of Chevron Environmental Management Company (Chevron), Conestoga-Rovers & Associates (CRA) is submitting this *Additional Assessment and Revised Interim Remedial Action Plan* for the site referenced above. Alameda County Environmental Health Services (ACEHS) requested the revised workplan in a letter dated August 22, 2007 (Attachment A). Presented below are summaries of the site background and characteristics, a discussion of hydrocarbon characteristics, and revised scope of work.

SITE BACKGROUND

Site Description: The site is a vacant lot located on the east side of Grant Line Road, south of Interstate 580, Tracy, California (Figure 1). The site is at an elevation of approximately 320 feet above mean sea level. Site topography is hilly and slopes toward the site. The site is bounded by Interstate 580 to the north and ranch property to the south, east and west. Chevron operated a service station at the site until April, 1991 when all underground storage tanks (USTs), dispenser islands, and associated piping were removed and the station demolished. Previous site facilities included two 10,000-gallon and one 6,000-gallon gasoline USTs, one 1,000-gallon used oil tank, one 750-gallon heating oil tank, two dispenser islands and a station building (Figure 2).

Site Geology: Soil encountered at the site consists primarily of fill (combinations of sand, silt and clay), silty clay, clayey sand, silty sand and gravel from grade to 19 feet below grade (fbg). The soil is underlain by sandstone that extends to the maximum explored depth of 40 fbg. Cross sections are included as Attachment B. Boring logs are included as Attachment C.

Groundwater Depth and Flow Direction: Groundwater has been monitored quarterly since 1994 and semi-annually since 1999. Historical data shows that measured depth to groundwater has fluctuated from approximately 9 to 31 fbg. Groundwater flow is generally between 0.005 to 0.08 foot per foot (ft/ft) in a northerly direction. A copy of the *Groundwater Monitoring and Sampling Report Second Semi-Annual Event of 2006*, prepared by Gettler-Ryan Inc. (G-R) of Dublin, California is included as Attachment D.

PREVIOUS INVESTIGATIONS

October 1987 Soil Vapor Investigation: In October 1987, E. A. Engineering Science and Technology (EA) conducted a soil vapor investigation. Soil vapor samples were collected from 13 on-site and two off-site locations at depths ranging from 3 feet below grade (fbg) to 12 fbg. Hydrocarbons, benzene and toluene were detected at maximum concentrations of 28,500 parts per million (ppm), 3,200 ppm and 5,200 ppm, respectively, at 3 fbg .

December 1987 Borings: In December 1987, Kleinfelder, Inc. (Kleinfelder) advanced soil borings B-1 through B-7. Soil samples were collected and analyzed for total petroleum hydrocarbons as gasoline (TPHg), benzene, toluene, ethylbenzene and total xylenes (BTEX). TPHg and BTEX were detected at maximum concentrations of 2,300 ppm, 19 ppm, 85 ppm, 28 ppm and 140 ppm, respectively, in boring B-4 at 15 fbg .

December 1987 through December 1993 Domestic Well Monitoring: Between December 1987 and May 1989, concentrations of benzene in groundwater samples collected from the onsite water supply well ranged from 1.0 parts per billion (ppb) to 6.4 ppb. In May 1989, G-R installed a carbon adsorption treatment system on the onsite water supply wellhead. From December 1992 through November 1993, Pacific Environmental Group (PEG) sampled the well on a weekly basis. The water samples were analyzed for TPHg and BTEX. TPHg was not detected in any of the samples. Benzene was detected at a concentration of 0.8 ppb in the sample collected on March 19, 1993. Toluene and xylenes were detected at concentrations of 3 ppb and 2 ppb, respectively, in the sample collected on January 29, 1993.

April 1991 Tank, Product Piping and Dispenser Island Removal: In April 1991, two 10-000 gallon gasoline USTs, one 6,000-gallon gasoline UST, one 1,000-gallon used oil tank, one 750-gallon heating oil tank, dispenser islands and associated product piping were removed. No holes were observed in any of the tanks. Over-excavation of the tank basin and product piping trenches was conducted and soil samples were collected. TPHg and benzene were detected at maximum concentrations of 5,700 ppm and 30 ppm, respective, in the UST pit between 14 fbg and 15 fbg. No total petroleum hydrocarbons as diesel (TPHd) or total oil and grease were detected in the used oil tank or heating oil tank locations.

December 1992 Soil Boring and Well Installation: In December 1992, PEG advanced soil boring B-1 and installed monitoring wells MW-1 through MW-3. Soil samples were collected from B-1 and MW-1 and analyzed for TPHg and BTEX. TPHg and BTEX were detected at maximum concentrations of 8,100 ppm, 21 ppm, 560 ppm, 150 ppm and 840 ppm, respectively, in MW-1 at 29 fbg. Groundwater samples were collected from MW-2 and MW-3 on December 28, 1992 and analyzed for TPHg and BTEX. TPHg and BTEX were detected in MW-3 at concentrations of 19,000 ppb, 8,900 ppb, 660 ppb, 380 ppb and 720 ppb, respectively. MW-1 was not sampled due to the presence of separate-phase hydrocarbons (SPH).

May 1993 Soil Boring and Well Installation: In May 1993, PEG advanced soil borings B-2 through B-4. Borings B-2 and B-4 were converted to monitoring wells MW-4 and MW-5. Soil samples were collected from MW-5/B-4 and were analyzed for TPHg and BTEX. None of the constituents analyzed were detected in any of the soil samples. Grab-groundwater samples were collected from all three borings and analyzed for TPHg and BTEX. TPHg was detected in B-3 at a concentration of 96 ppb. Benzene, toluene and xylenes were detected at maximum concentrations of 12 ppb, 2 ppb and 1 ppb, respectively, in MW-4/B-2. Ethylbenzene was not detected in any of the groundwater samples.

October 1995 Well Installation: In October 1995, PEG installed monitoring wells MW-6 through MW-8. Soil samples were collected and analyzed for total purgeable petroleum hydrocarbons (TPPH) and BTEX. None of the constituents analyzed were detected in any of the soil samples.

August 1997 Assessment: In August 1997, a Risk Based Corrective Action (RBCA) Tier 2 Assessment was completed for the site. Results of the assessment indicated that groundwater ingestion could pose a risk to human health due to the elevated TPHg and benzene concentrations in MW-1, MW-3 and MW-4. The assessment also indicated that the onsite water supply well was a potential receptor for residual concentrations of petroleum hydrocarbons in the subsurface.

May 2001 Interim Corrective Action Plan: In May 2001, Delta submitted an Interim Corrective Action Plan in which Delta recommended hand bailing SPH from MW-1 on a monthly basis for two consecutive quarters and then reevaluating the SPH thickness.

April 2003 Remedial Action Plan and Feasibility Study: In April 2003, Delta Environmental Consultants, Inc. (Delta) submitted a remedial action plan and feasibility study for the site. Data from the study indicates that the groundwater beneath the site is in a perched zone overlying a confining bedrock and that the impacted soil appears to be confined to just above the groundwater table, within the capillary fringe approximately 25 to 30 fbg, in the vicinity of the former UST's. Remedial technologies evaluated included soil excavation, soil vapor extraction (SVE), groundwater extraction and natural attenuation. Due to the depth of the source and site lithology, soil excavation and SVE were not considered viable options for the site. Delta recommended removal of SPH from MW-1 using an active mechanical oil skimmer in conjunction with natural attenuation as the most feasible remedial options for the site.

May 2007 Interim Corrective Action Plan: In May, 2007, CRA submitted a Corrective Action Plan which evaluated three remedial alternatives; oxygen injection, batch groundwater extraction, and surfactant injection. The report recommended surfactant injection as the remedial alternative.

REMEDIAL ACTIONS PERFORMED

Soil Excavation: During the UST removal, additional excavation of the gasoline tank cavity was performed to remove impacted soil. The soil was aerated until concentrations were reduced to less than 10 ppm. The aerated soil was used to backfill the excavation.

Bioremediation: In August 1998, oxygen releasing compound (ORC) socks were installed in wells MW-1, MW-2 and MW-4. On July 17, 2001 the ORC sock in MW-1 was removed so that a passive product skimmer could be installed. No data is available as to when the remaining two ORC's were removed.

Hydrogen Peroxide Injection: On December 15, 1999, Cambria injected hydrogen peroxide into monitoring wells MW-1 and MW-3. Various concentrations of hydrogen peroxide were injected in the wells. For MW-1, ten gallons of 3.5 percent peroxide solution was injecting in the well, followed by ten gallons of 9 percent solution, ten gallons of 17.5 percent solution and eight gallons of 35 percent solution. For MW-3, ten gallons of 3.5 percent solution was injected, followed by ten gallons of 9 percent solution and 26 gallons of 17.5 percent solution. The maximum observed temperature was 130° Fahrenheit in MW-1 and 90° Fahrenheit in MW-3.

SPH Removal: On July 17, 2001 a passive product skimmer was installed in MW-1 and seven groundwater vacuum extraction events were conducted from July 2001 through April 2002. Approximately 8,300 gallons of groundwater and 2.19 gallons of SPH were extracted from MW-1. In July, 2002 vacuum extraction of petroleum hydrocarbon impacted groundwater from MW-3 was initiated. Due to an increase in SPH thickness in MW-1, vacuum extractions from MW-1 and MW-3 were terminated in October, 2002.

In 2007, three additional batch extractions were conducted on March 22nd, April 12th, and April 25th. Approximately 5,100 gallons of groundwater were extracted from MW-1. Product thickness was measured prior to each batch extraction event. Product thickness prior to each event was 0.5 feet, 0.36 feet and 0.39 feet, respectively.

HYDROCARBON DISTRIBUTION IN SOIL

The hydrocarbon source area appears to be in the vicinity of the former USTs and dispenser islands. The highest TPHg and benzene concentrations reported during the UST, dispenser and product piping excavations were 5,700 ppm and 30 ppm, respectively, in the UST pit at 14 fbg to 15 fbg. Varying hydrocarbon concentrations have been detected in soil samples from B-3, B-4 and MW-1. The highest TPHg and benzene concentrations reported during subsurface investigations were 8,100 ppm and 21 ppm, respectively, at 29 fbg in well MW-1. None of the soil samples were analyzed for methyl tertiary butyl ether (MTBE).

HYDROCARBON DISTRIBUTION IN GROUNDWATER

Table A below summarizes the second quarter 2007 semi-annual groundwater monitoring and sampling results.

Table A - Groundwater Analytical Data
Former Chevron Service Station 9-7127
May 9, 2007

Well I.D.	TPHg	Benzene	MTBE
	µg/L		
MW-1	Not sampled – 0.39 feet of sph		
MW-2	<50	<0.5	<0.5
MW-3	**40,000**	**9,200**	<10
MW-4	**940**	**170**	<0.5
MW-5	<50	<0.5	<0.5
MW-6	<50	<0.5	<0.5
MW-7	<50	<0.5	<0.5
MW-8	<50	<0.5	<0.5

TPHg and BTEX Distribution: Vertically, soil samples and observations during drilling such as PID readings, odors, and color changes indicate that the highest concentrations are located at the soil/water interface and capillary zone. Laterally, SPH has historically been detected in MW-1. SPH thickness has ranged from less than 0.2 feet to 1.54 feet. SPH thickness was measured on May 9, 2007 and was 0.39 feet thick. High concentrations of TPHg and BTEX have historically been reported in MW-3. During the most recent sampling event TPHg and BTEX were detected in MW-3 at concentrations of 40,000 µg/L, 9,200 µg/L, 660 µg/L, 590 µg/L and 1,300 µg/L, respectively. Lower concentrations of TPHg and BTEX have been detected in MW-4. During the last sampling event the only constituents detected in MW-4 were TPHg and benzene at concentrations of 940 µg/L and 170 µg/L. TPHg and BTEX have not been detected in MW-2, MW-5 and MW-7 since July 2002, in MW-6 since May 2001, in MW-8 since May 1998 and in the onsite supply well since April 1993.

MTBE Distribution: MTBE has not been detected in MW-2, MW-5 and the onsite supply well since November 1995, in MW-4 since November 2001, in MW-3 since May 2005, in MW-6 since May 2001 and in MW-7 and MW-8 since February 1996.

PROPOSED SCOPE OF WORK

To address RWQCB comments, CRA proposes a revised scope of work consisting of three phases:

- Additional Assessment/Remediation Wells Installed around well MW-1,
- Limited Multiphase Extraction (groundwater/vapor) Test,
- Surfactant Injection followed by numerous batch groundwater extraction events.

Bench scale testing is not included in this proposal. However, in lieu of bench scale testing, CRA is providing three relevant professional papers presenting the results of treatability testing. These papers are presented in Attachment D.

TPHg and BTEX Distribution: Vertically, soil samples and observations during drilling such as PID readings, odors, and color changes indicate that the highest concentrations are located at the soil/water interface and capillary zone. In addition, groundwater occurs beneath the site within a fractured sandstone/siltstone bedrock formation (Neroly, Tertiary age, Great Valley Sequence). These fractures have been previously described in boring logs as varying between 35 to 85 degrees and up to ½ inch thick, often comprised of hydrothermally deposited minerals such as epidote.

CRA proposes that the LNAPL present near MW-1 is located within these fractures. The proposed scope of work is designed to assess the presence and location of these fractures, assess the effectiveness of multiphase extraction within the fractured bedrock, and if judged appropriate, perform surfactant enhanced LNAPL recovery.

Additional Assessment/Remedial Well Installation

To better understand contaminant distribution, hydrogeologic characteristics, and potentially facilitate the remediation of groundwater and vapors from fractures beneath the site, CRA proposes to drill and install three groundwater monitoring wells (MW-9, MW-10, and MW-11). These wells will be located around well MW-1, encircling the well at varying distances (MW-9 at 10 feet, MW-10 at 15 feet, and MW-11 at 20 feet). Locations of the proposed wells are presented in Figure 2.

CRA proposes to perform the well installation following tasks:

Permits: CRA will obtain well installation permits from Alameda County Flood Control and Water Conservation District Zone #7 (Zone #7) prior to the beginning of any field operations. The ACEHS will be notified a minimum of 48 hours prior to field work commencement.

Site Health and Safety Plan: CRA will prepare a site safety plan to protect site workers. The plan will be kept onsite at all times and signed by all site workers and visitors each day.

Underground Utility Location: CRA will visit the site and mark the locations of proposed monitoring wells. CRA will then contact Underground Service Alert (USA) a minimum of 48 hours prior to drilling to mark and identify locations of utilities on and adjacent to the property.

Utility Clearance: Per safety requirements, each well location will be cleared to eight fbg using an air-knife assisted vacuum truck to detect any unknown utilities prior to advancing mechanical devices (e.g. hollow stem augers).

Soil Borings: CRA proposes advancing three eight-inch diameter soil borings. After clearing to 8 fbg, the borings will be advanced to approximately 38 fbg, and completed as groundwater wells MW-9, MW-10, and MW-11. The borings will be advanced using a sonic drill rig. Soil will be logged and sampled at approximately 5 foot intervals.

Soil Sample Selection: Soil samples will be selected for chemical analyses based on field screening for hydrocarbon vapors using a photo-ionization detector (PID), visual observation of soil characteristics such as discoloration, sample depth relative to the capillary fringe, and soil-texture considerations.

Well Installation: Actual monitoring well locations will be based on the field conditions and possible utility constraints. The wells will be constructed using 2-inch diameter, schedule 40 PVC pipe with 0.020-inch slotted casing from approximately 23 to 38 fbg with No. 3 Monterey Sand for the filter pack. Filter sand will be placed from the bottom of the borehole to approximately 2 feet above the screen. The well annulus will have a minimum 2-foot bentonite seal above the sand pack and will be filled with neat Portland cement to grade. CRA's standard field procedure for monitoring well installation is presented as Attachment B.

Chemical Analysis: Selected soil and groundwater samples will be analyzed for the following constituents:

- TPHg by EPA Method 8015M
- BTEX and MTBE by EPA Method 8260B

Soil and Water Disposal: Soil cuttings will be temporarily stored in 55-gallon DOT-approved steel drums. Rinse water generated during the investigation will be held temporarily onsite in 55-gallon DOT-approved steel drums. The soil and water will be transported to a Chevron-approved disposal facility following receipt of the analytical results.

Well Development and Sampling: The wells will be developed using agitation and evacuation prior to sampling. Gettler-Ryan Inc. of Dublin, California will develop and sample the wells a minimum of 72 hours after installation.

Well Elevation Survey: The well top-of-casing elevation will be surveyed with respect to mean sea level by a California Registered Surveyor.

Limited Multiphase (groundwater/vapor) Extraction Test

A multiphase extraction test will be performed prior to the injection of surfactant to determine the radial influence of enhanced-vacuum fluid recovery (EVFR) and to determine if there is preferential influence within the formation (i.e. fractures).

CRA proposes an 8 hour EVFR event, using a mobile vacuum truck, to extract groundwater from well MW-1. Tubing will be lowered into MW-1 and extraction will occur approximately one foot from the bottom of the well. The tubing will be sealed at the well surface using a rubber reducer to create a vacuum within the well and the surrounding area. A vacuum gauge will be installed on the extraction well (MW-1) to measure vacuum.

End caps will be placed over the casing of the three newly installed groundwater wells (MW-9, MW-10, and MW-11). These end caps will have Magnehelic vacuum gauges installed to measure the vacuum that is induced within the surrounding wells to determine the direction and extent of influence from the vacuum in well MW-1 and to monitor if there is preferential direction to the induced vacuum. If so, this may indicate the general orientation of the primary bedrock fractures. Additionally, water levels will be measured prior to the test, hourly during the test, and following to assist in estimating the direction and extent of influence (similar, but not the same as capture zone).

Vapor samples will not be collected for laboratory analysis. However, influent hydrocarbon concentrations in vapor will be measured with an FID. Vapor abatement will be accomplished using carbon. Water samples will be collected pre and post EVFR. Standard field procedures for groundwater monitoring and sampling is presented as Attachment C

Chemical Analysis: Selected groundwater samples will be analyzed for the following constituents:

- TPHg by EPA Method 8015M
- BTEX and MTBE by EPA Method 8260B

Surfactant Enhanced LNAPL Recovery by Multiphase Extraction

Surfactant solutions emulsify LNAPL found in formation pore spaces. The emulsification of the LNAPL greatly increases its mobility and, therefore, the ability to remove it by EVFR. Attachment D presents informational professional papers on the subject of surfactant use.

CRA believes that this site is a good candidate for surfactant enhanced LNAPL recovery by multiphase extraction. The expedited removal of LNAPL will mitigate the source of the plume, achieve regulatory compliance, and ultimately expedite case closure. Site attributes conducive to this technology include the fact that the LNAPL footprint and its accumulated thickness are small. The surfactant solution (essentially food-grade biodegradable soap) works by decreasing the interfacial surface tension between oil and water, creating a micro-emulsion of oil in water. This significantly increases the mobility of LNAPL and, during multiphase extraction, can thereby significantly enhance LNAPL recovery from a well. Ideally the subsurface around the well including bedrock fractures can be cleared of the majority of LNAPL mass, leaving low residual concentrations. This reduced residual mass will have decreased mobility, inhibiting its migration. Additionally, LNAPL removal often initiates a decreasing trend of dissolved hydrocarbon concentrations in groundwater.

A typical surfactant solution consists of approximately 5 percent surfactant in water. The surfactants we plan to use for remediation are non-toxic, biodegradable and are engineered specifically based on analysis of the LNAPL samples.

The general protocol for enhancing recovery of LNAPL around a single well is presented below: The approach used for this site will be similar but may be modified based on evaluation of Multiphase test results.

5% surfactant solution in approximately 100-gallons of water will be gravity fed into the LNAPL source area zone using the newly installed, up-gradient well MW-9. The rate of application will be slow to minimize any mounding effect during the surfactant application step. The surfactant solution will then be allowed to equilibrate in the source area smear zone for a period of 1 hour to envelop and micro-emulsify the LNAPL. This application will be followed by a 6 hour multiphase extraction event, using a mobile vacuum truck, to remove the surfactant and emulsified LNAPL from the source area. Groundwater will be extracted from wells MW-1 and MW-9 simultaneously. Extracted groundwater will be visually inspected hourly for the presence of surfactant and emulsified LNAPL from the formation. The actual duration of the multiphase extraction event will be dictated by the diminishing returns of LNAPL and surfactant concentrations observed in water produced from the wells. Typically, the volume withdrawn is at least three times the volume of applied surfactant solution. In this case, over 1,300-gallons is anticipated to be withdrawn on this initial event and all subsequent events. Subsequent multiphase batch extraction events will be scheduled for twice a month. Extraction events will cease when the recovery of surfactant and LNAPL becomes negligible.

The efficiency of the surfactant enhanced LNAPL recovery by multiphase extraction will be evaluated by measuring LNAPL thickness (if any) post-remediation, which is anticipated to be several months. We will monitor for post-treatment LNAPL rebound in the well on a twice-a-month basis in the month following the surfactant injection, followed by monthly monitoring for approximately three months. Changes in the dissolved plume will be monitored via the current quarterly groundwater monitoring program. Because the emulsion creates greater surface area contact between hydrocarbons and water, a temporary increase in dissolved hydrocarbon concentrations can occur. However, this spike is short lived and typically not observed after a few months. With the overall hydrocarbon mass removal during this process, the increase in dissolved hydrocarbon concentrations are only temporary and have historically decreased to lower than pre-treatment concentrations where this technology has been used.

Potential advantages of surfactant enhanced multiphase extraction for recovering mobile and residual LNAPL include:

- LNAPL below the water table can be recovered.
- Recovery is not restricted by LNAPL viscosity or volatility, or the thickness of the smear zone.
- Recovery does not depend on dewatering the smear zone.
- Surfactants improve the success of temporary vacuum-enhanced fluid recovery treatments in removing sufficient LNAPL to prevent its re-entry into wells.

SCHEDULE AND CLOSING

CRA will carry out this scope of work upon receiving approval from the ACEHS or after sixty (60) days with no response.

If you have any questions, please do not hesitate to contact Leon Gearhart at (916) 677-3407 ext. 115.

Sincerely,
Conestoga-Rovers & Associates

Leon Gearhart
Senior Staff Scientist

Michael Miller P.G. #6008
Senior Project Geologist

MICHAEL D. MILLER
No. 6008

Figures: 1 – Vicinity Map
2 – Site Plan

Attachments: A – Regulatory Correspondence
B – Standard Field Procedures for Monitoring Well Installation
C – Standard Field Procedures for Groundwater Monitoring and Sampling
D – Treatability Testing

cc: Mr. Tom Bauhs, Chevron Environmental Management Company, P.O. Box 6012, Room K2204, San Ramon, CA 94583

Ms.Vera Fischer, Regional Water Quality Control Board, Central Valley Region, 11020 Sun Center Drive, Suite 200, Rancho Cordova, CA 95670-6114

Mr. Ardavan Onsori, 29310 Union City Boulevard, Union City, CA 94587

Conestoga-Rovers & Associates file copy

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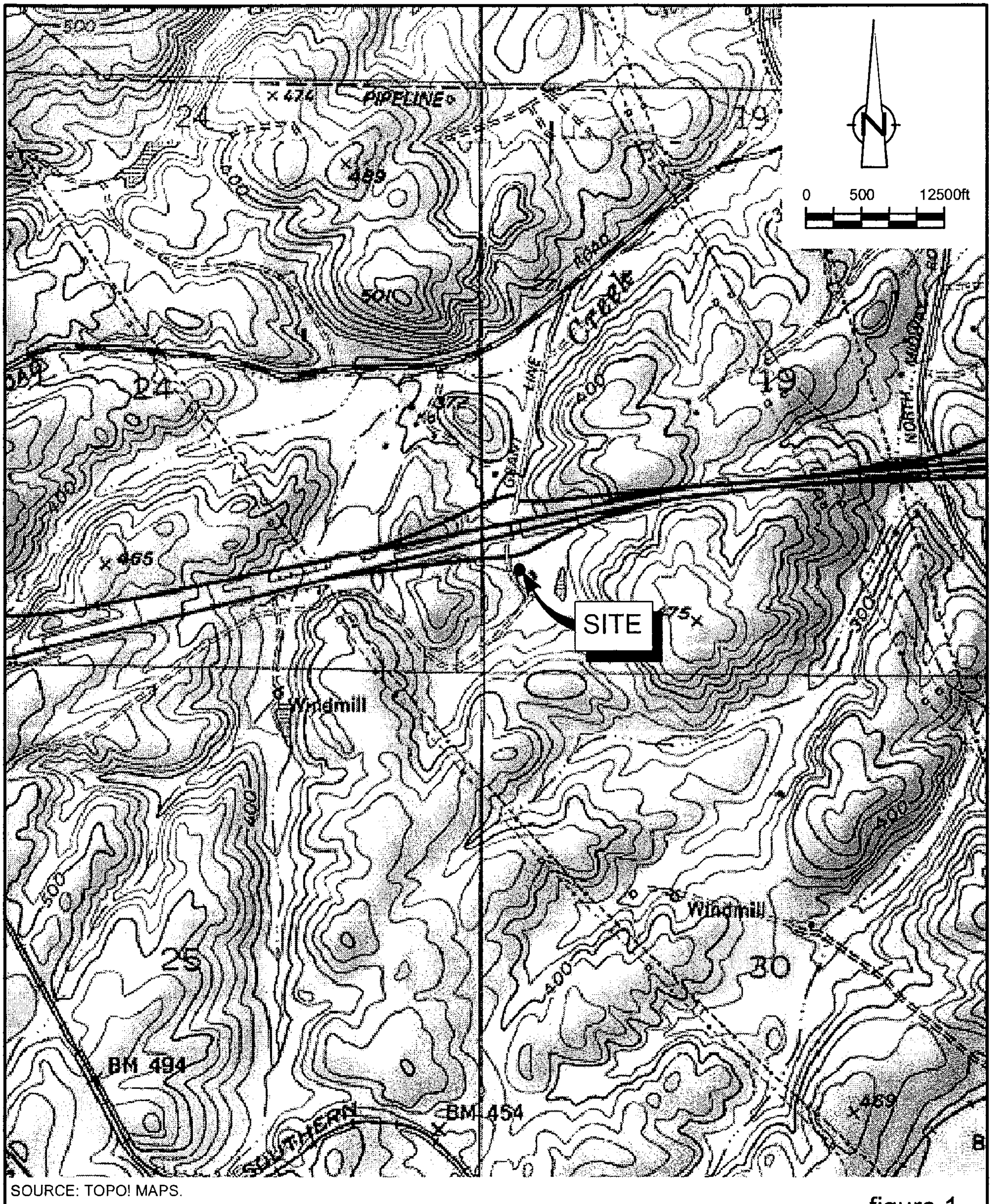

SOURCE: TOPO! MAPS.

figure 1

VICINITY MAP
FORMER CHEVRON SERVICE STATION 9-7127
GRANT LINE ROAD AND INTERSTATE 580
Tracy, California

CRA

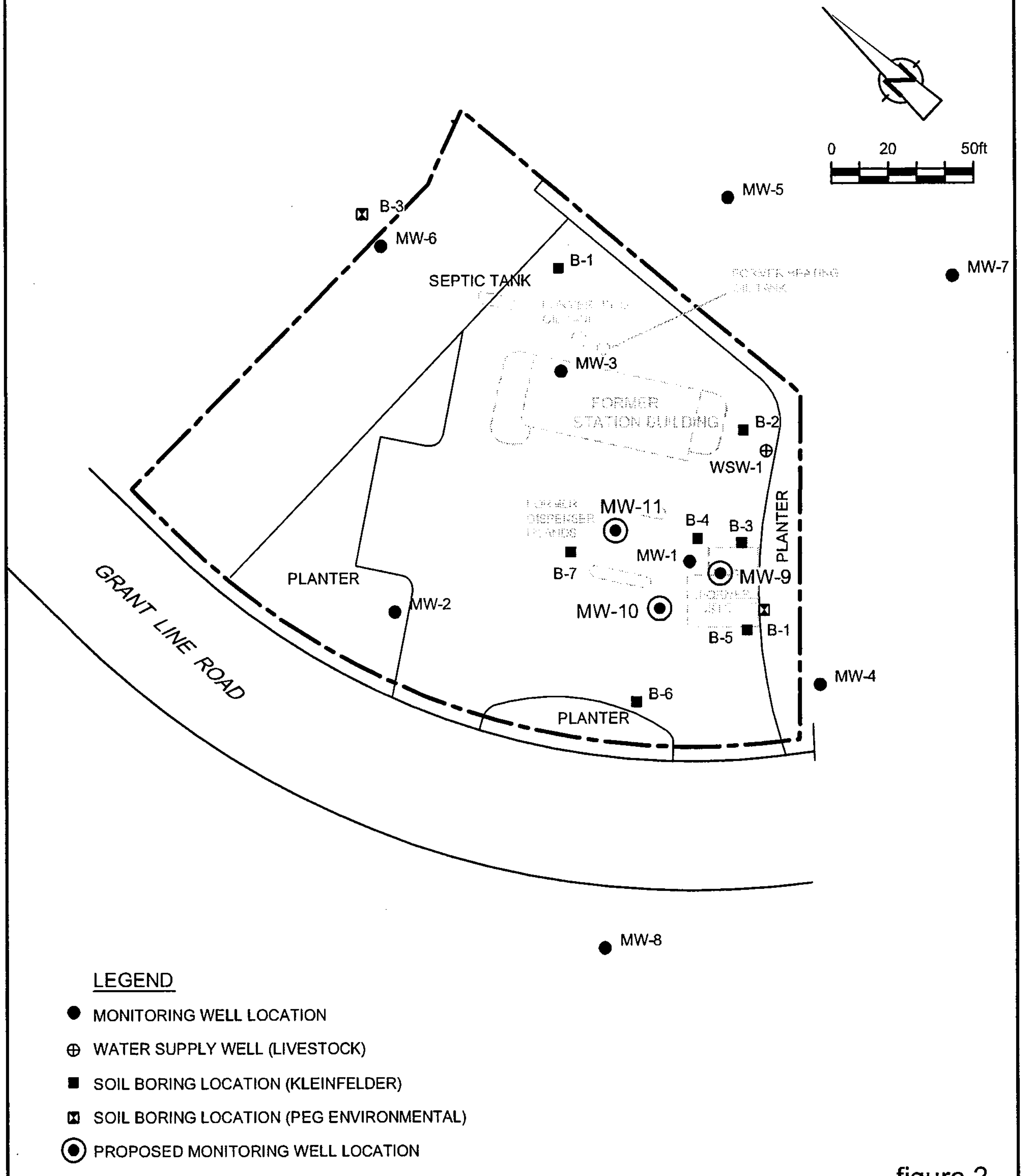

figure 2

SITE PLAN
FORMER CHEVRON SERVICE STATION 9-7127
GRANT LINE ROAD AND INTERSTATE 580
Tracy, California

ATTACHMENT A

Regulatory Correspondence

ALAMEDA COUNTY
HEALTH CARE SERVICES
AGENCY
DAVID J. KEARS, Agency Director

[illegible]
AUG 24 2007
By____

ENVIRONMENTAL HEALTH SERVICES
ENVIRONMENTAL PROTECTION
1131 Harbor Bay Parkway, Suite 250
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(510) 567-6700
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August 22, 2007

Mr. Tom Bauhs
Chevron Environmental Management Co.
Rm. K2204
6001 Bollinger Canyon Rd.
San Ramon, CA 94583

Mr. Ardavan Onsori
9310 Union City Blvd.
Union City, CA 94587

Approved____ Date____
Desc.____
Proj. #____
Acct Code____

Dear Messrs. Bauhs and Onsori:

Subject: Fuel Leak Case RO0000185 & Global ID T0600102298, Chevron #9-7127,
0 I-580 & Grant Line Rd., Tracy, CA 95376

Alameda County Environmental Health (ACEH) staff has reviewed the file for the subject site including the May 15, 2007 Corrective Action Plan, prepared by CRA & Associates. This work plan responds to the County's February 26, 2007 letter requesting a new feasibility study/corrective action plan. The corrective action plan evaluated three remediation alternatives; oxygen injection, batch extraction and surfactant injection. The report recommends surfactant injection as the remediation of choice. Prior to approval of this recommended remediation approach, our office has the following technical comments for you to address and request you submit the technical report requested below.

TECHNICAL COMMENTS

1. As you are aware, the Central Valley RWQCB has commented to you and CRA regarding their concerns with this technology, see attached May 9, 2006 letter to Mr. Bauhs. Our office echoes the Central Valley Board concerns and request that you provide the following:

    - Work plan for performing a bench scale test using contaminants at the site.

    - Work plan for contaminant characterization- Complete site characterization is essential for proper use of surfactant as a remediation tool. Such information should demonstrate the site subsurface has been completely characterized, and that any contaminant mobilized by surfactant injection will be captured by the extraction system. Such information must include, but not be limited to, capture zone analysis of an operating pump and treat system, cross-sections, maps delineating the contaminant plumes, monitoring well data, vertical and lateral definition of soil and groundwater contamination and gradient. Some of this information is included in your work plan, however, the capture zone analysis and the extent of the contamination in soil and groundwater have not been addressed. From the limited data to date, the site conceptual model stating that contamination is located in the capillary zone, 25-30' bgs has not been demonstrated. Please submit a work plan to complete contaminant characterization and verify the expected capture zone during extraction.

- Details of Surfactant Addition and Monitoring- The work plan states that an infiltration trench approximately 20' in diameter around MW-1 will be constructed to apply the surfactant and groundwater will simultaneously be extracted from this well. This process is based upon assumptions that have not yet been demonstrated. There is the assumptions that the contaminant areas will be adequately contacted, that the surfactant will migrate vertically in a uniform manner, that there will be vacuum influence from the extraction well through the vadose zone and that there will be adequate treatment time between application and extraction. These items will require additional monitoring wells and sampling data from a pilot test to demonstrate the efficacy and control of application. Please explain how these concerns will be addressed.
- ROWD Application- Please submit a copy of your approved ROWD or a variance from the Water Board to our office prior to initiating any surfactant treatment.

2. CAP and Public Participation Process- Assuming your CAP has been approved by our agency, it must then go out for public comment. Please identify all property owners within a 500' radius of this site and their mailing address so they can be notified of the proposed CAP once it has been accepted by our office. You must also provide a site map indicating the limits of the property owners who have been notified. Alternative, should you resubmit your CAP work plan as interim remediation, to avoid the Public Participation requirement.

TECHNICAL REPORT REQUEST

Please submit the following technical report according to the following schedule:

- September 22, 2007- Work Plan for bench pilot test, contaminant characterization, estimate capture zone.
- September 22, 2007- Response to Surfactant Issues/Concerns

These reports are being requested pursuant to California Health and Safety Code Section 25296.10. 23 CCR Sections 2652 through 2654, and 2721 through 2728 outline the responsibilities of a responsible party in response to an unauthorized release from a petroleum UST system, and require your compliance with this request.

ELECTRONIC SUBMITTAL OF REPORTS

Effective **January 31, 2006**, the Alameda County Environmental Cleanup Oversight Programs (LOP and SLIC) require submission of all reports in electronic form to the county's ftp site. Paper copies of reports will no longer be accepted. The electronic copy replaces the paper copy and will be used for all public information requests, regulatory review, and compliance/enforcement activities. Please do not submit reports as attachments to electronic mail. Submission of reports to the Alameda County ftp site is an addition to existing requirements for electronic submittal of information to the State Water Resources Control Board (SWRCB) Geotracker website. Submission of reports to the Geotracker website does not fulfill the requirement to submit documents to the Alameda County ftp site. In September 2004, the SWRCB adopted regulations that require electronic submittal of information for groundwater cleanup programs. For several years, responsible parties for cleanup of leaks from underground storage tanks (USTs) have been required to submit groundwater analytical data, surveyed locations of monitor wells, and other data to the Geotracker database over the Internet. Beginning July 1, 2005, electronic submittal of a complete copy of all necessary reports was required in Geotracker (in PDF format). Please visit the SWRCB website at (http://www.swrcb.ca.gov/ust/cleanup/electronic_reporting) for more information on these requirements. In order to facilitate electronic correspondence, we request that you provide up to date electronic mail addresses for all responsible and interested parties. Please provide current electronic mail addresses and notify us of future changes to electronic mail addresses by sending an electronic mail message to me at barney.chan@acgov.org.

PERJURY STATEMENT

All work plans, technical reports, or technical documents submitted to ACEH must be accompanied by a cover letter from the responsible party that states, at a minimum, the following: "I declare, under penalty of perjury, that the information and/or recommendations contained in the attached document or report is true and correct to the best of my knowledge." This letter must be signed by an officer or legally authorized representative of your company. Please include a cover letter satisfying these requirements with all future reports and technical documents submitted for this fuel leak case.

PROFESSIONAL CERTIFICATION & CONCLUSIONS/RECOMMENDATIONS

The California Business and Professions Code (Sections 6735, 6835, and 7835.1) requires that work plans and technical or implementation reports containing geologic or engineering evaluations and/or judgments be performed under the direction of an appropriately registered or certified professional. For your submittal to be considered a valid technical report, you are to present site specific data, data interpretations, and recommendations prepared by an appropriately licensed professional and include the professional registration stamp, signature, and statement of professional certification. Please ensure all that all technical reports submitted for this fuel leak case meet this requirement.

UNDERGROUND STORAGE TANK CLEANUP FUND

Please note that delays in investigation, later reports, or enforcement actions may result in your becoming ineligible to receive grant money from the state's Underground Storage Tank Cleanup Fund (Senate Bill 2004) to reimburse you for the cost of cleanup.

AGENCY OVERSIGHT

If it appears as though significant delays are occurring or reports are not submitted as requested, we will consider referring your case to the Regional Board or other appropriate agency, including the County District Attorney, for possible enforcement actions. California Health and Safety Code, Section 25299.76 authorizes enforcement including administrative action or monetary penalties of up to $10,000 per day for each day of violation.

If you have any questions, please call me at (510) 567-6765 or Donna Drogos at 510-567-6721.

Sincerely,

Barney M Chan

Barney M. Chan
Hazardous Materials Specialist

Enclosure: Messrs. Bauhs, Onsori & Ms. Chapman

cc: files, D. Drogos
Ms. J'ol Chapman, Cambria Environmental, 2000 Opportunity Drive, Suite 110,
Roseville, CA 95678
Ms. Vera Fischer, Central Valley RWQCB, 11020 Sun Center Drive, Ste. 200,
Rancho Cordova, CA 95670-6114

8_22_07 I580 Grant Line Rd

California Regional Water Quality Control Board
Central Valley Region
Robert Schneider, Chair

Dan Skopec
Acting Secretary

Sacramento Main Office
11020 Sun Center Drive #200, Rancho Cordova, California 95670-6114
Phone (916) 464-3291 • FAX (916) 464-4645
http://www.waterboards.ca.gov/centralvalley

Arnold Schwarzenegger
Governor

9 May 2006

Mr. Thomas K. Bauhs
Chevron Products Company
P.O. Box 6012
San Ramon, CA 94583

APPLICATION/REPORT OF WASTE DISCHARGE (DRAFT), CHEVRON SERVICE STATION 9-2174, 7700 AUBURN BLVD, CITRUS HEIGHTS, SACRAMENTO COUNTY

The Central Valley Regional Water Quality Control Board (Water Board) staff have received your Application/Report of Waste Discharge General Information Form 200 (ROWD) for injection of surfactants at Chevron Service Station 9-2174, 7700 Auburn Blvd, Citrus Heights, submitted on your behalf by Cambria.

According to Cambria's *Site Conceptual Model and Proposal for Remedial Pilot Testing (SCM)*, dated 4 August 2005, a pilot test to evaluate the effectiveness of applying surfactant compounds to soil and groundwater contamination at the site is proposed. The pilot test has proposed injecting a surfactant into the groundwater, allowing the surfactant to equilibrate, then recovering the surfactant and contaminants dissolved in the groundwater or adsorbed to soils by vacuum extraction.

Water Board staff have reviewed the draft ROWD submitted for the site and have the following comments:

1. A ROWD application is premature at this time. Prior to submitting a ROWD application, a bench scale test needs to be completed and the results evaluated to determine if surfactant technology would be successful at reducing petroleum concentrations at the site. The bench scale test should be conducted using soil and contaminants obtained from the site. A workplan for the bench scale test should be submitted to Sacramento County Environmental Management Department for approval, with Regional Board staff concurrence.

2. The information provided in the application is incomplete and does not provide specific information needed to determine if the proposed surfactant injection will have a negative effect on the beneficial uses of the local groundwater. Section VI, Other

Required Information, of the ROWD requests the applicant provide a *complete* characterization of the discharge. No information has been provided that details the injection procedure, recovery procedure, injection locations, best management practices that will be employed, length of test, MSDS sheets, monitoring procedures, etc. All of the information in the ROWD regarding the pilot test procedure is presented as a generalized narrative without substantive content. The application should, for example, contain information such as how the rate of surfactant injection will be determined such that the solution will not mound at the injection point and displace contaminants outward. Currently, the application only says "the rate of application will be low".

3. According to experts in the field of surfactant remediation, and Ivey International, Inc., the manufacturer of the surfactant proposed for use in the pilot test, complete site characterization is essential for proper use of surfactant as a remediation tool. Therefore, information should be provided in the application that demonstrates the site subsurface has been completely characterized, and that any contaminant mobilized by surfactant injection will be captured by an existing extraction system. Such information must include, but not be limited to, capture zone analysis of an operating pump and treat system, cross-sections, maps delineating the contaminant plumes, monitoring well data, vertical and lateral definition of soil and groundwater contamination, gradient and direction of groundwater flow, etc.
4. The ROWD should contain a copy of a bench scale test report, and information on how the results from the bench test will be used for the pilot study.

If you have any questions, please call me at 916-464-4607 or email at kamaru@waterboards.ca.gov.

KATHLEEN AMARU
Associate Engineering Geologist

cc: Mr. David Herzog, Cambria Environmental Technology, Inc.
Mr. Jack Bellan, Sacramento County Water Protection Division

ATTACHMENT B

Standard Field Procedures for Monitoring Well Installation

STANDARD FIELD PROCEDURES FOR SOIL BORING AND MONITORING WELL INSTALLATION

This document presents standard field methods for drilling and sampling soil borings and installing, developing and sampling groundwater monitoring wells. These procedures are designed to comply with Federal, State and local regulatory guidelines. Specific field procedures are summarized below.

SOIL BORINGS

Objectives

Soil samples are collected to characterize subsurface lithology, assess whether the soils exhibit obvious hydrocarbon or other compound vapor or staining, and to collect samples for analysis at a State-certified laboratory. All borings are logged using the Unified Soil Classification System by a trained geologist working under the supervision of a California Professional Geologist (PG).

Soil Boring and Sampling

Soil borings are typically drilled using hollow-stem augers or direct-push technologies such as the Geoprobe®. Soil samples are collected at least every five ft to characterize the subsurface sediments and for possible chemical analysis. Additional soil samples are collected near the water table and at lithologic changes. Samples are collected using lined split-barrel or equivalent samplers driven into undisturbed sediments at the bottom of the borehole.

Drilling and sampling equipment is steam-cleaned 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 Analysis

Sampling tubes chosen for analysis are trimmed of excess soil and capped with Teflon tape and plastic end caps. 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

One of the remaining tubes is partially emptied leaving about one-third of the soil in the tube. The tube is capped with plastic end caps and set aside to allow hydrocarbons to volatilize from the soil. After ten to fifteen minutes, a portable volatile vapor analyzer measures volatile hydrocarbon vapor concentrations in the tube headspace, extracting the vapor through a slit in the cap. Volatile vapor analyzer measurements are used along with the field observations, odors, stratigraphy and groundwater depth to select soil samples for analysis.

Water Sampling

Water samples, if they are collected from the boring, are either collected using a driven Hydropunch® type sampler or are collected from the open borehole using bailers. The groundwater 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. Laboratory-supplied trip blanks accompany the samples and are analyzed to check for cross-contamination. An equipment blank may 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.

MONITORING WELL INSTALLATION, DEVELOPMENT AND SAMPLING

Well Construction and Surveying

Groundwater monitoring wells are installed to monitor groundwater quality and determine the groundwater elevation, flow direction and gradient. Well depths and screen lengths are based on groundwater 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.

Well casing and screen are flush-threaded, Schedule 40 PVC. 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 feet 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. 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 is surveyed for horizontal location with respect to an onsite or nearby offsite landmark.

Well Development

Wells are generally developed using a combination of groundwater surging and extraction. Surging agitates the groundwater and dislodges fine sediments from the sand pack. After about ten minutes of surging, groundwater 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 groundwater are extracted and the sediment volume in the groundwater 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.

Groundwater Sampling

Depending on local regulatory guidelines, three to four well-casing volumes of groundwater are purged prior to sampling. Purging continues until groundwater pH, conductivity, and temperature have stabilized. Groundwater samples are collected using bailers or pumps and 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. Laboratory-supplied trip blanks accompany the samples and are analyzed to check for cross-contamination. An equipment blank may be analyzed if non-dedicated sampling equipment is used.

Waste Handling and Disposal

Soil cuttings from drilling activities are usually stockpiled onsite and covered by plastic sheeting. At least three individual soil samples are collected from the stockpiles and composited at the analytic laboratory. The composite sample is analyzed for the same constituents analyzed in the borehole samples in addition to any analytes required by the receiving disposal facility. Soil cuttings are transported by licensed waste haulers and disposed in secure, licensed facilities based on the composite analytic results.

Groundwater removed during development and sampling is typically stored onsite in sealed 55-gallon drums. Each drum is labeled with the drum number, date of generation, suspected contents, generator identification and consultant contact. Upon receipt of analytic results, the water is either pumped out using a vacuum truck for transport to a licensed waste treatment/disposal facility or the individual drums are picked up and transported to the waste facility where the drum contents are removed and appropriately disposed.

ATTACHMENT C

Standard Field Procedures for Groundwater Monitoring and Sampling

Conestoga-Rovers & Associates

STANDARD FIELD PROCEDURES FOR GROUNDWATER MONITORING AND SAMPLING

This document presents standard field methods for groundwater monitoring, purging and sampling, and well development. These procedures are designed to comply with Federal, State and local regulatory guidelines. Cambria's specific field procedures are summarized below.

Groundwater Elevation Monitoring

Prior to performing monitoring activities, the historical monitoring and analytical data of each monitoring well shall be reviewed to determine if any of the wells are likely to contain non-aqueous phase liquid (NAPL) and to determine the order in which the wells will be monitored (i.e. cleanest to dirtiest). Groundwater monitoring should not be performed when the potential exists for surface water to enter the well (i.e. flooding during a rainstorm).

Prior to monitoring, each well shall be opened and the well cap removed to allow water levels to stabilize and equilibrate. The condition of the well box and well cap shall be observed and recommended repairs noted. Any surface water that may have entered and flooded the well box should be evacuated prior to removing the well cap. In wells with no history of NAPL, the static water level and total well depth shall be measured to the nearest 0.01 foot with an electronic water level meter. Wells with the highest contaminant concentrations shall be measured last. In wells with a history of NAPL, the NAPL level/thickness and static water level shall be measured to the nearest 0.01 foot using an electronic interface probe. The water level meter and/or interface probe shall be thoroughly cleaned and decontaminated at the beginning of the monitoring event and between each well. Monitoring equipment shall be washed using soapy water consisting of Liqui-nox™ or Alconox™ followed by one rinse of clean tap water and then two rinses of distilled water.

Groundwater Purging and Sampling

Prior to groundwater purging and sampling, the historical analytical data of each monitoring well shall be reviewed to determine the order in which the wells should be purged and sampled (i.e. cleanest to dirtiest). No purging or groundwater sampling shall be performed on wells with a measurable thickness of NAPL or floating NAPL globules. If a sheen is observed, the well should be purged and a groundwater sample collected only if no NAPL is present. Wells shall be purged either by hand using a disposal or PVC bailer or by using an aboveground pump (e.g. peristaltic or Wattera™) or down-hole pump (e.g. Grundfos™ or DC Purger pump).

Groundwater wells shall be purged approximately three to ten well-casing volumes (depending on the regulatory agency requirements) or until groundwater parameters of temperature, pH, and conductivity have stabilized to within 10% for three consecutive readings. Temperature, pH, and conductivity shall be measured and recorded at least once per well casing volume removed. The total volume of groundwater removed shall be recorded along with any other notable physical characteristic such as color and odor. If required, field parameters such as turbidity, dissolved oxygen (DO), and oxidation-reduction potential (ORP) shall also be measured prior to collection of each groundwater sample.

Groundwater samples shall be collected after the well has been purged. If the well is slow to recharge, a sample shall be collected after the water column is allowed to recharge to 80% of the pre-purging static water level. If the well does not recover to 80% in 2 hours, a sample shall be collected once there is enough groundwater in the well. Groundwater samples shall be collected using clean disposable bailers or pumps (if an operating remediation system exists on site and the project manager approves of its use for sampling) and shall be decanted into clean containers supplied by the analytical laboratory. New latex gloves and disposable tubing or bailers shall be used for sampling each well. If a PVC bailer or down-hole pump is used for groundwater purging, it shall be decontaminated before purging each well by using soapy water consisting of Liqui-nox™ or Alconox™ followed by one rinse of clean tap water and then two rinses of distilled water. If a submersible pump with non-dedicated discharge tubing is used for groundwater purging, both the inside and outside of pump and discharge tubing shall be decontaminated as described above.

Sample Handling

Except for samples that will be tested in the field, or that require special handling or preservation, samples shall be stored in coolers chilled to 4° C for shipment to the analytical laboratory. Samples shall be labeled, placed in protective foam sleeves or bubble wrap as needed, stored on crushed ice at or below 4° C, and submitted under chain-of-custody (COC) to the laboratory. The laboratory shall be notified of the sample shipment schedule and arrival time. Samples shall be shipped to the laboratory within a time frame to allow for extraction and analysis to be performed within the standard sample holding times.

Sample labels shall be filled out using indelible ink and must contain the site name; field identification number; the date, time, and location of sample collection; notation of the type of sample; identification of preservatives used; remarks; and the signature of the sampler. Field identification must be sufficient to allow easy cross-reference with the field datasheet.

All samples submitted to the laboratory shall be accompanied by a COC record to ensure adequate documentation. A copy of the COC shall be retained in the project file. Information on the COC shall consist of the project name and number; project location; sample numbers; sampler/recorder's signature; date and time of collection of each sample; sample type; analyses requested; name of person receiving the sample; and date of receipt of sample.

Laboratory-supplied trip blanks shall accompany the samples and be analyzed to check for cross-contamination, if requested by the project manager.

Waste Handling and Disposal

Groundwater extracted during sampling shall be stored onsite in sealed U.S. DOT H17 55-gallon drums and shall be labeled with the contents, date of generation, generator identification, and consultant contact. Extracted groundwater may be disposed offsite by a licensed waste handler or may be treated and discharged via an operating onsite groundwater extraction/treatment system.

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ATTACHEMENT D

Treatability Testing

Surfactant Enhanced LNAPL Recovery and Attenuation

Robert J. Tworkowski, PG, URS Corporation
and
Jason L. Baer, REM, Maryland Environmental Service

Background

Many leaking underground storage tank cases, even those not considered to pose a threat to human health or the environment, remain open due to the periodic presence of residual light non-aqueous phase liquids (LNAPLs). Although the majority of the LNAPL has been removed at many of these sites, it is not unusual to find open environmental cases that exceed 10 years of age. The residual phase of the LNAPL continues to degrade ground water quality by partitioning into dissolved phase concentrations that can be in excess of regulatory criteria. Corporations have finite resources that they are able to allocate to the remediation of these types of sites. Although the individual budgets on these low-risk sites can be minimal, their collective impact on corporate environmental programs can be quite significant. In order to ensure that adequate funding is available for sites that truly pose a risk to human health and the environment and warrant active remediation, regulatory agencies and companies alike are evaluating alternative, non-traditional approaches and technologies for the cleanup of these low-risk sites. The expedited removal of residual LNAPL can help mitigate the source of the dissolved phase plume, minimize the risk to potential receptors, achieve regulatory compliance, and ultimately expedite case closure.

Approach

To accelerate cleanup and closure of these low-risk sites, two non-conventional remedial approaches have been combined: in-situ surfactant flushing and mobile multi-phase high-vacuum extraction. Surfactants are designed to change the interfacial tension between the water and NAPL bodies and desorb the residual LNAPLs entrained in the soil matrix by micro-emulsifying the organic particles, and forming a micelle. In the case of weathered LNAPLs, surfactants have been used to decrease the viscosity of the material, resulting in increased and more efficient recovery. Surfactants are also considered bioremediation enhancing and vapor suppression agents. The use of mobile multi-phase high-vacuum extraction allows the environmental engineer to focus remediation efforts at a targeted area of the site without incurring the cost and disruption associated with traditional permanent remediation approaches. Additionally, this method increases the effective radius of influence, while minimizing the volume of effluent recovered that requires treatment and/or disposal. This combined approach involves the in-situ application of a surfactant mixture, under pressure, into the site subsurface. The injection is followed by high-vacuum induced multi-phase recovery from an extraction well, via a mobile vacuum truck.

In addition to the physical removal of residual LNAPL and dissolved constituents during the flushing and extraction process, this study evaluated the solubilization and mobilization of the residual LNAPL and dissolved constituents following extraction. While there has been concern that the addition of a surfactant mixture may only result in the dilution and physical dispersion of any residual LNAPL and potentially increase the concentrations of the dissolved constituents, this study observed the successful mass phase transfer/removal following surfactant application/extraction and tracked the resulting attenuation of the dissolved constituents.

When surfactants are introduced into a water / NAPL system, they have two major results: 1) mobilization of free NAPL and 2) solubilization of residual NAPL. Of these two, mobilization is more rapid and has resulted in much of the negative views of surfactant use. In order to counteract the effects of mobilization and prevent unwanted migration, this study followed the surfactant injection with an extraction event to capture and remove the majority of the mobilized NAPL mass. Additionally, as shown with many other remediation technologies, more effective mass removal is achievable when a system is not allowed to achieve equilibrium. One example of this is the use of pulsed air sparging versus continuous air sparging. It was decided that the combined use of an injection and extraction event in close temporal proximity could help achieve this desired "push-pull" type of disequilibrium.

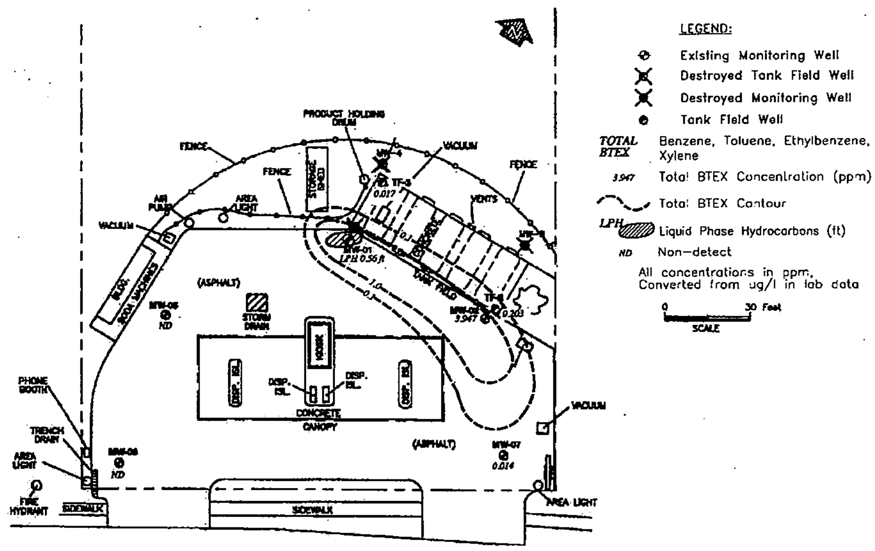


FIGURE 1
TOTAL BTEX ISOCONCENTRATION MAP (ppm)

Data from May 9, 2003.

URS

Site Background

The site selected for this test is an operational retail gasoline service station. The site is located in the southern portion of Maryland, within the Coastal Plain. The lithology of the site is characterized by interbedded alluvial sands, silts, clays and gravels. Ground water at the site is found at a depth of approximately 15-feet below ground surface. Ground water at the site generally flows to the southwest at an approximate gradient of 0.0003 feet/foot. Figure 1 depicts a map that shows the general features of the site and the location of the injection / extraction and monitoring wells as well as total benzene, toluene, ethylbenzene, and xylenes (BTEX) concentrations detected in the monitoring wells prior to applying the surfactant.

There has been an open environmental case at the site since 1984, due in part to the intermittent presence of LNAPL in several of the ground water monitoring wells at the site. Although the case has been open for over two decades, active remediation was not undertaken due to the limited areal distribution of LNAPL and high dissolved BTEX in the ground water at the site. Additionally, since only the surficial, water-table “aquifer” was impacted and the site is not located in an area with potable wells, active remediation was not deemed necessary to protect human health and the environment. The case could not be closed previously due to the limited presence of LNAPL in one of the monitoring wells (Maryland regulations prohibit the closure of cases with LNAPL present and require the removal of LNAPL to the maximum extent practical – a sheen). Environmental activities at the site were limited to quarterly ground water monitoring and the use of passive bailers for LNAPL recovery.

Historically, a dissolved BTEX plume has extended from the area of the underground storage tank (UST) tank field to the area of well MW-7. Well MW-1 has historically contained several inches of LNAPL, while well MW-2 has contained periodic traces of LNAPL. The maximum LNAPL thickness reported historically in well MW-1 was approximately 1.40 feet. However, at the beginning of the pilot test, MW-1 contained approximately 0.56 foot of LNAPL.

Surfactant Injection / Extraction Event #1

On October 6, 2003, all wells at the subject site were gauged. Monitoring well MW-1 was found to contain 0.56 foot of LNAPL and MW-2 was found to contain 0.01 foot of LNAPL. Following well gauging and preparation of necessary materials, 150 gallons of 4% solution proprietary-blend non-ionic surfactant (EC-165, EnviroClean, LLC) was injected into well MW-1. Approximately 100 gallons of 3% solution surfactant was injected into well MW-2. The surfactant mixture was injected through a down-well surge block at a flow rate of approximately 5 gallons per minute (gpm) and a pressure of approximately 15 pounds per square inch (psi). It was estimated that the surfactant mixture achieved a radius of influence of approximately 10 feet around the injection wells. Based on literature research of surfactants, the surfactants were left in the ground for a period of approximately 72 hours prior to extraction.

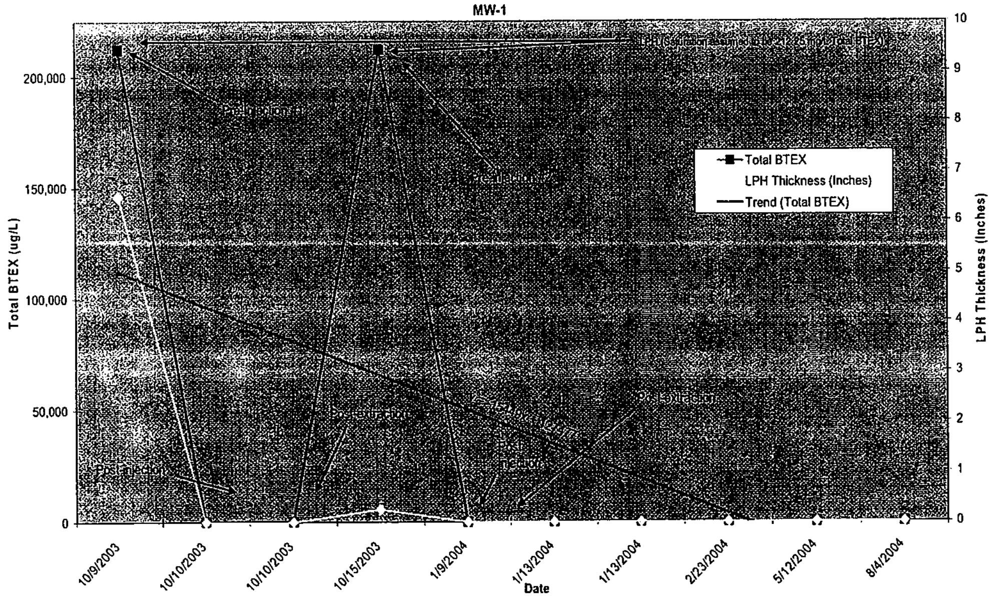
On October 9, 2003, all wells at the subject site were gauged. MW-1 and MW-2 were not found to contain any LNAPL. Following well gauging, a vacuum truck equipped with a down-well drop-tube and well seal was utilized to evacuate the liquid in the two injection wells, under vacuum. Approximately 500 gallons of water, LNAPL, and emulsion was removed from well MW-1 and approximately 300 gallons of water and emulsion was removed from well MW-2.

Following completion of the first surfactant injection and extraction event, the monitoring wells at the site were gauged several times. Approximately 0.02 foot of LNAPL was detected in MW-1 one week subsequent to the completion of the extraction event, and LNAPL did not return to MW-2. Due to the presence of residual LNAPL in MW-1, it was decided that one additional surfactant application would be conducted.

Ground Water Monitoring Results Subsequent to Event #1

Subsequent to the first surfactant injection / extraction event, but prior to the second event, a round of ground water samples was collected from all of the monitoring wells at the site. A >99.99% reduction in total BTEX concentrations was observed in injection / extraction well MW-1 and a 97% reduction in total BTEX concentrations was observed in injection / extraction well MW-2. BTEX concentrations in downgradient wells MW-5 and MW-6 remained non-detect during this sampling period. However monitoring well MW-5 did exhibit a slight increase in methyl tertiary butyl ether (MTBE) concentrations (64 parts per billion [ppb] to 285 ppb). A slight increase in dissolved BTEX concentration was observed in Well MW-7 (14 ppb to 68 ppb) subsequent to the first injection / extraction event. The ground water monitoring results from MW-1 are included in Figure 2. The ground water monitoring results from MW-2 are included in Figure 3.

Figure 2
Surfactant Injection & Extraction Well
MW-1



Surfactant Injection / Extraction Event #2

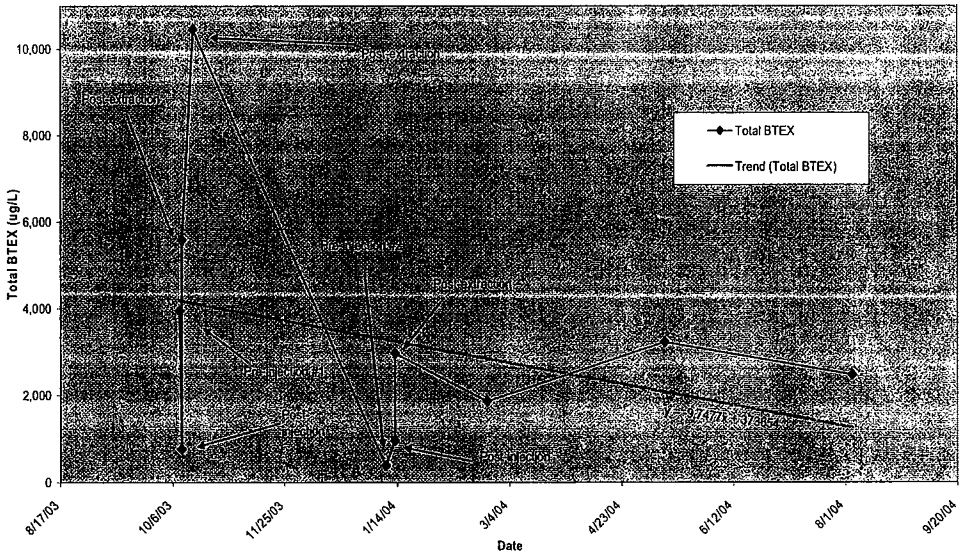
On January 9, 2004, all wells at the subject site were gauged. MW-1 and MW-2 were not found to contain any LNAPL. However, due to the presence of relatively high levels of dissolved BTEX in the vicinity of the two injection / extraction wells, a second surfactant injection and extraction event was completed. Following well gauging and preparation of necessary materials, 200 gallons of 5% solution proprietary-blend non-ionic surfactant (EC-165, EnviroClean, LLC) was injected into well MW-1. Approximately 100 gallons of 5% solution surfactant was injected into well MW-2. The surfactant mixture was injected through a down-well surge block at a flow rate of approximately 5 gpm and a pressure of approximately 15 psi. The surfactants were left in the ground for a period of approximately 96 hours prior to extraction during this injection event.

On January 13, 2004, all wells at the subject site were gauged. MW-1 and MW-2 were not found to contain any LNAPL. Following well gauging, a vacuum truck equipped with a down-well drop-tube and well seal was utilized to evacuate the liquid in the two injection wells, under vacuum. Approximately 390 gallons of water and LNAPL emulsion was removed from well MW-1 and approximately 625 gallons of water and LNAPL emulsion was removed from well MW-2.

Ground Water Monitoring Results Subsequent to Event #2

Subsequent to the second surfactant injection / extraction event, a round of samples was collected from all of the ground water monitoring wells at the site. Approximately an additional 60% reduction in total BTEX concentrations was observed in injection / extraction well MW-1, for a net reduction of >99.99% over pre-test concentrations, and a net 40% reduction in overall total BTEX concentrations was observed in injection / extraction well MW-2. BTEX concentrations in downgradient monitoring well MW-5 went from non-detect levels of benzene to a detectable concentration of 1 ppb. MTBE concentrations in monitoring well MW-5 increased from 285 ppb to 555 ppb. Downgradient monitoring well MW-6 remained non-detect for BTEX and MTBE. BTEX concentrations in monitoring well MW-7 slightly increased from 68 ppb to 80 ppb. The ground water monitoring results from MW-1 are included in Figure 2. The ground water monitoring results from MW-2 are included in Figure 3.

Figure 3
Surfactant Injection & Extraction Well
MW-2

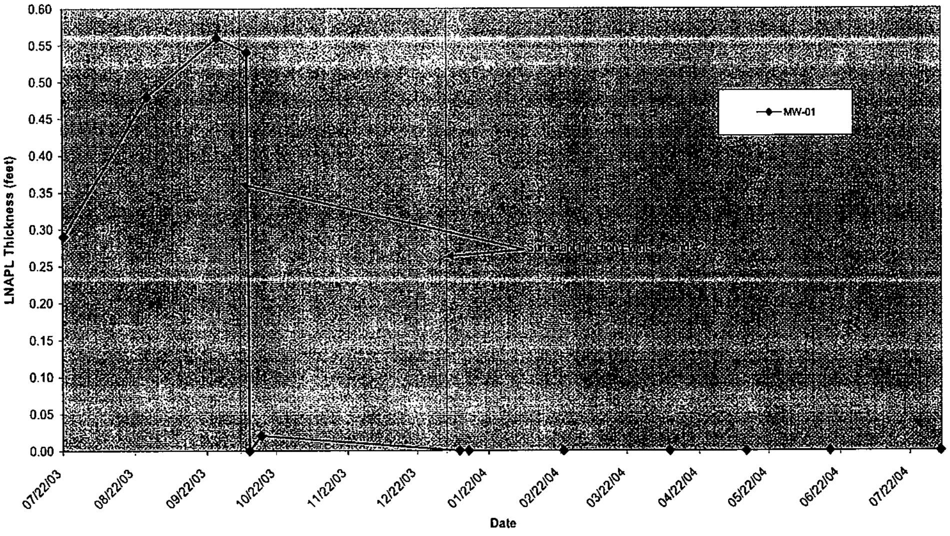


Ground Water Monitoring Results in Surfactant Injection / Extraction Wells

The study found that LNAPL was not observed in any of the test sites following the two surfactant injection and extraction events. The LNAPL reduction observed in MW-1 was significant. Prior to the initiation of the test, MW-1 contained 0.56 foot of LNAPL. Subsequent to the completion of the test, MW-1 was found to not contain measurable LNAPL. LNAPL monitoring results are depicted in Figure 4. Also, the study found that dissolved BTEX concentrations in the injection / extraction wells was reduced by 99.99% and 18% in wells MW-1 and MW-2, respectively, following the two surfactant injection and extraction events.

As discussed previously, the two main mechanisms associated with the use of surfactants in a water / oil system are mobilization and solubilization. Both of these mechanisms were observed during the study. First, the majority of the LNAPL mass in the site subsurface was mobilized following the injection of the surfactant solution. Within several days of the injections, Winsor Type III reactions were observed in MW-1. The Winsor Type III reaction is characterized by the presence of three distinct phases: an aqueous or dissolved phase, a micro-emulsion phase, and a NAPL phase. During the vacuum extraction event performed on October 9, 2003, this multi-phase phenomenon was observed. Fluids recovered from the vicinity of MW-1 included hydrocarbon-impacted ground water, micro-emulsion globules, and LNAPL. The amount of fluid recovered from well MW-1 was approximately 500 gallons. It was estimated that approximately 25% of this fluid consisted of NAPL and micro-emulsion, with the remainder of the mixture being comprised of impacted ground water and surfactant solution. Within a relatively short period of time (several days to weeks) following the initial injection / extraction event, dissolved BTEX concentrations in well MW-2 increased significantly. During this same period of time, residual LNAPL in the vicinity of MW-1 continued to be mobilized by the residual surfactant. The occurrence of the residual surfactant was confirmed during subsequent monitoring events, visually by the presence of a tracer dye that was included in the surfactant formulation. Following the initial extraction event on MW-1, no LNAPL was detected. However, within one week after the extraction event, the LNAPL thickness in MW-1 had returned to 0.02 foot. Solubilization of the LNAPL mass present in the site subsurface was observed during this study; however, mobilization appeared to be the predominant mechanism, followed by solubilization. As shown in Figure 3, there was a marked increase in dissolved BTEX concentrations immediately following the initial surfactant injection. As shown in this figure, however, the relatively high dissolved BTEX concentrations appeared to quickly attenuate. It is believed that the surfactant released the NAPL mass from the relatively unavailable residual phase into the extremely bioavailable dissolved or aqueous phase, where it can be readily broken down by resident microbe populations.

Figure 4
Measured LNAPL Thickness
MW-1



Ground Water Monitoring Results in Downgradient Wells

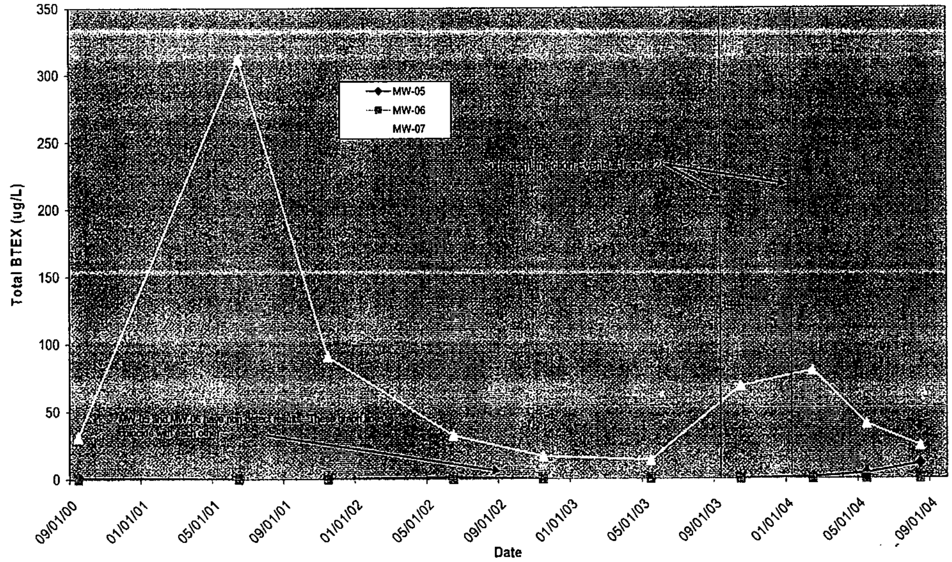
There is concern that the surfactant treatments can be simply diluting, displacing, or dispersing the LNAPL mass and result in creating a more dissolved fraction. In order to evaluate this potential concern, close attention was given to the two ground water monitoring wells located hydraulically downgradient from the surfactant injection / extraction wells, MW-1 and MW-2. Figure 5 depicts the results of ground water samples collected from downgradient wells MW-5 and MW-6, as well as the side gradient well MW-7. Given the historical direction of ground water flow at the site and the spatial proximity to the source and treatment area, special consideration was given to well MW-5.

As to the concept of dilution, during the initial surfactant injection event, approximately 250 gallons of surfactant solution were introduced into the subsurface in the areas of MW-1 and MW-2. The volume of non-native fluid introduced into the system is <0.5% of the total volume of the water contained in the area between MW-1 and MW-2. It is highly unlikely that this extremely small volume of water, relative to the water volume of the test area, resulted in the initial concentration reductions of 97% to >99% observed during the first phase of the test.

With regard to the role displacement and dispersion play on this site, the data collected from the downgradient monitoring wells may support limited contribution due to these mechanisms. Immediately following the first and second surfactant injection / extraction events, the dissolved petroleum concentrations in MW-5 increased. Benzene concentrations went from non-detect to 9 ppb. BTEX concentrations went from non-detect to 11 ppb. MTBE concentration went from 64 to 1,960 ppb. If a correlation does exist (there are no contributions from current operations at the service station), the decrease in mass observed in the areas of MW-1 and MW-2 would likely result in significantly higher dissolved petroleum concentrations than those observed in MW-5. It should also be noted that within 3-4 days of injection, the surfactant solution was extracted. In fact, 3-4 times the initial injection volume was recovered and removed by the vacuum extraction unit.

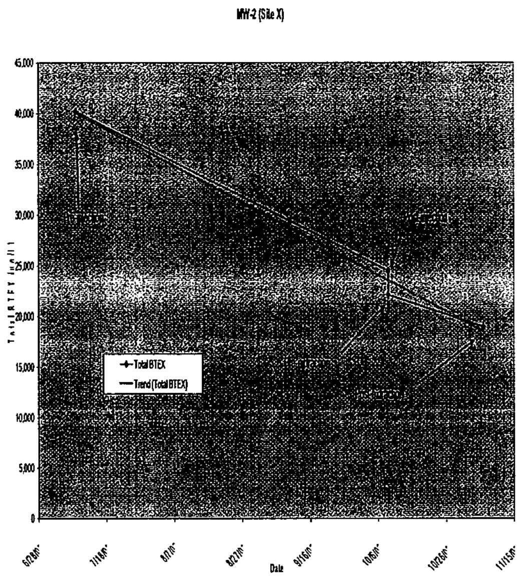
In the absence of dilution, dispersion, or displacement as the mechanisms for the attenuation observed at the site, the ideas of bioavailability and biodegradation are given more weight. Although no microbial samples were collected as part of this study and biodegradation was not directly studied, anecdotal evidence supports the occurrence of enhanced biodegradation subsequent to the injection / extraction events. It is believed that the significant attenuation rates observed in wells MW-1 and MW-2, subsequent to the injection / extraction events is due to the increased bioavailability of the contaminant mass as a by-product of increased solubilization.

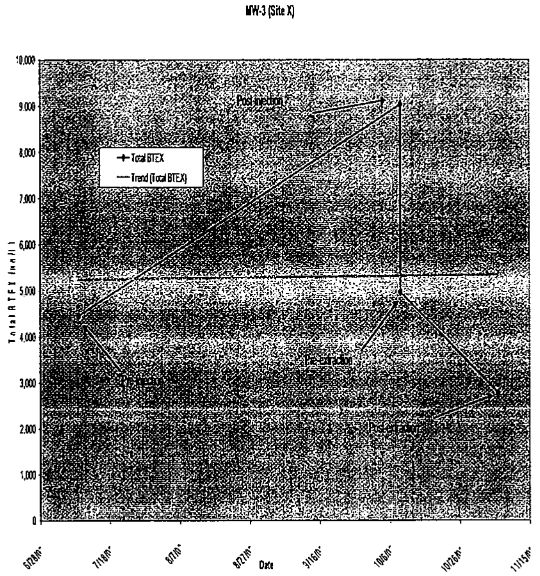
Figure 5
Downgradient Monitoring Well Data
MW-5, MW-6, & MW-7

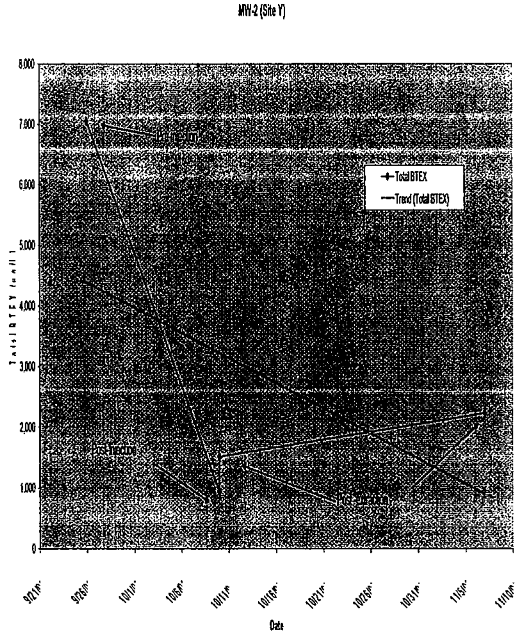


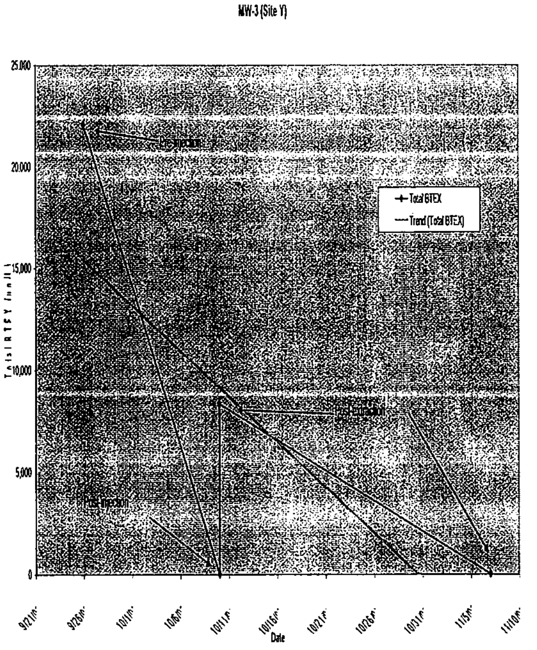
Results from Additional Test Sites

The results of this study were promising and the technology was employed at several other sites throughout Maryland. Results observed at this site were consistent with the results observed at the other sites. The following graphs show the results from two other surfactant injection / extraction sites. Although the results are not quite as remarkable as those from the study site, the results are consistent with the observations at the study site. It should be noted that the wells presented below contained only relatively high levels of dissolved BTEX and did not contain LNAPL as the study site did.







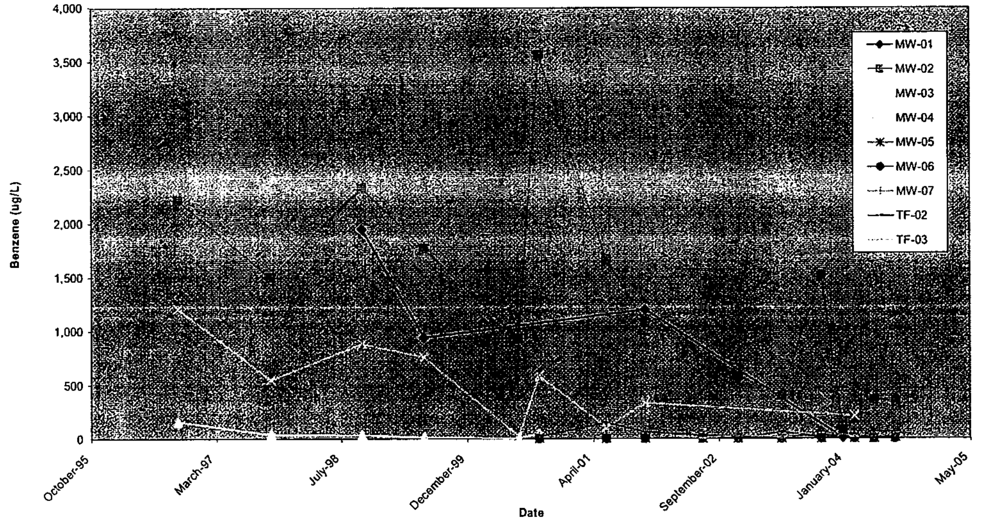


Conclusions and Path Forward

The goal of this study was to determine if surfactant injection / extraction could be a viable remediation option for low-risk petroleum sites that did not warrant full-scale active remediation efforts. Many sites and environmental cases exist that do not pose a significant risk to human health or the environment, but must remain open due to the continuous or intermittent presence of small amounts of LNAPL. In the State of Maryland, a site that has been shown to not pose a significant risk can be closed once LNAPL is removed and a declining contaminant mass and/or concentration trend is shown. Ultimately, the surfactant injection /

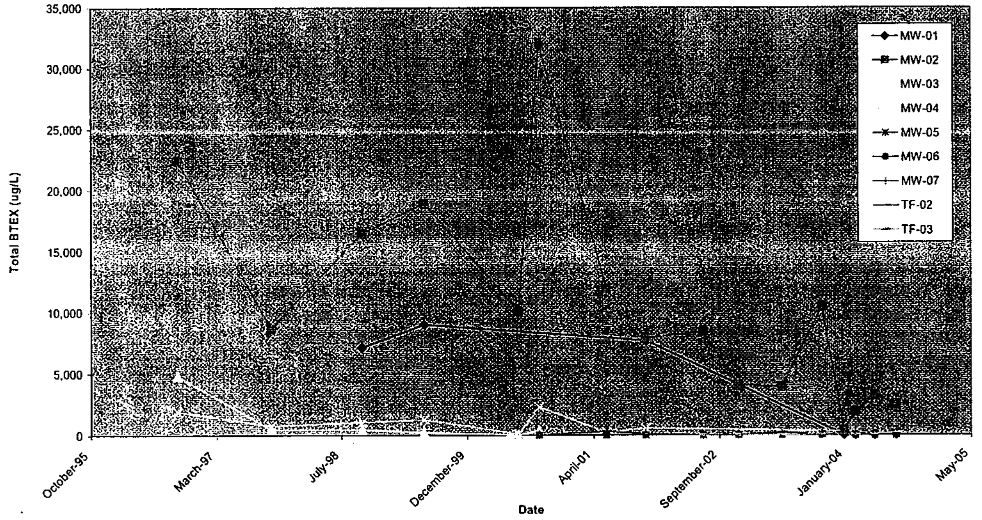
extraction events employed at the subject site were able to remove all the persistent measurable LNAPL from the site monitoring wells. The closure request for this site has been submitted and approved pending a final compliance inspection at the site (it is an operational retail gas station) by the Maryland Department of the Environment regulator.

Figure 6
Dissolved Benzene Concentrations



Figures 6 and 7 depict the dissolved benzene and Total BTEX concentrations observed at the site over time. Based on this data, and the resulting case closure, this form of remedial application appears to be successful. The client was able to achieve case closure in a period of a little more than one year, at a cost of approximately $25,000 (including monitoring costs). Operations at the site were minimally disrupted by the surfactant injection / extraction project, as it can be deployed as a mobile technology.

Figure 7
Dissolved Total BTEX Concentrations



Future studies will focus on the biodegradation of the dissolved phase of the contamination. This study demonstrated the successful physical removal processes of LNAPL from affected areas. Additional study is required to evaluate the processes of bioavailability and potential limiting factors that may affect biodegradation. If the surfactant injection / extraction technology is applied to a site, it is important to understand the biochemical parameters at the site that may limit the rate of removal so that if an increase in dissolved phase concentrations is observed in downgradient wells, measures can be put in place to address these potential concerns. These biochemical parameters may include dissolved oxygen concentration, CO_2, ORP, pH, sulfate, sulfide, nitrate, nitrite, iron, alkalinity, BOD, COD, methane and bacterial plate counts. It is recommended that the biochemical and hydrogeologic parameters be understood at sites where there may be risk to potential downgradient receptors prior to incorporating this technology.

Biographical Sketches of the Authors:

Robert J. Tworkowski is a Professional Geologist with over 20 years of experience in the field of environmental site assessment and remediation. Mr. Tworkowski works for URS Corporation, and manages a Remediation Services Group that provides services primarily to the petroleum sector. Mr. Tworkowski has a BS degree in Geology from Rutgers University.

Jason L. Baer is a Registered Environmental Manager with over 10 years of experience in the field of environmental site assessment and remediation. Mr. Baer, formerly with URS Corporation, currently works for the State of Maryland, Maryland Environmental Service as a Project Manager, specializing in the remediation of petroleum- and solvent-impacted sites. Mr. Baer has a BA degree in Liberal Arts from St. Mary's College of Maryland and an MS in Environmental Management from the University of Maryland.

Multiphase Extraction Techniques

Mary Anne Kuserk

Bureau of Underground Storage Tanks

New Jersey Department of Environmental Protection

Multiphase Extraction Techniques

- Description of Techniques
  - What is Multiphase Extraction
  - Effective Uses
  - Appropriate Site Conditions
  - Monitoring the Effectiveness of the Remediation
  - Use of Surfactants
- Case Examples
- Cost Effectiveness

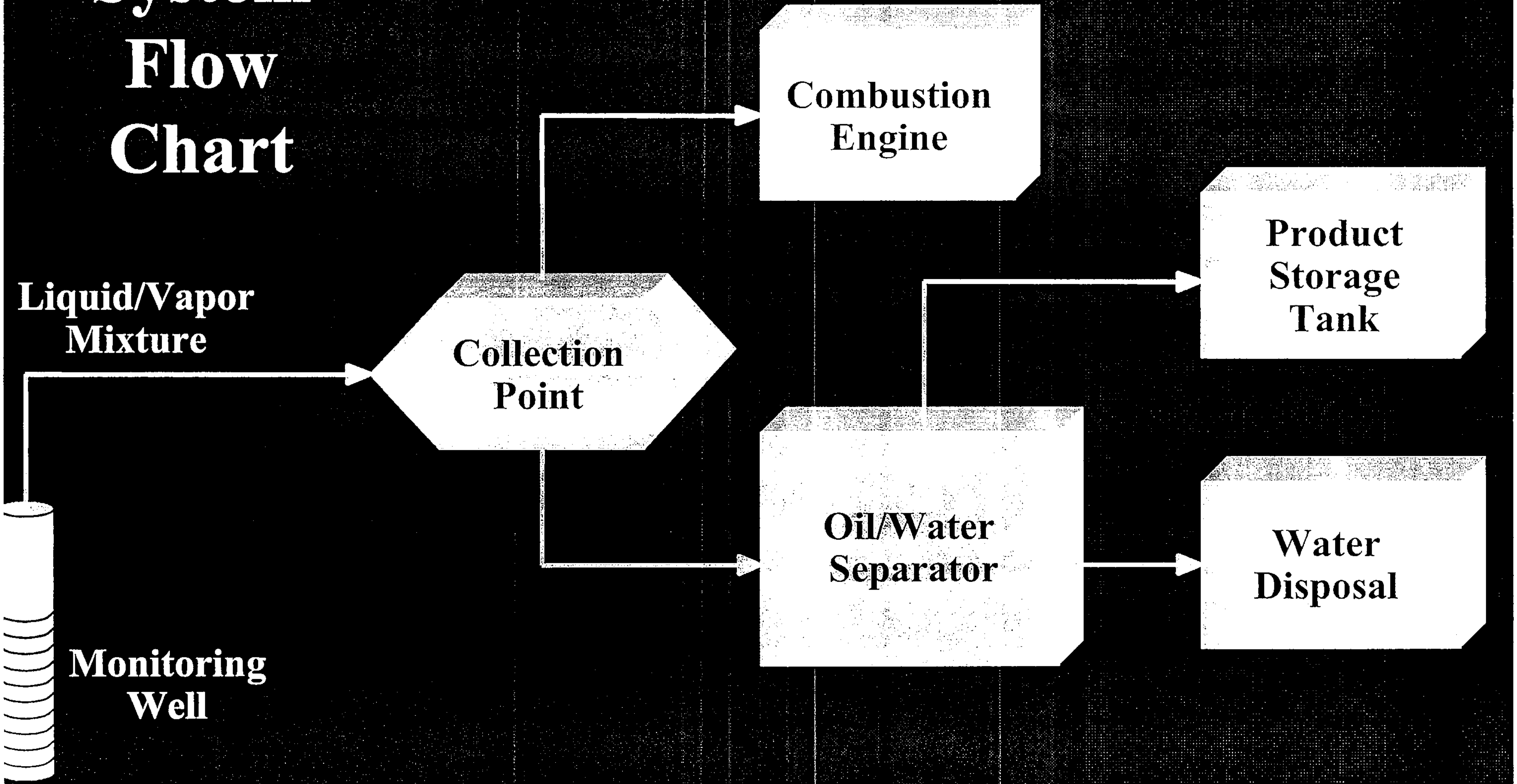
Multiphase Extraction

- High Vacuum Processes which remove vapors and total fluids, both dissolved and residual phase product, from the subsurface.
- Usually short term (6-8 hours) and temporary (once a month).

Multiphase Extraction

- Extraction of total fluids through the installation of extraction points in a single well or multiple wells.
- High vacuum is placed on the point : 29 inches of mercury with flow rate of 150 cfm.
- Vapor is treated with combustion engine and water/product is disposed off-site.

System Flow Chart



Multiphase Extraction

- Trade Names
  - HIT – High Intensity Extraction and Treatment
  - HEAT – High Vacuum Extraction and Treatment
  - EFR – Enhanced Fluid Recovery

Effective Uses

- Removing residual free product from saturated and unsaturated zone.
  - Most effective at site where product is relatively isolated and < .5 feet in wells.
  - Objective is to remove mass of contamination to then allow for Natural Attenuation.

Effective Uses

- Emergency Situations
  - – catastrophic tank failure
  - – enables RP to respond quickly – no need for permanent equipment
- Not to be used to establish hydraulic control or used as a method or receptor control

Site Characteristics

- Sites where SVE or g.w. pump tests have shown influence (demonstrating air and water flow through)
- Hydraulic conductivity of .5 to 15 feet/day
- Product found in a few monitoring wells (ideally <.5 feet of product)
- < 30 feet to the water table
- Unconsolidated material that is relatively homogeneous

Monitoring Effectiveness of System

- During remediation must monitor :
  - water flow rates
  - vapor flow rates
  - vacuum response
  - water level response
  - concentration data – both ground water and vapor
  - amount of total fluids removed
  - calculation of amount of product recovered

Use of Surfactants

- Some RP's use a surfactant inconjunction with Multiphase Extraction Techniques.
- Surfactant mobilizes free product bound to the soils which allows the product to be recovered in monitoring wells.

Cost Effectiveness

- Allows RP to remediate without upfront capital costs
- Uses existing monitoring well network
- Does <u>not</u> disrupt on-going station activities
- Specific events – RP pays for direct use

Cost Effectiveness

- Least expensive method of mass removal to then allow for Natural Remediation.
- In general, \$10 to \$75 per gallon of product recovered vs. \$250 per gallon for traditional methods.

Estimated Hydrocarbon Recovered

	WEEK							
	1	2	3	4	5	6	7	8
HOUR	112	112	112	56	56	56	28	28
I(PPM)	6200	5800	5400	5000	4500	4100	3800	3300
Q(CFM)	200	200	200	200	200	200	200	200
PRODUCT (GAL)	296	277	258	119	107	98	45	39

TOTAL (GAL) 1239

Insitu Flushing
Gold Crew GC-165 REM
Rocky Mountain Oil Test Center (RMOTC)
BP/Amoco Treatability Testing

May 2003

Insitu Treatability Testing: Rocky Mountain Oil Test Center (RMOTC)

Gold Crew 165-RM Insitu was tested for efficacy for use on a major soil-flushing project. The site's profile characteristic includes groundwater at 12 to 15 feet, smear zone 2 to 5 feet from groundwater with up to 3 foot of free-floating product on top of groundwater.

A test procedure was developed to determine the product's efficacy in releasing the entrained contaminant in the smear and capillary zone while reducing the total TPH in the soil. The entire protocol can be found in Experimental Procedure B.

In setting up the procedure it was determined to construct the model to mimic the site conditions. Tanks were set up with 4 inches of water on the bottom of each tank. A pre assembled bridge device was placed inside each tank to suspend the soil above the groundwater allowing the soil to come into contact with the groundwater. A fine layer of gravel was placed on top of the bridging material and 8 inches of soil removed from the site was placed in each tank. One tank utilized only water as a control while the other tank utilized a 2% solution of Gold Crew 165-REM.

The injection flow rate was established to reproduce retention and flow rates experienced on the site. The solution tanks were pumping at the rate of 20-23ml/minute allowing a 1 to 2 day retention time. Total daily volume of 8.8 gallons was sustained to assure this rate and retention time was maintained. Flow rates can be seen in the table below. The HRT (hydraulic retention time) is the average flow rate measured by the volume pumped from each tank.

Table 1

Soil Volume	Flow (CM^3/min)	HRT	HRT (hours)	HRT (days)
Control				
IN - 33,406.06	11.08	3014.98	50.24	2.09
OUT- 33,406.06	13.33	2506.08	41.76	1.74
Gold Crew				
IN - 33,406.06	12.33	2709.33	45.15	1.88
OUT- 33,406.06	14.46	2310.23	38.50	1.60

The second set of HRT is based on the average flow rate measured by the volume of liquid discharged into the receiving drum. The retention time held consistent at 1 to 2 days while the test vessels were completely saturated (approximately 7 gallons) which represents pore volume.

Testing

Testing included sampling events on day 1, 15 & 22.

Testing included:

- a. TPH-DRO, 8015 modified - 6
- b. BTEX, 8260 - 6
- c. Trimethylbenzene-1,2,4 - 6
- d. Benzene - 6
- e. Soil particle size – 2

Results

Complete results can be seen in attachment B.
The results are broken down into two matrixes, soil & water. The soil was measured as to the total removal of contaminant. This could include flushing or biodegradation or both. The water matrix was measured to quantify contaminant removal from flush action only.

Discussion

Review of the results indicates an effective removal of contaminant from the soil matrix. The reduction of overall contamination averages a 97% reduction in a 30-day period. There were some instances of increased volume of specific contaminants. This can be attributed to the flushing of contaminant to the specific point of sampling. Since there are no bacteria in the Gold Crew 165 REM, the specific degraders may not have had time to acclimate and establish quantifiable mass to effectively remove the target contaminant.

Attachment B

	Baseline Sampling Event 3/25/03				Mid-test Sampling Event 4/3/03			Final Sampling Event 4/17/03		
Matrix: Soil										
Parameter	**Results**	**Units**	**Report Limit**		**Results**	**% Change**		**Results**	**% Change Mid-test**	**% Change Overall**
GC Semivolatiles										
Total Extractable Hydrocarbons OA2										
Disel Fuel	2900	mg/kg	11		690	76.21		210	69.57	92.76
n-Tetracosane (S)	102	%	11		105	(2.94)		128	(21.90)	(25.49)
o-Terphenyl (S)	97	%	11		103	(6.19)		146	(41.75)	(50.52)
Organics Prep										
% Moisture										
Method: SM 2540G										
% Moisture	6.20	%	NA		4.40	29.03		5.60	(27.27)	9.68
GS/MS Volatiles										
GC/MS VOCs in Soil by 8260										
Method: EPA 8260										
1,2,4-Trimethylbenzene	180000	ug/kg	6700		23000	87.22		5	99.98	100.00
1,3,5-Trimethylbenzene	21000	ug/kg	670		4000	80.95		19	99.53	99.91
Ethylbenzene	40000	ug/kg	6700		5100	87.25		5	99.90	99.99
soproprylbenzene (Cumene)	9200	ug/kg	670		1600	82.61		5	99.68	99.94
m&p xylene	40000	ug/kg	670		6000	85.00		5	99.91	99.99
Napthalene	32000	ug/kg	13000		2700	91.56		11	99.60	99.97
n-Butylbenzene	23000	ug/kg	670		3900	83.04		5	99.87	99.98
n-Propylbenzene	39000	ug/kg	6700		5200	86.67		5	99.90	99.99
p-Isopropyltoluene	4000	ug/kg	670		770	80.75		5	99.32	99.87
sec-Butylbenzene	7000	ug/kg	670		1400	80.00		5	99.63	99.93
Xylene (Total)	41000	ug/kg	690		6000	85.37		5	99.91	99.99
Dibromofluormethane (S)	95	%	NA		96	(1.05)		97	(1.04)	(2.11)
Toluene-d8 (S)	96	%	NA		95	1.04		92	3.16	4.17
4-Bromofluorobenzene (S)	87	%	NA		93	(6.90)		87	6.45	0.00
1,2-Dichloroethane-d4 (S)	110	%	NA		97.00	11.82		99	(2.06)	10.00

					Mid-test Sampling Event 4/3/03			Final Sampling Event 4/17/03		
Matrix: Water										
Parameter					**Results**	**Units**		**Results**	**Units**	**% Change Overall**
GC Semivolatiles										
Total Extractable Hydrocarbons OA2										
Disel Fuel					79.00	mg/l		130.00	mg/l	(64.56)
Total Petroleum Hydrocarbons					590.00	mg/l		0.00	mg/l	100.00
n-Tetracosane (S)					124.00	%		74.00	%	40.32
o-Terphenyl (S)					128.00	%		63.00	%	50.78
Organics Prep										
% Moisture										
Method: SM 2540G										
% Moisture					NA	%		NA	%	NA
GS/MS Volatiles										
GC/MS VOCs in Soil by 8260										
Method: EPA 8260										
1,2,4-Trimethylbenzene		ug/l	5.00		13000.00			1500.00	ug/l	88.46
1,3,5-Trimethylbenzene		ug/l	5.00		1800.00			740.00	ug/l	58.89
Benzene		ug/l	5.00		190.00			24.90	ug/l	86.89
Ethylbenzene		ug/l	5.00		1700.00			24.90	ug/l	98.54

Materials

2-Long 40-gallon treatment tank (48"x12"x16")
mesh screen
2-variable speed pumps (low pressure/high volume)
Glass sample jars (provided by the laboratory)
250 milliliter glass jars (provided by the laboratory)
Measuring beakers
Digital timer
Thermometer
2-Collection drums
Soil sampler
Water sampler (bailer)
Notebook
Vendor product
Potable water (enough volume to achieve 2" depth per tank)
BP Amoco contaminated soil (enough volume to achieve 12" per tank)
Electrical source to support 220 volts (3-phase) with breaker protection.

Experimental Method

Pre-Test Procedure

1. Perform bulk density test on soil to determine percent sand and percent clay values, and soil porosity.
2. Pretreat potable water with vendor product according to procedure provided by individual vendor prior to introducing to treatment tank.
3. Using a soil sampler, pull composite samples of contaminated soil from control tank and treatment tank(s). Homogenize soil and fill sample containers. Samples will be analyzed for:
    a. Total Petroleum Hydrocarbon EPA Method 418.1,
    b. Diesel Range Organics, EPA Method 8015 Modified.
    c. BTEX, EPA Method 8260B,
    d. Benzene,
    e. Trimethlybenzene Method E524.2
    f. soil particle size analysis.

Tank Set-up Procedure

Prepare two tanks. One tank is control set; the second tank is test set.

1. Place volume of water in bottom of each tank to achieve a 4" water depth.
2. Place pre-assembled bridge device inside of each tank to suspend soil above groundwater. Allow soil and water contact.
3. Place fine layer of gravel on top of bridging screen material in each tank.
4. Place 8" of soil mixture in each tank.
5. Allow soil-filled tanks to reach ambient room temperature.

Water Injection Set-up Procedure

The steps below describe assembly of the water injection system for the control system and test system. Only potable water will be introduced to the control tank. A solution of potable water and vendor product will be introduced to the treatment tank.

1. Place one drum of potable water on the side of the control tank by which the influent will be introduced to the tank.
2. Place one drum of vendor solution on the side of the test tank by which the influent will be introduced to the test tank.
3. Run outlet tubing into collection drum for test tank. Repeat this step for control tank.
4. Using a digital timer and a beaker marked in milliliter increments, pump water from the influent drum into the beaker for one minute. Using this information calculate the hourly volume rate. Adjust the pump speed as necessary. Repeat this step for the test tank.

Control Tank Operation and Data Collection Procedure (21 days)

The steps below describe flow rates, leachate collection procedures, and sampling procedures relating to the operation of the control tank.

Daily

1. Record pump rates in hourly increments for control tank.
2. Record hourly rate and cumulative rate of leachate collected from each tank.

Mid-Test Sampling Procedure (day 15)

1. Using a water bailer, collect six (6) bailer volumes from the leachate collection drum. Homogenize liquid and fill appropriate sample containers for mid-treatment water analyses. Samples will be analyzed for:
    a. Total Petroleum Hydrocarbon EPA Method 418.1
    b. Diesel Range Organics, EPA Method 8015 Modified
    c. BTEX, EPA Method 8260
    d. Benzene
    e. Trimethlybenzene, Method E524.2
2. Using a soil sampler, pull composite samples of soil from the control tank. Homogenize this soil and fill sample containers. Samples will be analyzed for
    a. Total Petroleum Hydrocarbon EPA Method 418.1
    b. Diesel Range Organics, EPA Method 8015 Modified
    c. BTEX, EPA Method 8260
    d. Benzene
    e. Trimethlybenzene, Method E524.2
    f. soil particle size analysis.

Post-Test Sampling Procedure (day 22)

1. Using a water bailer, collect six (6) bailer volumes from the leachate collection drums. Homogenize liquid and fill appropriate sample containers for mid-treatment water analyses. Samples will be analyzed for:
    a. Total Petroleum Hydrocarbon EPA Method 418.1,
    b. Diesel Range Organics, EPA Method 8015 Modified.,
    c. BTEX, EPA Method 8260,
    d. Benzene,
    e. Trimethlybenzene
2. Using a soil sampler, pull composite samples of soil from the control tank. Homogenize this soil and fill sample containers. Samples will be analyzed for
    a. Total Petroleum Hydrocarbon EPA Method 418.1
    b. Diesel Range Organics, EPA Method 8015 Modified
    c. BTEX, EPA Method 8260
    d. Benzene
    e. Trimethlybenzene, Method E524.2
    f. soil particle size analysis.

Test Tank Operation and Data Collection Procedure (21 days)

The steps below describe flow rates, leachate collection procedures, and sampling procedures relating to the operation of the test tank.

Daily

1. Pump vendor product solution at a rate of __________gal/hr (ml/min) water to test tank.
2. Record pump rates in hourly increments for control tank.
3. Record hourly rate and cumulative rate of leachate collected from each tank.

Mid-Test Sampling Procedure (day 15)

1. Using a water bailer, collect six (6) bailer volumes from the leachate collection drums. Homogenize liquid and fill appropriate sample containers for mid-treatment water analyses. Samples will be analyzed for:
    a. Total Petroleum Hydrocarbon EPA Method 418.1
    b. Diesel Range Organics, EPA Method 8015 Modified
    c. BTEX, EPA Method 8260
    d. Benzene
    e. Trimethlybenzene, Method E524.2
2. Using a soil sampler, pull composite samples of soil from the test tank. Homogenize this soil and fill sample containers. Samples will be analyzed for
    a. Total Petroleum Hydrocarbon EPA Method 418.1
    b. Diesel Range Organics, EPA Method 8015 Modified
    c. BTEX, EPA Method 8260
    d. Benzene
    e. Trimethlybenzene, Method E524.5
    f. soil particle size analysis.

Post-Test Sampling Procedure (day 22)

1. Using a water bailer, collect six (6) bailer volumes from the leachate collection drums. Homogenize liquid and fill appropriate sample containers for mid-treatment water analyses. Samples will be analyzed for:
   a. Total Petroleum Hydrocarbon EPA Method 418.1
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