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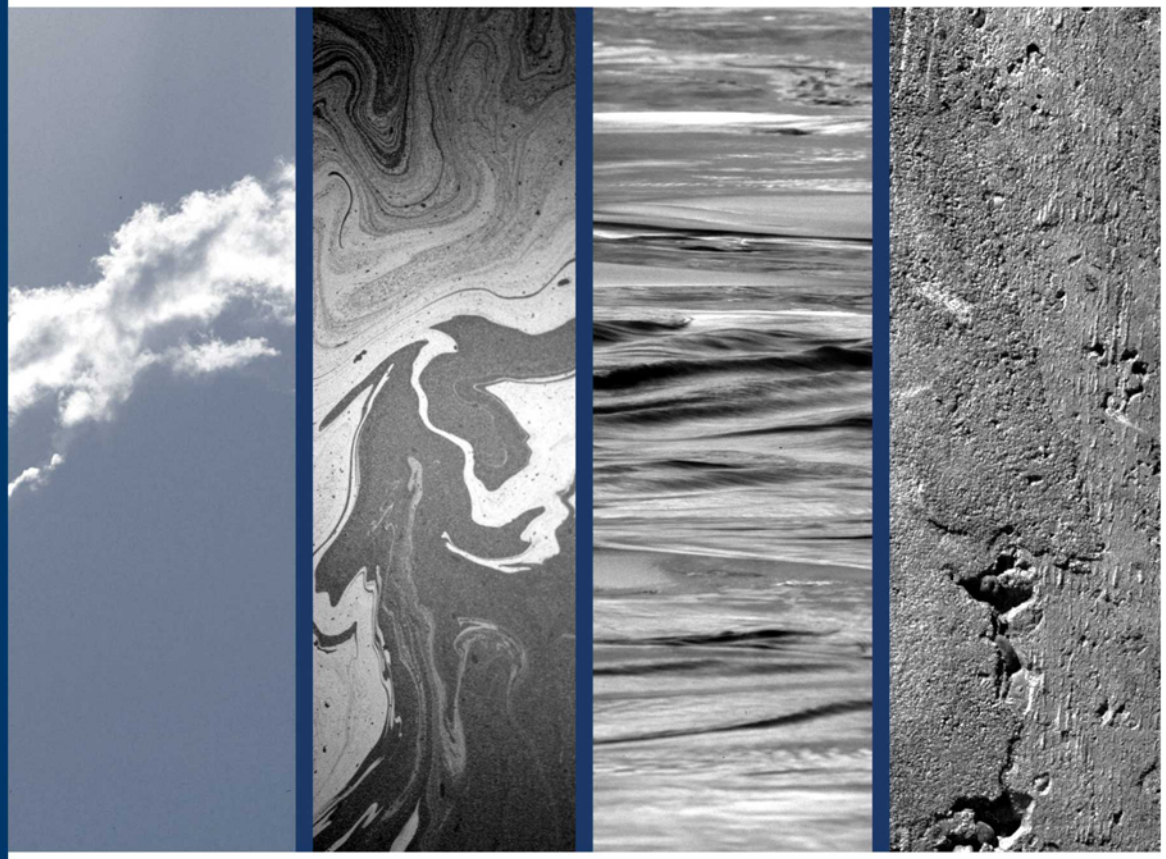

Chemical Oxidation Injection System: A Case Study

Chemical Oxidation: Case Study

- Site History
- Application Process
- Lessons Learned

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Site Setting

- Former Petroleum Service Station located in Cincinnati, Ohio
- Located in a mixed residential/commercial land use area
  - Residential dwellings adjoin the property to the North and West
  - Brotherton Road bounds the property to the East
  - Undeveloped land to the South
- Currently occupied by an assisted living nursing home and retirement facility

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Surrounding Properties

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Site Assessment

- Release first discovered in 1984 during an underground storage tank removal/upgrade
- The site has undergone multiple phases of investigation and remediation:
  - 32 monitoring wells
  - 12 extraction wells
  - 44 soil borings

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Monitoring Well Locations

Monitoring Well Recovery Well

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Soil Boring Locations

Soil Boring

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3905 Brotherton Road
Cincinnati, Ohio

Soil Boring Monitoring Well Recovery Well

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3905 Brotherton Road
Cincinnati, Ohio

Maximum Extent of Impacts — Chemical Injection Remediation Boundaries

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Contaminant Footprint

Soil Boring · Monitoring Well · Recovery Well

Maximum Extent of Impacts · Chemical Injection Remediation Boundaries

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Remediation Timeline

- 1985 – Free Product Recovery System Installed
- 1987 – Installation of second Free Product Recovery System
- 1989 – UST Removal and Source Mitigation Conducted
- 1990 – Soil Gas Survey Conducted
- 1990 - Installation of Soil Vapor Extraction (SVE) system with catalytic treatment for off gas emissions
- 1992 – Installation of Groundwater Recovery Treatment System
- 1994 – Risk Assessment Completed for the site (RBCA)
- 1995 – Pilot Study Conducted for new remedial system/RAP
- 1997 – Installation of second soil vapor extraction (SVE) and groundwater recovery/treatment system.
- 1999 – Groundwater recovery system modifications – New Airstripper, extraction pumps, and filtration beds

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Client Objective

- Since 1985, over $750,000 had been incurred in investigation and remediation costs. The client needed to fix its closure costs due to financial restructuring.
- The client required expedited site closure. A status of “No Further Action” needed to be issued within a 6-month period.
- The client no longer owned the property, but has retained the environmental liability.
- The client was looking for aggressive remedial approach.

Lithology

Soil Conditions

- 0 ‘-8’ – Brown silty CLAY (CL)
- 8’ – 14’ – Brown silty SANDS, wet to saturated
- 14’ – 16’ Brown sandy CLAY wet
- 16’ – 22’ Gray CLAY, firm, moist to dry water content

Groundwater Conditions located between 10’ – 12’ below grade surface with a saturated thickness of approximately five feet.

Petroleum impacts appeared to be limited to the 8’ – 16’ in depth.

No onsite potable water wells or wells within 300’. The surrounding properties are on city water supply.

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Chemicals of Concern

Soil Conditions (Maximum Concentration Listed)

- Benzene: 9,200 ug/Kg
- Toluene: 1,600 ug/Kg
- Ethylbenzene: 20,000 ug/Kg
- Xylenes: 58,000 ug/Kg
- TPH: 1,900 ug/kg

Groundwater Conditions (Maximum Concentration Listed)

- Benzene: 2,800 ppb
- Toluene: 230 ppb
- Ethylbenzene: 1,500 ppb
- Xylenes: 7,800 ppb

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Benzene Isopleth Concentration in Groundwater

All results are expressed in parts per billion

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Benzene Isoconcentrations in Soil

All concentrations are expressed in ug/kg (ppb)

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Remedial Approach

Chemical Oxidation using Hydrogen Peroxide

- Proven technology for petroleum hydrocarbon degradation in soil and groundwater.
- Could be accomplished through a mobile treatment system.
- Accessible to soil and groundwater under buildings, foundations, and previously inaccessible areas.
- Designed for rapid clean up (few weeks) at a cost comparative price
- Meets the clients timeline objectives
- Did not disrupt onsite operations
- Accepted remedial technology by regulating agency

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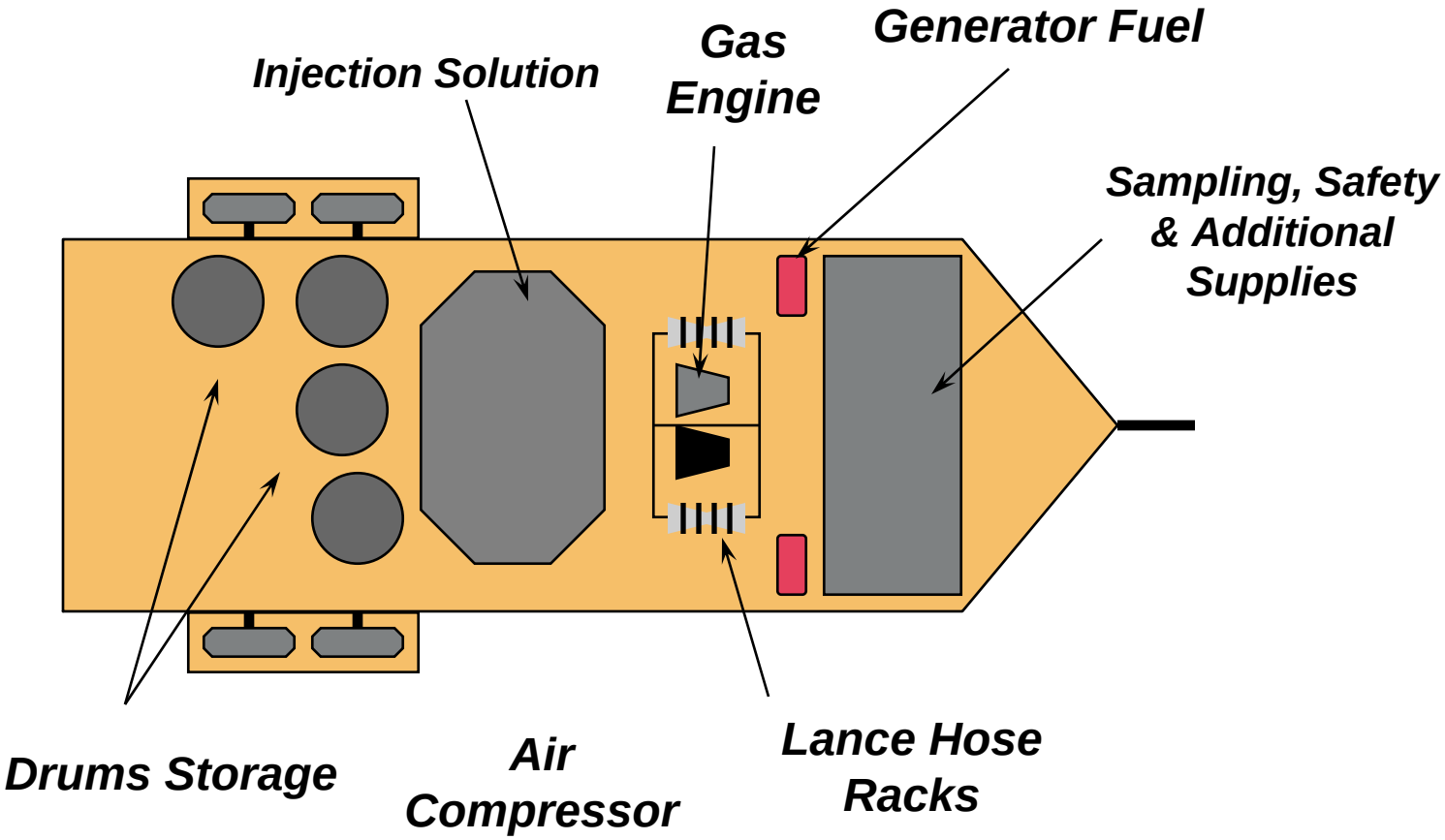
Mobile Unit



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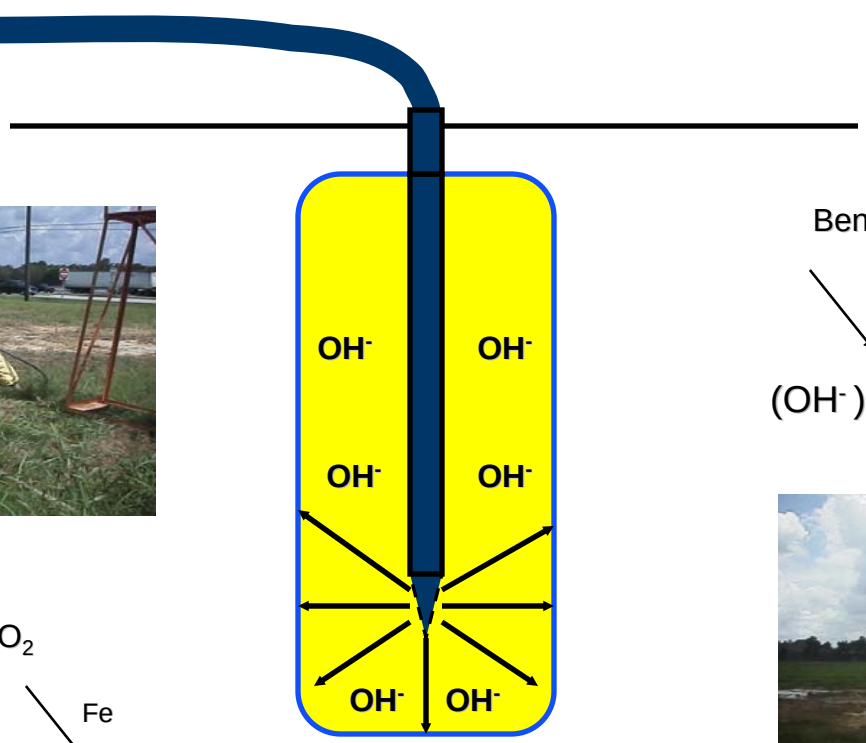
Treatment Technology



Benzene + H_2O_2

$\xrightarrow{Fe}$

$(OH^-)(OH^-) \longrightarrow CO_2 + H_2O$

Tetrachloroethene + H_2O_2

$\xrightarrow{Fe}$

$(OH^-)(OH^-) \longrightarrow CO_2 + H_2O + \text{Salts}$

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Treatment Technology Continued

Treatment is engineered to site specific conditions, such as:

- Geology and hydrogeology
  - Affects the number and density of injection points
- Soil and groundwater chemistry
  - Effects injection concentration and rates
- Organic environmental constituent levels
  - Effects number of treatment applications and total pounds of Inoculants

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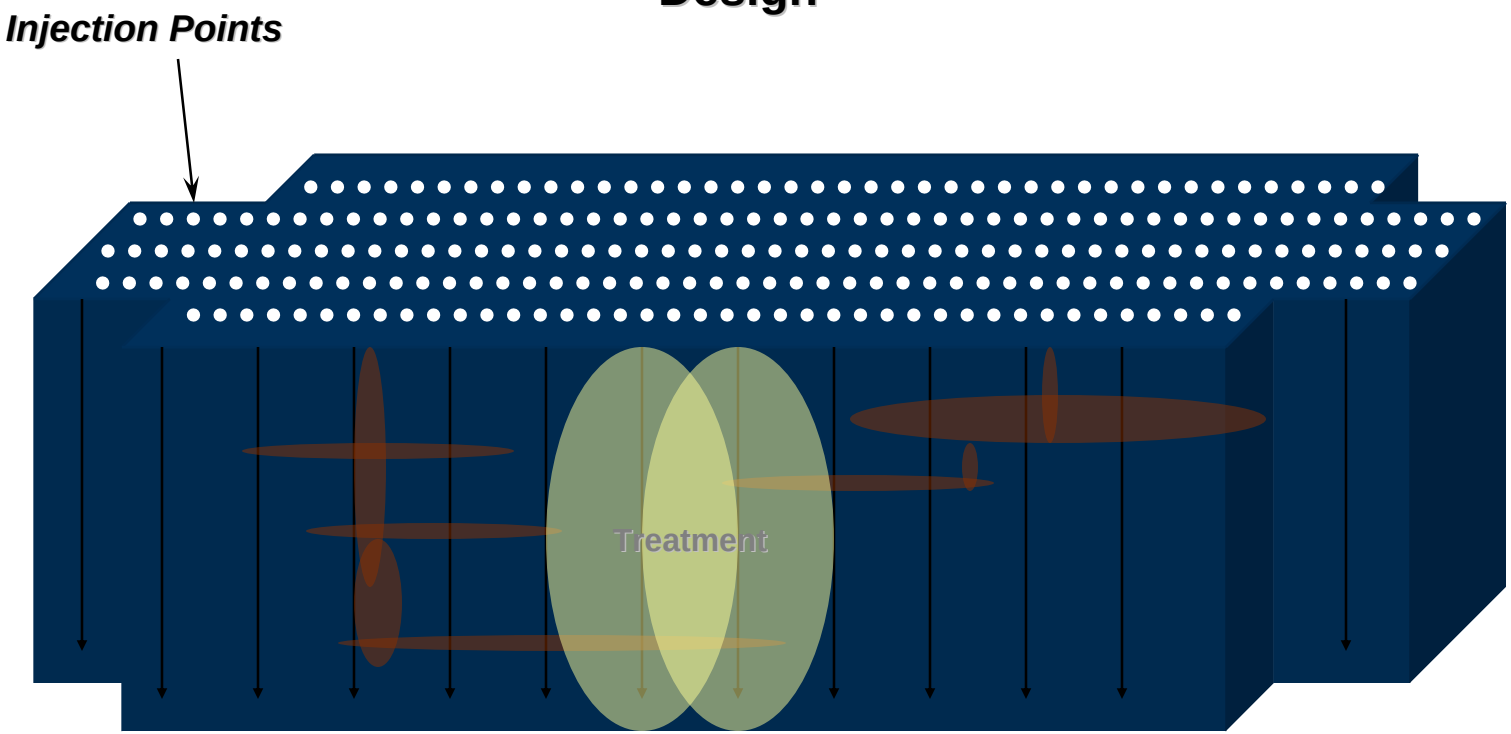
Treatment Technology Continued

Design



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Advantages

- **In situ Treatment w/Chemical Oxidation**
  - Cost Effectiveness
  - Permanent Solution
  - No Long Term Liability
  - Efficient and Fast
  - Mobile Operation
  - Proven Success
  - By-products are CO_2 and H_2O (Steam)

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Disadvantages

- **In situ Treatment w/Chemical Oxidation**
  - By-products are CO_2 and H_20 (steam)
  - Non-selective, reacts instantly
  - Application process: How to get the chemicals to the contamination

Approach

Two Treatment Areas:

- Treatment Area A – Double application
  - 80 Injection points
  - 17% Solution of hydrogen peroxide
  - Estimate quantity of 60,000 lbs required
  - 3-4 gallons per minute at 5,000 PSI
- Treatment Area B – Single application
  - 140 Injection points
  - 17% concentration of hydrogen peroxide
  - Estimate quantity of 90,000 lbs required
  - 3-4 gallons per minute at 5,000 PSI

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3905 Brotherton Road
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Soil Boring Monitoring Well Recovery Well

Treatment Area A Treatment Area B

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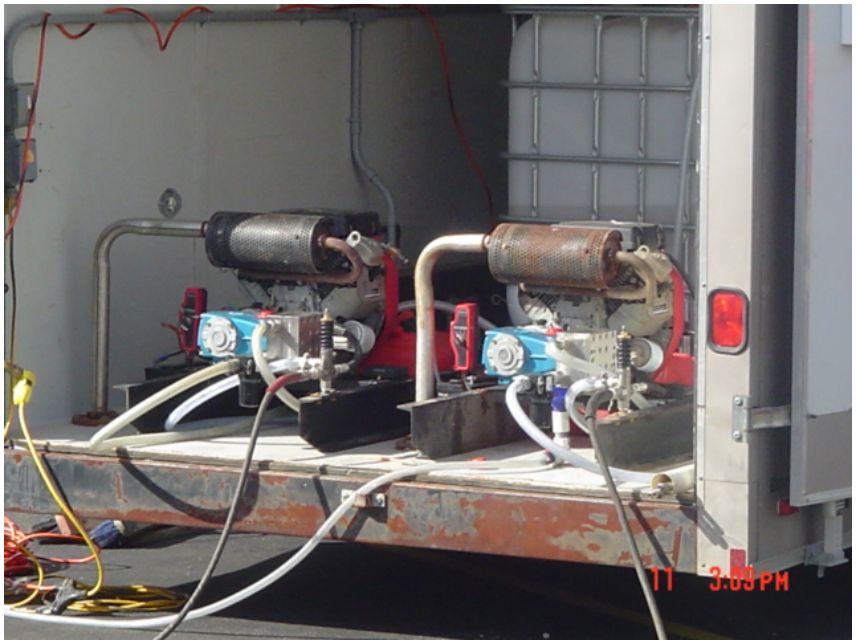

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Confirmatory Groundwater Results

Monitoring Well ID	Date Sampled	Benzene (ppm)	Toluene (ppm)	Ethylbenzene (ppm)	Xylenes (ppm)	Total BTEX (ppm)
MW-3	01/29/04	**0.3100**	<0.0050	<0.0050	<0.0050	<0.3250
	12/08/05	**<0.0050**	<0.0050	<0.0050	<0.0050	<0.0050
MW-4	01/29/04	**0.0050**	<0.0050	<0.0050	<0.0050	<0.0200
	12/08/05	<0.0010	<0.0050	<0.0010	<0.0030	<0.0100
MW-6	01/29/04	**<0.0050**	<0.0050	<0.0050	<0.0050	<0.0200
	12/08/04	<0.0010	<0.0050	<0.0010	<0.0030	<0.0100
MW-9	01/29/04	**0.0580**	0.0050	0.0150	0.0100	0.0880
	12/08/04	**0.5800**	0.0089	0.0520	0.0360	0.6769
MW-33	01/29/04	**1.6000**	0.0440	0.4500	0.3100	2.4040
	12/08/04	**0.0440**	<0.0500	0.0120	<0.0300	<0.1360
MW-34	01/29/04	**2.3000**	0.1100	0.8100	2.0700	5.2900
	12/08/04	**1.7000**	<0.2500	0.1300	0.3100	<2.3900
MW-35	01/29/04	**2.8000**	0.2300	1.5000	4.9800	9.5100
	12/08/04	**1.4000**	<0.2500	0.6300	1.5000	<3.7800
RW-1	01/29/04	NS	NS	NS	NS	N/A
	12/08/04	0.0015	<0.0050	<0.0010	<0.0030	<0.0105
RW-4	01/29/04	**1.5000**	0.0310	0.1700	0.2200	<1.9210
	12/08/04	0.0010	<0.0050	<0.0010	<0.0030	<0.0100
RW-5	01/29/04	**<0.0050**	<0.0050	<0.0050	<0.0050	<0.0200
	12/08/05	<0.0010	<0.0050	<0.0010	<0.0030	<0.0100
BUSTR Action Levels						
Category 2		**0.0050**	**1.0000**	**7.0000**	**10.0000**	**N/A**

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Confirmatory Soil Sampling

Boring ID	Pre-Treatment/ Post Treatment	Benzene ppm	Toluene ppm	Ethylbenzene ppm	Xylenes ppm	TPH ppm
B-2	Pre-Treatment	**0.510**	< 0.010	0.017	0.036	6.400
	Post-Treatment	**0.220**	< 0.500	< 0.100	< 0.300	**NA**
B-3	Pre-Treatment	**0.350**	0.053	0.120	1.920	13.000
	Post-Treatment	0.079	< 0.025	0.082	0.280	9.800
B-4	Pre-Treatment	**0.350**	0.100	7.000	29.200	160.000
	Post-Treatment	< 0.050	< 0.250	0.560	0.920	17.000
B-5	Pre-Treatment	**2.000**	0.110	1.600	1.520	110.000
	Post-Treatment	**0.360**	**< 12.000**	< 2.500	< 7.500	61.000
B-7	Pre-Treatment	**2.000**	0.230	2.200	6.760	160.000
	Post-Treatment	< 0.017	< 0.250	0.120	0.410	13.000
AM-3	Pre-Treatment	**< 1.000**	1.100	**27.000**	**58.000**	**1,700.000**
	Post-Treatment	**< 0.500**	< 2.500	6.200	6.800	240.000
AM-5	Pre-Treatment	**5.800**	< 1.000	4.600	25.000	440.000
	Post-Treatment	< 0.017	< 0.250	0.320	0.800	4.300
AM-5	Pre-Treatment	**9.200**	1.600	8.300	31.600	**800.000**
	Post-Treatment	**0.260**	< 1.200	0.800	3.100	150.000
AM-6	Pre-Treatment	**0.380**	< 0.250	4.300	9.400	500.000
	Post-Treatment	0.086	< 0.500	1.000	5.200	24.000
AM-7	Pre-Treatment	**< 1.000**	< 1.000	**20.000**	**49.000**	**1,900.000**
	Post-Treatment	0.025	0.039	0.890	1.200	35.000
AM-8	Pre-Treatment	**< 0.500**	< 0.500	< 0.500	3.400	320.000
	Post-Treatment	0.100	< 0.250	0.350	0.760	68.000
AM-13	Pre-Treatment	**0.390**	0.260	2.800	10.200	**NA**
	Post-Treatment	0.0053	< 0.025	1.400	2.300	190.000
AM-15	Pre-Treatment	**1.600**	2.400	**11.000**	**57.000**	**NA**
	Post-Treatment	**0.580**	0.620	**13.000**	36.000	120.000
BUSTR Category 2 Action Levels		**0.170**	**7.000**	**10.000**	**47.000**	**642.0**

***Bold** cells represent concentrations above BUSTR action levels.

NA - Not Applicable

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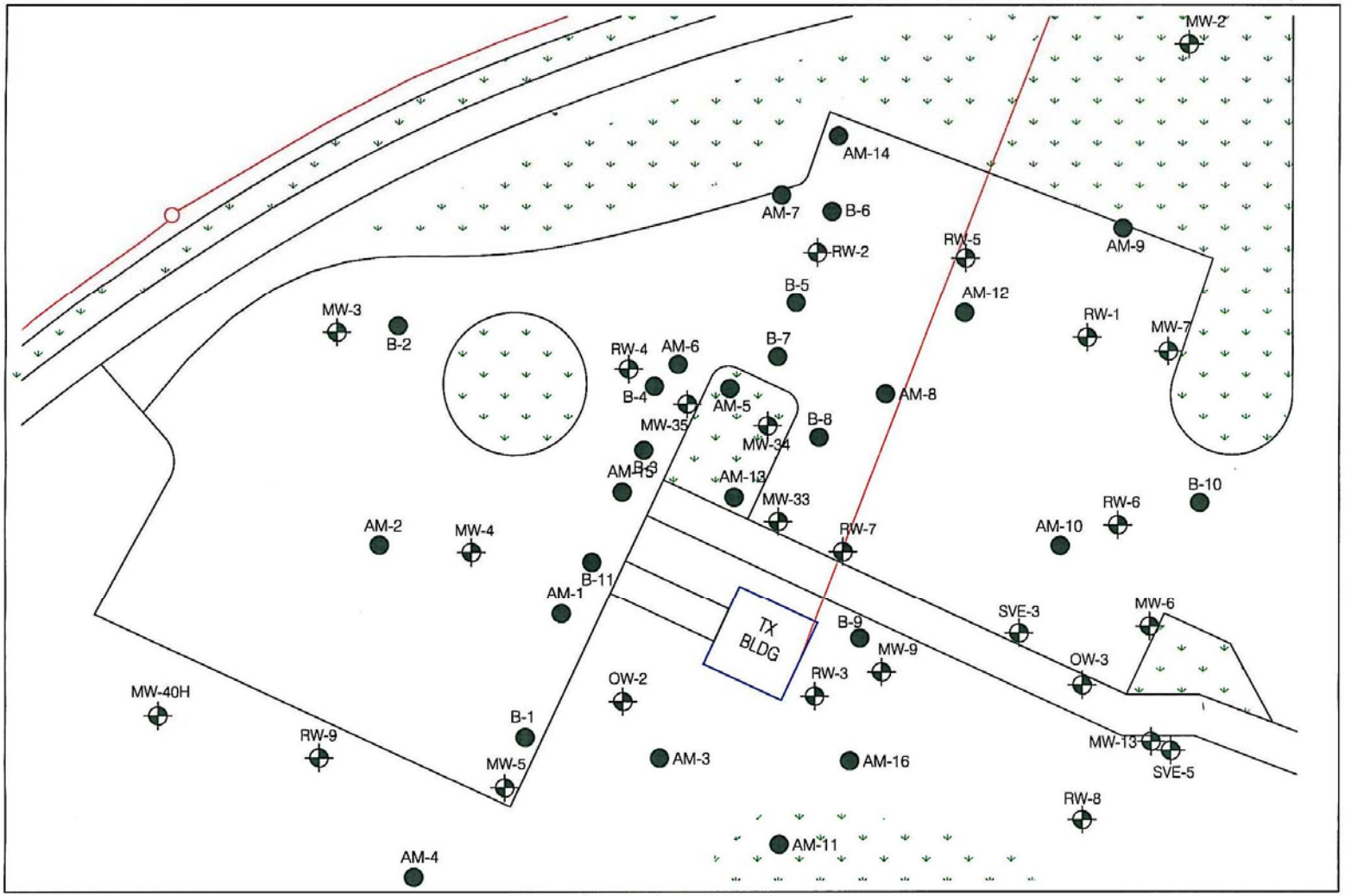
Site Plan



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Lessons Learned

- Characterization and more characterization
- The application process is a critical component
- Ferric Oxide means “Iron”
- Communication with local authorities can save a lot of headaches and emergency runs

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