

# Advancing urban site remediation using in-situ bioaugmentation for chlorinated aliphatic hydrocarbons in groundwater

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**HALEY**  
**ALDRICH**

# Agenda

1 Setting the Stage for Bioaugmentation

2 Success Factors

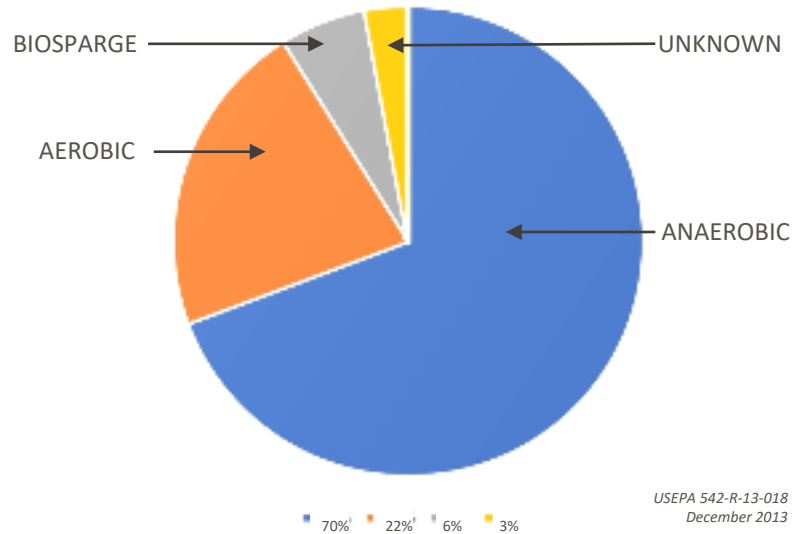
3 Case Study No.1 – Active Dry Cleaner

4 Case Study No.2 – Former Dry Cleaner (Vacant Land)

5 Questions

# Setting the stage for aerobic bioaugmentation

BIOREMEDIATION REMEDIES AT NPL SITES 1989 TO 2008



## Processes:

- Aerobic
- Anaerobic

## Types:

- Biostimulation
- Bioaugmentation
- Intrinsic bioremediation

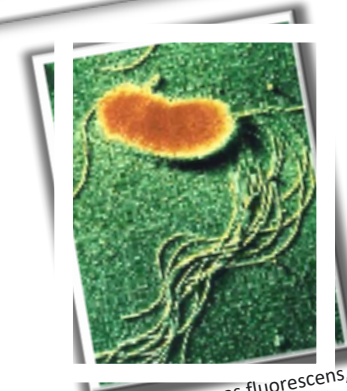
## Technology:

- Sustainable
- Flexible implementation techniques
- Non-toxic

# Factors for success for bioaugmentation in urban areas

- Work within site constraints
- Types of contaminants
- Geochemical conditions
- Mitigate/Eliminate impacts to sensitive receptors
- Types of microorganisms
- Electron donor = carbon substrate
- Electron acceptor = oxygen

Parameter	Effective Range	Optimum Range
PH	5-9	6.5-7.5
Temperature	55-95°F	65-75°F
Salinity	0-5%	<5%
Dissolved Oxygen	>1.0 mg/L	1-8 mg/L
ORP	>+10	+10-300



*Pseudomonas fluorescens*,  
National Institute of Health

# Aerobic bioaugmentation factors for success

- Geology/Hydrogeology

- Gravel/Cobble
- Sands (fine to coarse)
- Silt
- Clay



Increasingly difficult amendment distribution

- Implementation techniques:

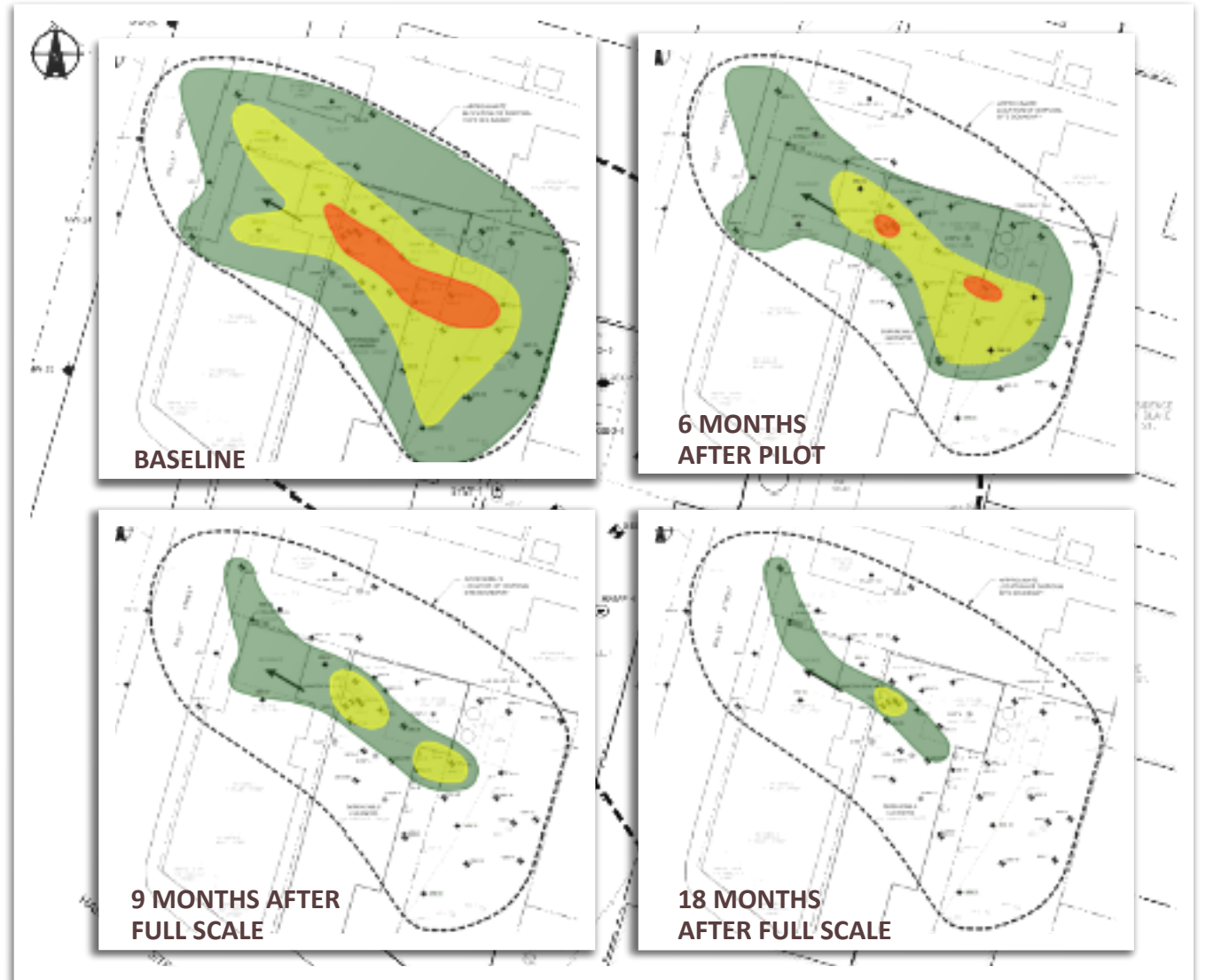
- Well injection
- Injection/recirculation
- Direct Push Technologies

EII Sieve Sizes		USCS (D2487/D422)	AASHTO (M145/T88)	USDA (Soil Survey Manual)	USGS (Udden-Wentworth)	International (ISO 14688-1)
Metric (mm)	Size (in.) or No.					
630		Boulder		Boulder	Boulder	Boulder
475			Boulder & Cobble	Stone		Boulder
250		Cobble		Cobble	Cobble	Cobble
75	3					Cobble
47.5	1 No. 4					
42.5	1 No. 4					
37.5	1 No. 4					
33.7	1 No. 4					
30.0	1 No. 4					
26.5	1 No. 4					
23.0	1 No. 4					
19.0	1 No. 4					
16.0	1 No. 4					
14.75	1 No. 4					
13.2	1 No. 4					
11.75	1 No. 4					
10.0	1 No. 4					
8.5	1 No. 4					
7.5	1 No. 4					
6.3	1 No. 4					
5.6	1 No. 4					
4.75	1 No. 4					
4.0	1 No. 4					
3.35	1 No. 4					
2.8	1 No. 4					
2.5	1 No. 4					
2.0	1 No. 4					
1.7	1 No. 4					
1.5	1 No. 4					
1.18	1 No. 4					
1.0	1 No. 4					
0.85	1 No. 4					
0.75	1 No. 4					
0.6	1 No. 4					
0.5	1 No. 4					
0.425	1 No. 4					
0.375	1 No. 4					
0.3	1 No. 4					
0.25	1 No. 4					
0.212	1 No. 4					
0.18	1 No. 4					
0.15	1 No. 4					
0.106	1 No. 4					
0.075	1 No. 4					
0.063	1 No. 4					
0.05	1 No. 4					
0.0425	1 No. 4					
0.03	1 No. 4					
0.025	1 No. 4					
0.02	1 No. 4					
0.0075	1 No. 4					
0.002	1 No. 4					
0.001	1 No. 4					
0.00075	1 No. 4					
0.0002	1 No. 4					
0.0001	1 No. 4					

Photo Credit: www.aashtoresource.org

# Case Study No.1

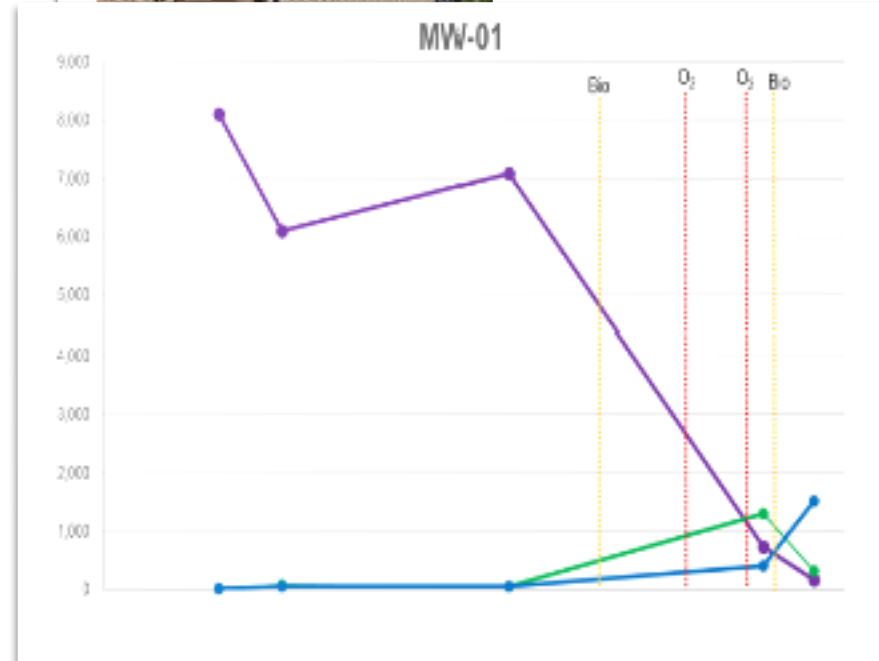
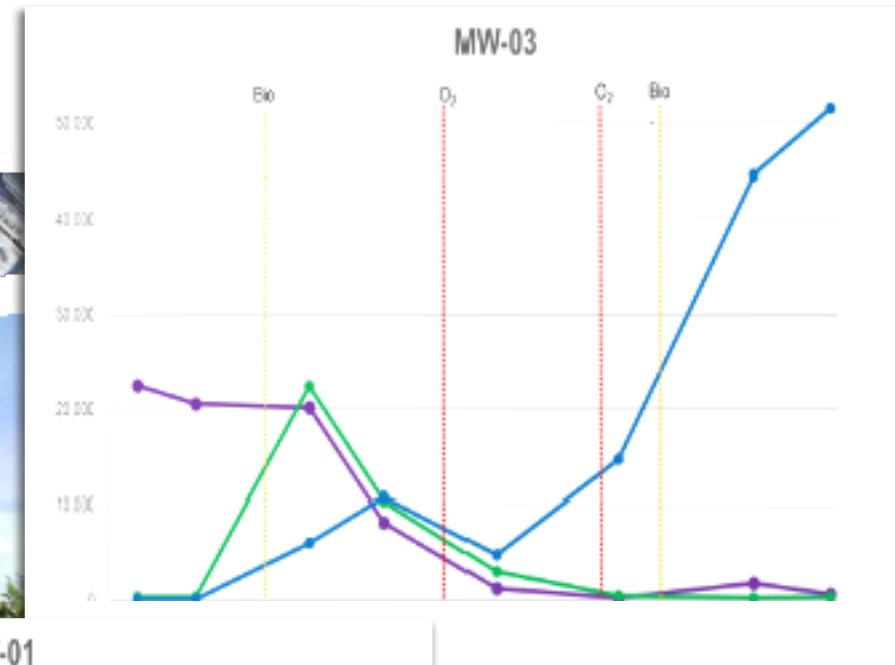
- Active dry cleaner
- Residential/Commercial
- Soil
  - Glacial till and lake sediments
  - Concentrations <75 mg/Kg
- Groundwater
  - Shallow (10-12')
  - Naturally aerobic (1-4 mg/L)
  - Impacts from grade to 30 ft bgs
  - Low and high K zones
  - Concentrations 0.1 to 70 mg/L PCE



# Case Study No.2

Similar to Case Study No.1 except:

- Soil consisted of fill materials underlain by fine sands and silt
- Shallower groundwater (~8-9')
- Groundwater concentrations of PCE ~ 5 mg/L to 50 mg/L.
- No daughter products in groundwater
- Sumps in basements
- Vapor intrusion = Imminent Hazard





# Questions



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