Enhanced Physical Recovery of Petroleum NAPL from Groundwater – Reagent Injection For Increasing Efficacy of Mechanically Assisted Recovery

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REGENESIS

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BACKGROUND

Sorbed Hydrocarbons

- Residual from leaks or spills
- Long-term source of groundwater contamination
- Large quantities difficult to treat
  - Stoichiometry limitations
- Also difficult to remove physically
  - Stuck on soil
  - Poor mobility
  - Bailing, P&T – diminishing returns

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Remediation Site Investigation

Boring Log: B-4

Project Name: Indiana Gas Station Date Started: 10/03/07 Logger:

Depth (feet)	Blows (/6 in.)	Recover (inches)	Sample	PID (PPM)	Graphic Log	Soil Class	Description
0						FILL	FILL
				0.0		SW	SAND, brown, fine, loose
				0.0		SP	SAND, tan, fine, loose
				0.0		SP	SAND, tan, fine, loose
4				0.0		SP	SAND, tan, fine, loose
						GW-	SAND, tan, medium coarse
						SW	SAND, tan, fine, loose
				0.0		SW	SAND, brown, fine, loose, wet, moist
						SP	
8				0.0		SP	SAND, tan, fine, loose, wet
						SP	SAND, light brown, fine, medium dense, odor at 9'
				63.3		SP	SAND, gray, fine
						SP	SAND, gray, fine, loose, wet, odor
12				118.6		SP	SAND, gray, fine, medium density, wet, odor
				5.0			SAND, gray, fine, loose, wet, odor
16							SAND, tan

234 mg/Kg BTEX

12' bgs

16' bgs

BACKGROUND

RegenOx® ISCO Technology

- Activated Sodium Percarbonate
  - Silica/silicate catalyst
  - Contaminant destruction
- Widely used (500 + sites)
- Detergent-like properties
  - Silicates and carbonates
- Known to promote desorption
  - Areas of high sorbed mass

STIMULATING DESORPTION

- RegenOx® has desorption effect on sorbed mass
  - Soil-bound hydrocarbons are released after RegenOx applications

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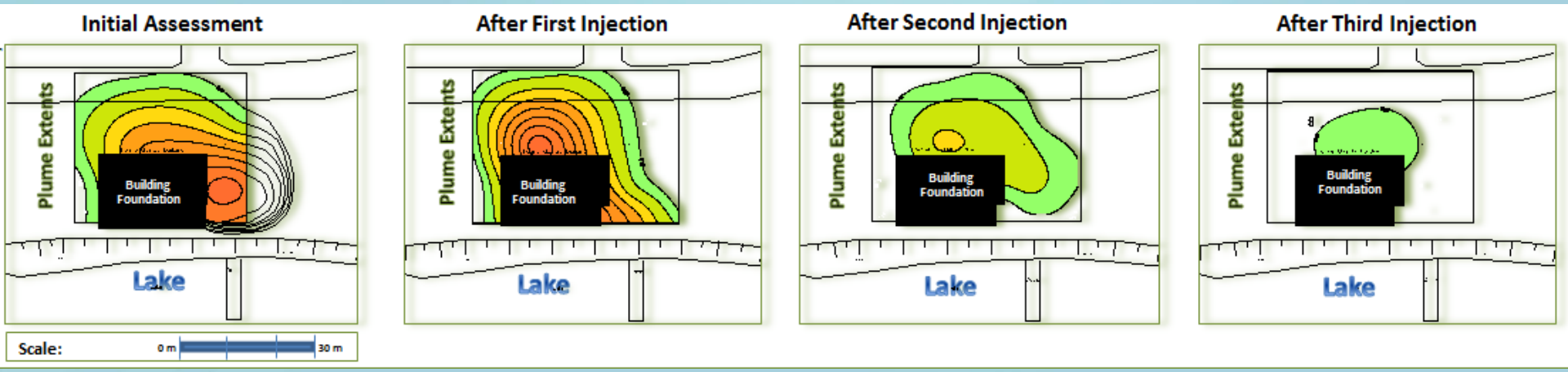
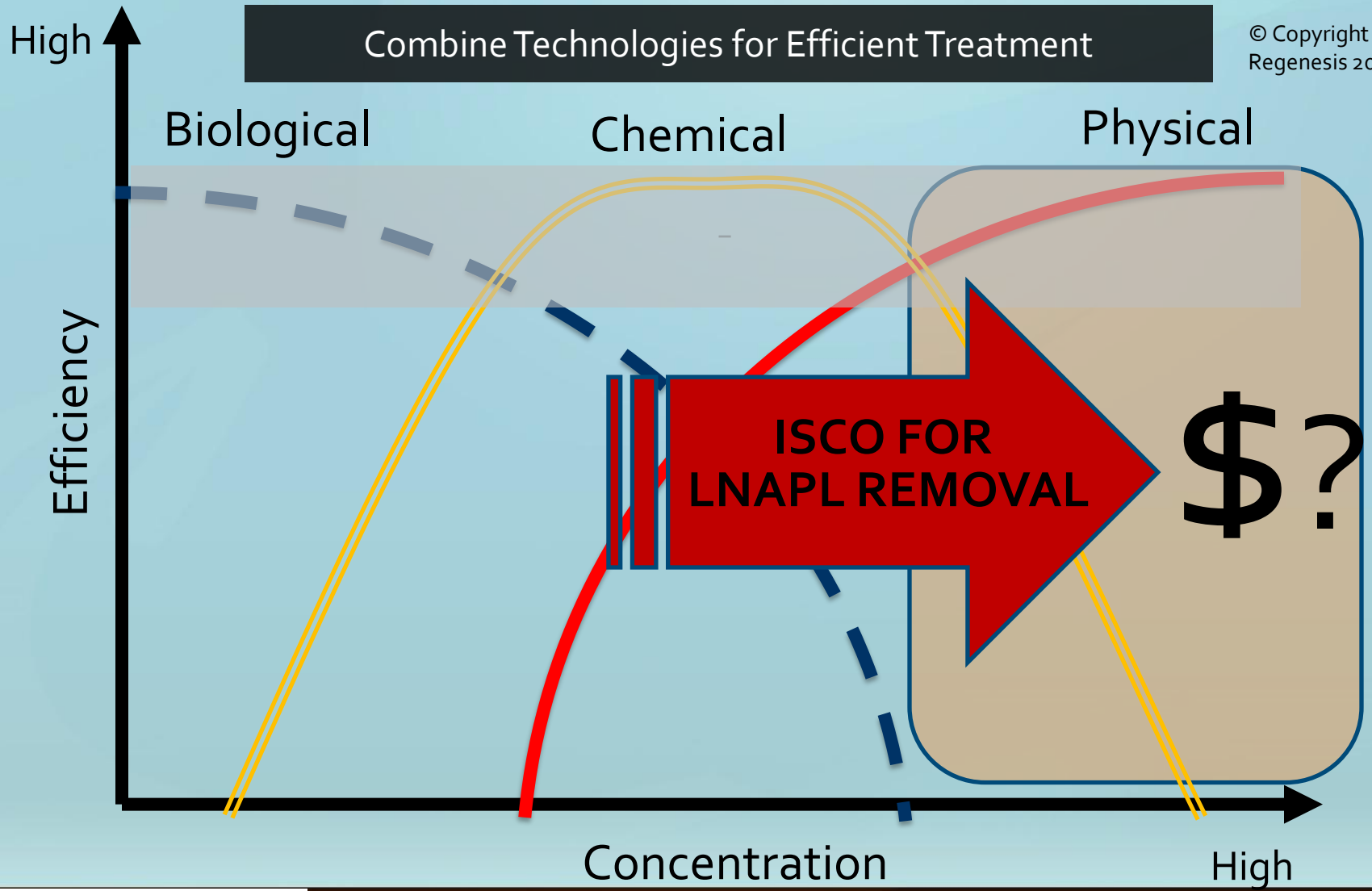
OBSERVATION: REGENOX DESORBES CONTAMINATION AFTER FIRST INJECTION



Example NFA project after first Injection:
23x increase in dissolved BTEX and TPH-G
27x decrease in sorbed BTEX and TPH-G

INTEGRATED SITE REMEDIATION



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SORBED HYDROCARBONS

- De-sorbing mass allows for physical recovery
  - More efficient compared to chemical oxidation or bioremediation
  - Increase GW concentrations
  - Mobilize NAPL

NEW TECHNOLOGY APPROACH

- Emphasize features of RegenOx that cause desorption
  - Detergent properties
  - Alkaline pH
- Use of technology: strictly with physical removal
  - Bailing wells
  - Extraction
  - Pump & Treat
- **New Development: (PetroCleanze™)**

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PRODUCT FORM

2- Part Product Formulation

- RegenOx Part A: Sodium Percarbonate Oxidant
- PetroCleanze Activator: In embedded silicate gel

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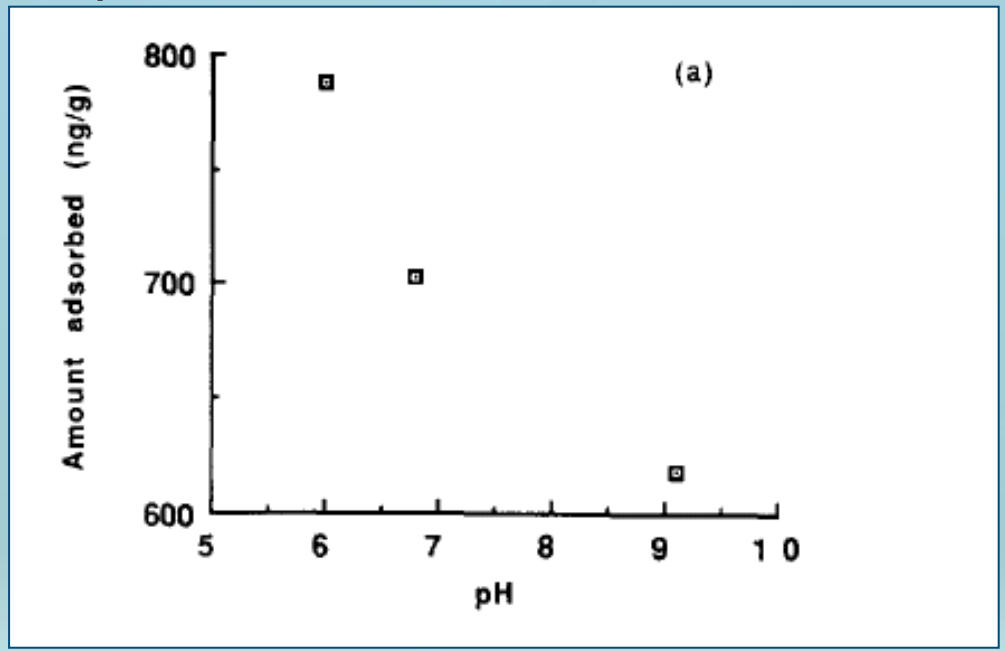
DEVELOPMENT

- Standard RegenOx Mechanisms
  - Desorption of contaminant from soil to groundwater
    - Detergent ingredients – silicates and carbonates
    - Alkaline pH favors desorption

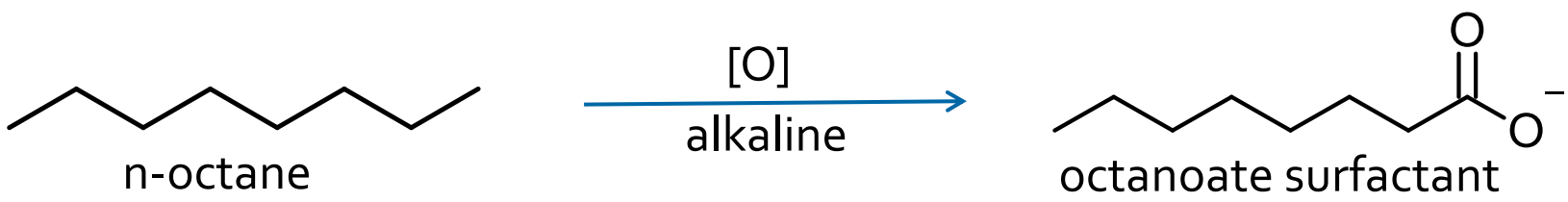
Sorption of Xylenes on Soil vs. pH



Kango, R. A.; Quinn, J. G. *Chemosphere,* **1989**, *19*, 1269-1276.

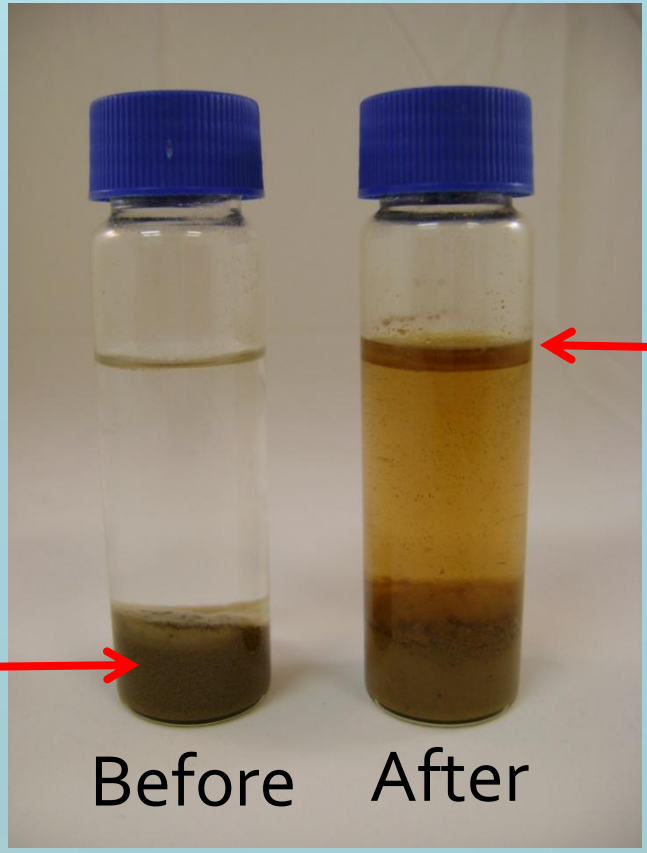
DEVELOPMENT

- Oxidation of Contaminants
  - Sodium percarbonate-based oxidant
  - RegenOx catalyst: sorption and destruction
  - Alkaline pH favors desorption
  - Partial oxidation generates surfactants



DEVELOPMENT

- PetroCleanze in the Lab
  - Same oxidation performance as RegenOx
  - Desorption enhanced in slurry mixtures
  - Experiment: Soil + Water + TPH



FIELD APPLICATION OF PETROCLEANZE

- First hand experience on applications and remediation chemistry
  - PetroCleanze

Pre-injection

21 hrs post

24 hrs post

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BENEFITS

- Inorganic mixture that stimulates desorption of bound hydrocarbons
  - Allows for rapid and low cost removal
- No residual BOD left behind as with surfactant flushing
  - Increases oxygen content in subsurface – stimulating biodegradation
- Avoid expensive well networks and O&M typical of surfactant applications

TREATING SOURCE AREAS

- Excellent for treating smear-zones, source zones
  - Inject with direct-push rigs or wells

REGENESIS
REMEDIATION SERVICES

TREATING SOURCE AREAS

Treating Residual Sorbed Mass

- Excellent for treating smear-zones, source zones
  - Inject with direct-push rigs or wells
  - Rapidly recover hydrocarbon with wells or vacuum trucks

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PetroCleanze™

STIMULATING PUMP & TREAT SYSTEMS

Increases Efficiency of P&T Systems

- Inject in plume area where bound hydrocarbon exists

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RRS APPLICATION: PETROCLEANZE

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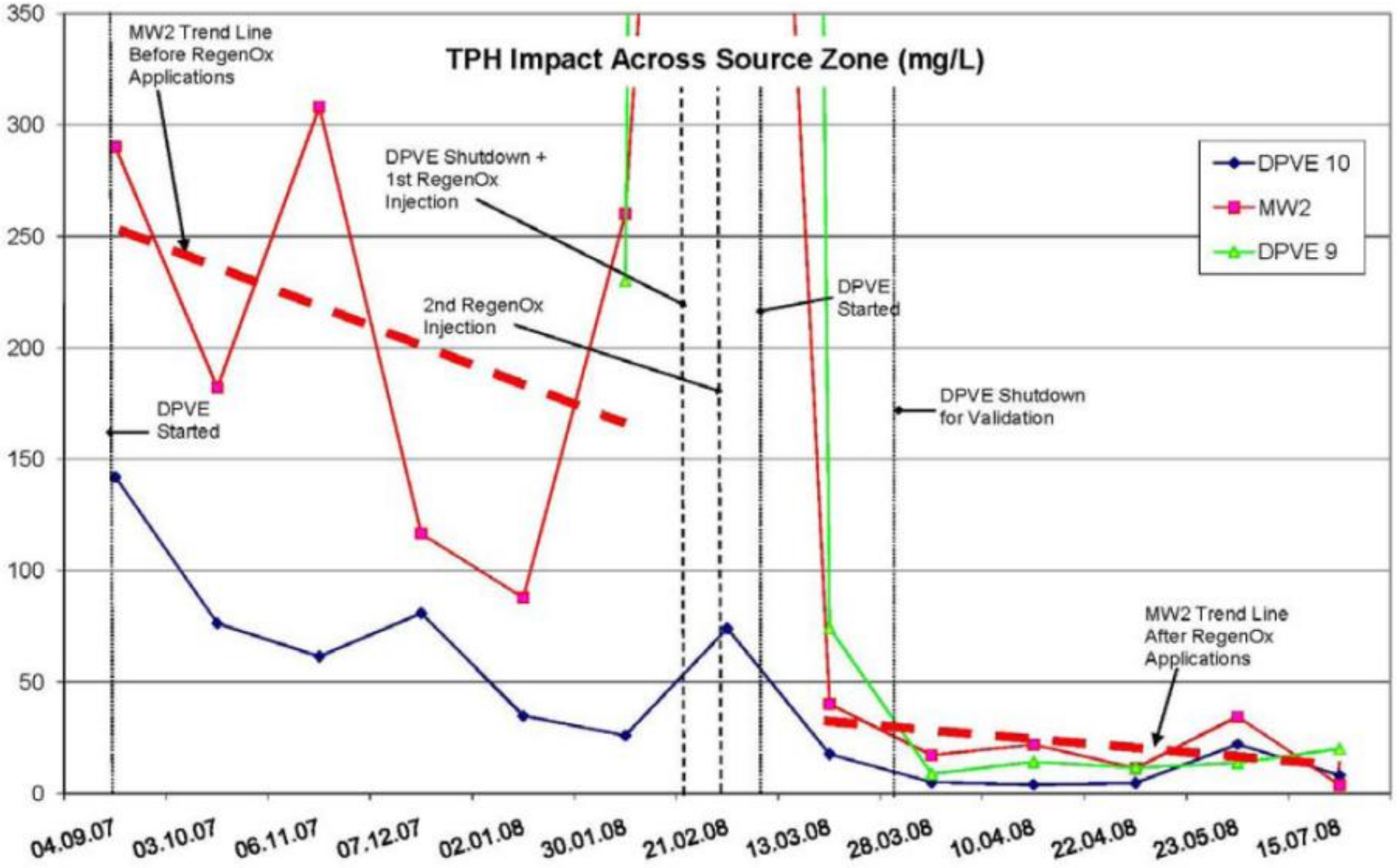
Advanced Technologies for Contaminated Site Remediation

RegenOx PetroCleanze Application Summary Report

Table 2

Date	Time	Location	Temperature (Farenheit)	Conductivity (uS/cm)	Dissolved Oxygen (mg/L)	pH	ORP	Comments
12/13/2011	9:44 AM	MW-8	60.8	2,188	5.5	6.7	190.5	No IPs completed nearby
12/14/2011	10:18 AM	MW-8	58.9	24,053	44.0	11.7	98.2	IP-10 completed 12/13
12/15/2011	1:32 PM	MW-8	58.7	32,060	49.6	11.5	33.5	
12/14/2011	10:51 AM	MW-5	60.6	1,022	8.4	7.0	105.5	Next to IP-25, prior to pumping
12/14/2011	2:34 PM	MW-5	56.0	944	29.1	6.9	180.0	After injecting in IP-16
12/15/2011	1:11 PM	MW-5	61.6	25,400	47.0	11.9	151.0	During injection at 15
12/15/2011	1:26 PM	MW-2D (s)	58.8	25,070	53.6	11.3	50.5	Foam in well. Well plug in tact.
12/15/2011	1:20 PM	MW-2 (north)	63.4	738	9.3	7.2	85.5	After IP-34-36 were done

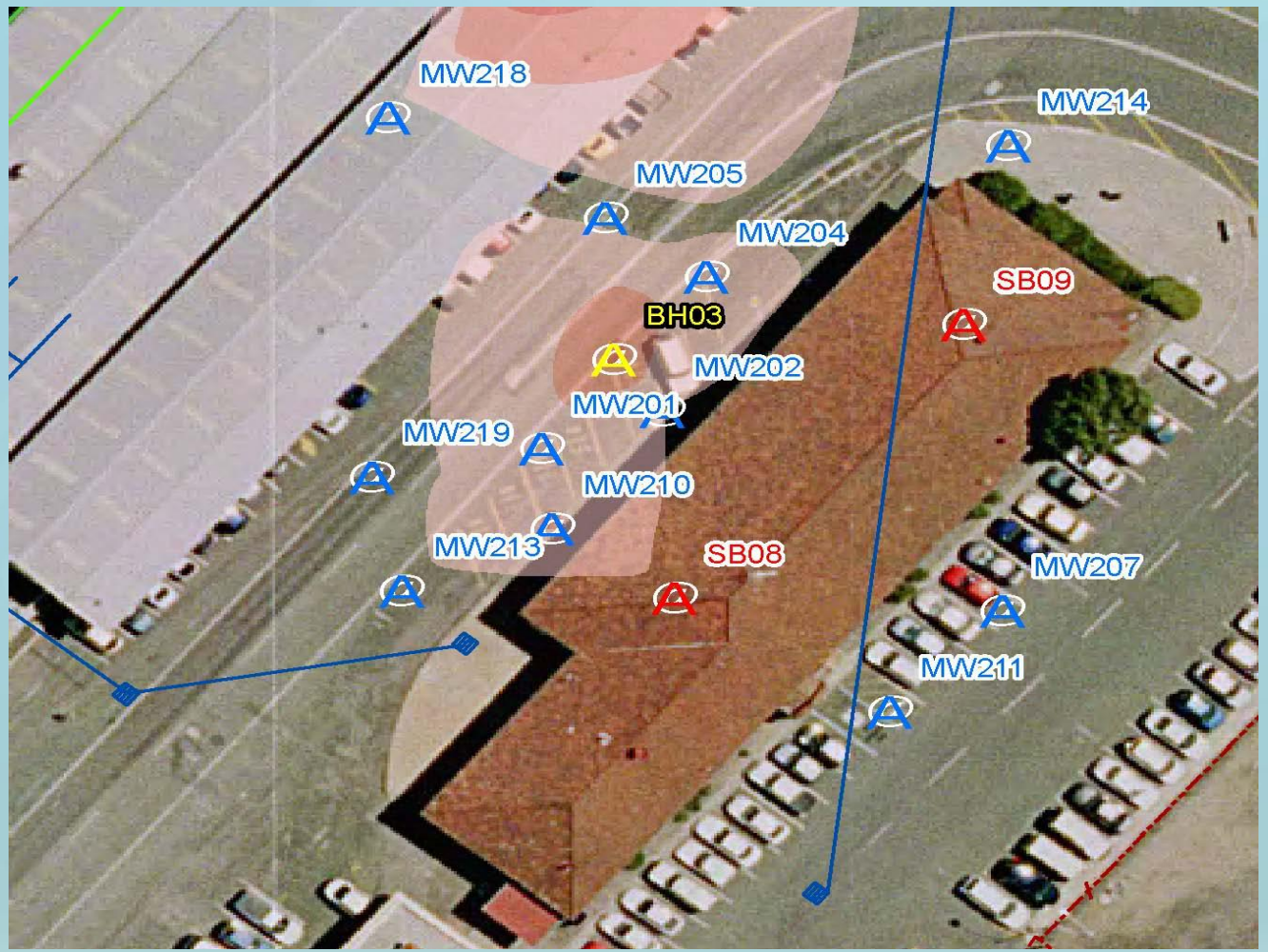
STIMULATING PUMP & TREAT SYSTEMS



CASE STUDY: SITE BACKGROUND

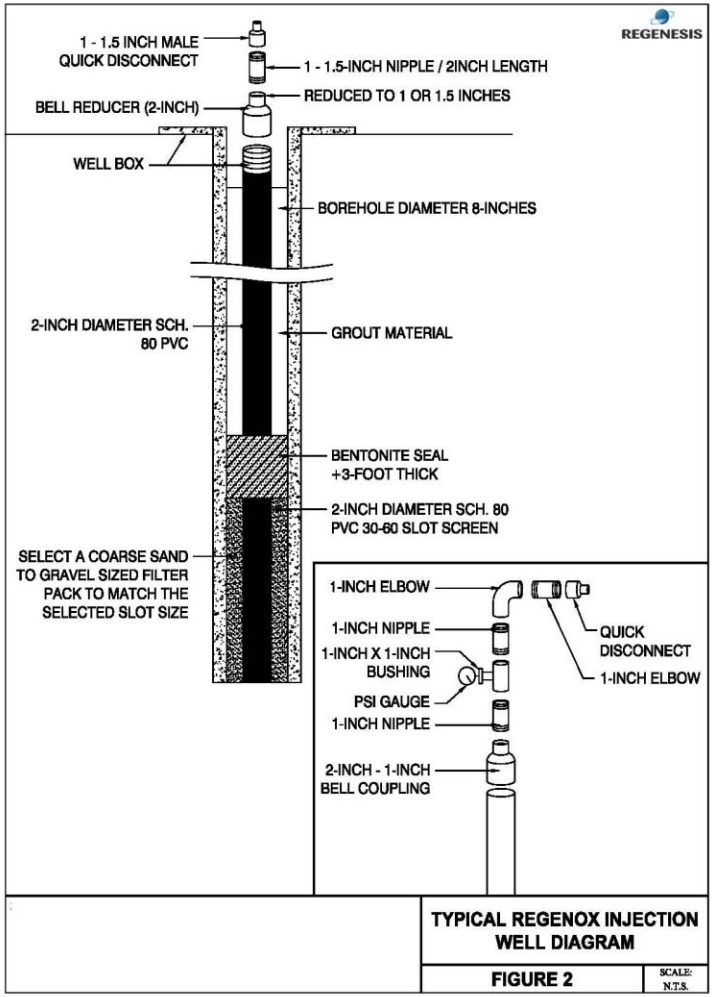
- Site: International Sea Port
- Remedial Driver: Redevelopment
- Source: Line leaks between USTs and offloading points
- Aquifer Type: Sand
- Contaminant: Diesel Range HC's (weathered)
- GW Depth: Approx. 20 feet bgs
- GW TPH Concentration: Range 10-100 mg/L
- Soil TPH Concentration: >5,000 mg/kg

CASE: TPH-D GW


MW218
MW214
MW205
MW204
SB09
BH03
MW202
MW201
MW219
MW210
MW213
SB08
MW207
MW211

CASE: METHODS

- Injection – Extraction
  - "Push-Pull"
- Injection "Push" Phase
  - Injection via 17 dedicated injection–extraction wells
  - App. Rate Approx. 20 lbs/yd3
  - 5% Solution

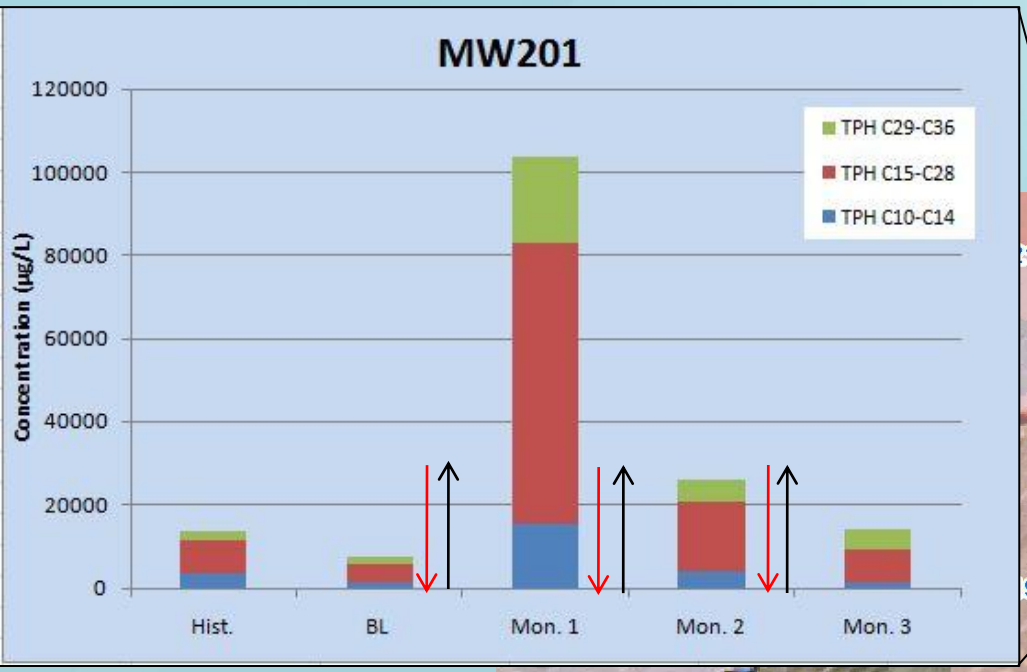


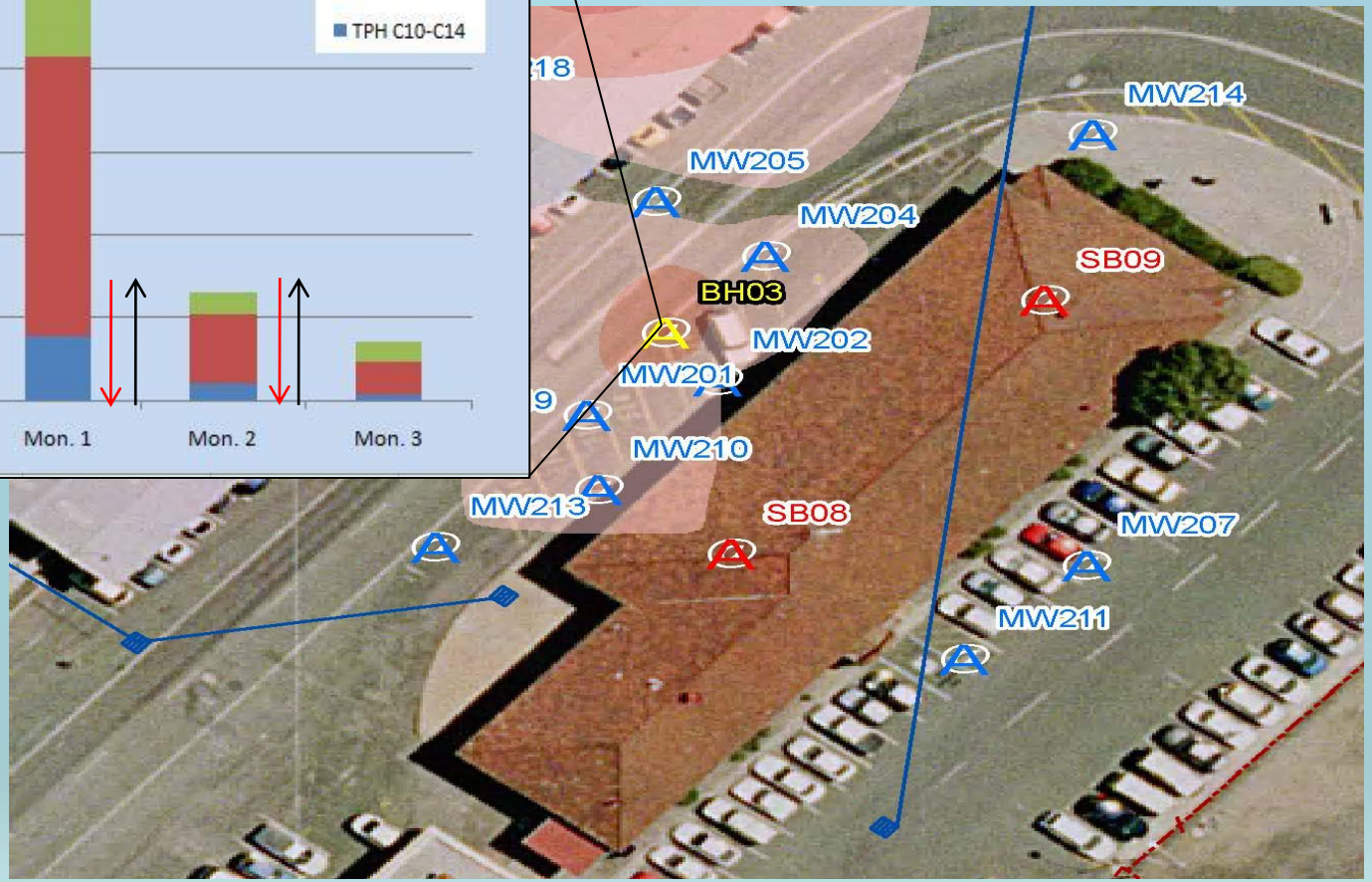
CASE: METHODS

- Reaction
- Allowed 14-21 days between "Push" and "Pull"

  Maximize desorption & ISCO rxn
- Extraction "Pull" Phase
  - Vacuum Truck
  - Extracted from Injection Wells
  - Removed 5,000 gals/event

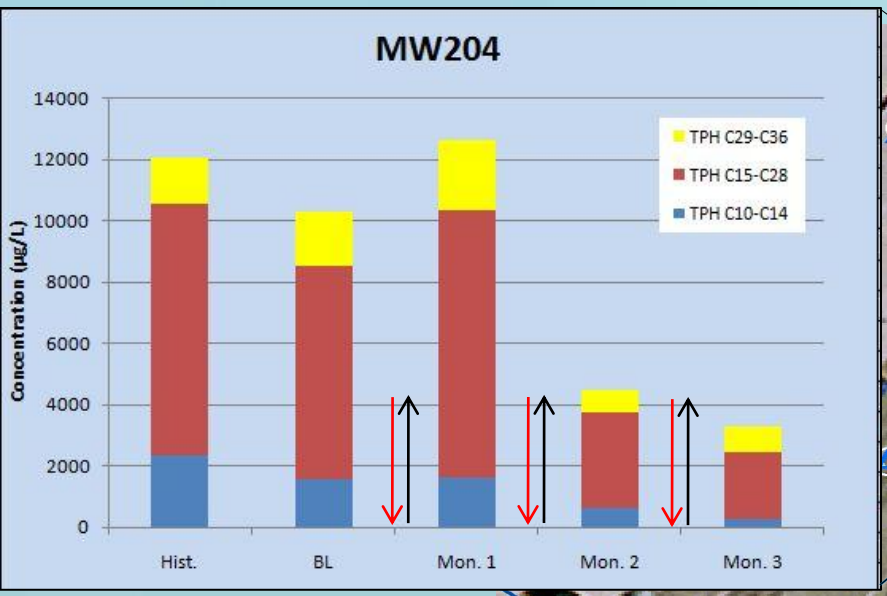
CASE: CONTAMINANT CONCENTRATION CHANGES

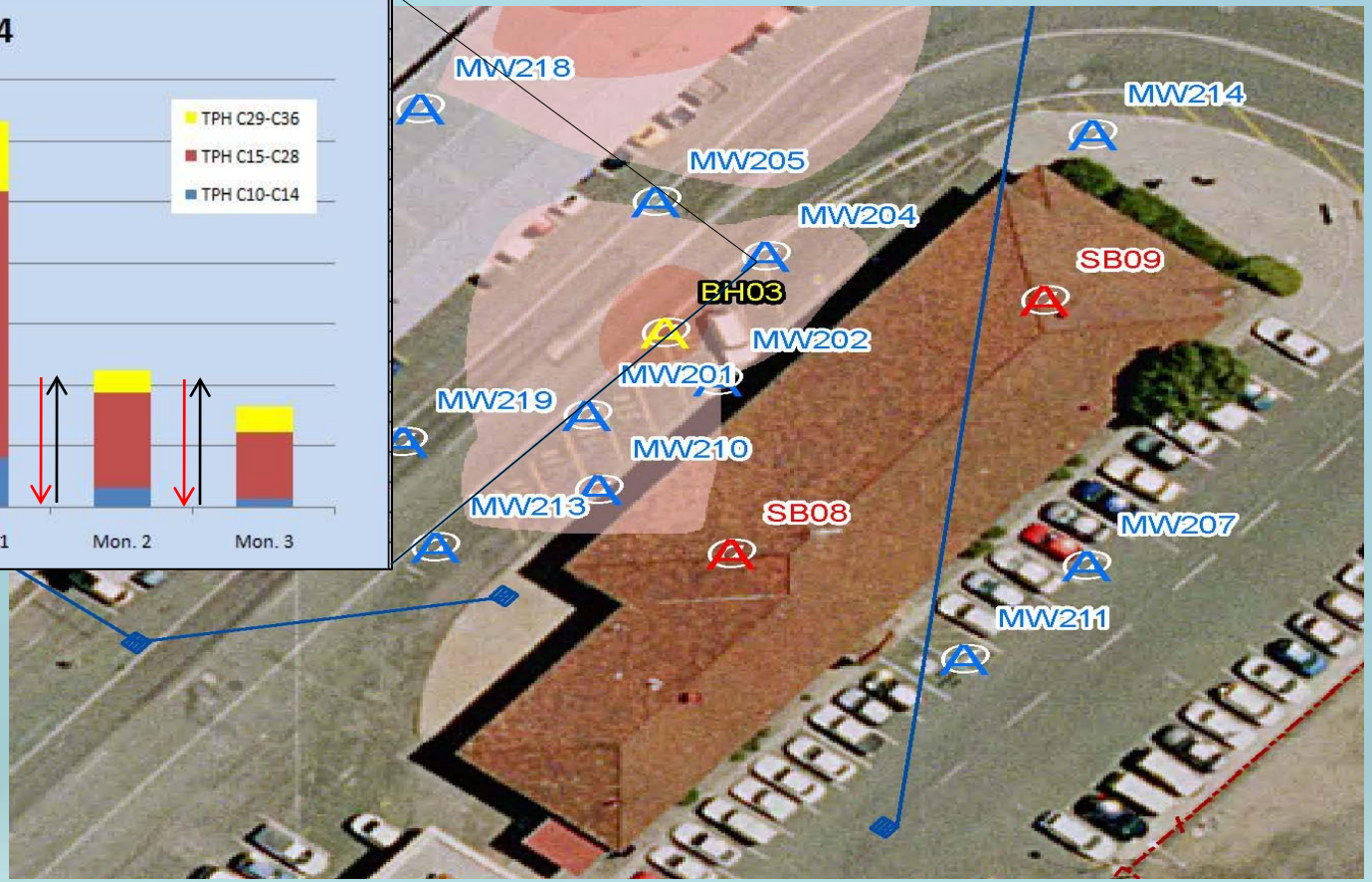




CASE: POST APPLICATION WATER QUALITY (VISUAL)

CASE: CONTAMINANT CONCENTRATION CHANGES





CASE: RESULTS

- Average Site Reduction 71%
  - Representative Reductions
    - High Concentration Wells:

      105 to 21 mg/L
    - Medium Concentration Wells:

      36 to 3 mg/L
    - Low Concentration Well:

      7 to 2 mg/L

CASE: RESULTS (CONT.)

- Remedial Results
  - 3-6 month period
  - removed about 1,000 lbs. of HC mass
- Site Implications
  - Minimal Rebound
  - GW remains below cleanup criteria 24 months later

PETROCLEANZE™

- Stimulates desorption of bound hydrocarbons
  - Vadose zone or smear zone
  - body of dissolved plume
  - NAPL mobilization/emulsification
- Rapid and low cost removal of hydrocarbon mass
- Significantly enhances recovery methods (P&T, Vacuum Extraction, etc.)
- Creates oxygen-rich environment for aerobic bioremediation and natural attenuation
- No added BOD

LET RRS HELP YOU REMEDIATE NAPL SITES

REGENESIS
REMEDIATION SERVICES

THANK YOU

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