

Performance of a New Activated Carbon Amendment for Bioremediating Petroleum-Impacted Sites



REGENESIS[®]

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Outline

- An optimized activated carbon-based injectate for petroleum sites: PetroFix Remediation Fluid
 - What is it?
 - Features
 - Common applications
- Two Case Studies
 - Application
 - Performance results
 - Evidence for biodegradation



R&D at REGENESIS

Team of Chemists, Engineers, & Material Scientists

- Problem solvers: Looking for solutions to remediation challenges
- New technology development
- Optimizing and evolving existing technology lines
- Treatability testing



Optimizing & Evolving Technologies

- Experienced in carbon-based injectates
 - PlumeStop® Liquid Activated Carbon™ launched in 2013
 - Applied on 300+ sites to treat various VOCs
- Identified an opportunity to evolve the formulation for petroleum sites
 - Tailored the PlumeStop formula for improved performance at petroleum sites:
 - Higher contaminant mass
 - Promotes the desired destruction method
 - Easy to handle and apply
 - DIY



What is PetroFix Remediation Fluid?

Two-part product:

1. PetroFix Fluid

- 2 μm activated carbon suspension in water
- Slow-release source of sulfate

2. Electron Acceptor Blend, two options:

a) Mix of sulfate + nitrate (preferred)

- Ammonium Sulfate
- Sodium Nitrate

b) Sulfate only

- Ammonium Sulfate
- Potassium Sulfate



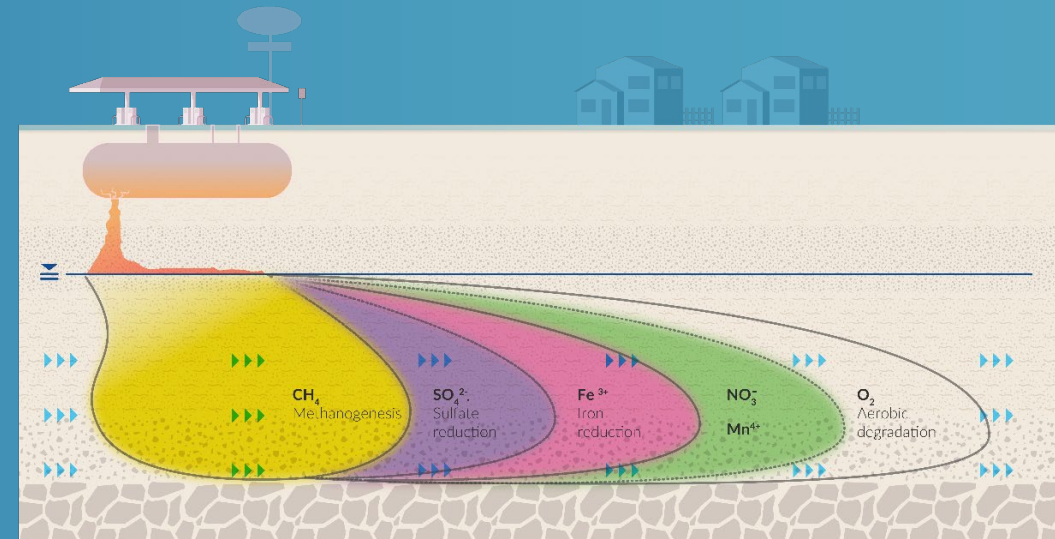
Handling on site:

1. Dilute PetroFix Fluid to prescribed concentration
2. Mix in electron acceptor blend

Features of PetroFix

1. Formulated for Petroleum Hydrocarbon Treatment

- Two modes of action:
 - Activated carbon to quickly reduce contaminant concentrations
 - Slow and fast-release electron acceptors to stimulate anaerobic biodegradation
 - Support a diverse, healthy microbial population
- No competing carbon sources in formulation
- Able to address a wide range of contaminant concentrations
 - Not recommended for LNAPL treatment



Features of PetroFix

2. Fluid Delivery: Ease of Use + Improved Aquifer Coverage

- Applied with routine mixing and injection equipment
 - Ex. DPT, injection wells
- Low-pressure, non-fractured placement
 - Goal: Maximize contact between reagent and contaminants in flux zones
 - 2 μm activated carbon is the right size to fit through pore throats
 - Complete coverage when applied at recommended spacing
 - Typically 5 – 7' on center



Features of PetroFix

3. Self Design and Self Apply

- Online software invites industry to complete their own designs/injections
- Rapid designs provides dosage, volume and spacing and other variables
- Injection tooling recommendations and instructions
- Design Assistant Tutorial to get you started

www.petrofix.com



PetroFix Design Assistant Tutorial



Most Common Applications

Case Study #2

Case Study #1

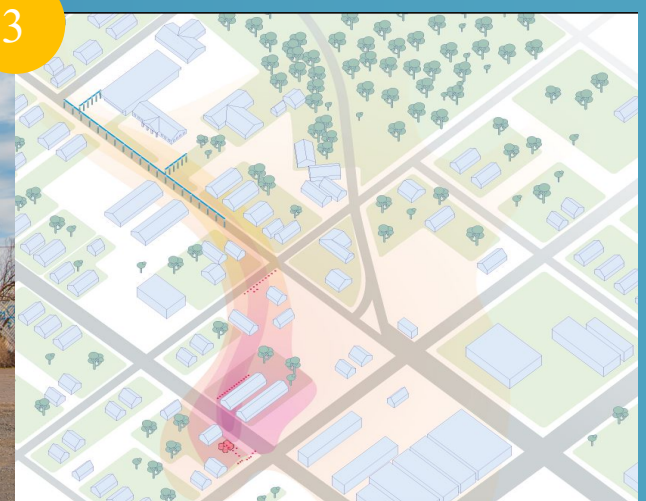


Tank Removal/Upgrade
Excavation application
addressing residual mass



Contaminated Source Areas

- Grid Approach
- Smear Zone



Migration Management

- Eliminate off-site migration
& reduce liability

Case Studies: Beta Site Performance



PetroFIXTM Remediation Fluid Product Beta Testing

- Two beta applications performed
- Performance Monitoring
 - Verify PetroFix distribution
 - Groundwater concentrations
 - Microbial Populations trends
 - Do we sustain a diverse population of degrading microbes?



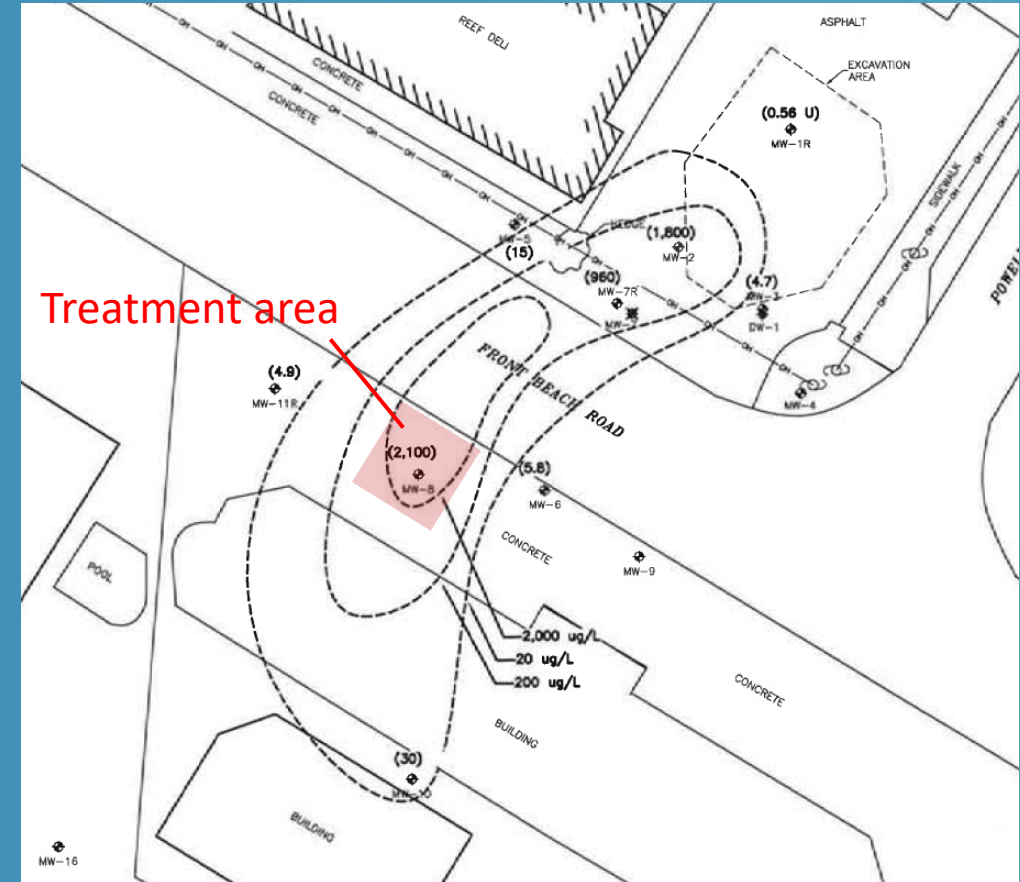


Site 1: Panama City Beach, Fl

Site Background:

- Former gasoline service station
- 1,000 Gal gasoline release 2007
- Excavation completed 2007 (~300 tons)
- Several remedial technologies have been implemented. Limited success
- BTEX + Naph – 1,300 to 14,300 ug/l,
- TPHg 4,300-15,000 ug/l

Goal: Residual Plume Migration Management





Site 1: Panama City Beach, FL Results

Pilot Test:

- 1,700 lbs of PetroFix injected w/ sulfate + nitrate EA Blend
- 10 direct push points, 20'x20' test area
- Target zone: 5-15' bgs
- Homogenous beach sand

Distribution verification:

- Excellent distribution across target treatment zone
- Confirmed 7 ft spacing was optimal



GW Concentrations:

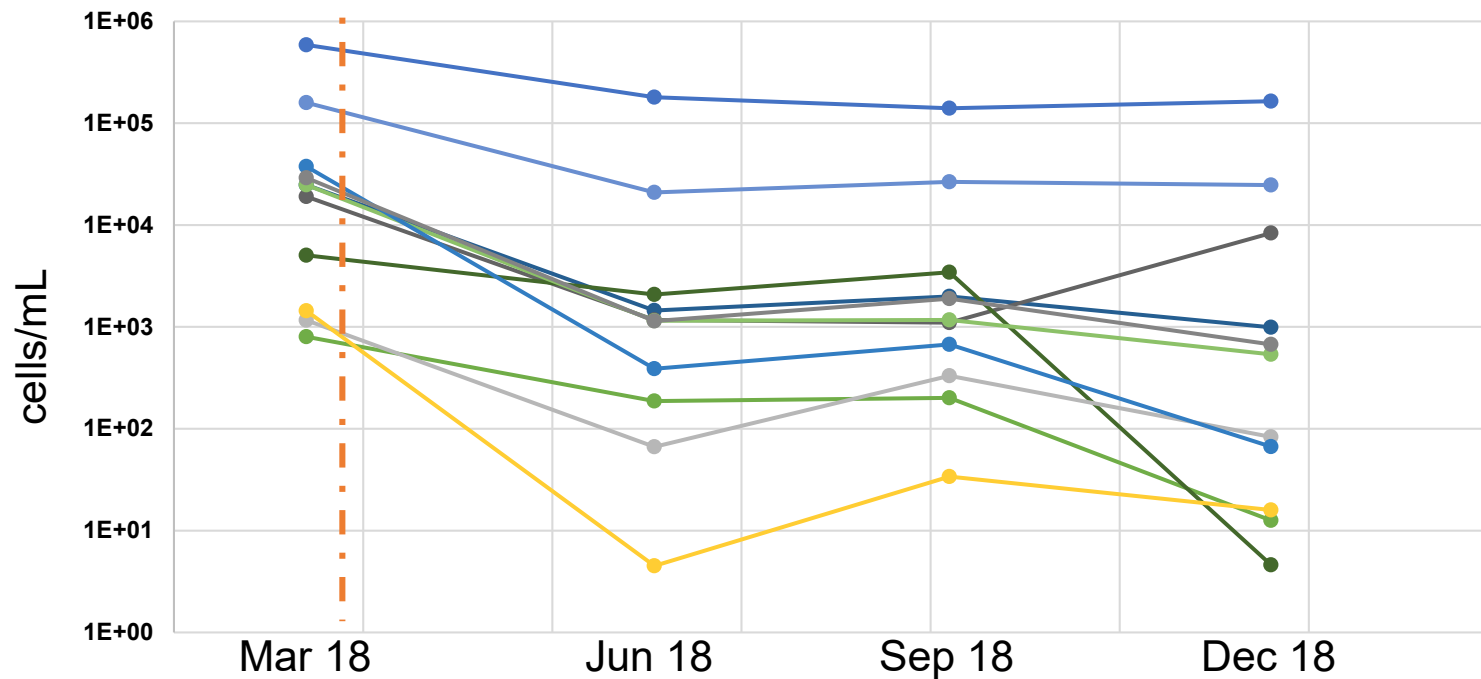
- Non-detect concentration by first monitoring event, results have sustained

(units µg/L)	Baseline: Mar 2018	May 2018	June 2018	Sept 2018	Dec 2018
Benzene	1.5	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	0.3 J
Ethylbenzene	270	ND	ND	ND	ND
Xylenes	860	ND	ND	ND	ND
TPH-GRO	3,100	ND	ND	ND	ND



Site 1: Panama City Beach, FL Results

QuantArray® Petro



- APS —●— assA —●— BCR —●— bssA —●— mnssA —●— PHE
- PHNA —●— PM1 —●— RDEG —●— RMO —●— TOD

Microbial Analysis:

- All hydrocarbon went to non-detect, removed from GW
- QuantArray® Petro data: Key petroleum degraders are still abundant
 - Supports on-going biodegradation even with adsorption to activated carbon
- Full scale application planned for summer 2019



Site 2: South Bend, IN

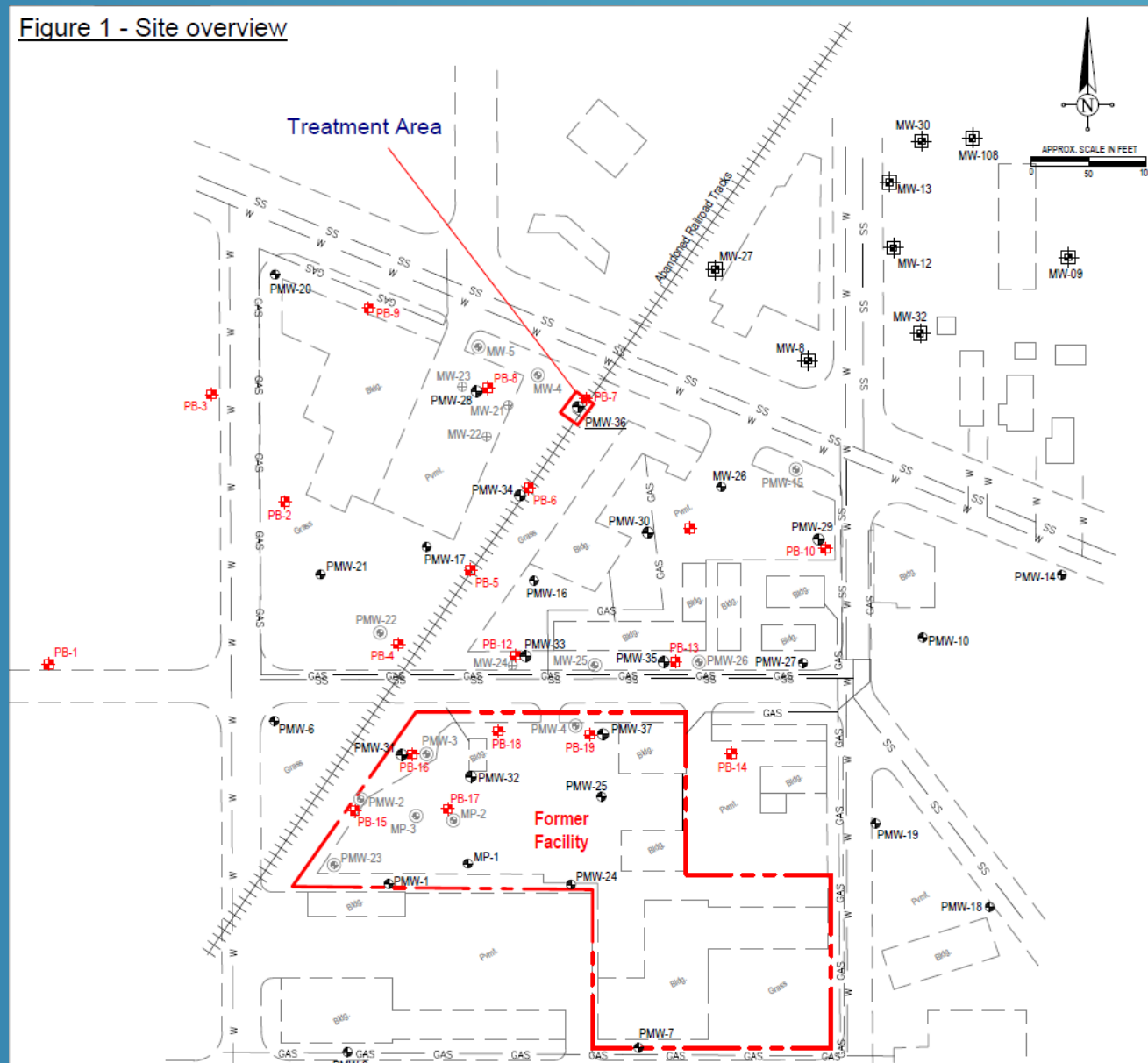
Site Background:

- Historical Bulk Petroleum Storage Facility
- Remedial activities initiated in 2006
 - LNAPL Recovery – 2006
 - AS/SVE – 2007-2009
- BTEX – 3,500 ug/l
- TPH-G – 38,800 ug/l
- TPH-D – 17,800 ug/l

Approach: Mass reduction, grid application



Figure 1 - Site overview





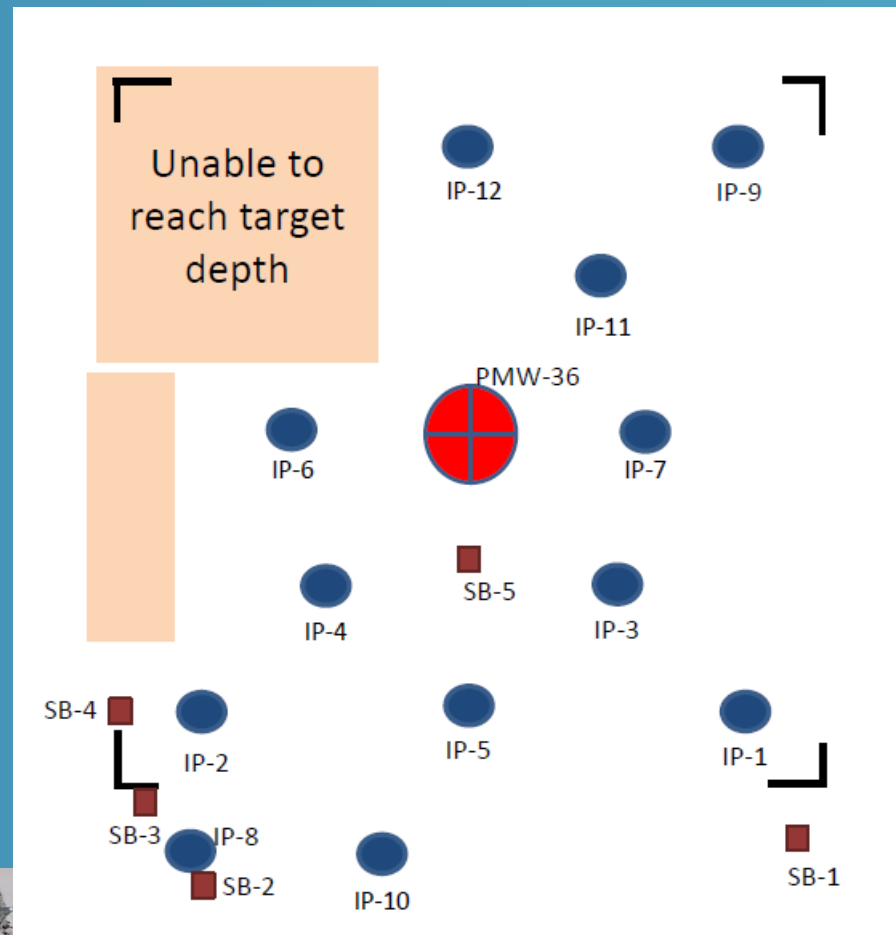
Site 2: Application

Pilot Test:

- 2,000 lbs of PetroFix injected w/ sulfate + nitrate EA Blend
- 12 direct push points
- Target treatment zone: 15-22' bgs
- Heterogeneous soils

Distribution Confirmation:

- 5-7' spacing was optimal for complete coverage





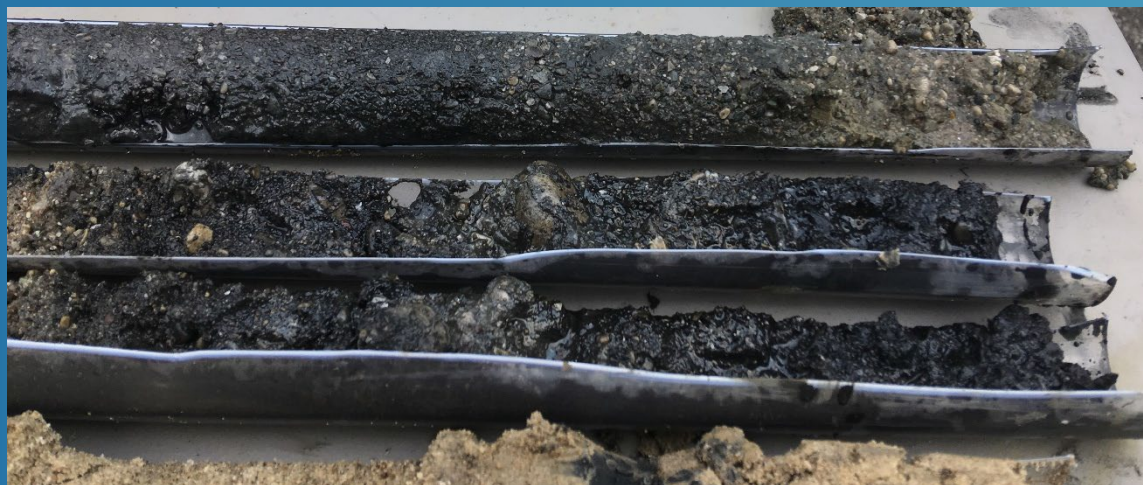
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GW Results:

(units µg/L)	Baseline May 2018	Jun 2018	Aug 2018	Nov 2018	Feb 2019
Benzene	149	ND	ND	ND	69.9
Toluene	191	ND	5.7	ND	139
Ethylbenzene	330	ND	5.6	14	49.1
Xylenes	2,610	ND	30	ND	181
TPH-GRO	33,800	ND	ND	ND	1,170
TPH-DRO	17,800	3,600	4,200	250	596
% Reduction	--	93%	92%	99+%	96%

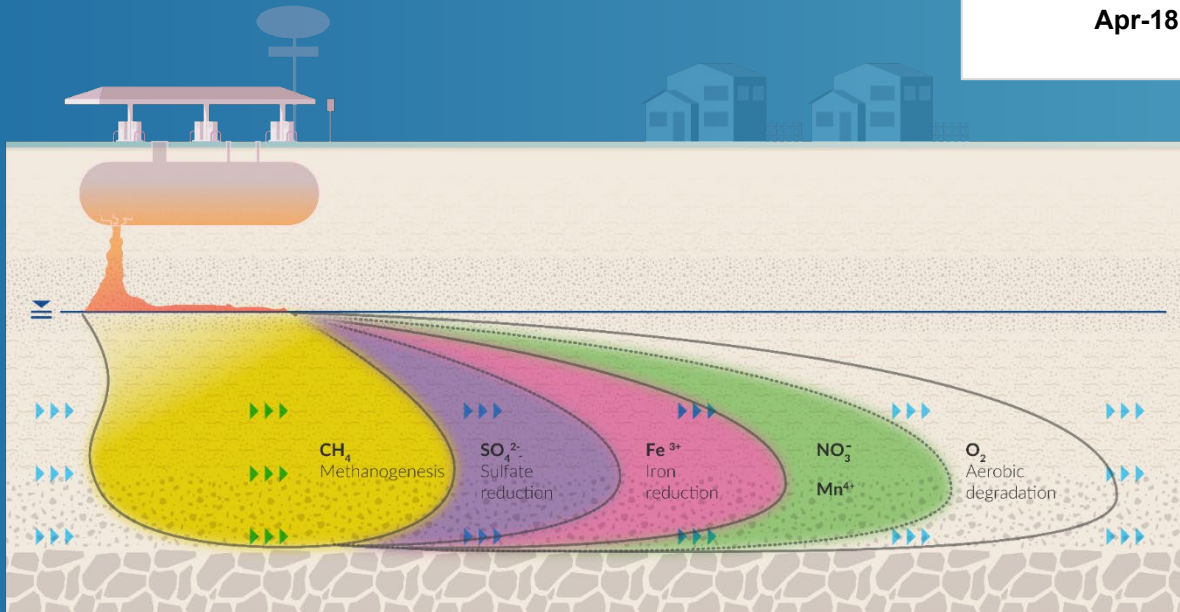
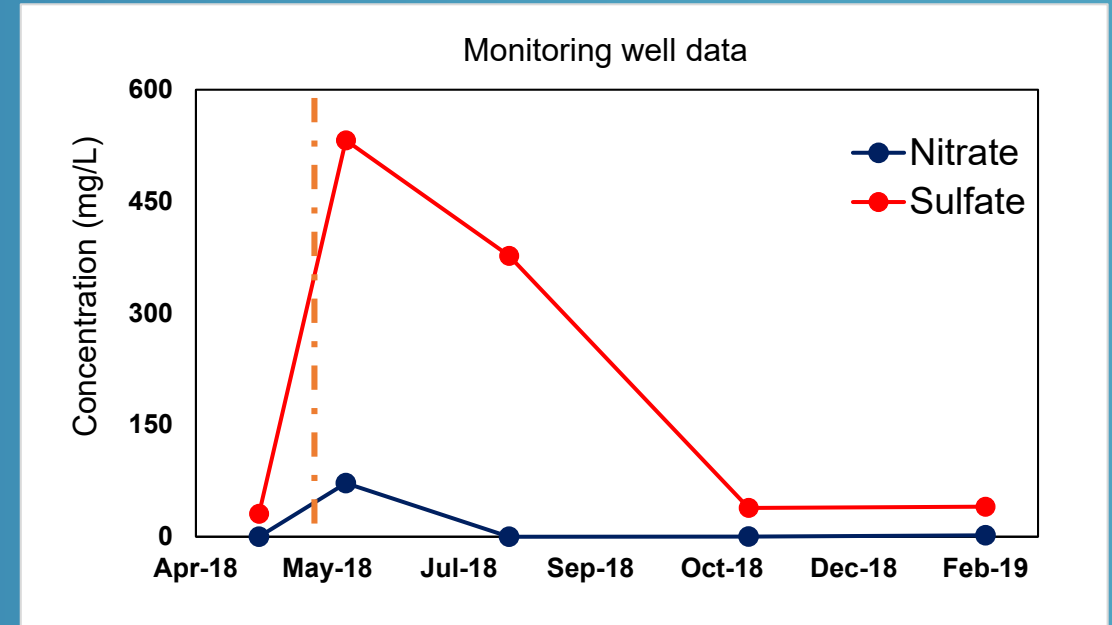
Full-scale application
went in last week!



Site 2: South Bend, IN RESULTS

Additional Monitoring:

- Lines of Evidence for biodegradation
1. Electron Acceptors over time
 - Expected nitrate to be consumed faster than sulfate

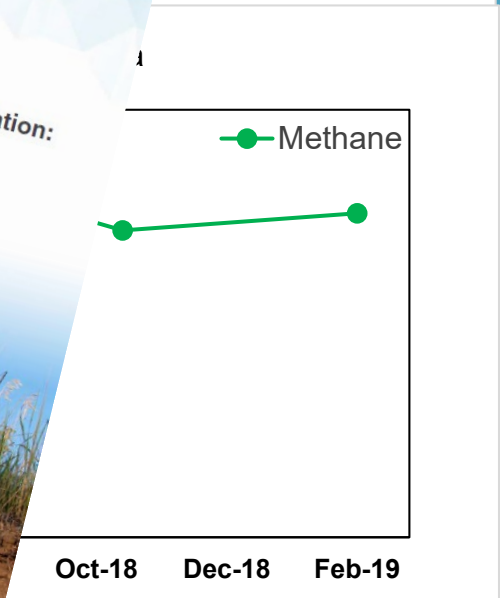
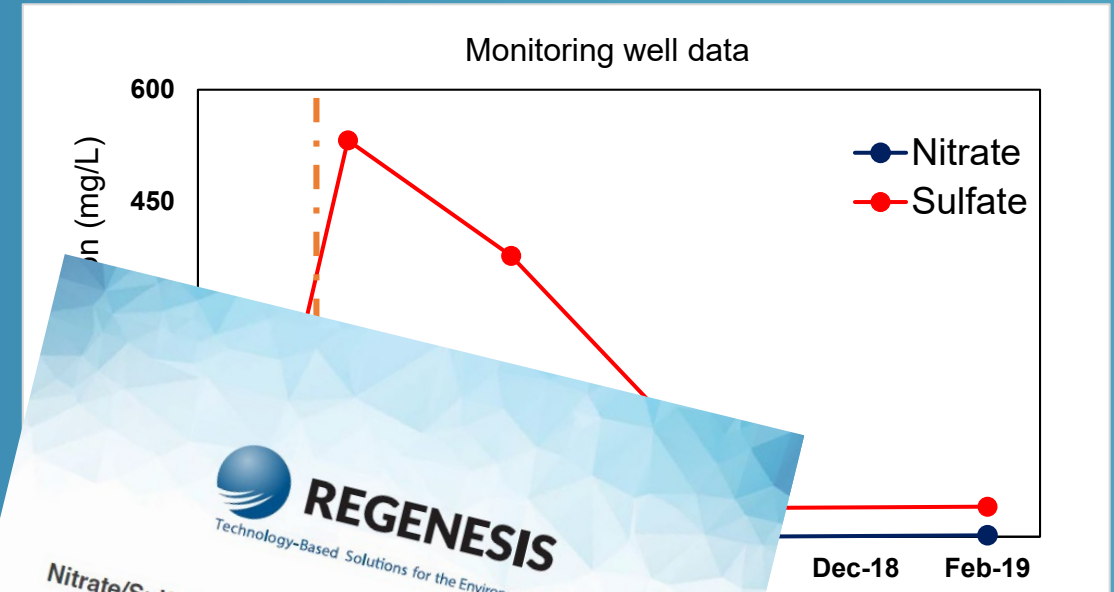




Site 2: South Bend, IN RESULTS

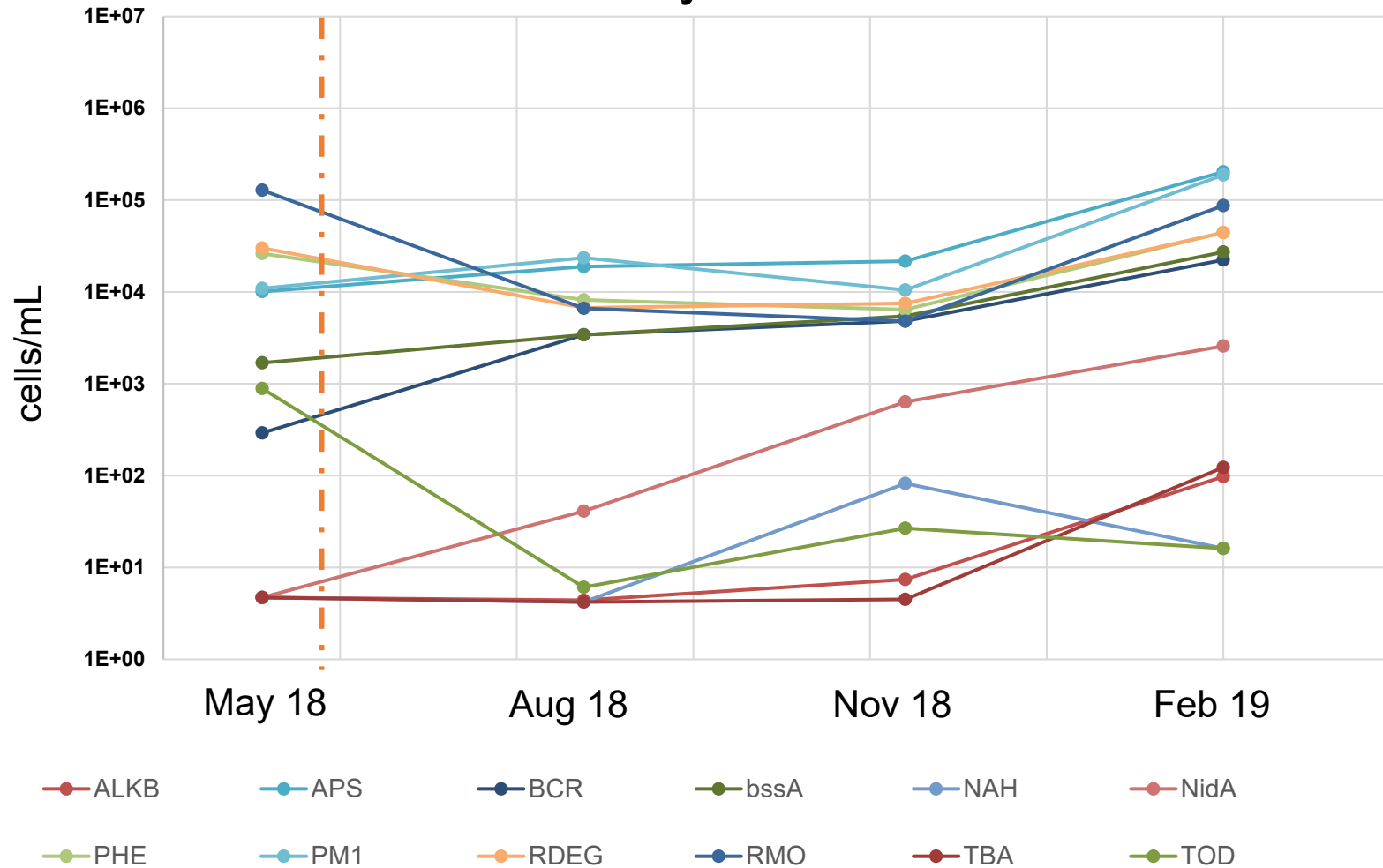
Additional Monitoring:

- Lines of Evidence for biodegradation
 1. Electron Acceptors over time
 - Expected nitrate to be consumed faster than sulfate
 2. Products of reaction
 - Observe sustained methane production (from hydrocarbon biodegradation) lasting after nitrate, sulfate consumed
 - Attributed to syntrophic biodegradation



Site 2: South Bend, IN RESULTS

QuantArray Petro

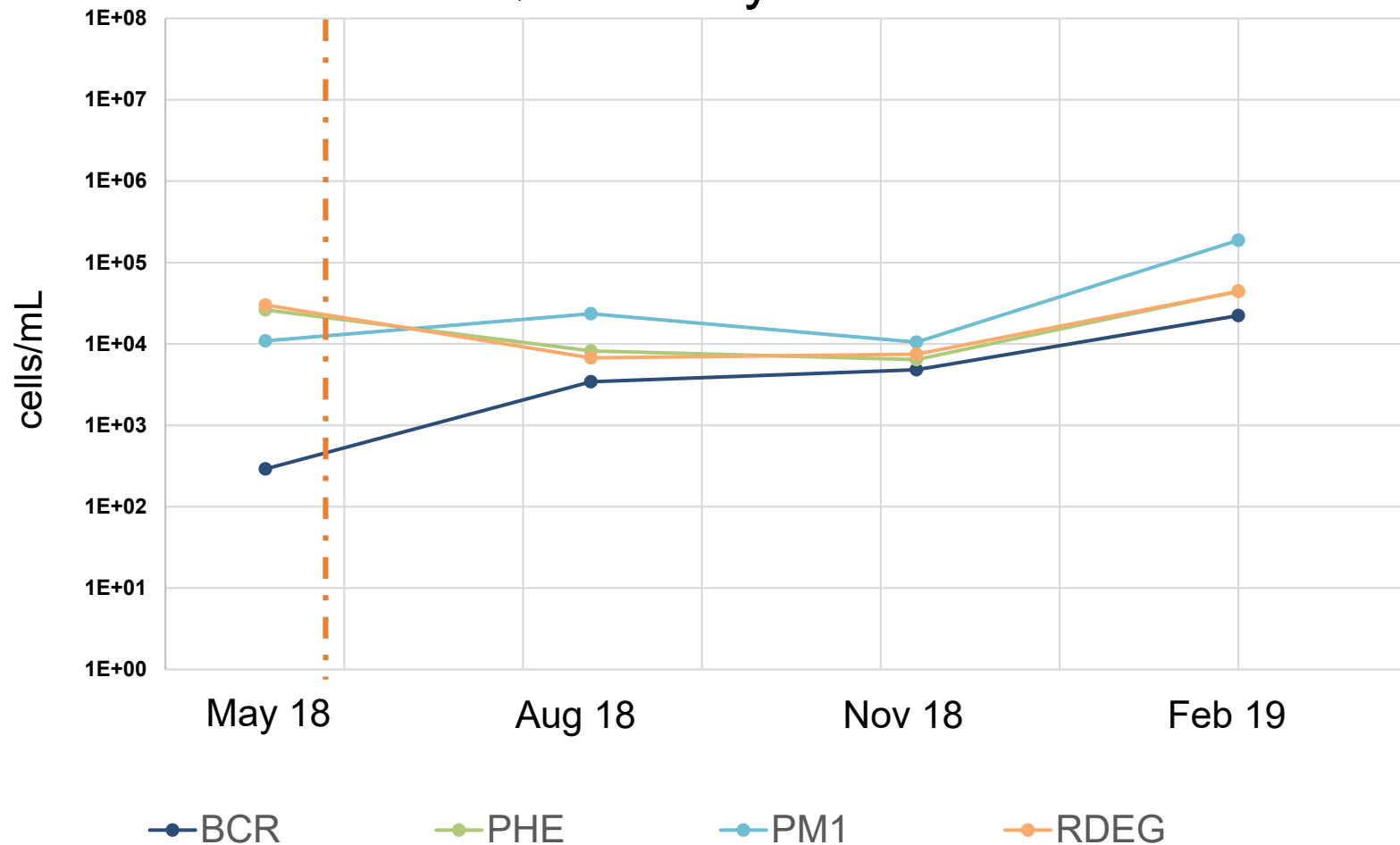


3. Microbial Analysis:

- Hydrocarbon concentration reduced by 90+%
- QuantArray® Petro data: Key petroleum degraders are still abundant
 - Diverse, healthy populations present
 - Supports on-going biodegradation even with adsorption to activated carbon

Site 2: South Bend, IN RESULTS

QuantArray Petro: mRNA

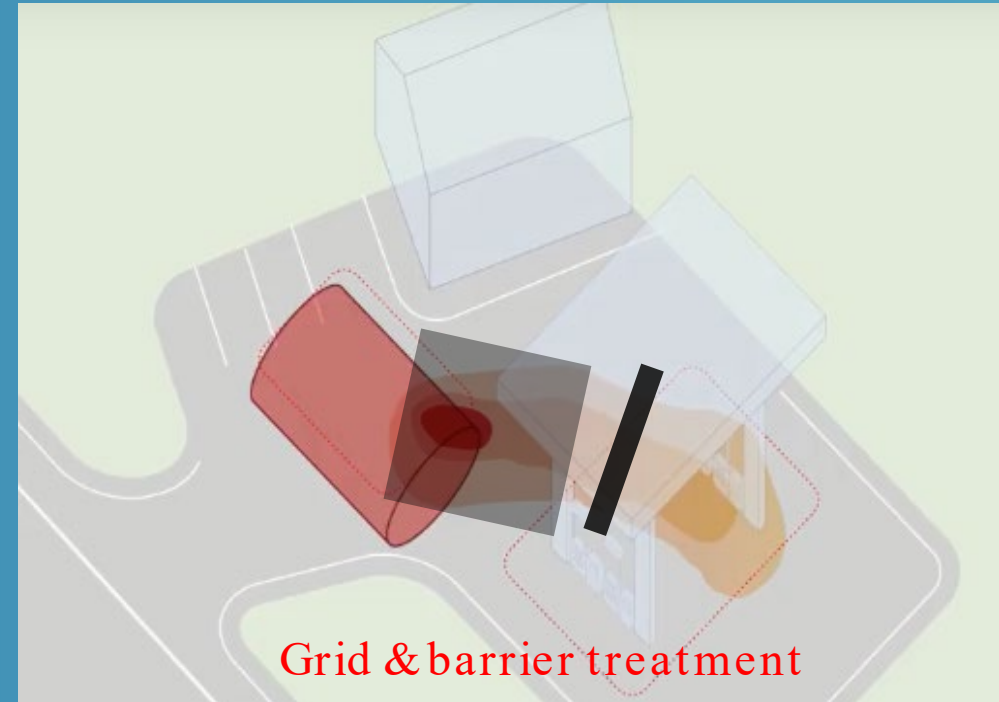


3. Microbial Analysis:

- Hydrocarbon concentration reduced by 90+%
- QuantArray® Petro data: Key petroleum degraders are still abundant
 - Diverse, healthy populations present
 - Supports on-going biodegradation even with adsorption to activated carbon
- mRNA data (Microbial Insights) indicates key populations are active and thriving

Conclusions

- PetroFix is an activated carbon-based product optimized for petroleum hydrocarbon remediation
- Two case studies demonstrated:
 - Effective for PHC remediation
 - Dual action: Sorption + anaerobic biodegradation
- GW, microbial, geochemical data support treatment principle



Thank you for your attention!

Questions?



For More Information Go To:
www.petrofix.com