Natural Source Zone Depletion and the Activated Carbon Remedy: Friend or Foe

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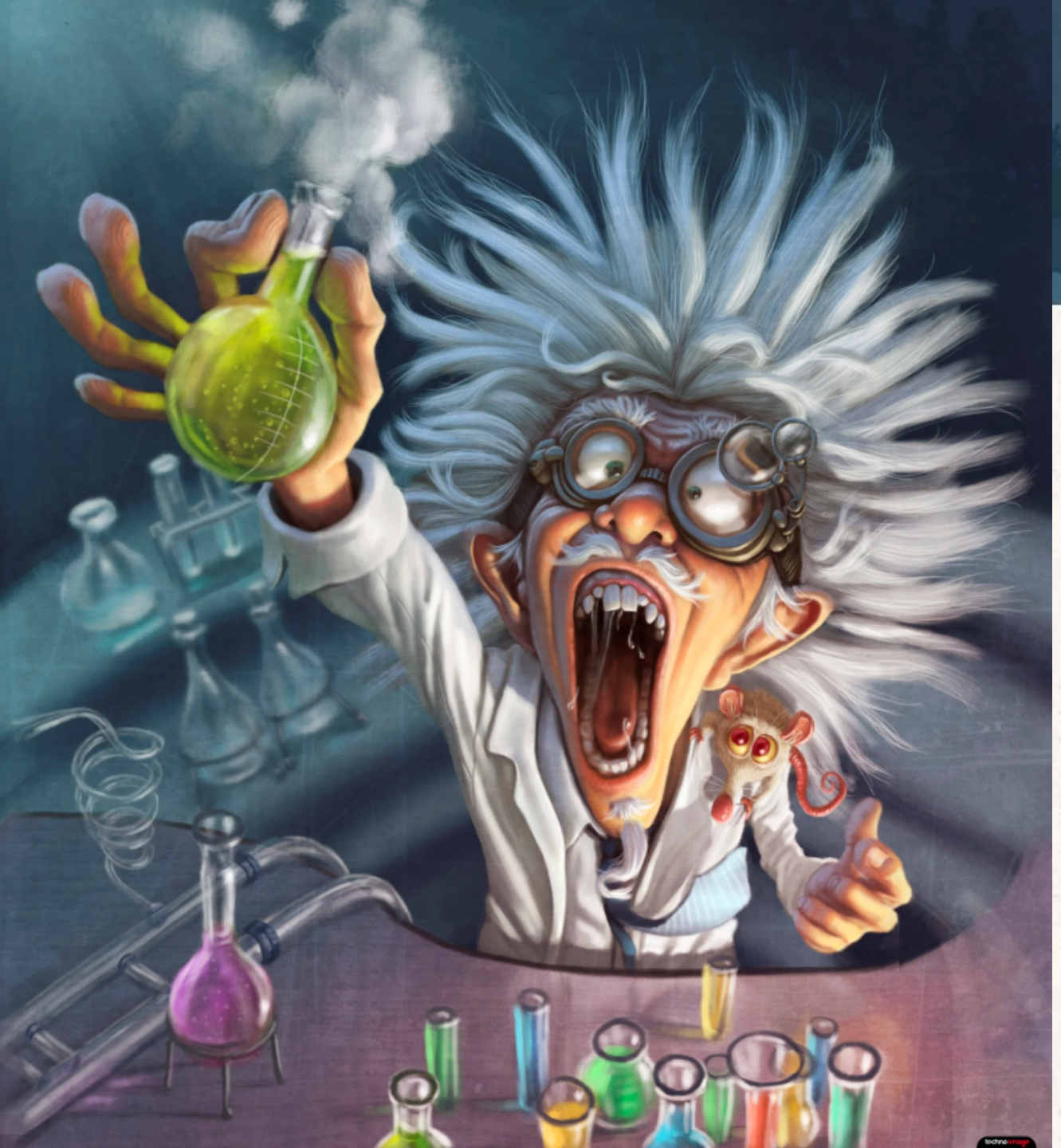
AST ENVIRONMENTAL, INC.

RPI GROUP



What About Activated Carbon?

The Industry Said…

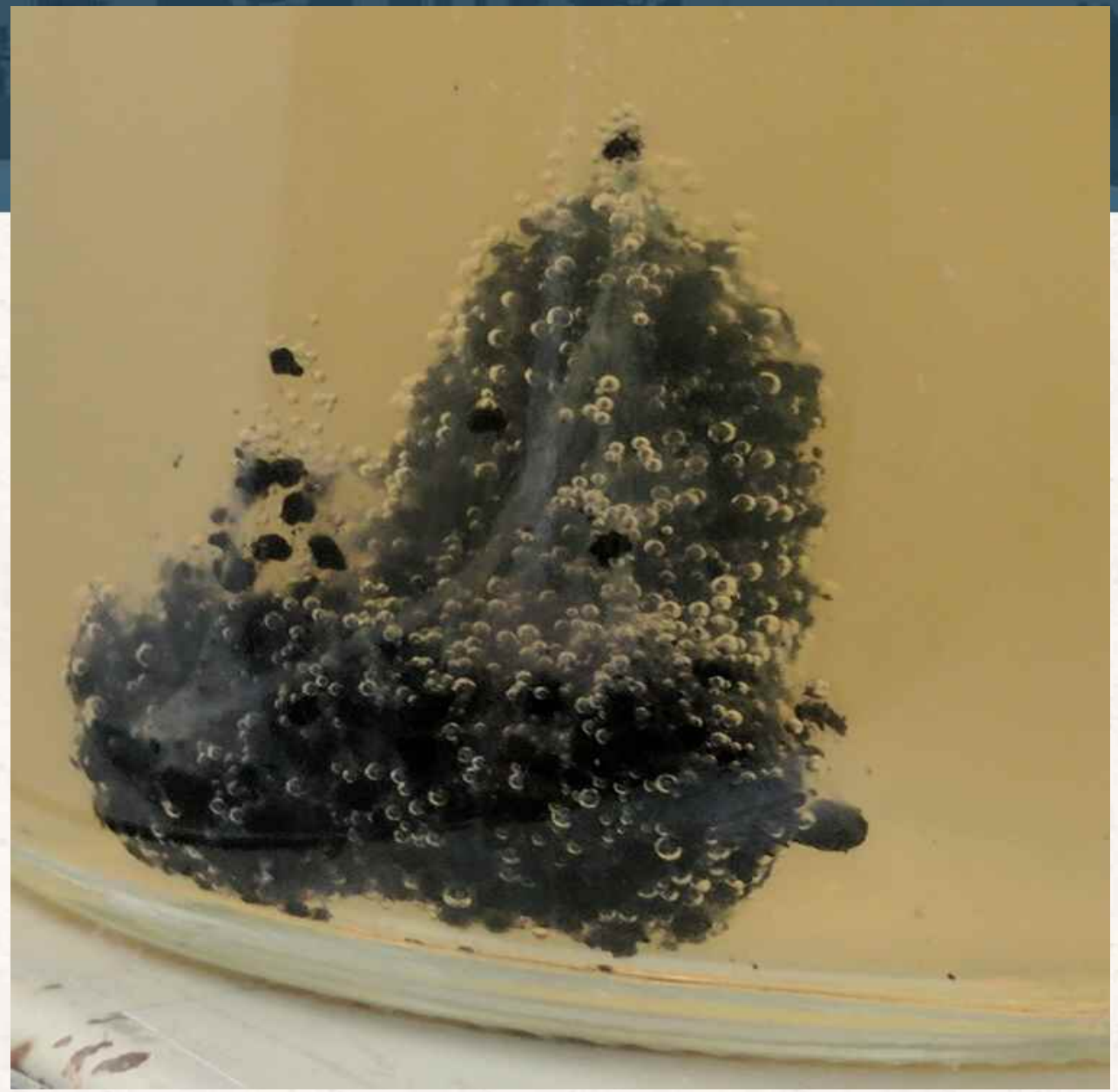
You Can’t Add Enough Carbon

Microbes Are Too Large

Step One – Bench Study

Measure the Adsorption Capacity of RPI's BOS 200® Carbon

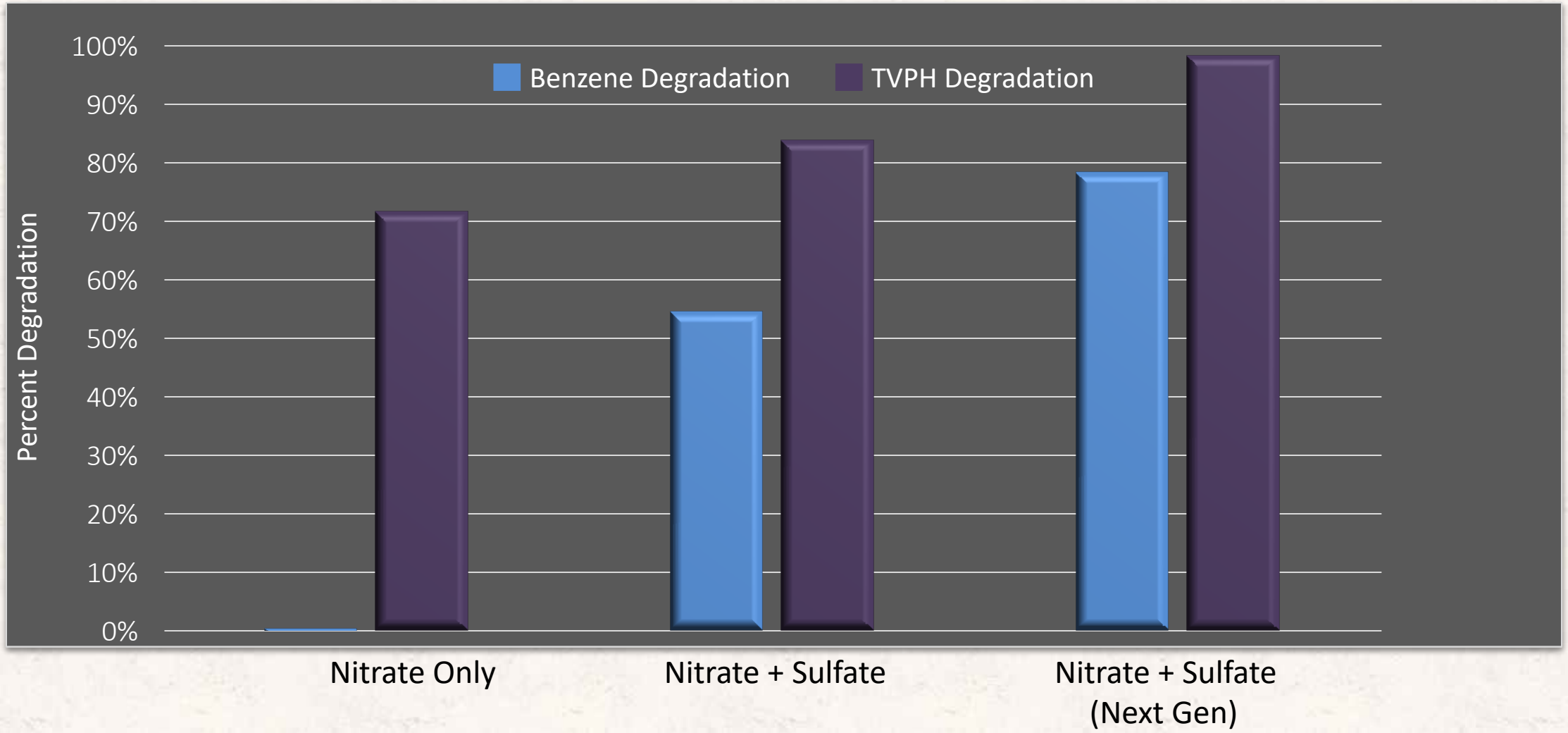
LNAPL Treatment using BOS 200®



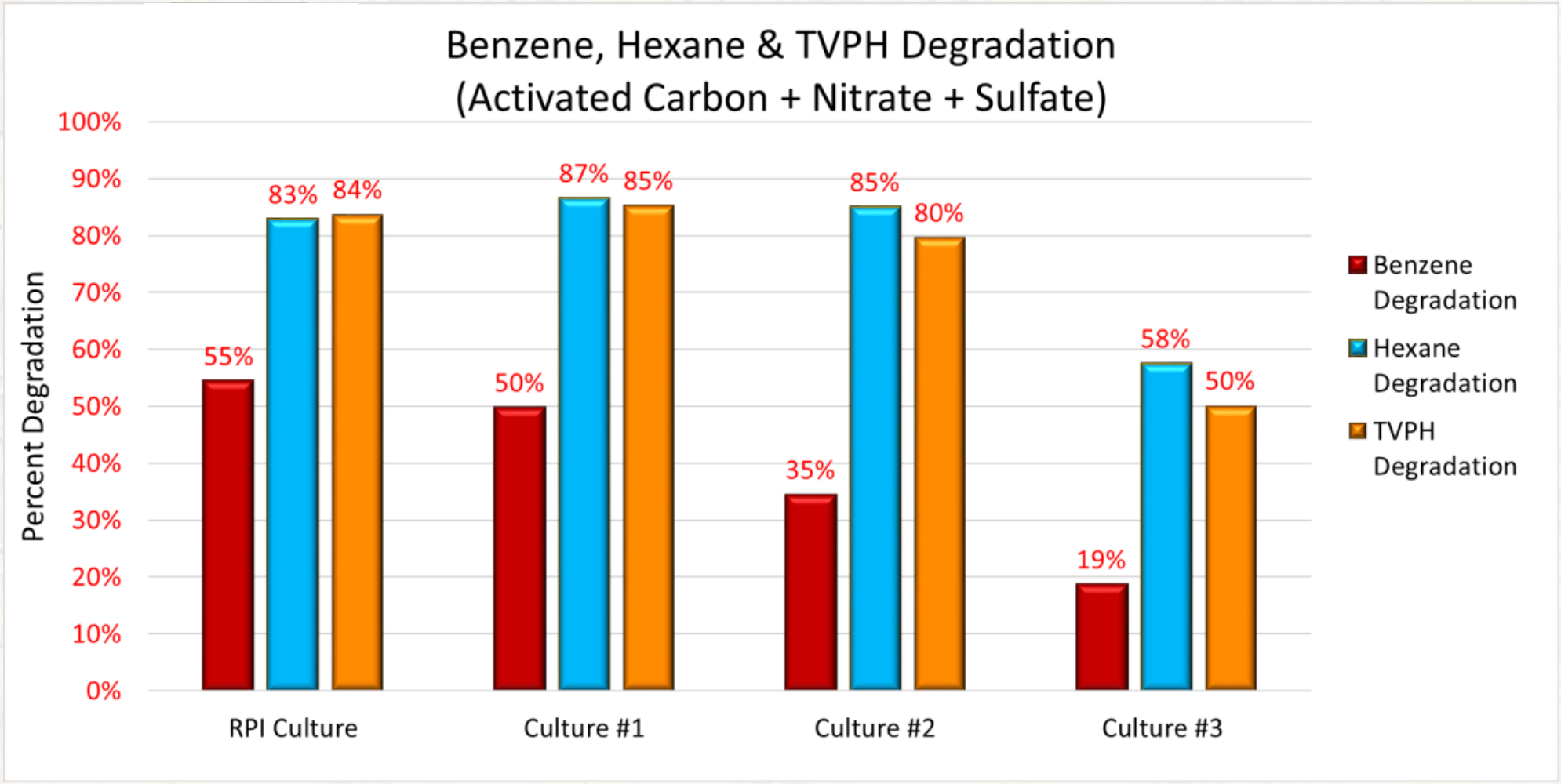
Bench testing involving both GRO and DRO

- Varying TEAs (e.g. NO_3 only, NO_3 + SO_4)
- Varying types of GAC (e.g. coal vs. wood)
- Varying bacterial blends
- Focus on bio-regeneration of AC

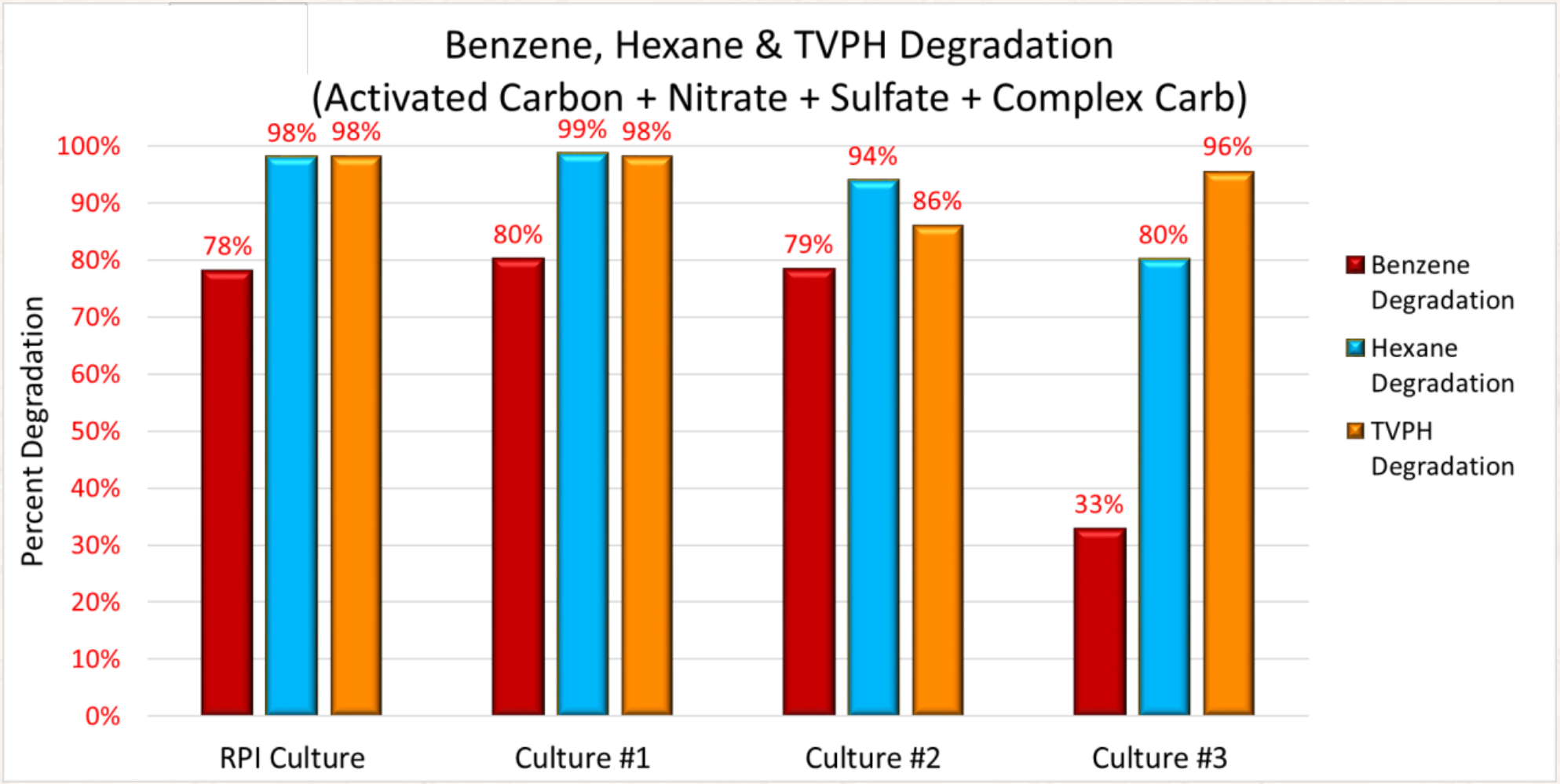
NAPL Bench Data



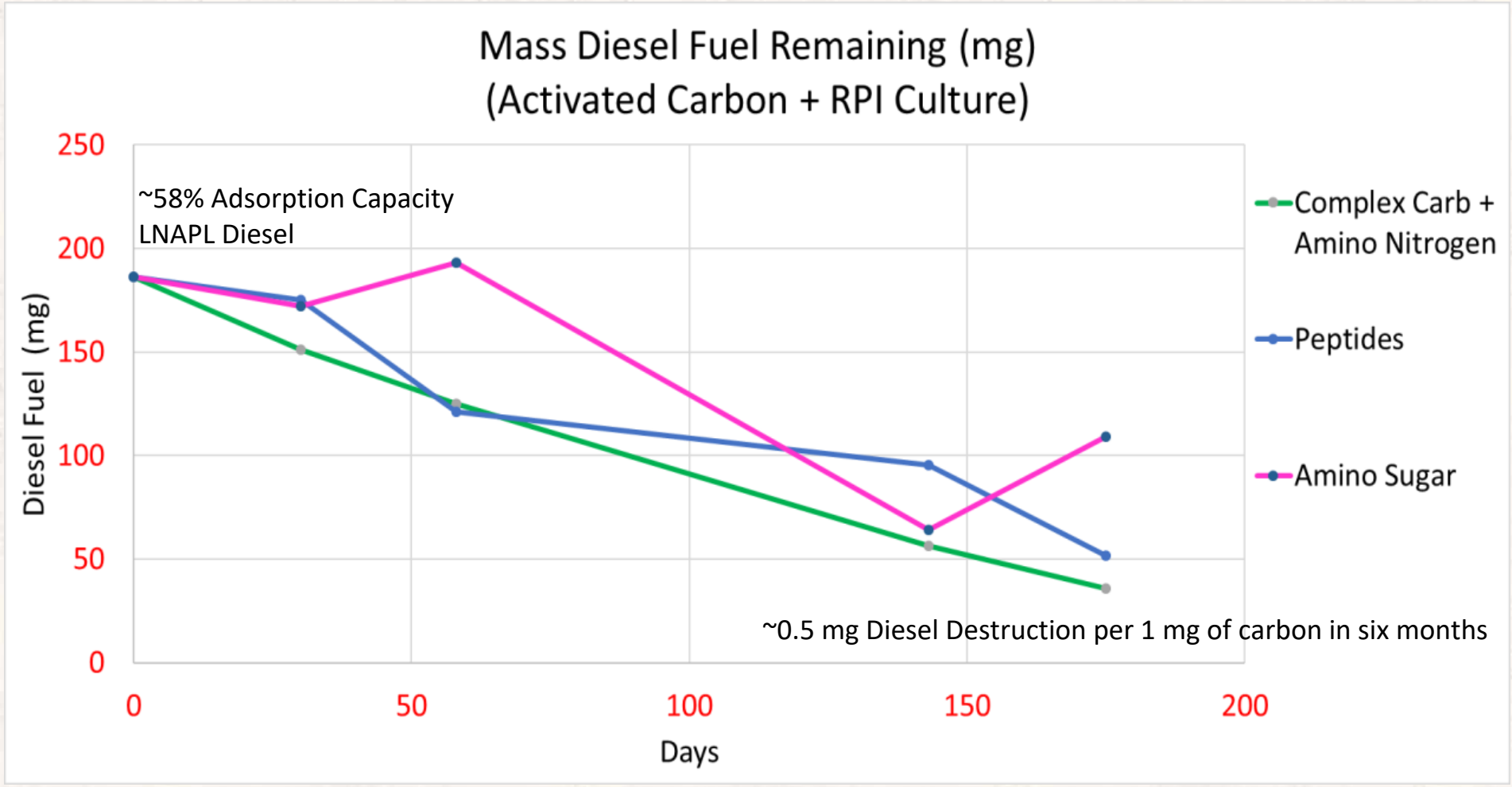
Laboratory Experiments – BOS 200



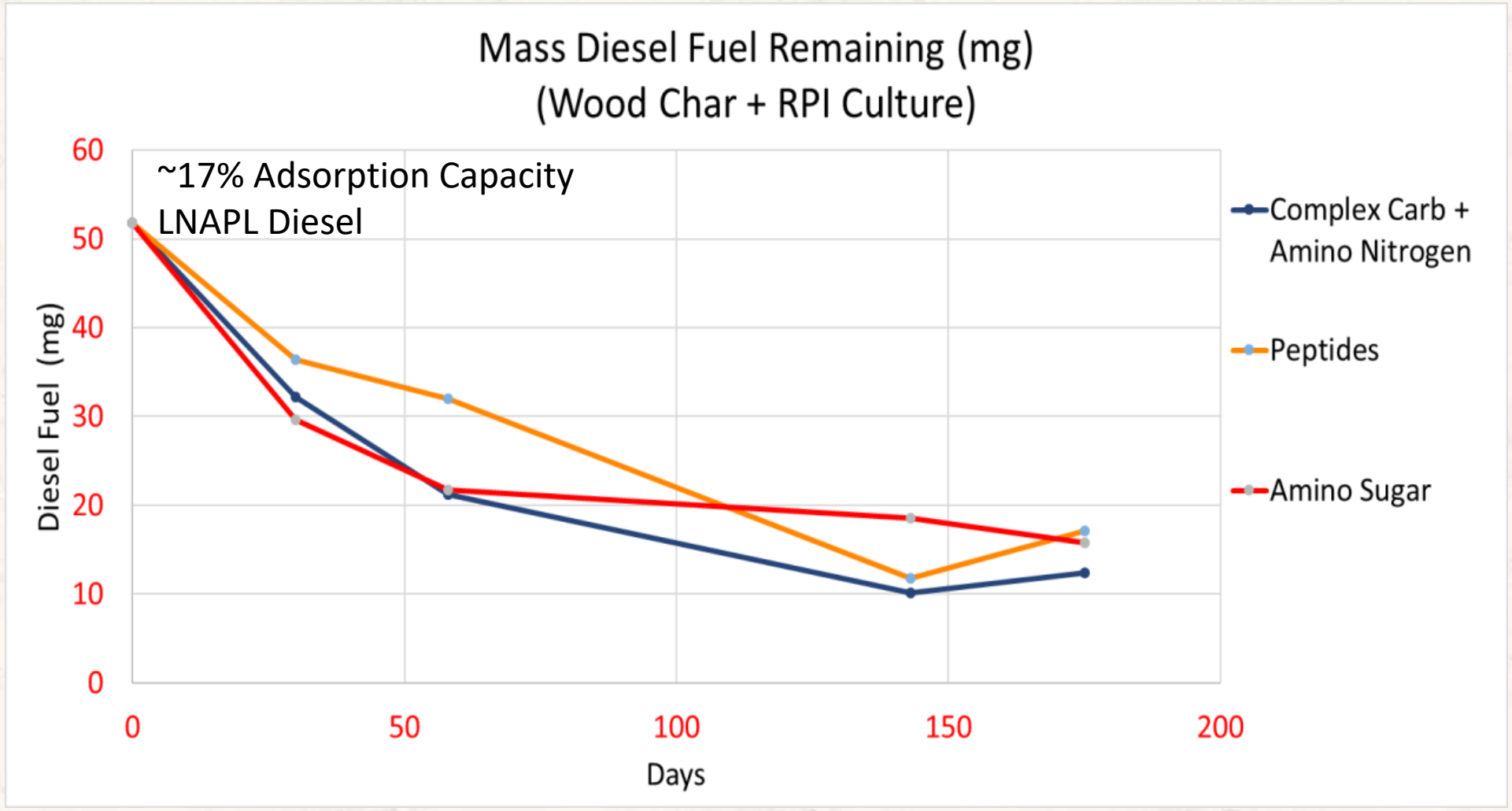
Laboratory Experiments – BOS 200+



Laboratory Experiments



Laboratory Experiments



BOS 200® to BOS 200+® Comparison

Both BOS 200 & 200+

- Powdered activated carbon
- Supplemental electron acceptors of nitrate and sulfate
- Microbes (bacteria, yeast, and fungi)

BOS 200+ adds

- Supplemental nitrogen for anabolic processes
- Supplemental carbon for energy production and anabolic processes

BOS 200+ adds

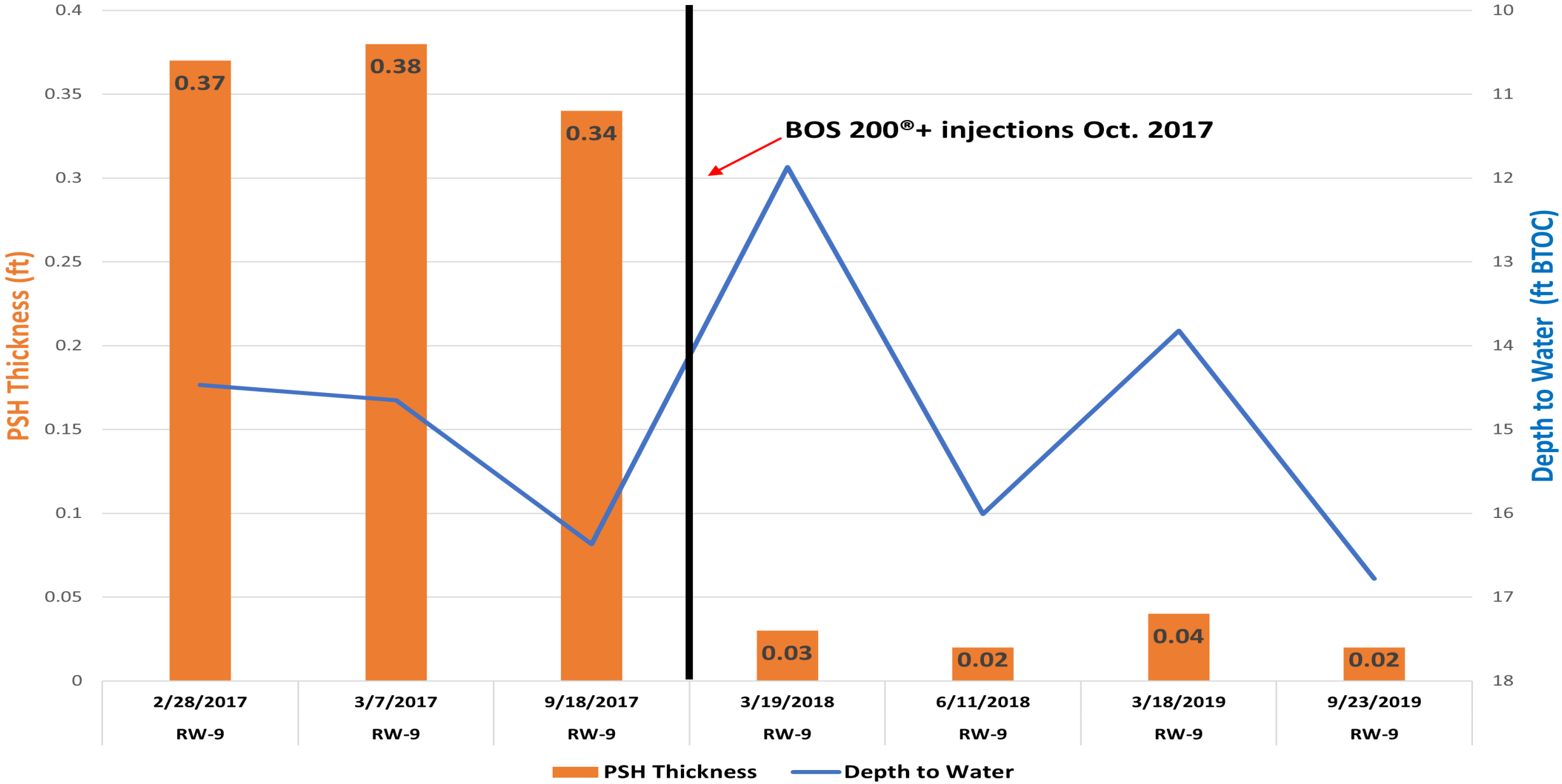
- Additional microbes to augment four characteristics
  1. Breakdown the supplemental and endogenous carbons to base sugars
  2. Additional sources of vitamins
  3. Additional measures to ensure ***no*** H_2S build-up
  4. Robust in the presence and breakdown of LNAPL

Case Study – Large LNAPL Site: Kinetic Design

- Two Plumes – Condensate LNAPL (high in benzene)
- Use of Dissolved Benzene as Indicator of Submerged LNAPL
- Original Design Estimated Elimination of LNAPL in 24 to 30 Months

NAPL Thinkness vs Depth to Groundwater

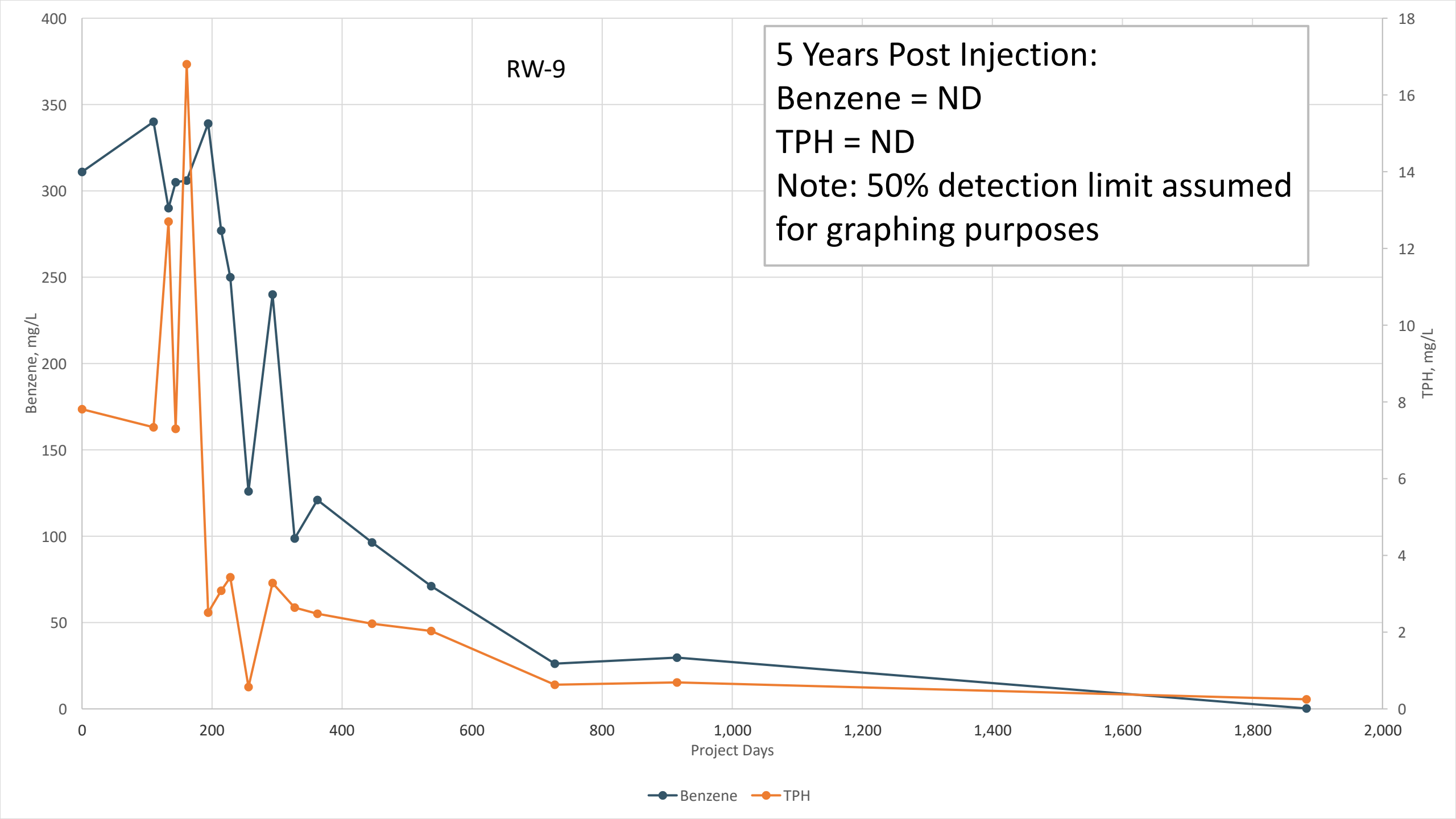
Condensate Site SW US



ID	Benzene Pre-Inj (ug/L)	Benzene < MCL 9/2019	NAPL 9/2017 (ft)	NAPL 9/2019 (ft)	Sulfide Present	NH_3 Generation
MW-02	246			0.66	X	X
MW-04	23.4	X	0.07	Sheen		X
MW-06	125	X				
MW-11	22.5	X				
MW-20	341		0.01		X	X
RW-05	1350	X	0.06	Sheen		X
RW-07	387		0.19	0.02	X	
RW-08	256	X	Sheen			X
RW-09	311	X	0.34	0.02		
RW-10	0.69	X	Sheen			X
MW-16	21.0	X			X	X
MW-29	103		Sheen			X
MW-32	11.4	X				X
MW-33	153		Sheen			
MW-03	309					X
RW-01	141			Sheen	X	X
RW-02	28.0	X				X
RW-04	340		Sheen			X

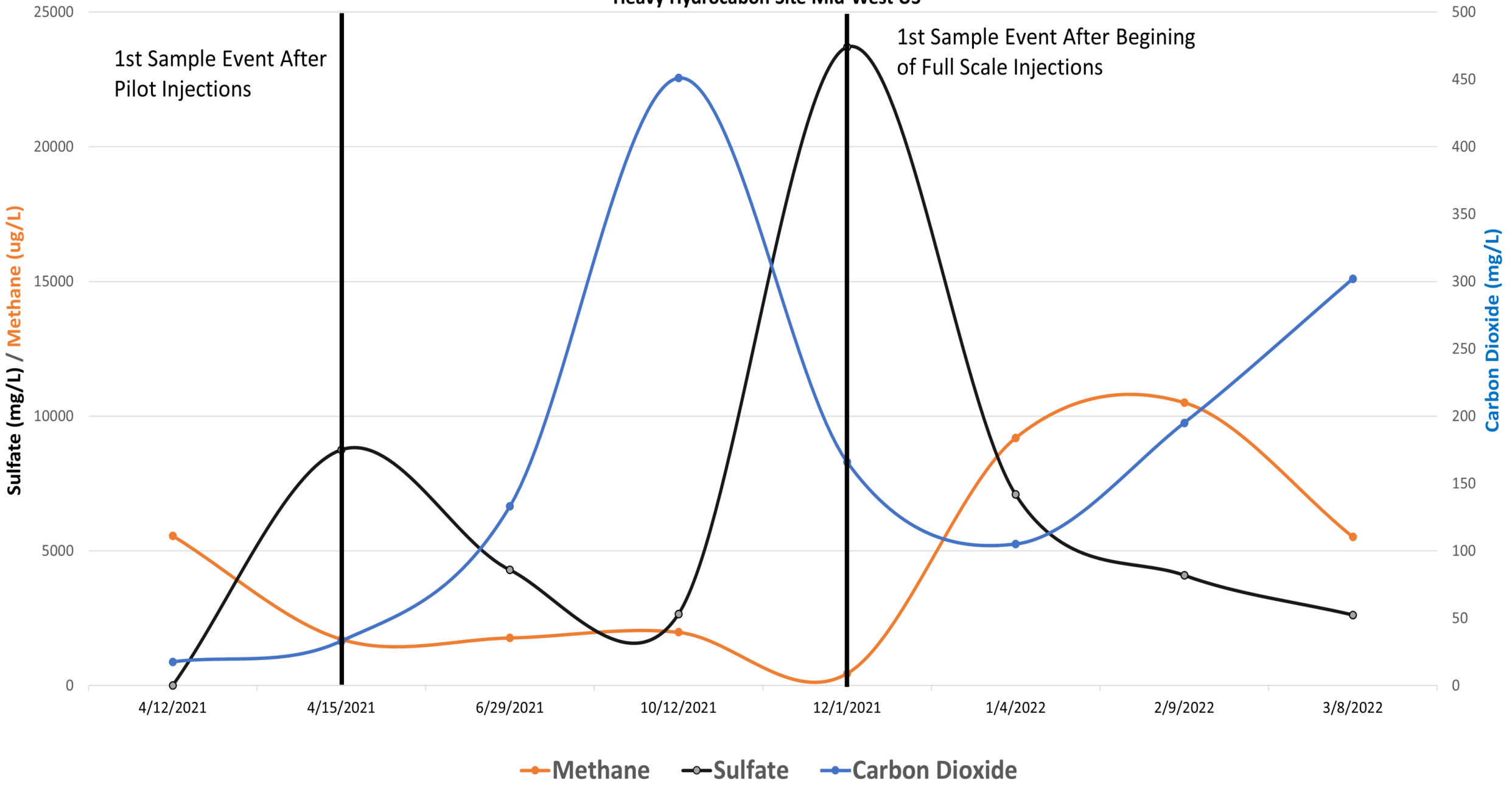
Note: analytical data does not support hydrocarbons are the source of "sheen" at highlighted entries.

ID	Benzene pre-inj (ug/l)	Benzene < MCL 2022	NAPL 9/2017	NAPL 9/2019	NAPL 5/2022	Carbon Dioxide (mg/L)
MW-02	246	122		0.66	??	354
MW-04	23.4	X	0.07	sheen	ND	216
MW-06	125	X			ND	243
MW-11	22.5	X			ND	138
MW-20	341	X	0.01		ND	223
RW-05	1350	X	0.07	sheen	ND	259
RW-07	387	X	0.19	0.02	ND	206
RW-08	256	X	sheen		ND	194
RW-09	311	X	0.34	0.02	ND	198
RW-10	0.69	X	sheen		ND	239
MW-16	21	X			ND	257
MW-29	103	X	sheen		ND	164
MW-32	11.4	X			ND	199
MW-33	153	X	sheen		ND	189
MW-03	309	X			ND	244
RW-01	141	X		sheen	ND	231
RW-02	28	X			ND	265
RW-04	340	X	sheen		ND	301


RW-9
5 Years Post Injection:
Benzene = ND
TPH = ND
Note: 50% detection limit assumed for graphing purposes
Benzene, mg/L
TPH, mg/L
Project Days
0
50
100
150
200
250
300
350
400
0
2
4
6
8
10
12
14
16
18
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
Benzene
TPH

MW-201 Dissolved Gases and Sulfate

Heavy Hydrocabon Site Mid-West US



1-year and 16 months post-BOS 200+ emplacement Heavy Hydrocarbon Site

Impacted Control

Smithella sp. F21	93.27
Methanoregula formicica SMSP	2.63
Pseudomonas graminis	1.41
Sulfuricurvum kujiense DSM 16994	1.05
Pseudomonas sp. GM21	0.97
Candidatus Sulfuricurvum sp. RIFRC-1_u_t	0.68
Bacteria_u_t	0.00

Pseudomonas sp. JL972	40.12
Simplicispira hankyongi	13.37
Smithella sp. F21	8.64
Sulfurospirillum arsenophilum NBRC 109478	7.81
Arcobacter suis CECT 7833	5.97
Geobacter daltonii FRC-32	3.59
Sulfuricurvum kujiense DSM 16994	3.19
Pseudomonas stutzeri TS44	2.51
Pseudomonas veronii 1YdBTEX2	2.34
Desulfosporosinus sp. BG	2.30
Desulfobulbus sp. Tol-SR	2.13
Geobacter_u_t	1.21
Pseudomonas borbori	1.06
Herminiimonas sp. CN	1.04
Giesbergeria anulus	0.89
Sulfuricella sp. T08	0.63
Thermomonas fusca DSM 15424	0.56

Pseudomonas sp. JL972	22.56
Smithella sp. F21	17.50
Pseudomonas_u_t	13.08
Desulfosporosinus sp. BG	8.96
Desulfobulbus sp. Tol-SR	8.42
Parvibaculum sedimenti	7.16
Simplicispira hankyongi	5.54
Hydrogenophaga sp. T4	2.52
Sulfurospirillum arsenophilum NBRC 109478	1.67
Sulfuricurvum kujiense DSM 16994	1.60
Pseudomonas stutzeri TS44	1.30
Methanoregula formicica SMSP	1.10
Rhodococcus erythropolis	1.08
Methylobacter tundripaludum SV96	1.04
Rhodococcus sp. AK5	0.99
Pseudomonas aeruginosa	0.92
Methylotenera mobilis 13	0.92
Thermomonas fusca DSM 15424	0.80
Candidatus Sulfuricurvum sp. RIFRC-1_u_t	0.67
Rhodoferax ferrireducens T118	0.65

Focus on 16 months post-BOS 200+

Smithella sp. F21	93.27
Methanoregula formicica SMSP	2.63
Pseudomonas graminis	1.41
Sulfuricurvum kujiense DSM 16994 SO	1.05
Pseudomonas sp. GM21	0.97
Candidatus Sulfuricurvum sp. RIFRC-1_u_t	0.68
Bacteria_u_t	0.00

	12 months	16 months
Pseudomonas sp. JL972 NR	40.34	22.77
Smithella sp. F21	8.69	17.66
Pseudomonas_u_t	0.00	13.20
Desulfosporosinus sp. BG SR	2.32	9.05
Desulfobulbus sp. Tol-SR SR	2.14	8.50
Parvibaculum sedimenti	0.00	7.23
Simplicispira hankyongi DN	13.44	5.59
Hydrogenophaga sp. T4	0.00	2.54
Sulfurospirillum arsenophilum NBRC 109478 NF	7.85	1.68
Sulfuricurvum kujiense DSM 16994 SO NR	3.20	1.61
Pseudomonas stutzeri TS44 NR	2.53	1.31

Fermentation from facultative anaerobes

Hydrocarbon Degradation

Hydrogen oxidizing & CO_2 fixation

SO Sulfur Oxidizing: H_2S to S_n^{2-}

SR Sulfur Reducing (Desulfo…)

NR Nitrate Reducer

DN Denitrifying

NF Nitrate Fixation

Thank You For Joining Me

AST Webinars: https://astenv.com/webinars/

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