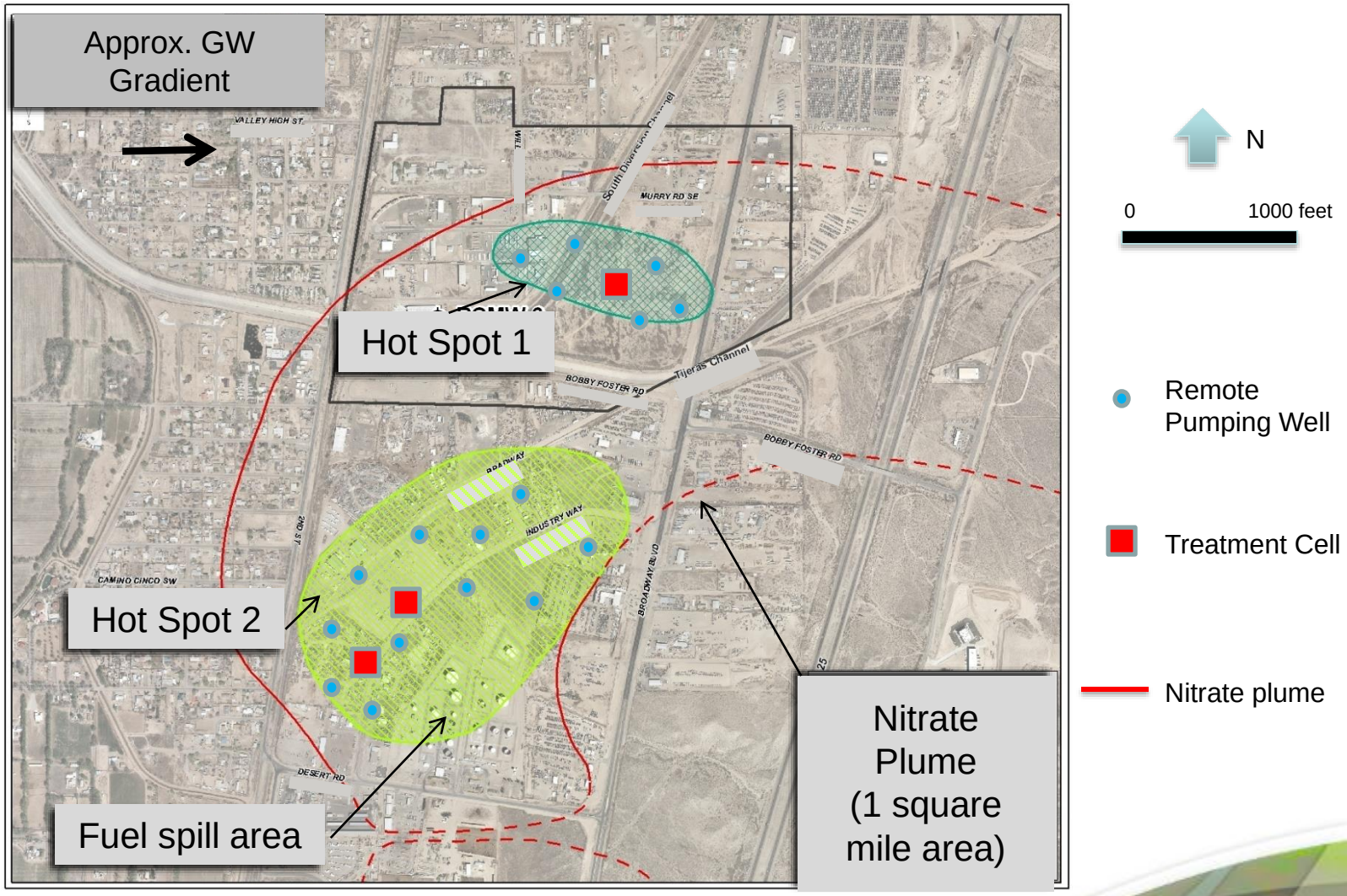
Lessons Learned from the Optimization of In-Situ Bioremediation Through Injection of Carbon Substrate

Presented by Ted Tyler, PE, Kleinfelder Inc.
Thanks to Joe Galemore and Lee Dalton, Intera Inc.
Thanks to Dr. Eric Nuttall, UNM/Kleinfelder

Site Description



Source: Intera

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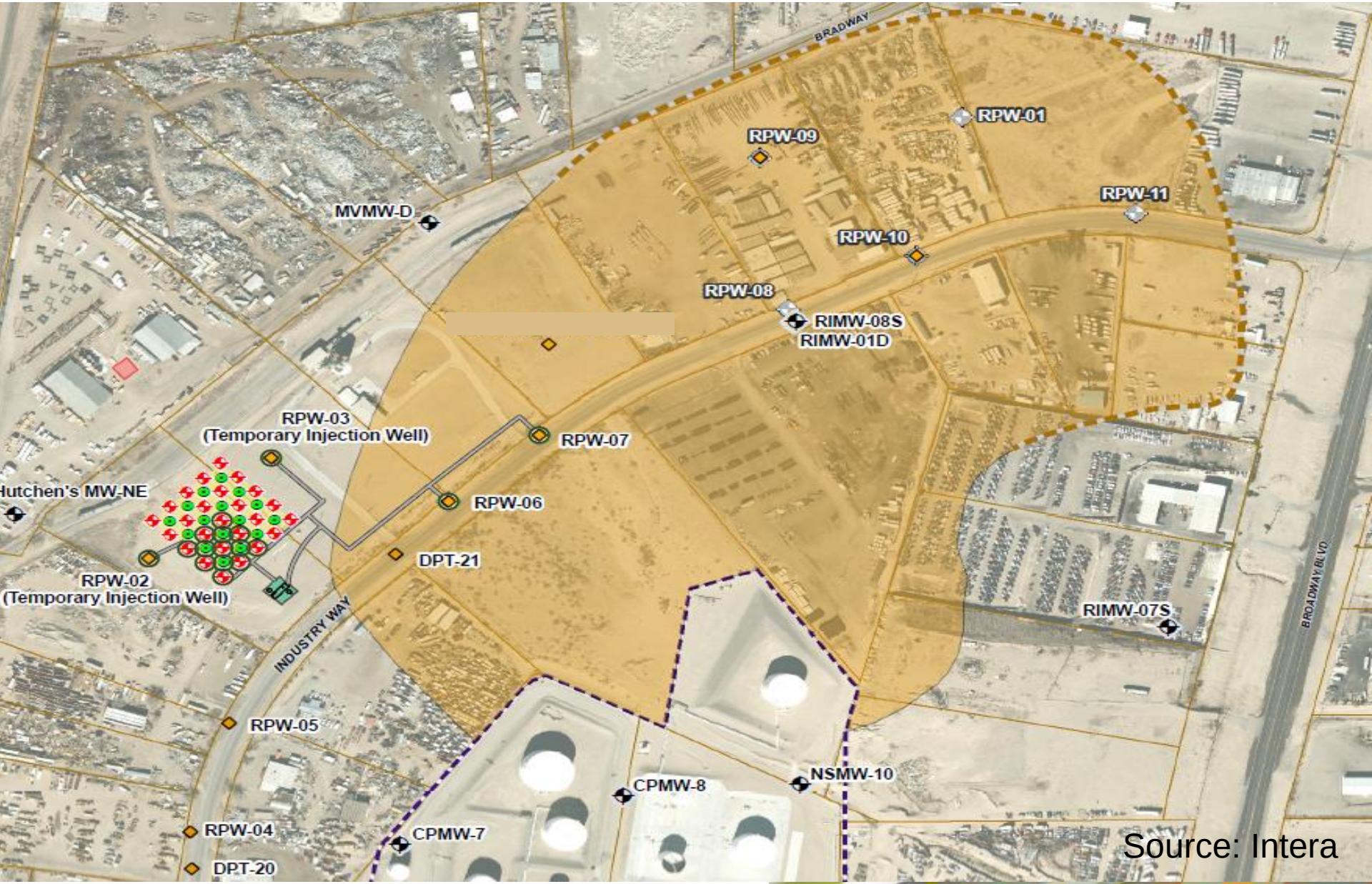
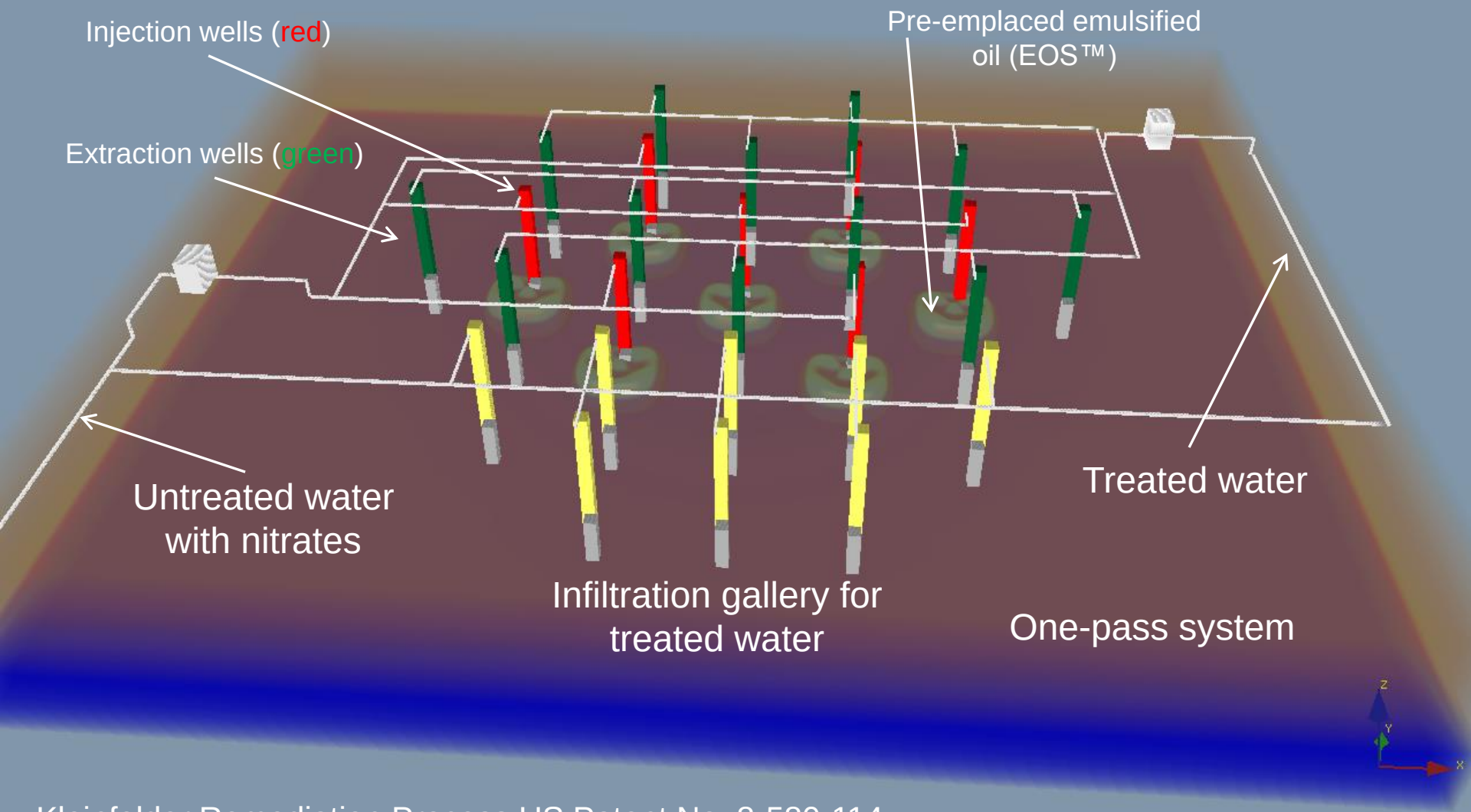
Remediation Process



Source: Intera

Remediation Process (Treatment Cell)



Kleinfelder Remediation Process US Patent No. 8-580-114

Site Selection – Topographic Features

- Ideal topography
  - Open field
  - Open parking lot ideal
- Three sites selected

Pilot Test Site

Full Scale Site 1

Full Scale Site 2

Alternative Site

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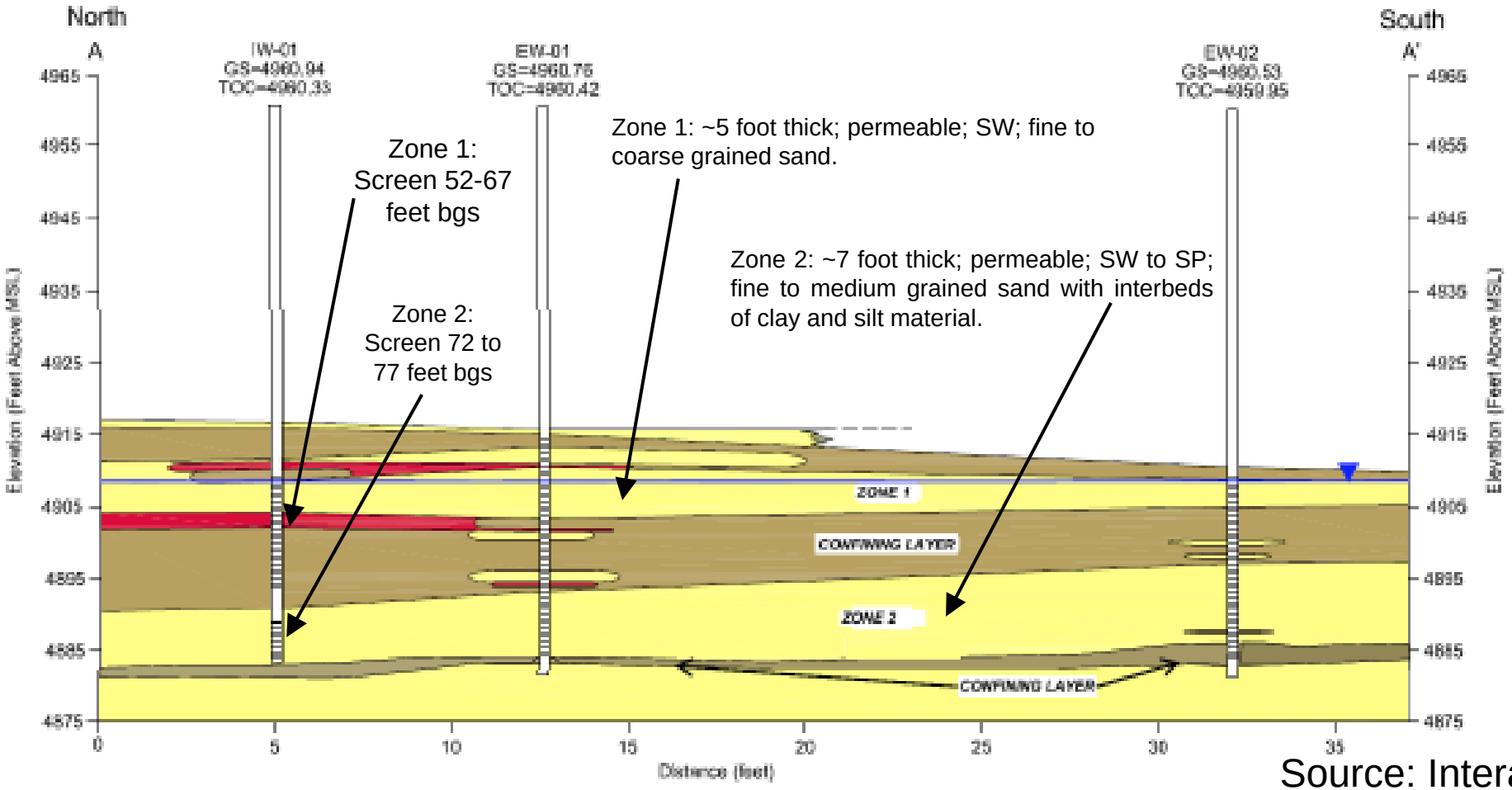
Site Selection - Hydrogeology



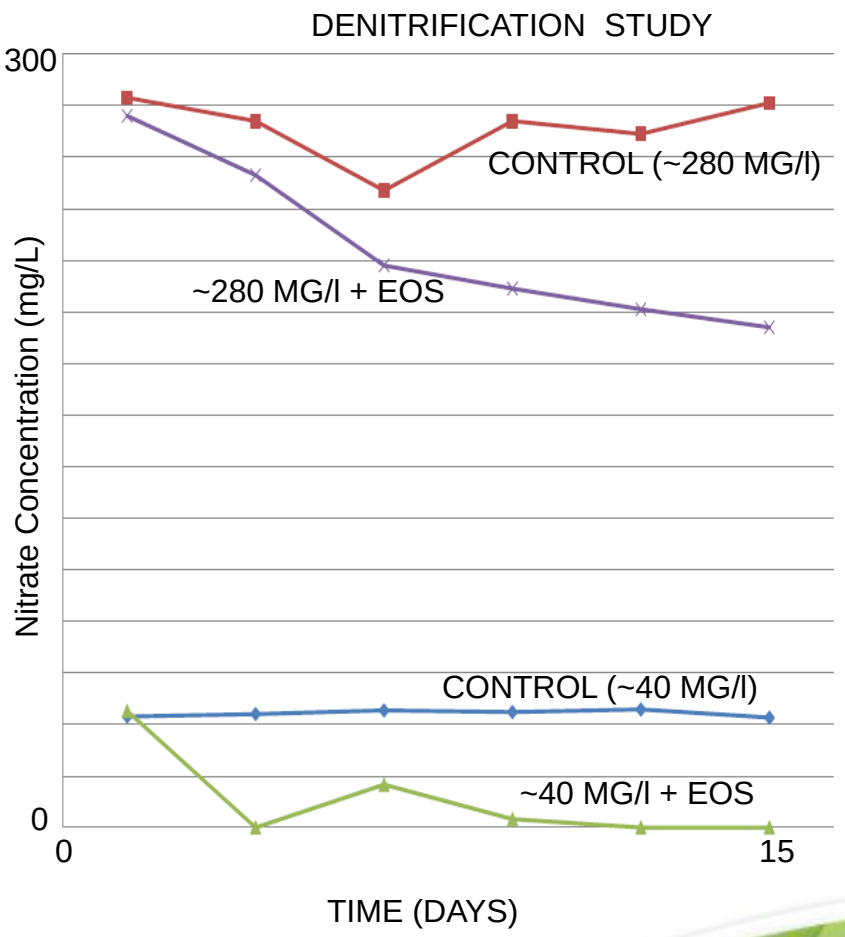
Source: Intera

Site Selection – Column/Bench Tests

- Column Testing
- Biodenitrification Testing
  - Soil and groundwater from 70 to 74.8 feet bgs (treatment zone)

COLUMN TESTING

CARBON SUBSTRATE	DILUTION (water/oil)	MAX OIL RETENTION	SOURCE
EOS-450	19:1	0.0004 g/g	Column Test
EOS-598	19:1	0.0027 g/g	Column Test
EOS-598	**9:1**	**0.0034 g/g**	Column Test
EOS - Unspecified	not specified	0.0037 g/g	ESTCP



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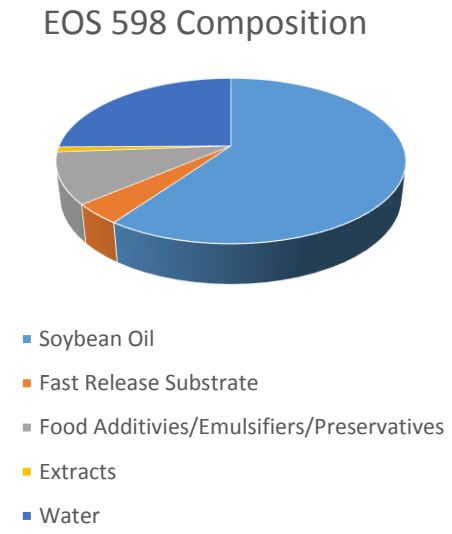
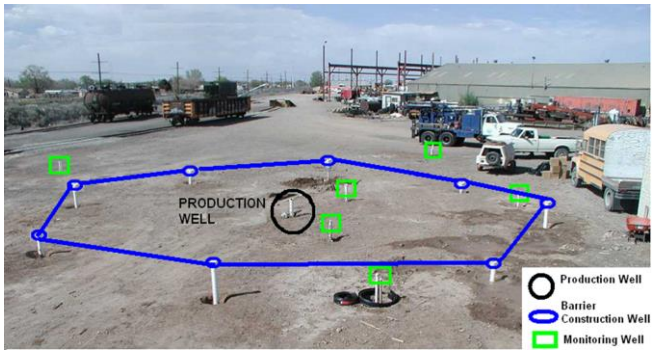
Carbon Substrate Selection and Mass Requirement

- Previous work at the site
  - Acetate injection
  - Molasses injection
  - Biofouling issues
- EOS-598
  - Consider need for fast release substrate
- EOS mass requirement based on column test results





Previous Molasses Application

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Injection Approach (Pilot Test)

- Injection setup
- Balance flow rates
- Establish hydraulic gradient
- Tracer injection
- EOS injection
  - 4:1; 9:1 and 19:1
- Minimize mounding

Injection Setup

Balancing Flow Rates

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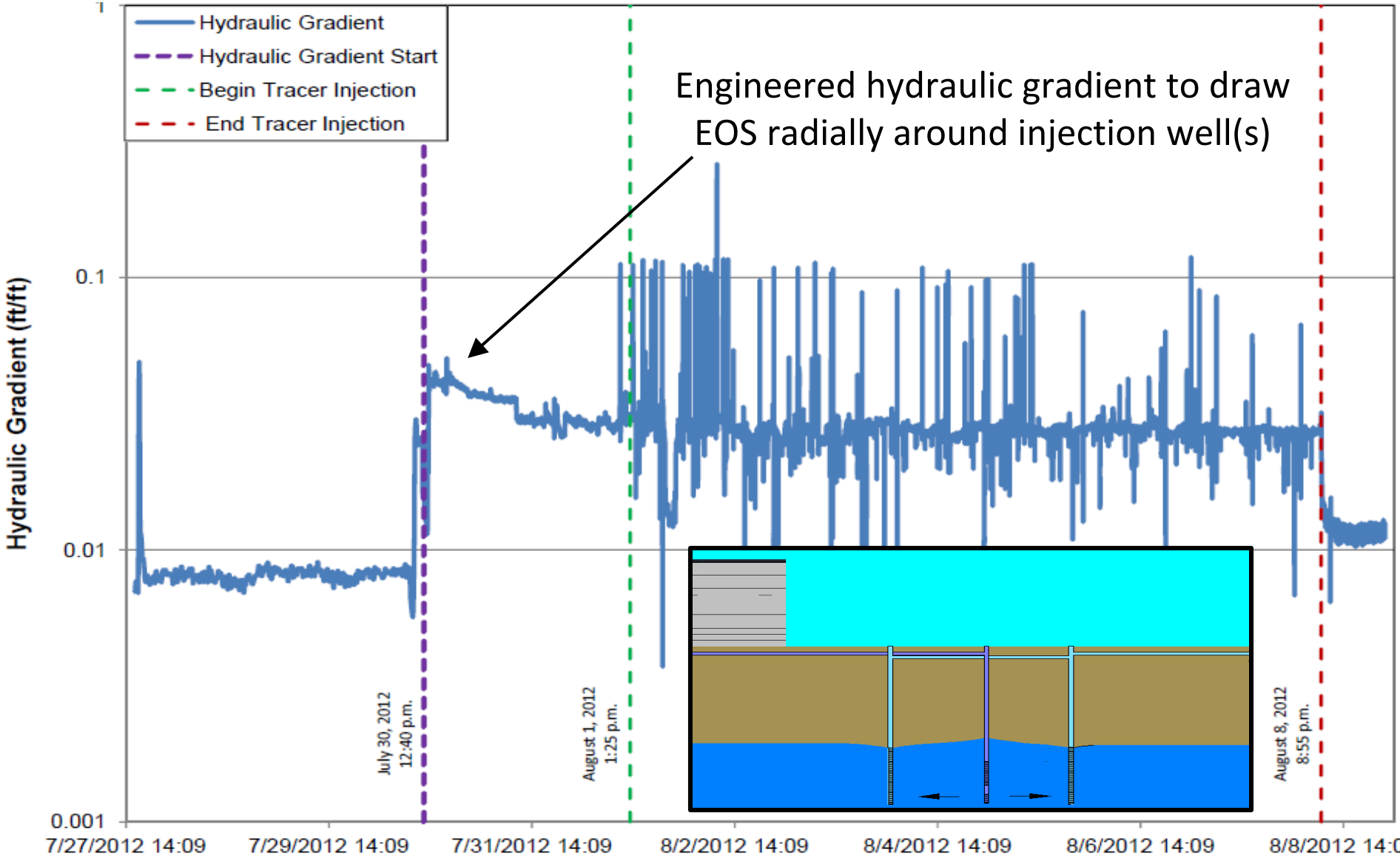
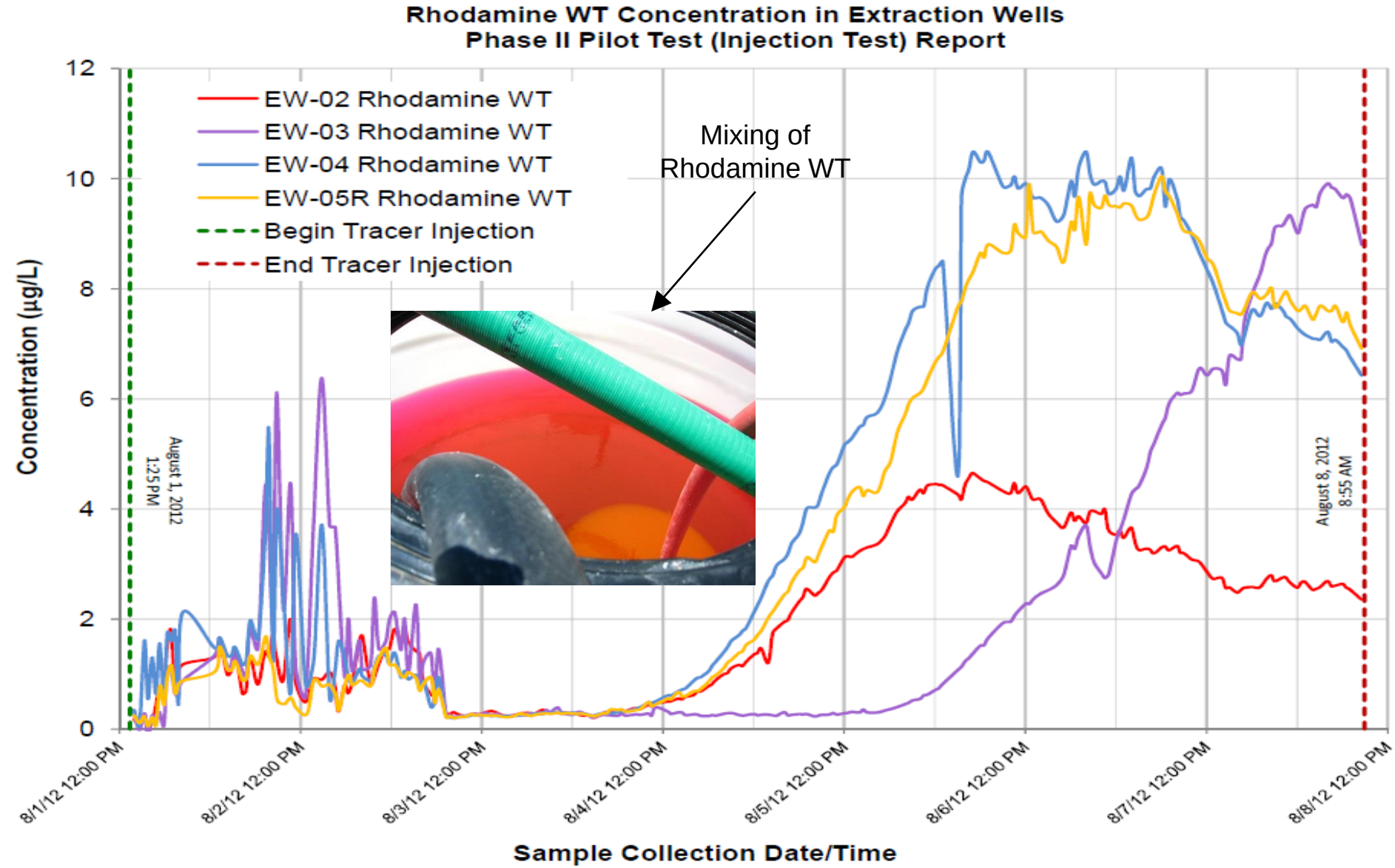
Injection Setup (Pilot Test)

IW flow rate must balance with combined EW flow rates

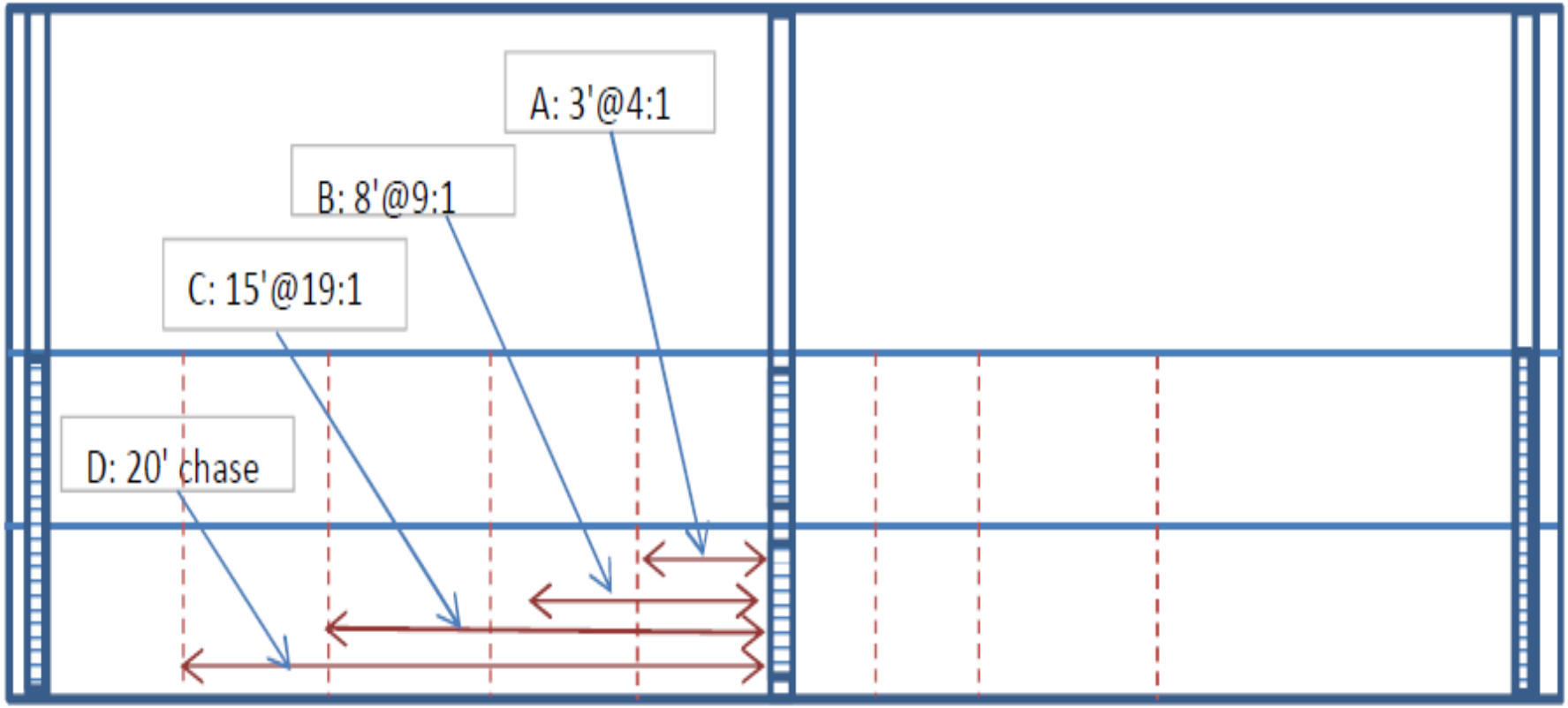
Hydraulic gradient (Pilot Test)



Tracer Testing (Pilot Test)



Carbon Substrate Injection Approach



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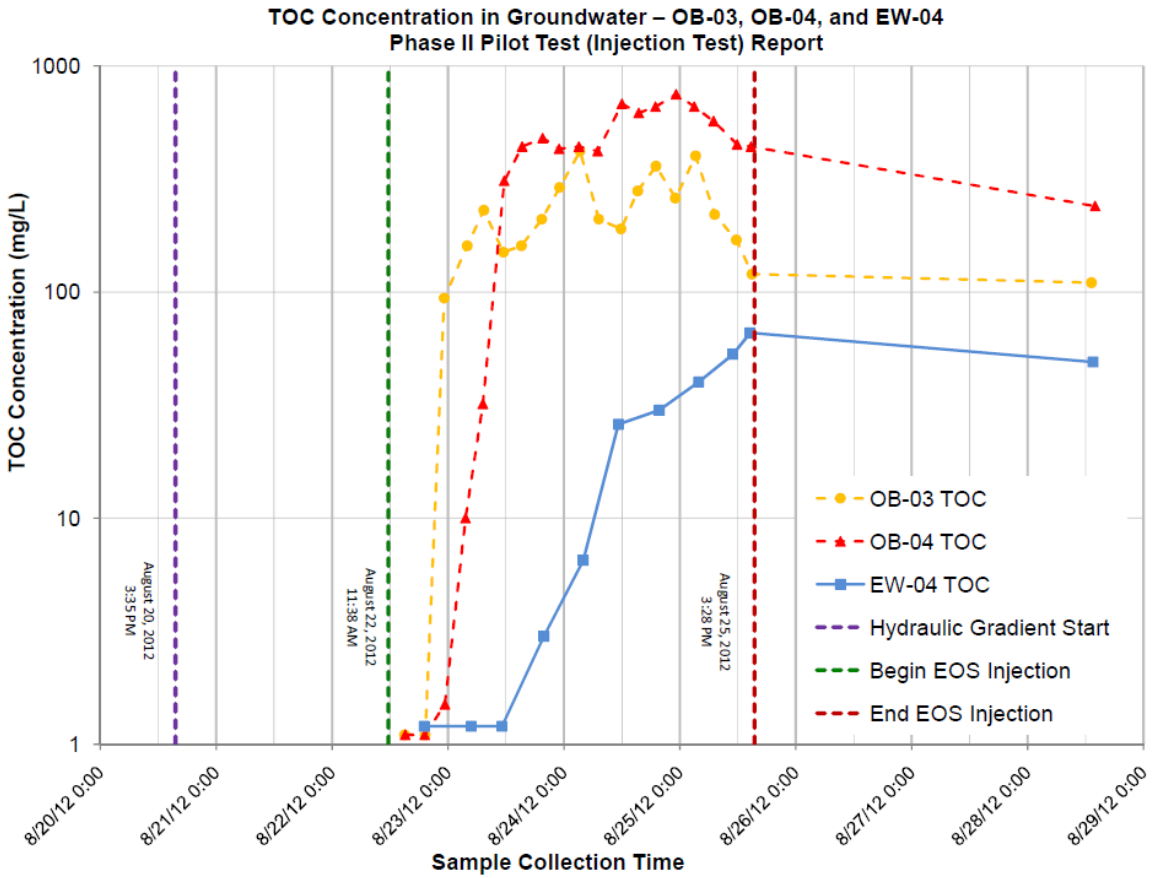
EOS Injection (Pilot Test)

EOS Injection Setup

EOS Observation



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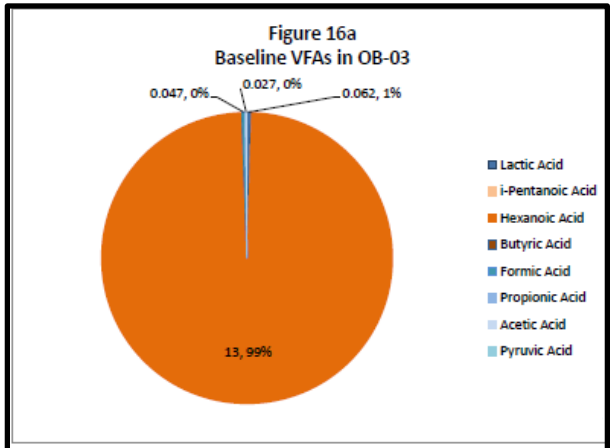
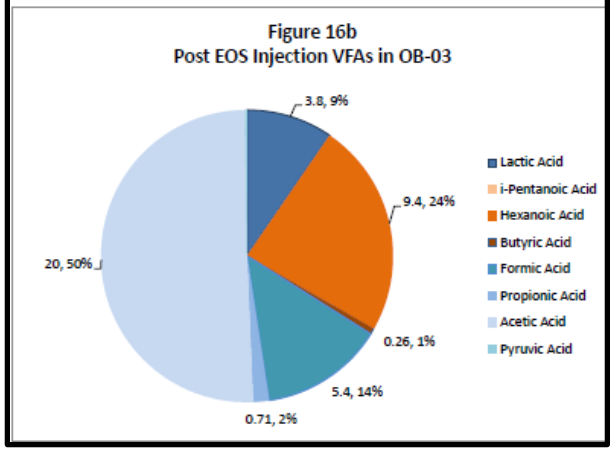
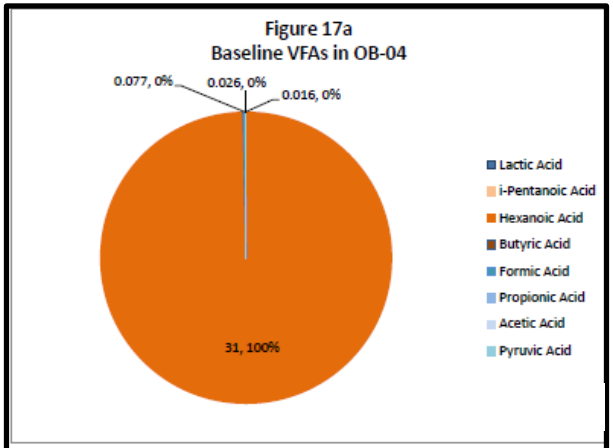
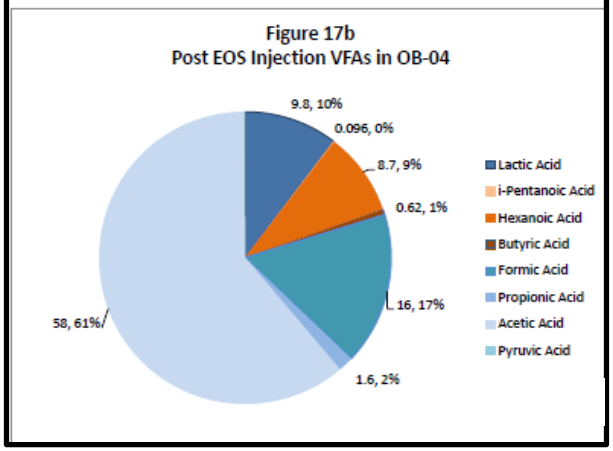
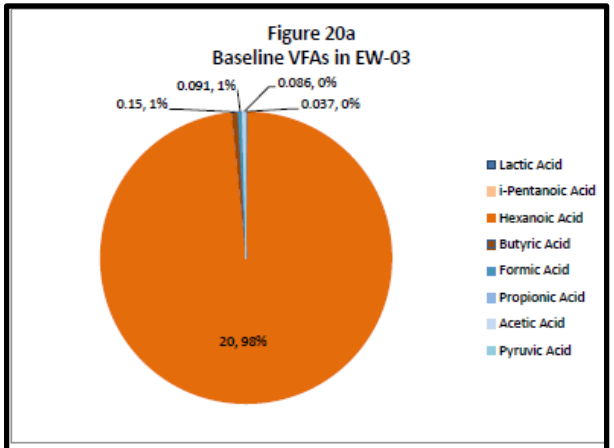
EOS Injection (Pilot Test)

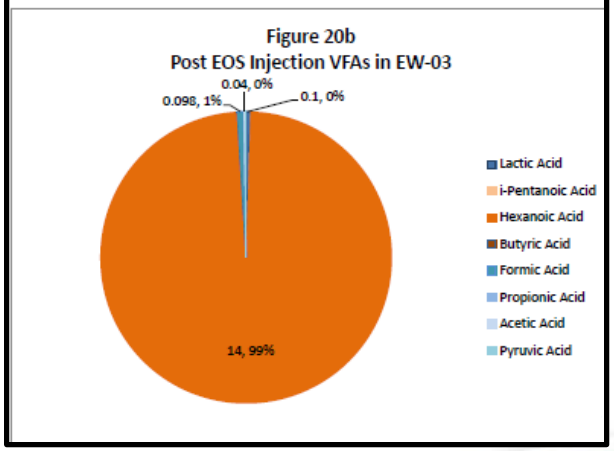












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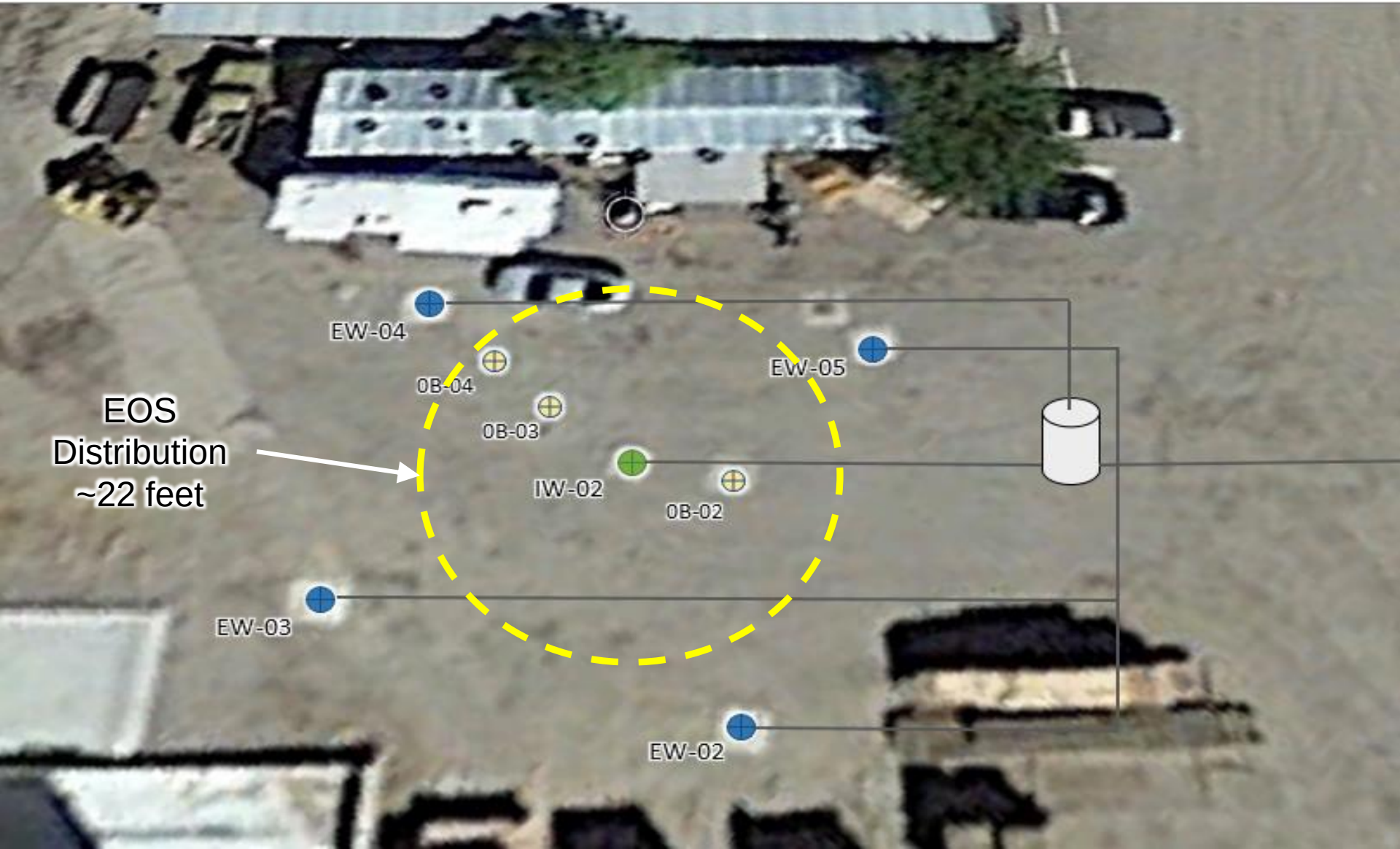
Pilot Test EOS Distribution



Monitoring EOS Vertical Distribution (Pilot Test)

Post Injection TOC in Treatment Zone*

	DPT-01	DPT-02	DPT-03	DPT-04	DPT-05
Distance from IW-1 (feet)	5	10	15	20	25
Confining layer					
68-70	NS	1200	1300	800	1500
70-71	500	500	500	400	1100
71-72		700	600	300	400
72-73	3600	700	500	800	1100
73-74	1100	6800	3300	700	1400
74-75	15000	NS	6600	2400	1000
Confining layer					

NS = not sampled

TOC units: mg/kg

*Note: pre injection TOC was 800 ppm in EW-01/EW-02 and 600 ppm in EW-05R

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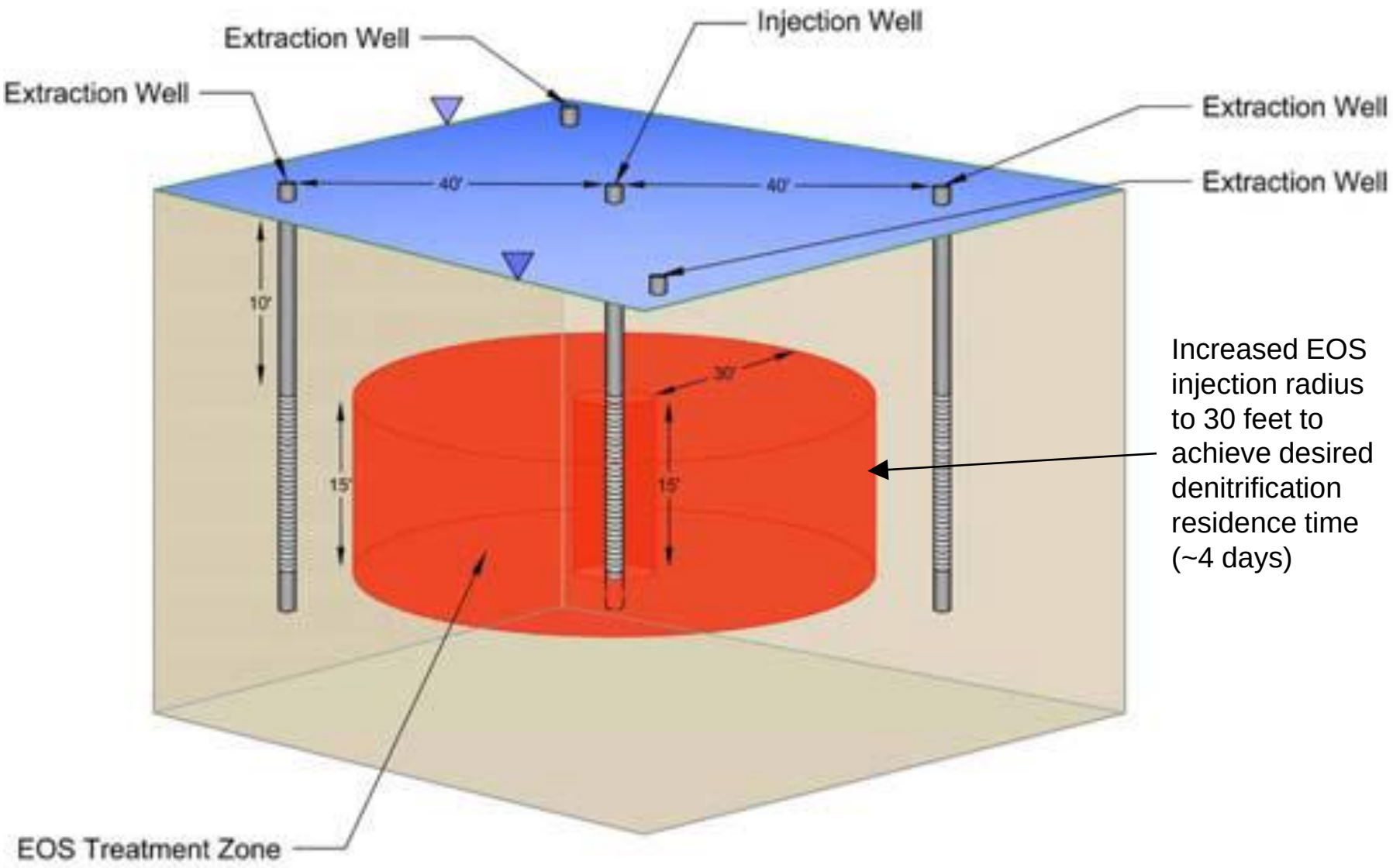
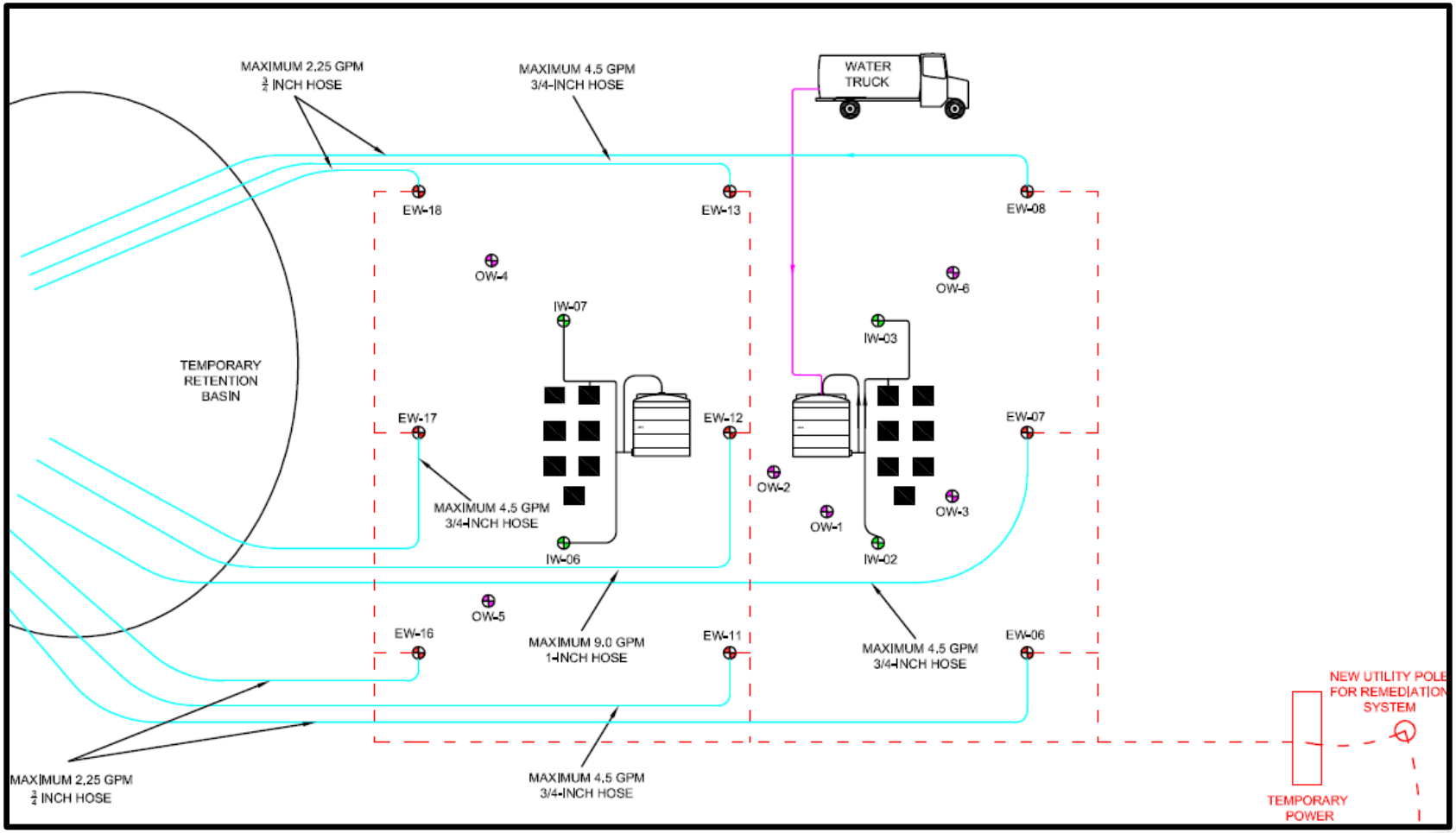
Full Scale System I



Increased EOS injection radius to 30 feet to achieve desired denitrification residence time (~4 days)

Full Scale System I



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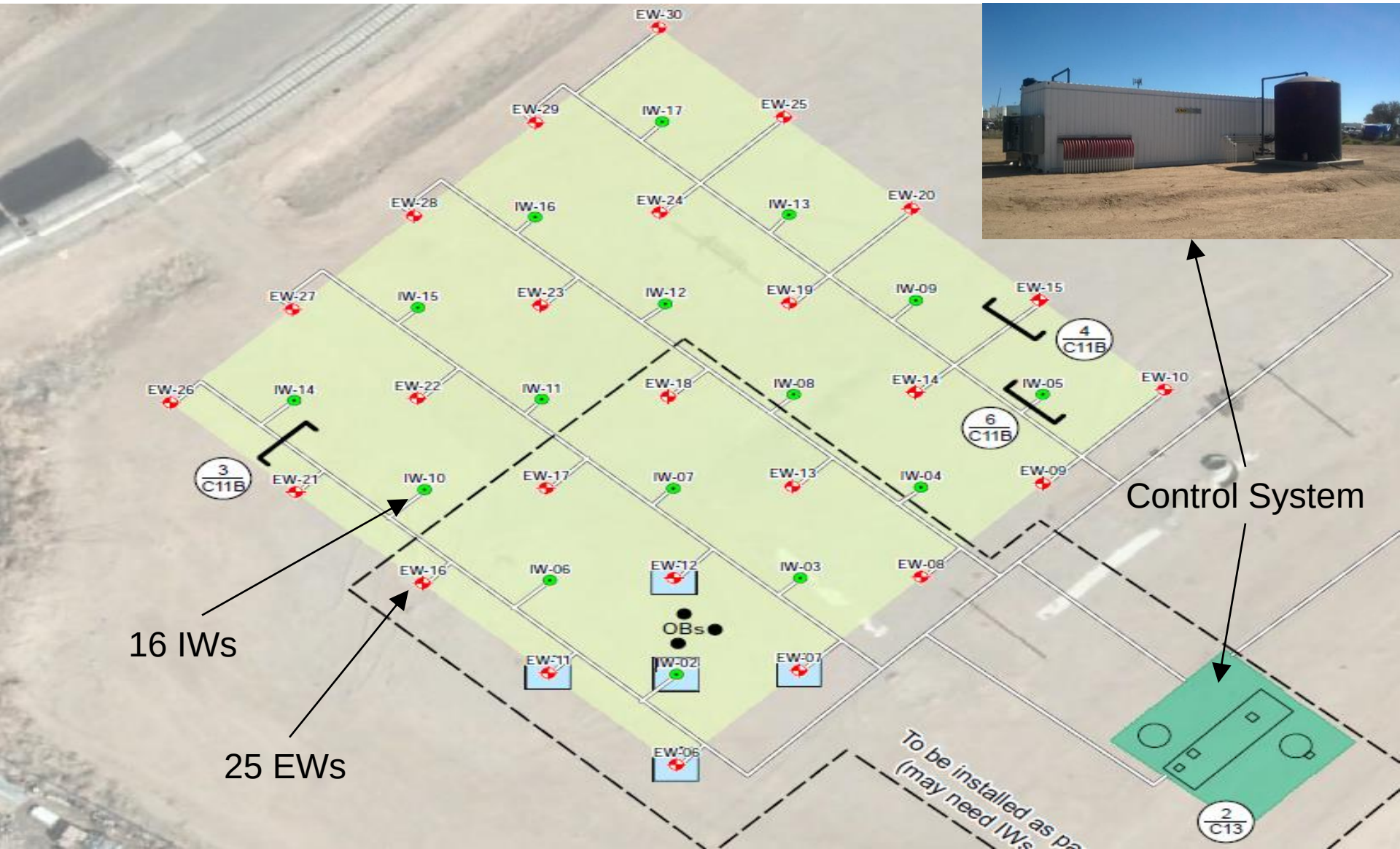
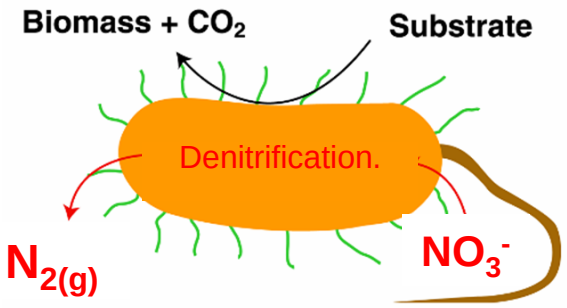
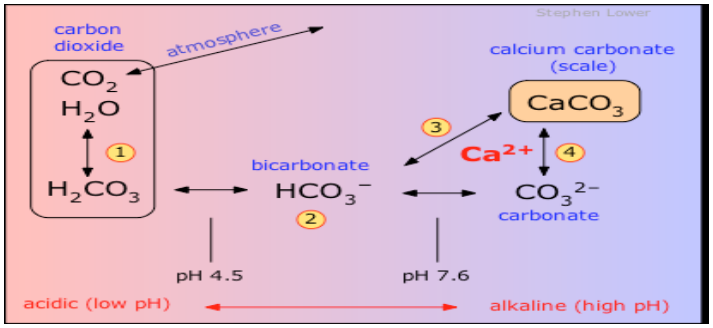
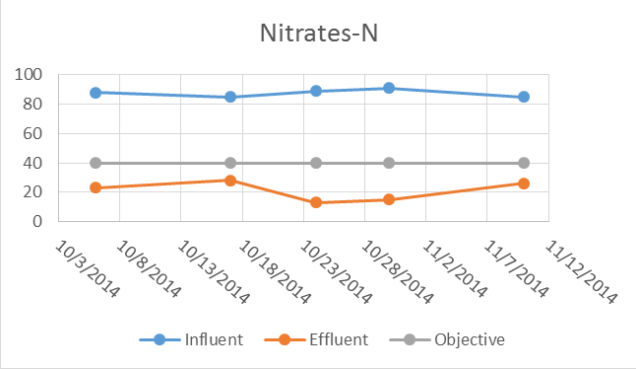
Full Scale System I

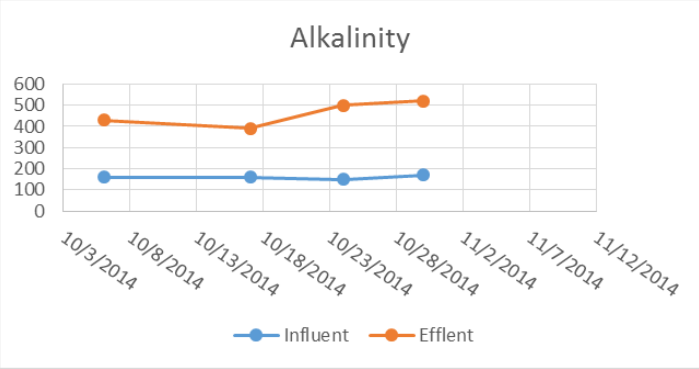


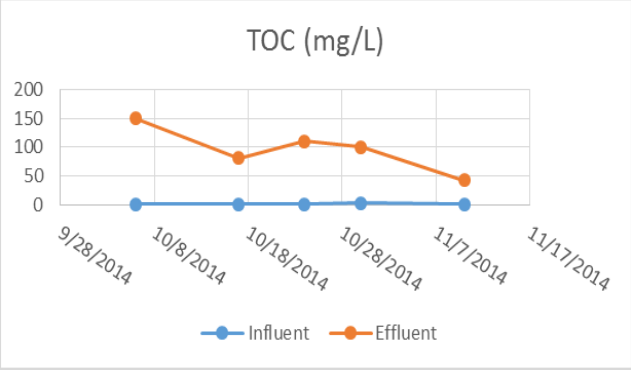
Full Scale System 1 Results

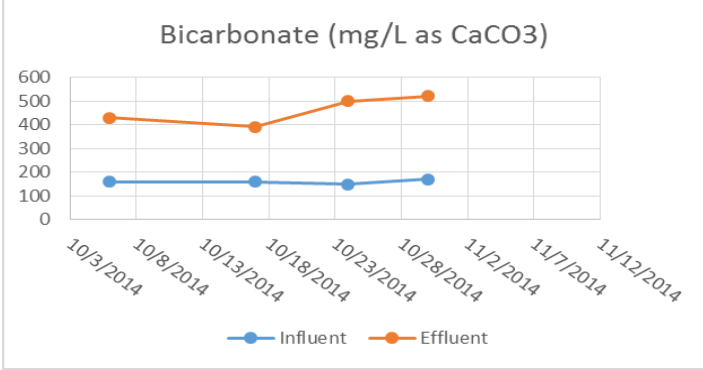












Questions

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