

Enhanced Multi-phase Extraction using Groundwater Re-circulation for Oxygenated Water and Biological Enhancement Delivery

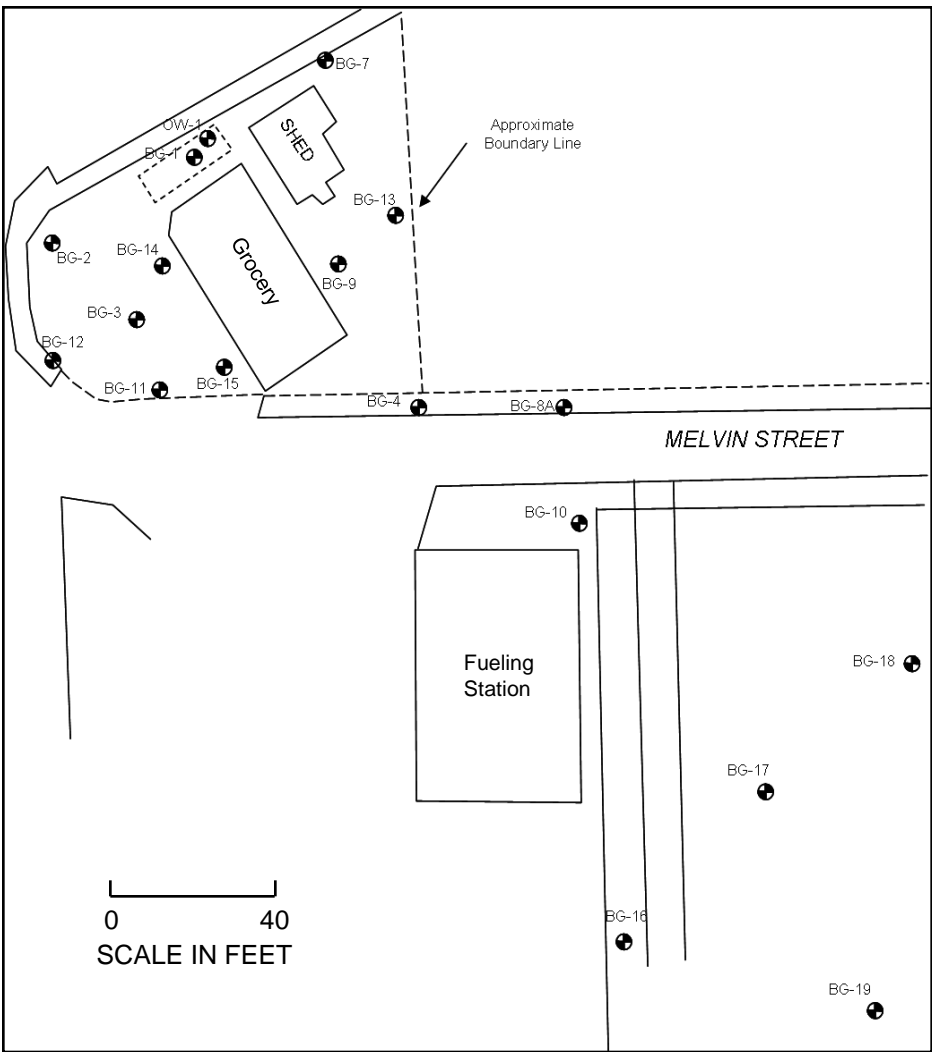
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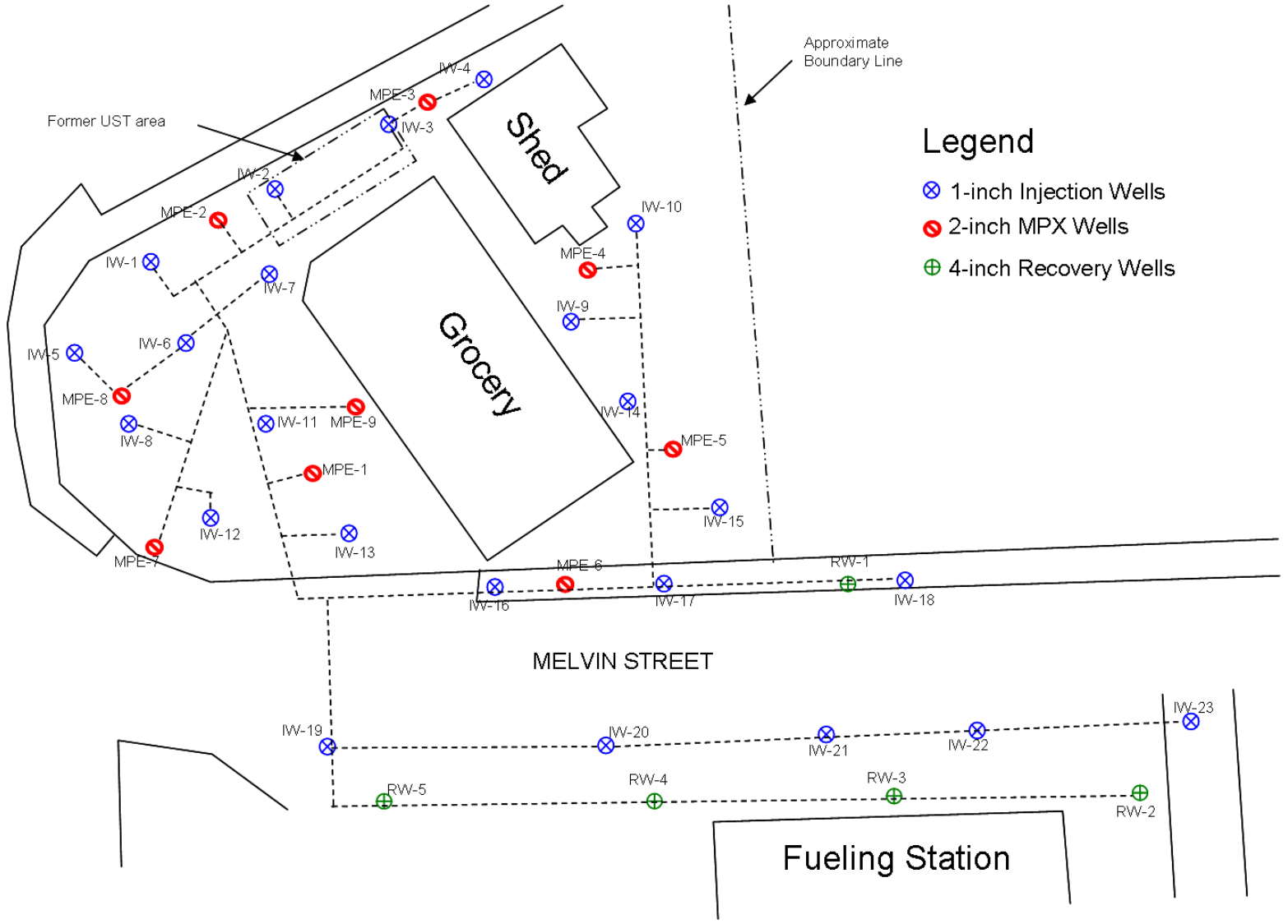
Site Description

- Former fueling facility
 - Releases of gasoline from the UST and dispenser islands
 - Currently not in use
- Contaminants of Concern
 - BTEX (9,020 ppb)
 - Naphthalene (300 ppb), 1-methylnaphthalene (78 ppb), 2-methylnaphthalene (110 ppb)
 - TRPH (10,000 ppb)
- Soil
 - Fine grained sand
- Aquifer
 - DTW ranging from 5 feet to 14 feet bgs, unconfined
 - Impacted groundwater depth – 22 feet bgs
- Plume Migration
 - 300 feet x 100 feet
 - Both on- and off-site

Site Layout



Site Infrastructure



- ### Legend
- ⊗ 1-inch Injection Wells
 - ⊗ 2-inch MPX Wells
 - ⊕ 4-inch Recovery Wells

Extraction/Pre-treatment System

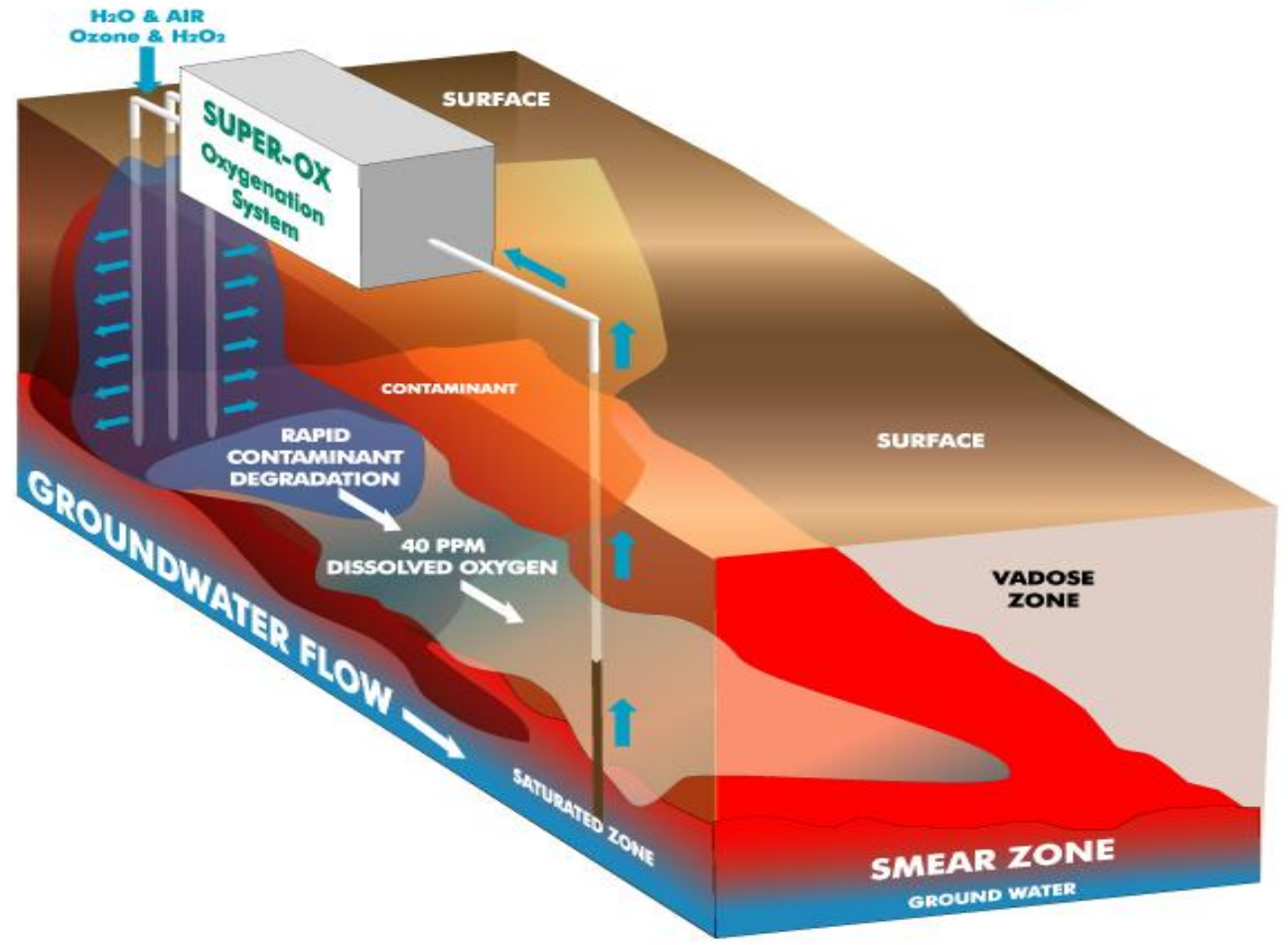
- Vacuum Extraction System
 - One 7.5 HP rotary claw vacuum pump (120 ACFM @ 18" Hg)
 - One 15 HP rotary claw vacuum pump (320 ACFM at 18" Hg)
- Groundwater Extraction System
 - Five 3" 1/3 HP Grundfos submersible pumps
- Treatment System
 - Low profile tray stripper
 - Activated carbon for vapor treatment

Extraction System

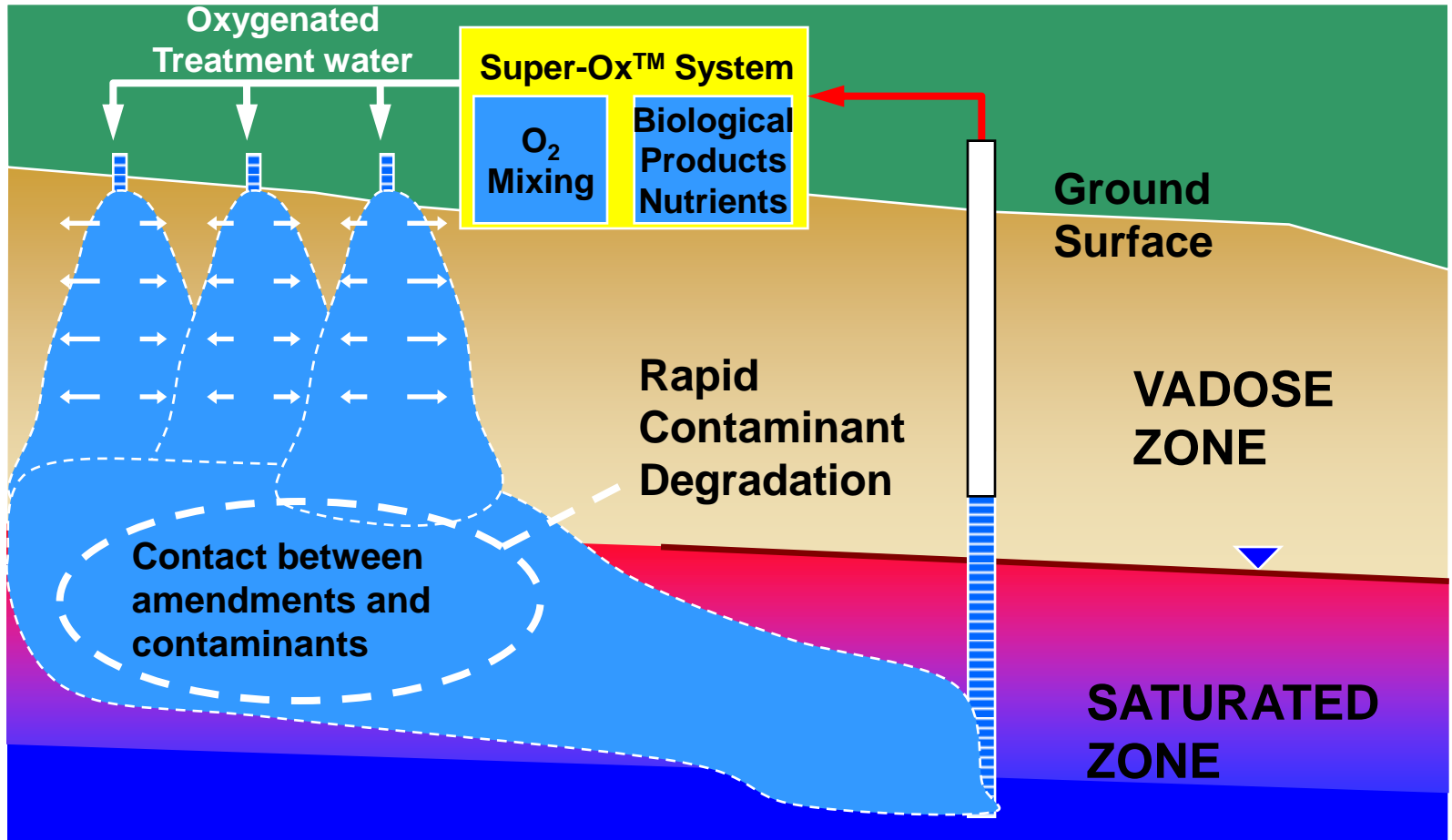
- Operation
 - Start-up February 22, 2006
 - 5,594 operating hours (~ 7 months)
 - 2,500,000 gallons extracted (7 gpm)

DISSOLVED OXYGEN **DO-IT** IN SITU TREATMENT

The Ultimate Bioremediation System



DO-IT Concept



- Effective electron acceptor & amendment delivery via 24/7 GW recirculation
- Increases contact between contaminants & electron acceptors/amendments
- Maximizes microbial activity by ensuring no limiting conditions exist

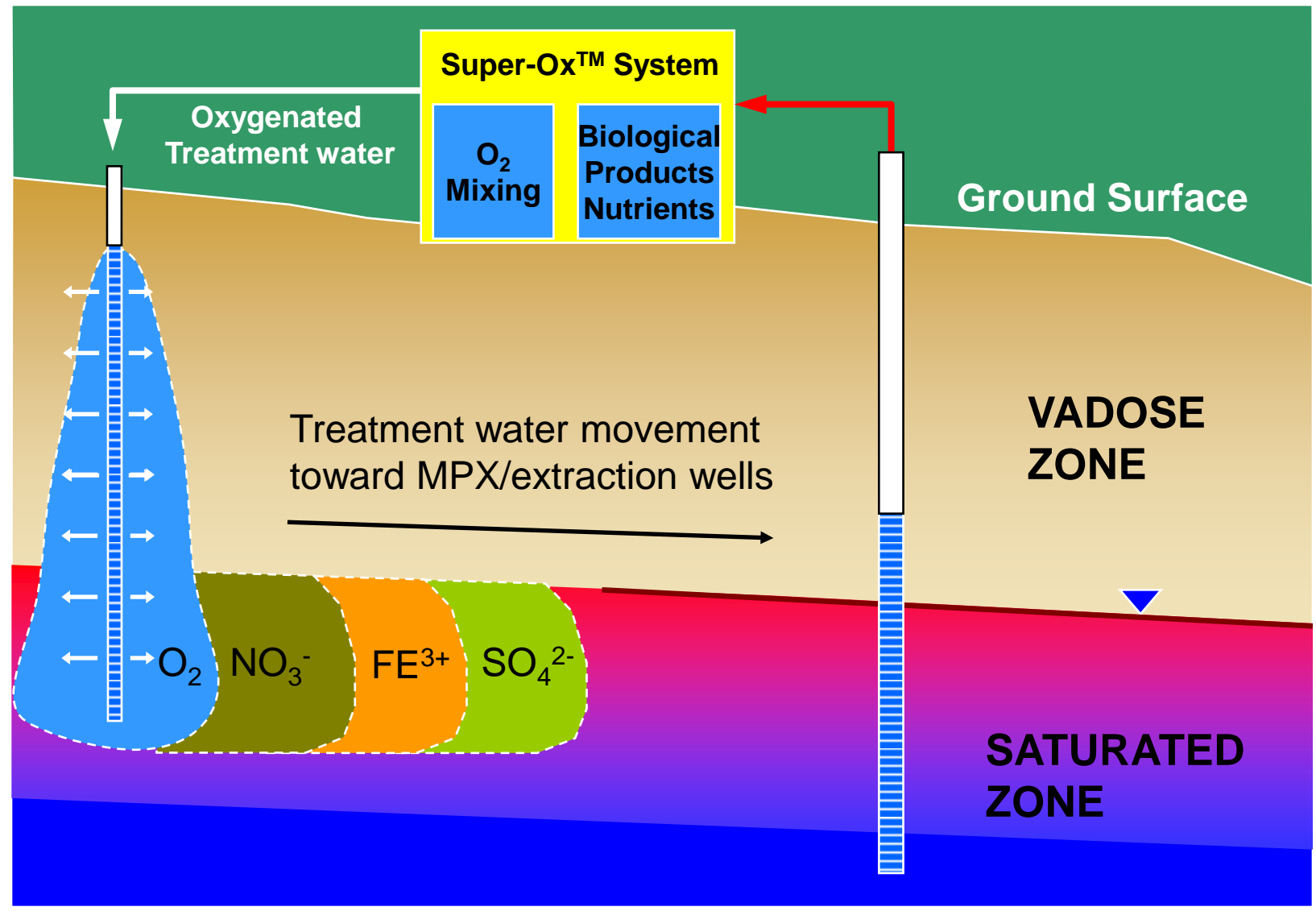
Electron Acceptor Delivery

- From stoichiometry, 1 part of TPH/BTEX requires 3 parts of dissolved oxygen for biological oxidation

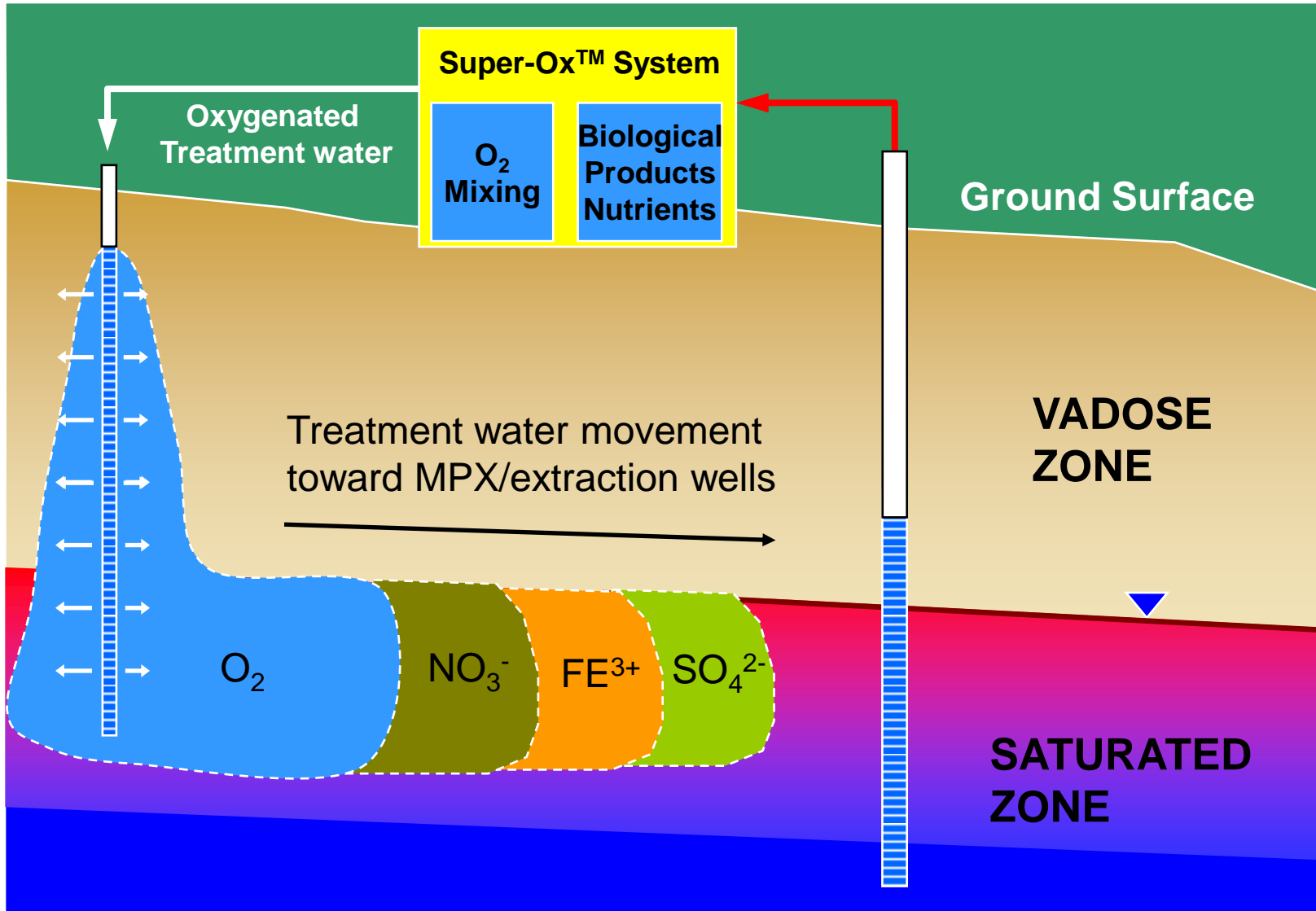


- Also, 1 part TPH can be biologically oxidized by 5-7 parts NO_3 , SO_4
- For example, at a site with a 100 gallon diesel release, between 1,800 – 3,000 lbs. of electron acceptors need to be applied to the impacted soil and groundwater site-wide

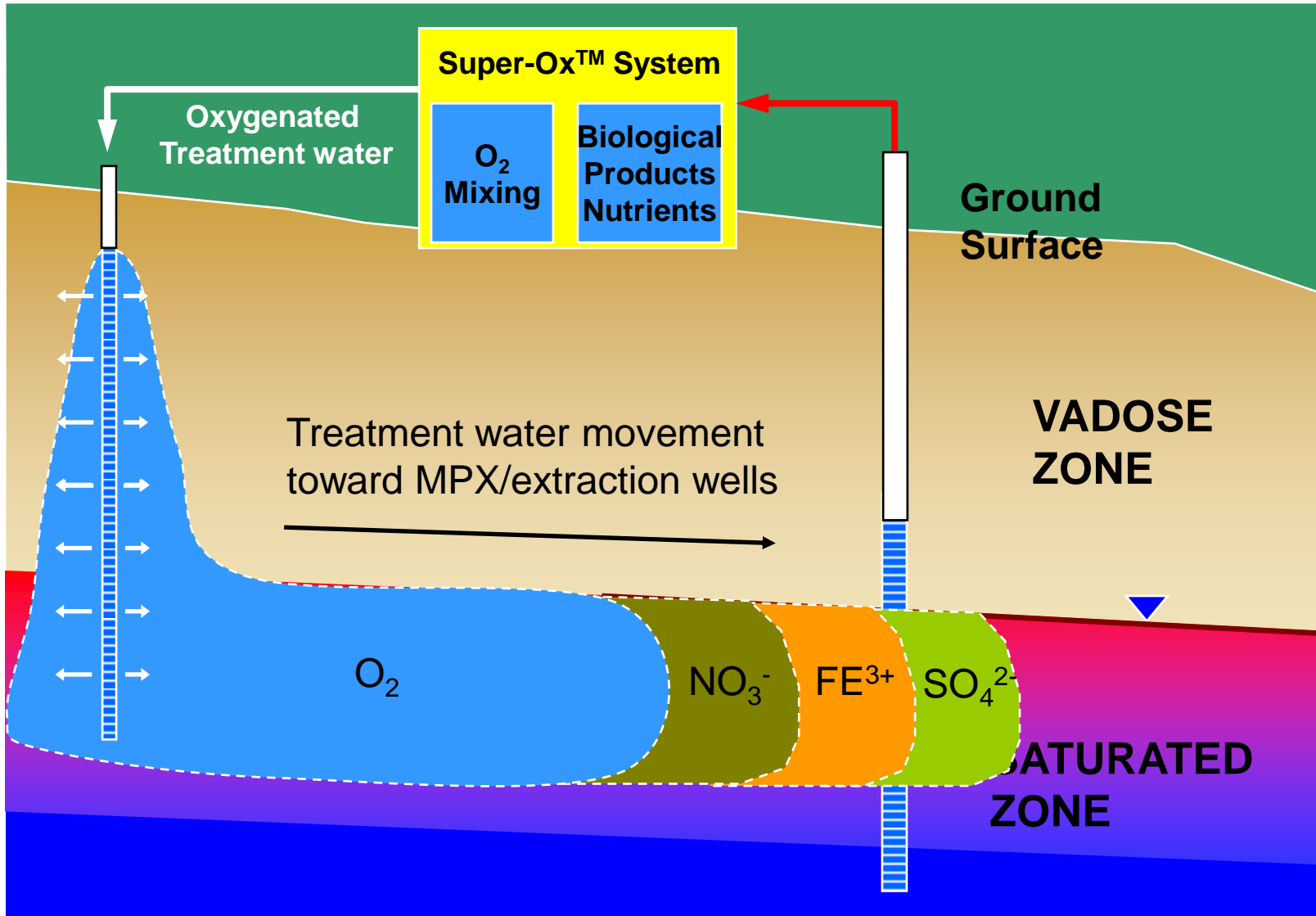
Electron Acceptor Usage



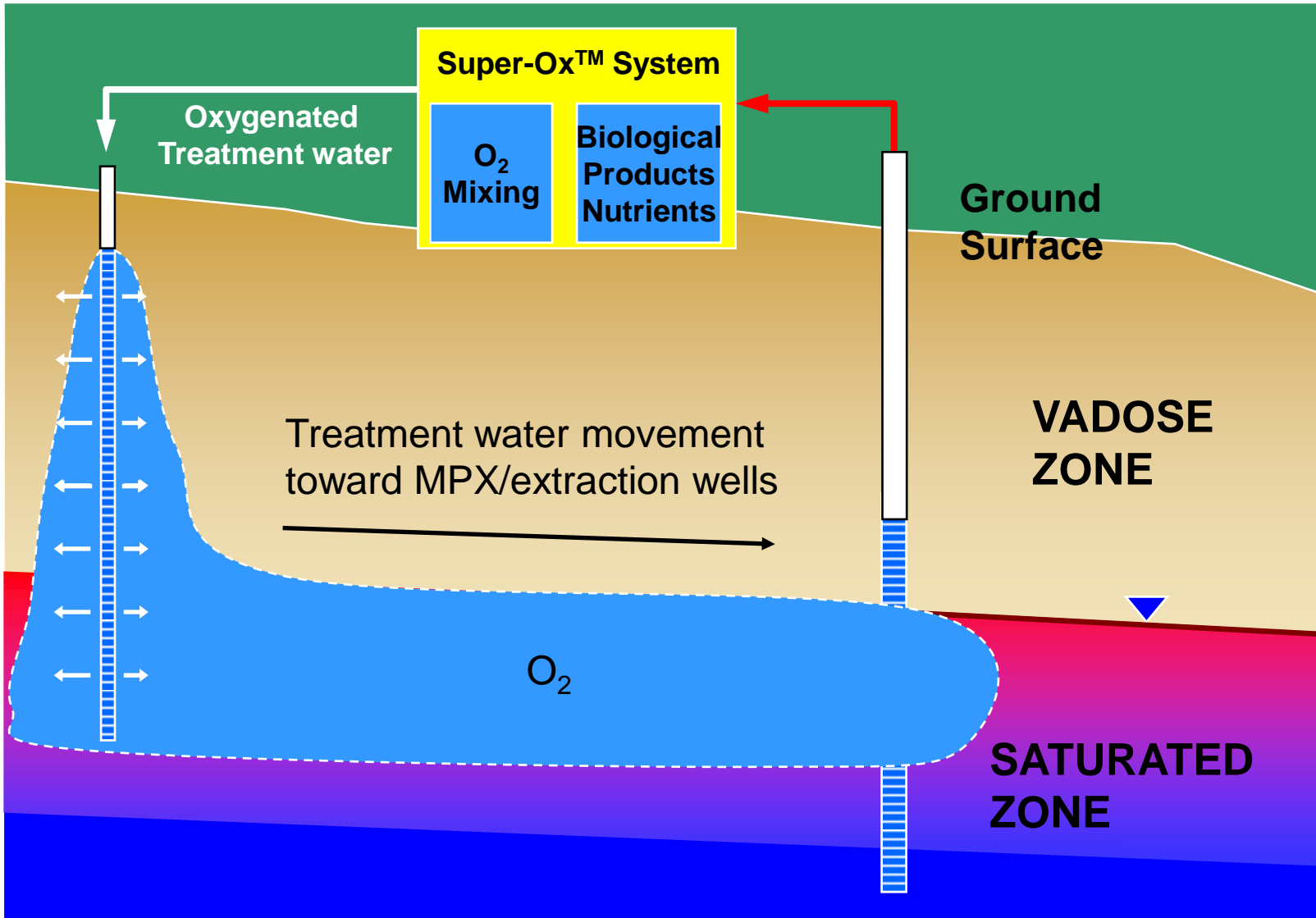
Electron Acceptor Usage



Electron Acceptor Usage



Electron Acceptor Usage



Super-Ox Equipment

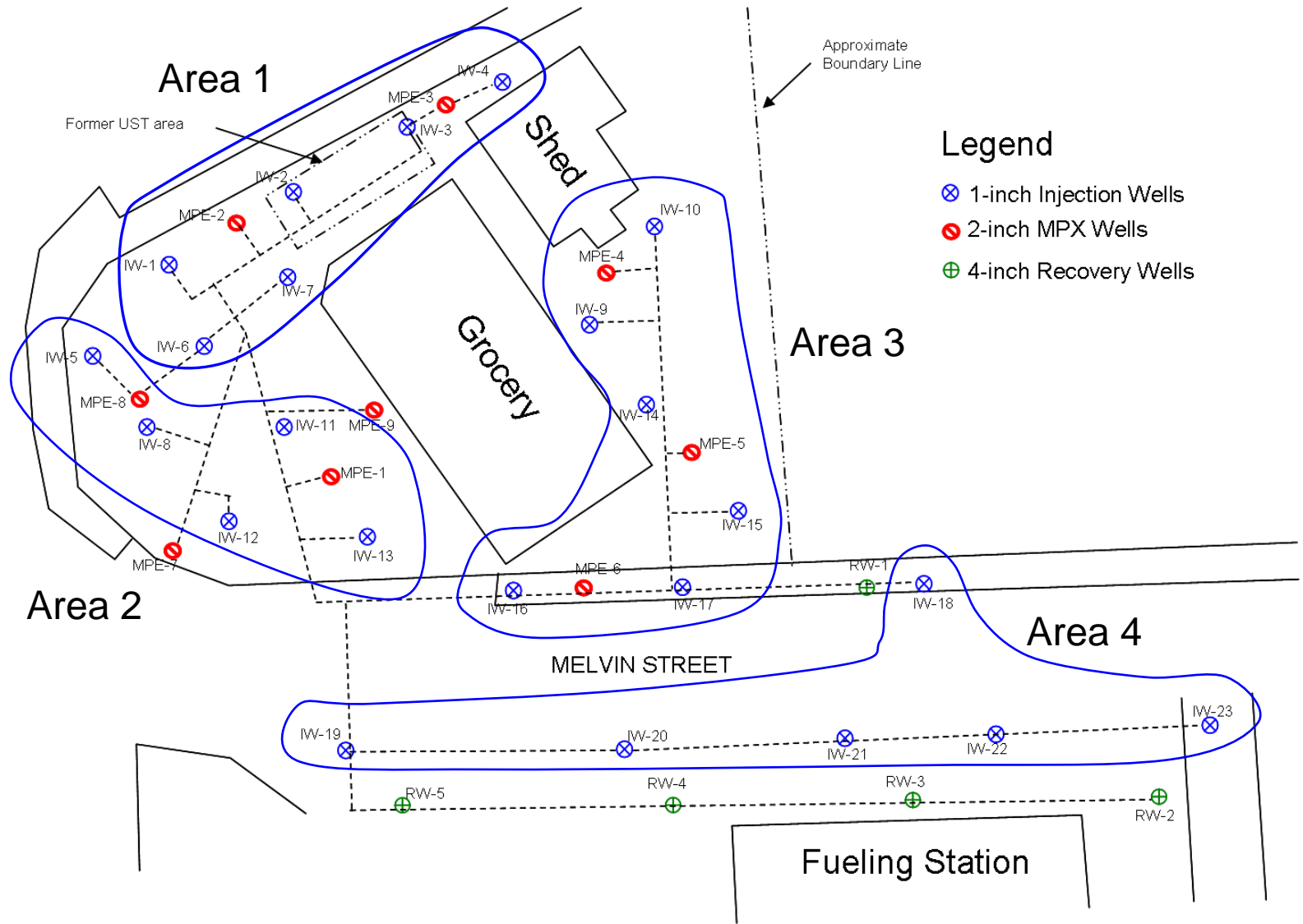
- Features
 - Fully automated, 24-hour injection
 - 40+ ppm dissolved oxygen
 - Biological product metering
 - Customizable injection strategies
 - Weather-proof enclosure
 - Touch screen control panel
 - Capable of delivering up to 650 lbs. of dissolved oxygen & support degradation of 215 lbs. of TPH/month



Touch Screen Controller

RUNNING	RUNNING	RUNNING	RUNNING	ON	
INJECTION PUMP	BOOSTER PUMP	AREA BLOWER	COMPRESSOR	OXYGEN GENERATOR	
OFF AUT MAN	OFF AUT MAN	OFF AUT MAN	AUTO	AUTO	
RUNNING	RUNNING	RUNNING	RUNNING	ALARM HISTORY	
A2 METERING PUMP	EA METERING PUMP	MZC METERING PUMP	NUT METERING PUMP	Alarm History	
OFF AUT MAN	OFF AUT MAN	OFF AUT MAN	OFF AUT MAN		
FLOW GMP	SYSTEM STATUS	PRODUCT LEVEL INDICATOR	ALARM ACKNOWLEDGE		
0.00	MULTI STATE INDICATOR	MULTI STATE INDICATOR	ACKNOWLEDGED		
TREATED GALLONS TOTALIZER	PROGRAM STATUS	HOLDING TANK	ALARM RESET		
0000 0000	MULTI STATE INDICATOR	MULTI STATE INDICATOR	RESET		
TIME/DATE	AREA VALVE STATUS	PSI /SYSTEM	HIGH PSI SP	LOW PSI SP	GO TO
10:14:20 13-JAN-06	MULTI STATE INDICATOR	0.00	0.00	0.00	SCREEN NAVIGATOR

Site Injection Areas



Legend

- ⊗ 1-inch Injection Wells
- ⊙ 2-inch MPX Wells
- ⊕ 4-inch Recovery Wells

Biological Products

- Biological (PetroZyme) Products
 - Pre-activated, liquid 4-strain culture (10^8 CFU/mL)
 - Enzyme to increase bioavailability
 - Bacterial amino acids, proteins, & enzymes
- Nutrients (Custom-Blend Nutrients)
 - Contains secondary electron acceptors
 - Nitrogen, phosphorus, & essential micronutrients

Electron Acceptor Delivery

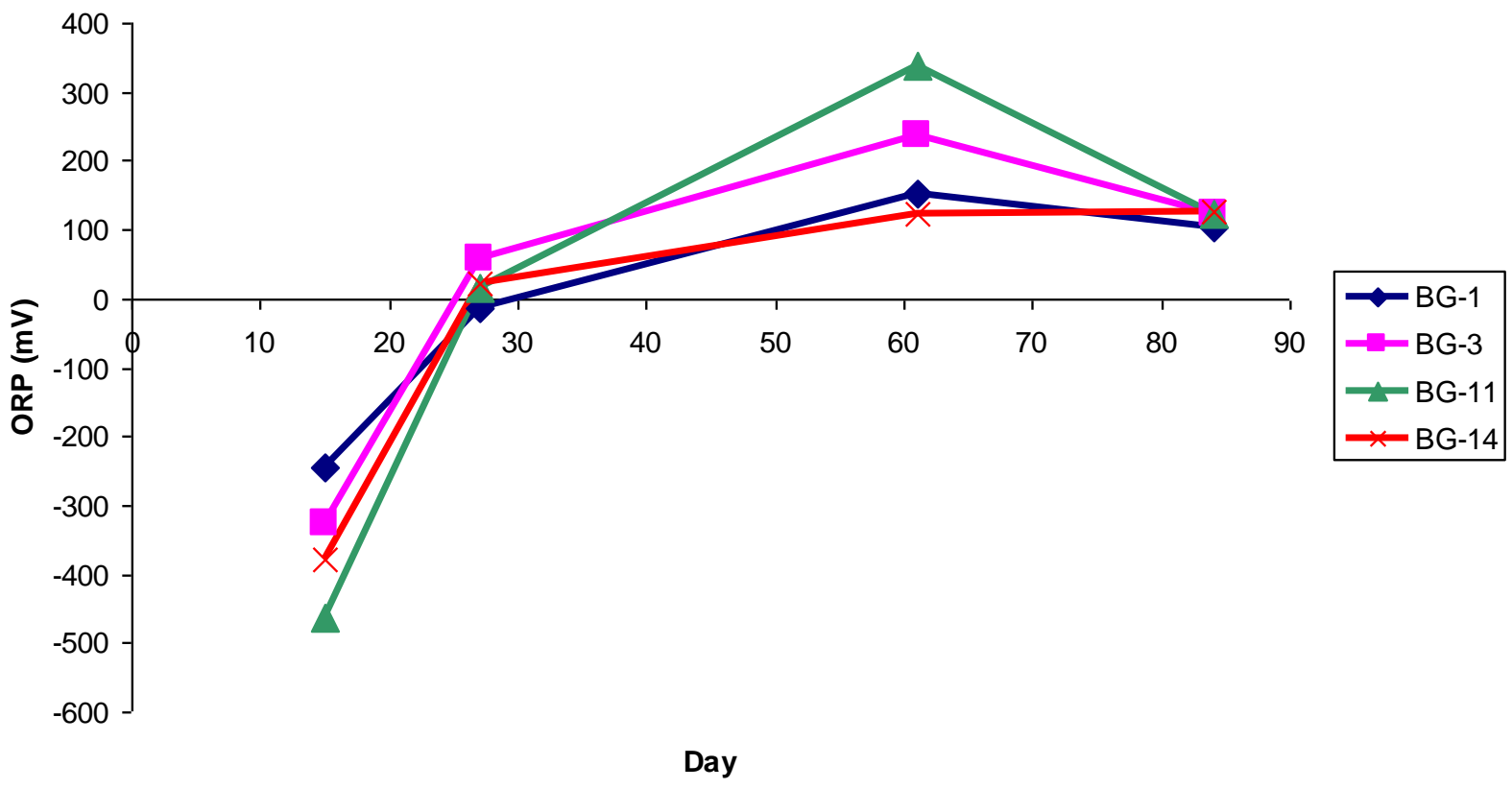
- Oxygen delivery
 - 2.5 million gallons of oxygenated water
 - 13,000 total lbs. of oxygen¹ delivered
 - At 40+ ppm DO = 939 lbs. of DO
- Secondary electron acceptor delivery
 - Initial dosing = 600 lbs. of electron acceptors
 - Monthly dosing = 120 lbs. of electron acceptors
 - Total delivery = 1,920 lbs. of electron acceptors

¹ 2,700 hours operation with 20 scfh flow of oxygen @ 40 psi

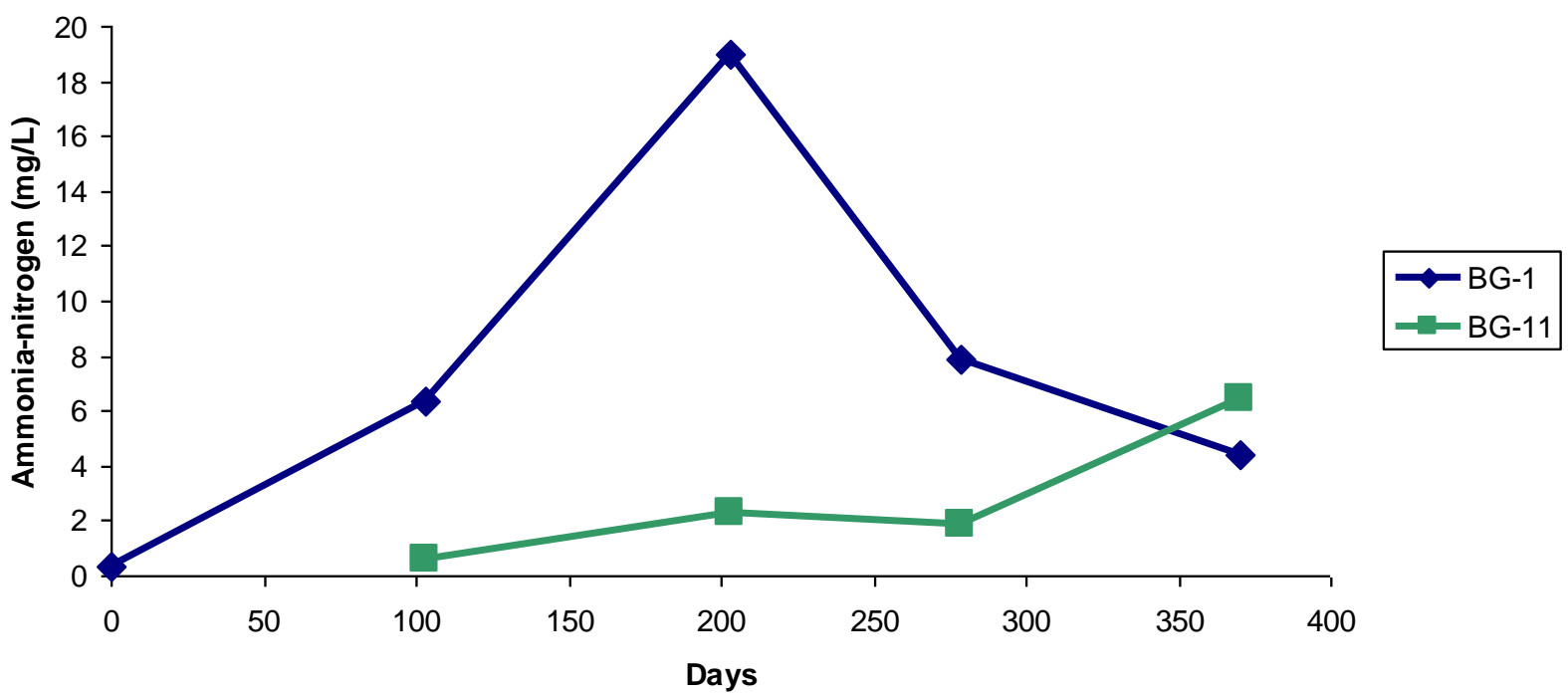
Biological Sampling

- Field Sampling
 - DO, ORP, pH
- Nutrient Sampling
 - Ammonia- & nitrate-nitrogen
 - Sulfate
 - orthophosphate
 - Manganese/soluble iron
- Microbial Sampling
 - Heterotrophic plate counts
 - Hydrocarbon-degrading counts

ORP Data



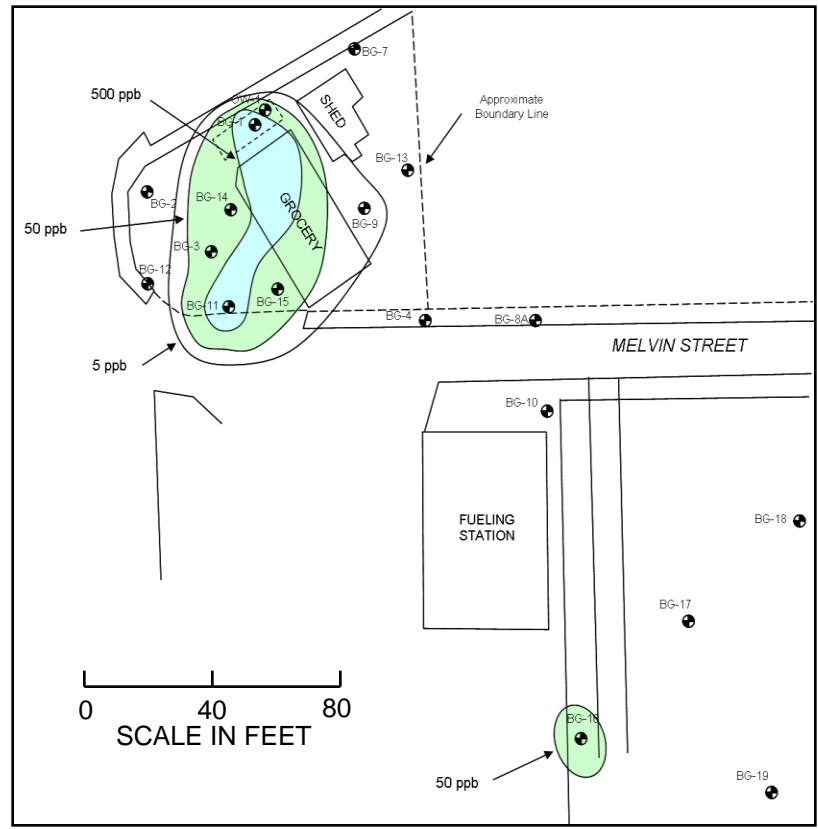
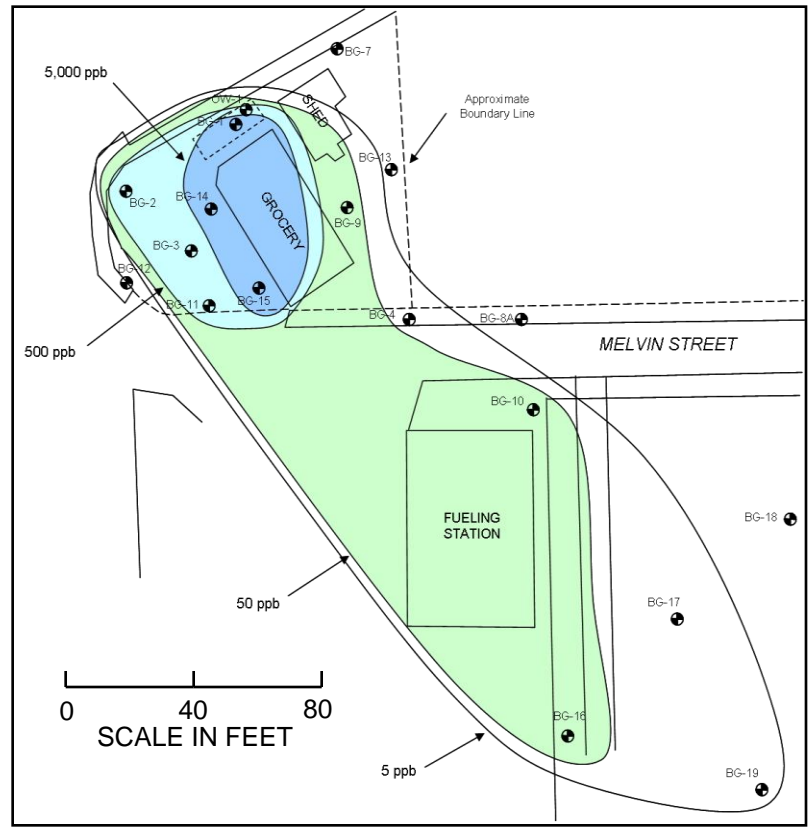
Ammonia-nitrogen Data



BTEX Plume Reduction

Start-up

12 Months



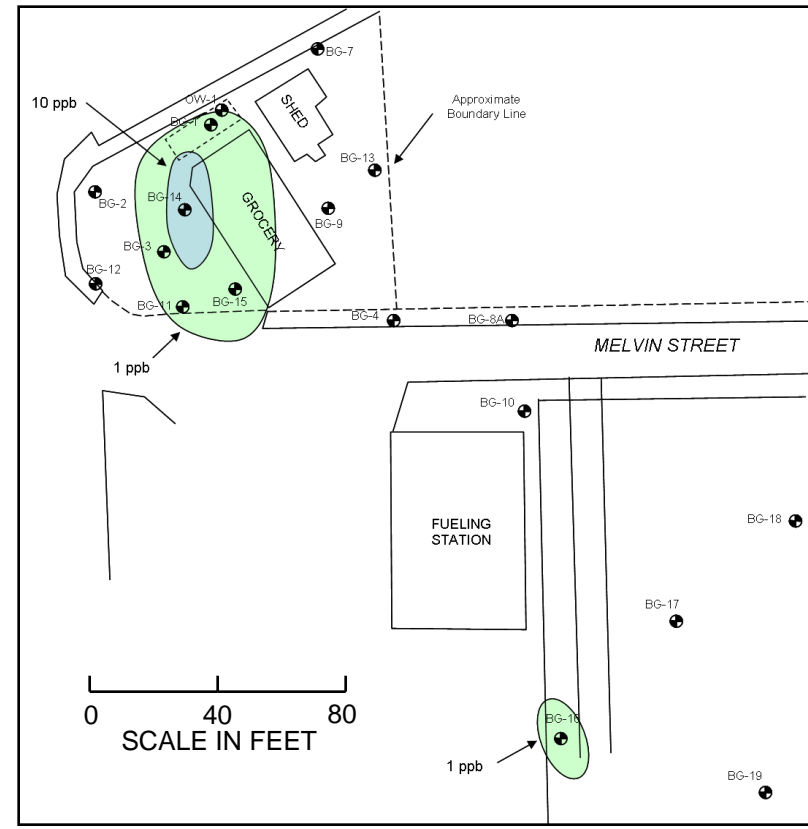
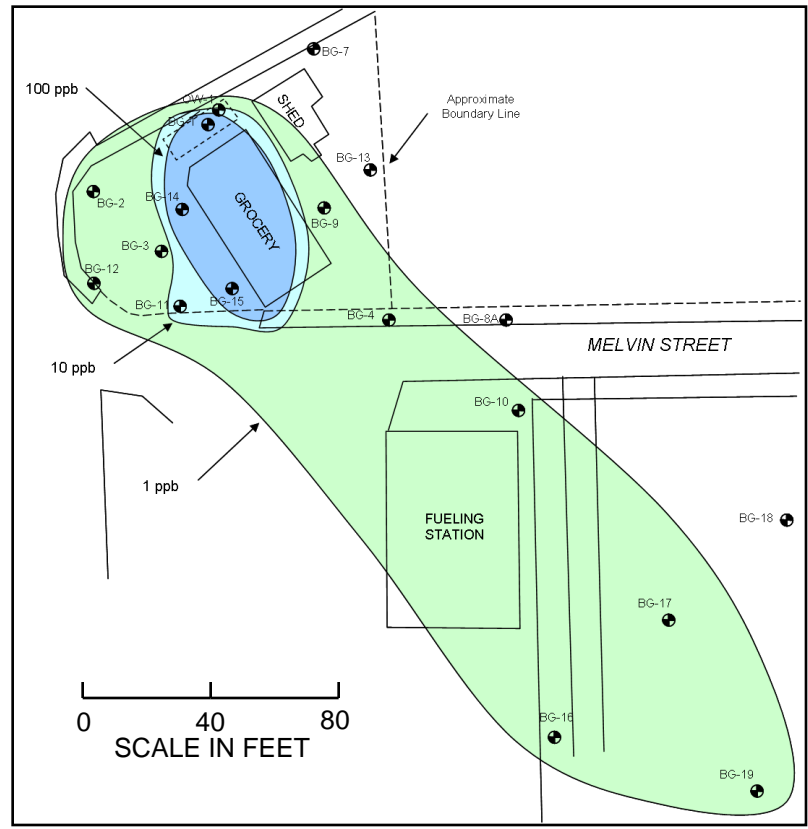
Benzene Reductions



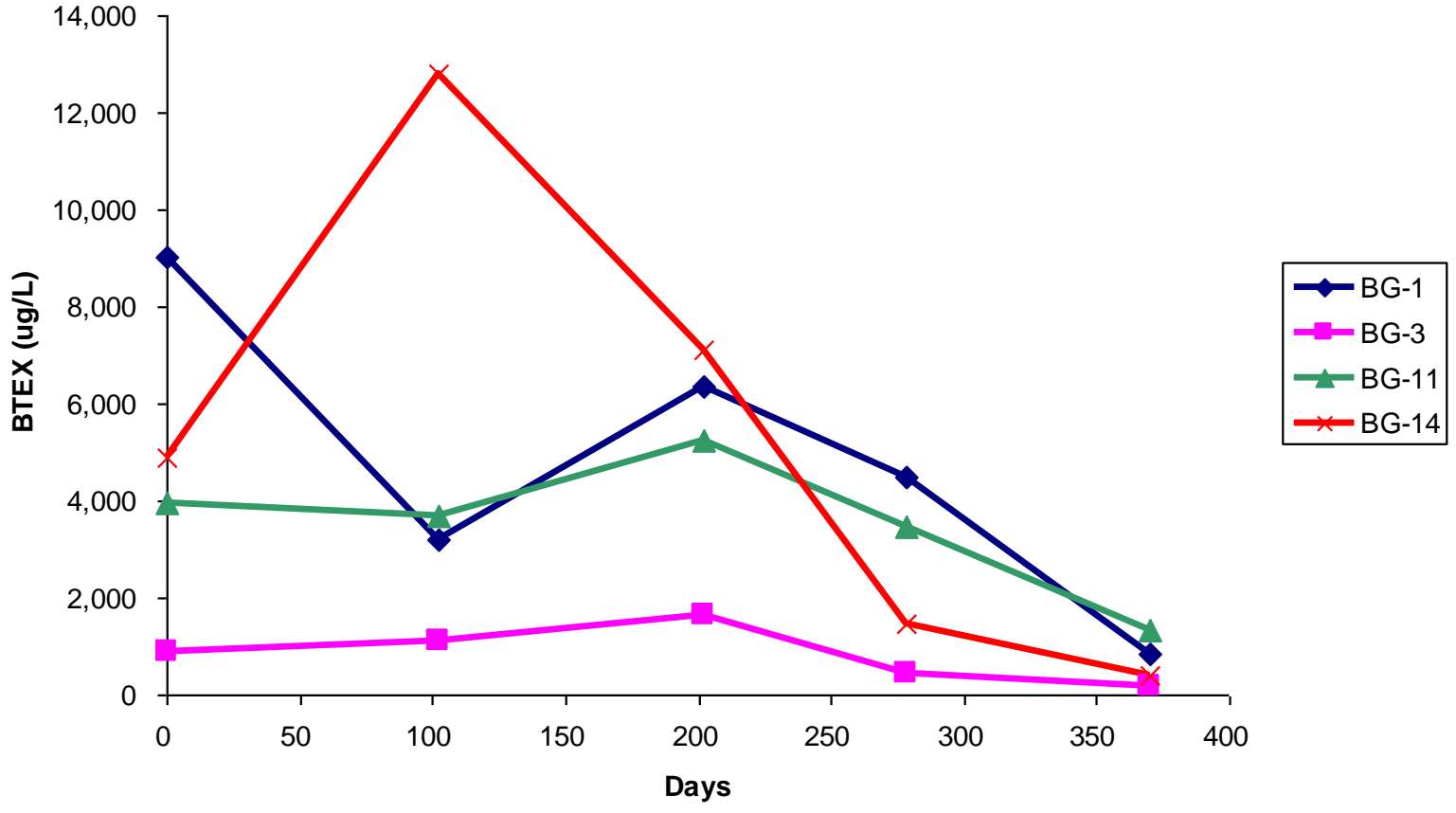
Petro-Chem Environmental Systems, Inc.

Start-up

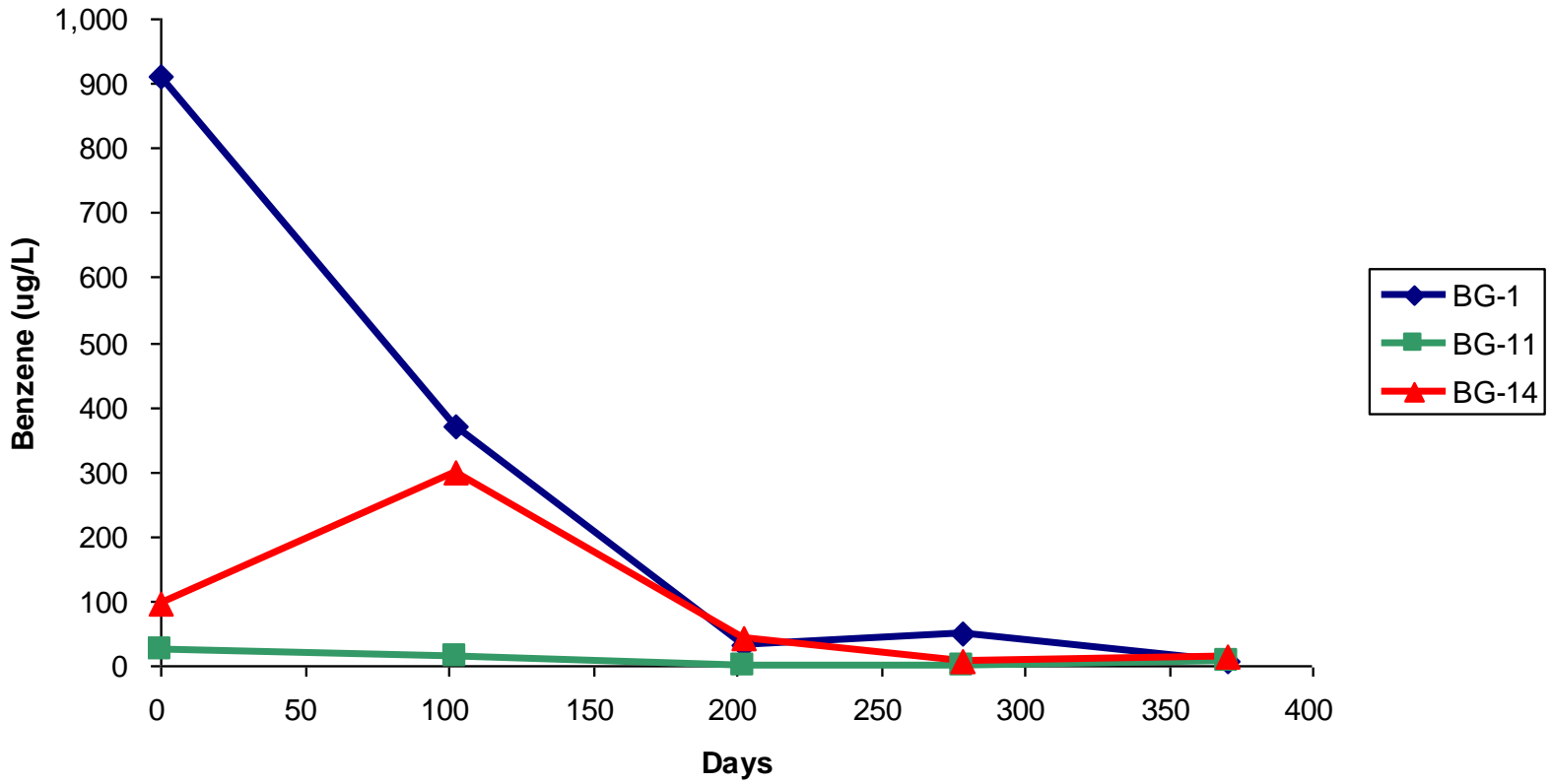
12 Months



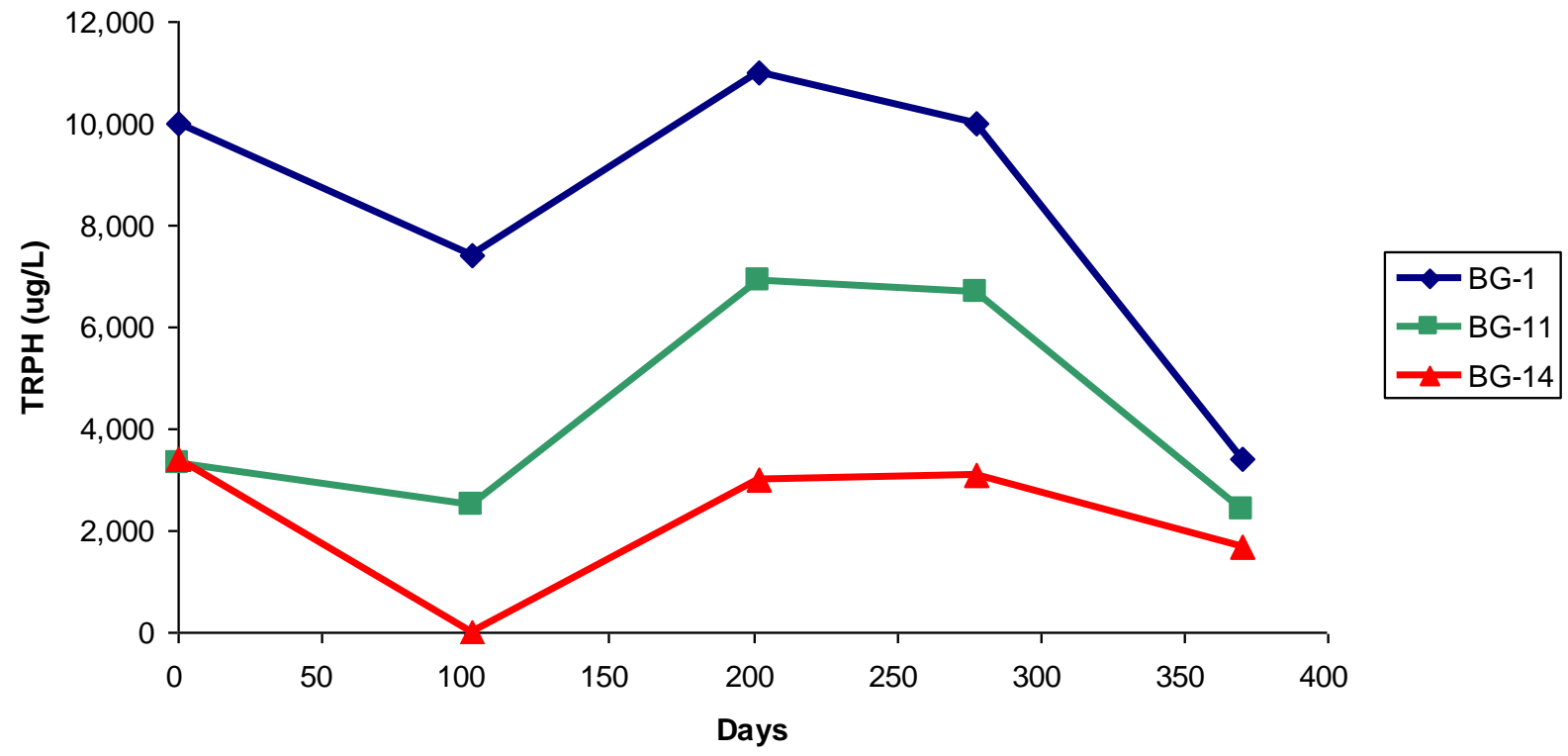
BTEX Reductions



Benzene Reductions



TRPH Reductions



Estimated Contaminant Removal

- GW recovery
 - BTEX = 1.7 lbs.
 - TPH = 15.1 lbs.
- Vapor recovery
 - BTEX = up to 130 lbs.
 - TPH = up to 2,400 lbs.
- DO-IT system degradation
 - Total supplied oxygen = up to 4,000 lbs. TPH
 - Dissolved oxygen = up to 313 lbs. TPH
 - Secondary electron acceptors = up to 384 lbs. TPH

Conclusions

- Advantages

- Hydraulic control & capture
- No sewer discharge permitting or costs for disposal
- Treatment of the subsurface underneath the building
- Effective delivery of dissolved oxygen & biological amendments
- Elimination of electron acceptor & nutrient limiting conditions
- Increased contact with groundwater & smear-zone contaminants
- Ability to optimize/focus delivery based on data
- Achieve maximum results using both physical & biological removal mechanisms

Conclusions

- Lessons Learned
 - Importance of infrastructure construction
 - Equipment integration
 - Drought conditions
- Costs
 - Consultant O&M (REI) - \$40,000/year
 - Extraction/treatment system - \$100,000
 - DO-IT system - \$4,700/month