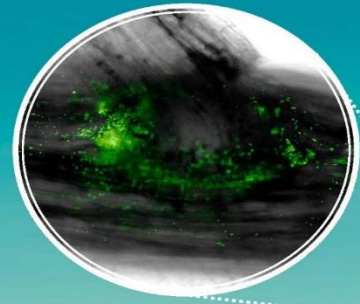




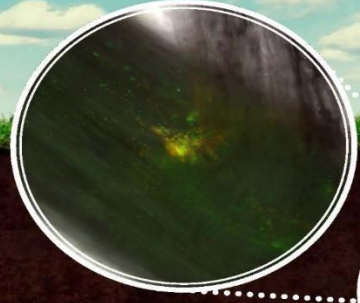
Intrinsyx Environmental

Combining nature with engineered solutions for sustainable environmental remediation

Phytoremediation



Endophytes



Endophytes

Sequestration + Mineralization
Organic Chemicals + Metals

Uptake + Phytoextraction
Water + Contaminants

Sun Light

Photosynthesis

Xylem
 $H_2O + \text{Nutrients}$

Phloem

Transpiration

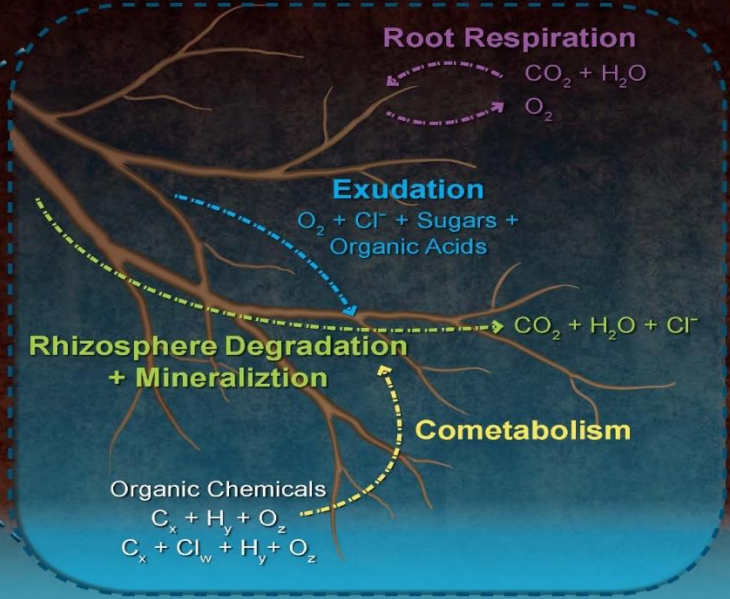
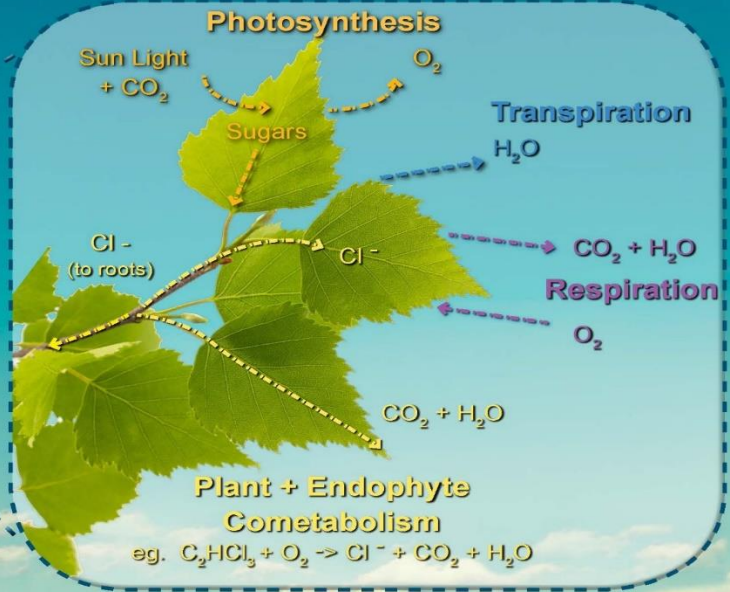
CO_2

Carbon Sequestration

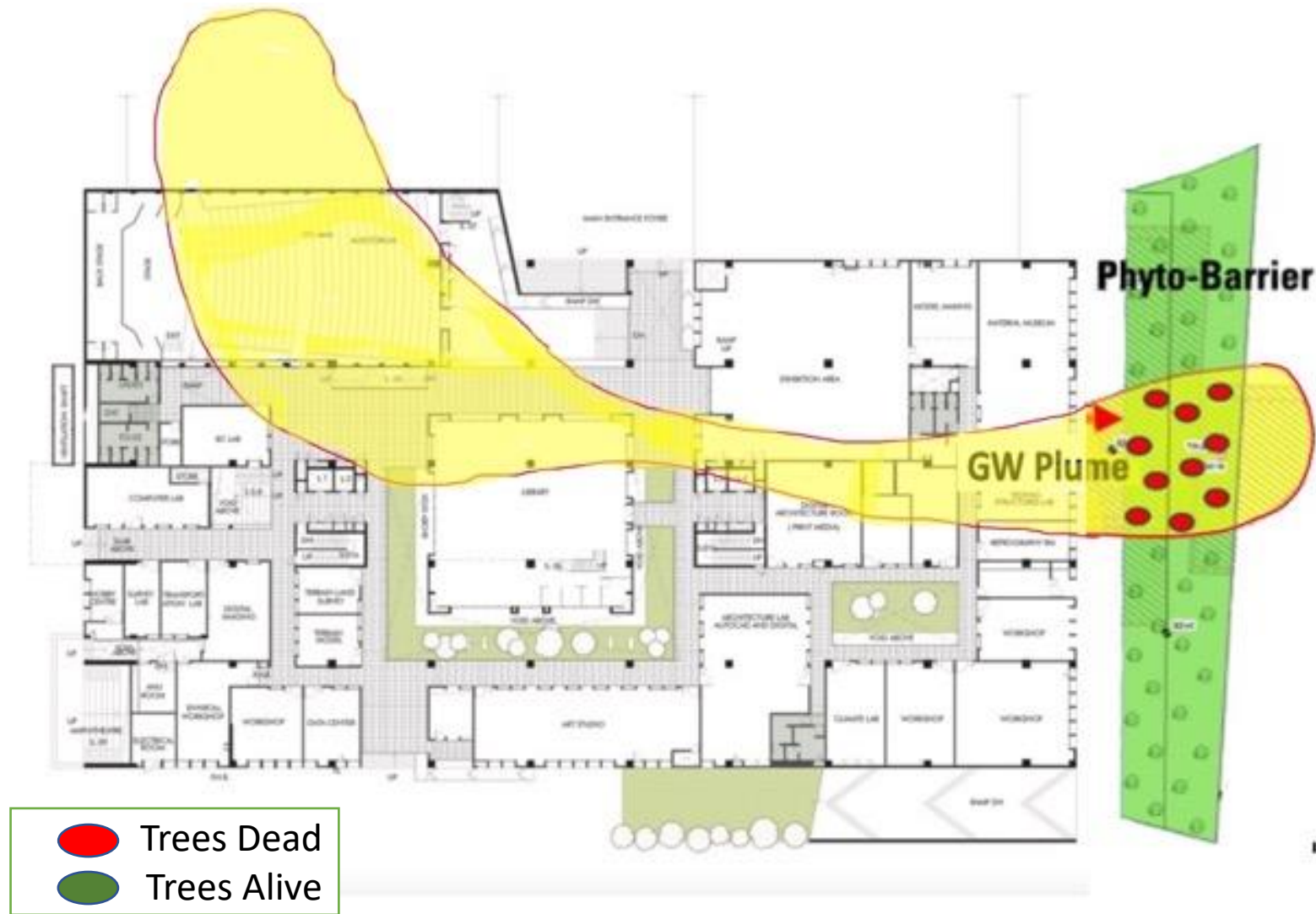
Rhizosphere Degradation

Contaminants

Water Table



Limitations of phytoremediation without endophytes



Accumulation of VOCs = Phytotoxicity = Decreased Growth and Tree Mortality

Contaminated Site



Lower cost



Reduce carbon footprint



Increase Land Value



Sustainable



Regulator approved



Beneficial community impact

Without Endophyte Technology

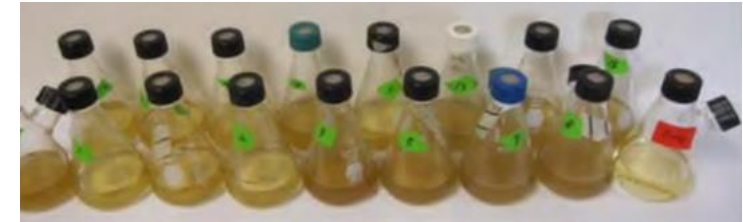
With Endophyte Technology



**School of Environmental
and Forest Sciences**

UNIVERSITY *of* WASHINGTON

College of the Environment



Enhanced Phytoremediation

Dr. Sharon Doty

Inoculation of Endophyte Bacteria into Trees

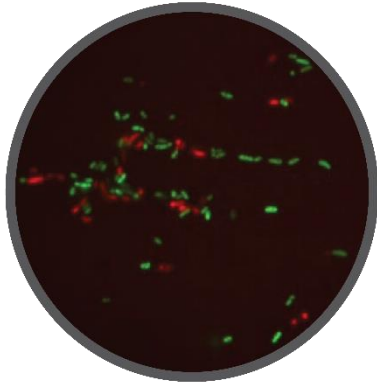
- Grow in extreme environments
- Increased biomass
- Tolerance to pollutants
- Enhanced contaminant degradation
- Increase carbon sequestration
- Improve water use efficiency

**endophytes are ubiquitous in nature



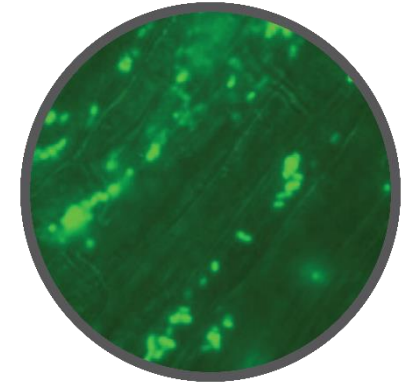
PAH / BTEX Oil / Gas

*Pseudomonas putida &
Sphingomonas yanoikuyae*

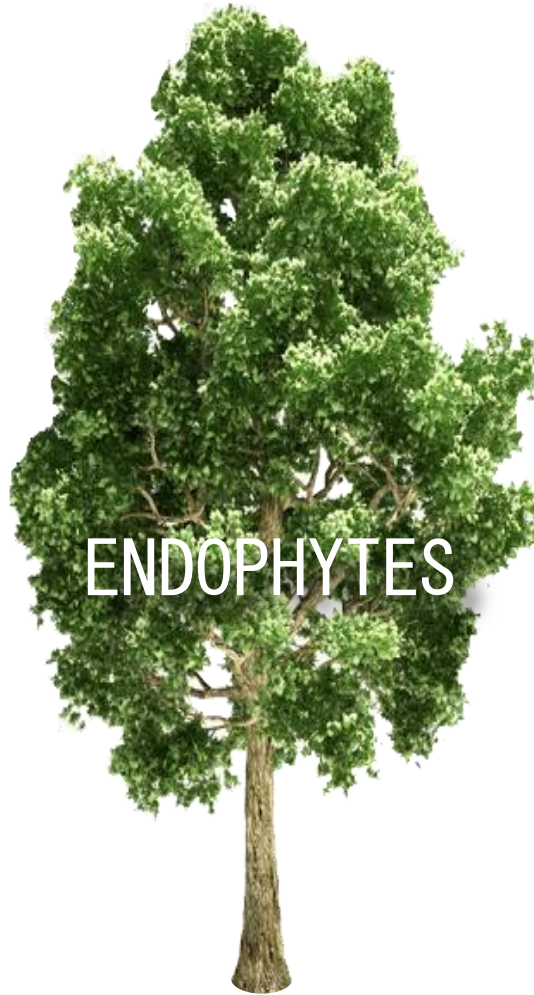


Chlorinated Solvents (TCE/PCE)

Enterobacter sp.

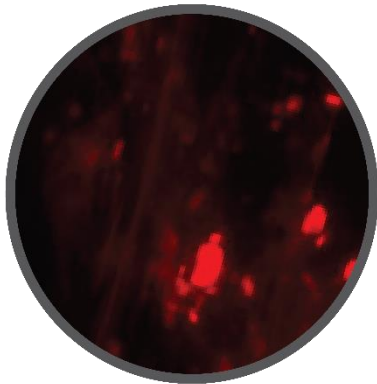


ENDOPHYTES



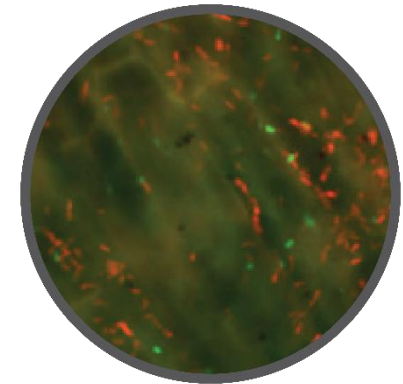
Polychlorinated biphenyl (PCB)

Paraburkholderia xenovorans



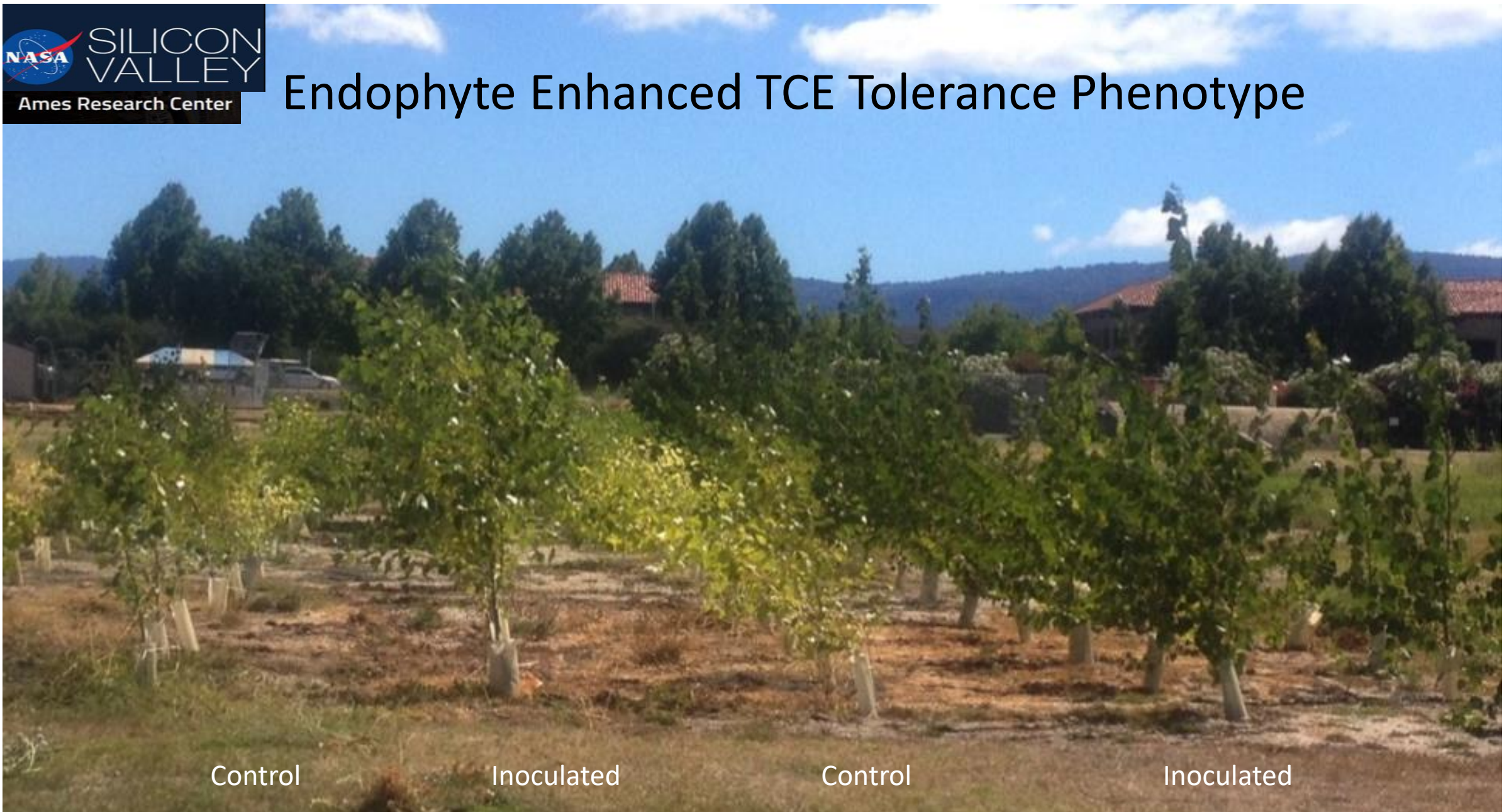
Munitions TNT / RDX

Pseudomonas sp.

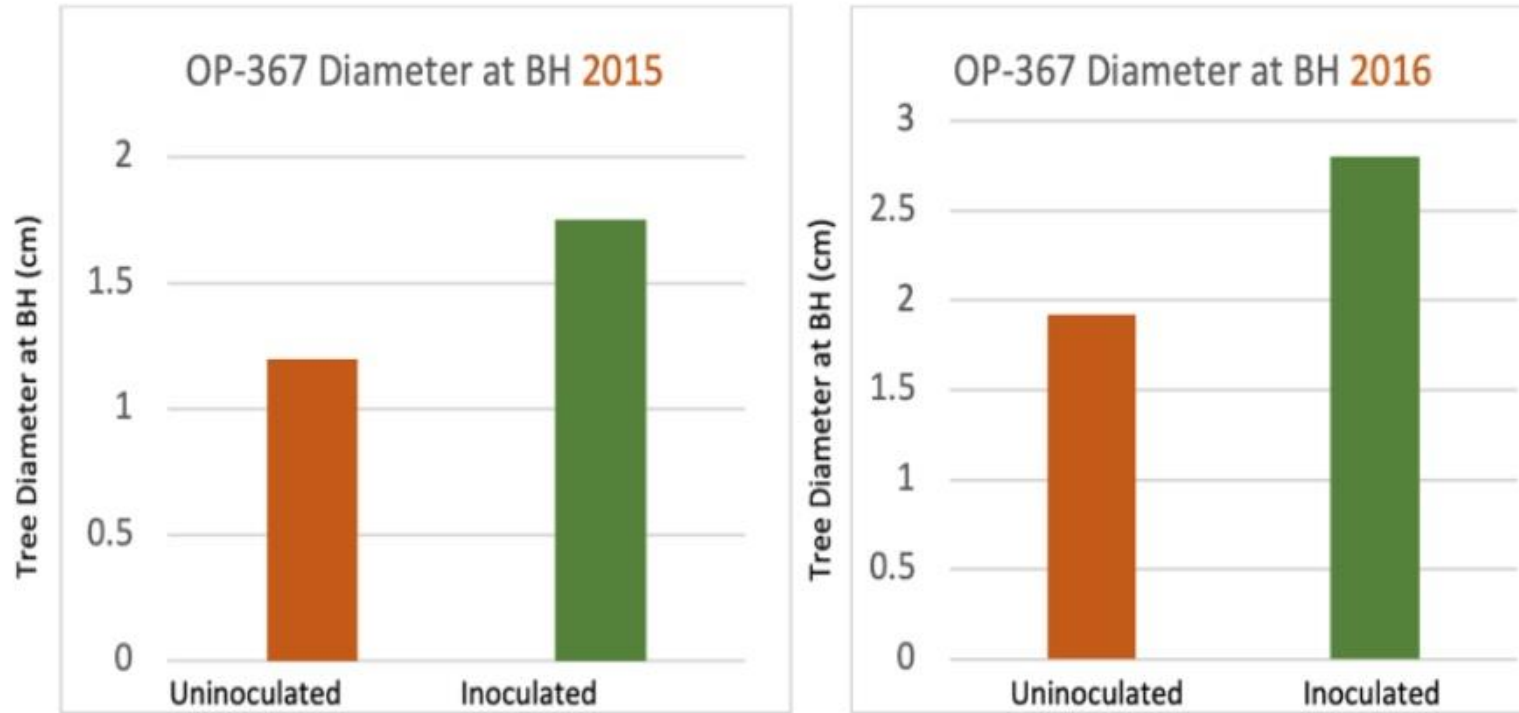


Contaminant Specific Microbes

Endophyte Enhanced TCE Tolerance Phenotype



Growth Benefits from Endophyte Inoculation



Tree trunk diameter at breast height (cm)

Monitoring Well Results

Test Well 1 Upgradient from Trees vs. **Test Well 2 Down Gradient** from Trees

	August 28, 2016 Test Well		November 21, 2016 Test Well		July 28, 2017 Test Well		July 19, 2018 Test Well		MDL	Reporting Limit
	1	2	1	2	1	2	1	2		
	µg/L									
Trichloroethene	280	ND	300	ND	260	ND	130	ND	1.1	5
trans-1,2-Dichloroethene	1.7	ND	3.1	ND	2.2	ND	2	ND	0.13	0.5
cis-1,2-Dichloroethene	140	ND	160	ND	120	ND	90	ND	1.5	5
1,1-Dichloroethene	7.6	ND	6.8	ND	5.8	ND	4.6	ND	0.092	0.5
1,1-Dichloroethane	7.9	0.64	9	0.58	8.1	ND	6	0.48	0.12	0.5
Vinyl chloride	0.54	ND	0.77	ND	ND	ND	0.50	ND	0.17	0.5
Tetrachloroethene	0.85	ND	0.88	ND	0.86	ND	ND	ND	0.12	0.5
Chloroform	0.38	ND	ND	ND	ND	ND	ND	ND	0.13	0.5
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	1.5	ND	1.5	ND	2.2	ND	2.4	ND	0.15	0.5

- Effectively cut off TCE plume migrating onto base
- EPA Approval to expand remediation efforts over the next phase – incorporating phytoremediation into the redevelopment plan for a housing project

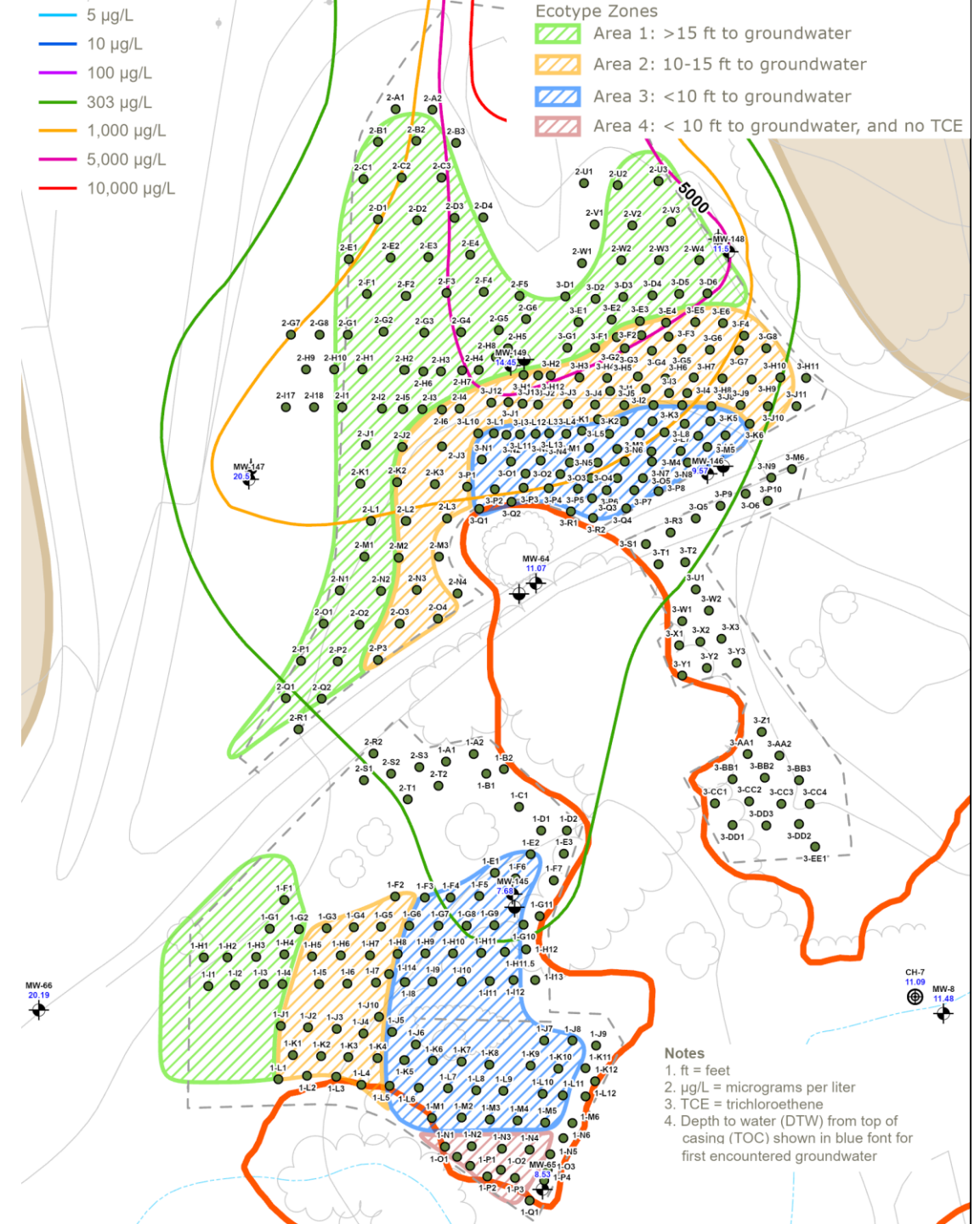
TCE Site – Former Military Testing Facility

Salt and Boron Tolerant Poplar in Groundwater in an Arid Environment



Measuring treatment effects:

1. Tree health Assessment
 - SPAD/Chlorophyll leaf measurements
 - Visual evaluation
2. Tree core VOC analysis
 - gas chromatography mass spectrometry (GC-MS)
 - Low detection limits (ppt)
3. Leaf ion analysis
4. Soil Vapor and ion analysis



Gasoline and Diesel Transfer Station – Dos Palos, California

Benzene, hydrocarbons and diesel fuel, Feet of LNAPL on groundwater

Vapor intrusion in community homes

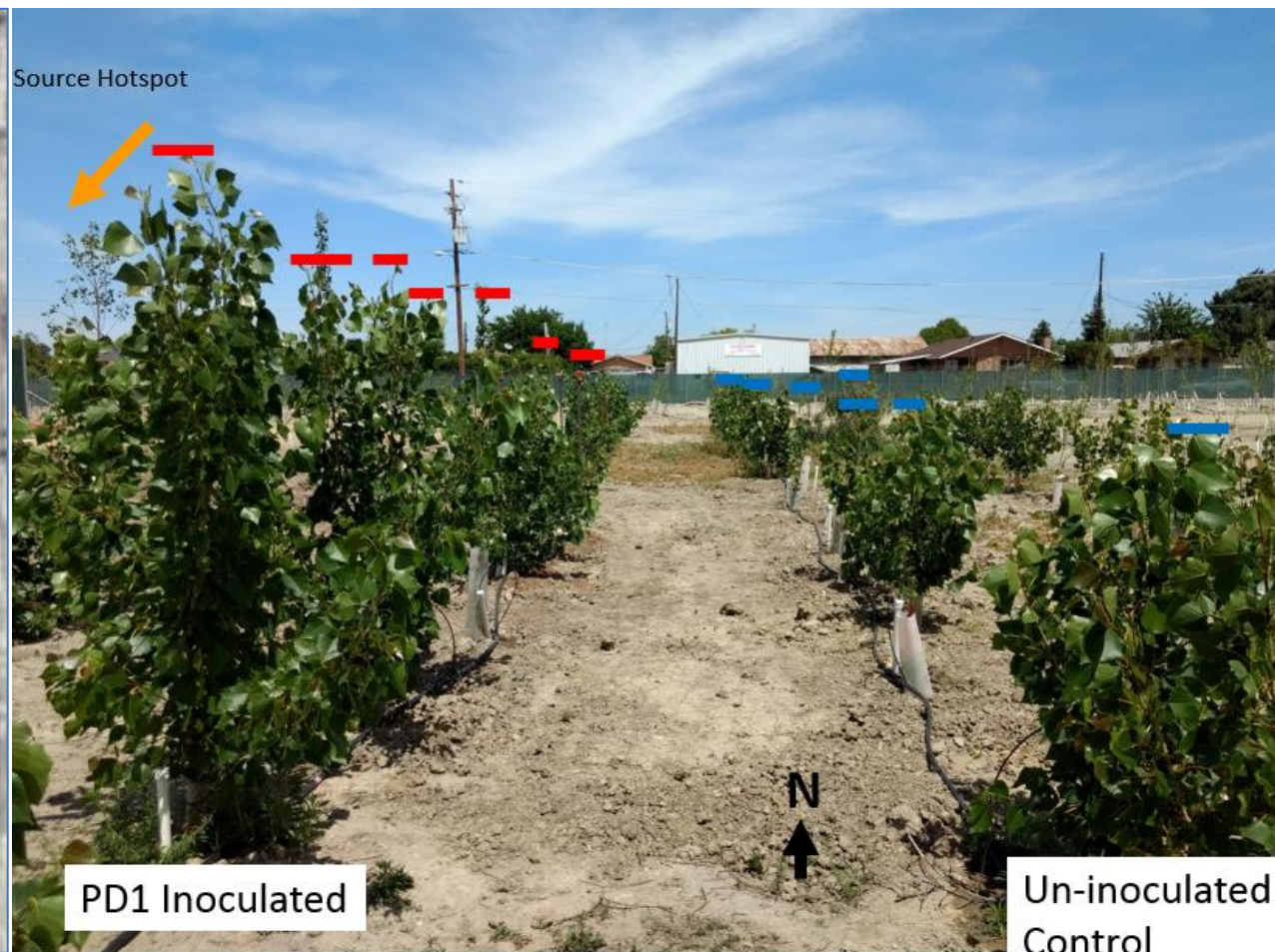
Failing Soil Vapor Extraction (SVE) as well as Pump and Treat System on property



Phytoremediation Pre- and Post-Endophytes

Endophyte Root Drench Tree Rescue using PD1 on **blue rows**

RESULT: Increase in tree health and survival rate

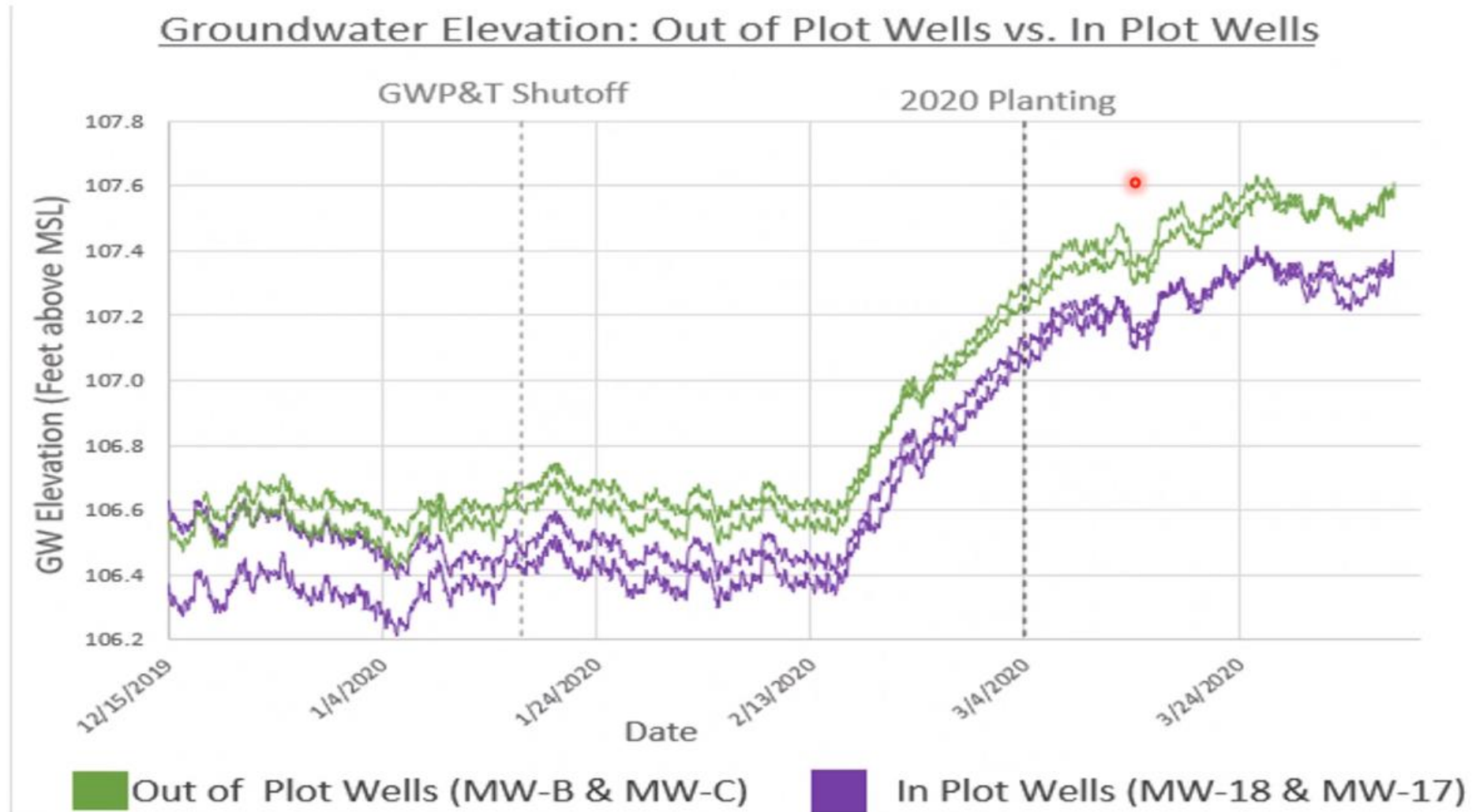


Trees Dead: ●

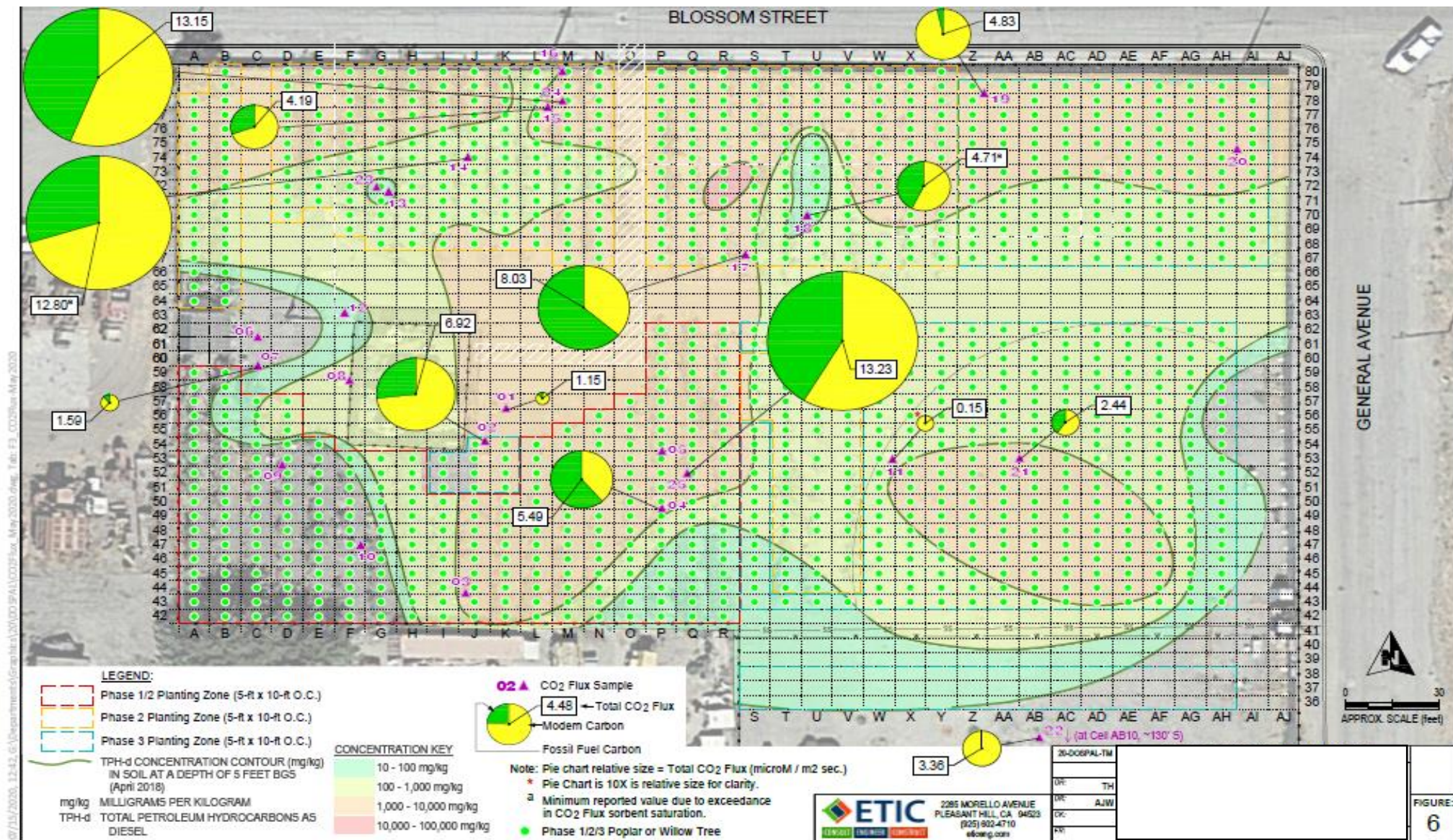
Trees Dying: ●

Trees Severely Stressed: ●

Groundwater Elevation, 2020 Analysis



Carbon Dioxide Soil Flux Results



Results of Dos Palos site

State Water Board authorized shut-off of SVE and Pump & Treat System

Positive impact on neighborhood community

Client saving ~\$1M/year





Former refinery tank storage - Corpus Christi, TX

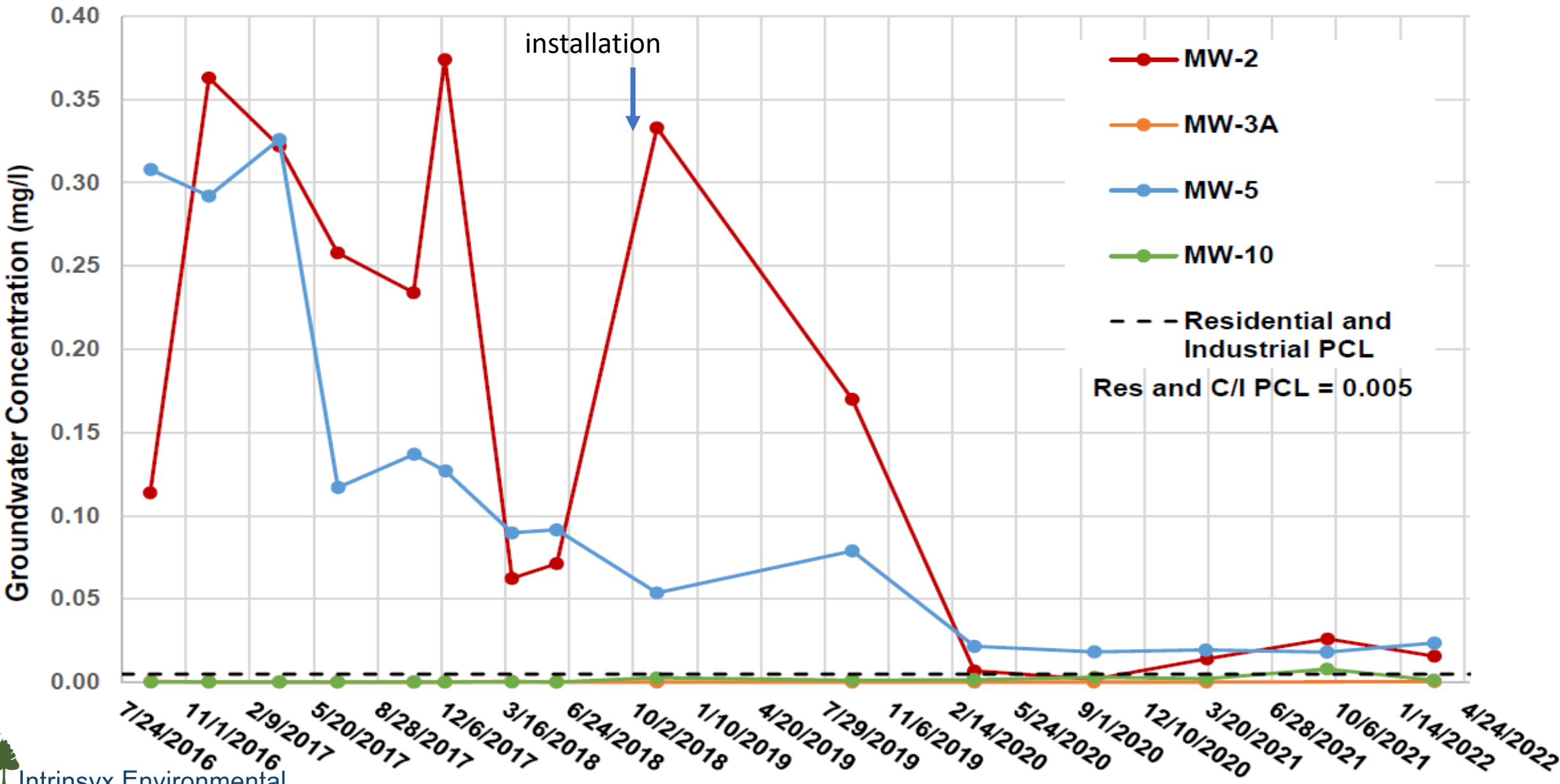
Contaminated soil and ground water with nonexistent vegetation
Inoculated poplar trees and buffalo grass seed treatment with PD1

RESULTS: Reductions in benzene and ethylbenzene in ground water within 2 years of planting

Texas, 2016-2022

Benzene Concentrations in Groundwater Versus Time

Monitor Wells MW-2, MW-3A, MW-5 and MW-10





Major Alaska Airport

Diesel fuel, TPH, benzene, EDC (chlorinated solvent) in groundwater and soil



Project Outcomes

Contaminants are being degraded, trees are surviving well
Regulators approve of current progress of phytoremediation
Phytoremediation system is expanding in 2023



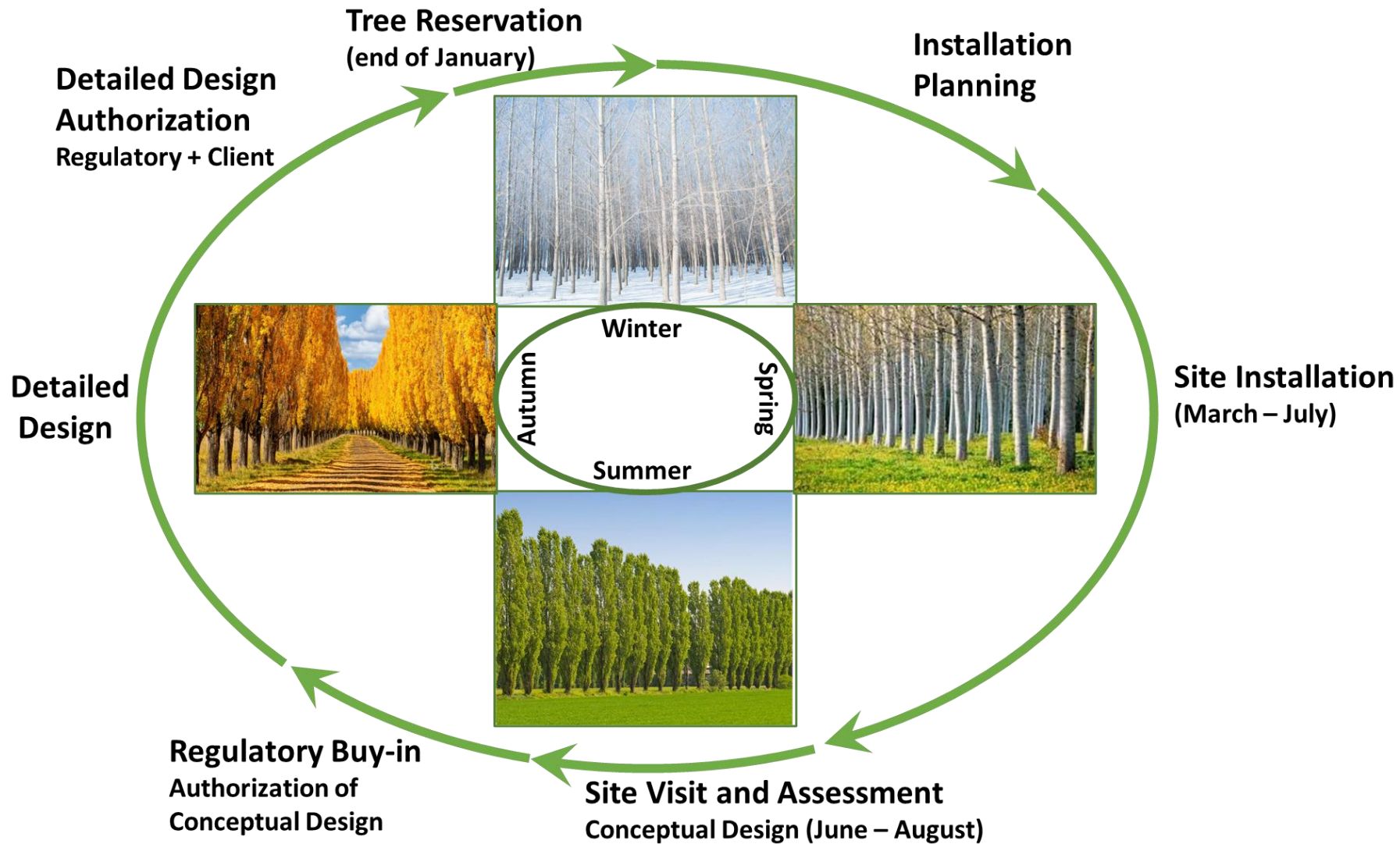
TCE Site Former Manufacturing Facility

Danville, Illinois

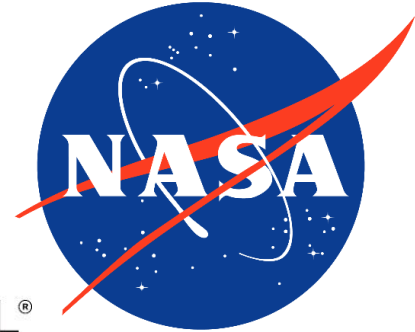
- Trees planted in augured holes through asphalt
- current discussion of site closure
- City turning remediated site into park



Project Cycle



Partners and Collaborators





Galen O'Toole

Lead Environmental Engineer

galen@intrinsyx.com

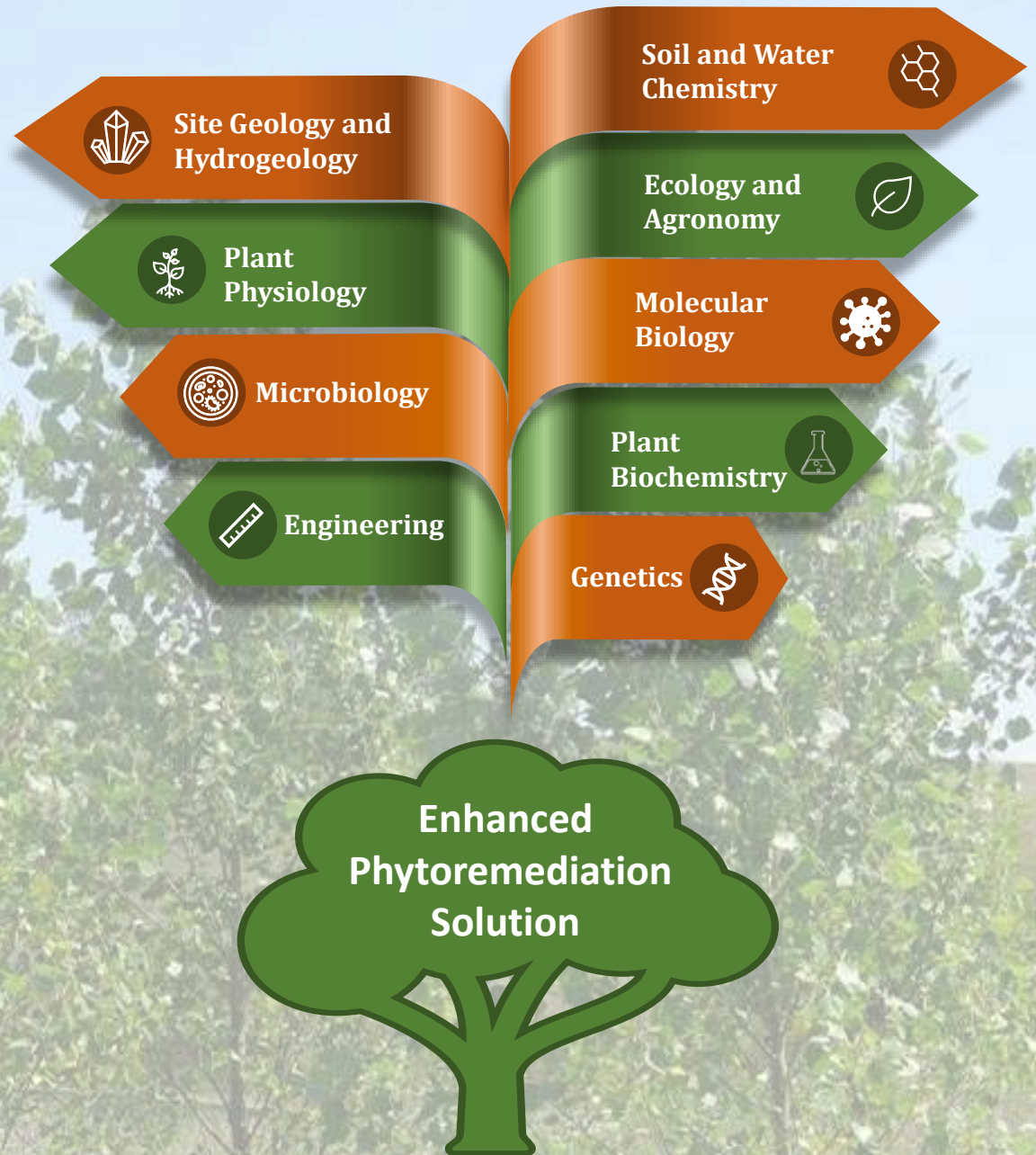
**1237 Midas Way
Sunnyvale, CA 94085**



Intrinsyx Environmental

[www. IntrinsyxEnvironmental.com](http://www.IntrinsyxEnvironmental.com)

Multidisciplinary Approach



Rhizofiltration

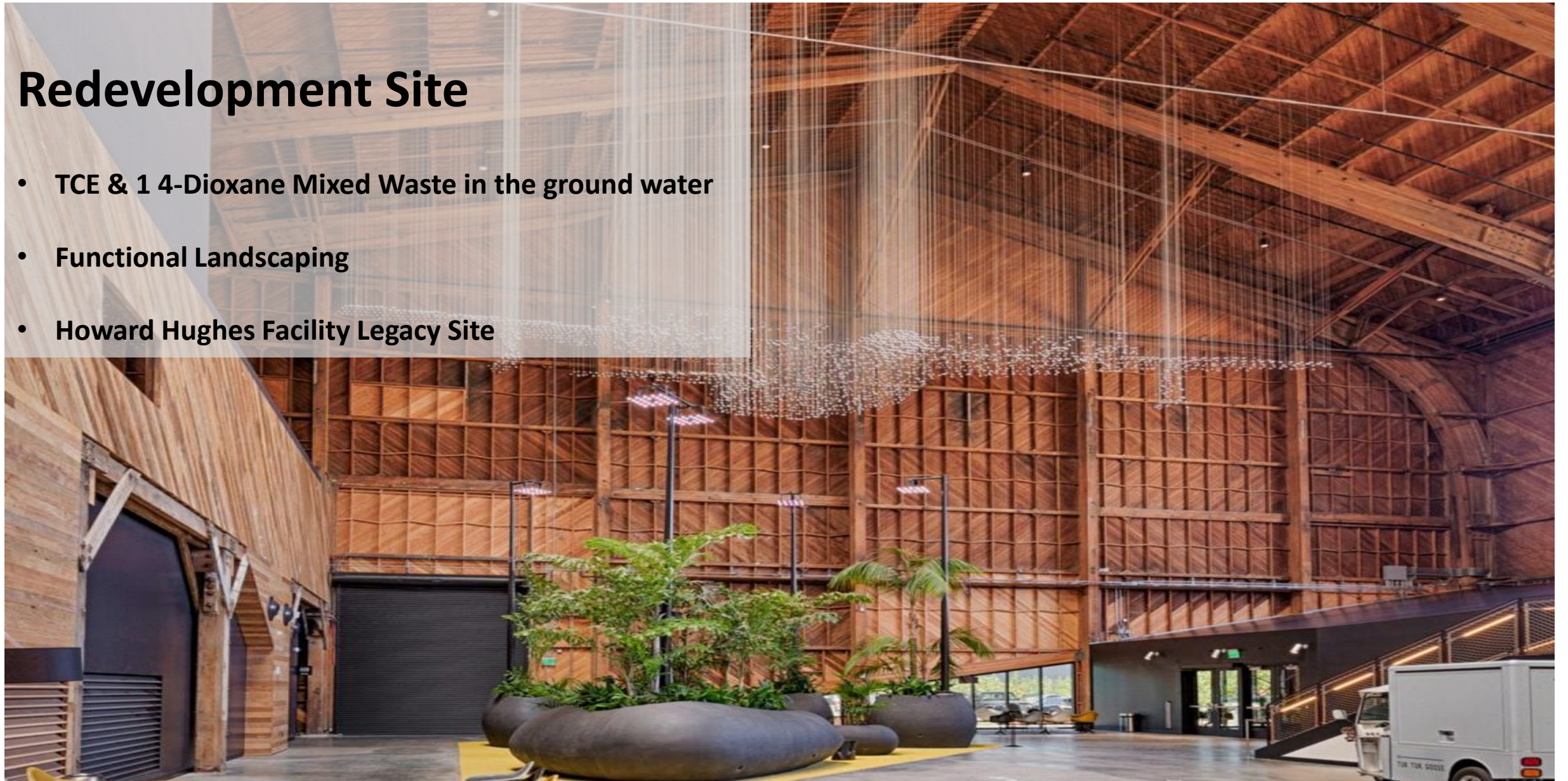
Surface Water and Wastewater

- Root-zone water treatment
- In-situ—lakes, ponds, reservoirs
- Effluent treatment
- Floating wetlands
- Sub-surface-flow wetlands



Redevelopment Site

- TCE & 1,4-Dioxane Mixed Waste in the ground water
- Functional Landscaping
- Howard Hughes Facility Legacy Site



Functional Landscaping – Increased value – Reduced Heat Island Effect



RDX, TNT, Nitrates, and UXO Sites



- Aerial Seeding and endophyte application has been proven in the field
- Tractor-driven application (Seeding +inoculating)
- Plants + endophytes will degrade TNT/RDX and thriving in diverse environments
- Looking for new sites to help refine tools

