Thank you for signing in early

The webinar will begin promptly at
12:00 pm ET, 9:00 am PT

SERDP DOD • EPA • DOE | ESTCP

SERDP and ESTCP Webinar Series

The webinar will begin promptly at 12:00 pm ET, 9:00 am PT

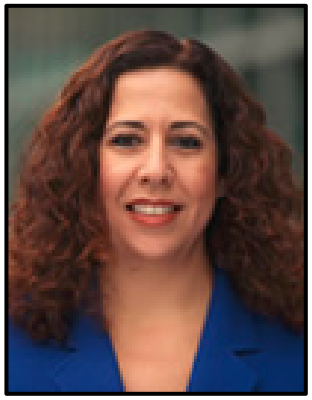
- You have two options for accessing the webinar
  1. Listen to the broadcast audio if your computer is equipped with speakers
  2. Call into the conference line: 303-248-0285
     Required conference ID: 6102000
- For any question or issues, please email serdp-estcp@noblis.org or call 571-372-6565

Managing Groundwater Impacts at Chlorinated Solvent Sites

October 4, 2018

Welcome and Introductions

Rula A. Deeb, Ph.D.
Webinar Coordinator

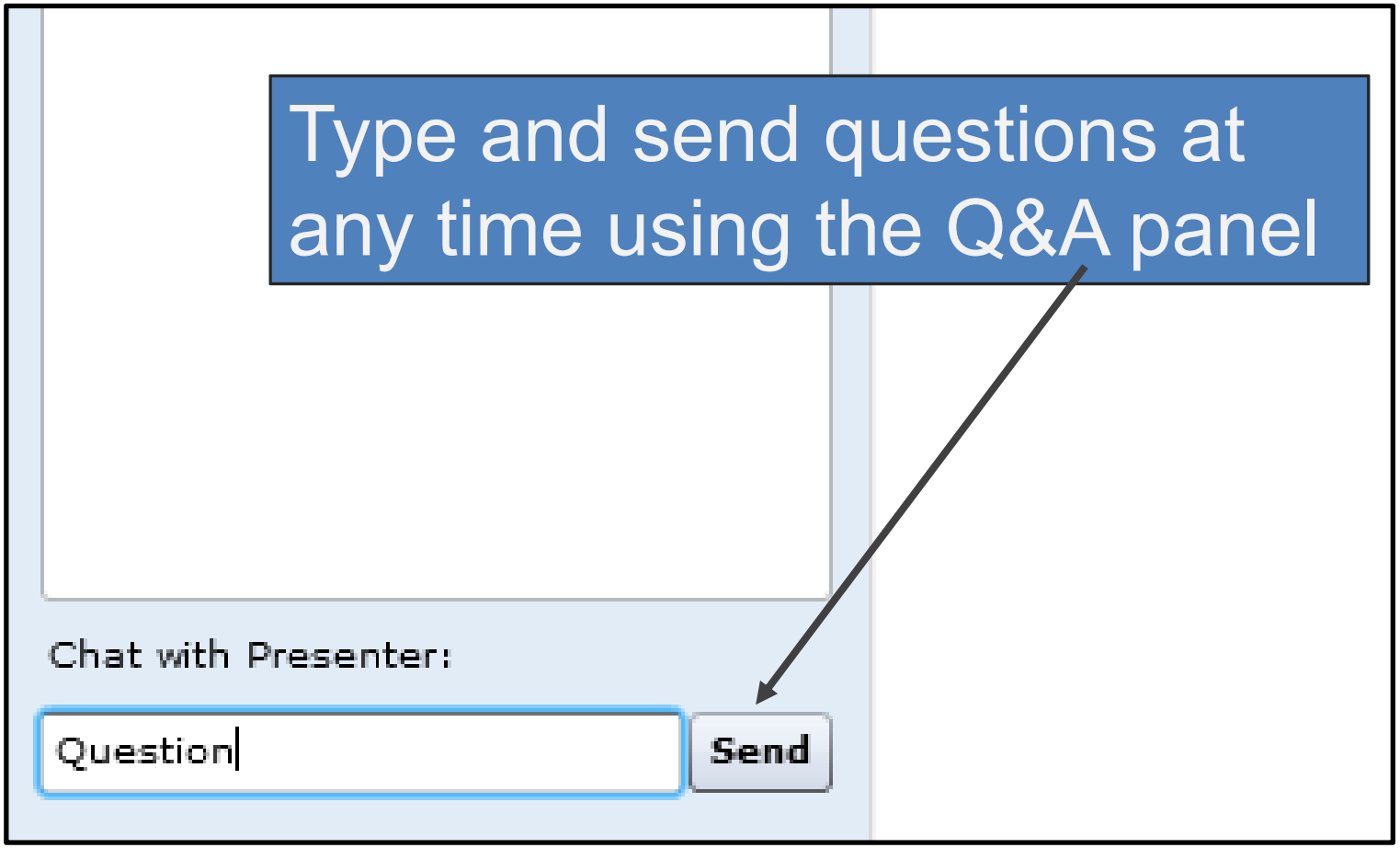


SERDP DOD ▪ EPA ▪ DOE | ESTCP

Webinar Agenda

- **Webinar Logistics** (5 minutes)
  Dr. Rula Deeb, Geosyntec Consultants
- **Overview of SERDP and ESTCP** (5 minutes)
  Dr. Andrea Leeson, SERDP and ESTCP
- **SERDP and ESTCP Strategic Research for Managing Chlorinated Solvents in Groundwater** (15 minutes + Q&A)
  Dr. Andrea Leeson, SERDP and ESTCP
- **Effective Treatment of Chlorinated Solvents in Clay and Silt Using Electrokinetic Techniques** (35 minutes + Q&A)
  Mr. Evan Cox, Geosyntec Consultants
- **Final Q&A session**

How to Ask Questions



In Case of Technical Difficulties

- Delays in the broadcast audio
  - Click the mute/connect button
  - Wait 3-5 seconds
  - Click the mute/connect button again
  - If delays continue, call into the conference line
    - Call into the conference line: 303-248-0285
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- Submit a question using the chat box

SERDP & ESTCP Overview

Andrea Leeson, Ph.D.
SERDP & ESTCP

SERDP DOD • EPA • DOE | ESTCP

DoD's Environmental Technology Programs

Science and Technology

- Statutory program established 1991
- DoD, DOE, EPA partnership
  - Advanced technology development to address near-term needs
  - Fundamental research to impact real world environmental management

Demonstration and Validation

- Demonstrate innovative cost-effective environmental and energy technologies
  - Transition technology out of the lab
  - Establish cost and performance
  - Partner with end user and regulator
  - Technology transfer
    - Accelerate commercialization or broader adoption
    - Direct technology insertion

Environmental Drivers

Sustaining Ranges, Facilities and Operations

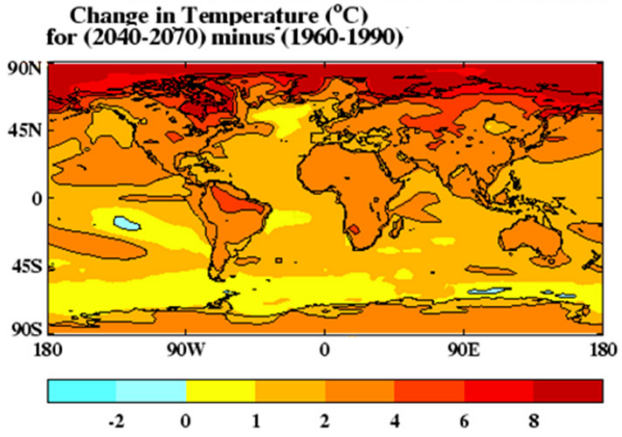
Maritime Sustainability
Threatened and Endangered Species

Toxic Air Emissions and Dust

UXO and Munitions Constituents

Noise

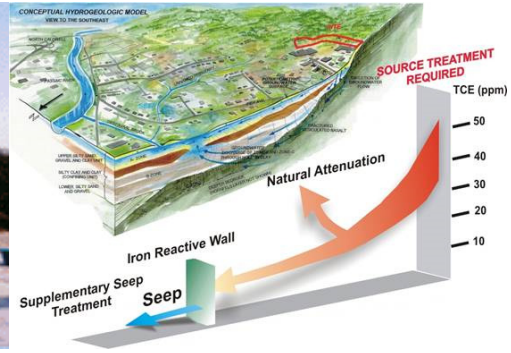
Sustainable FOB



Environmental Drivers

Reducing Current and Future Liability

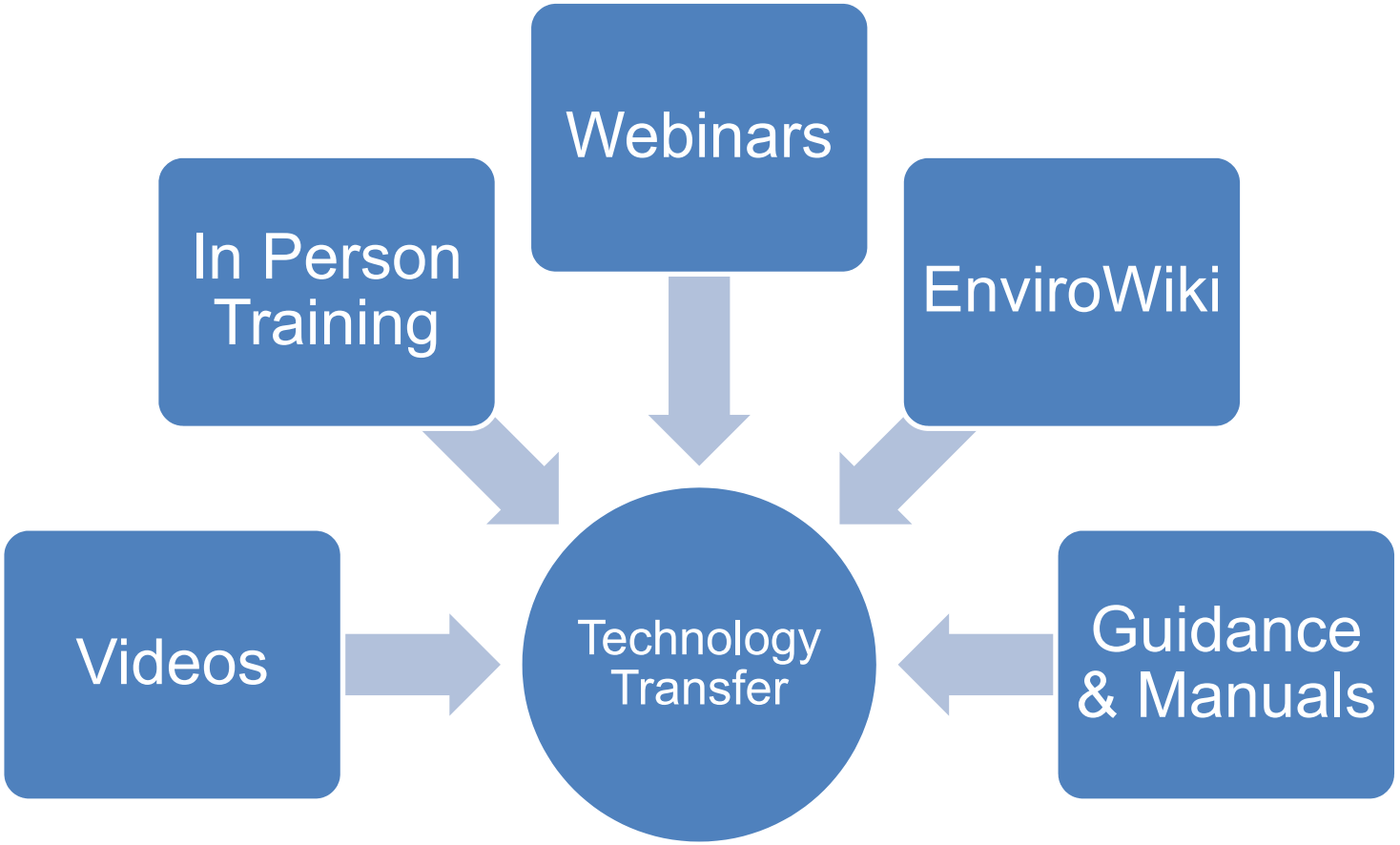
Contamination from Past Practices



- Groundwater, soils and sediments
- Large UXO liability
- Emerging contaminants

Pollution Prevention to Control Life Cycle Costs

- Elimination of pollutants and hazardous materials in manufacturing, maintenance, and operations
- Achieve compliance through pollution prevention


Webinars
In Person Training
EnviroWiki
Videos
Technology Transfer
Guidance & Manuals

www.serdp-estcp.org

SERDP and ESTCP Webinar Series

Date	Topic
October 18, 2018	Restoration of Chlorinated Solvent Contaminated Groundwater Sites: The Value of Information Challenge
November 1, 2018	Supporting DoD Installation Sustainability Through Informed Stormwater Management
November 15, 2018	Stormwater Impacts on Sediment Recontamination
December 13, 2018	Installation Energy and Water Program Area Webinar

For upcoming webinars, please visit

http://serdp-estcp.org/Tools-and-Training/Webinar-Series

Save the Date!

A three-day symposium showcasing the latest technologies that enhance DoD's mission through improved environmental and energy performance

November 27-29, 2018

Washington Hilton Hotel

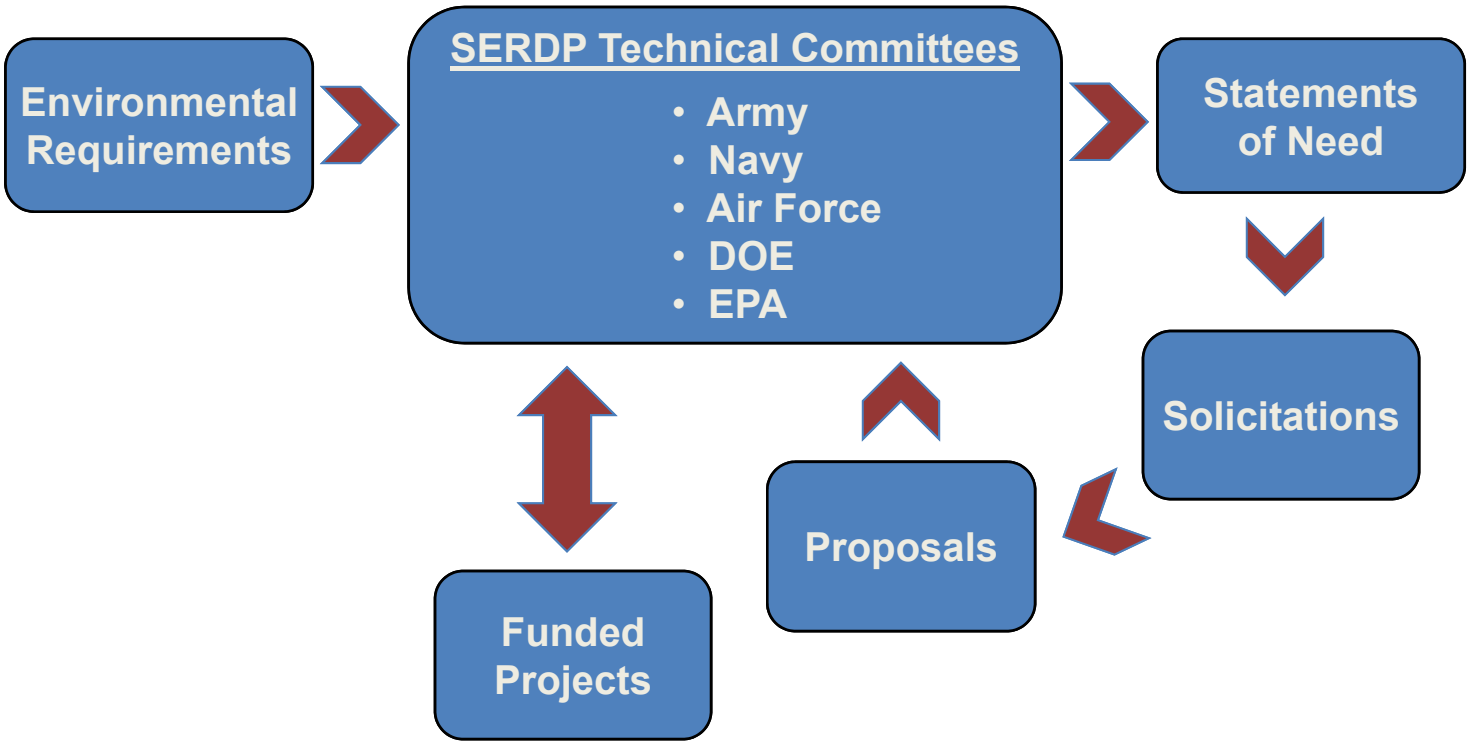
Registration is open

SERDP and ESTCP Strategic Research for Managing Chlorinated Solvents in Groundwater

Andrea Leeson, Ph.D.
SERDP & ESTCP

SERDP DOD • EPA • DOE | ESTCP

Strategic Process



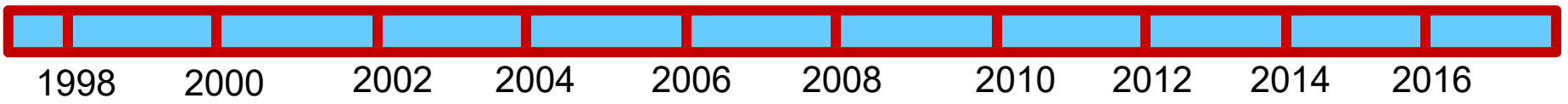
Workshops

Key to identifying data gaps and research questions

Research and Development Efforts

SERDP Chlorinated Solvents Statement-of-Needs

Technologies | Characterization | Complexities | Decision Support



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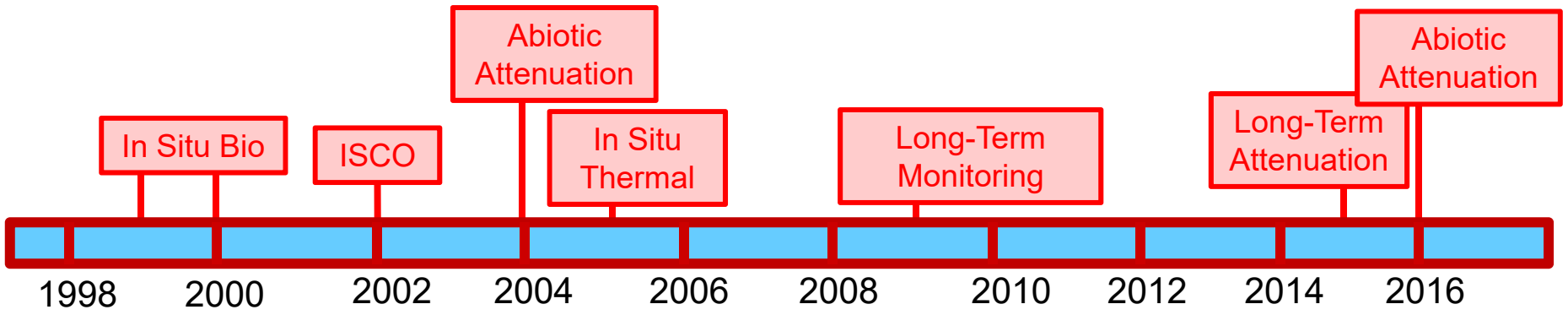

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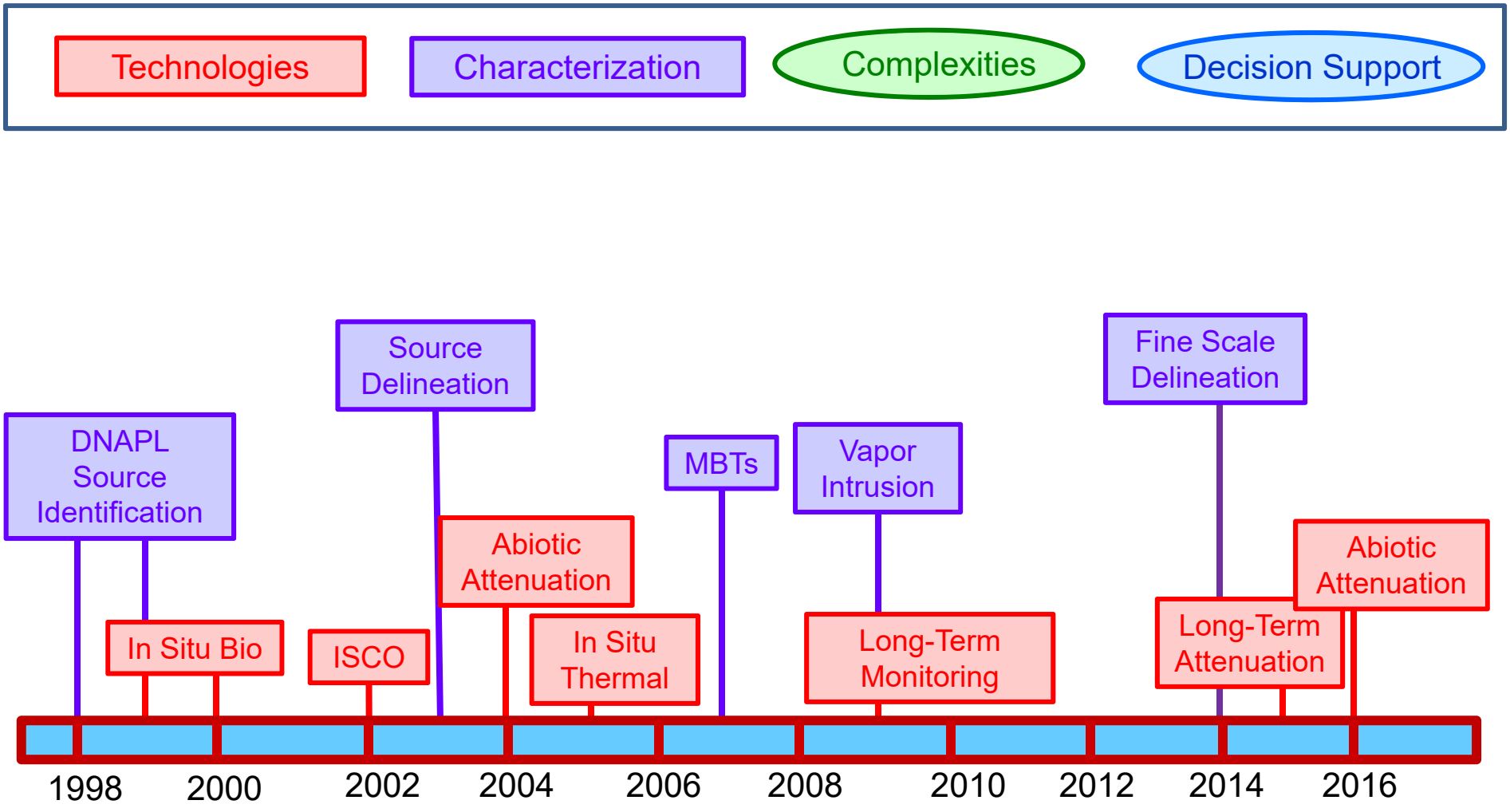

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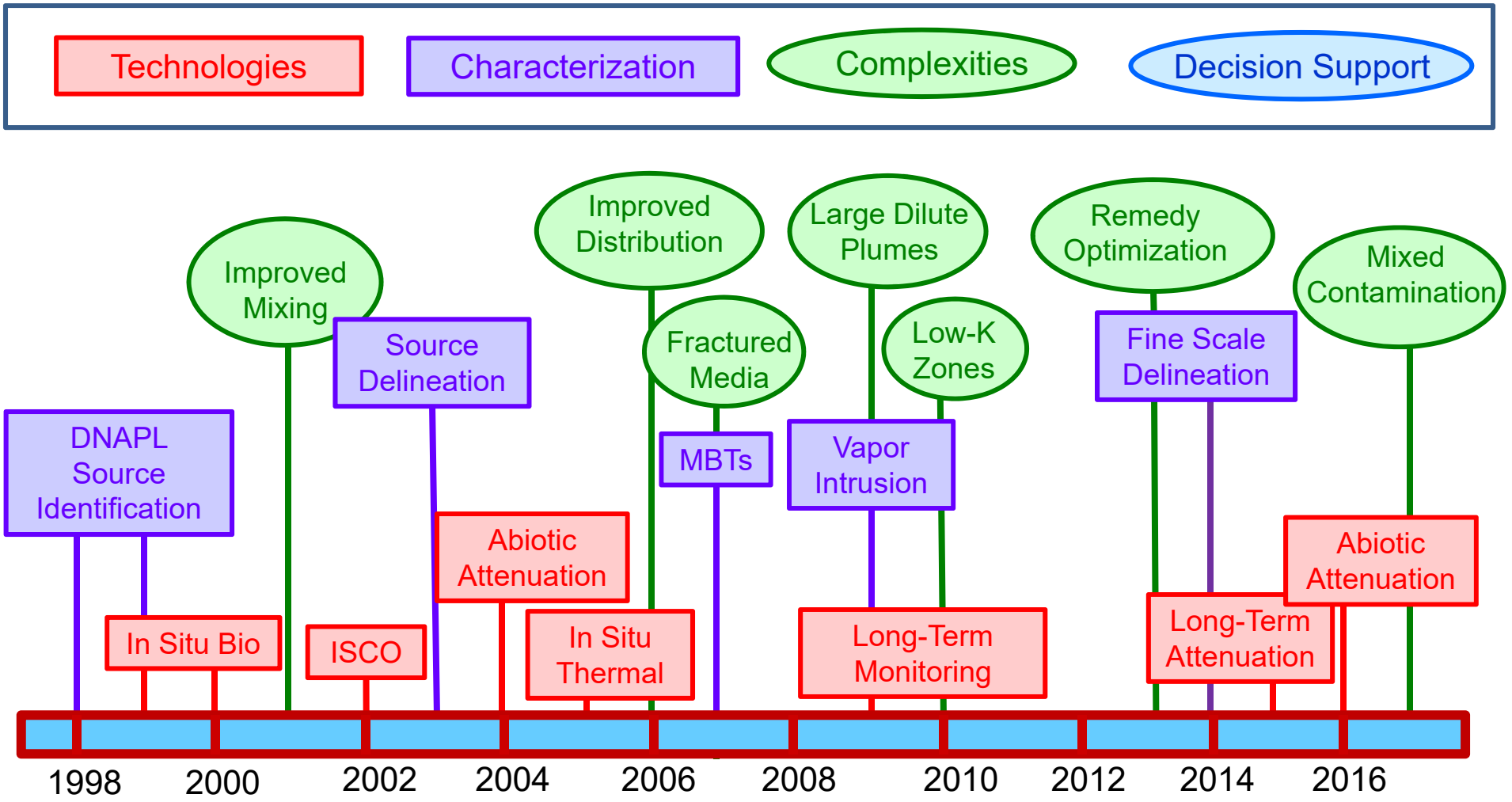

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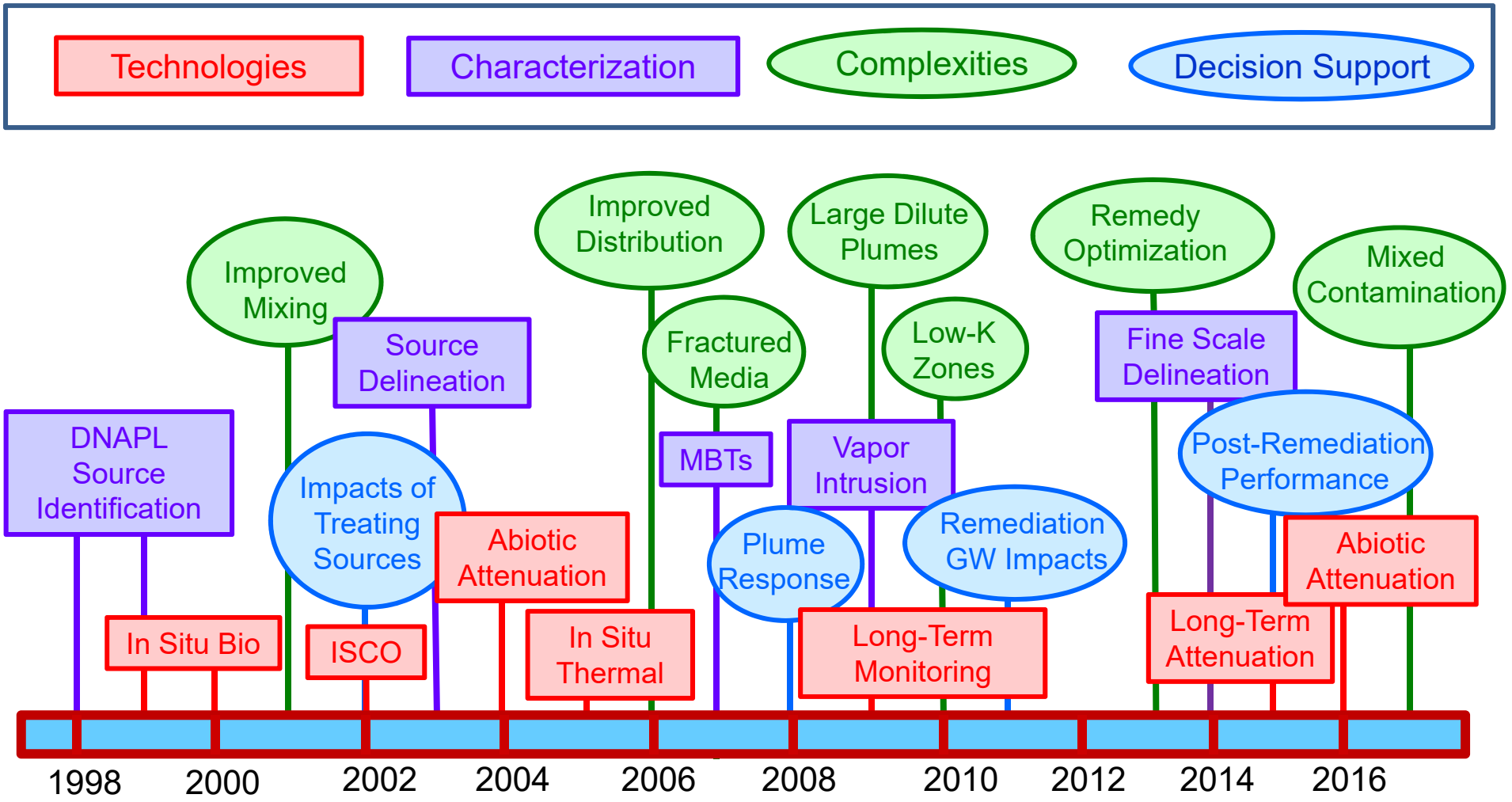


Pending Issues

- Are we done yet?
- Implications of shrinking budgets?
- Future technologies (omics, sensors, IoT)?
- How to handle “underperforming remedies”?
- Accept limits or overwhelm complex sites?

Workshop: Management of DoD's Chlorinated Solvents in Groundwater Sites

- Held July 2018; attended by ~70 representatives from academia, industry, DoD, DOE, EPA and State agencies
- Objectives
  - Review current state of the science regarding chlorinated solvent contamination in groundwater;
  - Evaluate whether currently available characterization, remediation, and monitoring technologies meet users' needs and requirements; and
  - ***Identify and prioritize remaining research, demonstration and technology transfer opportunities***

Workshop Approach

- Formal presentations
  - State of the science
  - Current management challenges, barriers and limitations to achieving cleanup goals
- Small breakout group discussions
  - Optimal role for SERDP/ESTCP
  - Each breakout group received focus questions
- Large group discussion for consensus

Focus Questions

- Defining the new conceptual site model (CSM) for remaining sites in the DoD inventory
  - Do we have source zones that still need to be addressed?
  - How should we address back-diffusion?
  - How does the presence of contaminants such as PFASs, ethanes, 1,4-dioxane, and other emerging and recalcitrant compounds impact the CSM?

Focus Questions (Cont'd)

- Site characterization and fine scale delineation
  - Do we have the tools we need?
  - What major challenges and opportunities in characterizing and managing chlorinated solvent sites remain?

Focus Questions (Cont'd)

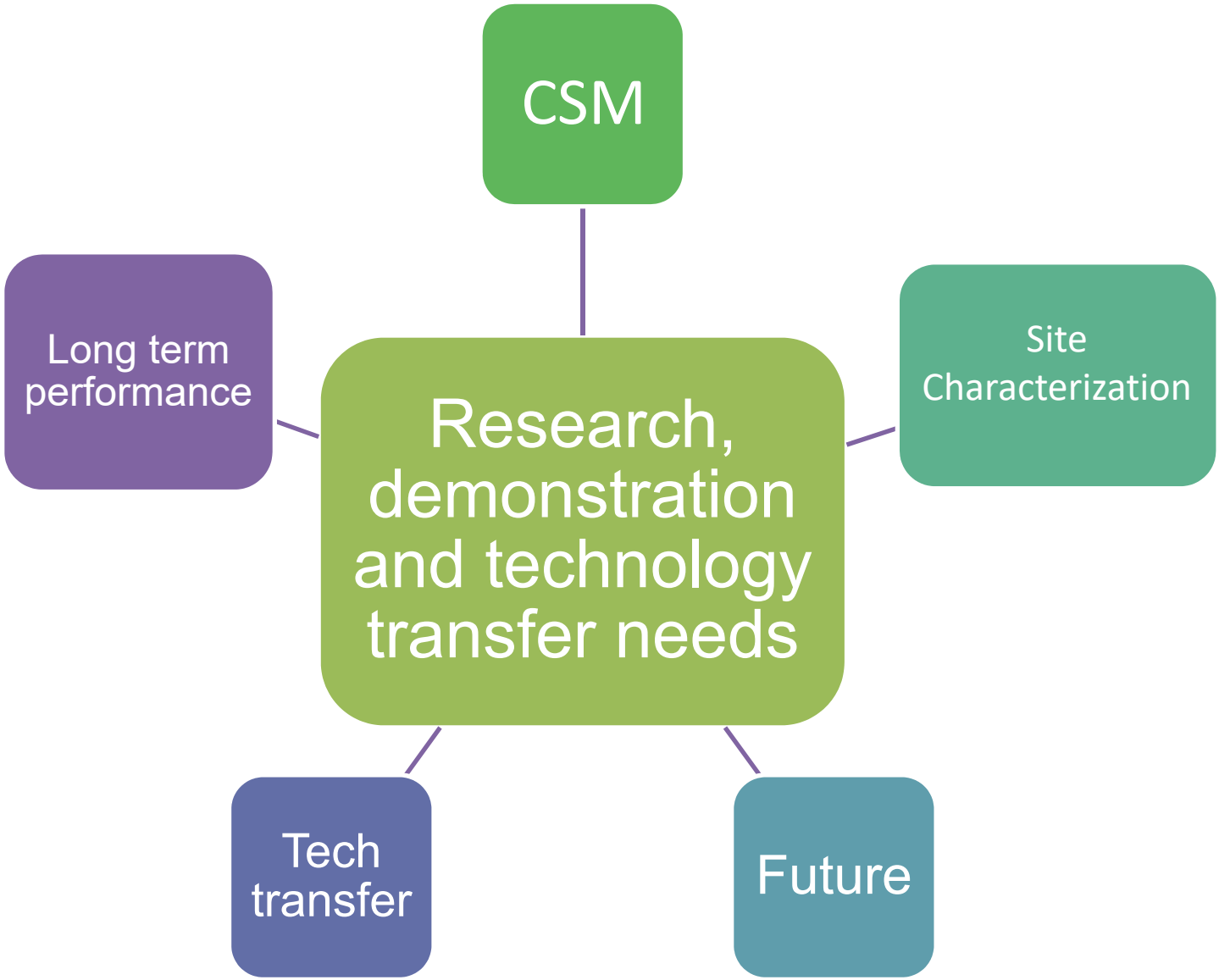
- Long term performance of remediation technologies
  - What are the most promising technologies?
  - What are the opportunities to reduce monitoring and O&M costs?

Focus Questions (Cont'd)

- Technology transfer issues
  - Where is technology transfer most critically absent?
  - What methodologies could be used to improve technology transfer to key communities?

Focus Questions (Cont'd)

- Future directions
  - Are there issues associated with contaminated groundwater that are not being addressed? Do we need to revisit issues we thought to be complete (i.e., petroleum hydrocarbons, etc.)?


CSM
Long term performance
Research, demonstration and technology transfer needs
Site Characterization
Tech transfer
Future

Preliminary Workshop Report Results

- Improved understanding and quantification of natural attenuation mechanisms in plumes
- Quantitative understanding of effect of co-contaminants on CVOCs
- Integration of information from fine-scale delineation tools for improved decision making at complex sites
- Comprehensive decision framework for remedy selection
- Improved CSMs for understanding the factors sustaining and controlling persistent chlorinated solvent plume behavior
- Fundamental understanding of processes influencing effectiveness and fate of particulate amendments
- Improved analysis of performance data from P&T systems to predict decline in mass discharge over time
- Methodologies to determine ability to transition from active measures

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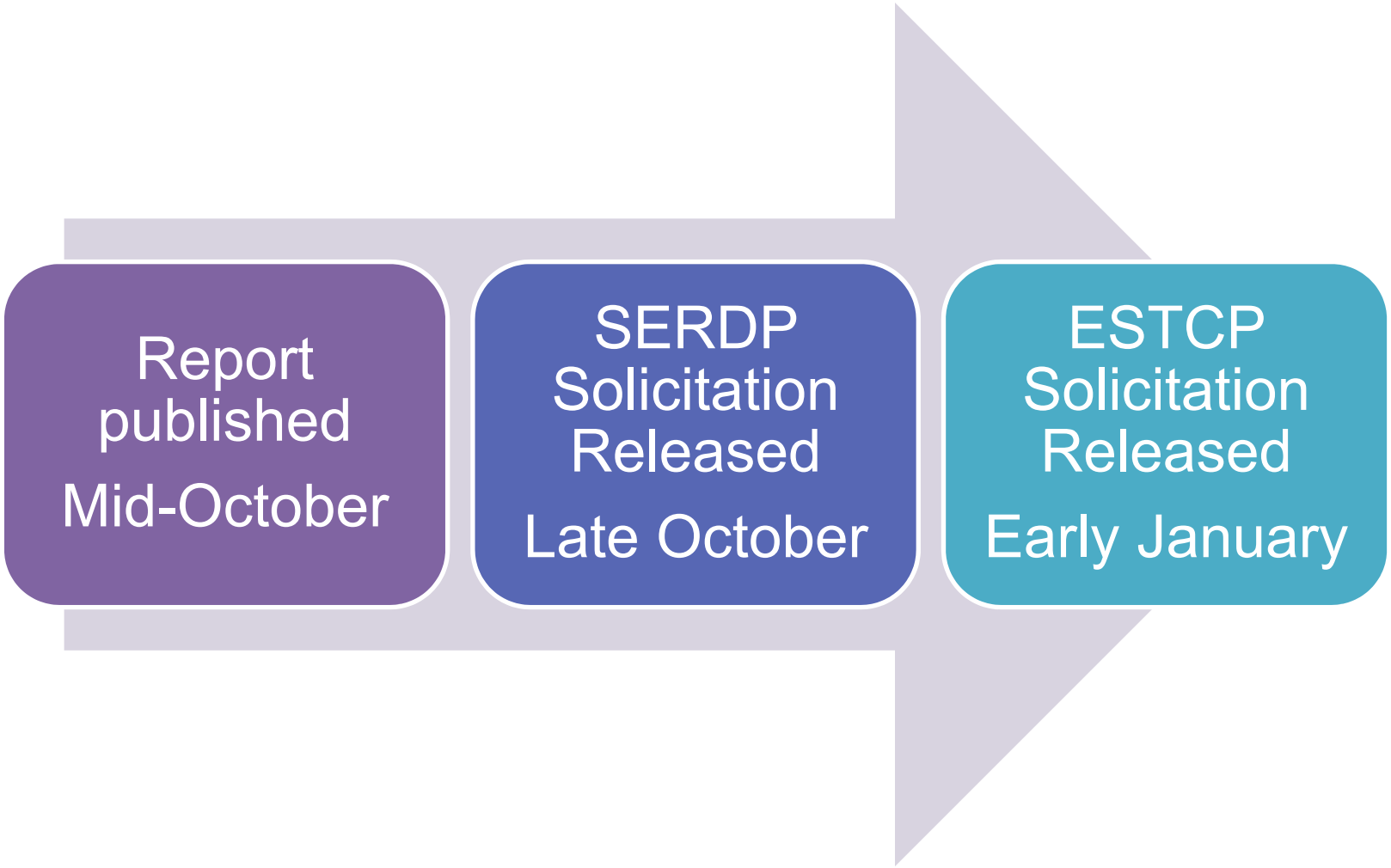
Timeline


Report published
Mid-October
SERDP Solicitation Released
Late October
ESTCP Solicitation Released
Early January

For additional information, please visit
https://www.serdp-estcp.org/

Speaker Contact Information

andrea.leeson.civ@mail.mil

SERDP DOD • EPA • DOE | ESTCP

Q&A Session 1

Effective Treatment of Chlorinated Solvents in Clay and Silt Using Electrokinetic Techniques

Evan Cox
Geosyntec Consultants

SERDP DOD • EPA • DOE | ESTCP

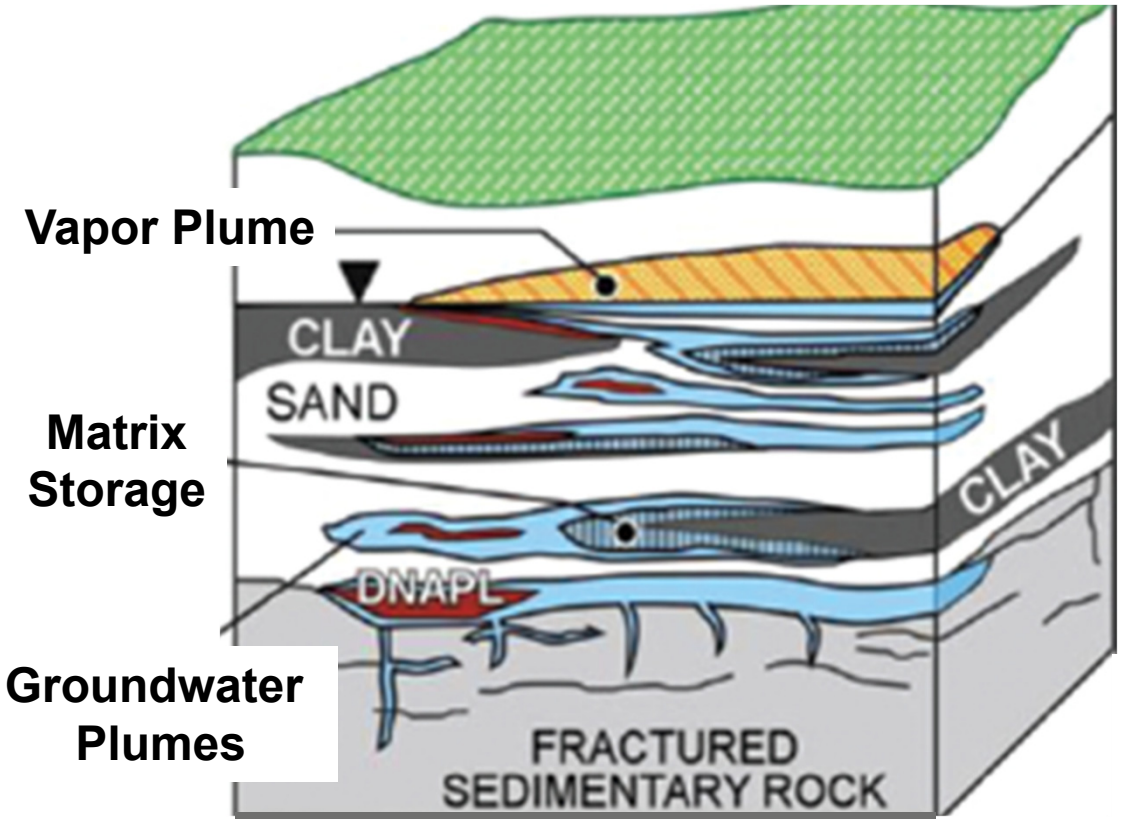
Agenda

- Frustrated with low permeability materials?
- What is EK and how does it work?
- How is EK applied in the field?
- EK applicability to DoD sites
- PCE source treatment by EK-BIO™
- New EK frontiers

Notes:
DoD = Department of Defense, EK = electrokinetic, EK-BIO™ = EK-enhanced bioremediation

Frustrated With Low Permeability Materials?

- Secondary sources of contaminants
- Distribution of EISB, ISCO, and ISCR amendment poor in low-K and heterogeneous materials



Notes:
DNAPL = dense non-aqueous phase liquid, EISB = enhanced in-situ bioremediation, ISCO = in situ chemical oxidation, ISCR = in situ chemical reduction

Frustrated With Low Permeability Materials?

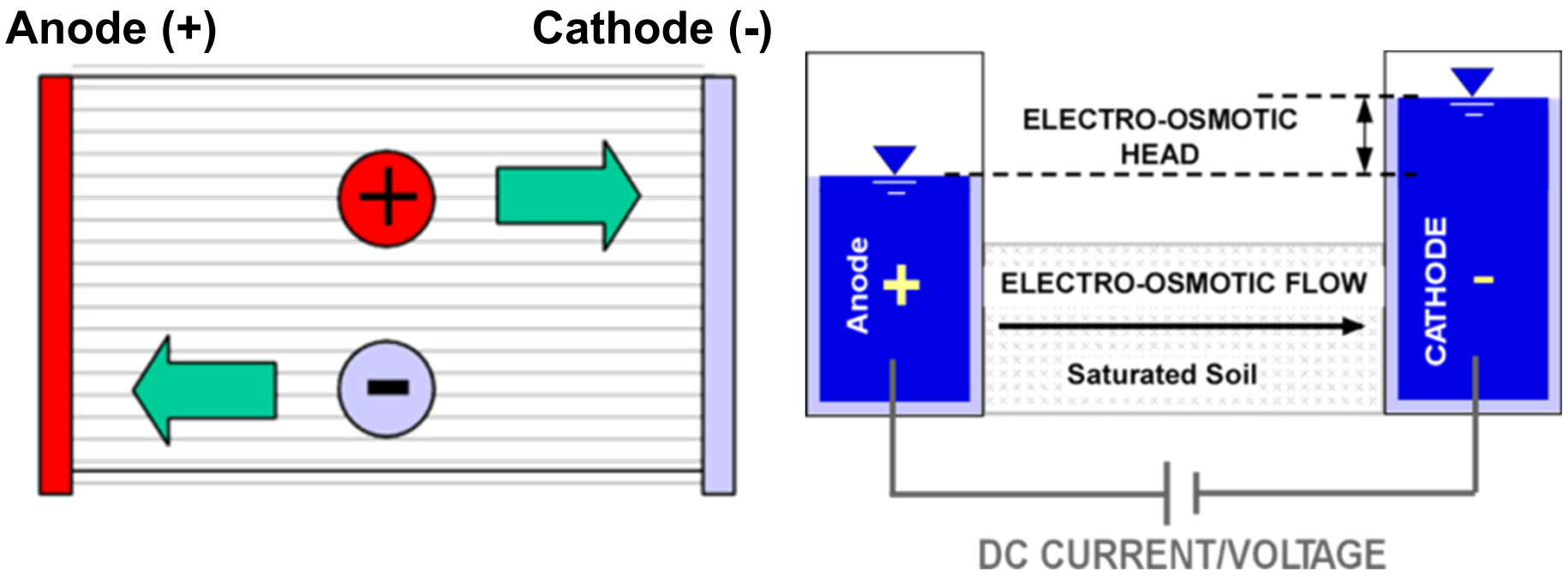
Need Better Amendment Delivery Techniques

Delivery + Contact

What is EK and How Does it Work?

- Application of direct current (DC) to saturated subsurface
- Amendments move through clays and silts by
  - Electro-migration (EM) – movement of charged ions
  - Electro-osmosis (EO) – bulk movement of water

What is EK and How Does it Work?



Notes:

Anions: negatively-charged ions
Cations: positively-charged ions

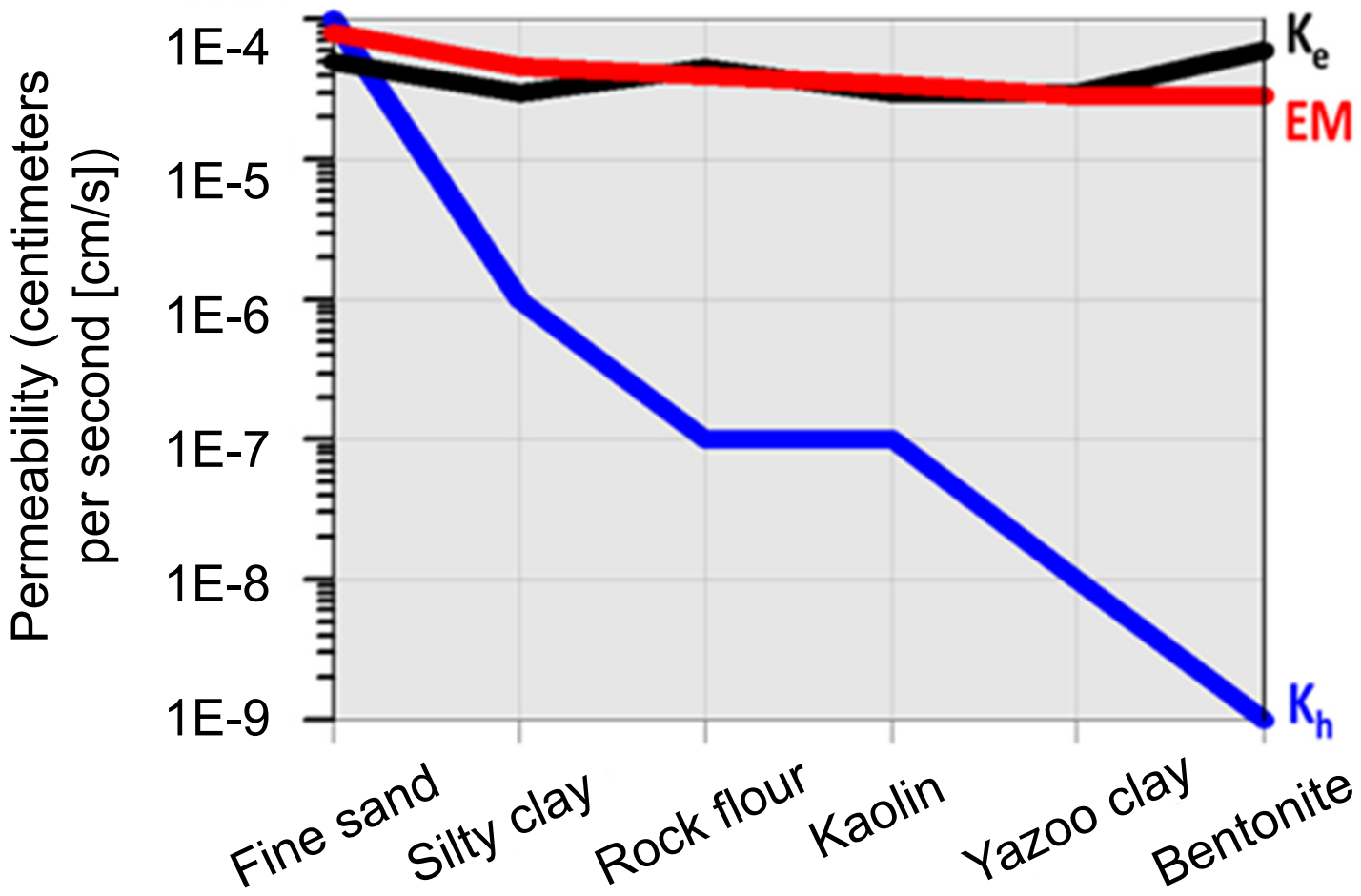
Anode: positively-charged electrode
Cathode: positively-charged electrode

Why EK where Hydraulic Injection Fails?

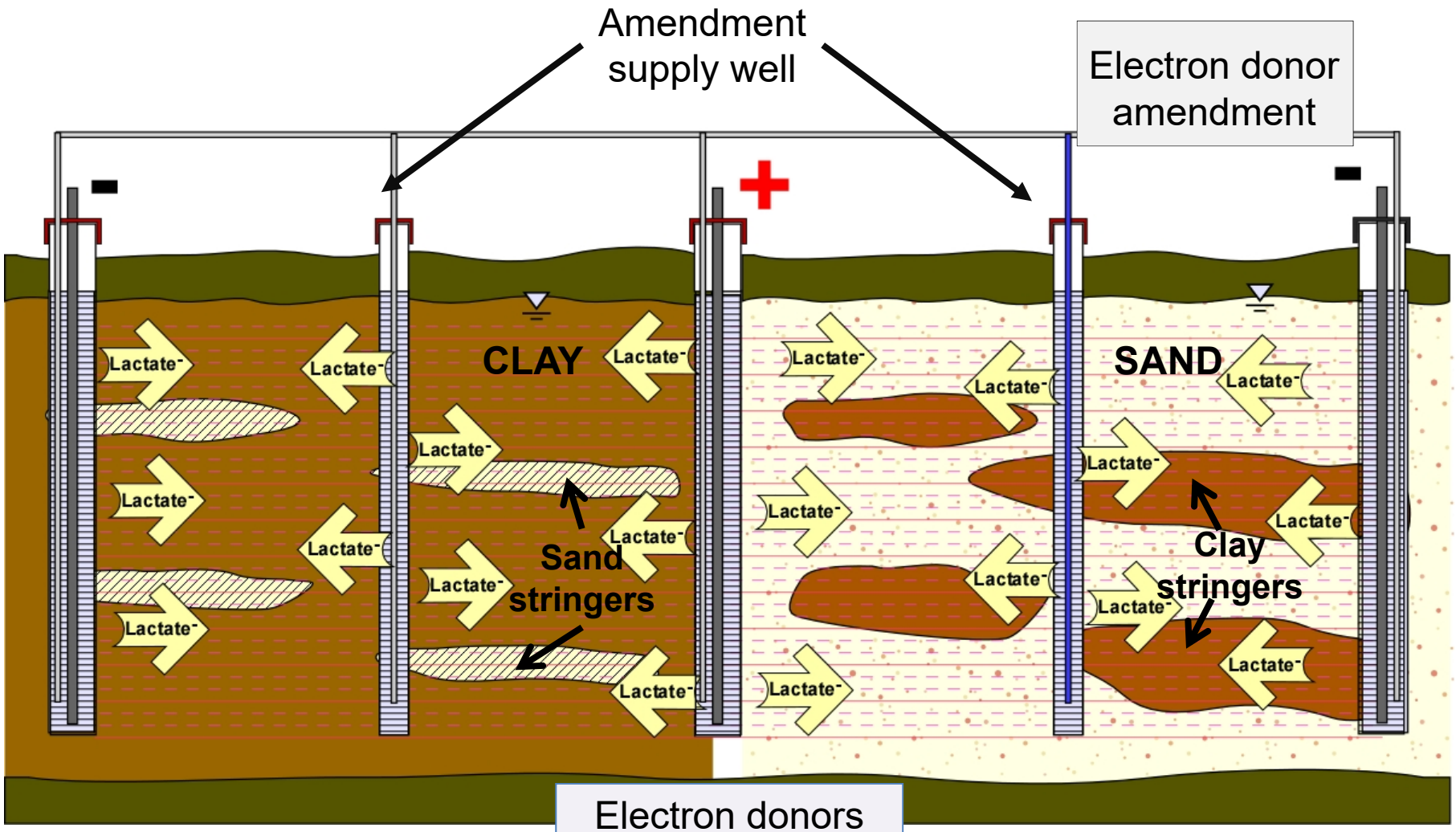
- Electrical (not hydraulic) soil properties affect transport
- Soil electrical properties = between sand and clay
- EK more efficient as K_h decreases

Note:
K_h =horizontal hydraulic conductivity

Why EK where Hydraulic Injection Fails?



How is EK Applied in the Field?



EK Technologies

Technology	Description
EK-BIO™	Distribution of electron donors (lactate) or acceptors (oxygen, nitrate) and/or microorganisms (*Dehalococcoides, Dehalobacter*) to promote biodegradation
EK-ISCO™	Distribution of permanganate (MnO_4^-) to promote oxidation
EK-TAP™	Distribution of persulfate ($S_2O_8^{2-}$) by EK (*DC* current), followed by thermal activation of the persulfate (*AC* current)
EK-ISCR™	Distribution of reductants such as nano-zero valent ion (ZVI) to promote reduction
EK-SALT™	Use of electromigration to migrate salts to collection points for removal or destruction

EK Applicablility to DoD Sites

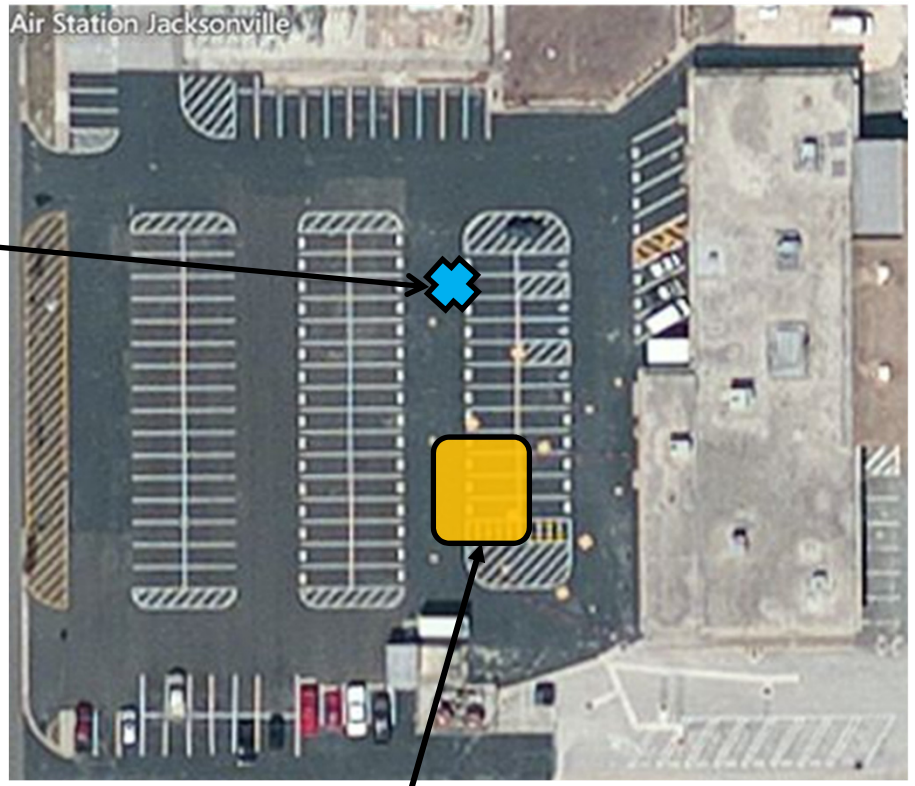
Contaminant	EK-BIO™	EK-ISCO™	EK-TAP™	EK-ISCR™	EK (Other)
Chlorinated Ethenes (PCE, TCE)	Yes	Yes	Yes	Yes	
Chlorinated Ethanes and Methanes (TCA, CT)	Yes	Selected	Yes	Selected	
1,4-Dioxane	TBD		Yes		
Perchlorate	Yes				Yes (SALT)
RDX	Yes	Yes	Yes		Yes (Alkaline Hydrolysis)
Redox-Sensitive Metals	Some			Some	
PFAS			TBD		TBD

CT = carbon tetrachloride, RDX = royal demolition explosive, PFAS = per- and polyfluoroalkyl substances, TBD = to be determined, TCA = 1,1,1-trichloroethane, TCE = trichloroethene

PCE Source Treatment by EK-BIO™

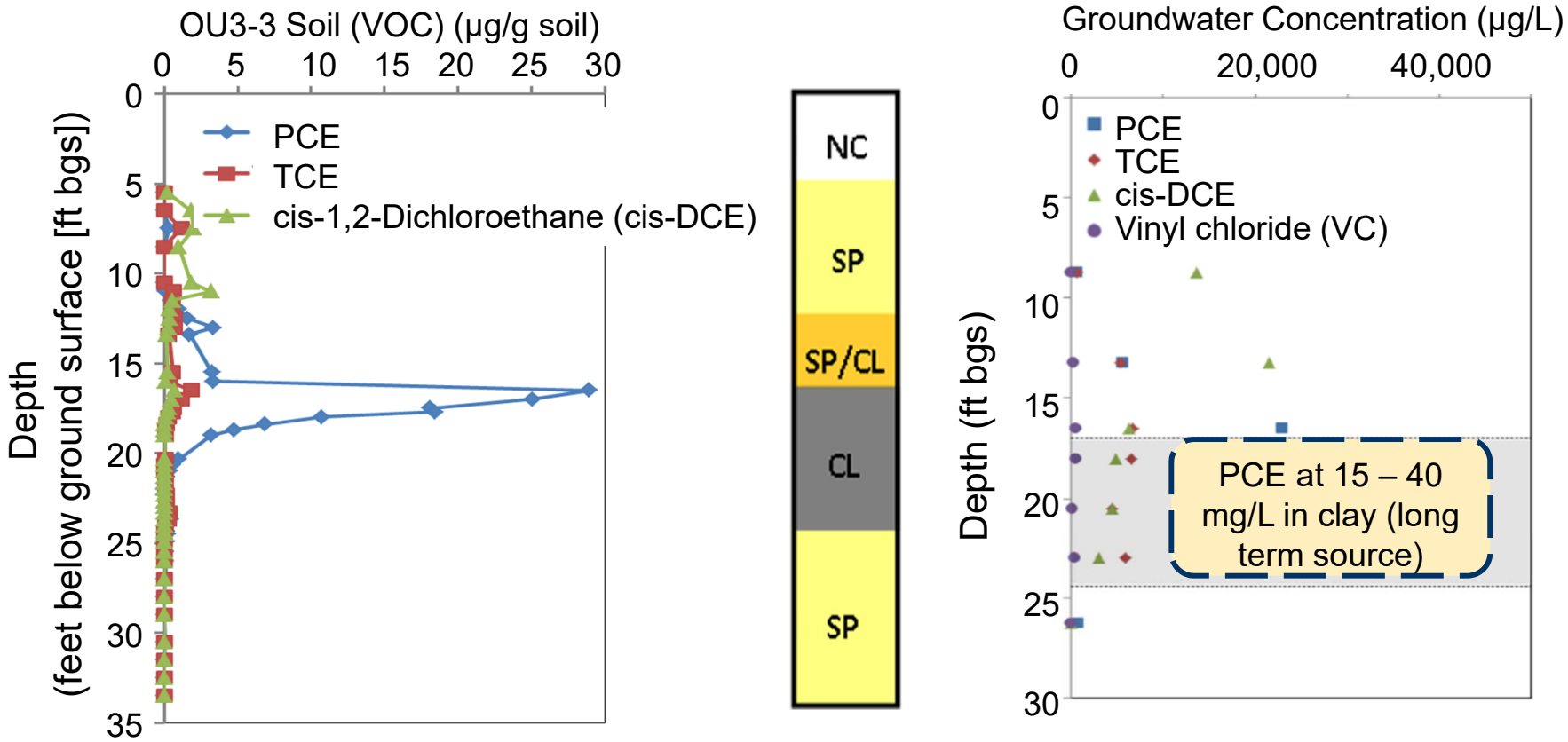
Naval Air Station Jacksonville, Florida

- Former dry cleaner
- Source for large dissolved plume in shallow sandy aquifer
  - Source area under active parking lot
- Many subsurface utilities



Source Area Characterization

Contaminants Diffused into Low-K Materials



Notes:
CL = clay, mg/L = milligrams per liter, NC = not characterized, SP = sand, µg/g = micrograms per gram, µg/L = micrograms per liter, VOC =volatile organic compound

EK-BIO™ Installation

- Treatment area 35 ft x 35 ft
- 9 electrode wells (~ 17.5 ft spacing)
- 8 supply wells (no electrode)

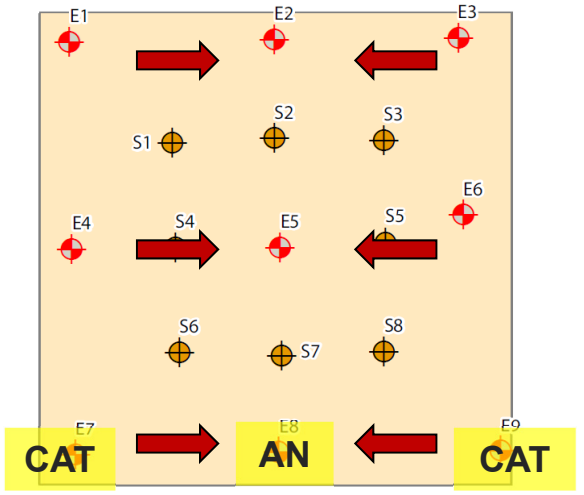




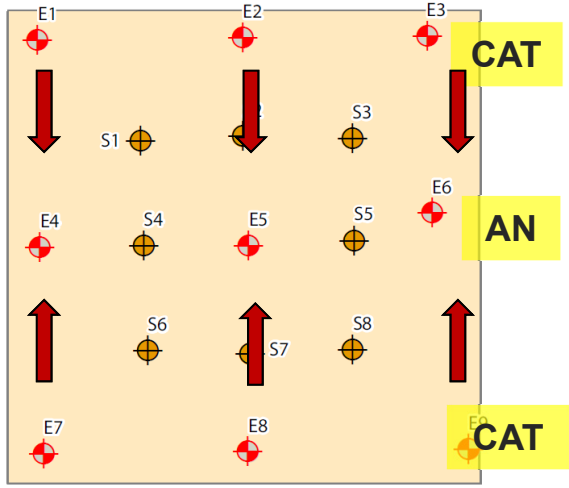
Remediation Operation

- Two stages of 5 months active operation
- Total power ~1,500 kilowatt-hours (kW-hr)
  - ~2 100-W lightbulbs
- Lactate and buffer amendment supply
- One-time KB-1® bioaugmentation

Stage 1



Stage 2

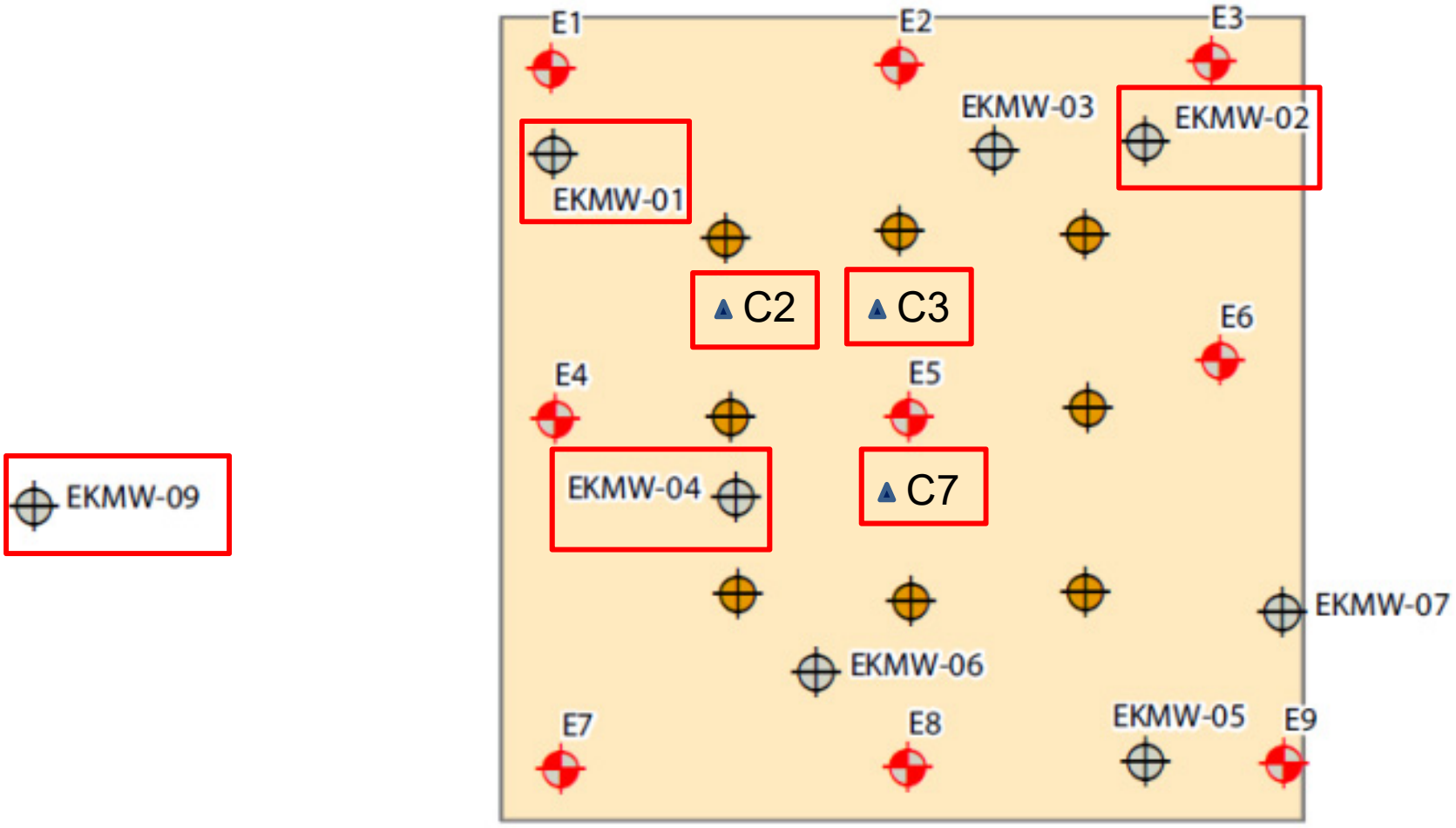


Electron Donor Distribution

Well ID	TOC (baseline)	TOC (maximum)	VFA (baseline)	VFA (maximum)
EKMW-01	2.5	20.1	2.3	60.7
EKMW-02	2.5	36.2	1.6	141.3
EKMW-03	2.5	57.9	0.7	233
EKMW-04	3.6	4.7	1.9	18.3
EKMW-05	1.7	15.9	1.8	6.6
EKMW-07	6.8	57	2.2	204.7
EKMW-09*	1.6	1.9	2.3	1.4
EKMW-10*	1.9	10.1	1.3	1.4

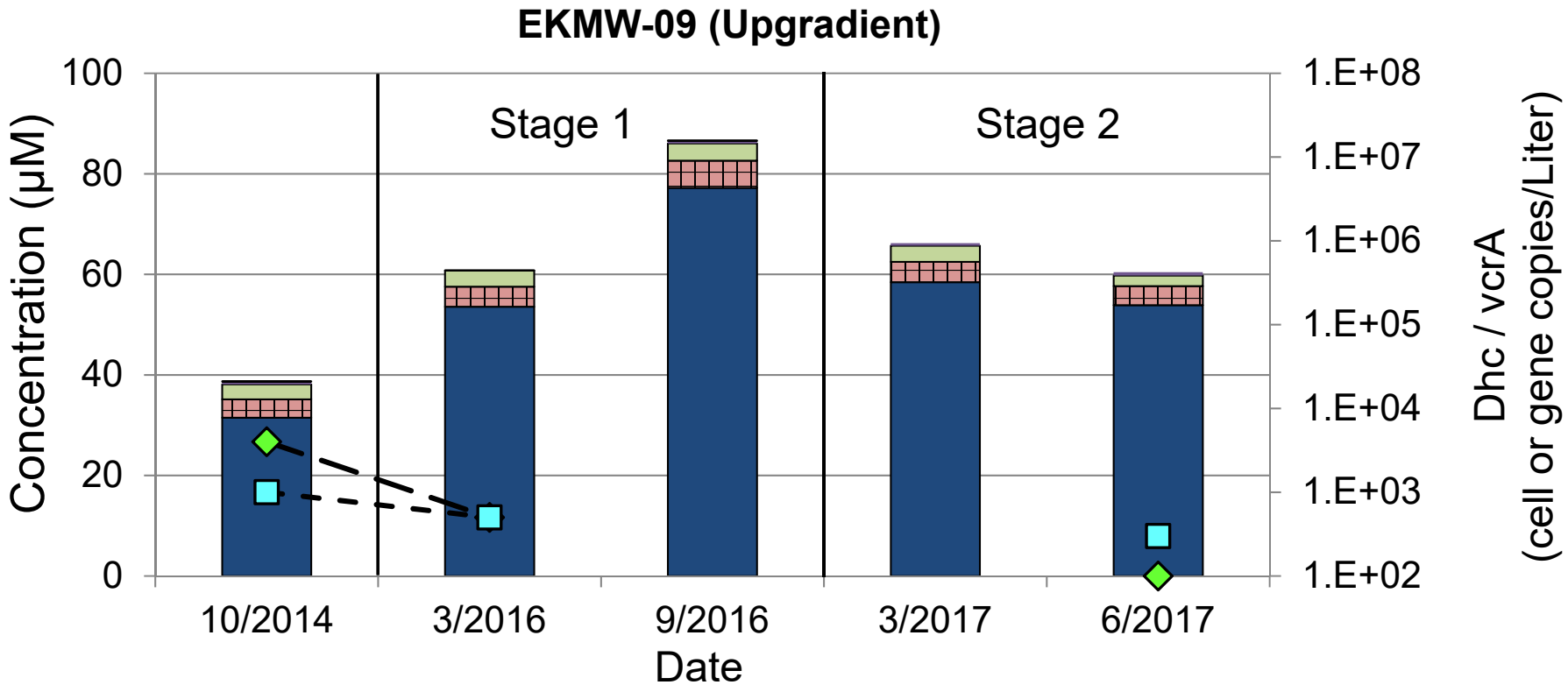
Notes:
TOC = total organic carbon; VFA = volatile fatty acids
* EKMW-09 and EKMW-10 are background wells outside target treatment area (TTA)

Well and Geoprobe Locations



Background Wells

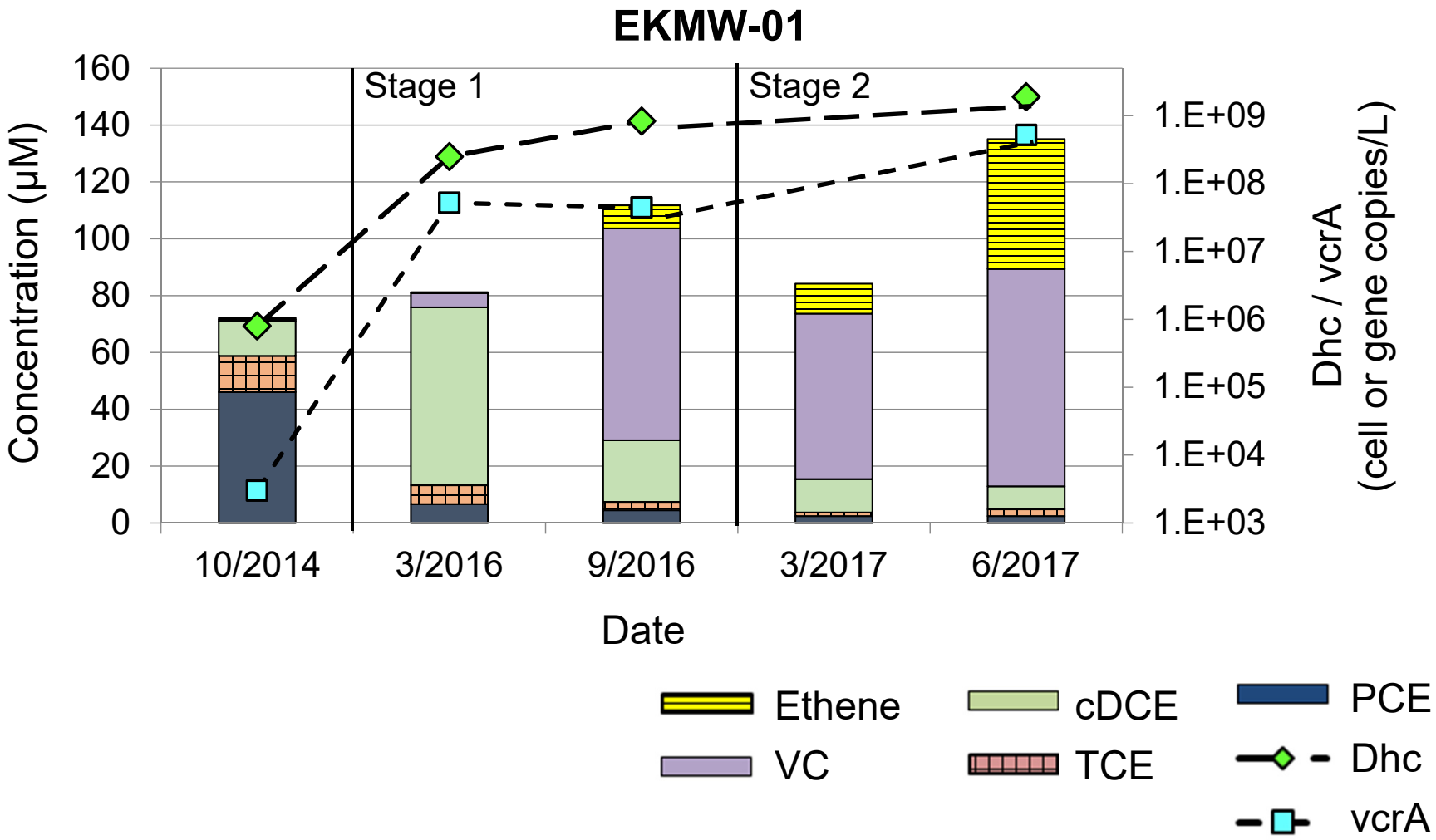
VOCs and Biomarkers



Notes:
Dhc = *dehalococcoides,* µm = micromolar,
vcrA = vinyl chloride reductase

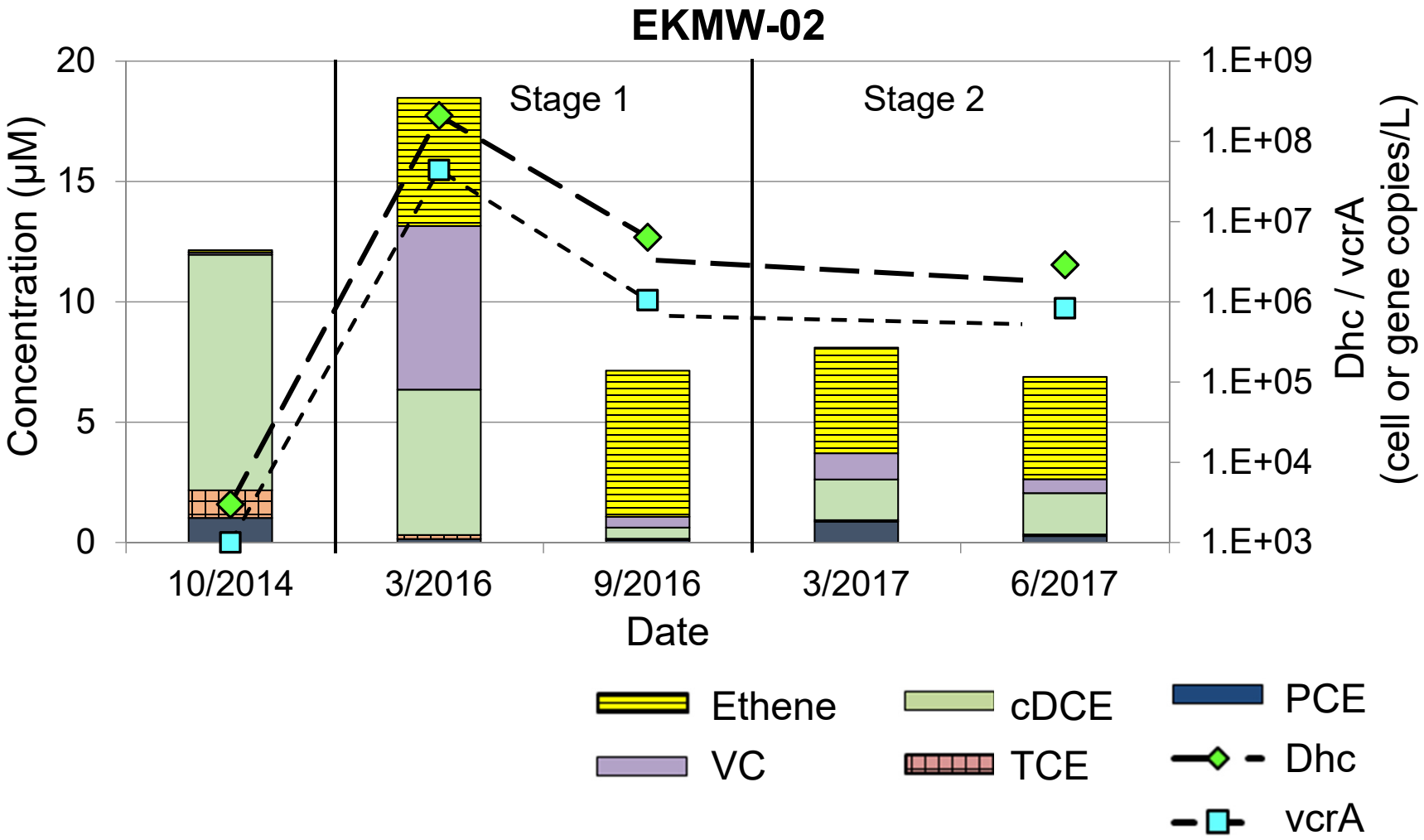
Groundwater Within Test Area

VOCs and Biomarkers



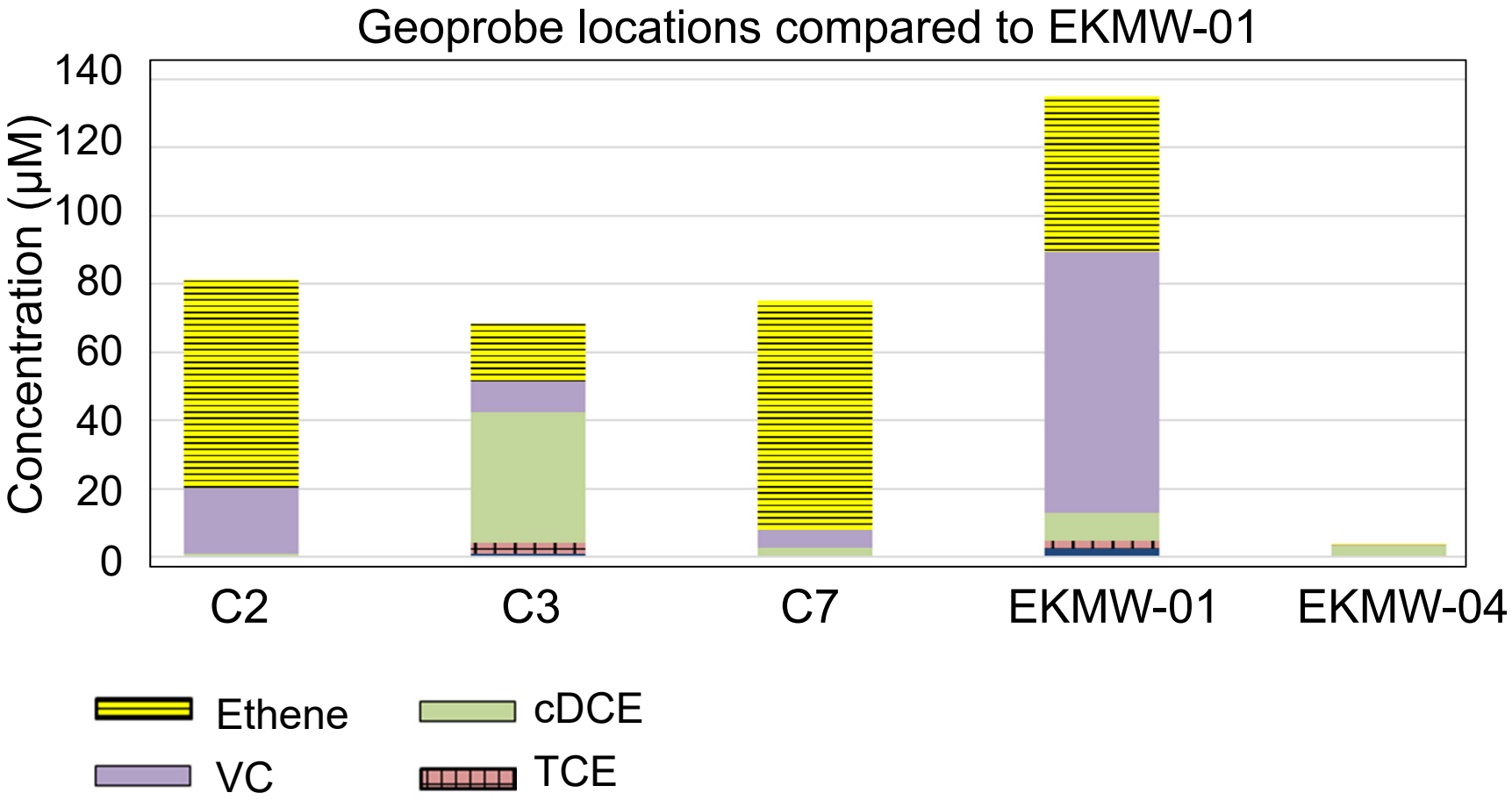
Groundwater Within Test Area

VOCs and Biomarkers



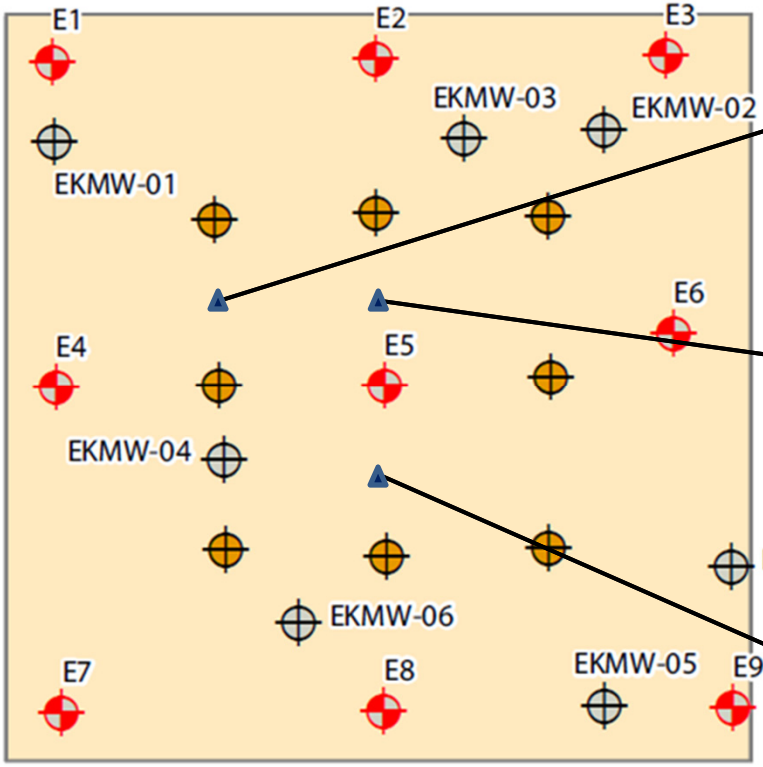
Groundwater Within Test Area

VOCs and Biomarkers (End - June 2017)



Groundwater Within Test Area

VOCs and Biomarkers (End - June 2017)



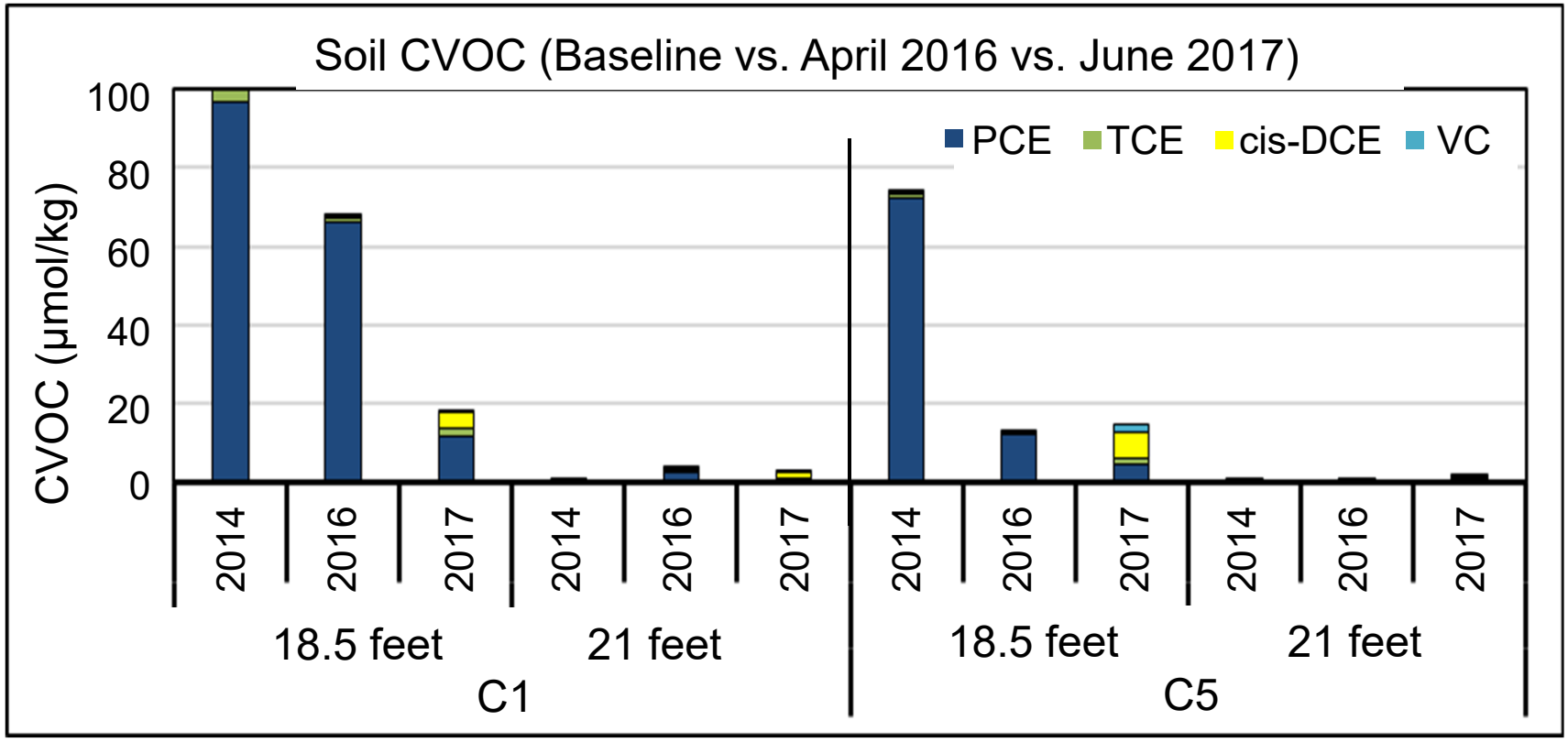
Location C2		
PCE	µg/L	11
TCE		5
cDCE		86
VC		1200
Ethene		1710
Dhc	gene/L	5E+06
vcrA		4E+06
TOC	mg/L	950

Location C3		
PCE	µg/L	160
TCE		430
cDCE		3700
VC		570
Ethene		474
Dhc	gene/L	2E+05
vcrA		1E+05
TOC	mg/L	160

Location C7		
PCE	µg/L	28
TCE		29
cDCE		220
VC		330
Ethene		1880
Dhc	gene/L	2E+07
vcrA		1E+07
TOC	mg/L	820

Treatment Results for Soil VOCs

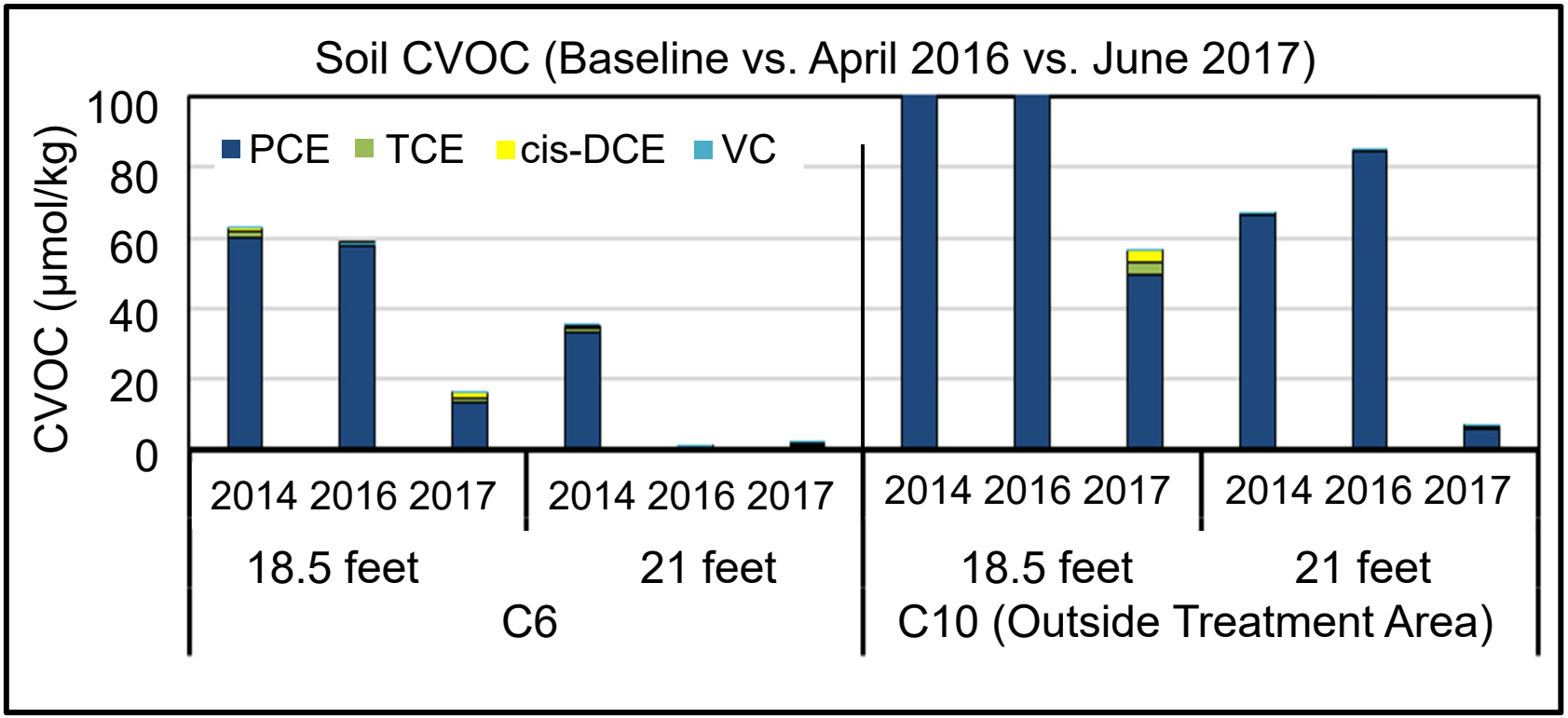
PCE Concentration Reduction 78%-99%



Note:
CVOC = chlorinated volatile organic compound

Treatment Results for Soil VOCs

Some Stage 1 → 2 Decrease Outside Treatment Area



Conclusions

- Complete dechlorination of PCE to ethene
- Substantial increases in dehalorespiring bacteria
- Treatment within clay materials
- Low energy consumption
- Safe implementation
  - Active parking lot, many utilities
- Innovative, fundamentally different solution to a vexing problem!

New EK Frontiers

- EK-TAP for the remediation of chlorinated and recalcitrant compounds in heterogeneous and low permeability zones
- Electrochemical oxidation of AFFF-impacted groundwater using boron-doped diamond anodes
- Alkaline hydrolysis to treat explosives
- EK-SALT – Removal or biodegradation of perchlorate in clay

New EK Frontiers

Electrokinetically-Delivered, Thermally-Activated Persulfate Oxidation (EK-TAP) for the Remediation of Chlorinated and Recalcitrant Compounds in Heterogeneous and Low Permeability Source Zones

Mr. Evan Cox | Geosyntec Consultants

ER-201626

Objective | Technology | Benefits

Objective

This project will demonstrate/validate (Dem/Val) the ability of a novel combined in situ remediation approach, referred to as electrokinetically-delivered, thermally-activated persulfate (EK-TAP), to remediate chlorinated solvents and recalcitrant chemicals (e.g., 1,4-dioxane) in low permeability (K) and heterogeneous geological materials. The technical objectives include: (1) demonstration and quantification of the ability to uniformly distribute persulfate throughout a low-K treatment area using a direct current (DC) electric field; (2) demonstration of activation of the persulfate by heating the treatment area using an alternating current (AC) electric field, and subsequent treatment of the chemicals of concern (COCs); (3) quantification of EK-TAP system operational parameters to develop tools for full-scale system design and optimization; (4) development of costing information for technology evaluation and use by the Department of Defense (DoD) and remediation practitioners; and (5) development of technical guidance to assist with rapid technology transfer.

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SERDP & ESTCP Webinar Series

For additional information, please visit https://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/Contaminated-Groundwater/Persistent-Contamination/ER-201325

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Q&A Session 2

The next webinar is on October 18, 2018

Restoration of Chlorinated Solvent Contaminated Groundwater Sites: The Value of Information Challenge

Survey Reminder

Please take a moment to complete the survey that will pop up on your screen when the webinar ends