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The Use of Colloidal Activated Carbon to Address PFAS

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Agenda

- Colloidal Activated Carbon
- Strategy using colloidal activated carbon
- Considerations for using colloidal activated carbon
- Field case study

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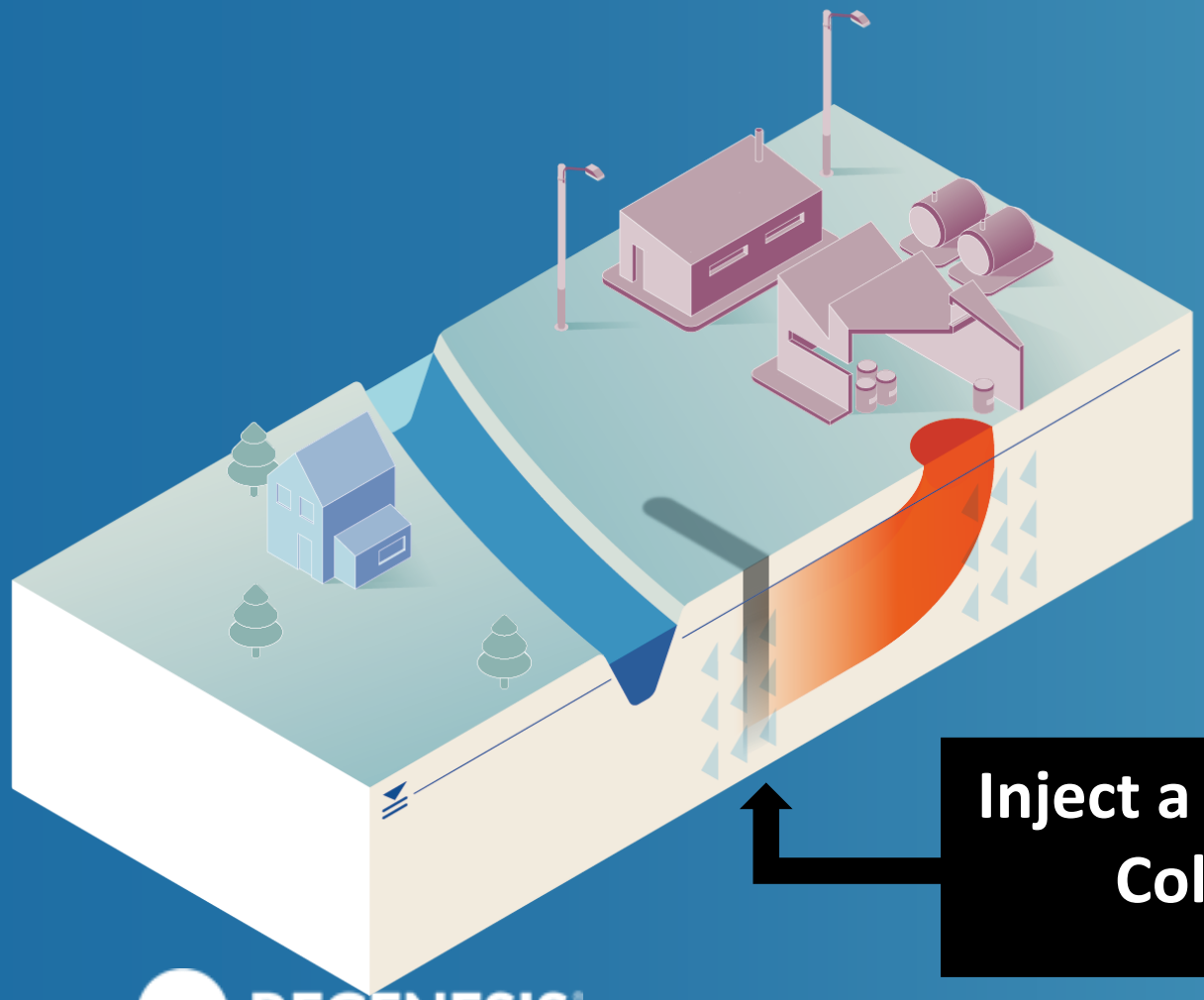
PFAS: The Challenges

- Large & dilute plumes
- Low target concentrations
- Limited in our tools
  - Pump and treat w/ GAC or IX

Protecting Sensitive Receptors from PFAS



- Bodies of water
- Drinking water supplies
- Neighborhoods
- Property Boundaries

Inject a permeable cut-off barrier of Colloidal Activated Carbon

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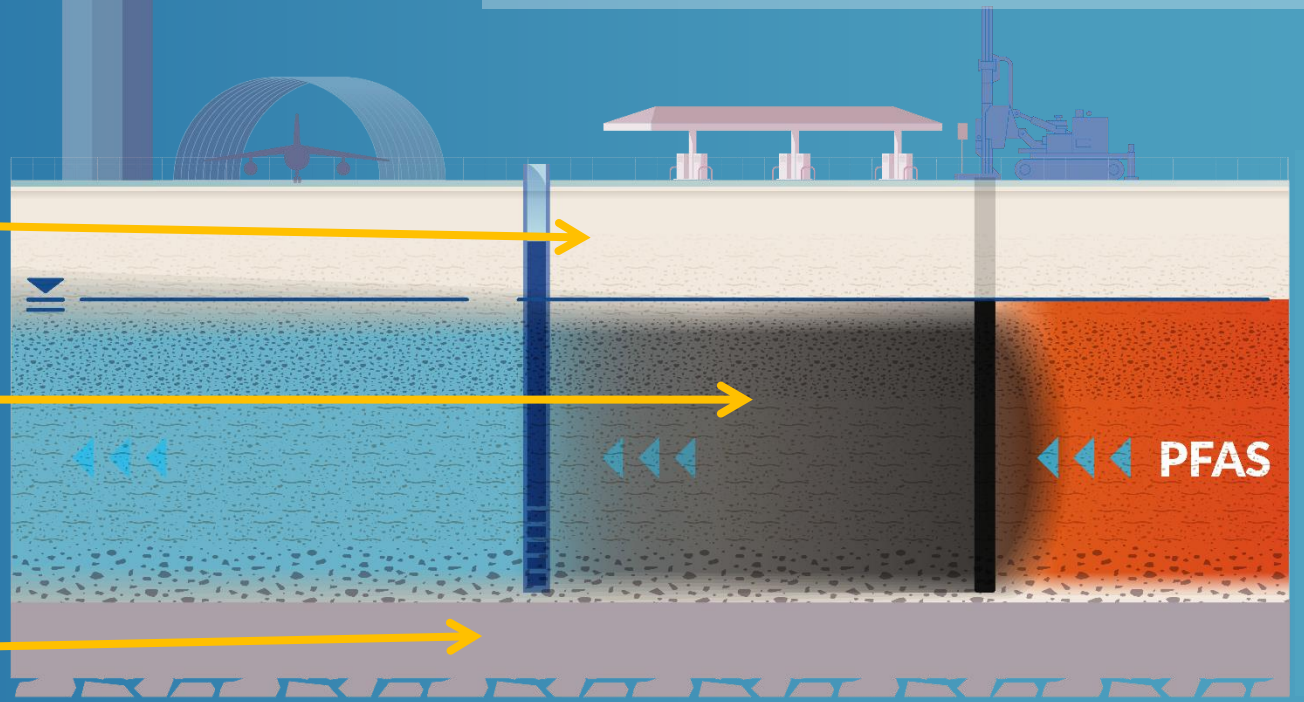
Colloidal Activated Carbon (CAC)

- Size: 1 – 2 µm
  - 2-3 OOM smaller than GAC (500-1,000 µm)
  - Size of a red blood cell
  - Suspended as a colloid in water/polymer
  - Distributes widely at low pressure
  - Extremely fast sorption
  - Converts polluted aquifer into purifying filter

Treatment of Flux Zones and Control of Back Diffusion



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CAC: Modes of Action

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- Mode of Action with PFAS:
  - Dynamic adsorption
    - Not a permanent immobilization
  - Effect: Increases the retardation of a PFAS plume
    - Natural retardation factors for PFAS: 3-20
    - Retardation factors achievable with CAC: 10,000
      - Containment for decades
      - PlumeForce Modeling™
      - Third Party Modeling (scientific articles available)

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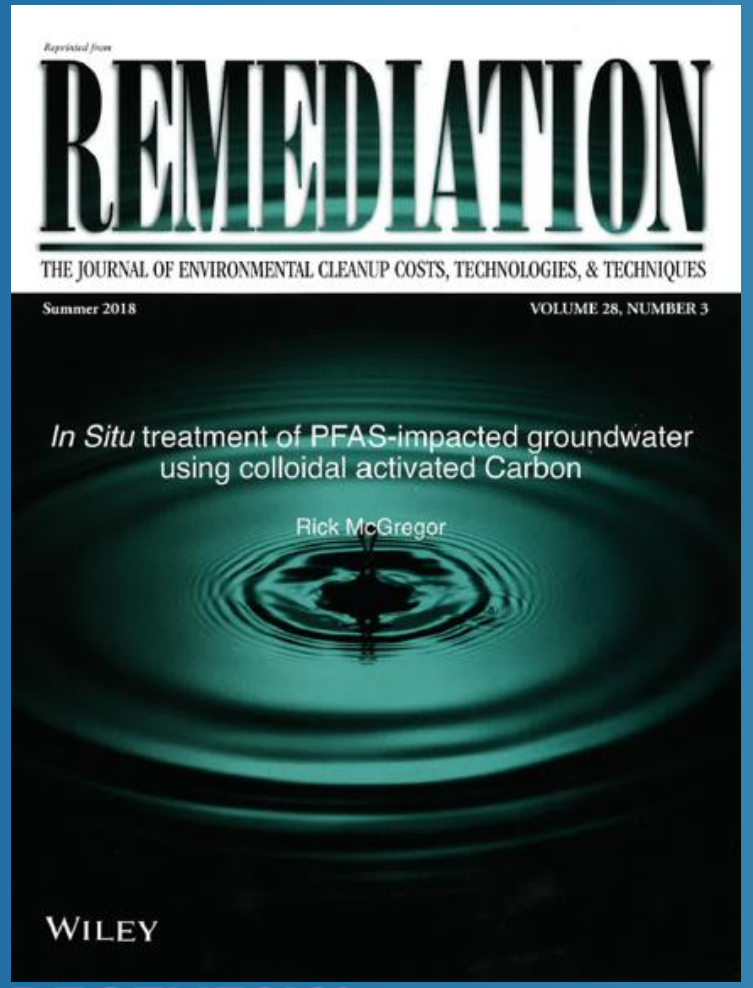
Longevity-Third Party Review



Longevity Conclusions:

- Increased by CAC concentration injected
- Length of treatment area

- University of Waterloo, Waterloo, Ontario, Canada
- University of Toronto, Toronto, Ontario, Canada
- Pro Water Solutions, Ottawa, Ontario Canada
- In Situ Remediation Services Ltd., St. George, Ontario, Canada

Why Colloidal Activated Carbon?

- Limited destructive options
- Low Cost
  - No O&M costs or generated waste
  - Reapplication only after years/decades
- Localized containment/concentration of PFAS
  - Pair with future destructive technologies?
- *In Situ* Sequestration
  - Preventing contaminant migration
  - Removes exposure → removes the immediate risk

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Considerations for using Colloidal Activated Carbon

- Identity of the target contaminants of concern
  - Longer chain PFAS > shorter chain PFAS
- Contaminant Flux
  - Groundwater velocity
  - Contaminant concentrations
- Presence of other non-target compounds
  - Compete for sorption sites (carbon demand)
- Application
  - Design Verification Testing
  - "Building an underground fence"

Soil borings from Camp Grayling

CASE STUDY

Grayling Army Airfield

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Case Study Background

Site Location:
Camp Grayling Joint Maneuver Training Center

- Founded 1913
- 147,000 acres
- Largest National Guard training center in the country
- Home to the Grayling Army Airfield (900acres)

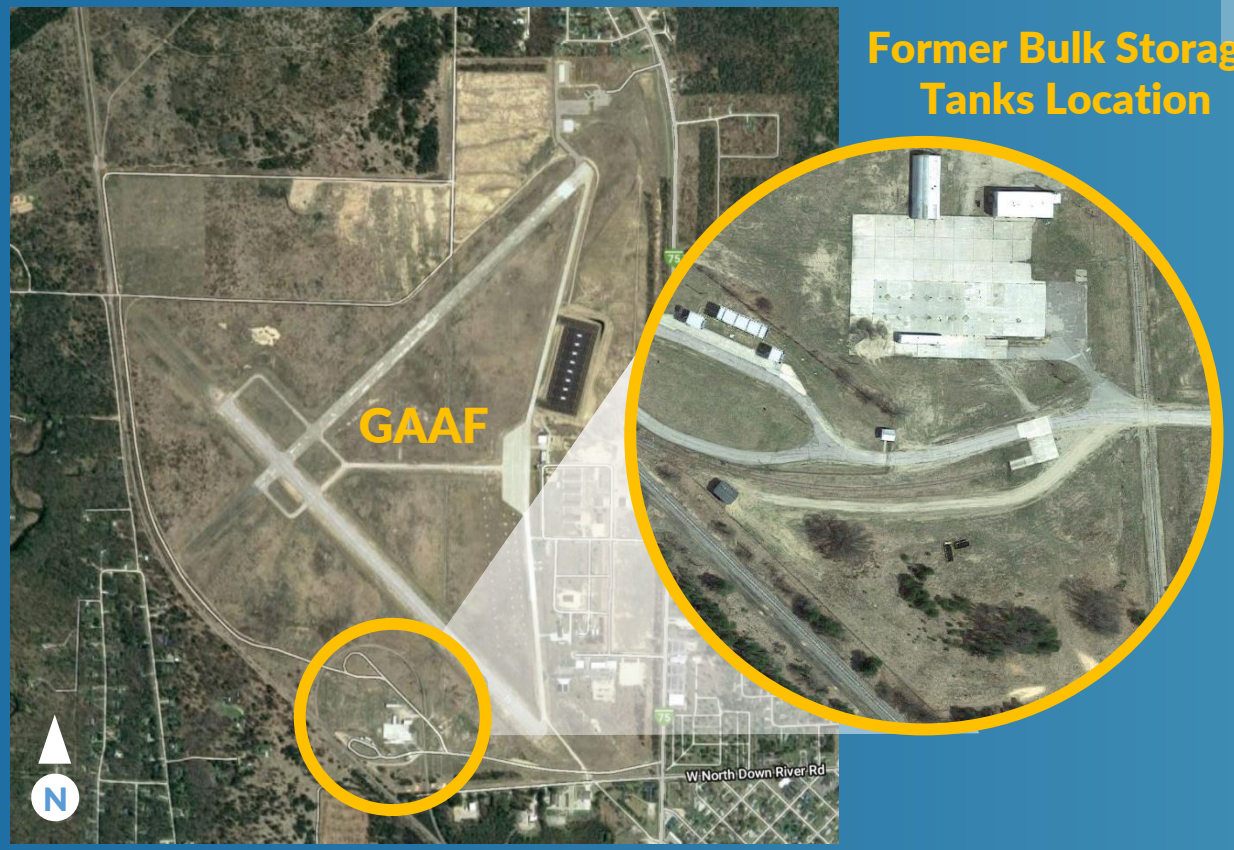
Contaminant Release History:

- Diesel, PCE/TCE, PFAS

Remediation History:

- Pump and Treat, air sparging/SVE

Case Study: Pilot Test



Aquifer:

- Sand & Gravel with some clay layers
- ~250'/yr gw seepage velocity
- Treatment Interval 15-27'bgs

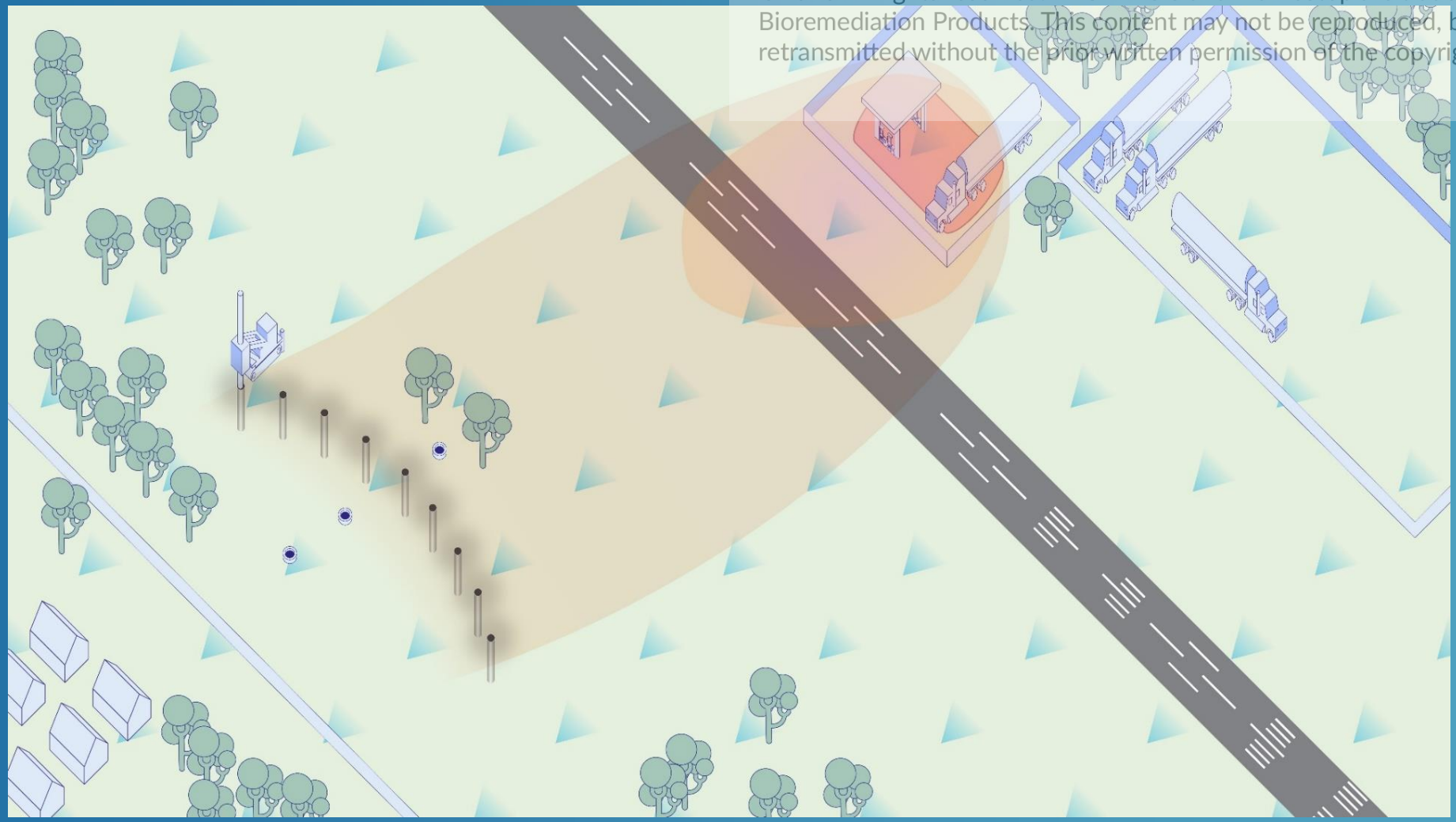
Contaminant levels:

- 10 µg/L PCE
- 130 ng/L Total PFAS (PFOS, PFHxS)

Sensitive Receptors:

- Residential areas
- Surface water bodies
- Property Boundary

Simple Plume Cut-Off Barrier



Modeling in the Design Process

PlumeForce

- Long-Term Prediction Model
- Competitive Sorption and Degradation (if applicable)
- Compound Specific Isotherms
- VOCs, PFAS, etc.

Considerations

- Soil Type/Porosity
- Groundwater Seepage Velocity/Mass Flux
- Vertical Variations
- Barrier Thickness
- Carbon Demand
- Time

Modeling in the Design Process

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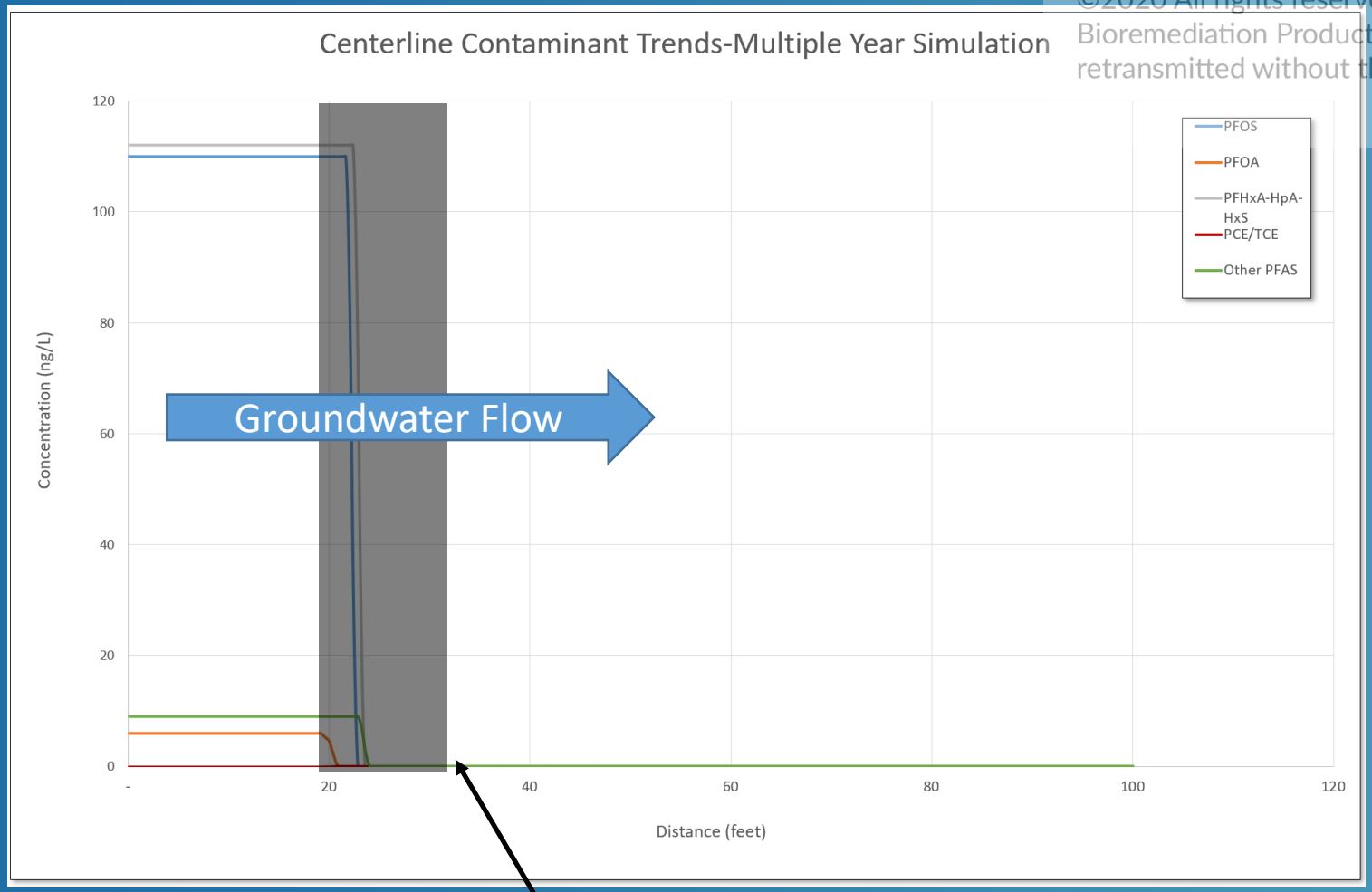

PLUME STOP® Liquid Activated Carbon

Inputs

- GW 219 feet/year
- Infinite Source
- PFOS 110 ng/L
- PFOA 8 ng/L
- PFHxA -HpA – HxS 112 ng/L
- Other PFAS 9 ng/L
- PCE 10 ug/L
- No degradation of any PFAS compound or CVOC's

- Time (>75yrs)

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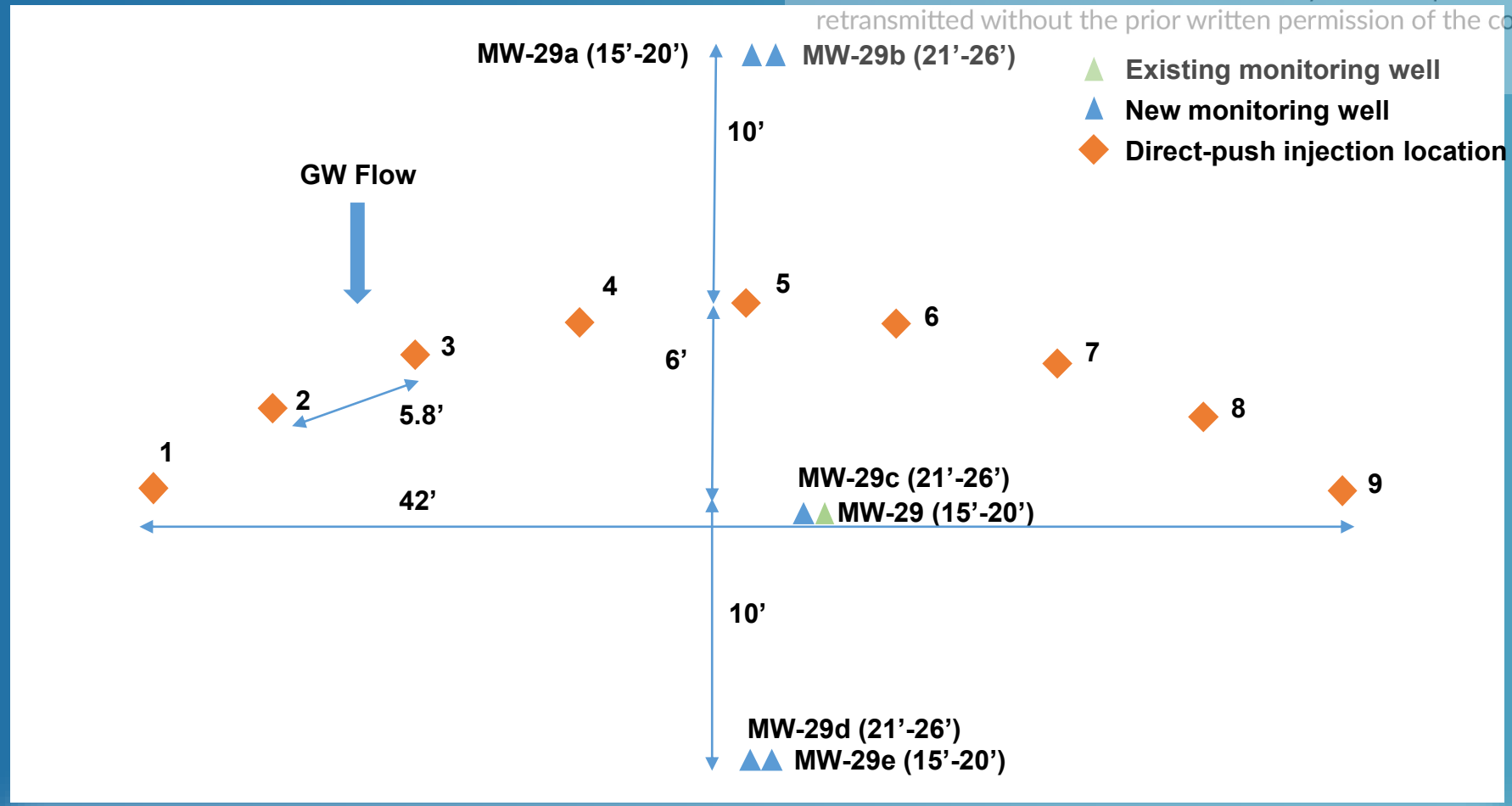
Field Test Layout



Field Test Layout

Field Test Layout

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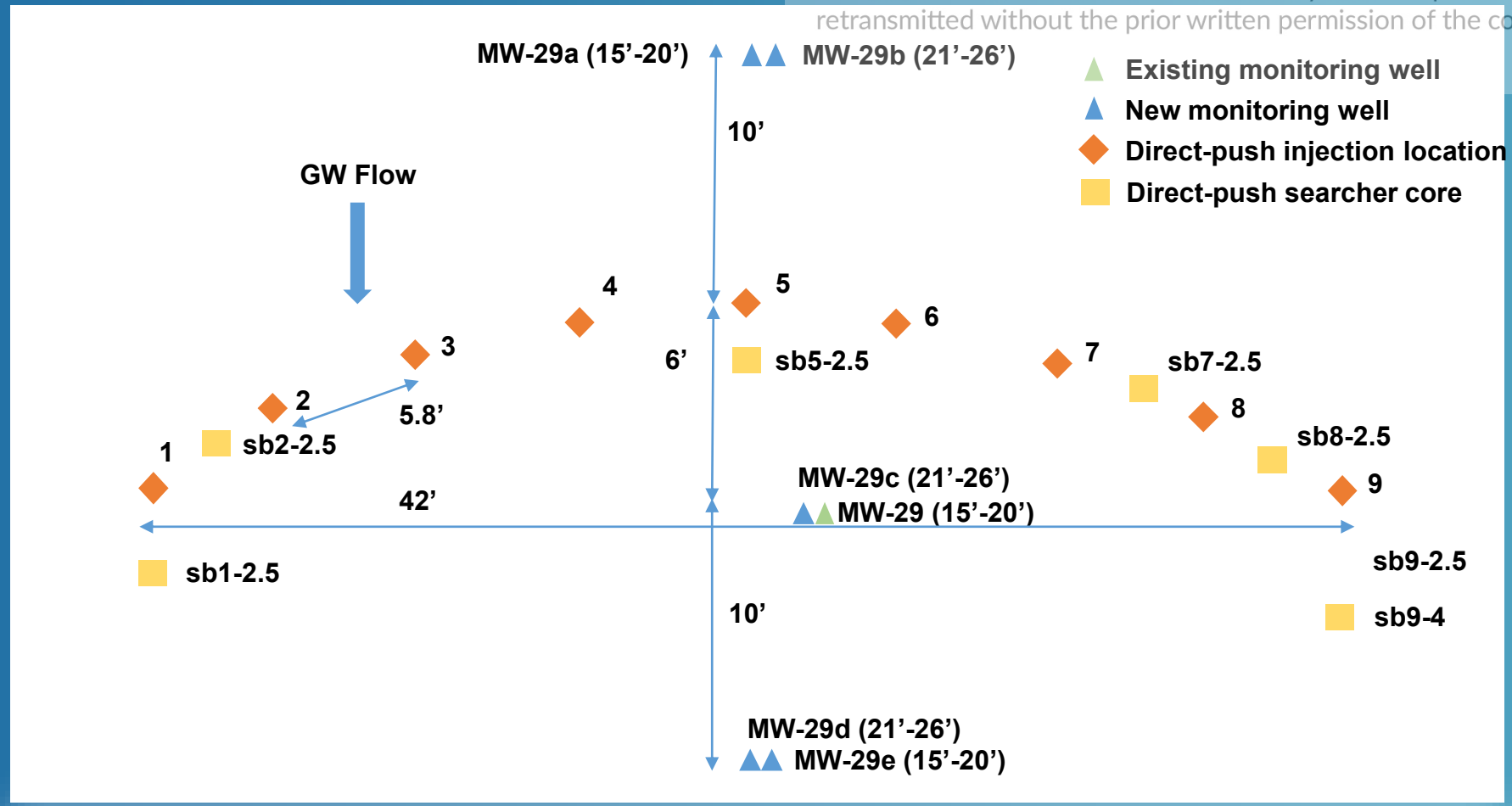

CAC-Distribution Confirmation

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0 feet bgs

27 feet bgs

15 feet bgs

30 feet bgs

CAC-Distribution Confirmation

REGENESIS®

0 feet bgs

27 feet bgs

15 feet bgs

30 feet bgs

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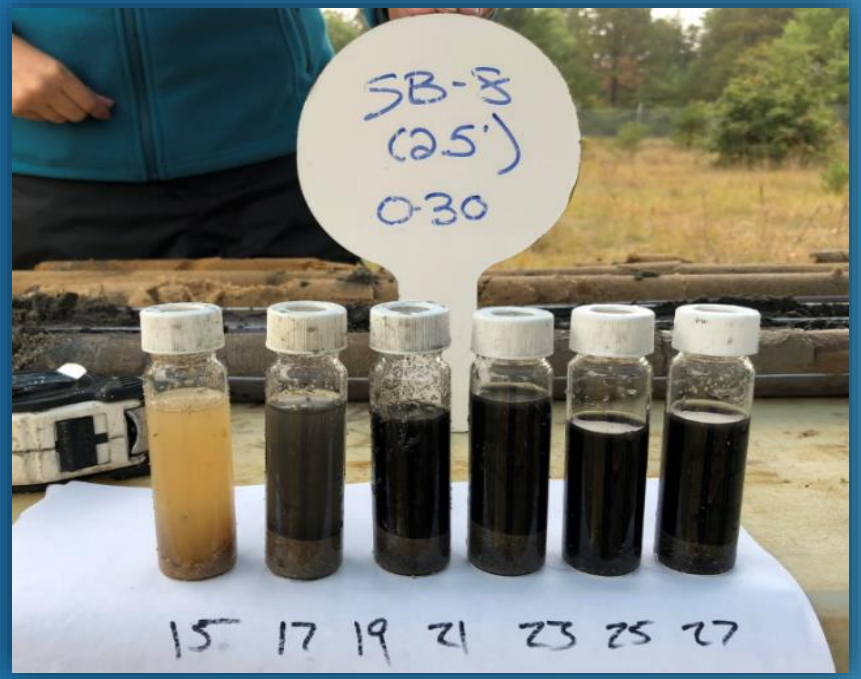
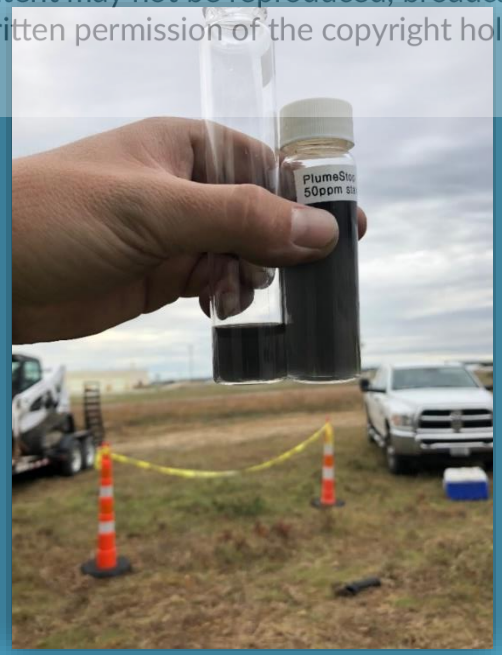
PlumeStop-Distribution Confirmation



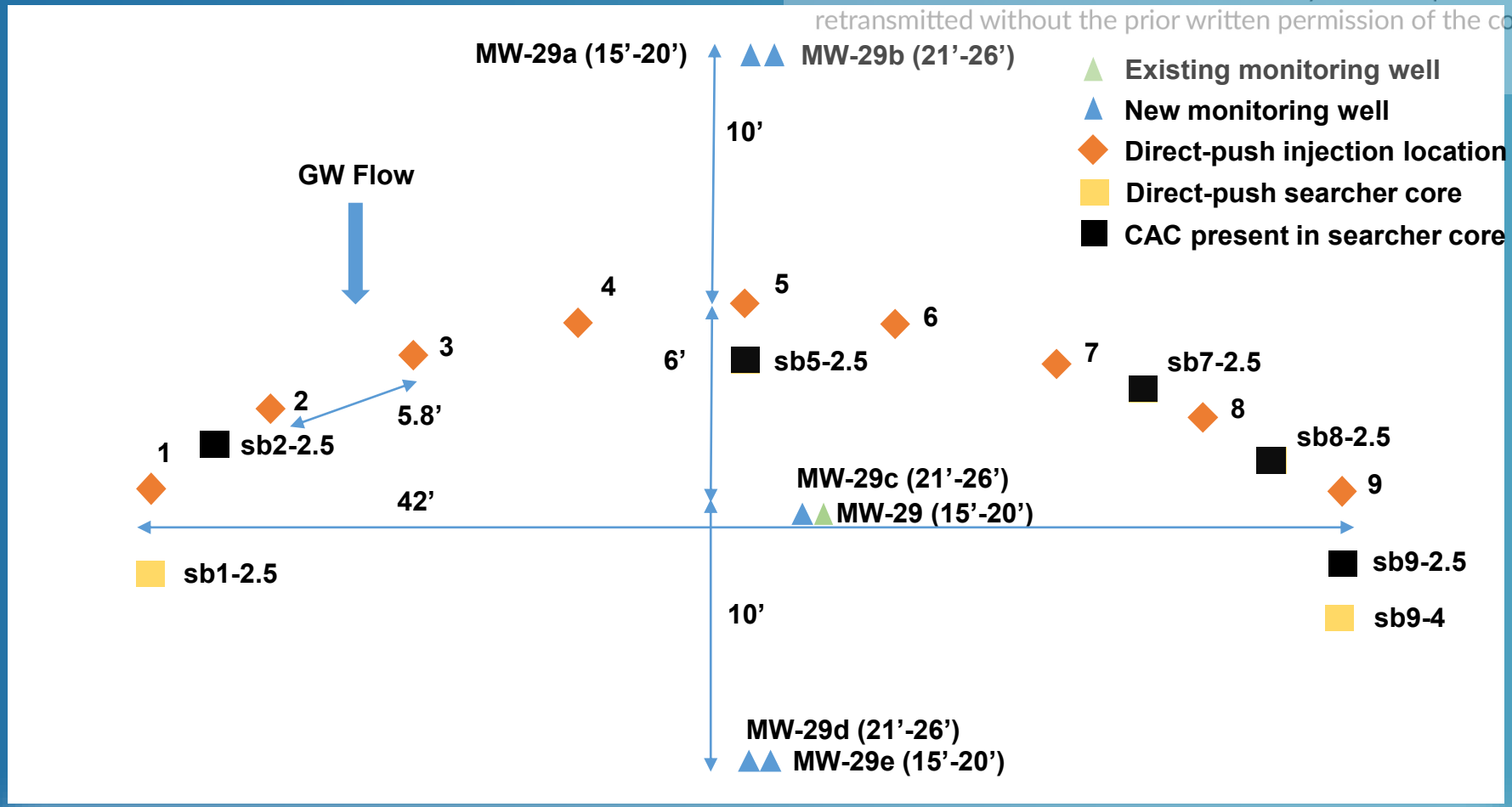
Soil Vial Shake Test

MW-29c



Field Test Kit

Field Test Layout



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CAC-Distribution Confirmation

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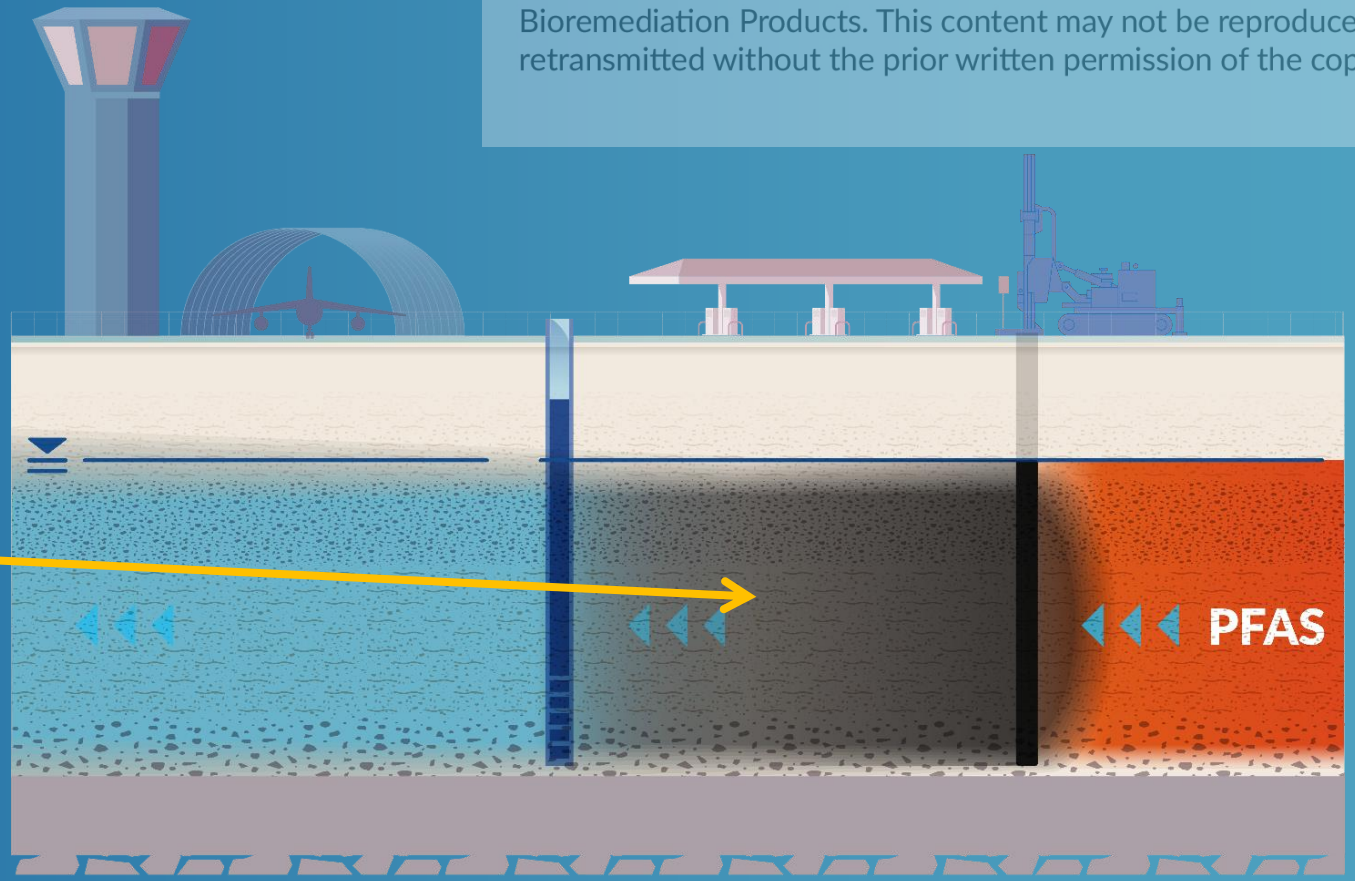

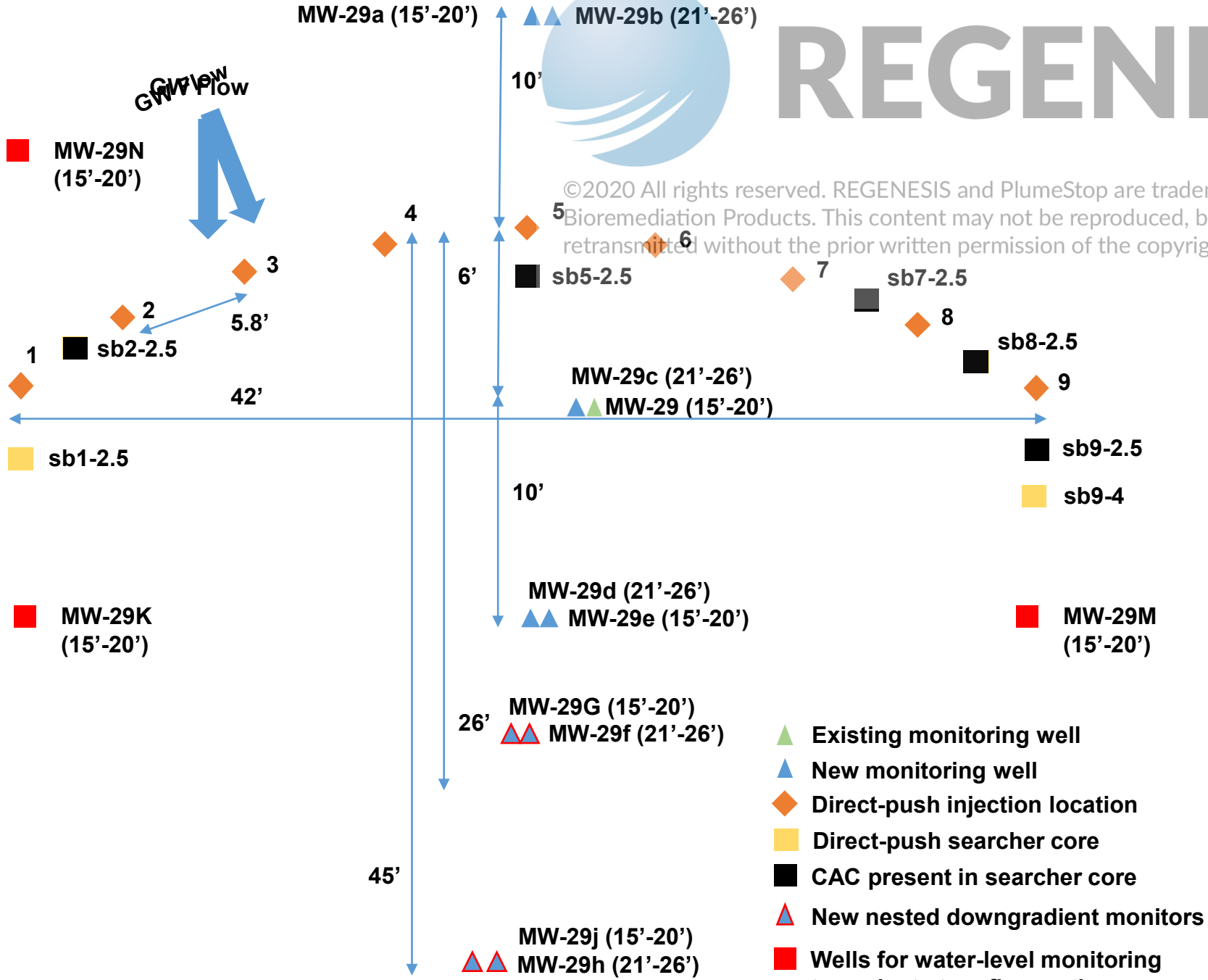

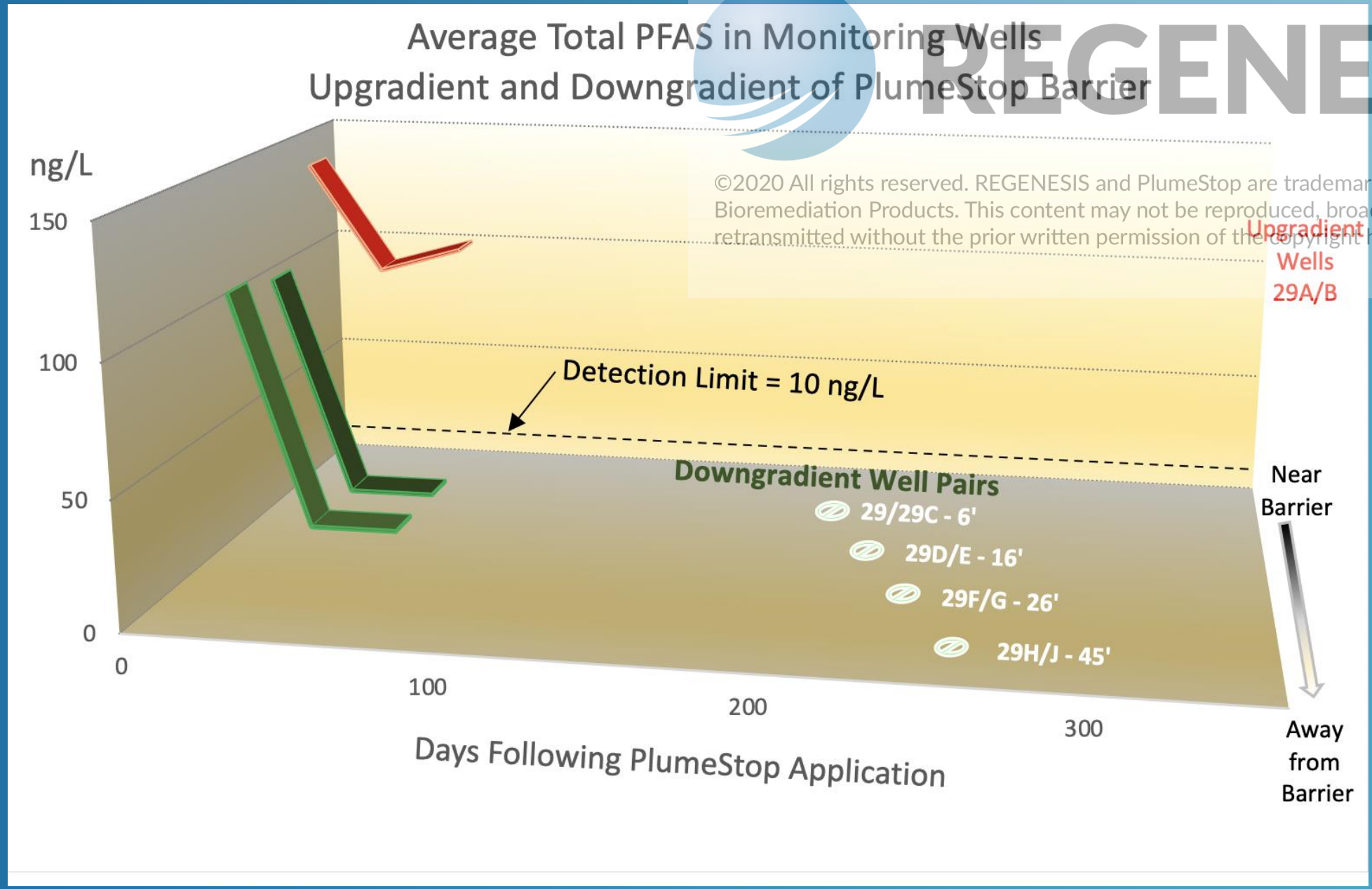

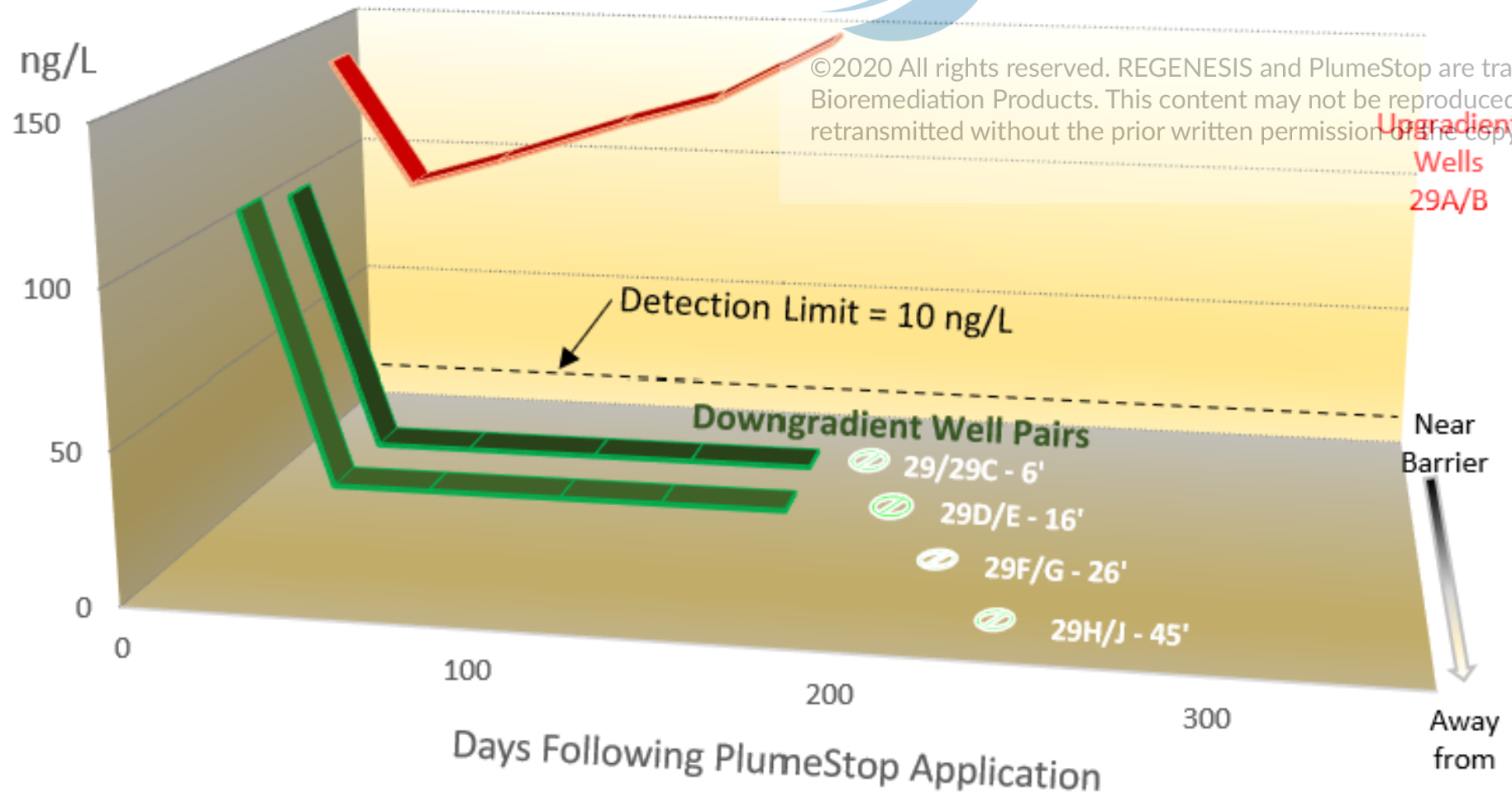

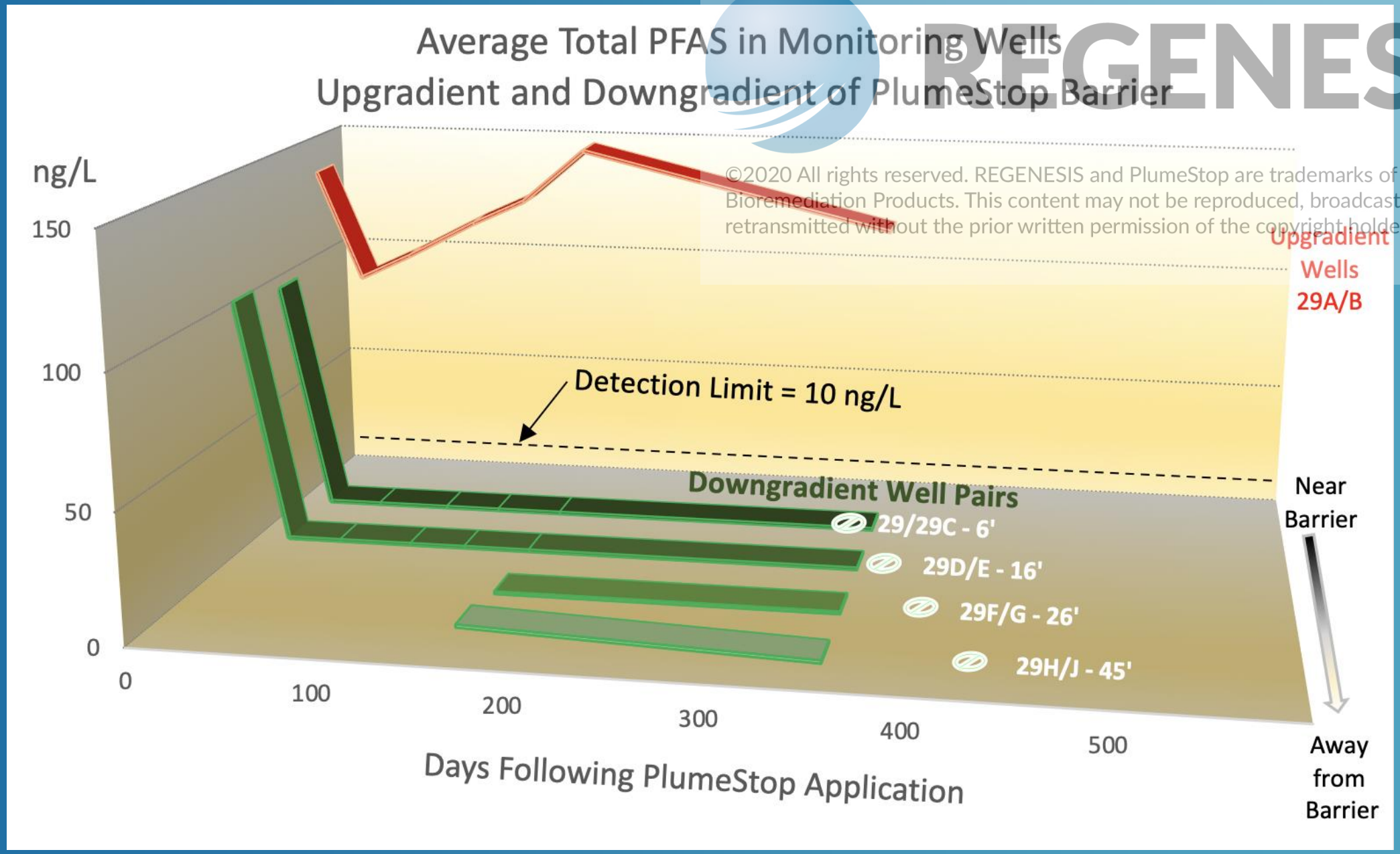

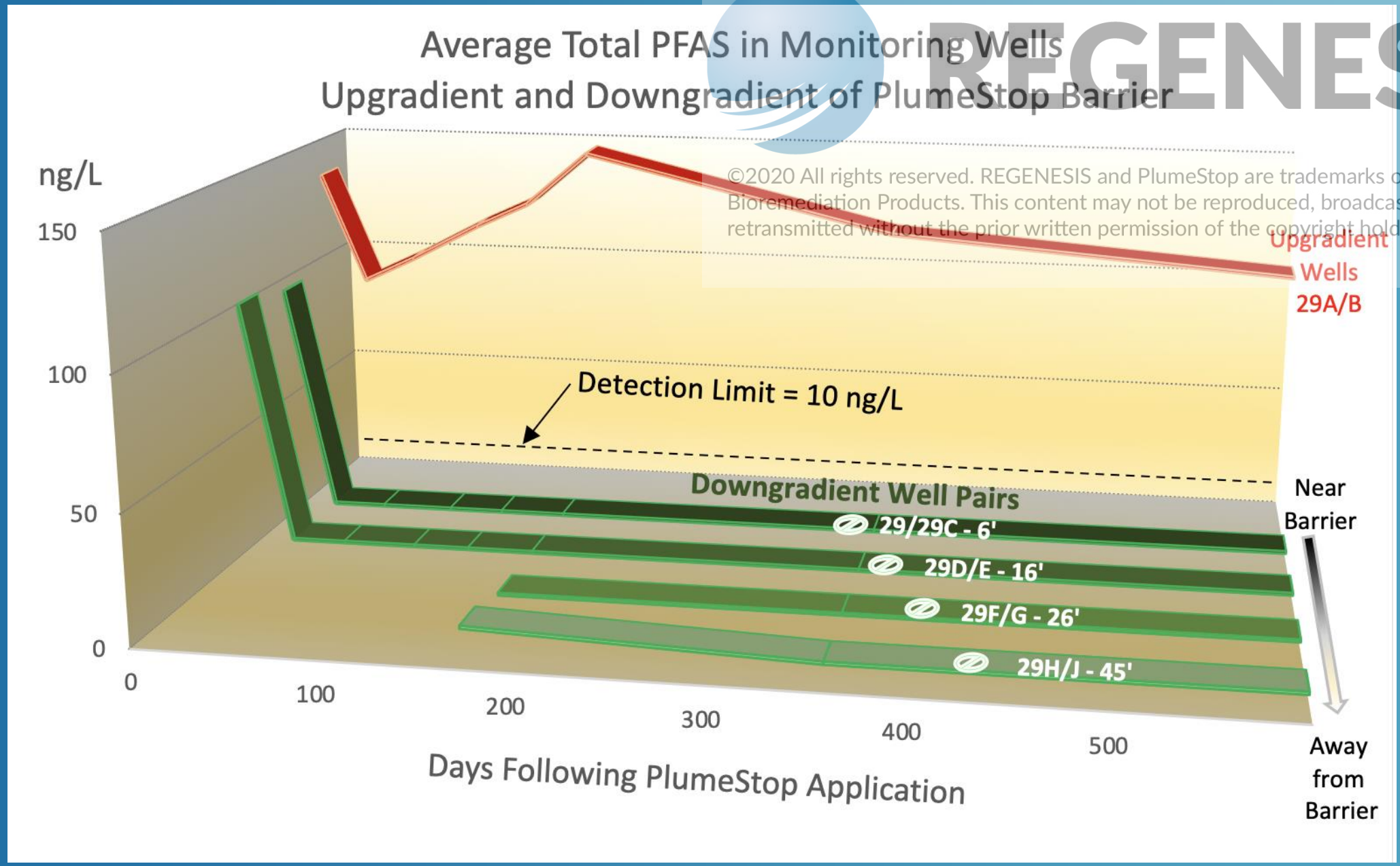

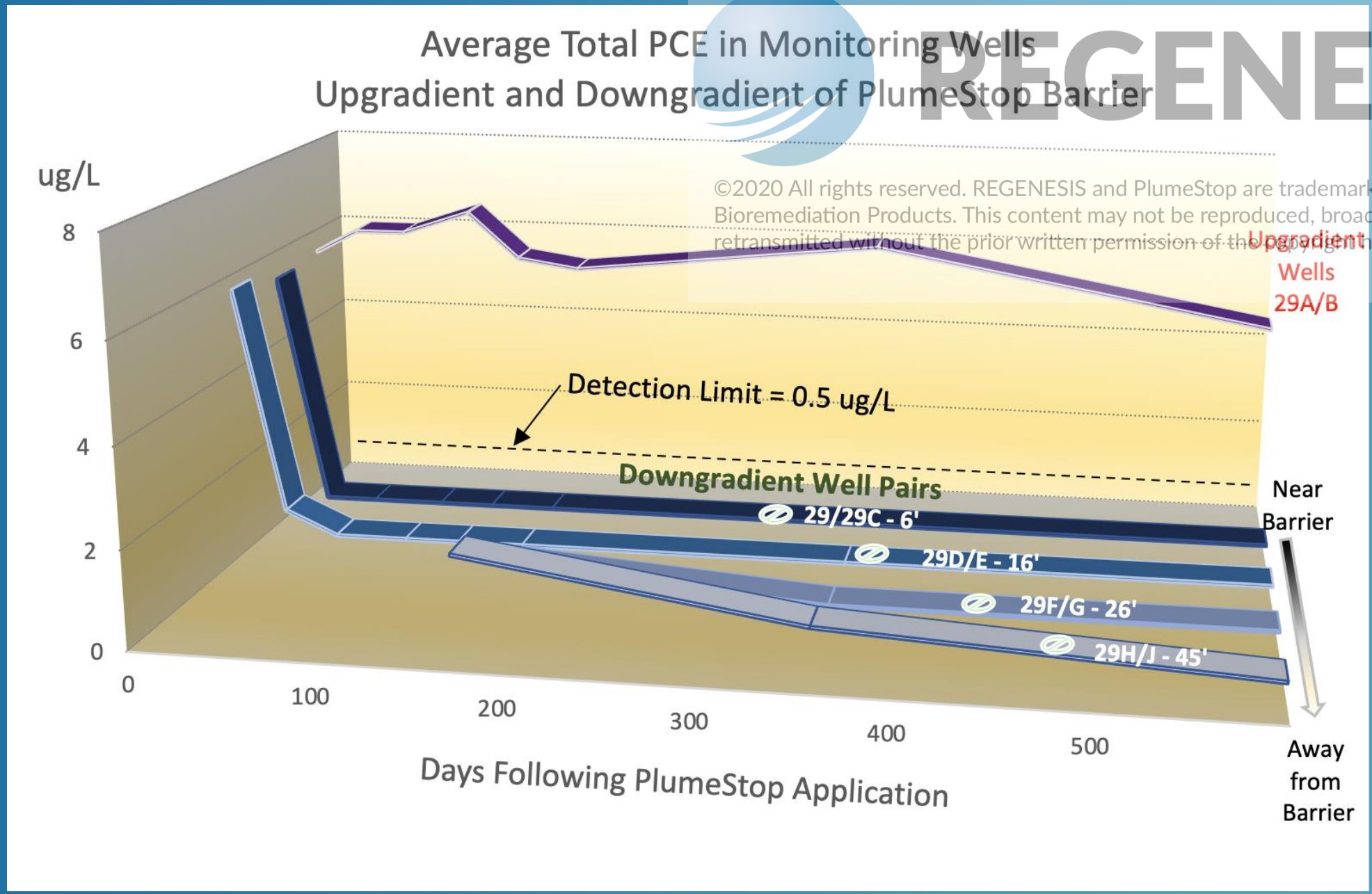

Summary

- Very Successful Test
  - Verified distribution of CAC
  - Sustained reductions of PFAS and PCE over time
  - Anticipated to last for decades
  - Low cost alternative for possible remediation
- CAC provides a flexible, effective, *in situ* option to address PFAS
  - Passive plume control & containment
  - Prevent expansion of the problem
  - Manages the risk of PFAS in groundwater for years

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Thank you!

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