



REGENESIS[®]

Implementing Effective In Situ Permeable Colloidal Activated Carbon (CAC) Barriers to Stop Hydrocarbon Plume Migration

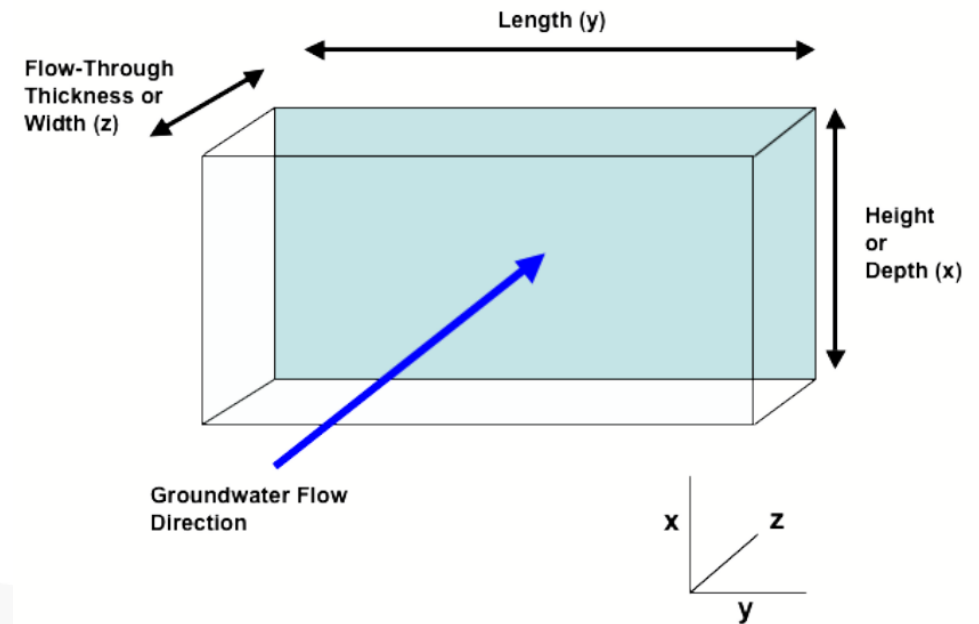
Todd Herrington

Director of Product Management, REGENESIS

Design and Construction of Colloidal iPRBs

A competent barrier requires:

- Good remedial conceptual model
- Appropriate reactive reagent
- Gapless placement of reagent
- Proper reagent dose and dimension



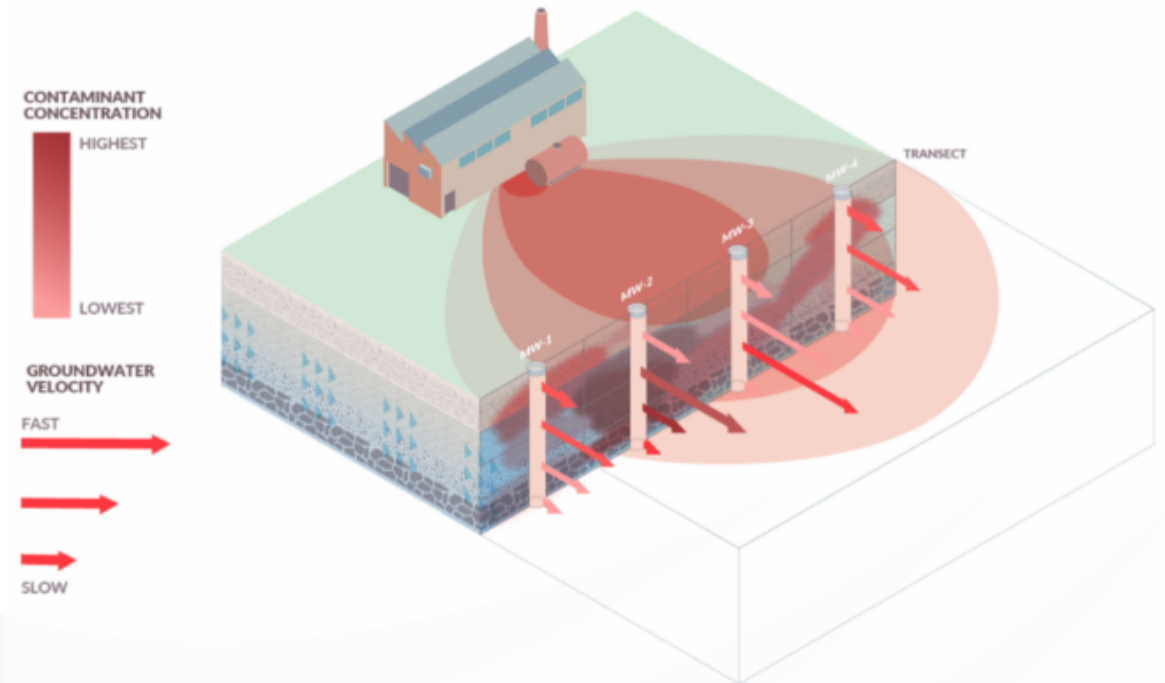
Idealized Barrier Cross Section and Average Mass Flux

Design and Construction of Colloidal iPRBs

A competent barrier requires:

- Good remedial conceptual model
- Appropriate reactive reagent
- Gapless placement of reagent
- Proper reagent dose and dimension

*Often harder to do with hydrocarbon sites
with limited budgets and perhaps less
data*



Aquifer Cross Section and Variable Mass Flux

Implementing Effective CAC Barriers

- CAC for Hydrocarbons
- Mass Flux
- Distribution
- Case Studies

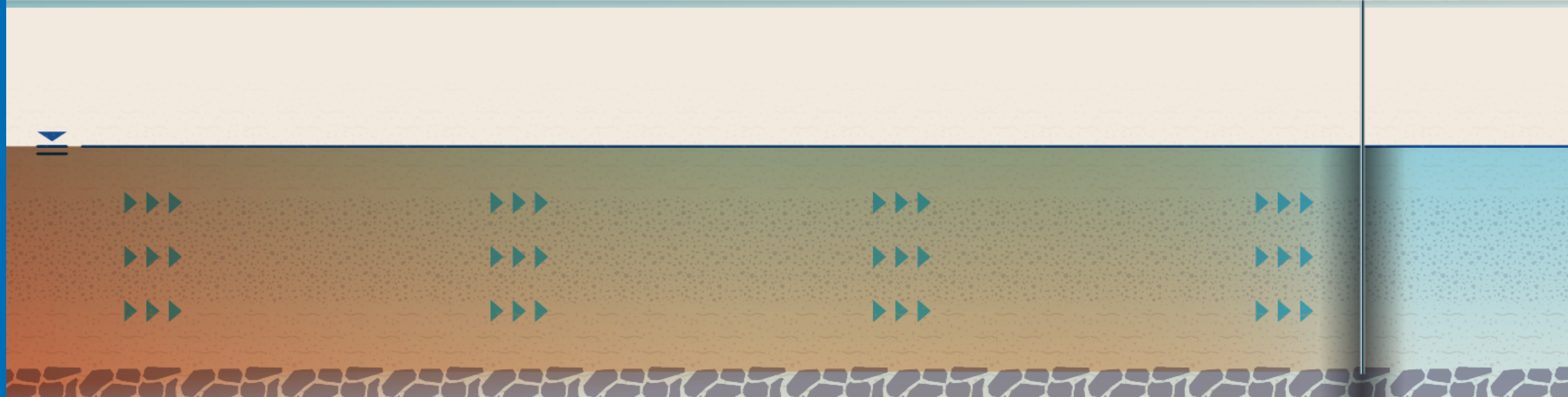
TEMPORARY
INJECTION RIG



Implementing Effective CAC Barriers

- CAC For Hydrocarbons
- Mass Flux
- Distribution
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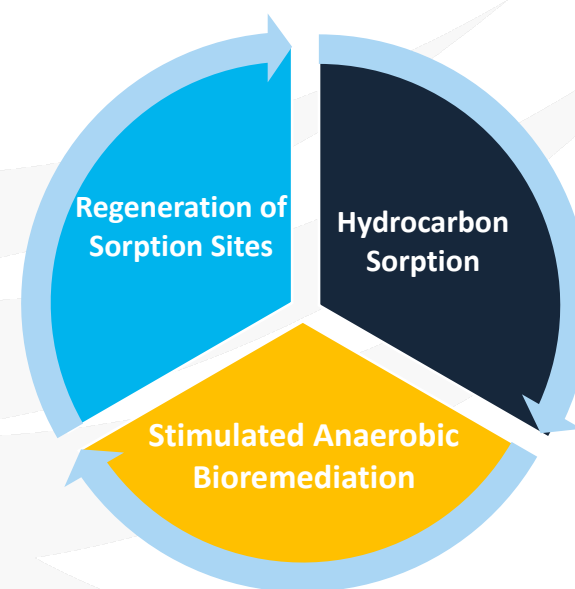
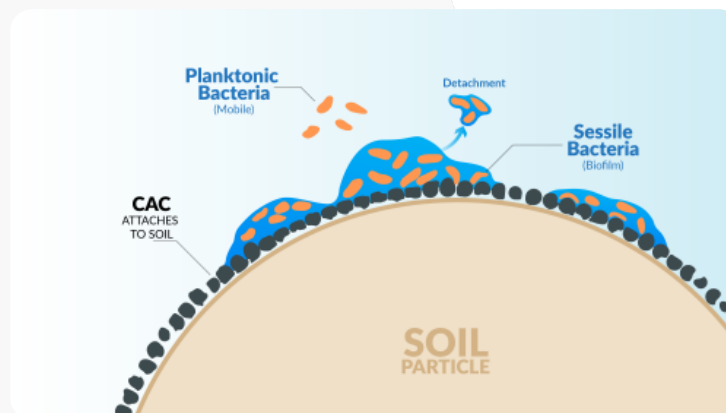
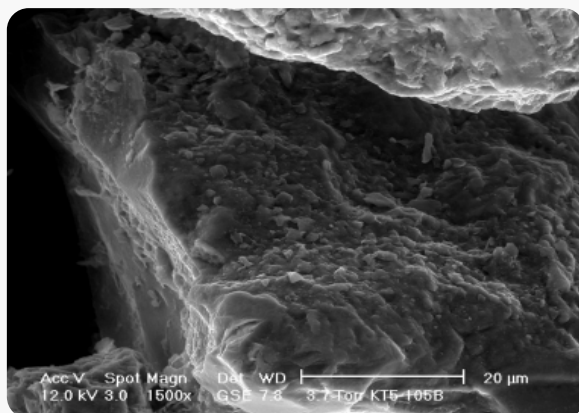
TEMPORARY
INJECTION RIG



CAC For Hydrocarbons



- PetroFix coats soils in flux zones with a micrometer-thick layer – contaminants adsorb
- Contaminant flux from advection or back-diffusion captured
- **$\text{NO}_3 + \text{SO}_4$ kick-start bioremediation = biofilm formation**
- **YES** - *In situ* carbon regeneration = contaminant destruction and multi-year longevity

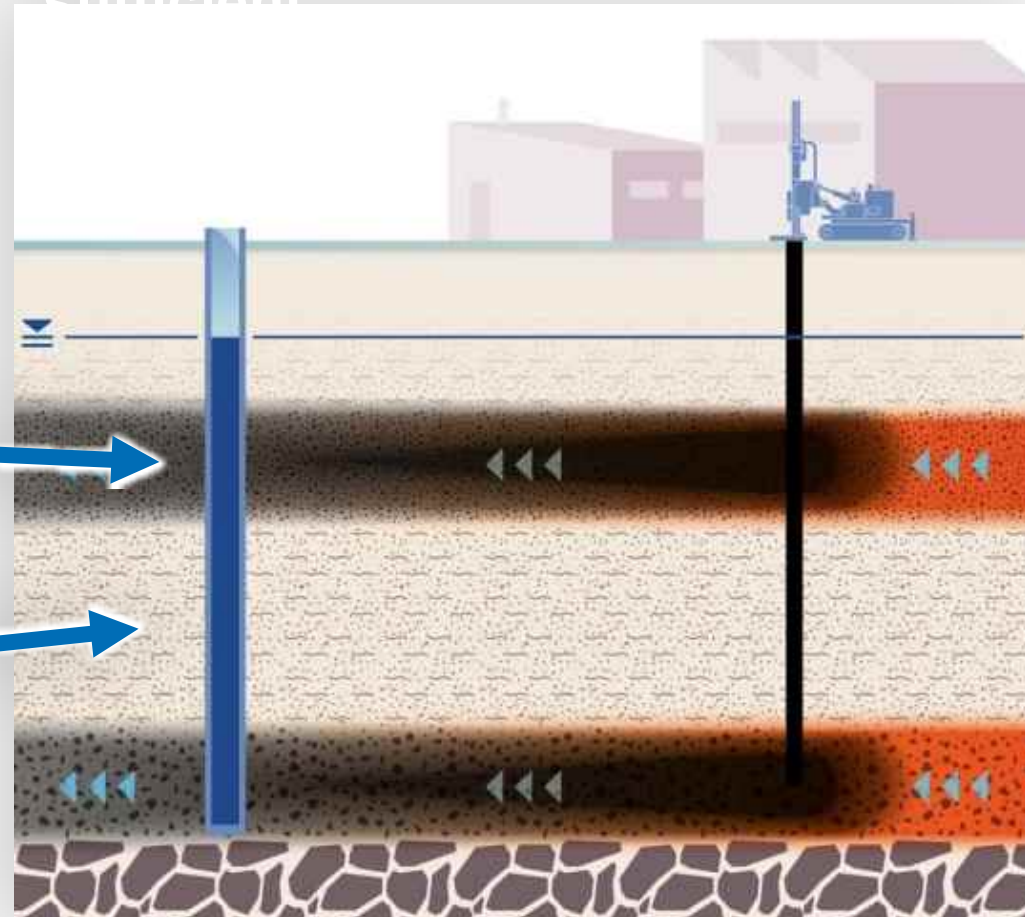


CAC – Gapless, Passive Barrier

Post
Application



Often a single row barrier



Implementing Effective CAC Barriers

- CAC For Hydrocarbons
- **Mass Flux (or velocity)**
- Distribution
- Case Studies

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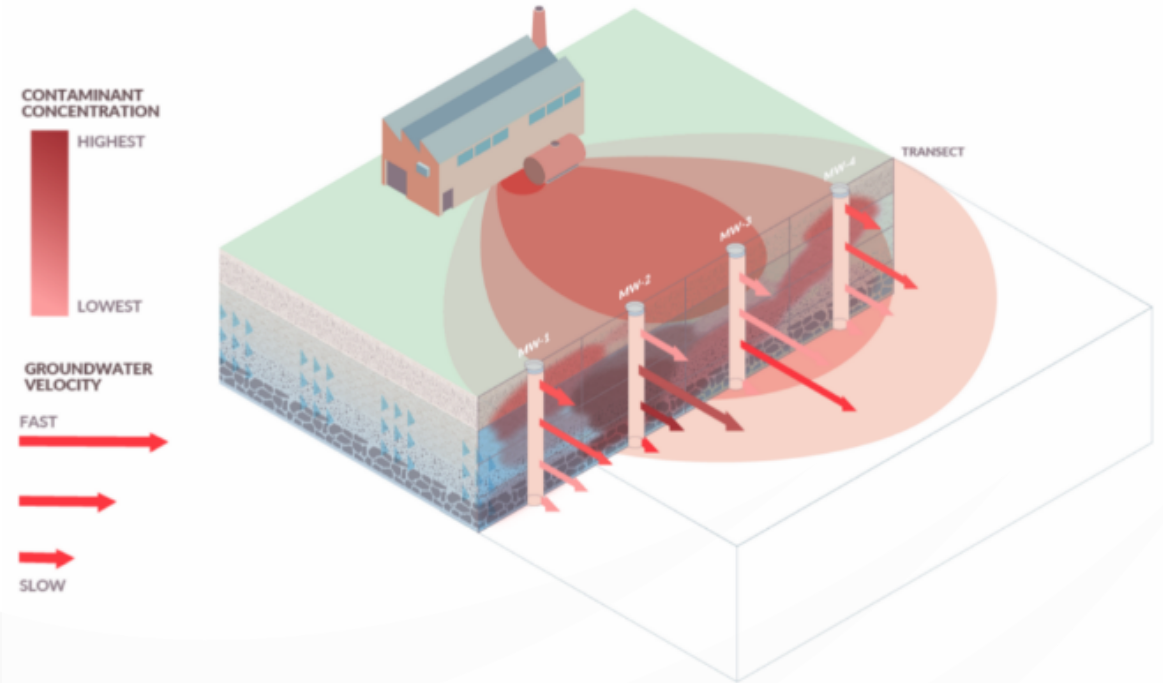
Hydrology and Contaminant Distribution

Design and Construction of Colloidal iPRBs

Mass Flux = Contaminant mass moving across a unit area (aquifer) perpendicular to the groundwater flow direction (lb/ft²/day)

Determines:

- Spacing, dose, number of points, number of rows (typically 1 or 2)
- Allows for strategic, accurate loading rates

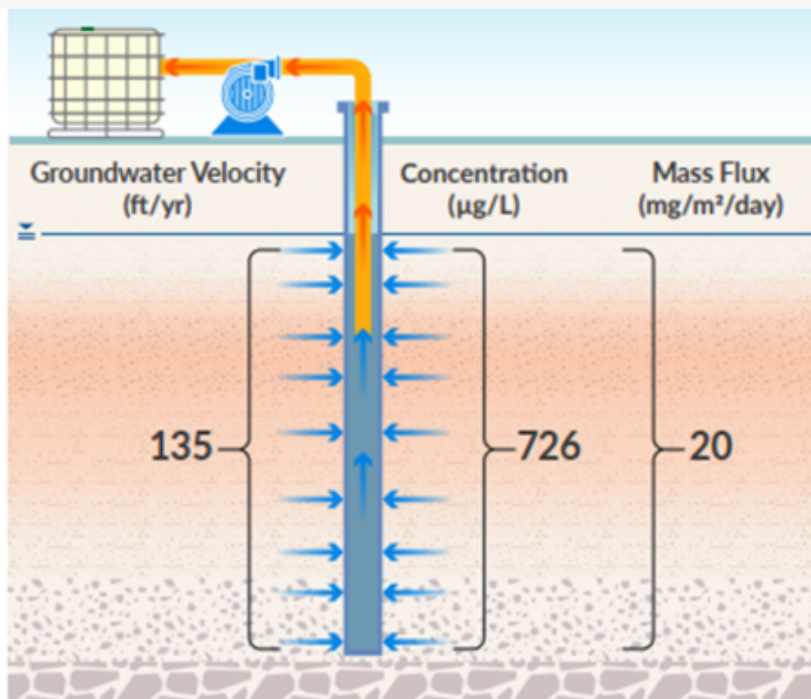


Actual Barrier Cross Section and Variable Mass Flu

Mass Flux Measurement – Best Practice

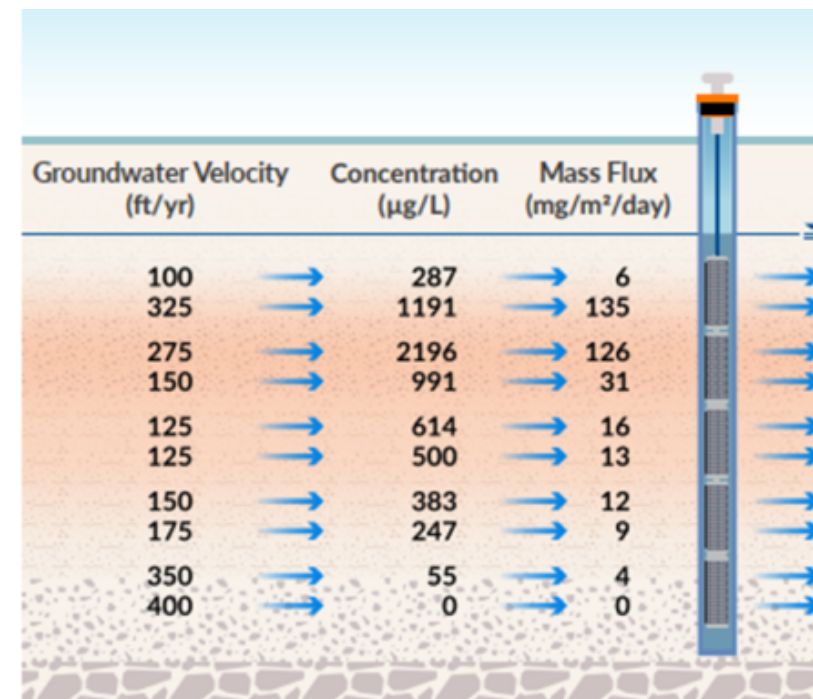
Bulk Average Methods (Pump/Slug Test)

- Does NOT delineate velocity and mass flux
- No data resolution
- Not ideal for in-situ remediation designs

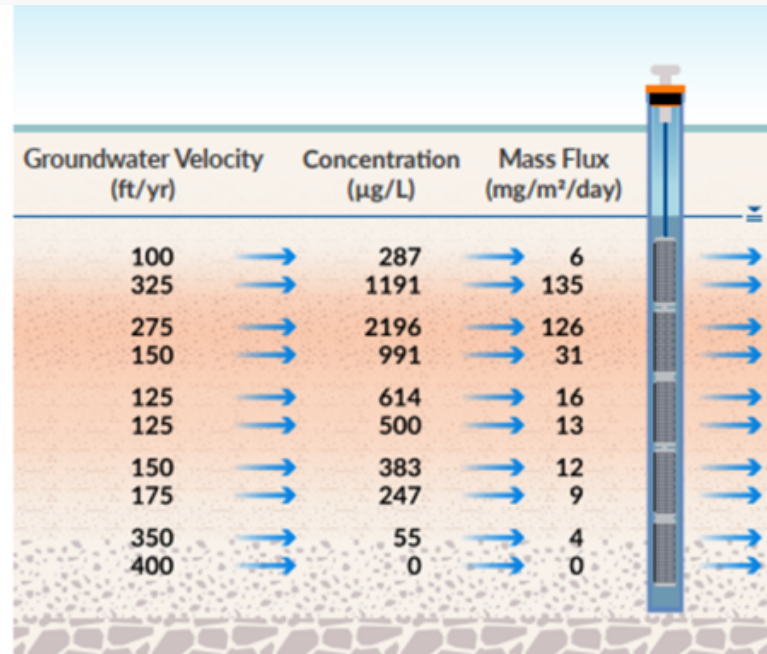


Higher Resolution Methods (FluxMeter™/FluxTracer™)

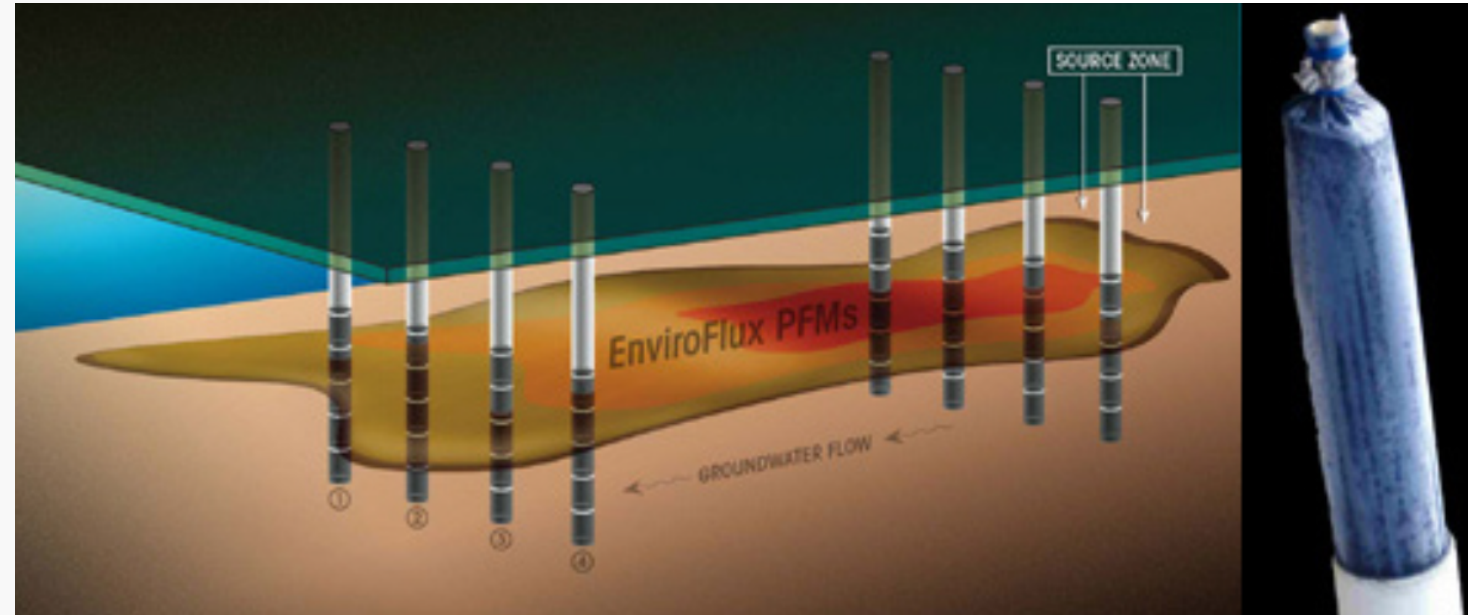
- Identifies zones with highest flux
- Optimize product placement
- More accurate insight into PRB longevity



Mass Flux Measurement – Best Practice



90% of the mass may be flowing through as little as 10% of the screened interval



EnviroFlux™ Flux Tracers
(www.enviroflux.com)

Can We Model PRB Performance?

Barrier lifespan modeled on isotherms,
dynamic sorption



Dose based on:

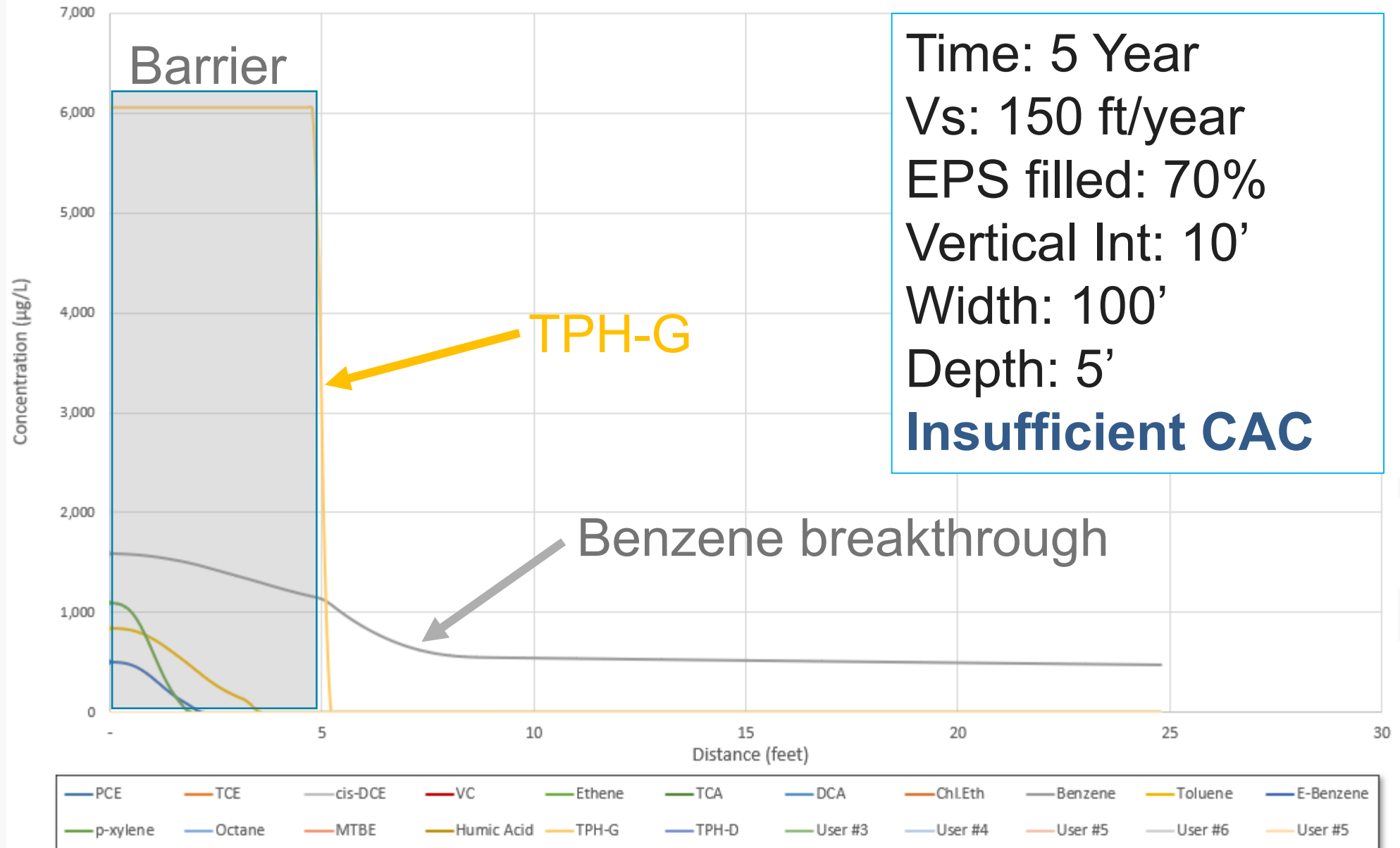
- Mass flux (or best velocity estimate >100 to 150 feet/year minimum)
- Concentrations
- 1st Order Bio Rates (MNA or better)
- Dimensions (length, width, height)
- Competitive Sorption
- Back Diffusion
- Time



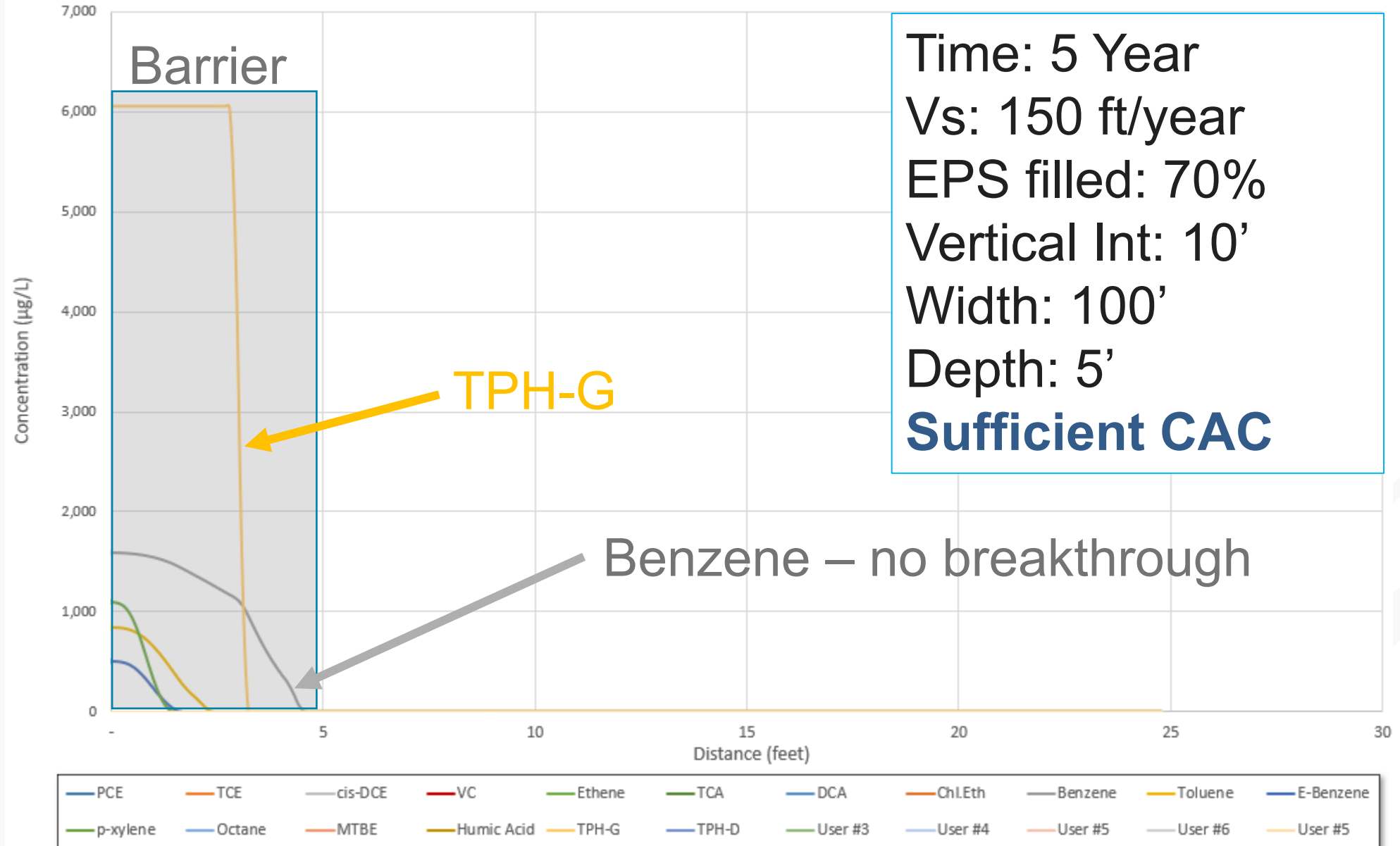
Developed by
Jeremy Birnstingl
Ph.D.



Calculating Dose With Model



Calculating Dose With Model



Implementing Effective CAC Barriers

- Colloidal Advantages
- Mass Flux
- **Distribution**
- Case Studies

TEMPORARY
INJECTION RIG



Injection Tooling – Plan A

- **Fixed Open or Retractable Multi-Port Tooling Recommended**
 - 2' to 3' vertical multi-port tooling most common
- Pressure and flow meter gauges
- As a rule-of-thumb, 20 to 80 psi and 2 to 7 gpm flow rates are common



www.shop-esp.com

Injection Tooling – Plan B

While multi-port vertical tooling is recommended, it may become damaged or prove ineffective

- 12" to 18" lifts maximum

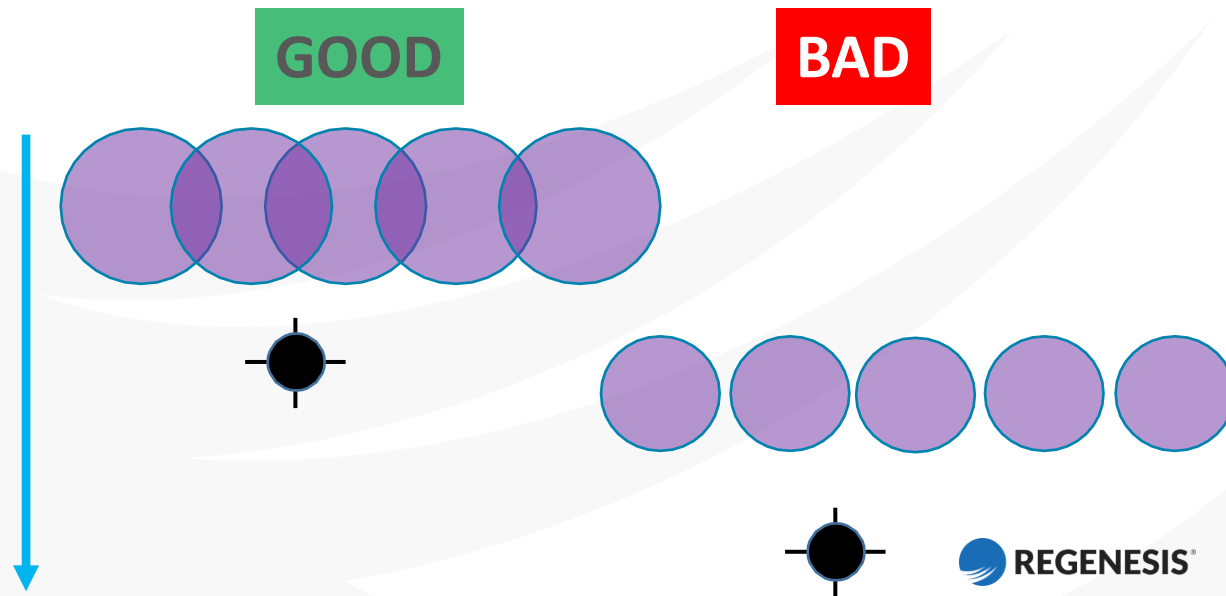


Construction

Distribution Verification?

- Don't let economic pressure necessarily dictate spacing for you
- Budget time for field testing

Gen. Soil Type	DPT Spacing (feet on center)	Minimum EPVF%
>75% sand/gravel	5 to 6	70%
Mix of course/fine	5	60%
>75% Silt Clay	5 to 6	60%



Does CAC Stop Moving or Does it Wash Out?

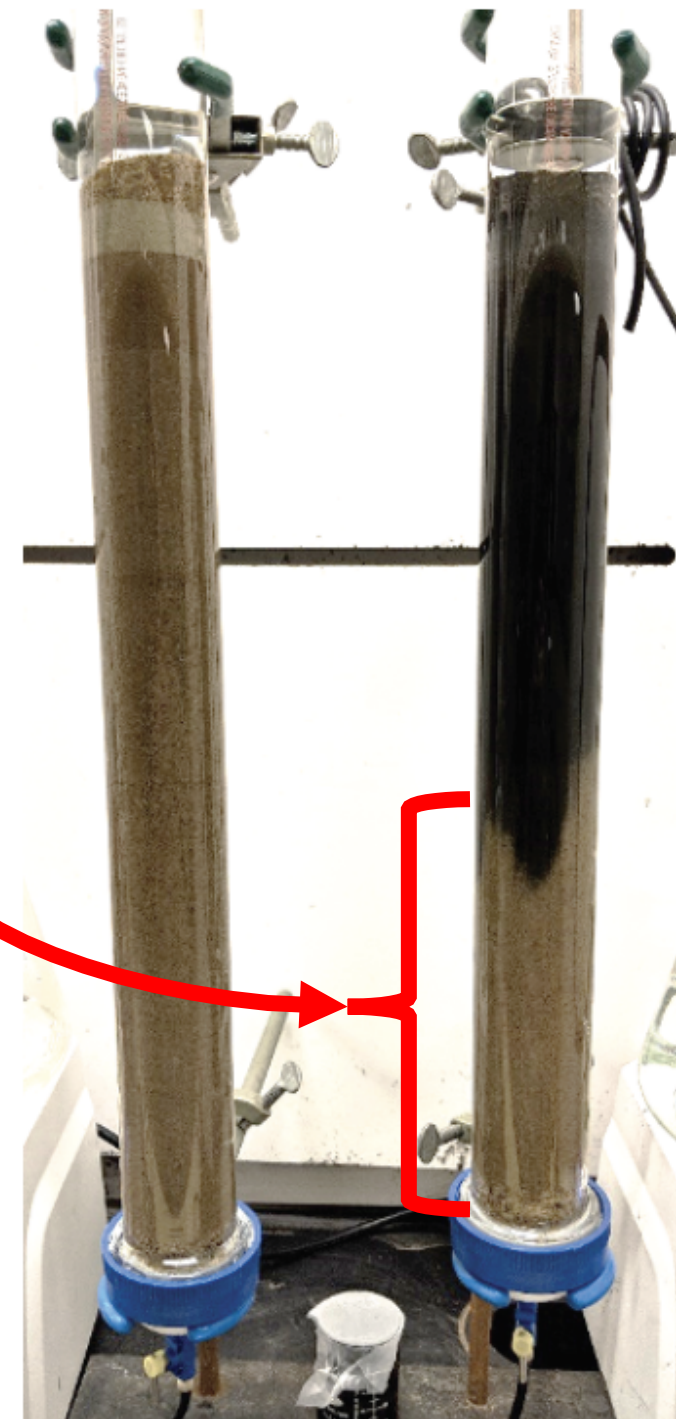
Right column: CAC solution applied and fed tap water for 24 hours. Mix of fine sand and sandy loam.

NO CAC elution from the column

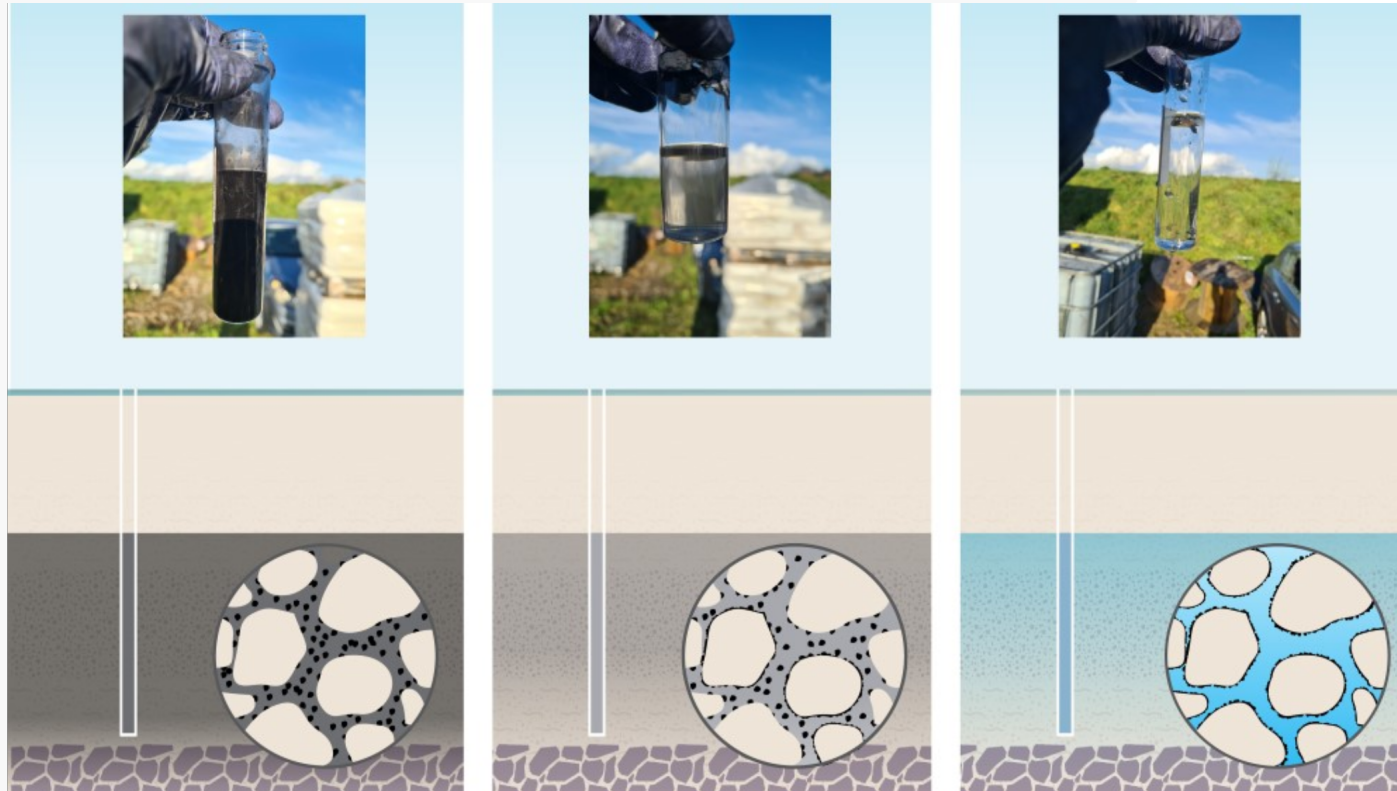
Higher surface area (silts, clay, fine sands) correlates to faster attachment.

Post application movement is minor

The control (left) and CAC-treated (right) columns used in the study to demonstrate the ability of CAC to capture small diesel spills.



CAC Can Be Park if Needed



Applying Di-valent salts such as Calcium Chloride (CaCl_2) to break colloidal chemistry of PetroFix.

- CAC usually adsorbs to soil before moving out of the injection area
- $<0.5\%$ of injection mass to turn water very black

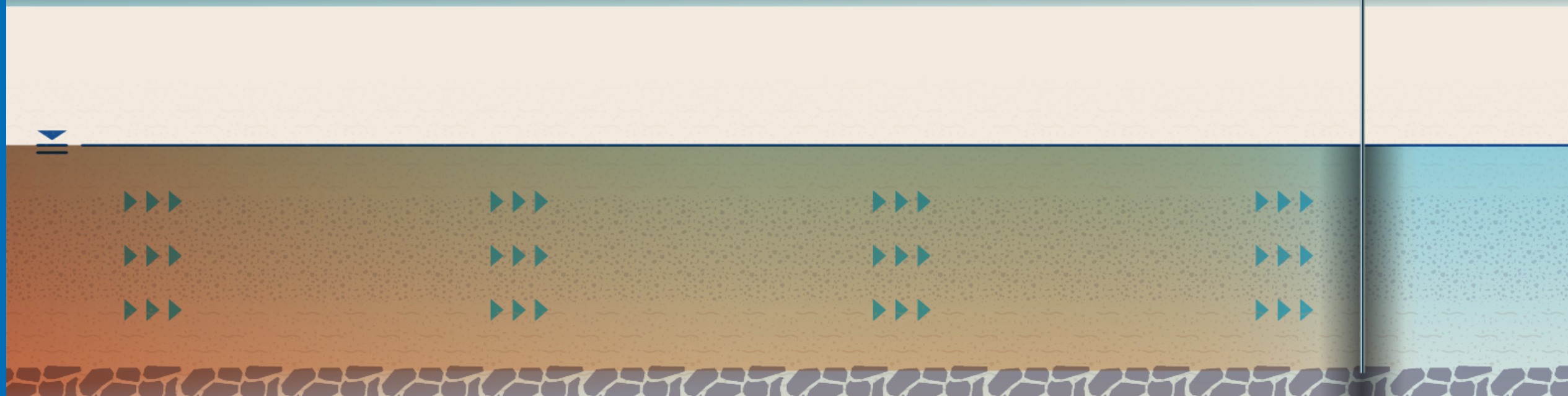
Option:

For High flow and/or low surface area (i.e. gravel/coarse sand) “Parking” is a solution

Implementing Effective CAC Barriers

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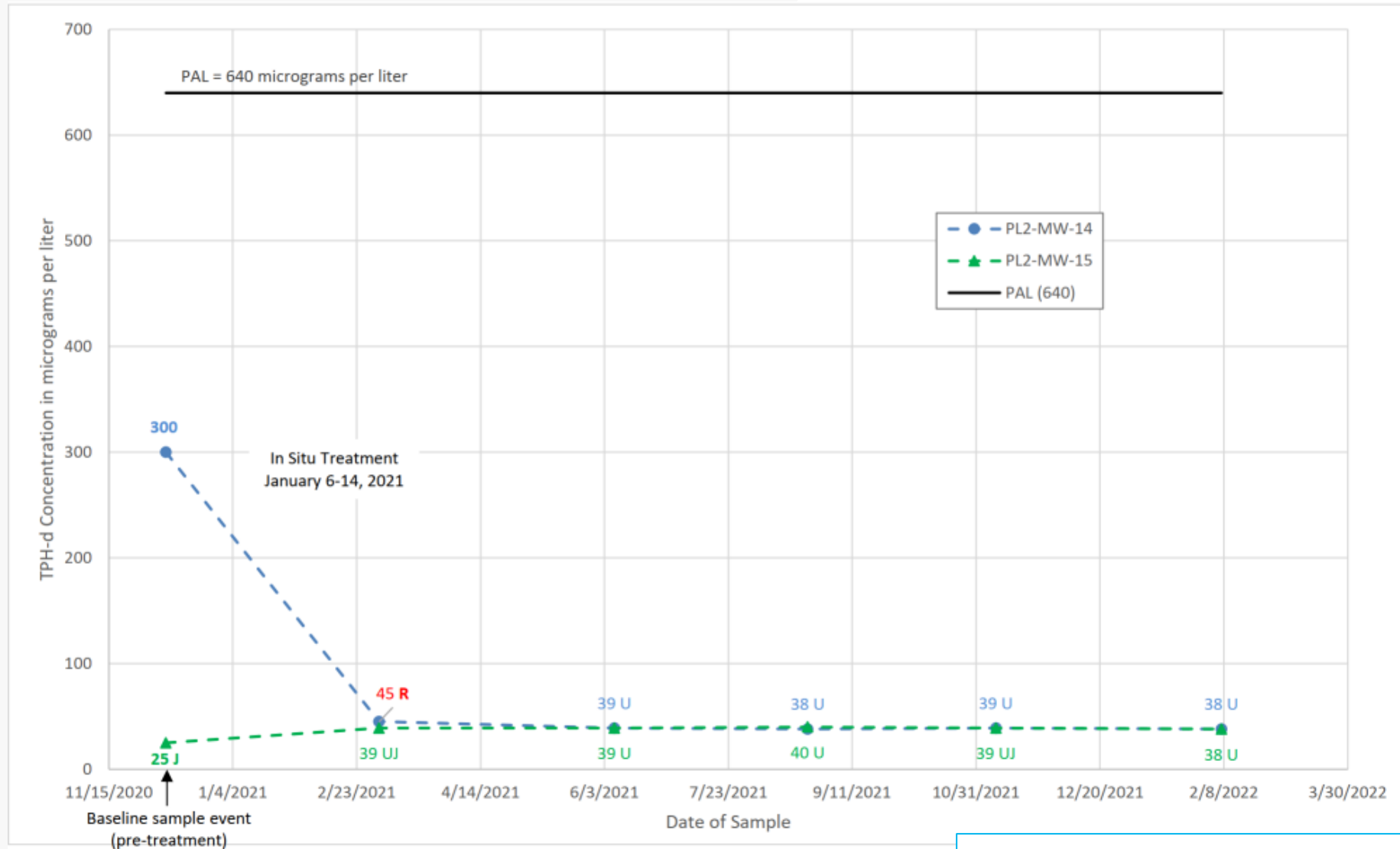
Barrier Protect San Diego Bay

Former UST Naval Base Point Loma, San Diego



- Diesel-range plume migrating to Bay
- Poorly graded sands, silty sands
- Velocity >95 ft/year
- January 2021 – 3 injection points to verify distribution in flux zones
- Immediately followed full scale:
 - 46 points (115' wide barrier)
 - 8 to 18' bgs
 - 281 gallons per point
 - Few hundred ug/L TPH-D

Barrier Protects San Diego Bay



6,400 lb PetroFix

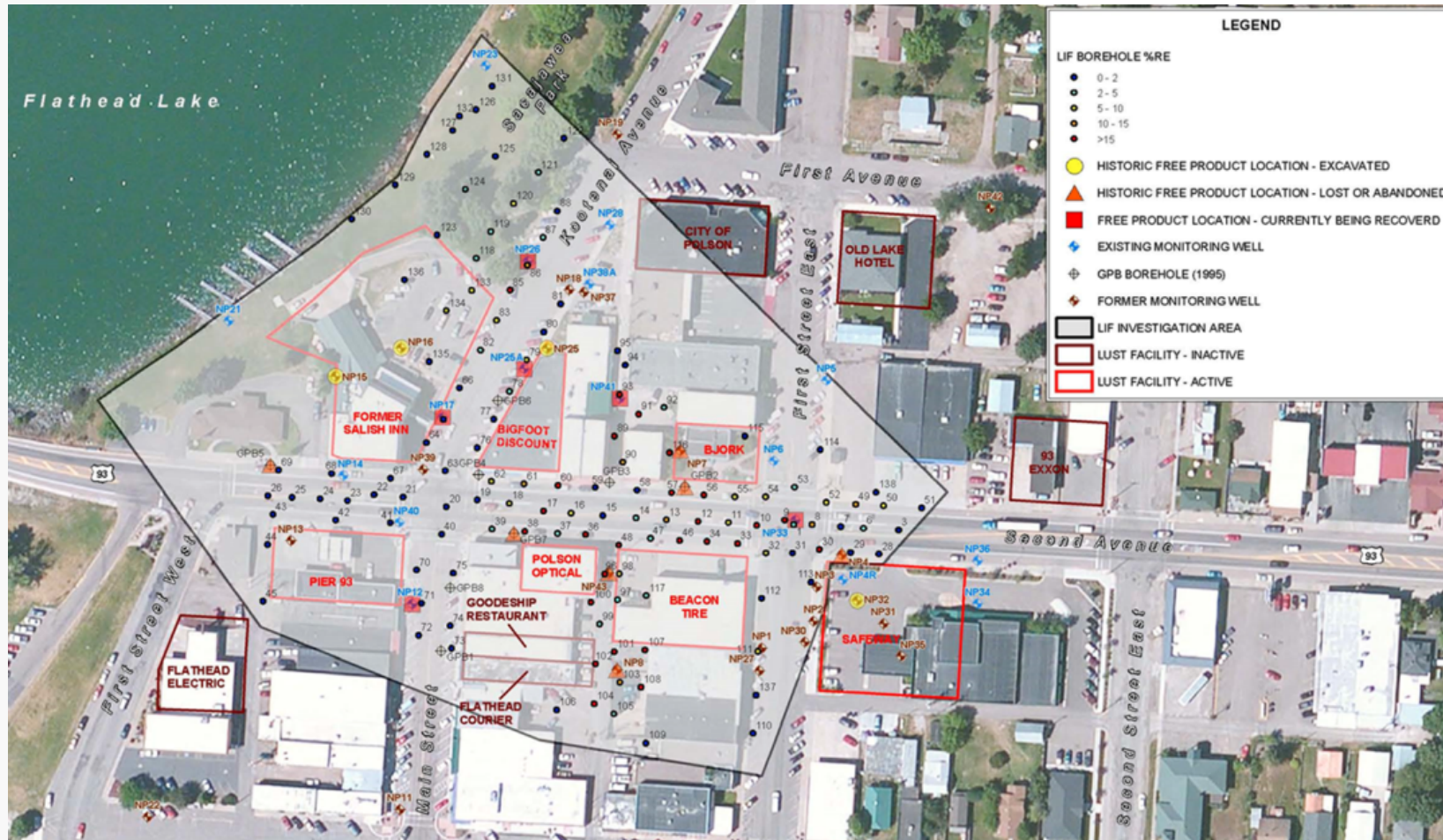
CAC Barrier Protects Flathead Lake, MT

Project Background

- Legacy petroleum release site in downtown Polson, initial investigation in early 1990s
- 13 facilities with releases and individual PRP ownership
- Large undefined LNAPL plume, LNAPL present in various monitoring wells across the site
- Complex lithology consisting of fine-grained, varved lakebed sediments
- Sensitive surface water receptor (Flathead Lake)

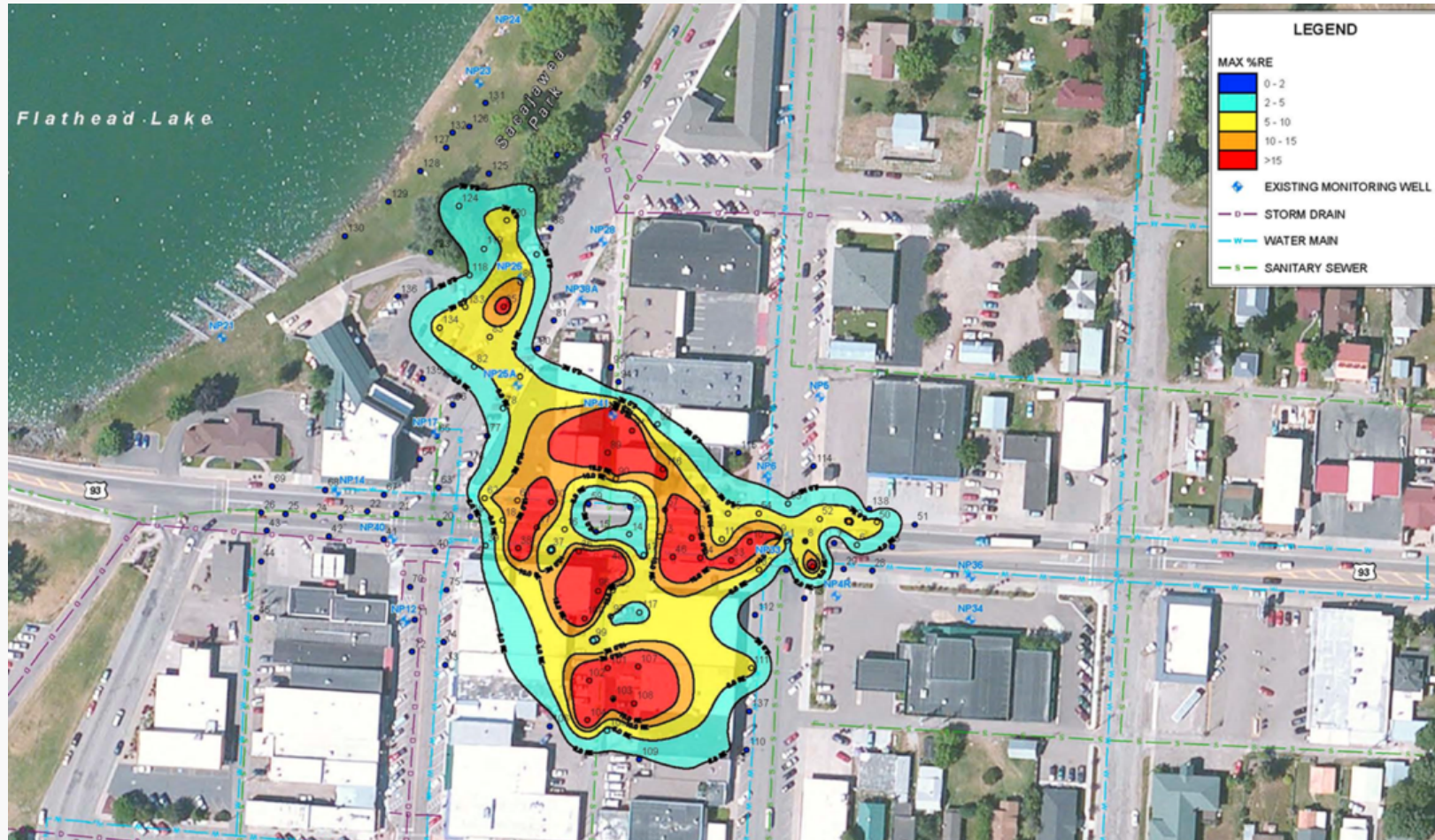
Flathead Lake Reactive CAC Barrier

CSM Development – HRSC Investigation

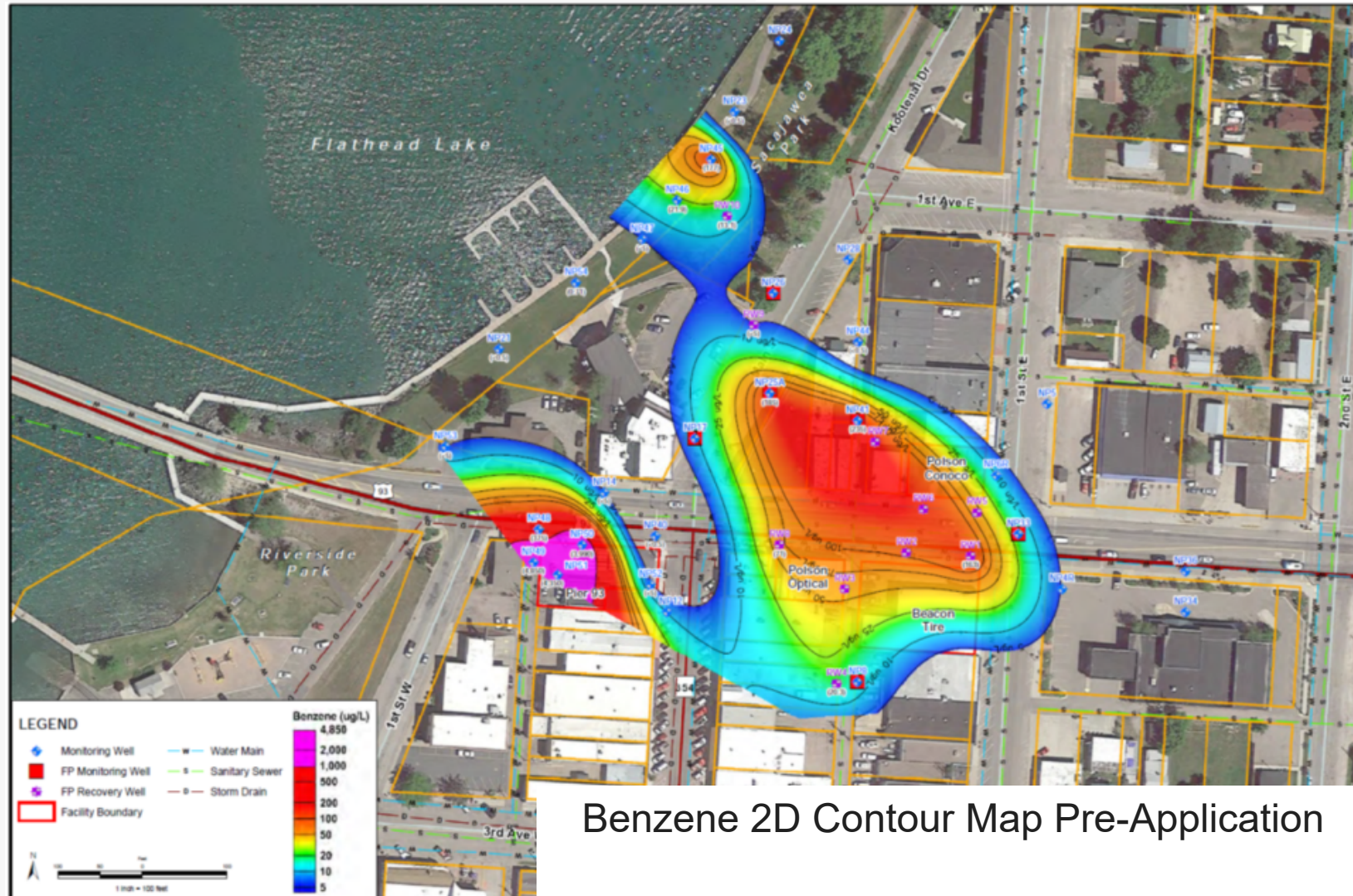


Flathead Lake Reactive CAC Barrier

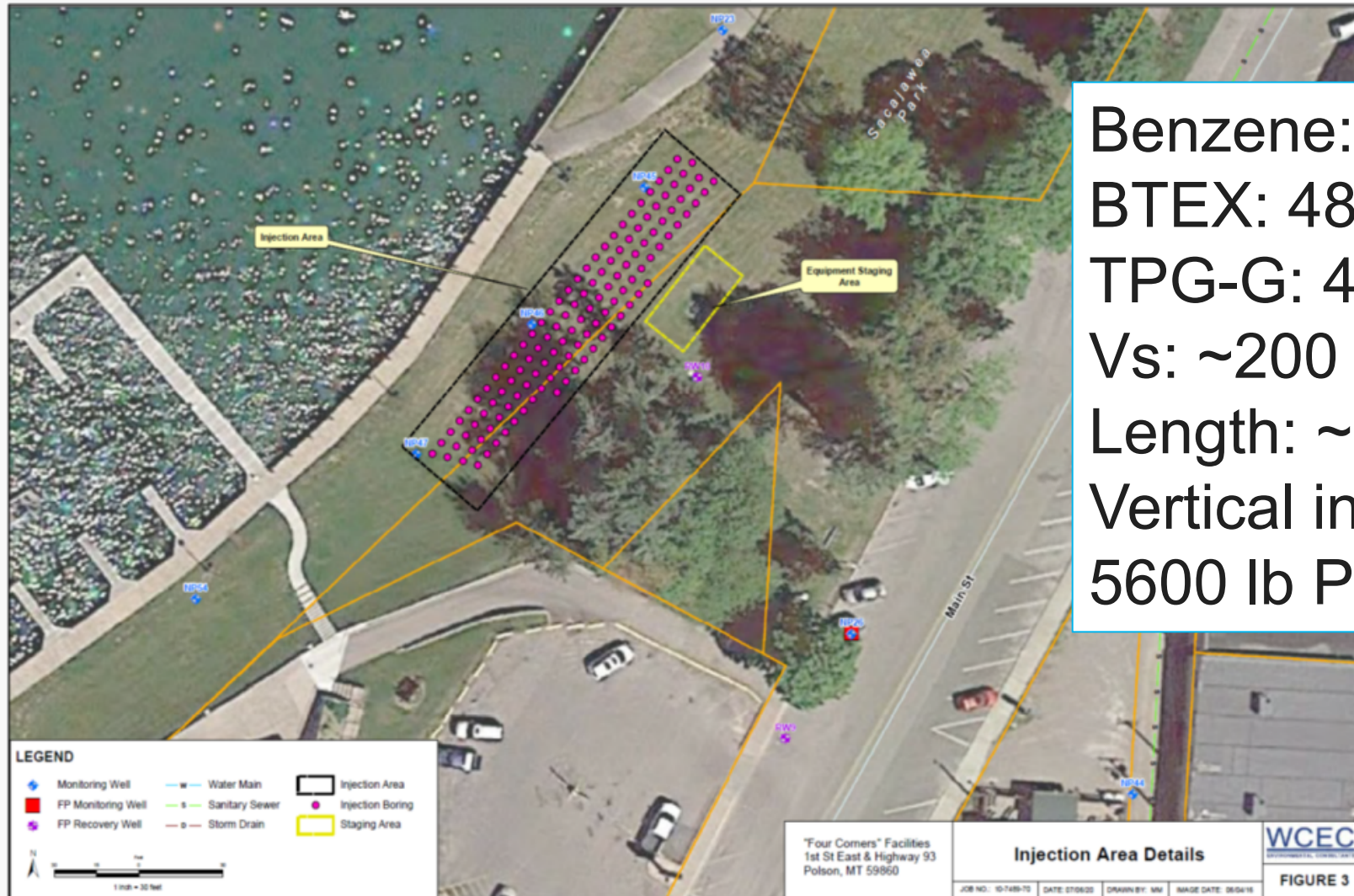
CSM Development – HRSC Investigation



Flathead Lake Reactive CAC Barrier



Flathead Lake Reactive CAC Barrier

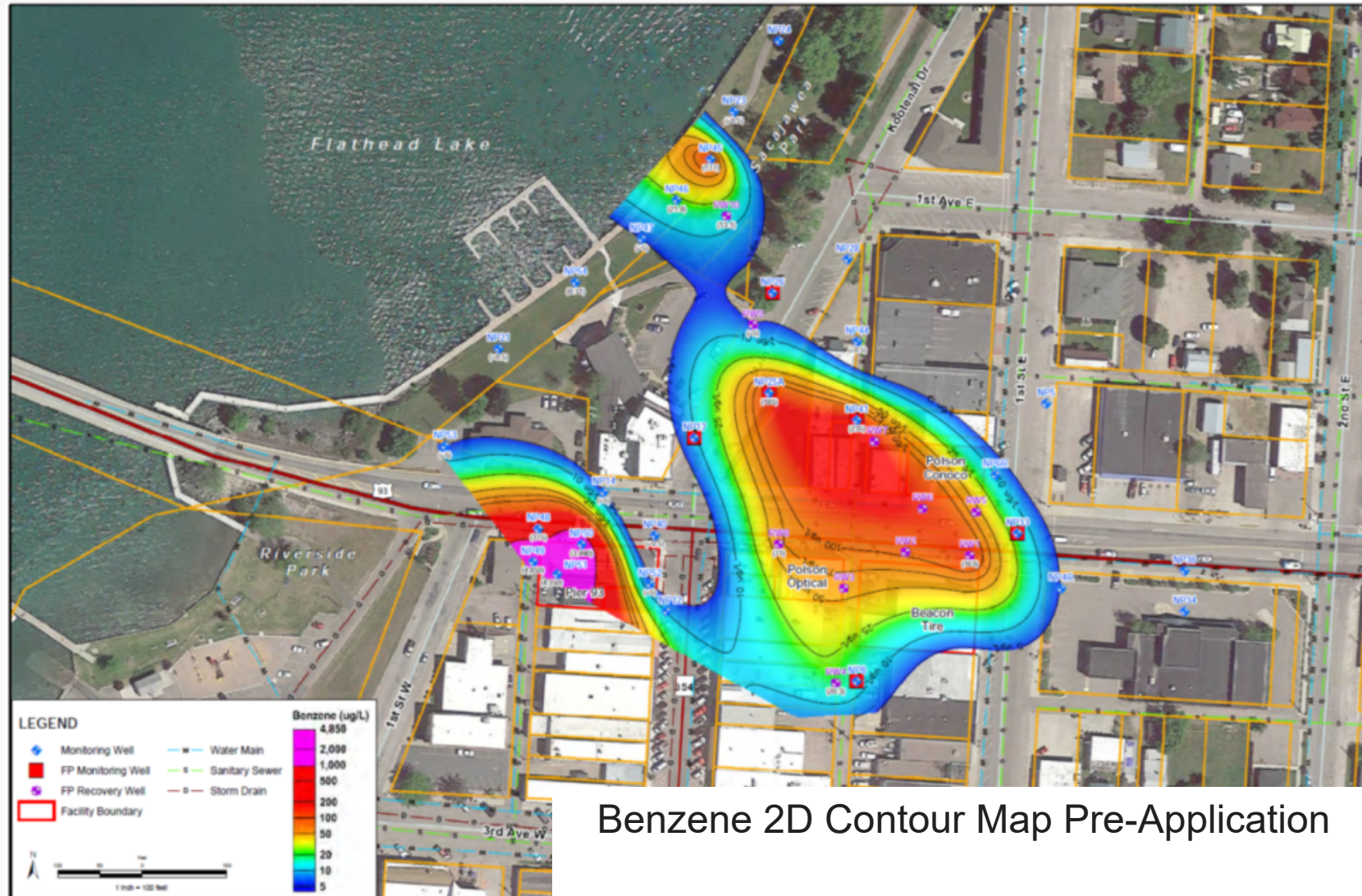


Benzene: 177 ppb
BTEX: 481 ppb
TPG-G: 4,590 ppb
Vs: ~200 ft/year
Length: ~180 ft
Vertical interval 6'
5600 lb PetroFix

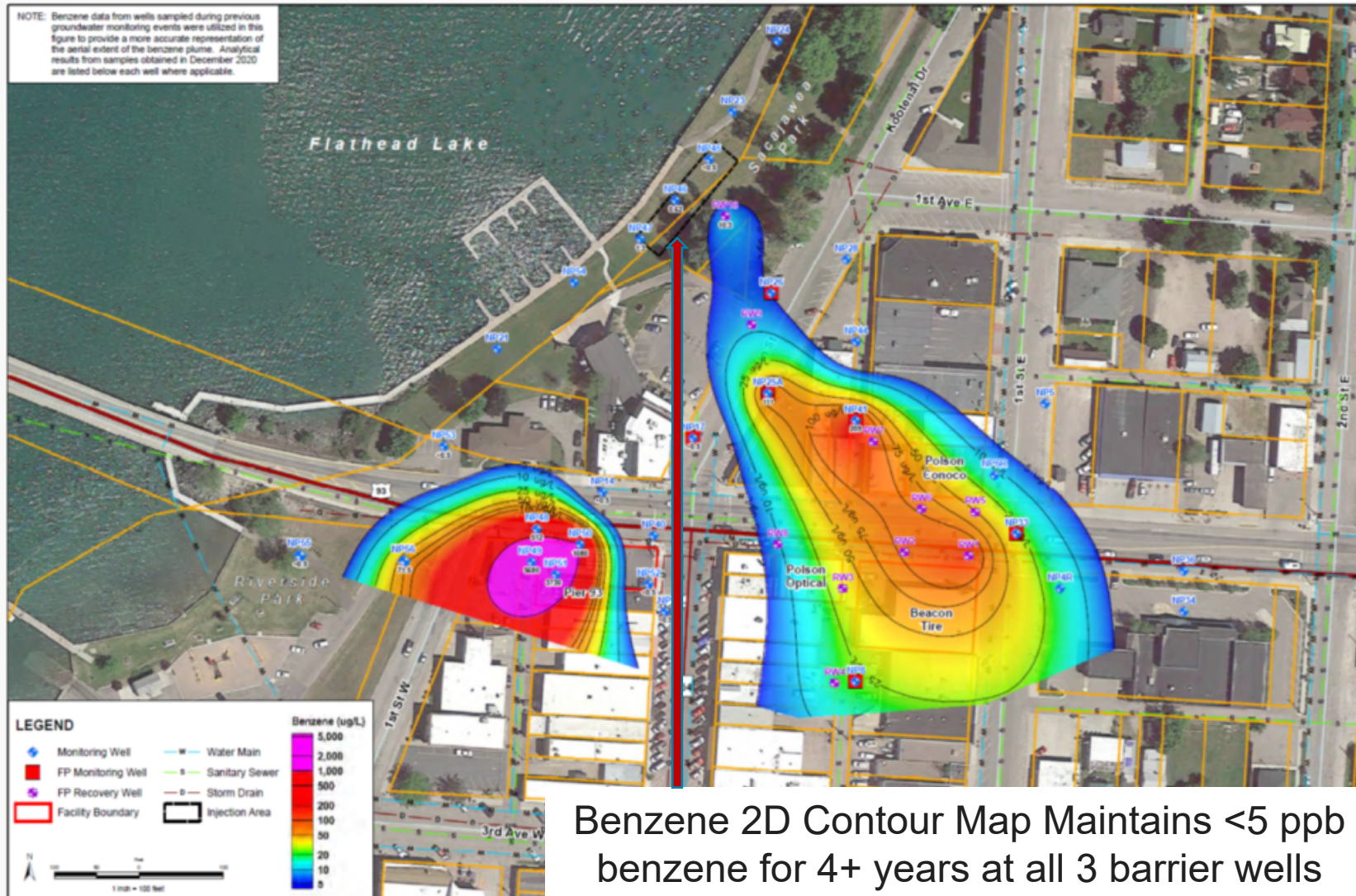
Flathead Lake Reactive CAC Barrier



Flathead Lake Reactive CAC Barrier



Flathead Lake Reactive CAC Barrier



Conclusions

Results:

- Mass flux is an important part of RCM
- CAC forms continuous, long-term barrier with bio-regeneration
- Field distribution verification is key
- Rapid achievement of low-concentrations
- Low concentrations can be achieved (to ND)
- Parking is an option, rarely needed
- Safe with wells

Questions?

Todd Herrington

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REGENESIS**

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