Site Characterization for ISCO Projects

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Site Characterization for ISCO Projects

- Primary considerations for an ISCO project:
  - What are the risk drivers at this site?
  - What are the goals of the remediation?
  - Where does the remediation process selection stand?
    - Is a plume management process required
    - Is a source control process required
    - What is the remediation history at this site?
    - What has been tried already?

Site Characterization for ISCO Projects

- Primary considerations for an ISCO project:
- What is the purpose/driver of the remediation?
  - Superfund, State, Brownfields?
    - What documentation/protocol is there for the site (PI/SI/RI/FS /CSM)? What data exists with respect to media and contaminants?
    - What methods were used to determine data?
    - Direct Push
      - MIPs/HPT
      - Waterloo Profiler
- Is there a success/failure history at this site?

Site Characterization for ISCO Projects

- Risk Drivers:
  - Receptors present and at risk
  - Defined pathway?
  - Nature of contaminants
  - Natural/background levels
  - Hazard assessment (Contaminant types)
    - Fuels
    - Solvents
    - Chlorinated solvents

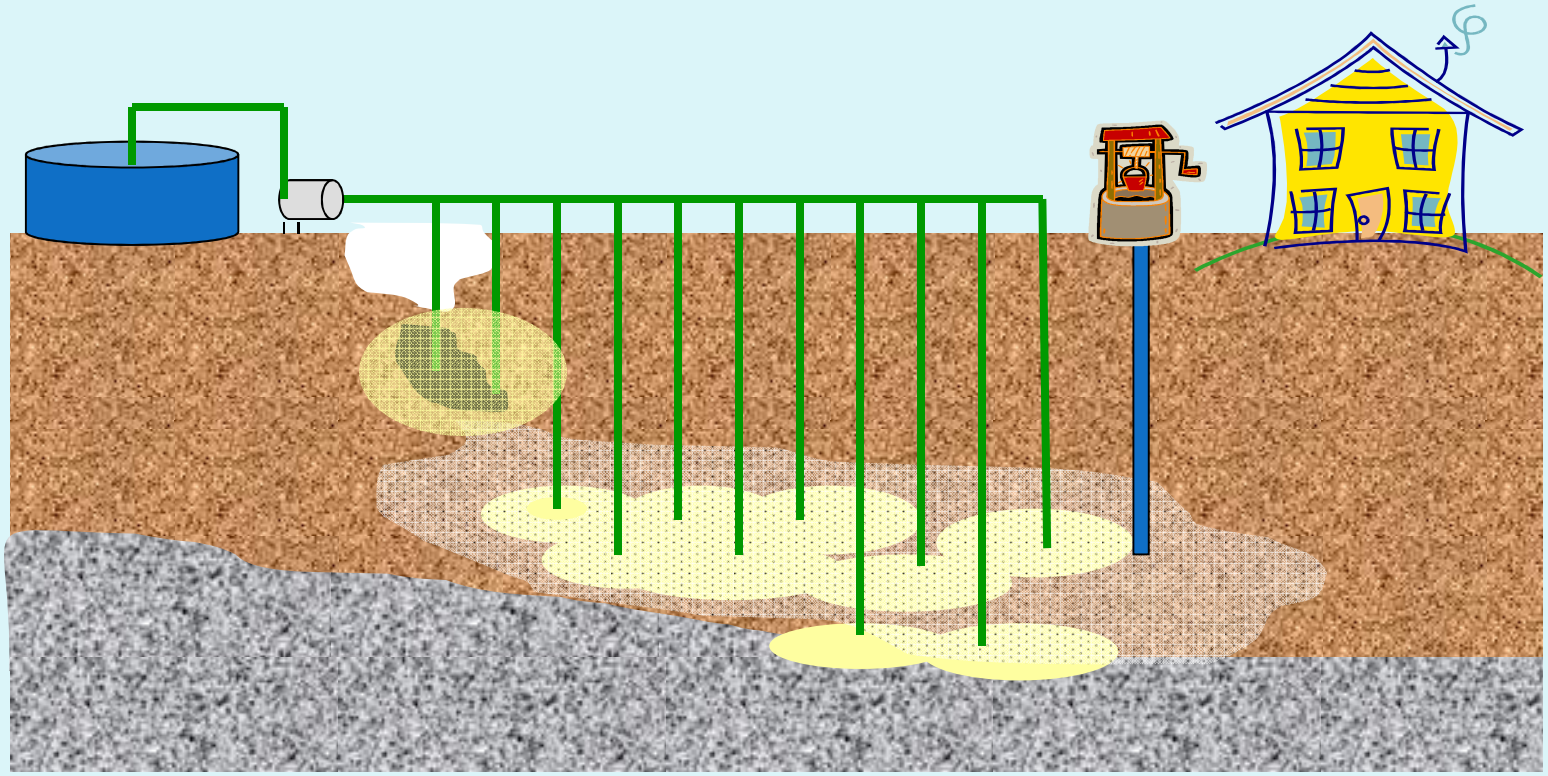
Site Characterization for ISCO Projects

- Requirements for ISCO Remediation Success
  - Proper Site Characterization
    - (soils, clays, silts, till, bedrock)
    - COC (solvents, hydrocarbons)
    - Sorption/desorption characteristics
  - Appropriate Oxidant / Activator Selection
    - (CHP, persulfate, permanganate, peroxone, peroxygens)
    - Chlorinated ethenes (PCE, TCE, DCE, VC,
    - Chlorinated ethanes (PCA, TCA, DCA, CT, CF,
    - Hydrocarbons
  - Oxidant Delivery and Monitoring

Site Characterization for ISCO Projects

- ISCO failures are commonly due to:
  - Under estimating COC mass or not addressing COC mass distribution (*e.g.,* lenses, varves, etc.)
  - Not understanding the geology and its impact on oxidant delivery, chemical interactions and the ability to establish contact with contaminants (Aqueous Contact Sport)
  - Low remedial target goals (MCLs) are difficult to achieve if the COCs are in low permeable material due to long term back diffusion
  - Skipped bench/pilot scale testing

Site Characterization for ISCO Projects



- **Oxidant + Contaminants + Soil →**

  CO_2 + oxidized soil components + stable intermediates

- **Mineralization SOD Demand ?**

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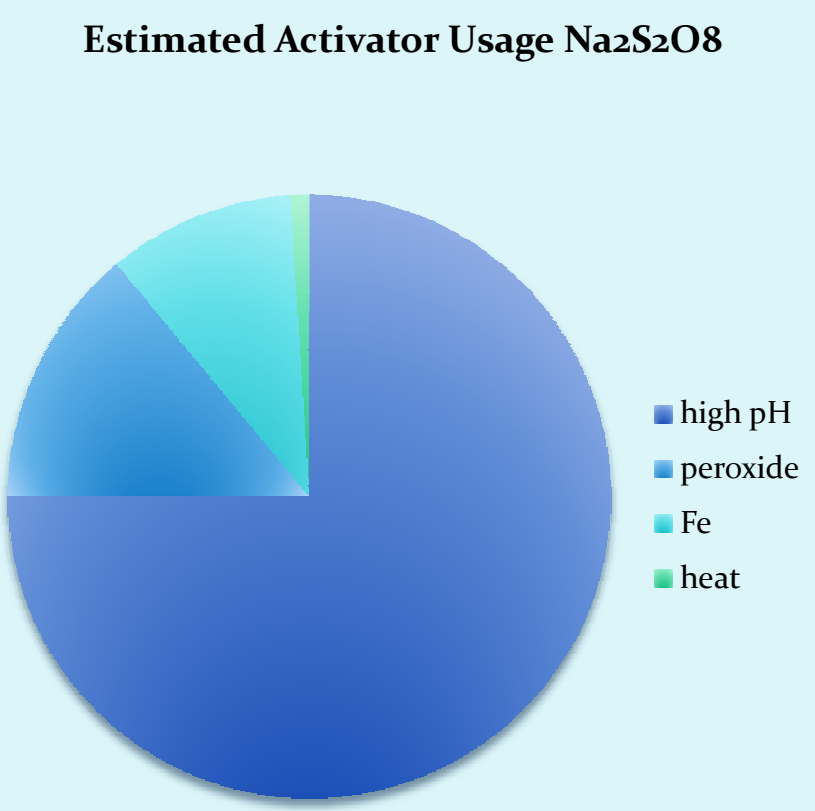
Oxidant Delivery and Monitoring

- Design based on Site Geology/COC/Mass Distribution/Architecture ; piloting
  - Primary COC mass on soils – Direct Injection strategy
  - Primary COC mass in GW – Recirculation Strategy
  - Multiple geologies/strata require different injection well design
  - Density driven flow of oxidant/activator considered in design
- Design monitoring program to demonstrate contact/distribution of oxidant/activator and COC destruction
  - Be prepared for field adjustments as needed
  - Monitor formation/destruction of by-products
  - Monitor soils/GW for remediation success

Site Characterization for ISCO Projects

- *Selecting the Right System Oxidant/Activator: Site conditions*
- lithology: clay, silt, sand, till, etc
- Mineralogy: catalysis, decomposition
- hydrogeology
- structures
  - buildings
  - subterranean utilities
- application method



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- Hydrogeology:

- Multiple aquifers
  - unconfined, confined

- GW velocity/direction is important to know:
  - Can effect ROI
  - Dilution effects
  - Effects contact time
  - Can eat up oxidant system if upgradient GW anaerobic
  - Soil organics/inorganics can eat up oxidant
  - High can prevent adequate contacting in silts and clays
  - High could flush mobilized metals downgradient
  - Too low inhibits “mixing/distribution”; many injectors

- Location of injectors and direction of flow important

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- Common Side Effects:

- Will bioremediation be feasible post-ISCO?
- What breakdown products will be of potential concern?
- Will pH recover?
- Will metals be mobilized?

Site Characterization for ISCO Projects

- BUGS: **Wimps or Warriors**:
- There are many strategies microbes use to survive
  - Can express water and hibernate
  - Cannot kill all microbes (some like it hot)
    - Microbes are survivors (3.5 billion years)
    - Microbes have survived catastophic changes
      - Earthquakes, sunamis, vulcanism, droubts, floods
  - Upgradient supply infinite: Resupply inevitable
  - Remediation merely establishes "King of the pile"
  - Resupply and nutrient availability more important

Site Characterization for ISCO Projects

- <u>Byproducts & Breakdown Products of ISCO</u>
  - Gas production: CO_2, O_2, H_2O (Steam) function of oxidant type and dose strength
  - Paramount is the type of contaminant (solvents, fuels)
    - Chorinated methanes from solvents
    - Acetone, ketones
  - Type of oxidant (permanganates, persulfates, activators)
  - Stability/persistence of oxidant/activator system
  - Desorption – “rebound”
  - Multiple ISCO events typical

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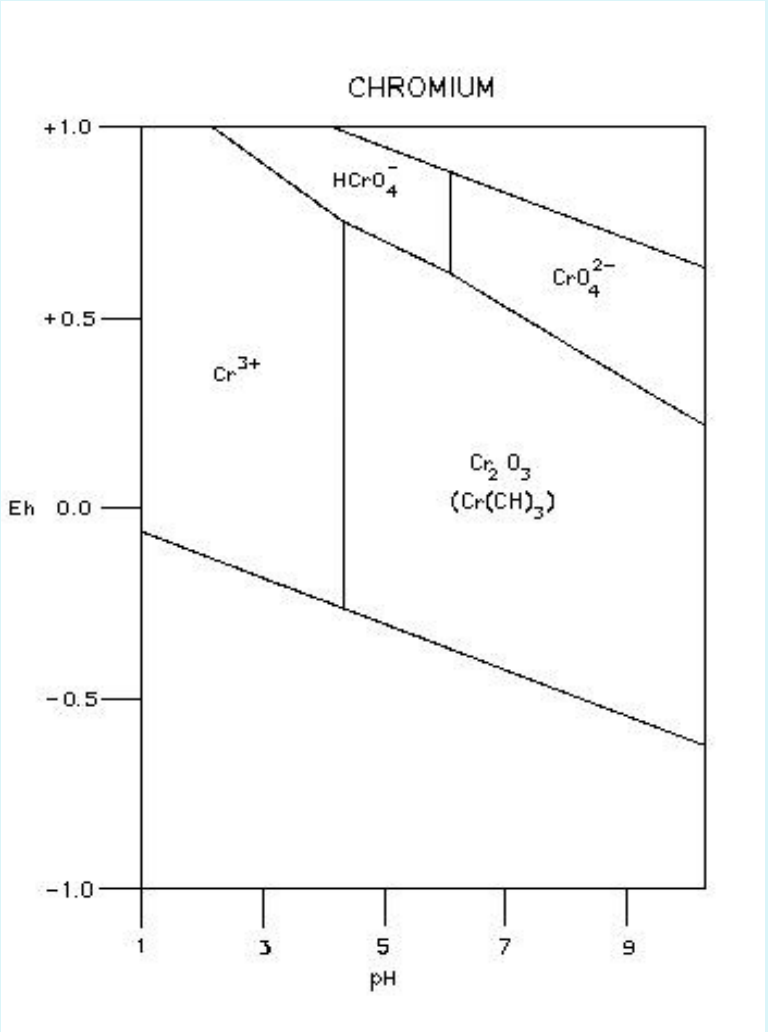
- Attenuation:
  - Buffering Capacity (redox, pH)
  - Solid-surface interactions/ion exchange
    - -ve surface charges/pH)
    - Metal oxides (MnOx, FeOx)
  - Mineral dissolution-precipitation reactions
    - Calcite [$CaCO_3$], gypsum [$CaSO_4$], etc.
- Dilution

Site Characterization for ISCO Projects

- <u>ISCO Side Effects</u>:
- pH
- Mobilization/Precipitation
  - pH effects
  - Change in redox conditions
    (oxidation/reduction of metals)
- Transformation
  - Cr (III); Cr (VI)



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- Metals Mobilization:

- Reduced metals will be oxidized
  - Chromium III will oxidize to Chromium VI
- Site conditions will determine long term fate
  - Generally site conditions will revert to pre ISCO
  - Monitoring will alleviate concerns
  - Time to revert to background is typically unpredictable

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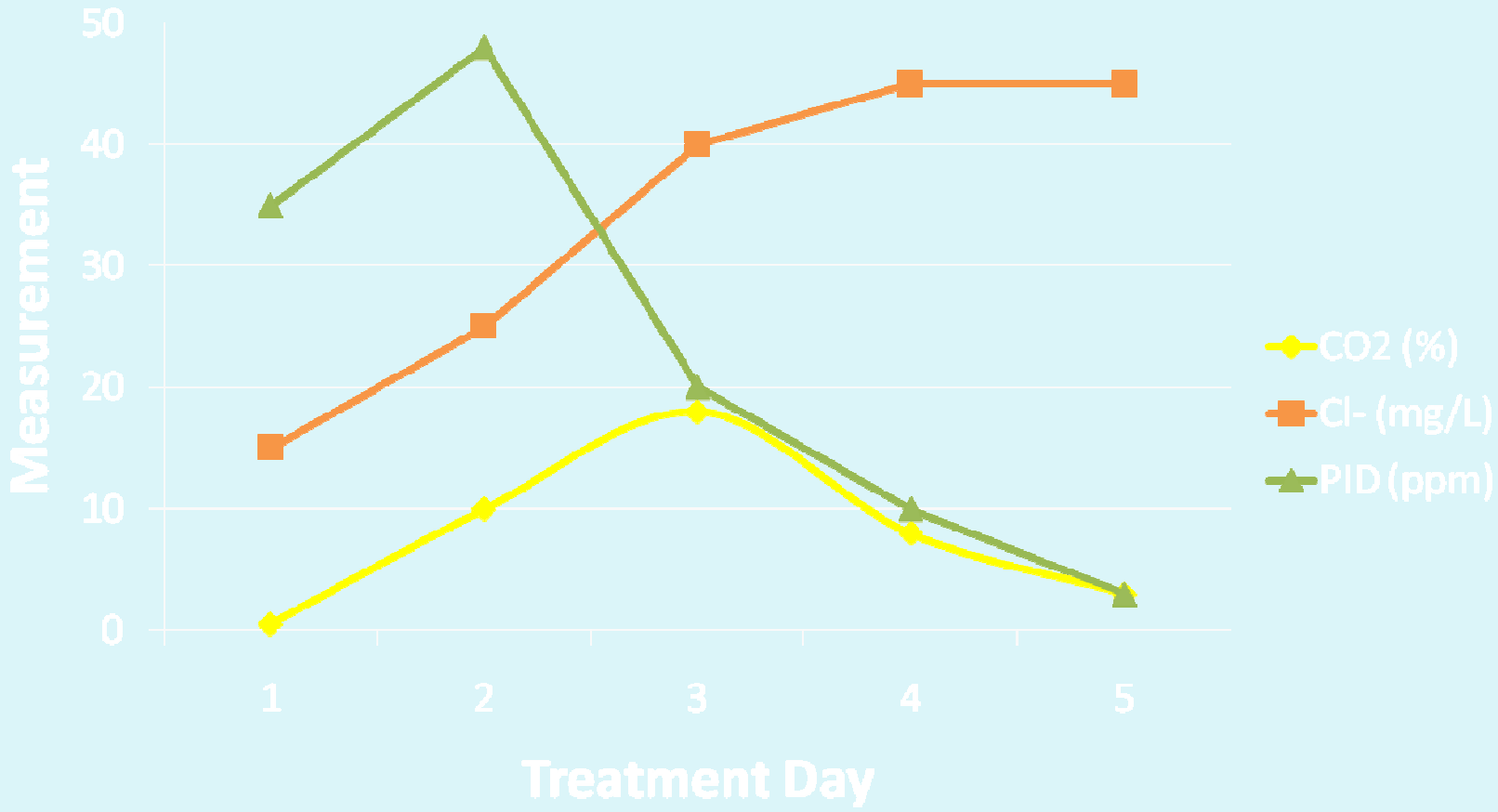

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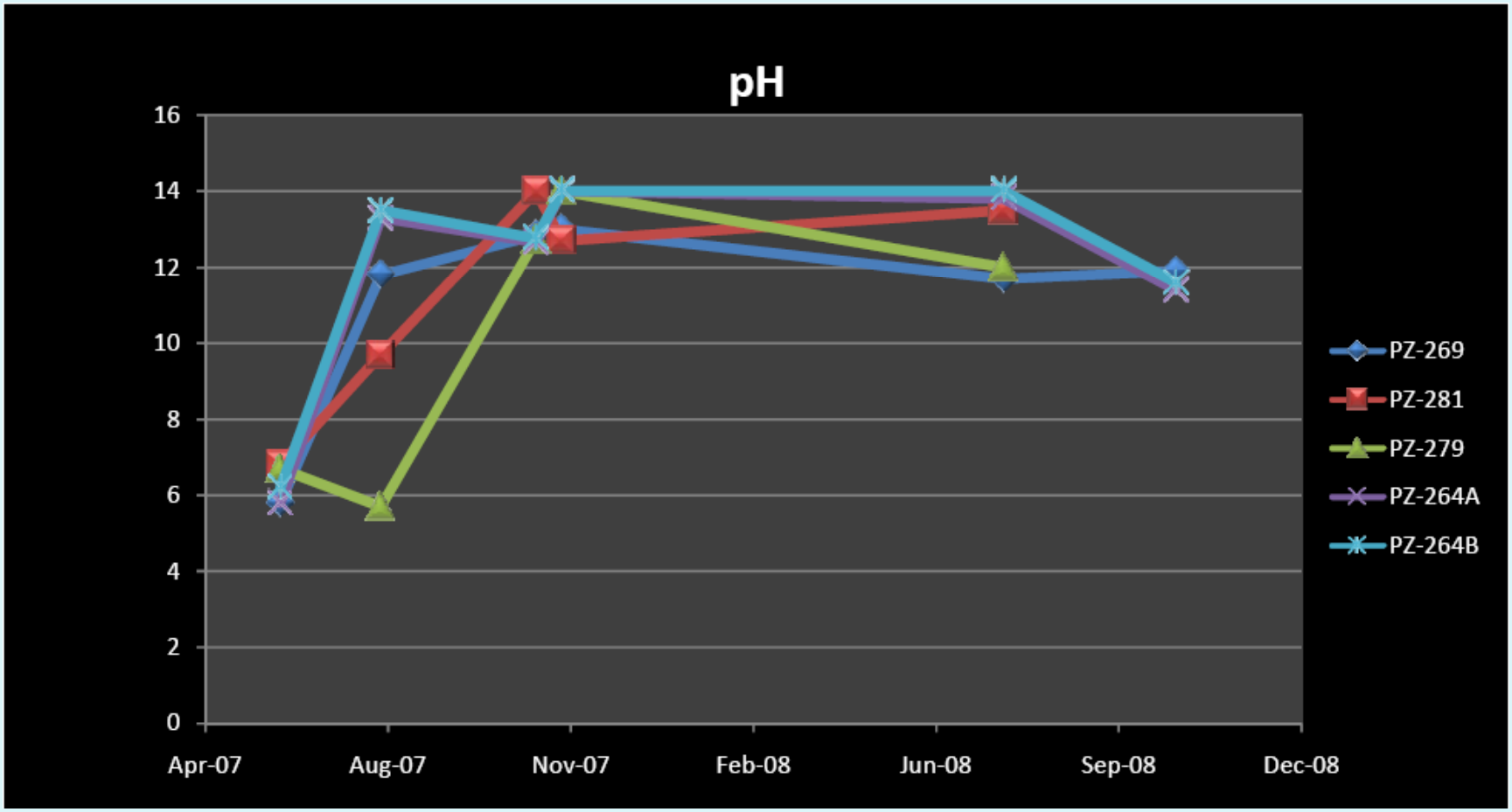
Alkaline Activated persulfate



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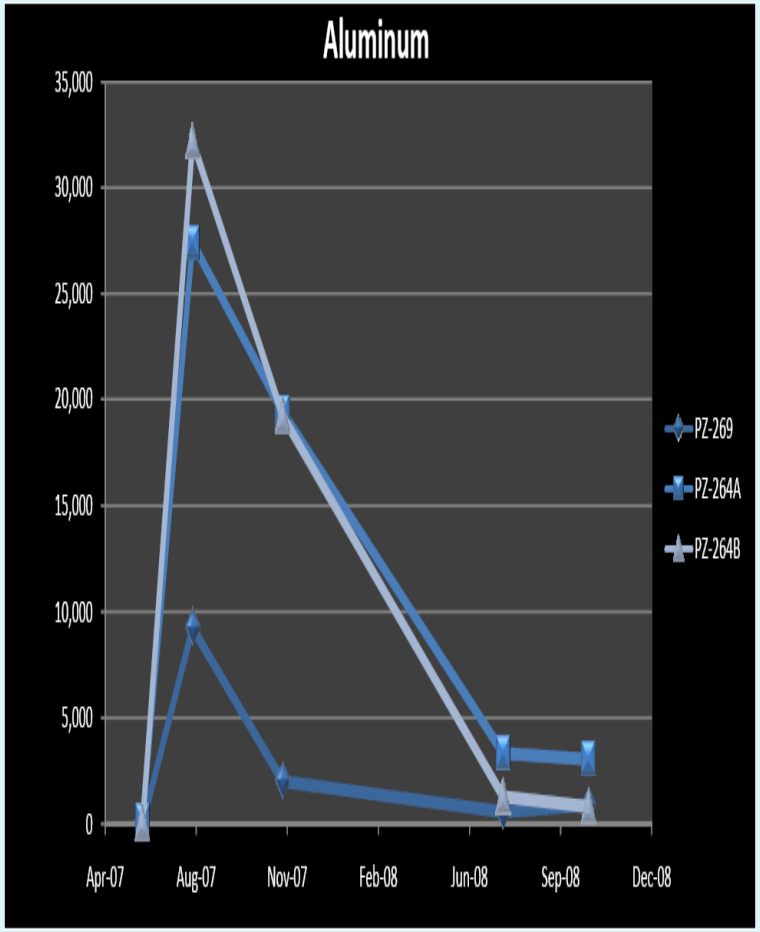

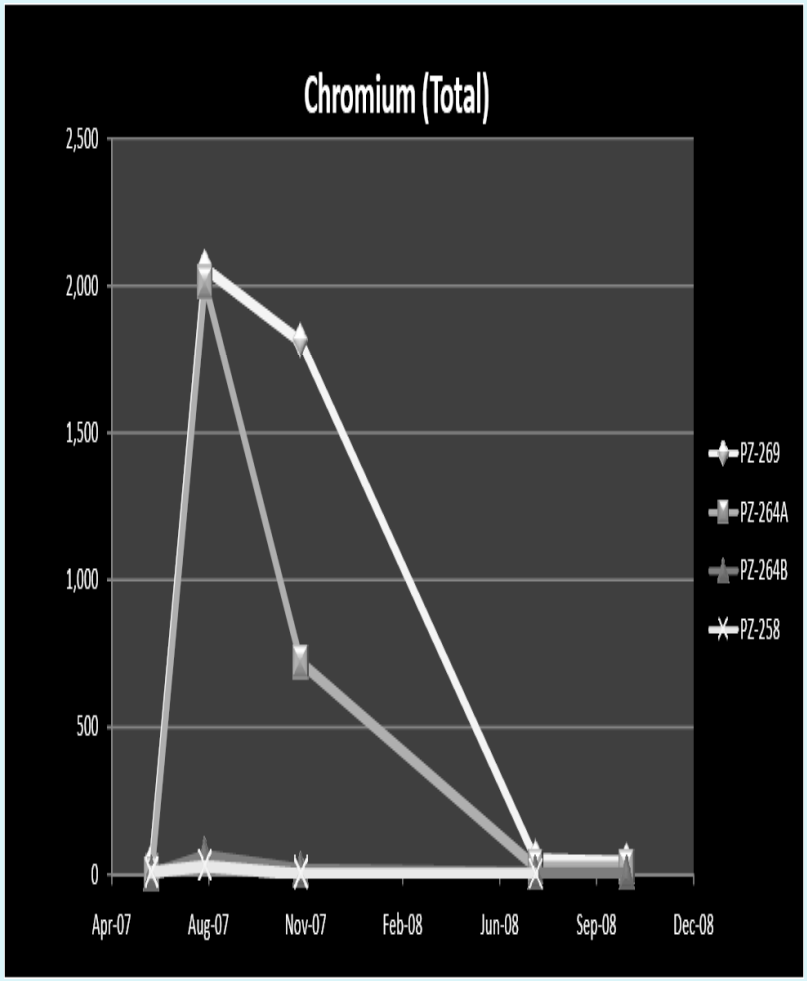

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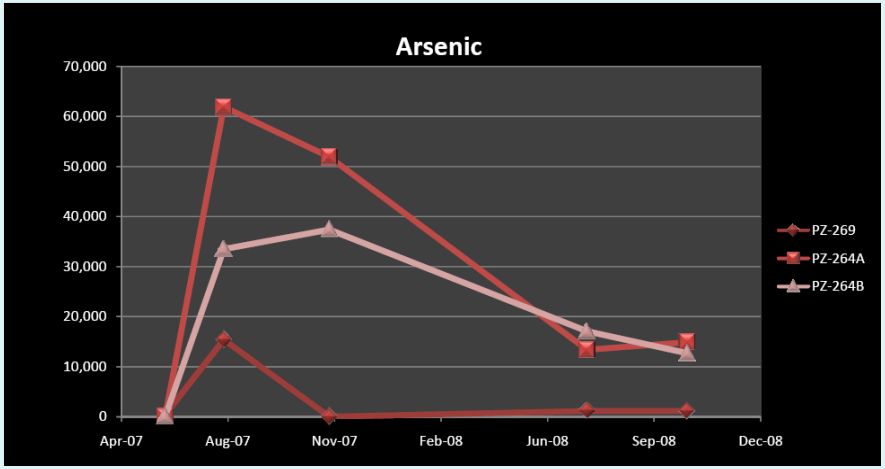

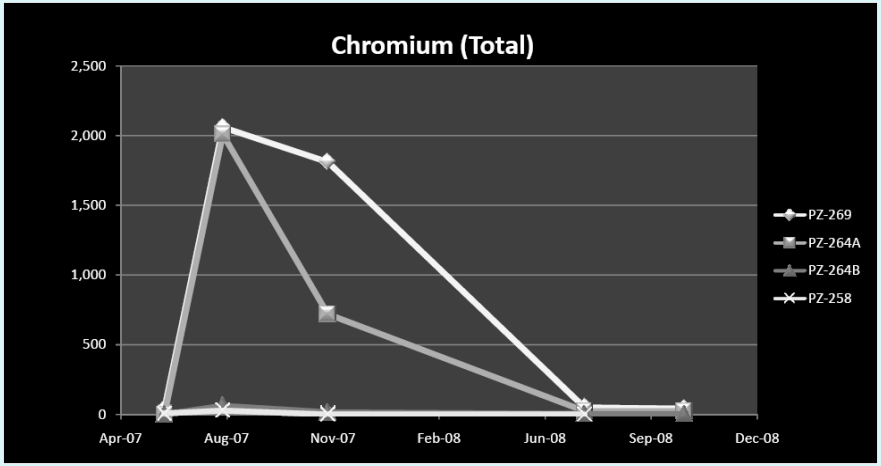

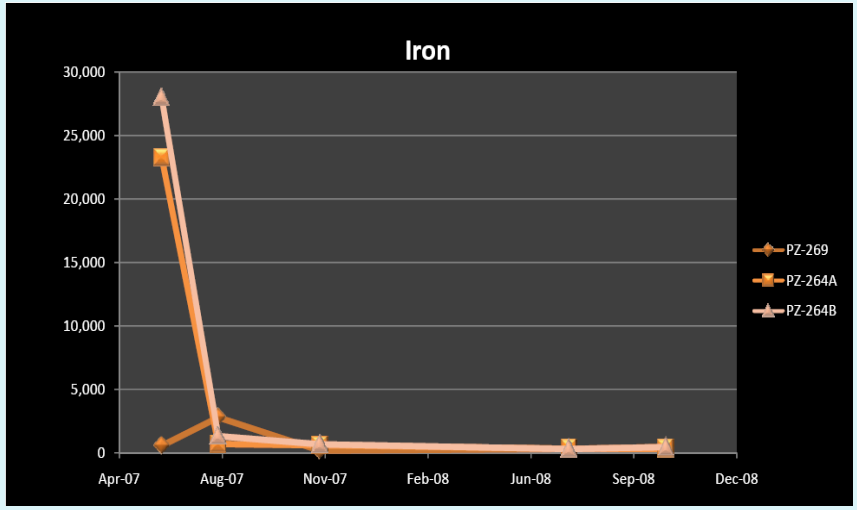

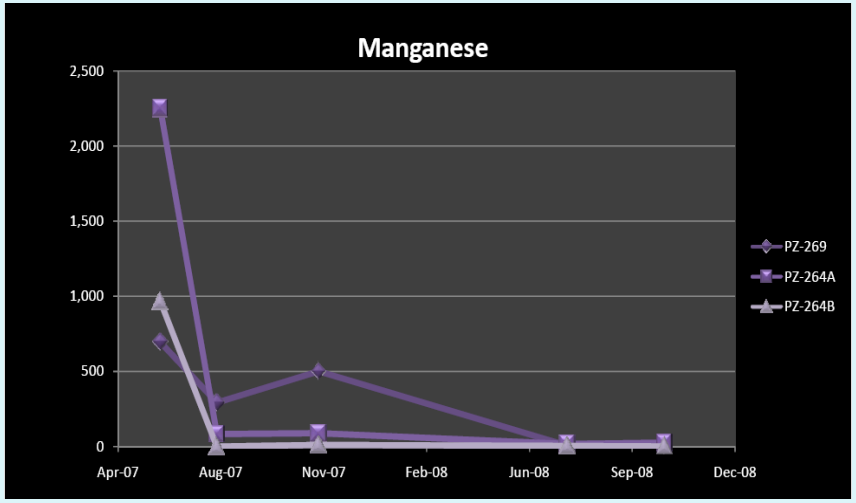

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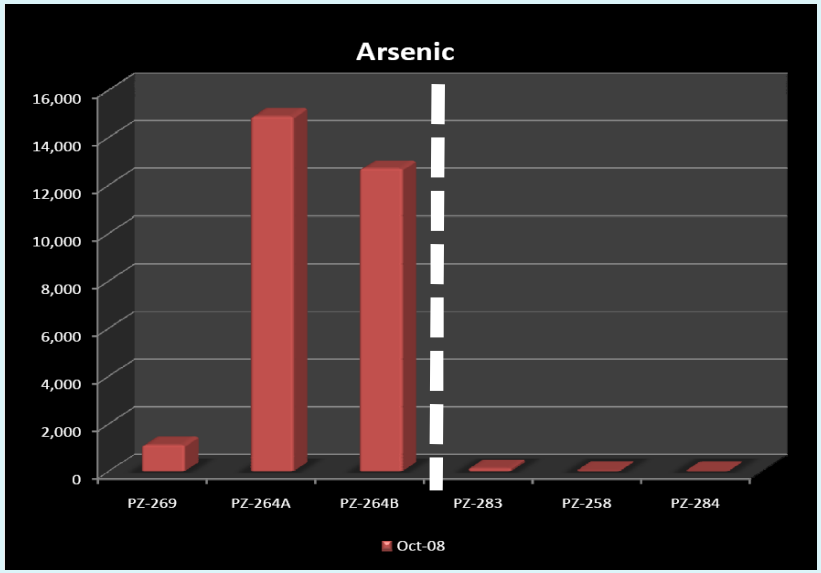
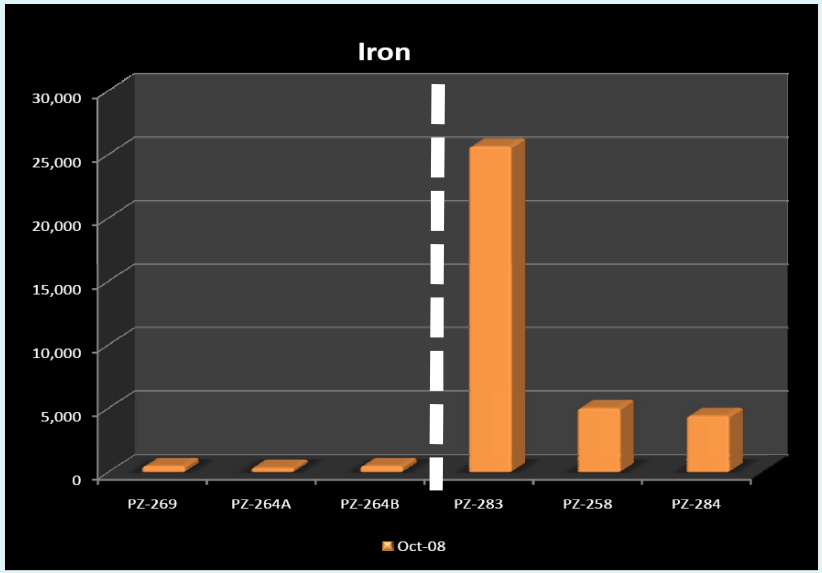
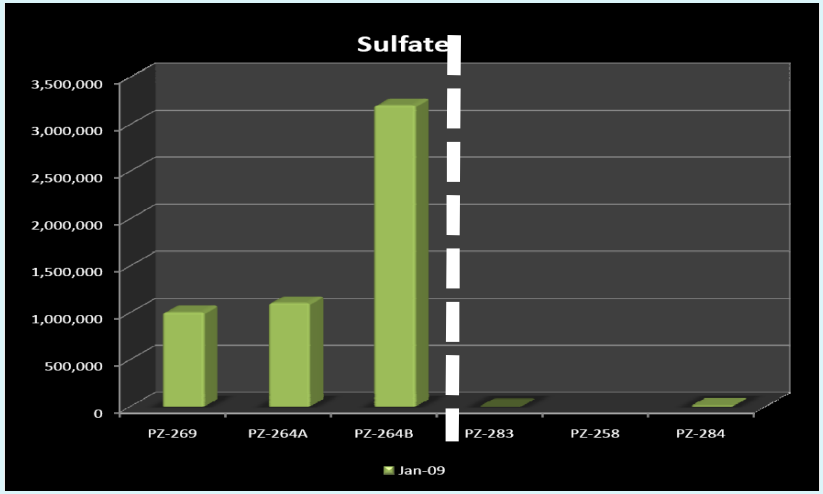
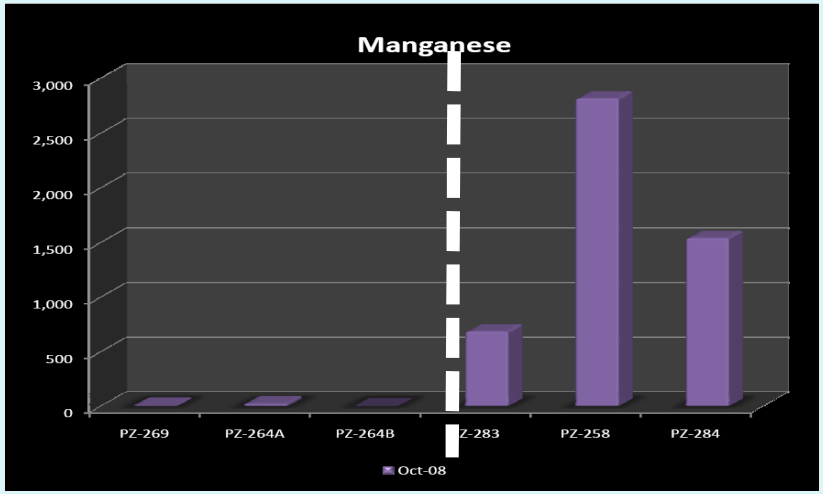
Downgradient Water Parameters







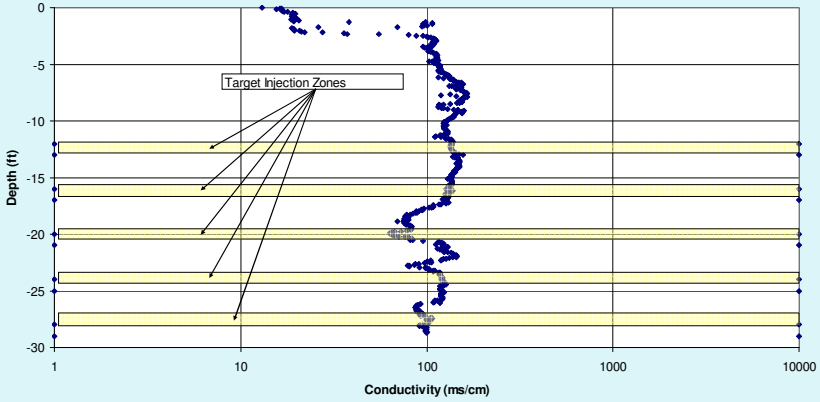


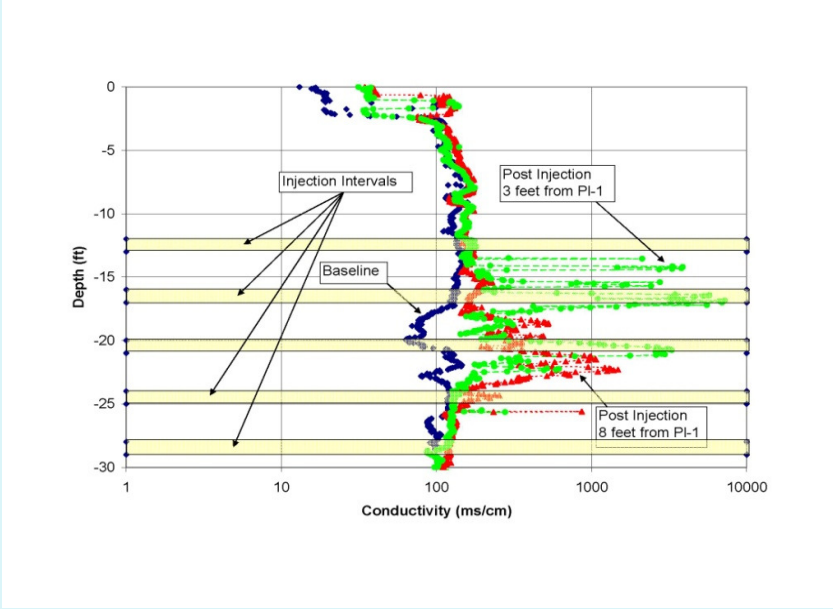
Site Characterization for ISCO Projects

Persulfate is an inorganic salt and will increase the conductivity of the groundwater into which it is injected

Measuring the soil conductivity before and after persulfate injection helps in determining if the persulfate was delivered in the subsurface aquifer zone of interest

Increases in soil conductivity indicate the persulfate was delivered to the target zone





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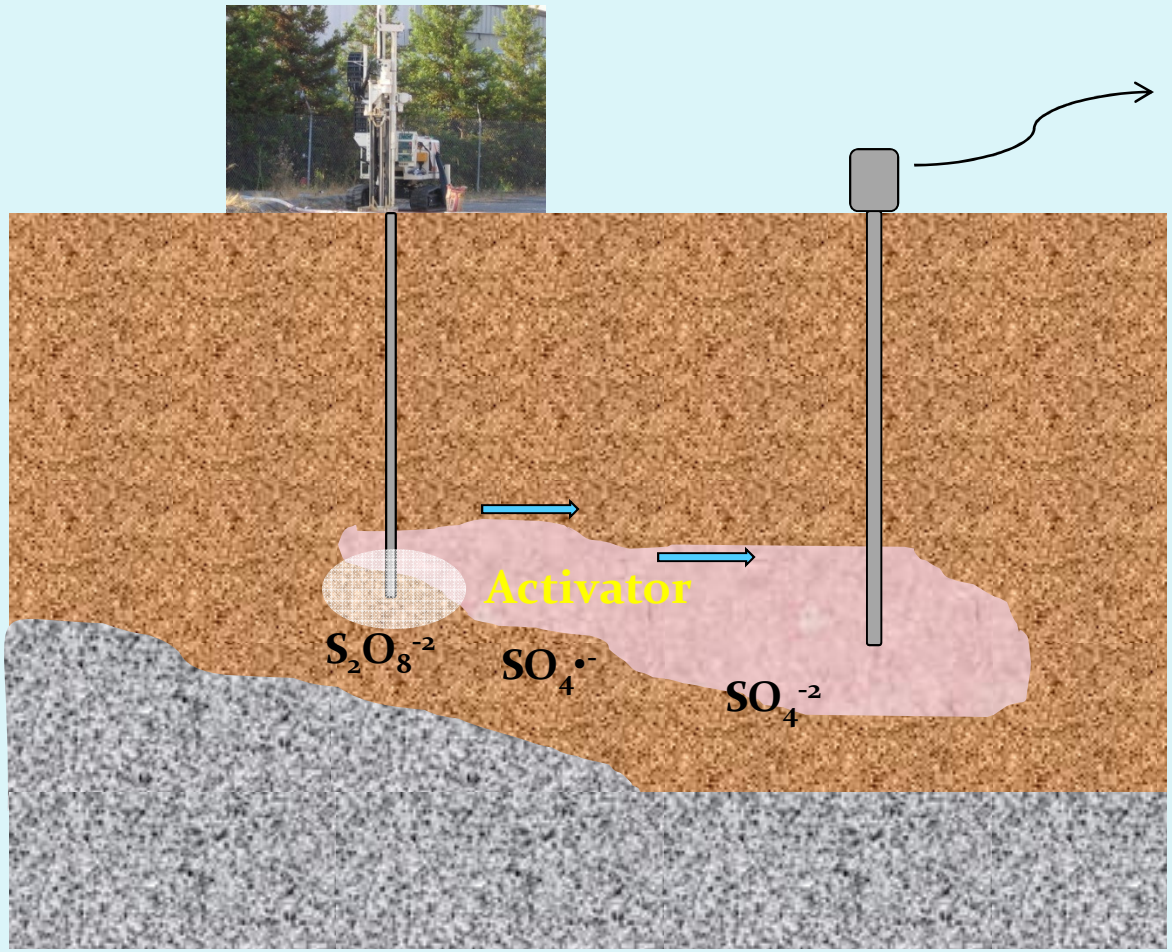


Groundwater Measurements

Primary

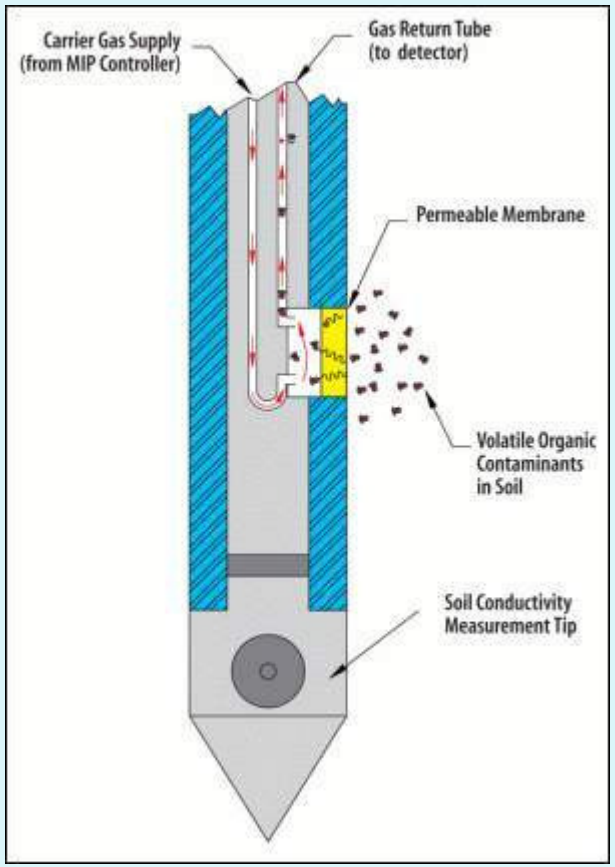
- Contaminant
- Oxidant (Persulfate)
- Activator

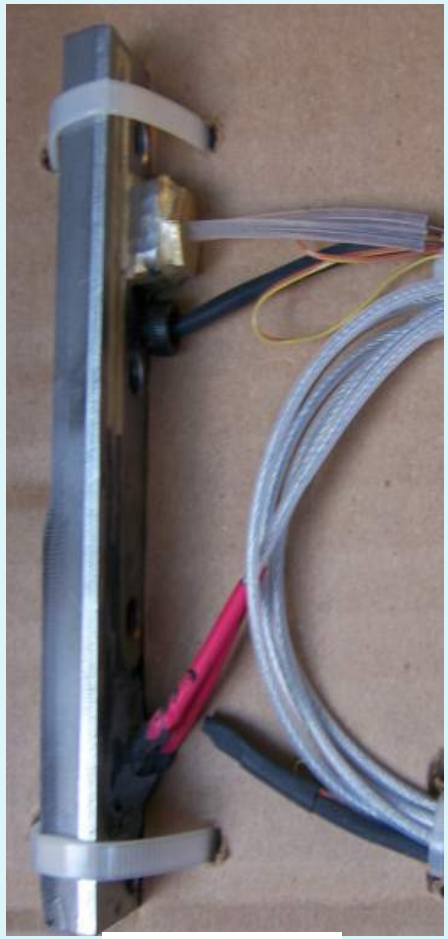
Secondary

- sulfate
- ORP
- DO
- pH
- conductivity
- (chloride)

Site Characterization for ISCO Projects

Membrane Interface Probe





VIRONEX

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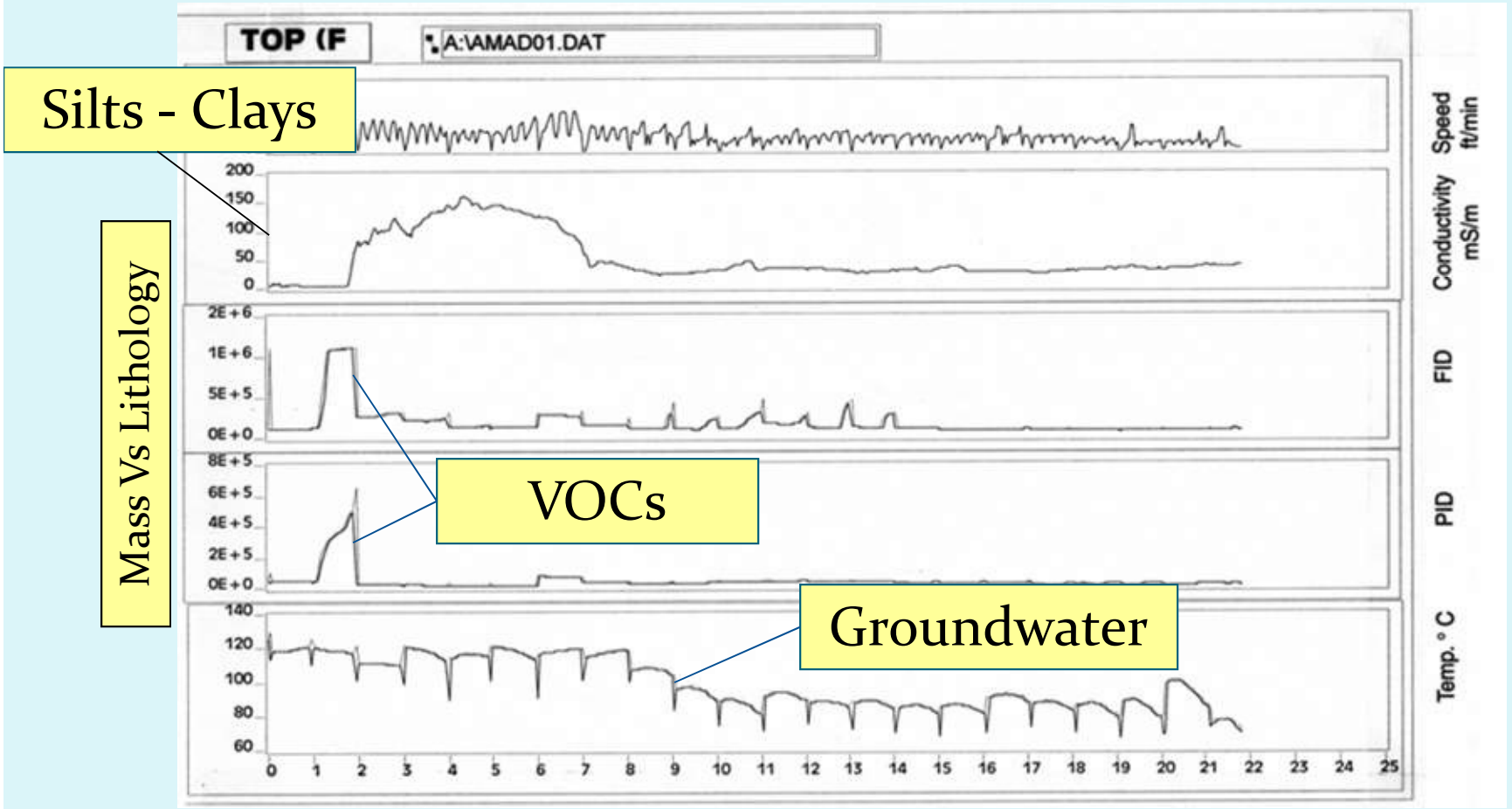

Site Characterization for ISCO Projects

- Direct push
- Fixed well
- *in situ* soil blending
- *ex situ* soil blending

On-site blending

Fixed SS Wells

In situ blending

CHURNGOLD

Thornton, England

Redox Tech, LLC

Hoboken, NJ

Direct Push Rig

VIRONEX

Site Characterization for ISCO Projects

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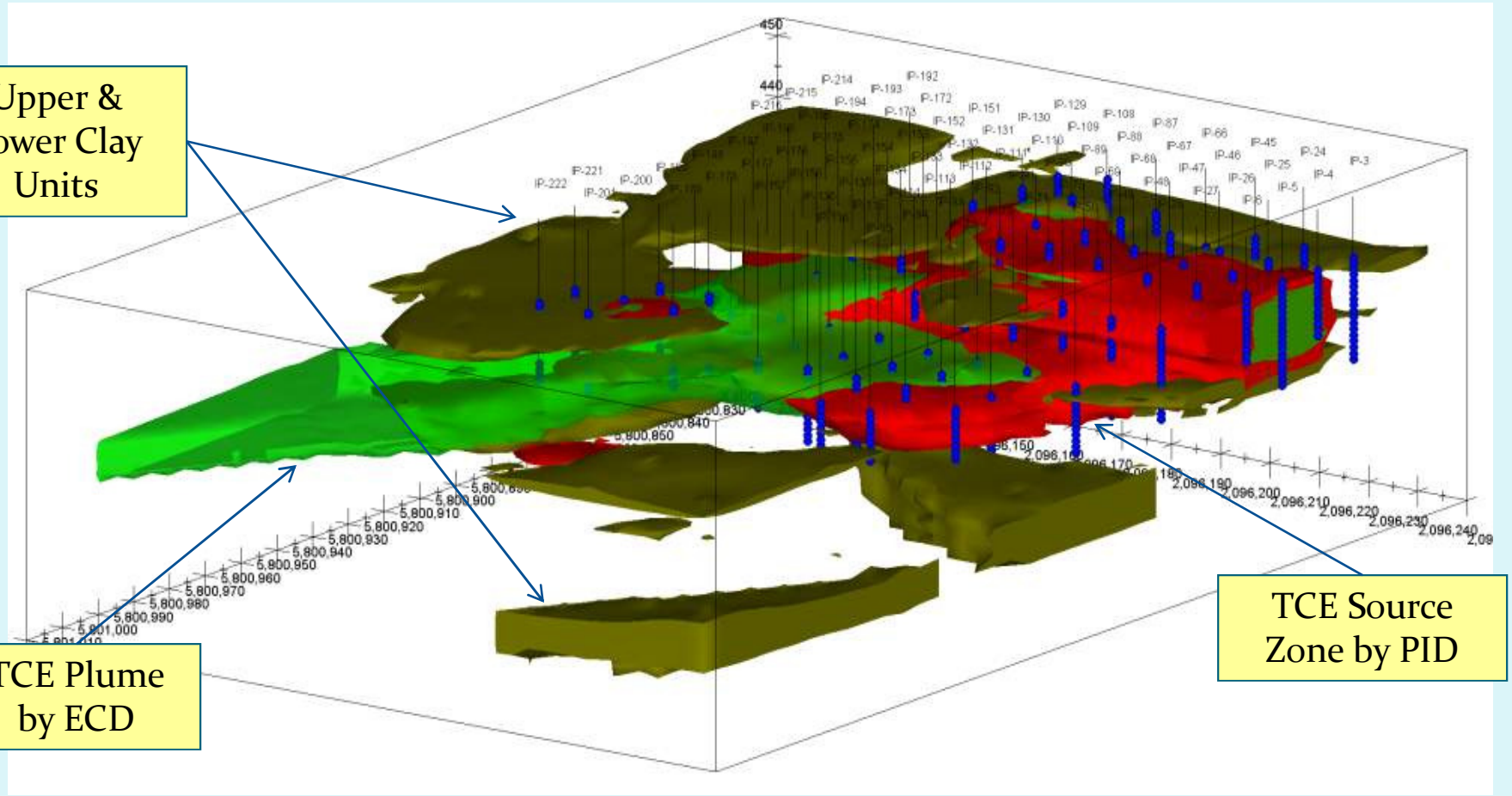
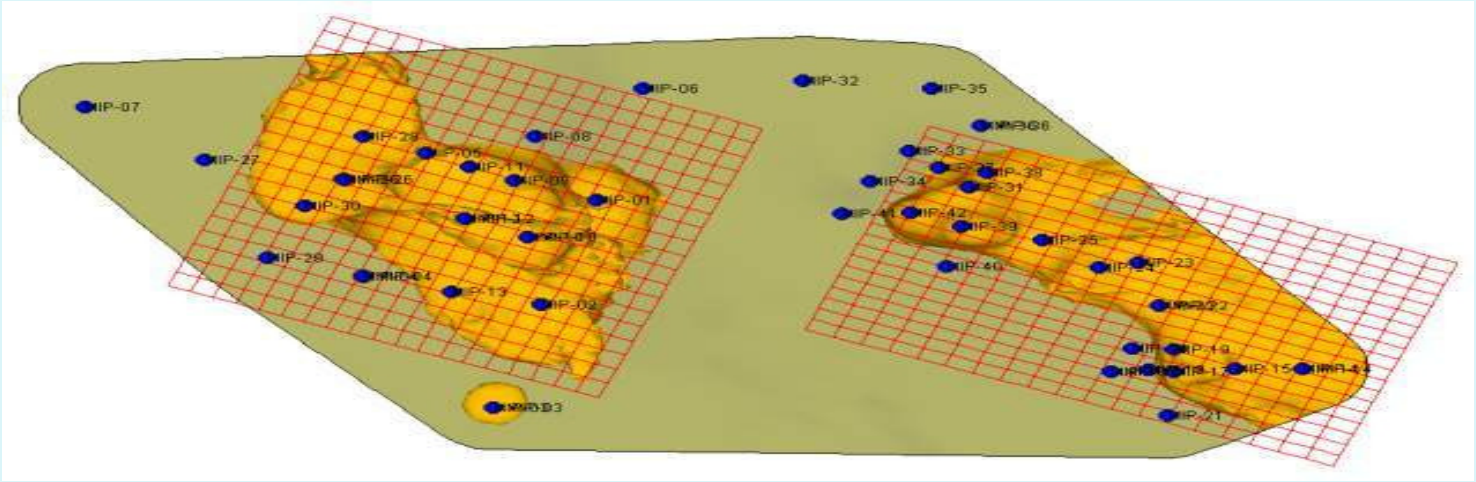
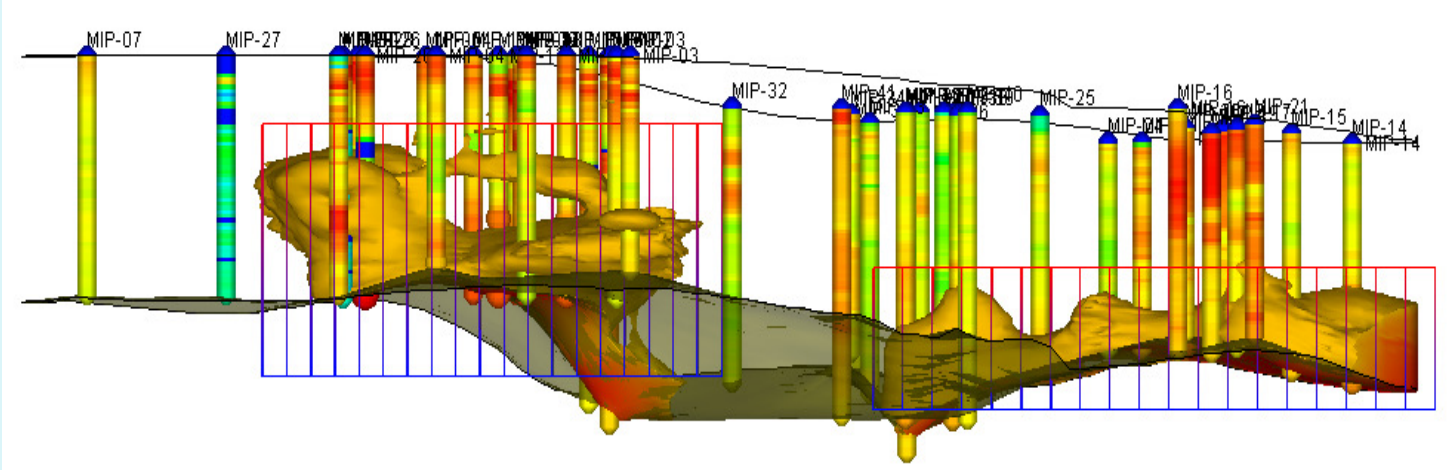


Site Characterization for ISCO Projects

Injection Strategy





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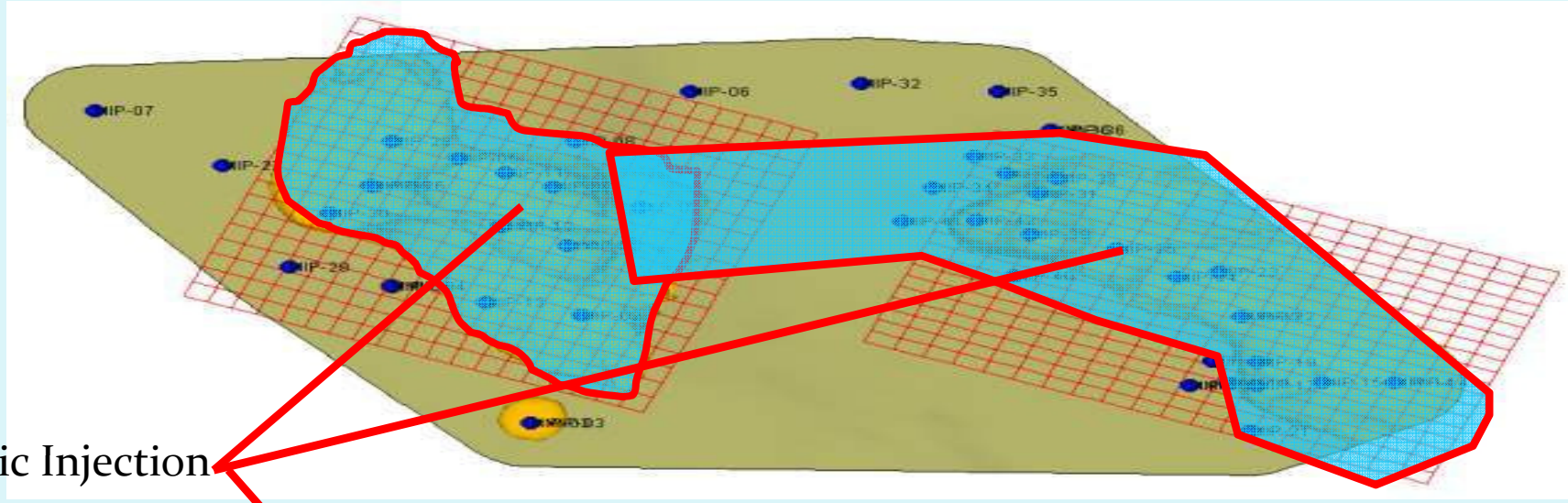
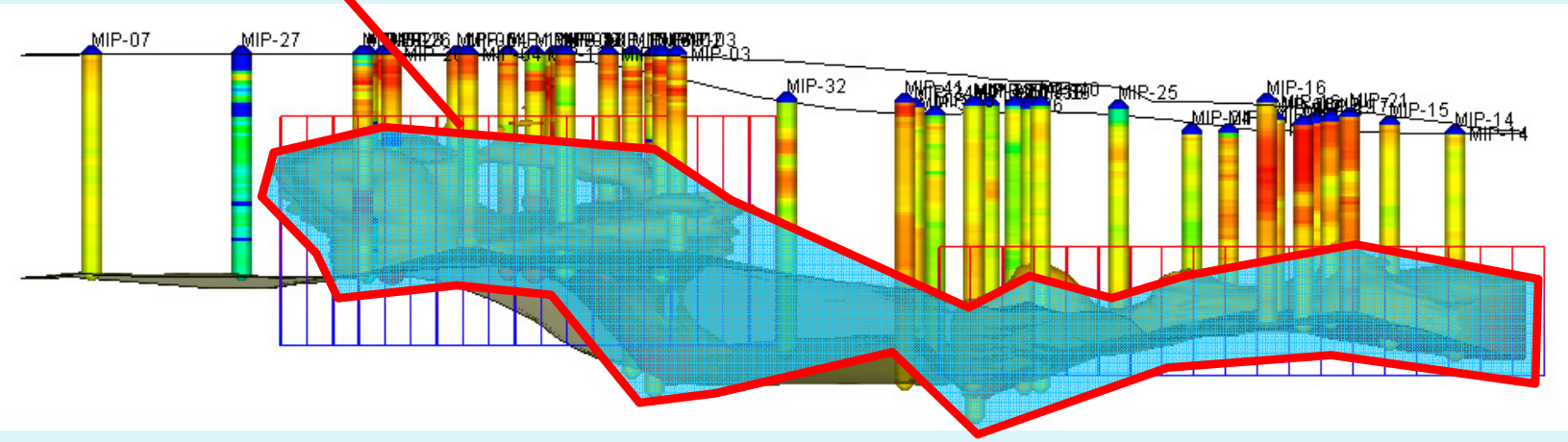


Strategic Injection



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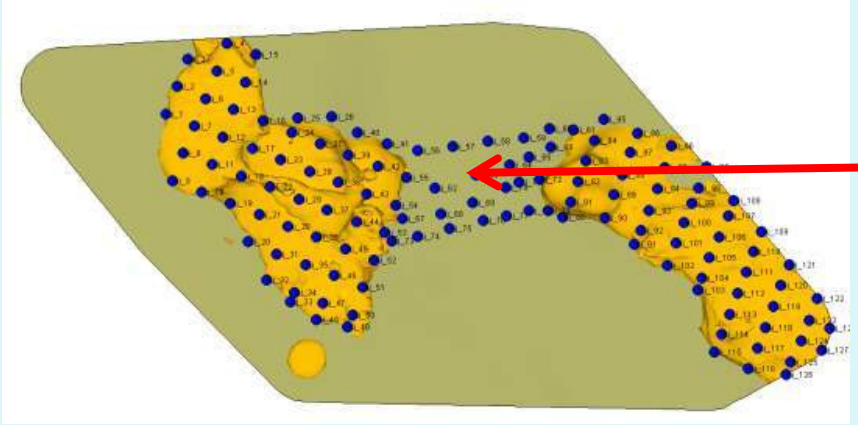
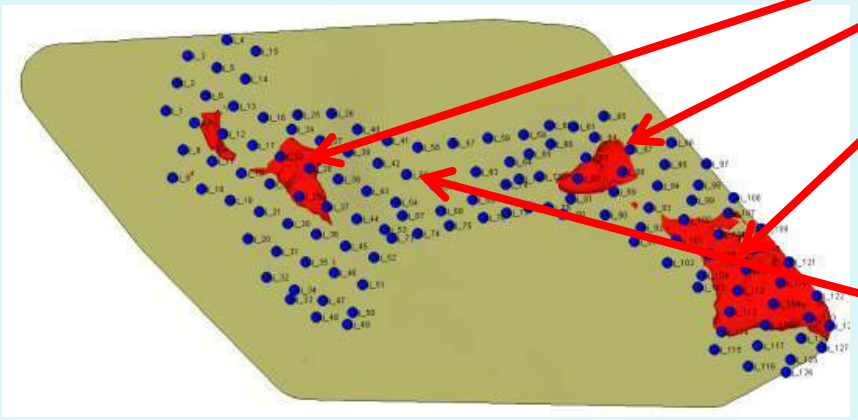


Pre-Injection MIP

Residuals



Post-Injection MIP

Site Characterization for ISCO Projects

- Some other example sites where characterization/testing was unusually critical:
- Quonset point
- Raritan : Bioremediation of source/ISCO downgradient plume under building
- Maui : Iron rich soils/manganese impacts to CHP
- Saipan : Aragonite coral “soil” on CHP
- Corinna : Aged soils and inorganic effects on oxidant selection