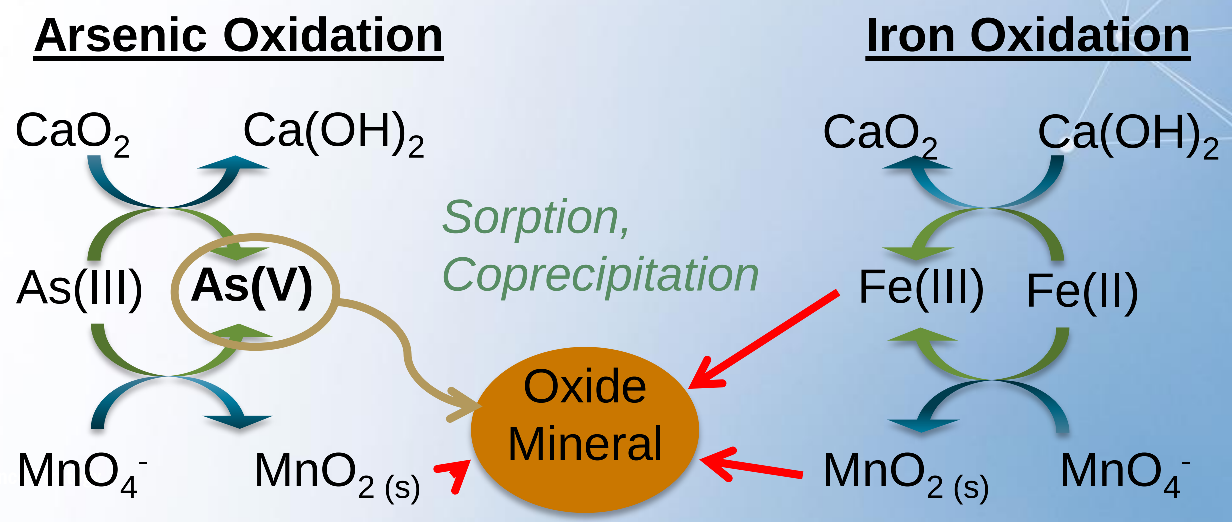
Remedial Technologies to Address CCR Constituents in Groundwater

Environmental Show of the South – May 2018

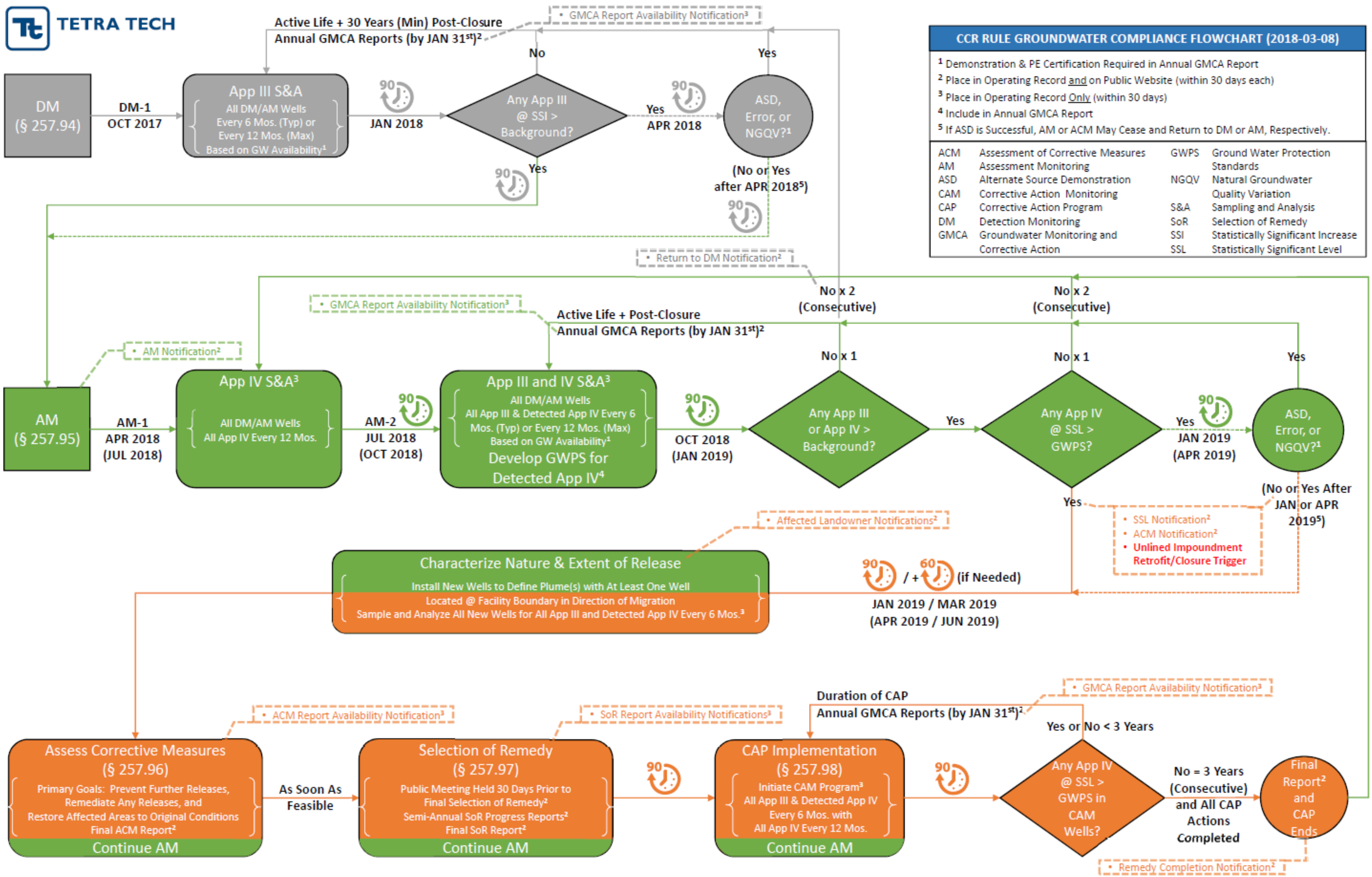


Agenda

- **Topics to be Covered**
  - Overview of CCR Rule Groundwater Monitoring Program and Timeline
    - Baseline Monitoring
    - Detection Monitoring
    - Assessment Monitoring
  - Corrective Measures Assessment
  - Selection of Remedy
  - Remediation and Timeline

CCR Rule Groundwater Monitoring

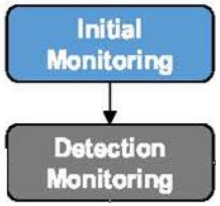
TETRA TECH



Initial (Baseline) Monitoring

- Minimum of 8 independent samples per well or spring required (background/upgradient and downgradient)
- Analyze for all Appendix III and Appendix IV parameters
- Sufficient number of samples obtained and analyzed for all four CCR units

Appendix III	Appendix IV	
Boron	Antimony	Lead
Calcium	Arsenic	Lithium
Chloride	Barium	Mercury
Fluoride	Beryllium	Molybdenum
pH	Cadmium	Radium 226+228
Sulfate	Chromium	Selenium
Total Dissolved Solids	Cobalt	Thallium
	Fluoride	



Statistical Analysis of Data

- **Goals of Statistical Analysis:**
  - Determine if statistically significant increase (SSI) greater than background concentrations for each Appendix III parameter for Detection Monitoring
  - Determine if statistically significant level (SSL) greater than MCL or alternative criteria concentrations for each Appendix IV parameter for Assessment Monitoring
  - Determine if Appendix IV parameters in downgradient wells have been below MCL or alternate criteria for 3 consecutive years after Corrective Action Measures implemented
- **Statistical Analysis is Dynamic**

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Total Dissolved Solids	Cobalt	Thallium
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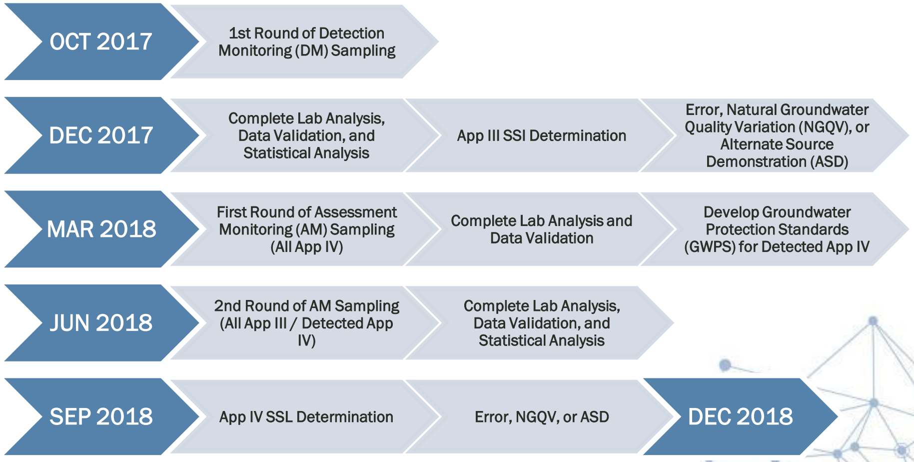
General Characteristics of Sites

- Located near rivers or other major water bodies
- Selection of upgradient and downgradient monitoring well locations
- Sites located on Karst with selection of springs as monitoring locations
- Existing water treatment systems

Next Steps in CCR Compliance Timeline

- **CCR Rule Overview**
- **Next steps in CCR Compliance Timeline**
  - Detection Monitoring
    - Error Analysis
    - Natural Groundwater Quality Variation
    - Alternate Source Determination
  - Assessment Monitoring
    - Same as Above
- **What is Unknown**



Detection Monitoring

Appendix III	Appendix IV	
Boron	Antimony	Lead
Calcium	Arsenic	Lithium
Chloride	Barium	Mercury
Fluoride	Beryllium	Molybdenum
pH	Cadmium	Radium 226+228
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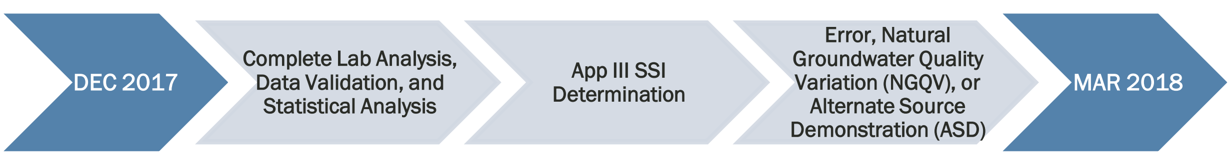
Total Dissolved Solids	Cobalt	Thallium
	Fluoride	

- Minimum semi-annual (2x year) monitoring for Appendix III



Assessment Monitoring-Baseline Data

Appendix III	Appendix IV	
Boron	Antimony	Lead
Calcium	Arsenic	Lithium
Chloride	Barium	Mercury
Fluoride	Beryllium	Molybdenum
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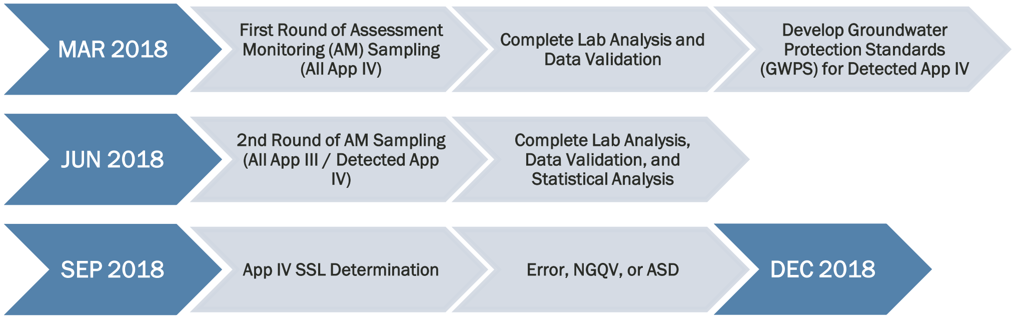
Total Dissolved Solids	Cobalt	Thallium
	Fluoride	

- If Appendix III SSI's are confirmed (no errors, natural groundwater variation, or alternate sources), initiate Assessment Monitoring



Assessment Monitoring-Baseline Data

- Initially analyze for App IV and establish Groundwater Protection Standards (GWPS) for each App IV constituent
- GWPS = Maximum Contaminant Level (MCL) if one exists, or background concentration, whichever is higher
- Within 90 days, resample for App IV constituents that were previously detected plus App III list
- If Appendix IV constituents are detected at a Statistically Significant Level (SSL) > GWPS, must characterize the nature and extent of the release
- Within 90 days, initiate assessment of corrective measures
- If SSL > GWPS for an unlined impoundment, cease receipt of CCR and initiate closure within 6 months (Ash Pond June 2019)

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Corrective Measures Assessment & Selection of Remedy

DEC 2018	Initiate Nature and Extent of Release Characterization	3rd Round of AM Sampling (All App III and Detected App IV)	Initiate Assessment of Corrective Measures	
MAR 2019 (MAY 2019)	Complete Assessment of Corrective Measures			
JUN 2019 (AUG 2019)	Selection of Remedy	Public Meeting	Ongoing AM Sampling	
As Soon as Feasible	Implement Corrective Action Plan (CAP)	1st Round of Corrective Action (CA) Sampling	Ongoing AM Sampling	
90 Days	Ongoing CA Sampling	Ongoing AM Sampling	Completion of CAP	2020 and Beyond

Corrective Measures Assessment & Selection of Remedy

- **Corrective Measures Assessment Goals:**
  - Prevent further releases
  - Remediate any releases
  - Restore affected area to original conditions

- **Step 1 – Collect and Evaluate Additional Data (Remedial Investigation/RFI)**
  - Define nature and extent of contamination
    - Additional monitoring wells, dye traces
    - Additional sampling for broad suite of analytes
    - Update the conceptual site model
      - Geology
      - Hydrogeology
      - Geochemistry
    - Data to support analysis of remedial alternatives

Corrective Measures Assessment & Selection of Remedy

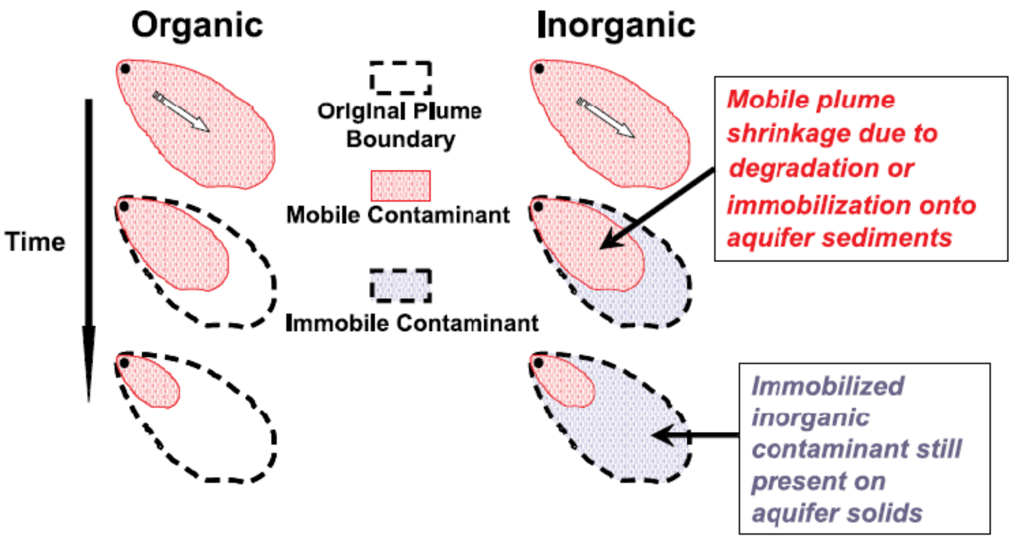
- **Step 2 – Evaluate a Range of Corrective Measures (Feasibility Study/CMS)**
  - Select feasible remedial approach
    - Addresses the contaminants
    - Implementable
    - Cost-effective
- **Step 3 – Select preferred approach (Proposed Plan)**
  - Detailed analysis of selected approach
  - Regulator approval
  - Public meeting
- **Step 4 – Finalize preferred approach (Record of Decision/Statement of Basis)**
  - Final adjustments to preferred approach
  - Schedule for design and implementation
- **Step 5 – Detailed design (Remedial Action Work Plan/Design)**
  - Possible Pre-design data collection
  - Define performance evaluation criteria
- **Step 6 – Design Implementation (Remedial Action/CMI)**
  - Remedy construction/installation
  - Remedy operation and maintenance

Corrective Measures Assessment & Selection of Remedy

- **Options**
  - Pump and Treat (existing water treatment systems)
  - Monitored Natural Attenuation (MNA)
  - In-Situ Treatments (i.e., Sorption/Precipitation)
  - Permeable Reactive Barriers
  - Cut-Off Walls (in combinations)

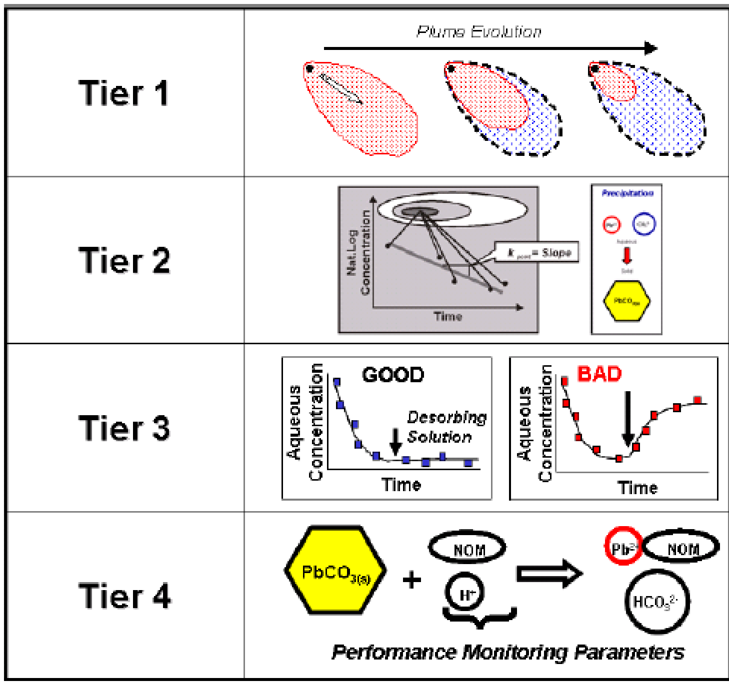
MNA – Application to Inorganics

- **Inorganic MNA applicable to the Appendix IV metals**
- **MNA relies on physical and chemical processes in the aquifer to address mobile contaminant**
- **MNA as a remedy normally requires:**
  - Source control
  - Detailed conceptual model to predict behavior
  - Long-term monitoring with periodic updates of the conceptual model



Source: ITRC 2010

MNA and Appendix IV Inorganics



Tier 1:
Plume Stable or Shrinking

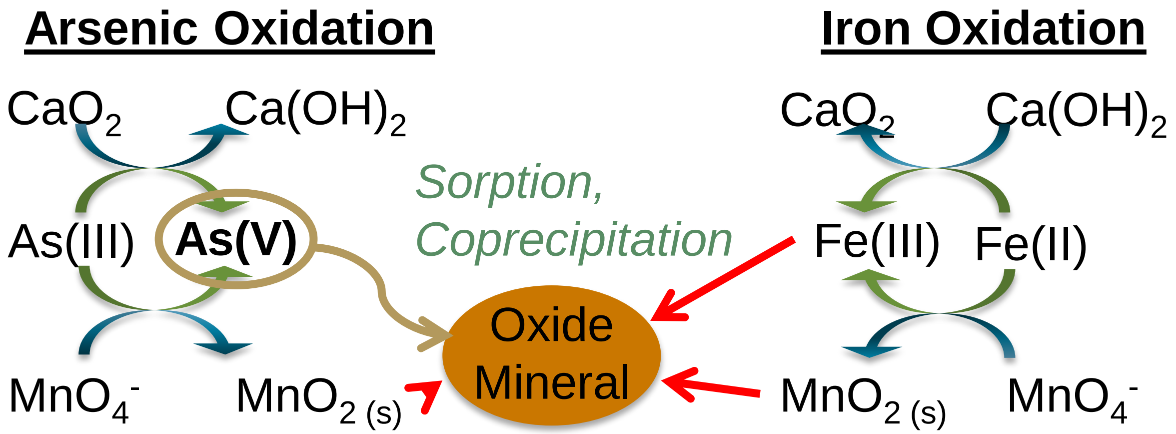
Tier II:
Identification of Attenuation Mechanisms

Tier III:
Attenuation Ability and Capacity

Tier IV:
Long Term M&M

- **Data to evaluate MNA as corrective action collected as part of investigation to define nature and extent of contamination**

Manipulate Aquifer Geochemistry



- **Approach: Oxidize As (III) to As(V), Increase sorptive capacity**
  - Oxidants under study: Permanganate, Calcium Peroxide
  - Manganese oxides: Increase sorptive capacity
  - Ferrous sulfate oxidation: Increase sorptive capacity
  - Calcium peroxide: pH buffer on iron hydrolysis

Manipulate Aquifer Geochemistry

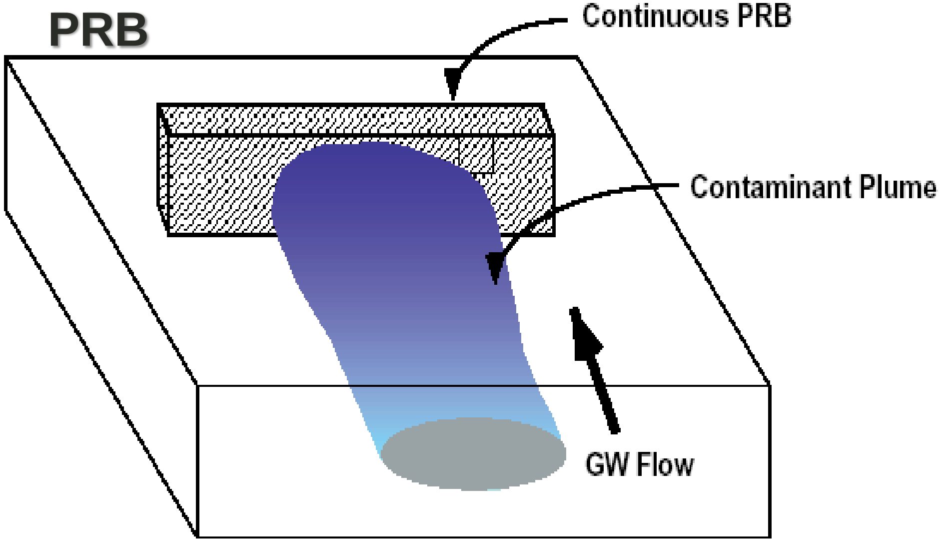
- **Can you manipulate the aquifer to precipitate Appendix IV metals from groundwater?**
- **Metal phosphates, sulfates, sulfides and hydroxides can be insoluble**
  - Permeable reactive barrier design could incorporate sources of anions
  - Aquifer chemistry may be manipulated to precipitate metals (e.g., modification of in situ bioreactor)

Appendix IV Metal	K_{sp}			
	Phosphate	Sulphate	Sulfide	Hydroxide
Antimony			1.6×10^{-93}	
Arsenic	Anionic			
Barium	3.4×10^{-23}	1.08×10^{-10}		2.55×10^{-4}
Beryllium				6.92×10^{-22}
Cadmium	2.53×10^{-33}		1×10^{-27}	7.2×10^{-15}
Chromium				3×10^{-29}
Cobalt	2.05×10^{-35}		5×10^{-22}	5.92×10^{-15}
Lead		2.53×10^{-8}	3×10^{-28}	1.43×10^{-20}
Lithium	2.37×10^{-11}			
Mercury		6.5×10^{-7}	2×10^{-53}	3.6×10^{-26}
Molybdenum	Anionic			
Radium		3.66×10^{-11}		
Selenium	Anionic			
Thallium			6×10^{-22}	1.68×10^{-44}

Permeable Reactive Barrier

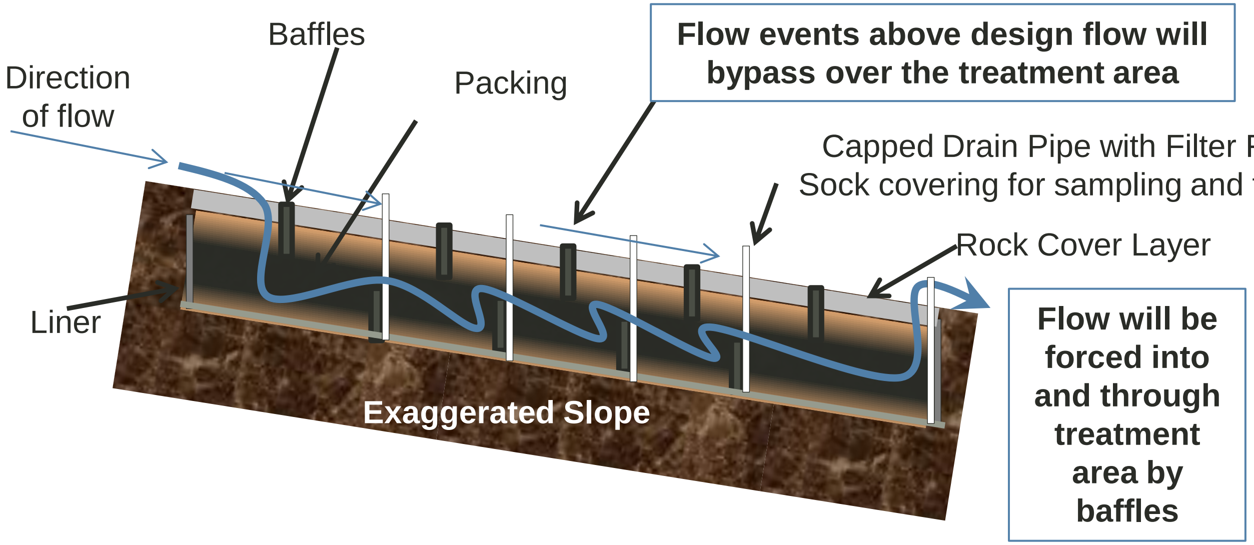
- **Reactive media in the PRB tailored to the contaminants of concern, e.g.,**
  - Alumina to adsorb As
  - Apatite (phosphate) to precipitate lithium
  - Iron filings to sorb arsenic and molybdenum oxyanions
  - Sulfate source to precipitate radium

Conventional PRB



Source: USEPA

Field Design of Packed Bed



Source: US Army Corps of Engineers, Engineer Research and Development Center – Patent Pending

Pilot Scale Implementation

TETRA TECH

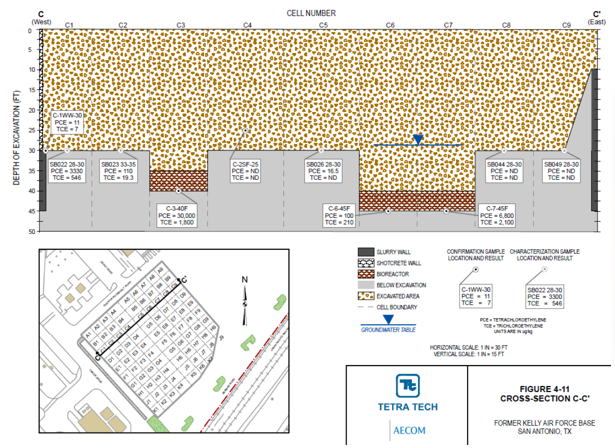
Sampling and Data Logging Unit

Permeable Reactive Barrier Installation

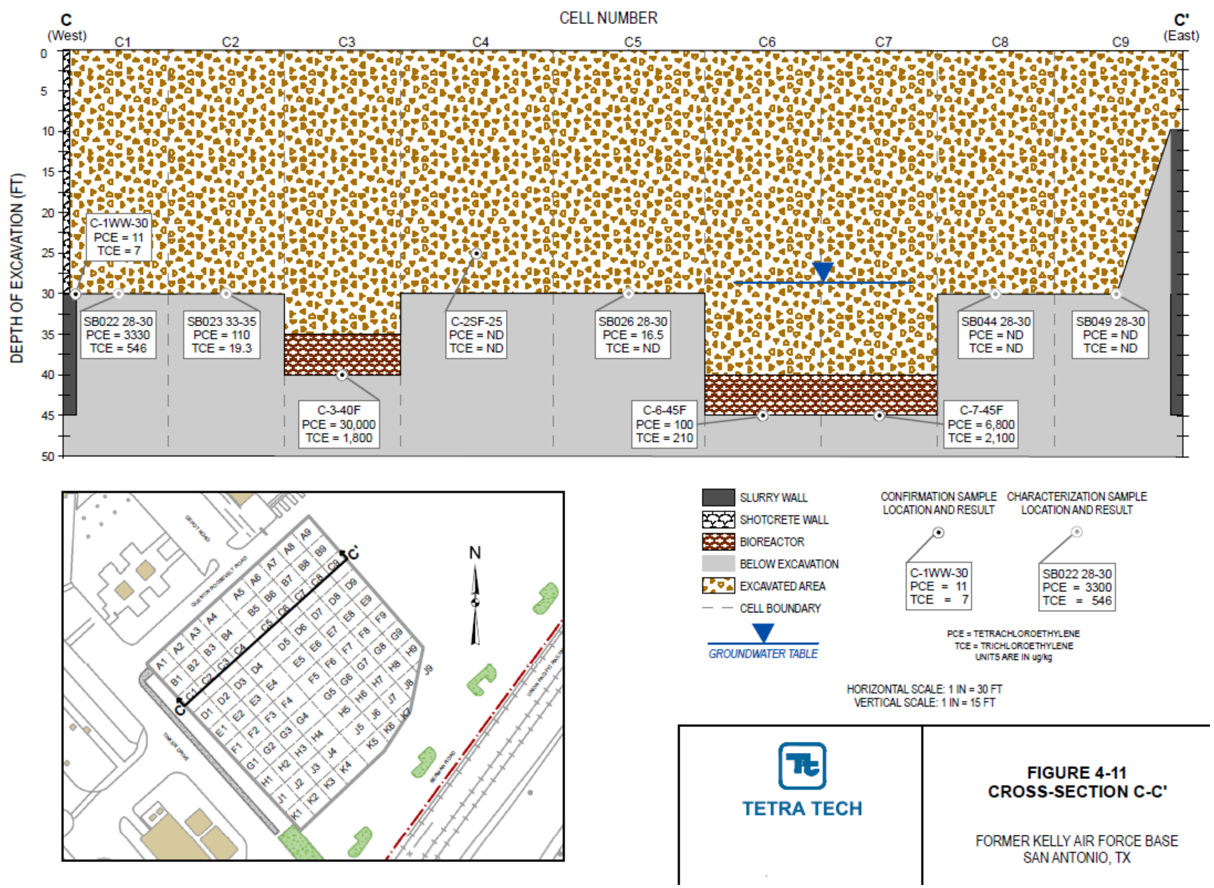
- **Long Stick Excavation**
  - Slurry Trench
  - Bench Setting
- **One-Pass Trencher**

In Situ Bioreactors

- **Engineered subsurface mechanism to control the groundwater chemistry**
  - Provides an initial “jolt” to the system
  - Mechanism for recharging the feed system
  - Biotic or abiotic actions can be stimulated



Case Study I – In Situ Bioreactors



Summary and Questions

- Sites often present physical limitation on remedial approaches (e.g., proximity to rivers)
- Sites often have extensive experience with conventional water treatment systems – pump and treat may be an attractive option
- CCR-related metals can be addressed with conventional remedial approaches
- CCR-related metals may be amenable to innovative in situ approaches
- Questions