



Groundwater Remediation



**WPCA/TVA
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CCR Groundwater Remediation

- ▶ How and what methods are likely to be used
- ▶ How to uncomplicate a very complicated subject
- ▶ Make sure that this is rolled into overall strategy early
- ▶ Issues that are still unresolved and their potential impact on the CCR market

Groundwater Remediation Methods

- ▶ What are my options?

Challenges for Utility Industry

- ▶ Very site specific
- ▶ No programmatic button to push
- ▶ Not always going to be direct action
- ▶ No immediate result
- ▶ Long term action may be required
- ▶ No industry standard

Groundwater Remediation Approaches

Source

- ▶ Excavation/disposal
- ▶ Capping
- ▶ Solidification/Stabilization



Groundwater Plume

- ▶ Monitored natural attenuation
- ▶ Hydraulic capture/containment
- ▶ Passive/reactive treatment barriers



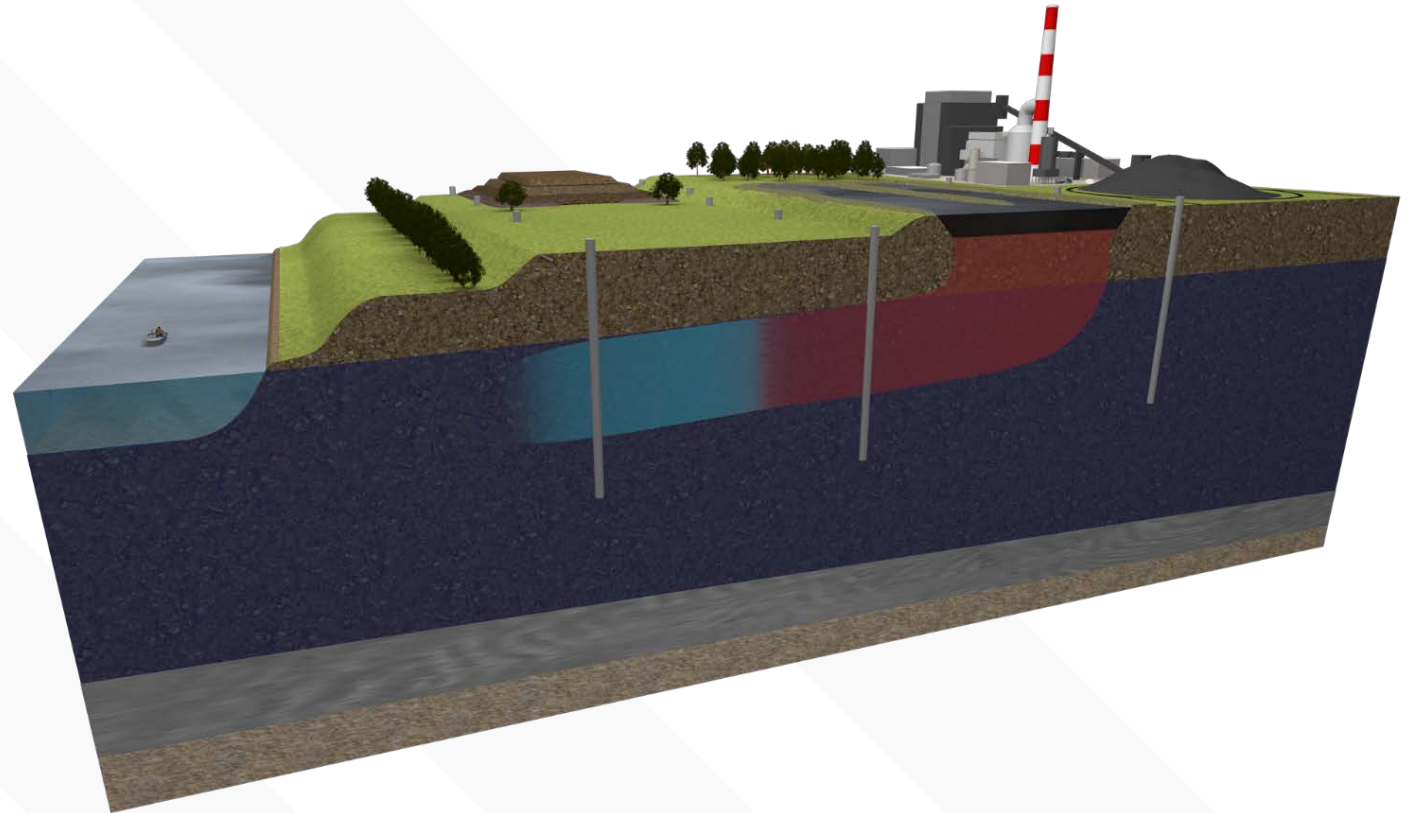
Monitored Natural Attenuation

What is it?

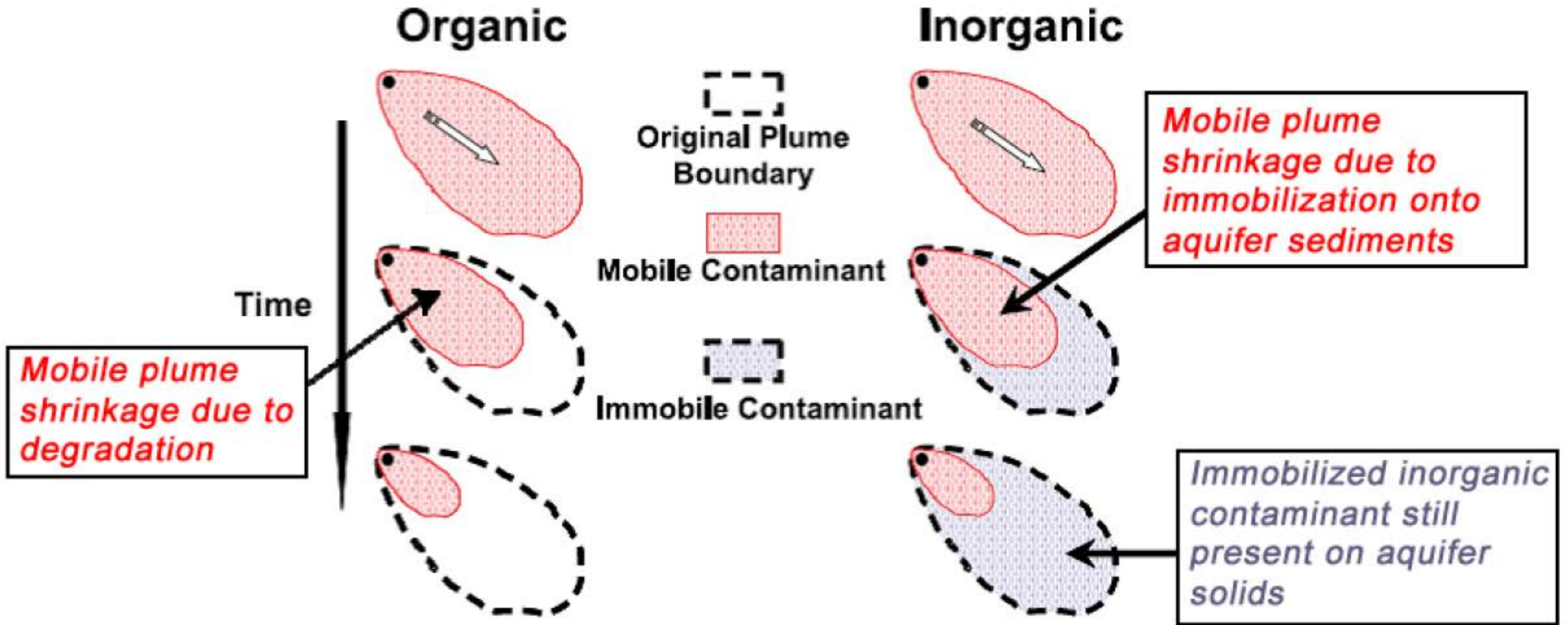
- ▶ “reliance on natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods. The ‘natural attenuation processes’ that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants.” (EPA 1999c, page 3)

Monitored Natural Attenuation

- ▶ CCR Constituents = Inorganics
- ▶ Attenuation Mechanisms for Inorganics
 - Sorption
 - Precipitation
 - Dispersion
 - Dilution
 - Radioactive decay



Monitored Natural Attenuation

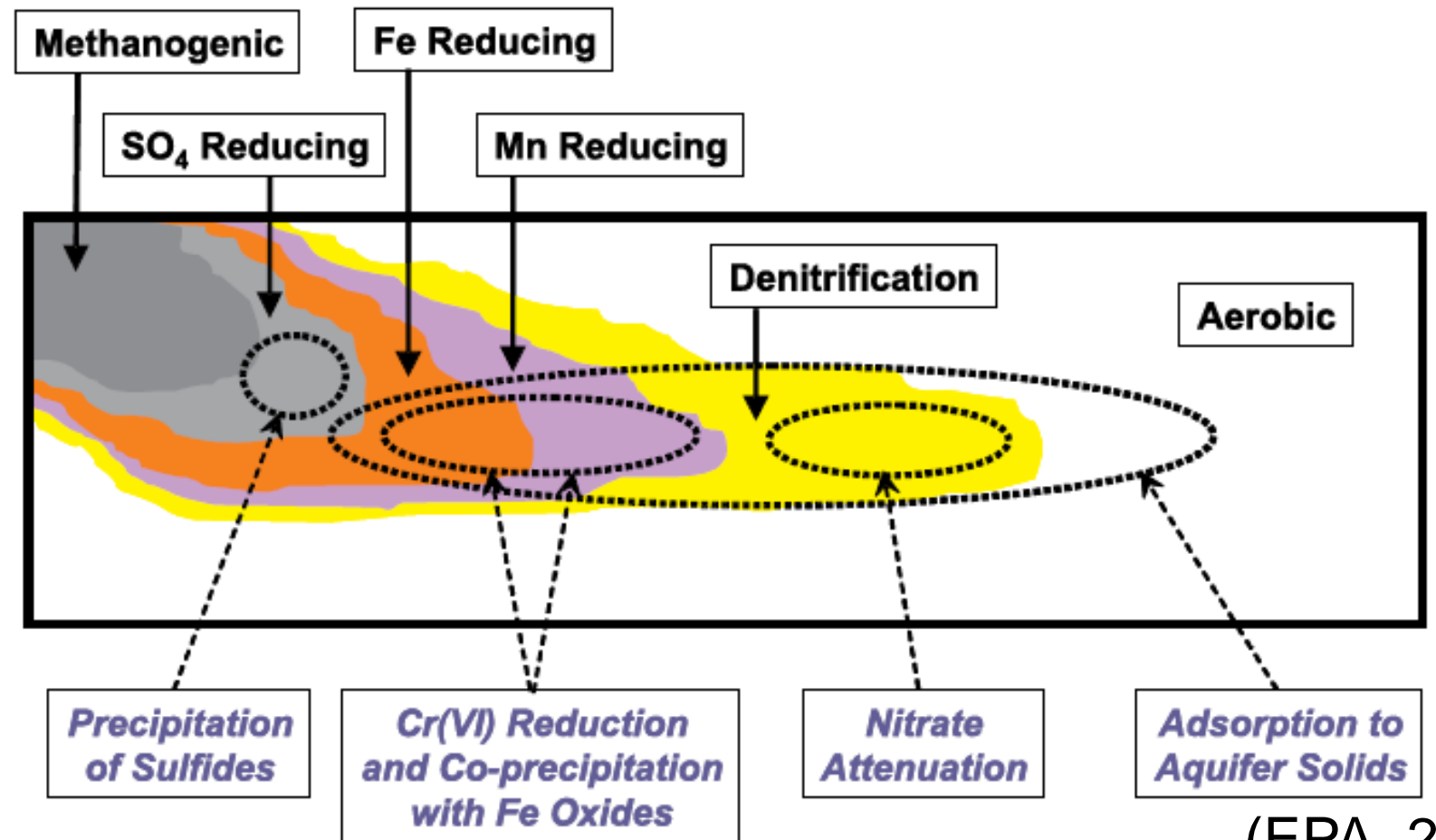


(EPA, 2015)

Monitored Natural Attenuation

Redox Transformation

- ▶ Abiotic – result of physical reactions not biological activities
- ▶ Biotic – result of biological activity

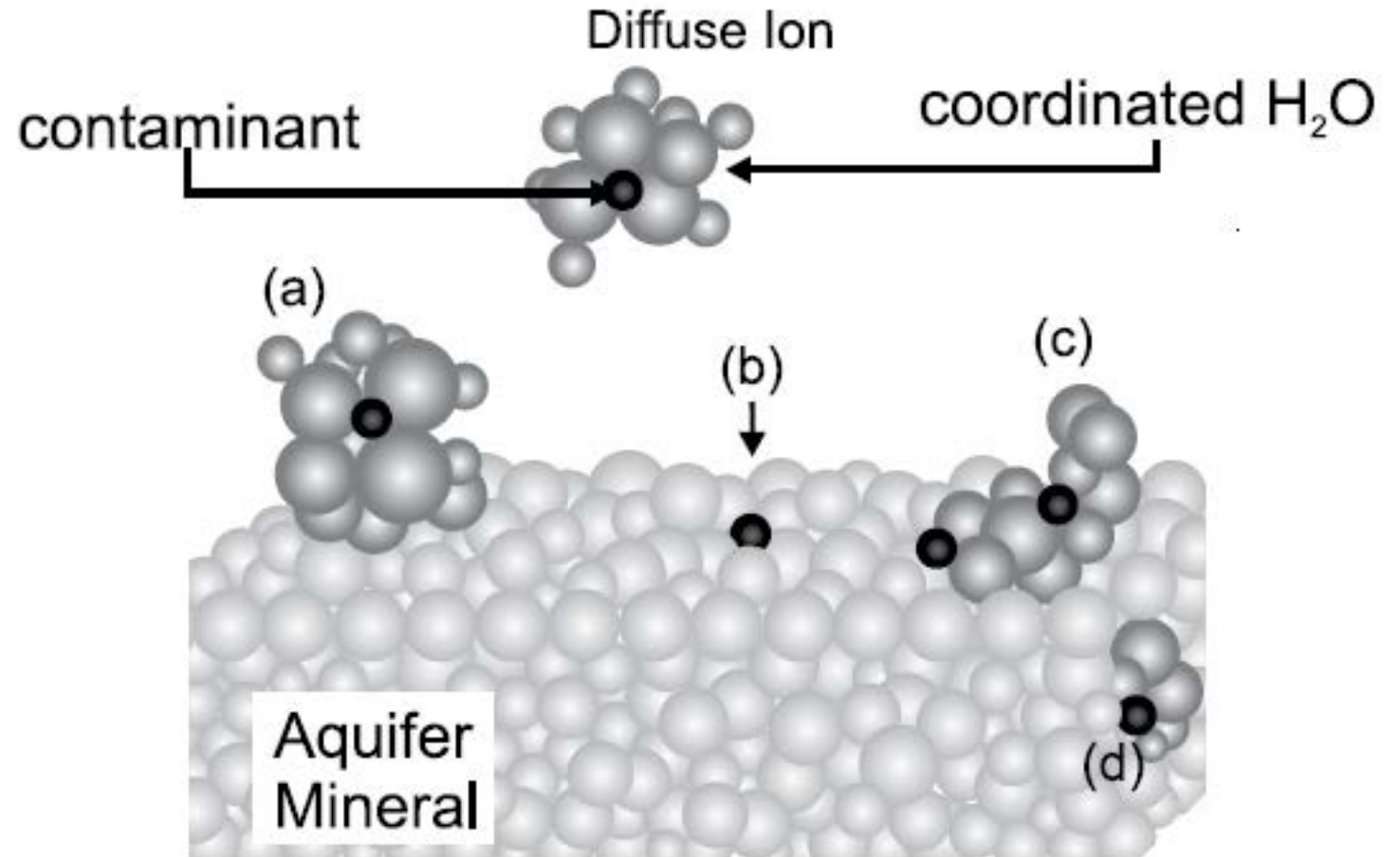


(EPA, 2007)

Monitored Natural Attenuation

Sorption

- ▶ Adsorption – surface interactions
- ▶ Absorption – diffusion into solid phase

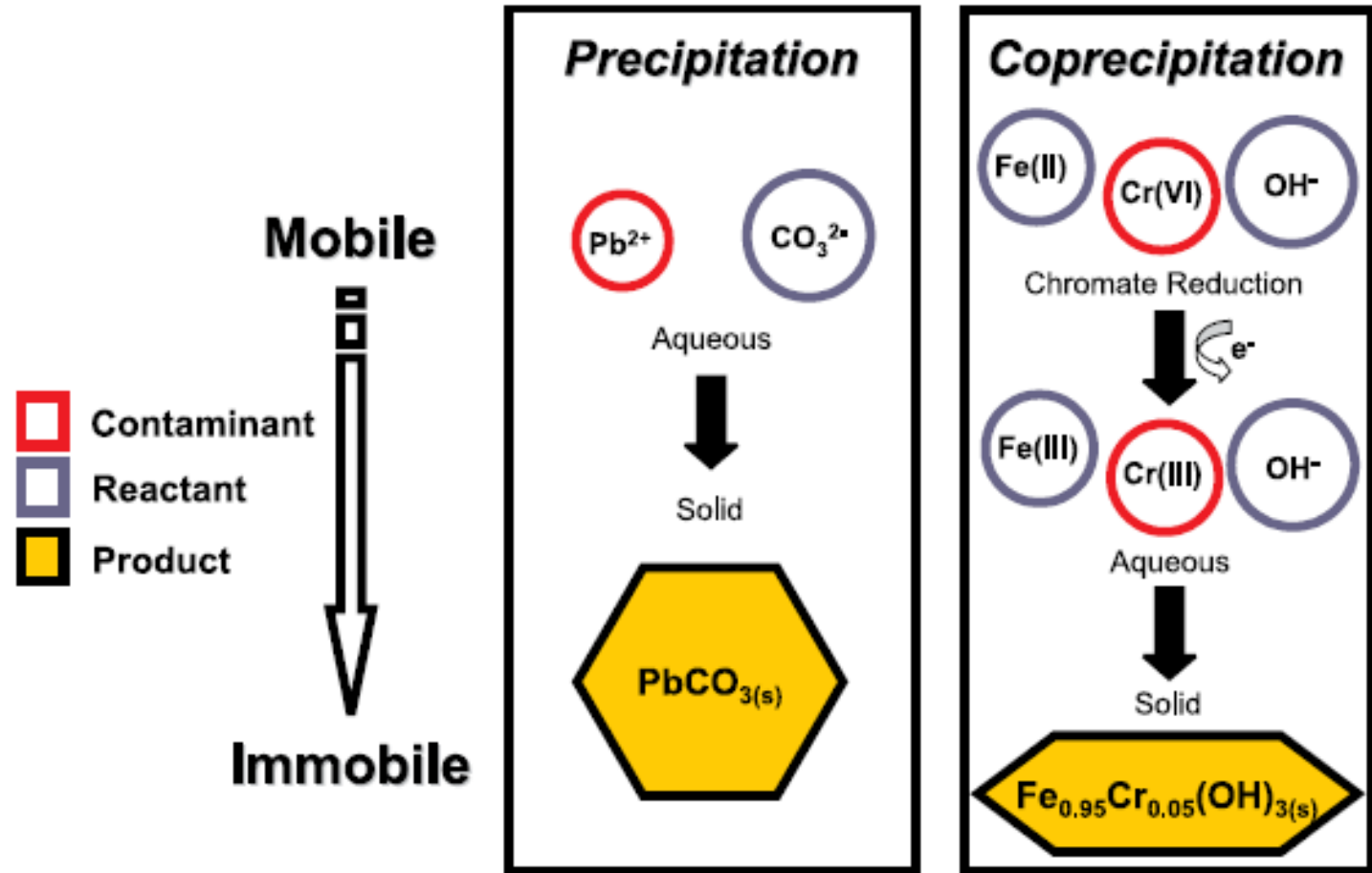


(EPA, 2007)

Monitored Natural Attenuation

Precipitation and Coprecipitation

- ▶ Precipitation – solid phase growth



(EPA, 2007)

Monitored Natural Attenuation

Tiered approach to MNA evaluation (EPA, 2015)

- ▶ Phase I: Demonstration that the groundwater plume is not expanding
- ▶ Phase II: Determination that the mechanism and rate of the attenuation process are sufficient
- ▶ Phase III: Determination that the capacity of the aquifer is sufficient to attenuate the mass of contaminant within the plume and the stability of the immobilized contaminant is sufficient to resist re-mobilization
- ▶ Phase IV: Design of a performance monitoring program based on an understanding of the mechanism of the attenuation process, and establishment of contingency remedies tailored to site-specific characteristics.

Monitored Natural Attenuation

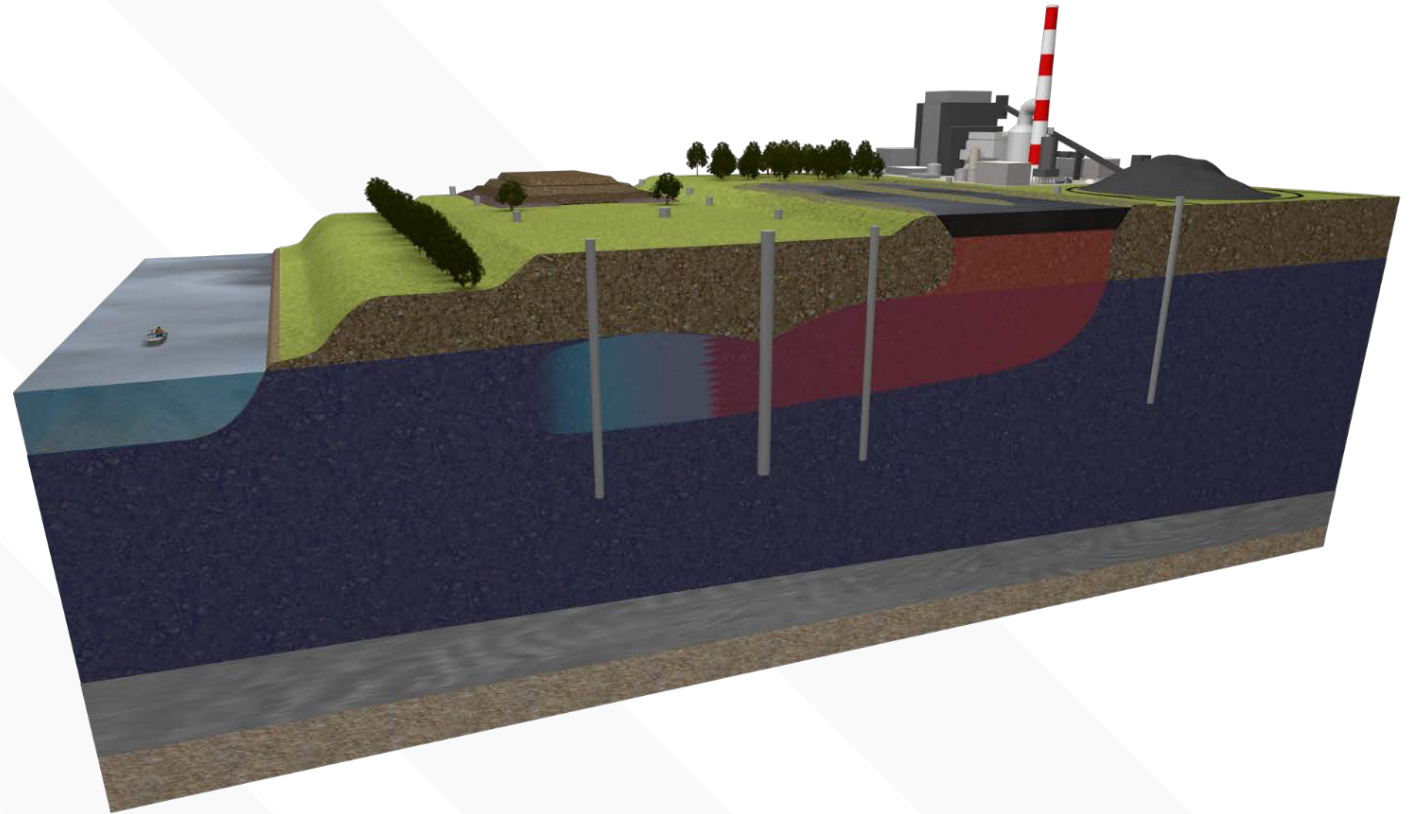
Summary

- ▶ Not a “Do Nothing” approach
- ▶ May not be appropriate for all groundwater plumes
- ▶ Often part of a broader remediation approach
- ▶ MNA evaluation/demonstration requires robust investigation, testing, and assessment
- ▶ Not likely to achieve compliance with Groundwater Protection Standards (GWPS) in short term (i.e., decades not years)

Hydraulic Capture/Containment

What is it?

- ▶ Extraction of groundwater to prevent plume migration and remove contaminant mass



Hydraulic Capture/Containment

Extraction Methods

- ▶ Vertical Wells
 - ▶ Horizontal Wells
 - ▶ Interceptor Trench
-
- ▶ Can be paired with a physical containment barrier
 - Slurry Wall
 - Sheet Pile Wall



Hydraulic Capture/Containment

Management of Extracted Groundwater

▶ Treatment

- Chemical/Physical
 - Conversion of soluble metal salts to insoluble salts which precipitate for subsequent removal through settling or filtering
 - Coagulation and flocculation used to increase the particle size in order to increase the settling rate of the precipitated solids
- Ion Exchange
- Reverse Osmosis

▶ Reuse

- Plant Water Balance

▶ Offsite Disposal

- POTW



Hydraulic Capture/Containment

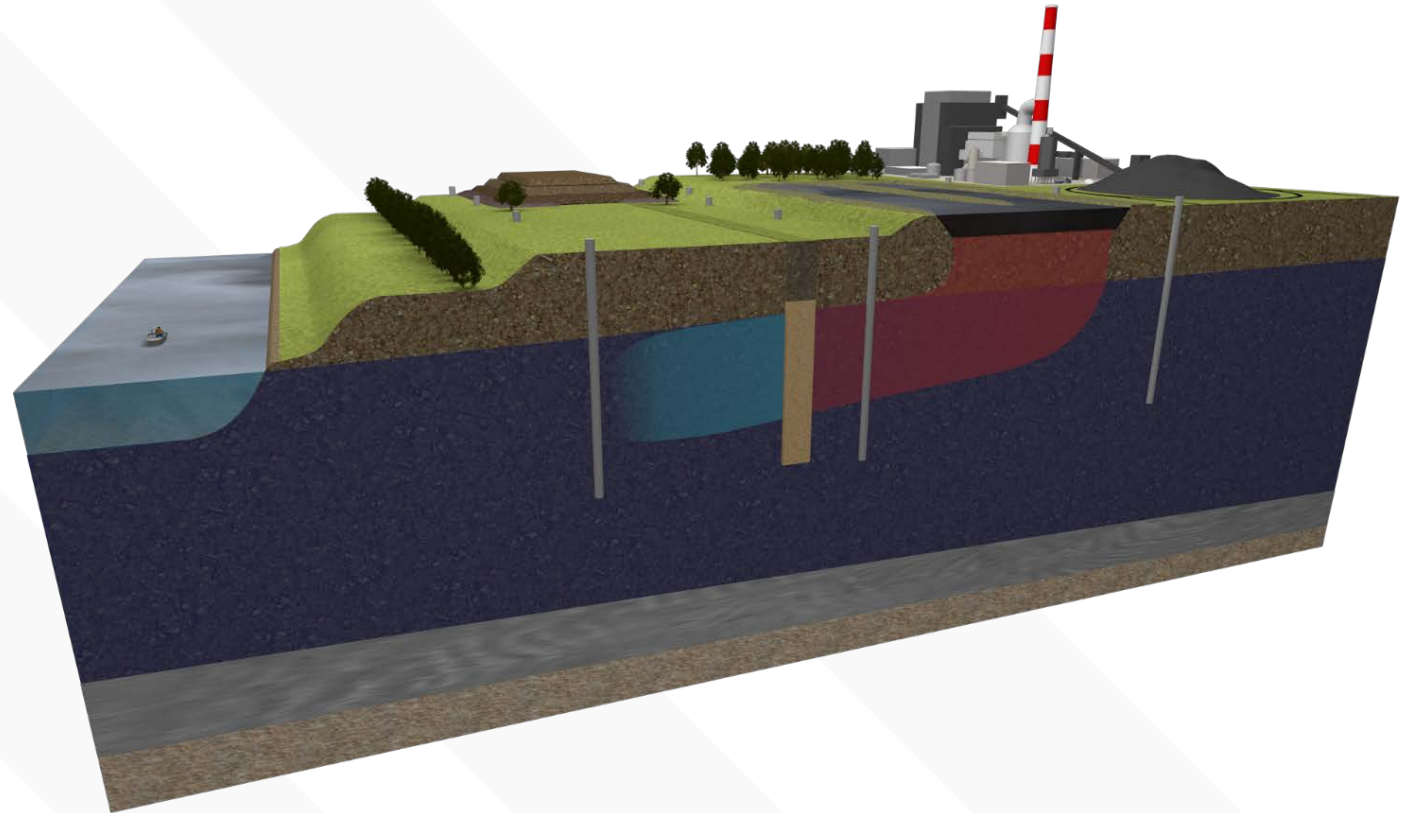
Summary

- ▶ Effective and verifiable plume containment or source control (dependent on extraction location relative to plume extent)
- ▶ Management of extracted groundwater may be challenging dependent on its quality and quantity
- ▶ Relatively high capital and operation, maintenance, and monitoring costs
- ▶ May not obtain GWPS (mass removal/concentrations becomes asymptotic)
- ▶ Not likely to achieve compliance with GWPS in short term (i.e., decades not years)

Treatment Zones/Barriers

What is it?

- ▶ Placement of amendments into the subsurface to create groundwater conditions decrease contaminant toxicity and/or mobility



Treatment Zones/Barriers

Placement Methods

- ▶ Permeable Reactive Barrier (PRB)
- ▶ Direct Push Injection (temporary, may require multiple events)
- ▶ Well Injection (permanent, may require multiple events)
 - Potential for circulation or recirculation

Amendment/Media Selection

- ▶ Dependent on target contaminant(s), geochemical conditions, and hydraulics
- ▶ Solids (PRB)
- ▶ Slurry, Liquid (Direct Push Injection/Fracturing)
- ▶ Liquid (Wells)

Treatment Zones/Barriers

Summary

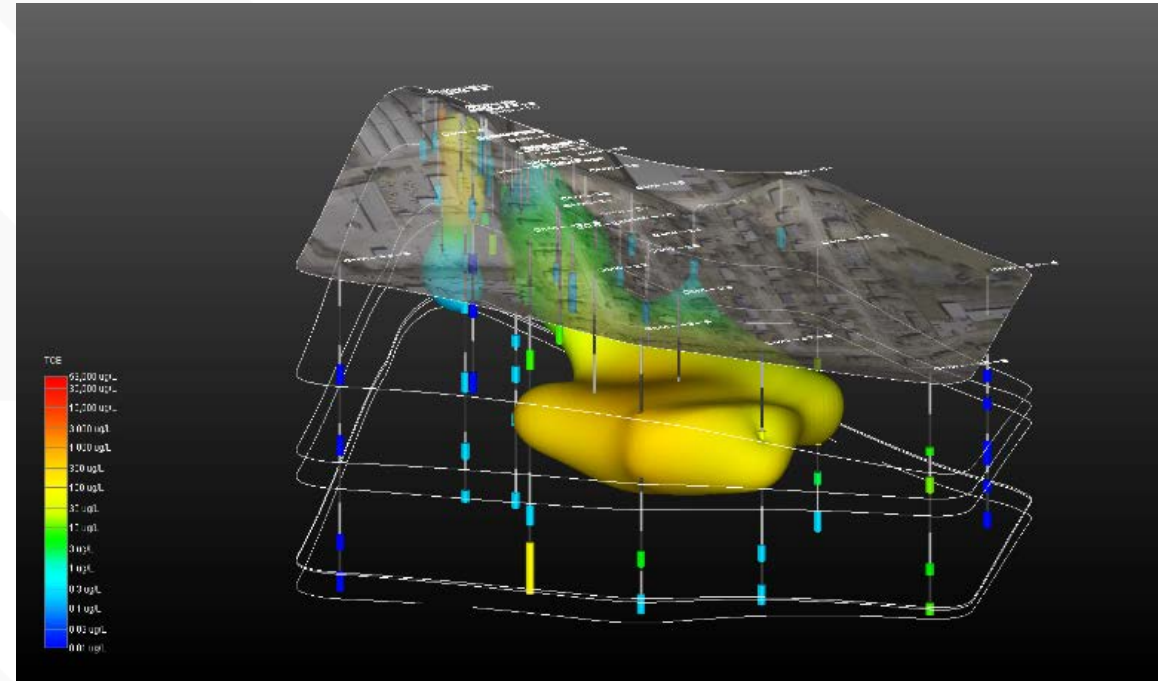
- ▶ If treatment occurs upgradient of leading edge of plume, not likely to achieve compliance with GWPS in short term (i.e., decades not years) downgradient of treatment
- ▶ May require multiple injection events or rejuvenation of PRB media
- ▶ Relatively high capital cost and relatively low to moderate operation, maintenance, and monitoring costs
- ▶ Not likely to achieve compliance with GWPS in short term (i.e., decades not years)

Uncomplicating a Complicated Issue

- ▶ Connecting the Dots

Conceptual Site Model (CSM)

- ▶ Serves as basis for:
 - Site understanding
 - Data gap identification
 - Demonstrating natural variability and alternate sources (ASD)
 - Critical decision making
- ▶ Purpose:
 - Data management and interrogation
 - Risk evaluation
 - Remedial alternative evaluation
 - Stakeholder management



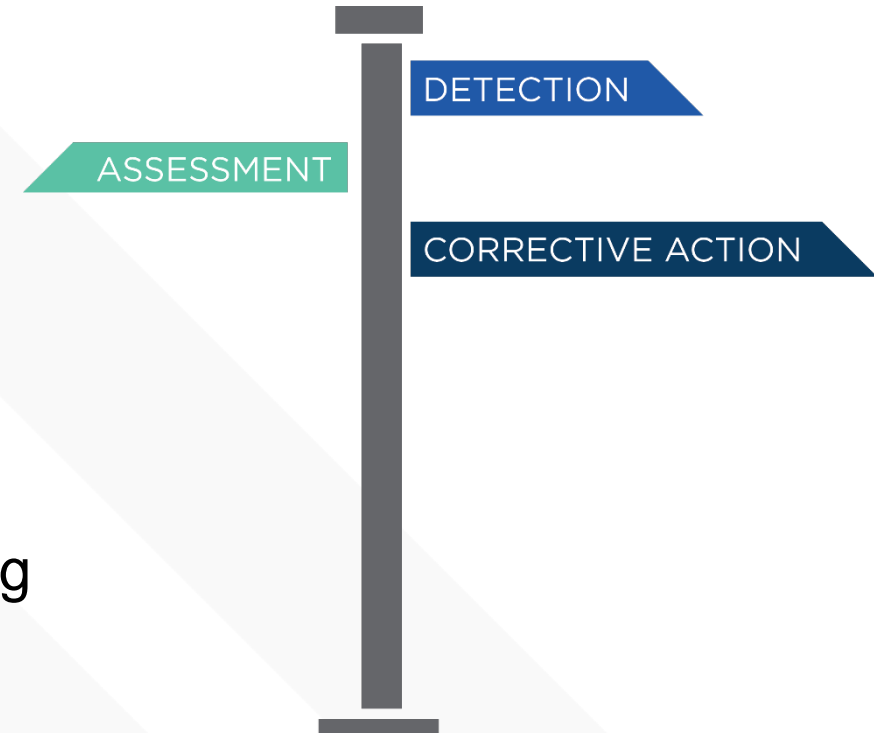
CSM Elements for CCR Sites

- ▶ Groundwater/surface water interaction
- ▶ Geochemical conditions
 - Speciation, mobility, attenuation potential
- ▶ Geology/stratigraphy
 - Impact of heterogeneity
- ▶ Hydrogeology
 - Variable flow regimes
 - Contaminant transport (vertical and lateral)
 - Dewatering
- ▶ Risk Assessment



Other Approaches and Considerations

- ▶ Define roadmap to desired outcomes
 - Establish well defined criteria
 - Eliminate variables/options
- ▶ Avoid oversimplification
 - Bad assumptions can compound/multiply
- ▶ Embrace complexity to reduce uncertainty
 - Identify and fill data gaps throughout the process
- ▶ Consider the scale when evaluating and communicating Site conditions
 - Build up/Drill down to improve understanding



Integration into Overall Strategy

- ▶ Consider groundwater conditions while planning closures
 - Enhancements to current closure approach that minimize risk and the potential need for post-closure groundwater corrective action
 - In general, an enhancement measure is considered viable if the benefits of immediate implementation, in conjunction with closure, outweigh the cost and other disadvantages.
- ▶ Evaluate potential corrective measures early
 - Aids long term planning, risk management, and development of roadmap
 - Conceptual feasibility study ahead of required Assessment of Corrective Measures
- ▶ Incorporate with other planning efforts
 - Plant operations
 - Asset Retirement
 - Other regulations (NPDES, ELG, etc.)

Unresolved Issues

- ▶ What might change? What are my risks?

Unresolved Issues – Federal Regulations

- ▶ Federal Regulation proposed March 15, 2018
 - Adding boron as an Appendix IV constituent
 - Adding performance standards for slope stability
 - Clarify Type and Magnitude of Non-groundwater releases that trigger corrective action procedures in 40 CFR 257.96-257.98
 - Alternative Closure requirements
- ▶ Federal Regulation proposed August 14, 2019
 - Beneficial use requirements
 - Consolidate approach to CCR Piles
 - Annual groundwater monitoring and corrective action reports requirements
 - Establishing an alternative GWPS for boron (4,000 µg/L)
 - Publicly accessible internet site requirements

Unresolved Issues – State Legislation/Regulations

Federal Approval of State Permit Programs

- ▶ Oklahoma (approved, subject to legal challenge)
- ▶ Georgia (proposed conditional approval)

State Legislation/Regulations

- ▶ Active in Southeast (Virginia, Carolinas, Alabama, Georgia, etc.)

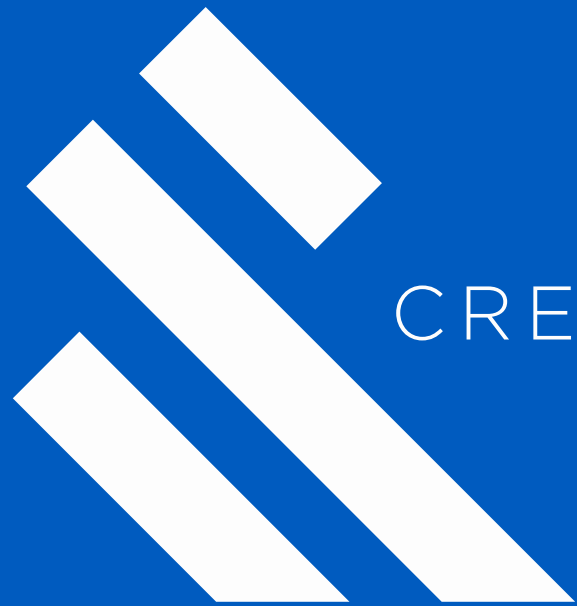
Unresolved Issues – Litigation

County of Maui, Hawaii, Petitioner v. Hawaii Wildlife Fund, et al.

- ▶ CWA regulation of groundwater
- ▶ SCOTUS oral arguments scheduled for November 6, 2019

Legal Tools for CCR Claims

- ▶ Clean Water Act (CWA) Citizen Suits
- ▶ Resource Conservation & Recovery Act (RCRA) Citizen Suits
- ▶ National Pollutant Discharge Elimination System (NPDES) permit renewal comments to state agencies
- ▶ Toxic tort litigation (trespass, nuisance common law claims)
- ▶ CCR Regulations



CREATE AMAZING.