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Overview of Remediation Technologies for Radionuclides in Soil and Groundwater

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Context

- ▶ Remediation technologies operate at the intersection of
 - radionuclide characteristics
 - the target problem
 - remedy functionality
 - remediation objectives

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Outline

- ▶ Radionuclide characteristics related to remediation
- ▶ Considering end states and attenuation in remedy decisions
- ▶ Remedy technologies and approaches
- ▶ Remedy implementation

- ▶ Discussion focused on
 - Uranium, Tc-99, Sr-90, I-129, tritium
 - Groundwater protection and groundwater remediation

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Radionuclide Characteristics (Friend or Foe)

- ▶ Half-life
 - Shorter is better (when exposure is controlled)
 - Sr-90 or tritium compared to uranium, I-129, or Tc-99
- ▶ Mobility (sorption)
 - Very low mobility generally good
 - Medium or high mobility - depends on the situation
 - Attenuated transport can be helpful (vadose zone contamination) or problematic (P&T)
 - Secondary sources are problematic unless balanced by attenuation

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Radionuclide Characteristics (Friend or Foe)

- ▶ Biogeochemical interactions
 - Helpful
 - Uranium and Sr-90 interactions with phosphate
 - Uranium silicate precipitates
 - Mixed
 - Uranium and I-129 (and Cr) interactions with carbonate
 - ◆ Depends on location/extent
 - I-129 species transformation
 - ◆ Depends on change in mobility and potential for attenuation/sequestration
 - Uranium and Tc-99 redox
 - ◆ Depends on setting and role in a remedy
 - No interactions
 - tritium

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Disposal Chemistry

Szecskody et al. 2013
Truex et al. 2014

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Radionuclide Characteristics (Friend or Foe)

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- ▶ The Conceptual Site Model helps us decide:
 - Friend or foe for risk and transport
 - Friend or foe for remediation

Truex et al. 2017b

Considering End States and Attenuation in Remedy Selection

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Remedy Technologies and Approaches

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- ▶ Vadose zone
 - Attenuation
 - Consider transport processes in the vadose zone
 - Flux control (enhanced attenuation)
 - Physical stabilization
 - Hydraulic control
 - Biogeochemical stabilization
 - Extraction (e.g., excavation, soil flushing)
 - Cost/benefit
 - Groundwater treatment (e.g., phosphate)
 - Consider vadose zone source characteristics for groundwater impact

Dresel et al. 2011

Attenuation

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Adapted from Dresel et al. 2011

Truex and Carroll 2013
Truex et al. 2015a
Ostrom et al., 2016

Desiccation

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- ▶ Desiccation as hydraulic control

Truex et al. 2017b

Geochemical stabilization – vadose zone

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- ▶ Ammonia gas for uranium sequestration

Szeocsody et al. 2012

Overview of Remediation Technologies for Radionuclides in Soil and Groundwater

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Reductants

- ▶ ZVI
- ▶ SMI

Truex et al. 2011a
Truex et al. 2011b

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Remedy Implementation

- ▶ Adaptive Site Management
 - National Research Council
 - ITRC
 - Remediation Management of Complex Sites
 - <http://rmcs-1.itrcweb.org/>
- ▶ Exit Strategies (P&T)
 - <http://bioprocess.pnnl.gov/Pump-and-Treat.htm>

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