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Central Plateau Cleanup Company

The Challenge of Deep Vadose Contamination in the Central Plateau

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Presentation Outline

Contaminants remain in the deep vadose zone of the Central Plateau, acting as continuing sources to the comingled groundwater plumes. Characterization of the nature and extent and subsequent remediation of continuing sources is a challenge.

Outline:

- Our current understanding of continuing sources
- Characterization
- Modeling
- Remediation options and challenges

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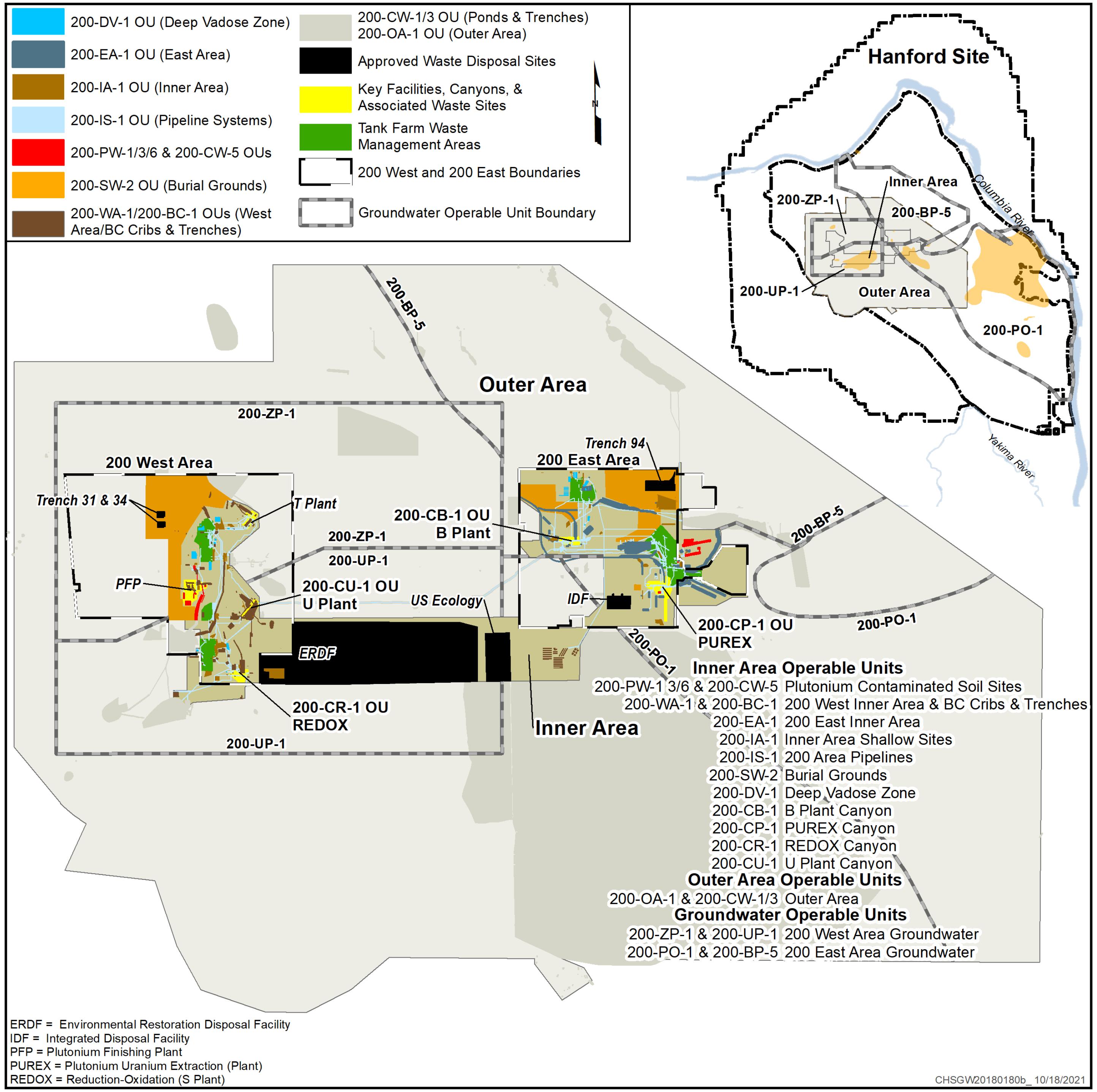
Central Plateau Operable Units

Multiple overlapping source operable units to address residual vadose zone contamination



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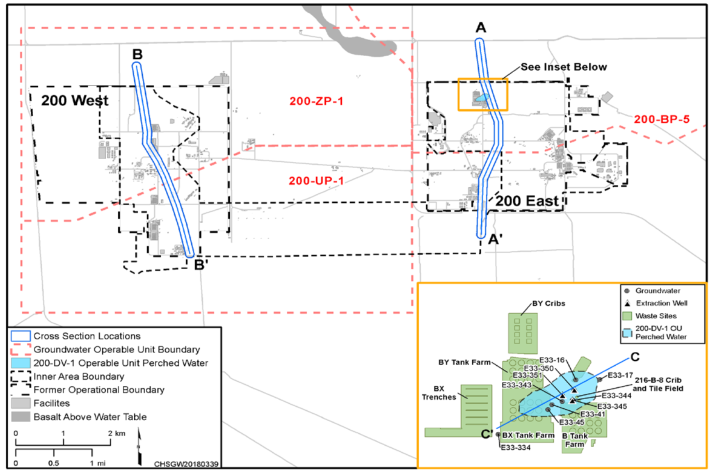
The Central Plateau Vadose Zone



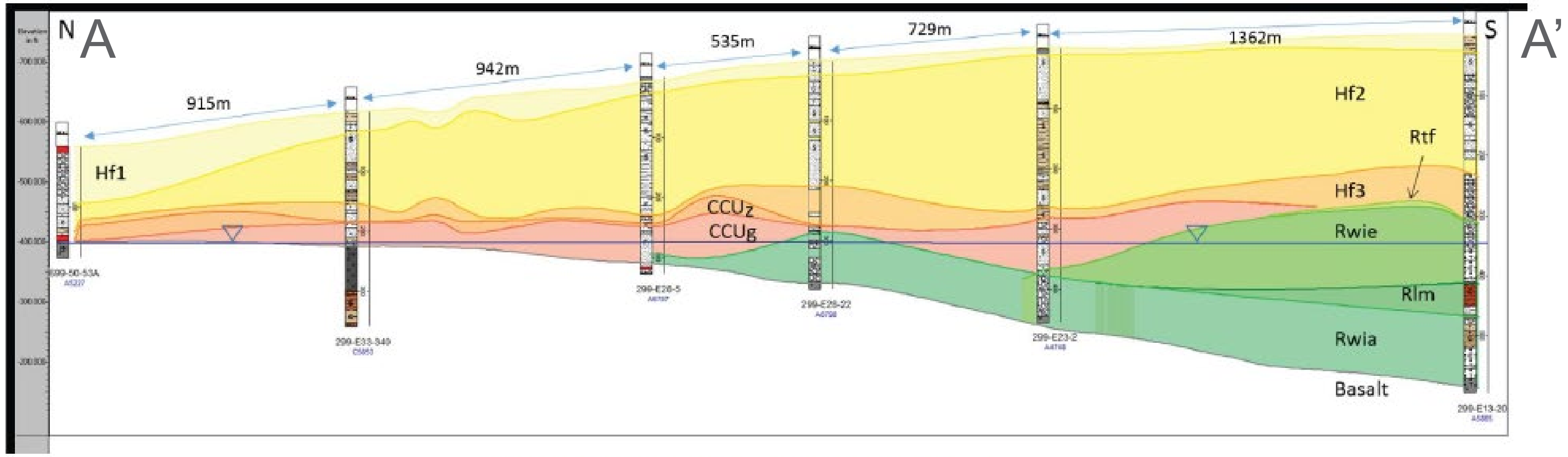


Figure 2-7. North-South Section View of 200 East Area

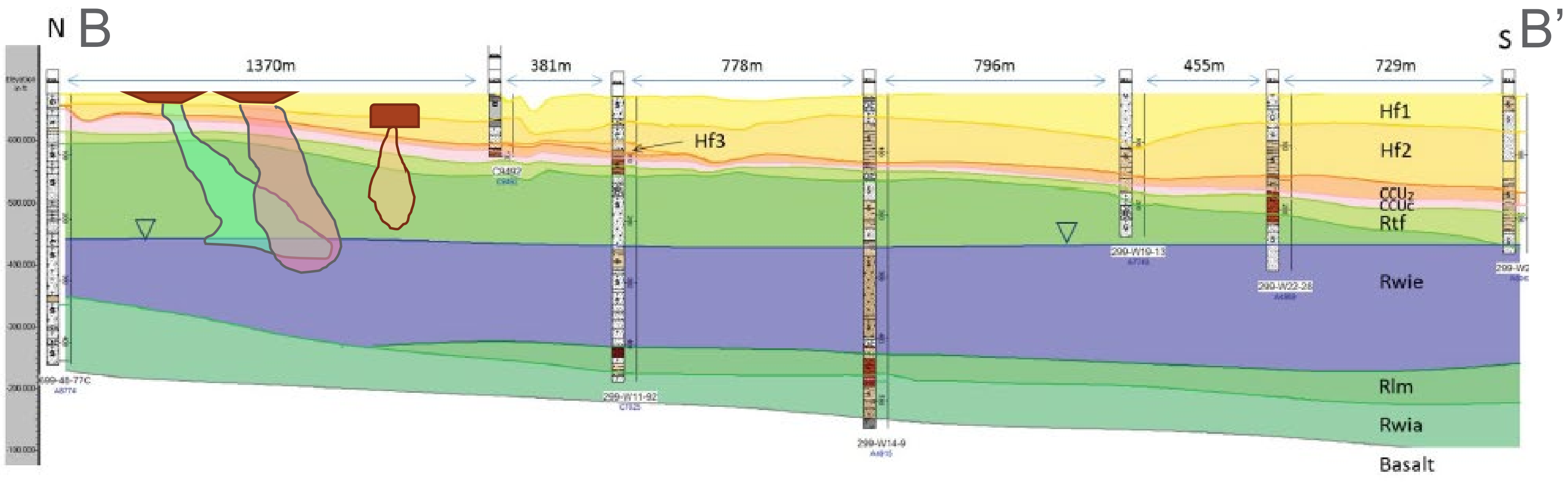


Figure 2-8. North-South Section View of 200 West Area

Vadose zone is 45-100m thick composed of Miocene-Pleistocene aged sand, silt and gravel.

Sources of vadose zone contamination:

- Liquid waste sites like cribs, trenches, ponds and ditches
- Reverse wells and French drains
- Tank leaks
- Burial grounds

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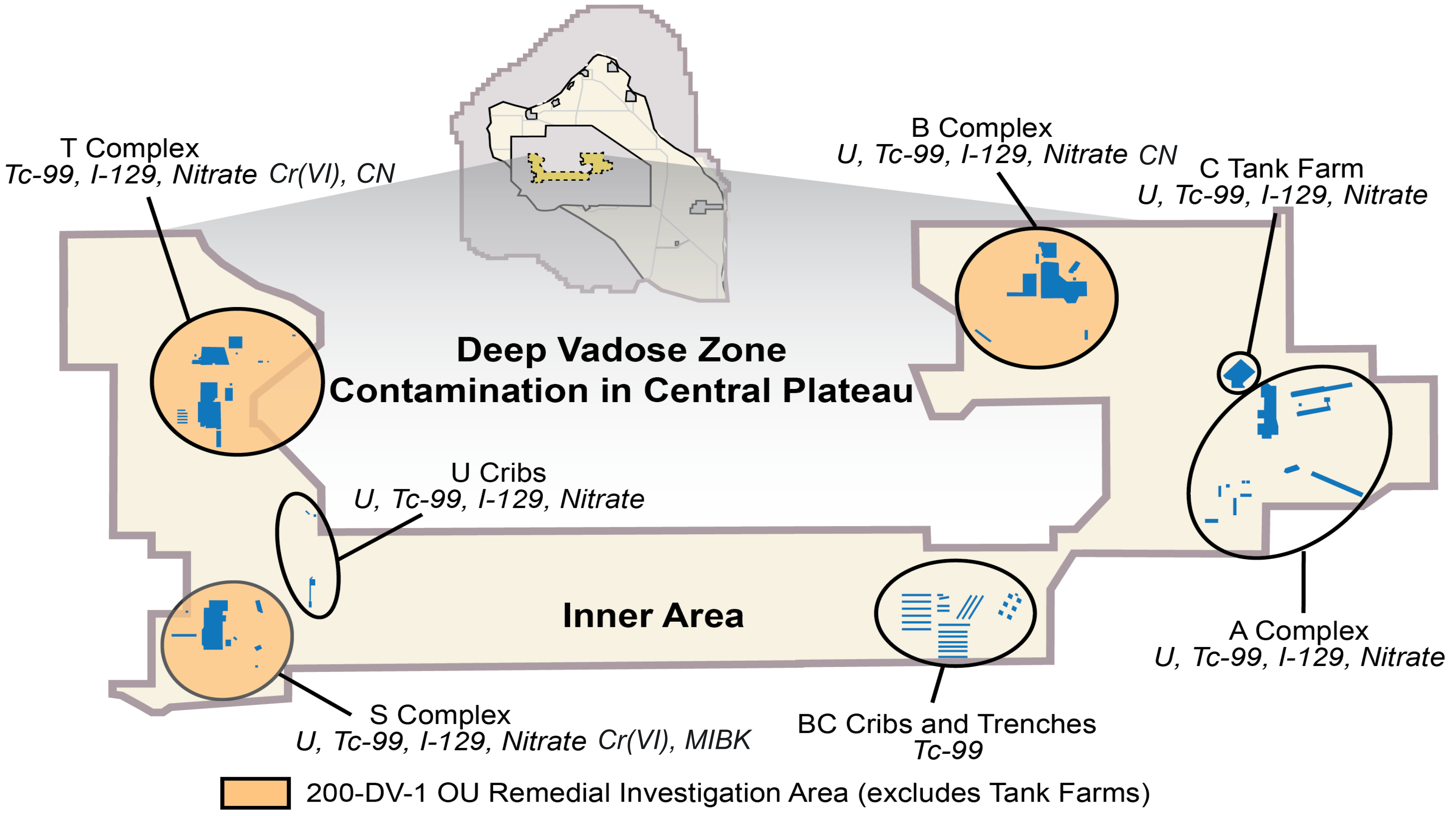
Continuing Sources to the Central Plateau Groundwater

Mobile contaminants of interest:

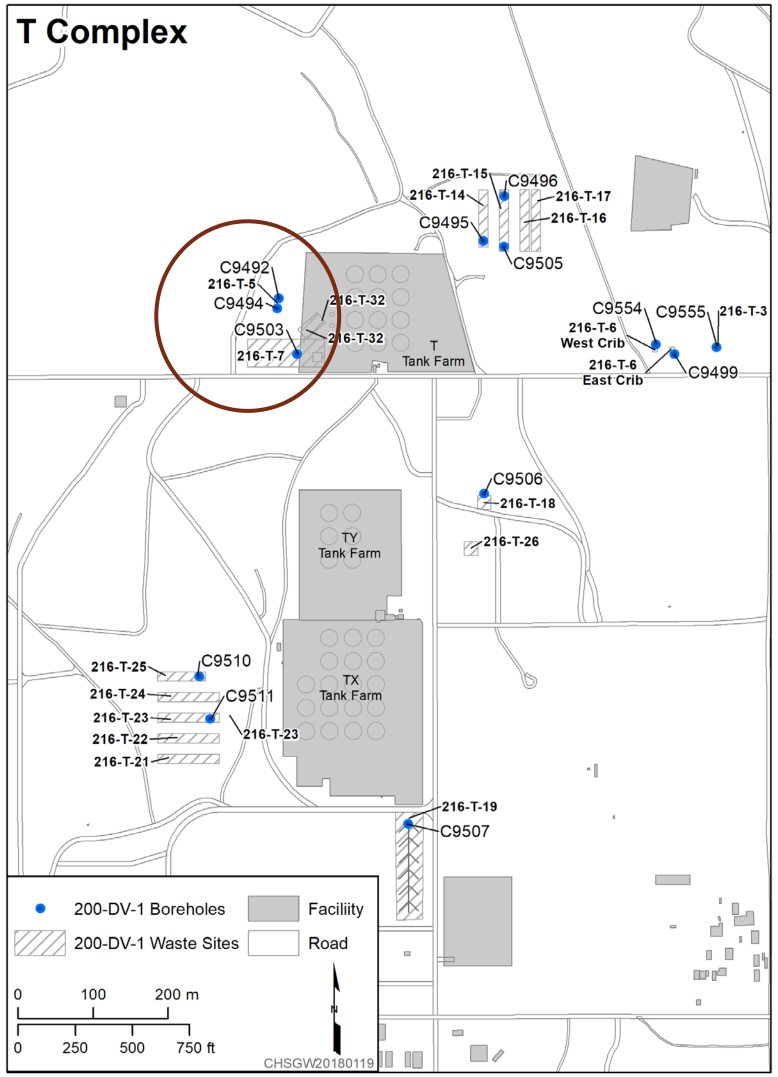


Evaluations of residual contamination in the deep vadose zone have focused on mobile contaminants in these portions of the Central Plateau

Categorizing a chemical or radionuclide as a contaminant of interest does not necessarily mean it is a continuing source to groundwater

Current continuing sources are determined through groundwater monitoring data, but it does not address future sources to groundwater

Characterizing Deep Vadose Contamination



216-T-5

Contaminant	Inventory
Uranium (total)	2.42×10^{1} kg
Technetium-99	1.50×10^{-2} Ci
Iodine-129	None
Cobalt-60	2.54×10^{-2} Ci
Tritium	8.77×10^{-3} Ci
Nitrate	2.42×10^{5} kg
Fluoride	1.31×10^{4} kg
Ferrocyanide	None
Hexavalent Chromium	1.21×10^{3} kg

216-T-7

Contaminant	Inventory
Uranium (total)	3.39×10^{2} kg
Technetium-99	1.90×10^{-1} Ci
Iodine-129	1.49×10^{-5} Ci
Cobalt-60	3.12×10^{-1} Ci
Tritium	9.16×10^{-2} Ci
Nitrate	6.55×10^{6} kg
Fluoride	3.73×10^{5} kg
Ferrocyanide	None
Hexavalent Chromium	2.81×10^{4} kg

Example from the 200-DV-1 Operable Unit characterization efforts: 216-T-7 crib and 216-T-5 trench outside the T Tank Farm

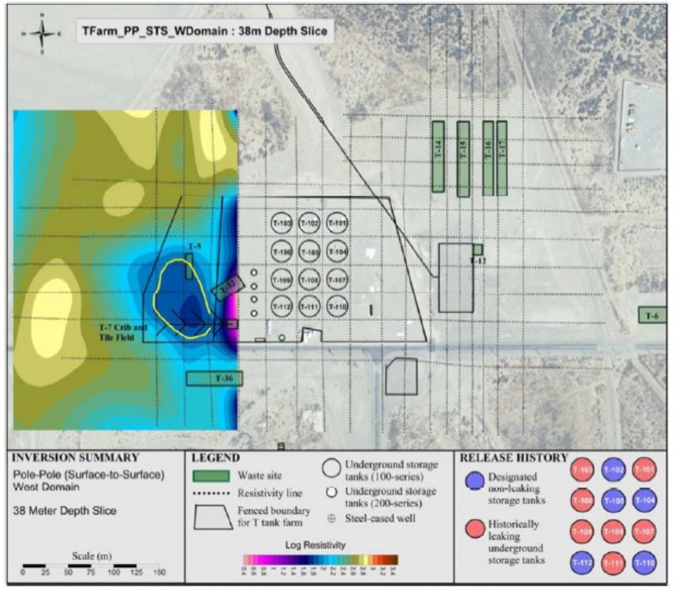
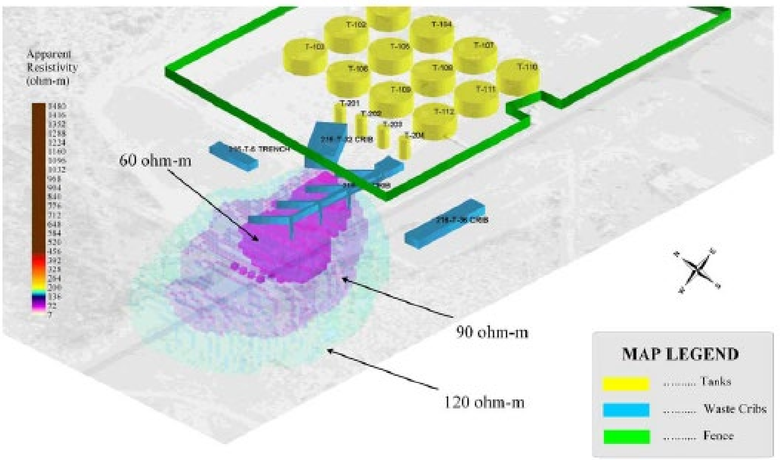


Figure 3-32. 3D Model Results for a Planar Slice at 38 m (125 ft) bgs for the 216-T-5, 216-T-7, and 216-T-32 Subregion

Figure 6-12. Three-Dimensional Surface Resistivity Inversion of Area 2 (Looking NE).

(Opaque at 60, 90 and 120 ohm-m)



Inventory records indicate large discharges and ERT results show sizeable plumes in the vadose zone

Characterizing Deep Vadose Contamination

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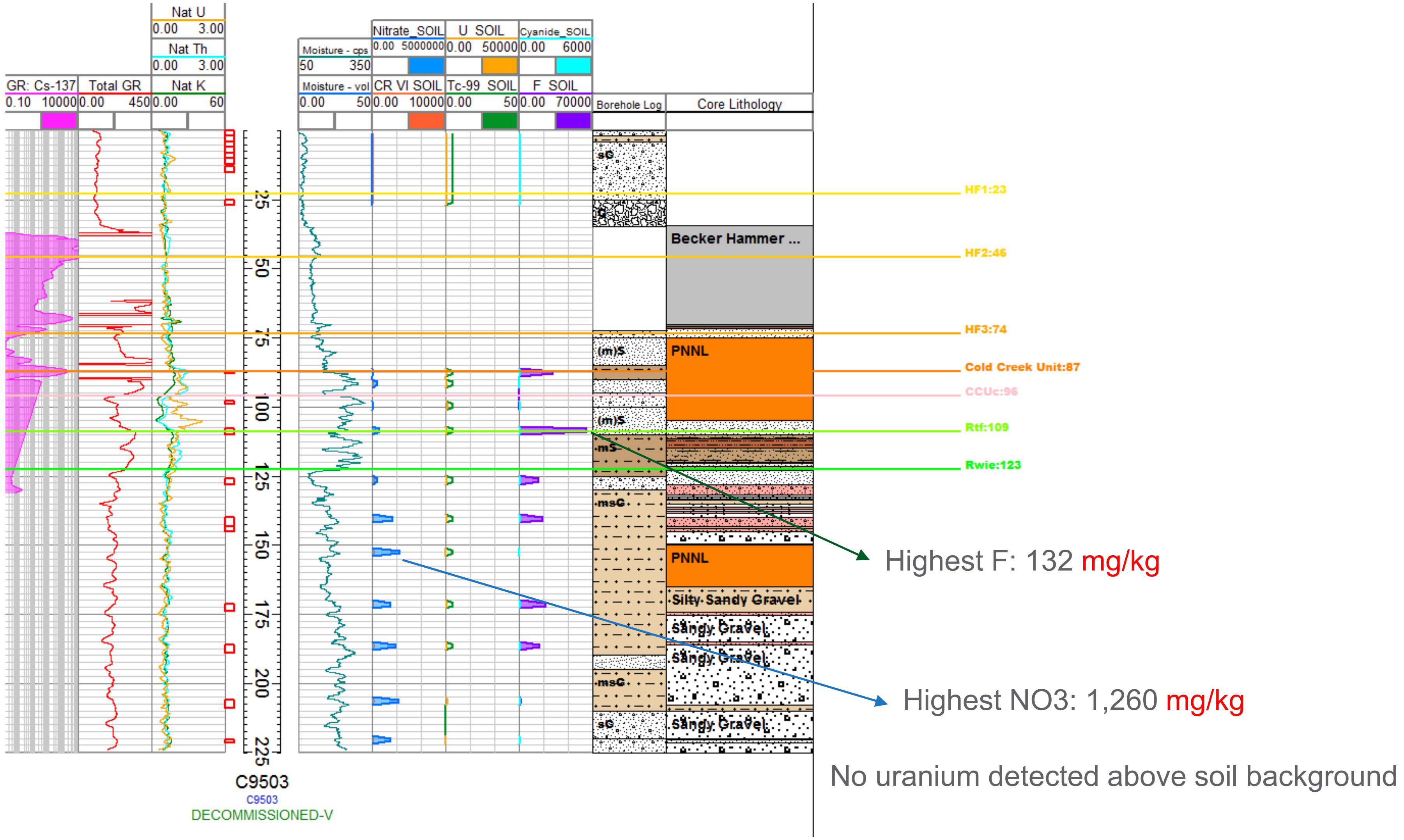
Borehole characterization results: nitrate and fluoride detected in subsurface, no uranium or hexavalent chromium.

Do these sites represent continuing sources to the groundwater? Can we predict the impact to groundwater from borehole data alone?

And how do we map nature and extent of contamination in such a complex comingled environment?



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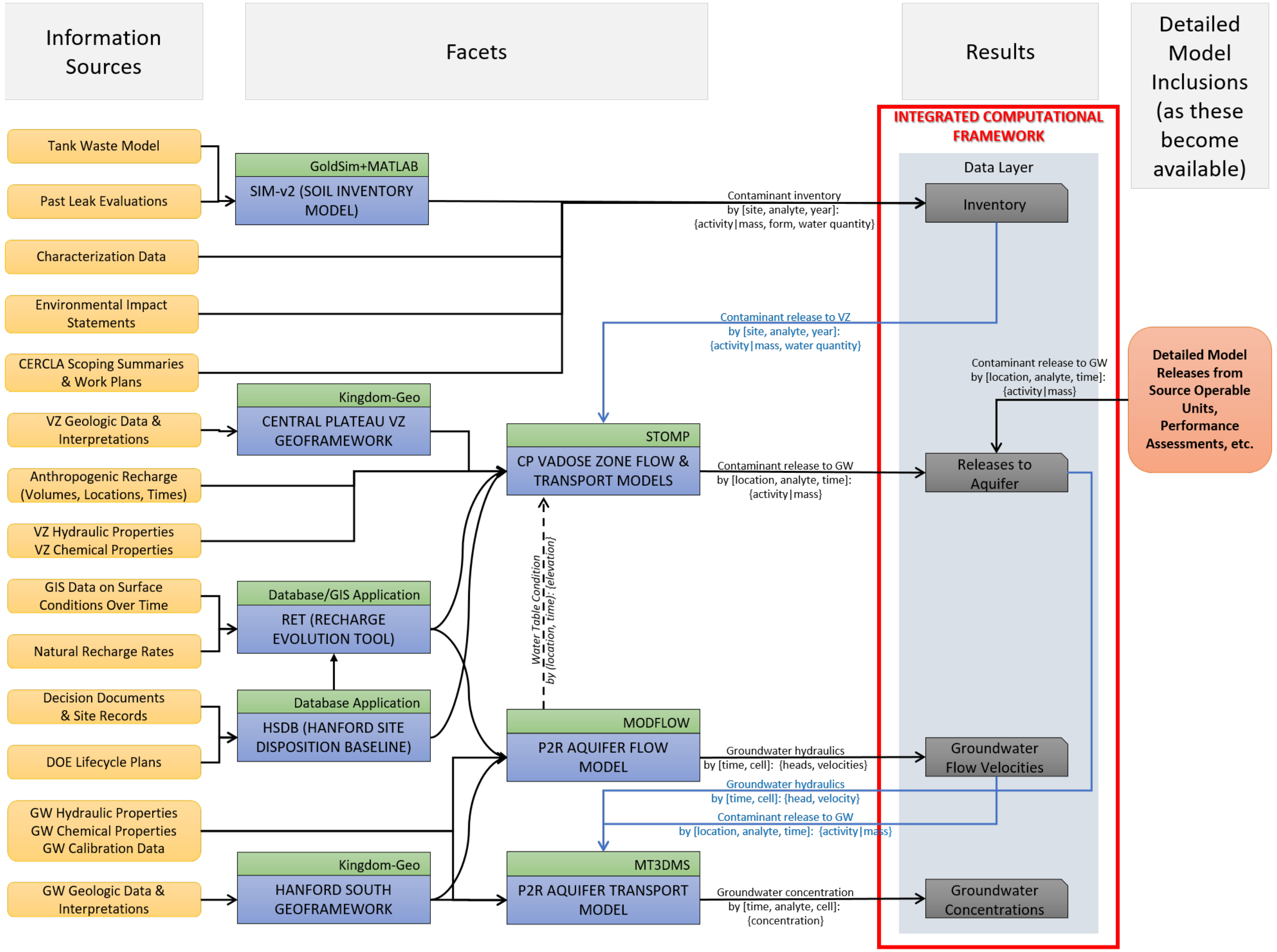
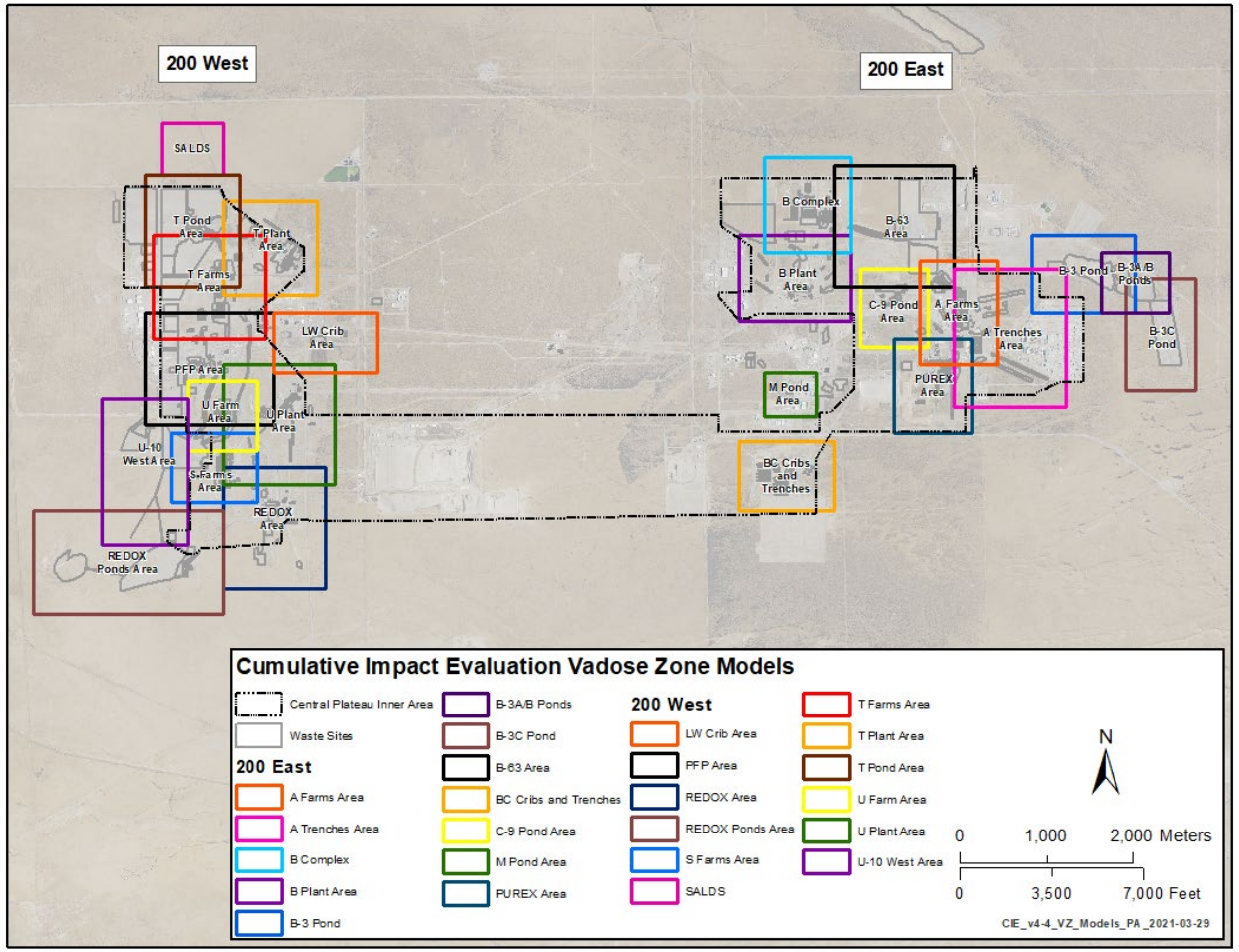
The Cumulative Impact Evaluation

The CIE is a set of modeling tools intended to evaluate the cumulative impact of multiple comingled contaminants on Central Plateau groundwater

The CIE uses a forward-modeling approach for contaminant and effluent discharges over time, so we can evaluate the effect of deep vadose contamination without having to speculate about the amount of residual contamination remaining.



Cumulative Impact Evaluation Modeling Approach



Overlapping vadose zone models on the Central Plateau

Flux to groundwater

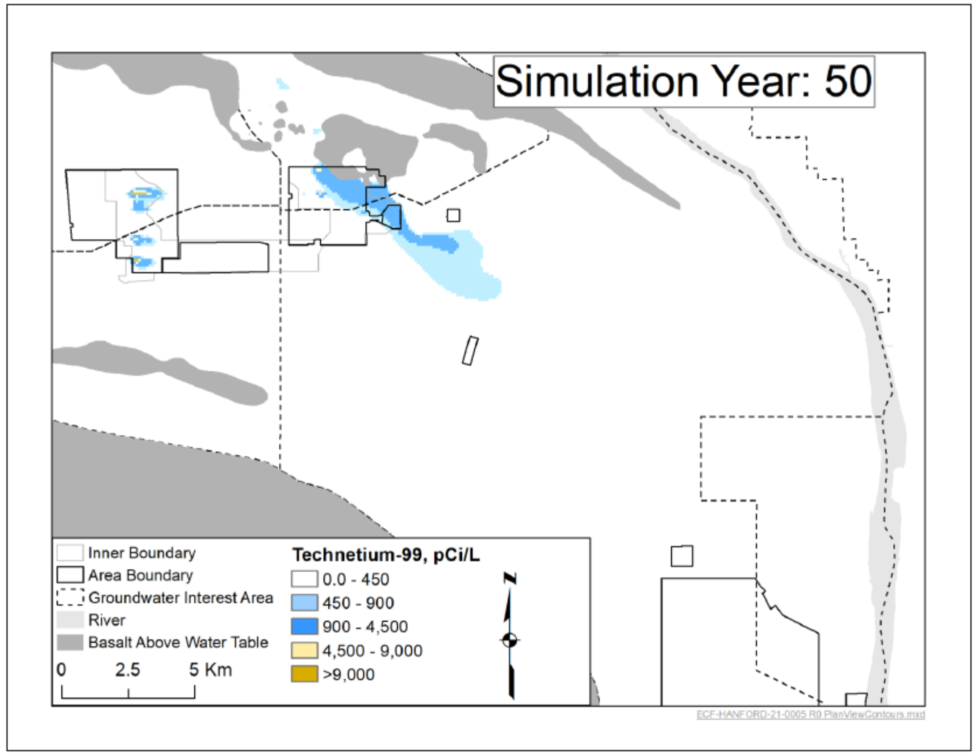
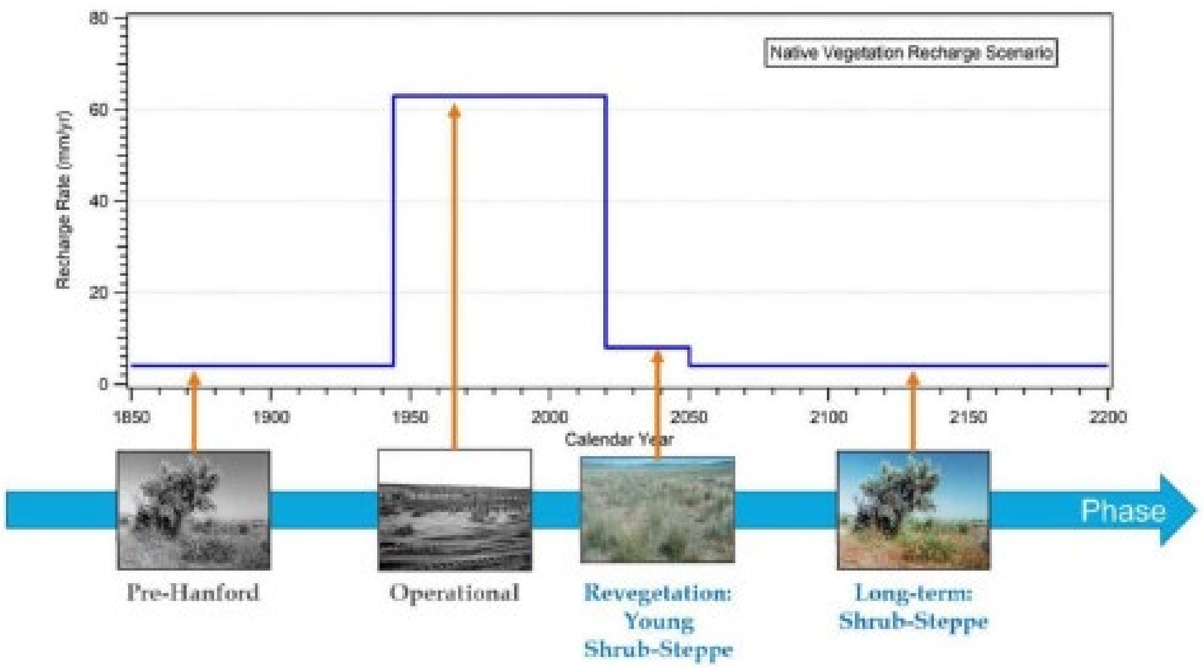


Figure C-62. Plan view contours of Technetium-99 concentration simulated 50 years from the start of simulation assuming the best estimate initial concentration.

Simulation of groundwater plumes over time

Cumulative Impact Evaluation Applications

- One of the tools in the CIE toolbox allows different remediation scenarios to be input, so that the change in source flux to the groundwater can be evaluated over time.
- This allows the CERCLA Operable Units to evaluate a range of remedial actions for protectiveness of the groundwater.



Options for Remediating the Deep Vadose Zone

- In-situ treatment of residual contamination:
  - Sequestration via chemical injection (e.g. phosphate or ammonia injection)
  - Dessication
  - Grout Injection
- Soil Flushing
- Surface Barriers
- Subsurface PRB at the water table interface

- Effectiveness, implementability and cost of DVZ technologies were evaluated in depth in DOE/RL-2017-58 *Technology Evaluation and Treatability Studies Assessment for the Hanford Central Plateau Deep Vadose Zone*

Remediating the Deep Vadose Zone: Example of In-Situ Treatment in the 300 Area

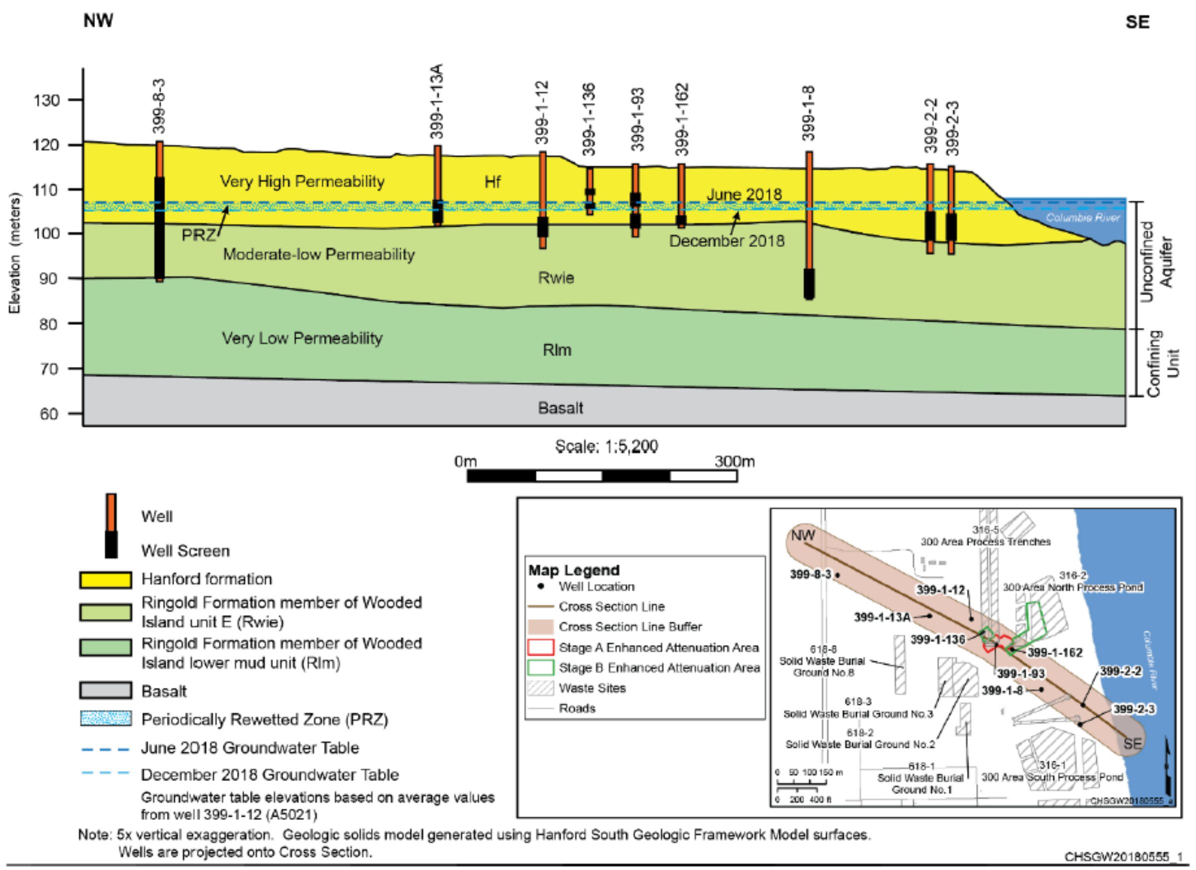


Figure 1-4. Cross Section of the General Geologic Features of the 300 Area Industrial Complex and Stage A and B Enhanced Attenuation Areas

Injection and infiltration of a polyphosphate solution into the vadose zone to sequester residual uranium that had been replenishing a groundwater plume as the river stage changed.

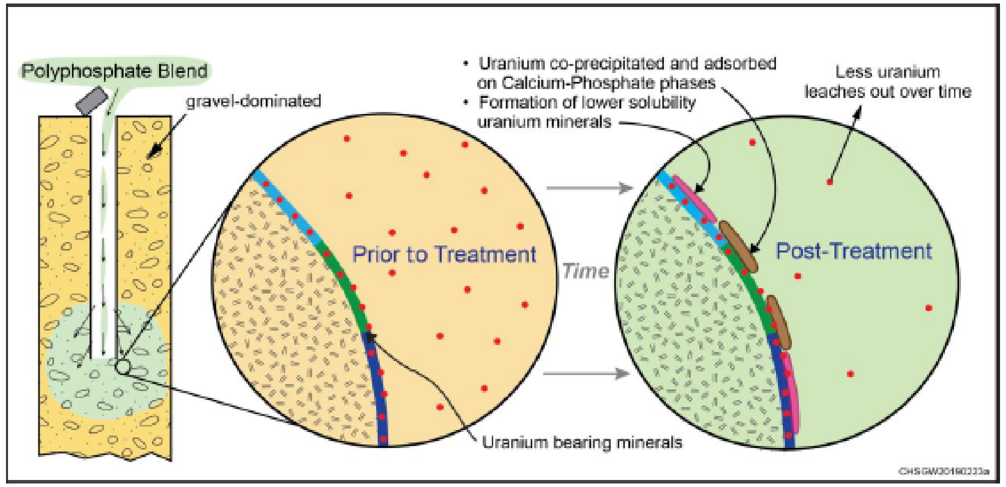


Figure 1-10. Uranium Mobility Change with Polyphosphate Treatment

Reference: SGW-63113 300-FF-5 Operable Unit Enhanced Attenuation Uranium Sequestration Completion Report

Remediating the Deep Vadose Zone: Example of In-Situ Treatment in the 300 Area

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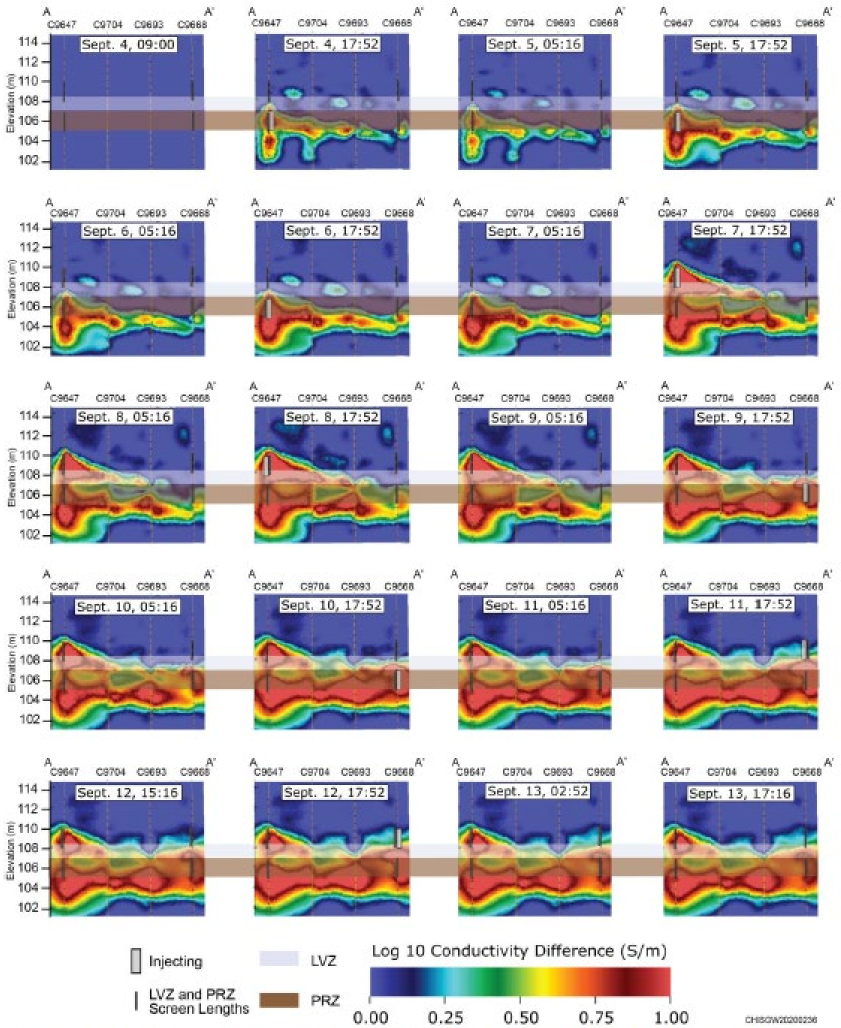

Source: Modified from Figure 17 in PNNL-28619, *Stage B Uranium Sequestration Amendment Delivery Monitoring Using Time-Lapse Electrical Resistivity Tomography.*

Figure 4-30. Twice Daily Images of ERT Amendment Distribution in Cluster 1

Extensive monitoring shows effective delivery of the phosphate from the 48 injection wells. Uranium concentrations have decreased in the groundwater, enhancing the natural attenuation of the U plume in the 300 Area.

Figure 2-1. Stage B Injection Well Locations in Four Injection Zones

Reference: SGW-63113 300-FF-5 Operable Unit Enhanced Attenuation Uranium Sequestration Completion Report

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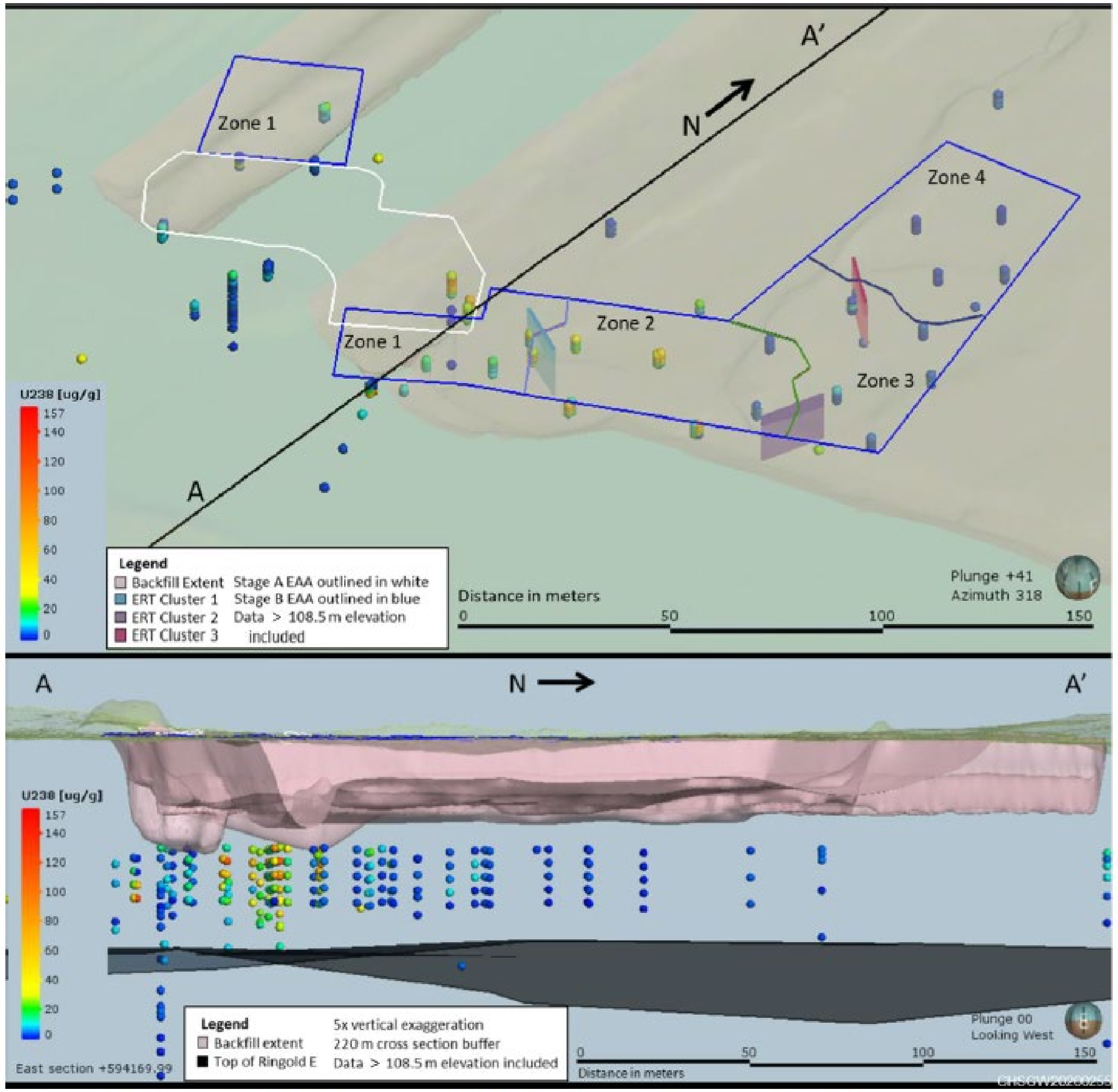
Factors that contributed to the success of in-situ sequestration at 300 Area

- Close out sampling during waste site remediation provided evidence for where the residual contamination remained in the vadose zone
- The relative thinness of the vadose zone reduces the volume of injected solutions necessary to sequester uranium



Reference: ECF-300FF5-16-0087, *Determination of Vadose Zone Uranium Concentration Distribution Extents and Development of a Three-Dimensional Geologic Framework Model for the 300-FF-5 Operable Unit, Hanford Washington.*

Figure 4-1. 3-D Plane View and Cross Section of EA Area with Excavation Footprint and Uranium Soil Samples from Stages A and B Below 108.5 m Elevation

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Conclusion

- Characterizing the nature and extent of comingled contaminants in a vadose zone up to 100m thick is challenging and has uncertainties
- Modeling tools have been developed to evaluate the continuing groundwater impacts from contamination in the vadose zone
- There are few options for remediation of contaminants in the deep vadose zone in the Central Plateau

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Thank you

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