Pacific Northwest
NATIONAL LABORATORY

RemPlex Seminar
December 9, 2025

Moab UMTRA Project: An Update on Progress Toward Closure at a Complex Groundwater Site

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Today's Seminar and Speakers

Moab UMTRA Project: An Update on Progress Toward Closure at a Complex Groundwater Site

Ken Pill
Groundwater Manager,
North Wind Portage, Inc.

Elizabeth Moran
Environmental Manager, Department of Energy (DOE) Environmental Management Consolidated Business Center

Moab UMTRA Project: An Update on Progress Toward Closure at a Complex Groundwater Site

Liz Moran, DOE-EM Moab UMTRA Project, *Environmental Manager*

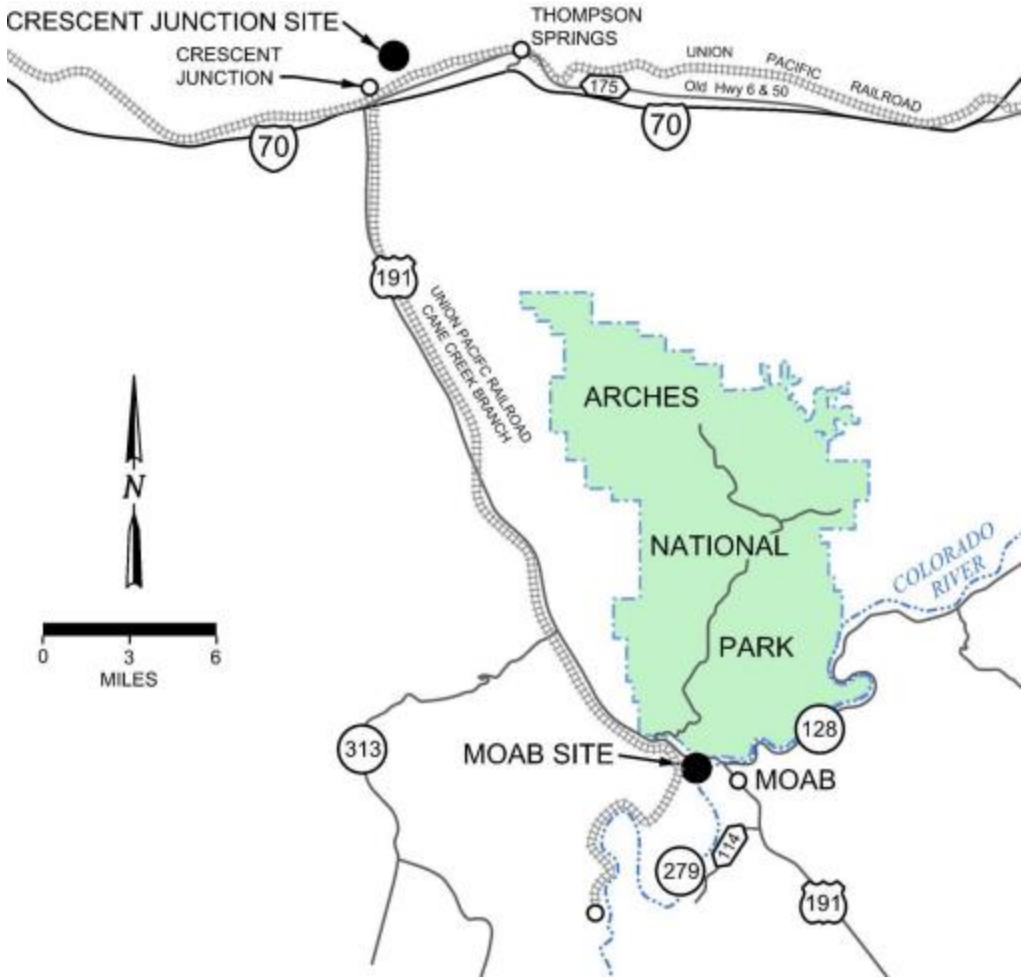
Ken Pill, Northwind Portage, *Groundwater Manager*

December 9, 2025

Outline

- Site introduction
- Groundwater issues
- Field investigations
- Technical support
- Looking toward the future

Moab UMTRA Project



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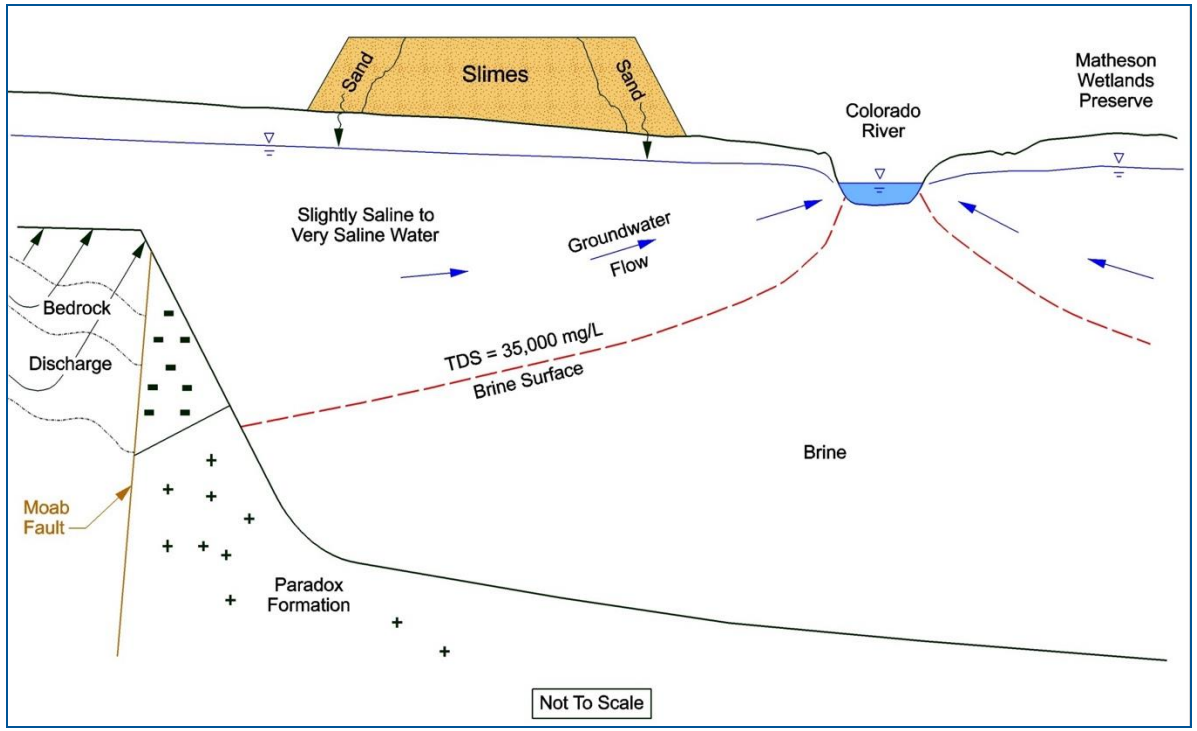
As the Site Approaches Closure…

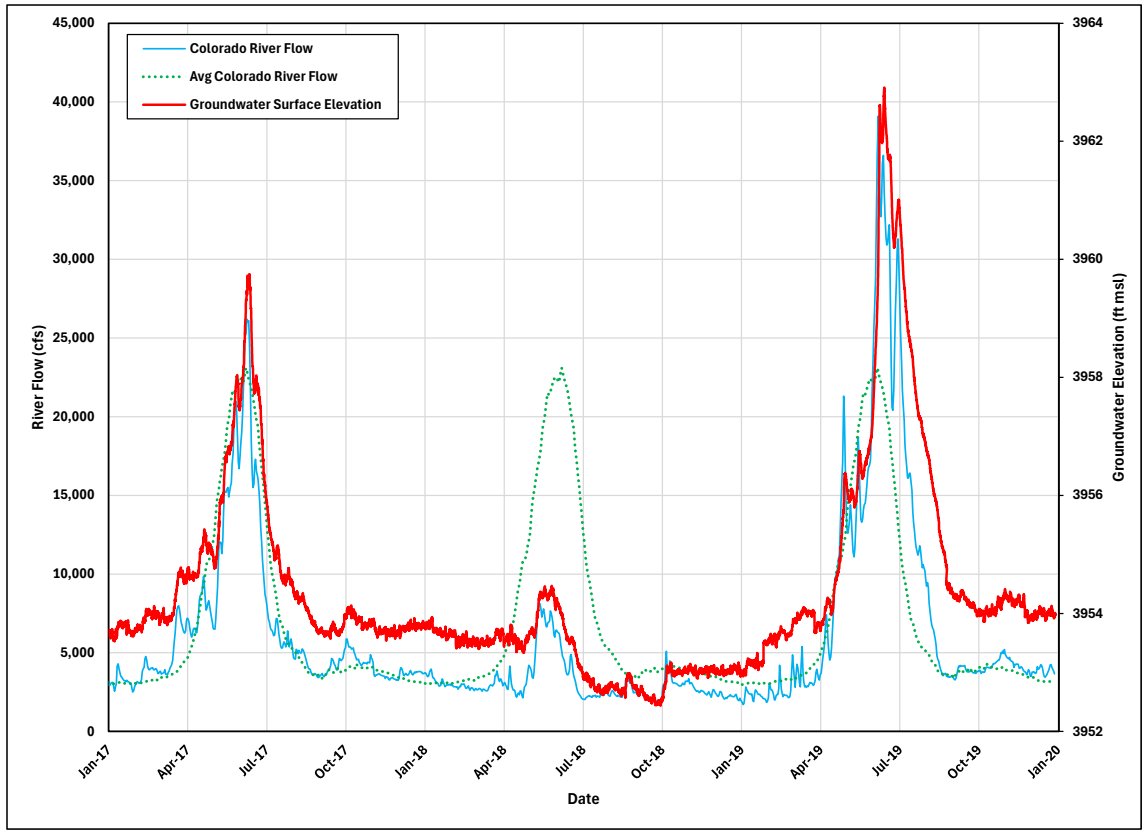
- Clean-up is regulated by 40 CFR 192
- Groundwater Compliance Action Plan
  - NNLEMS Collaboration (2022)
  - Field Investigations (2023-2025)
  - Groundwater Modeling (2025)
  - Technical Support
  - Regulatory and Stakeholder Interaction

Recap of Groundwater Issues – GW/SW Interaction

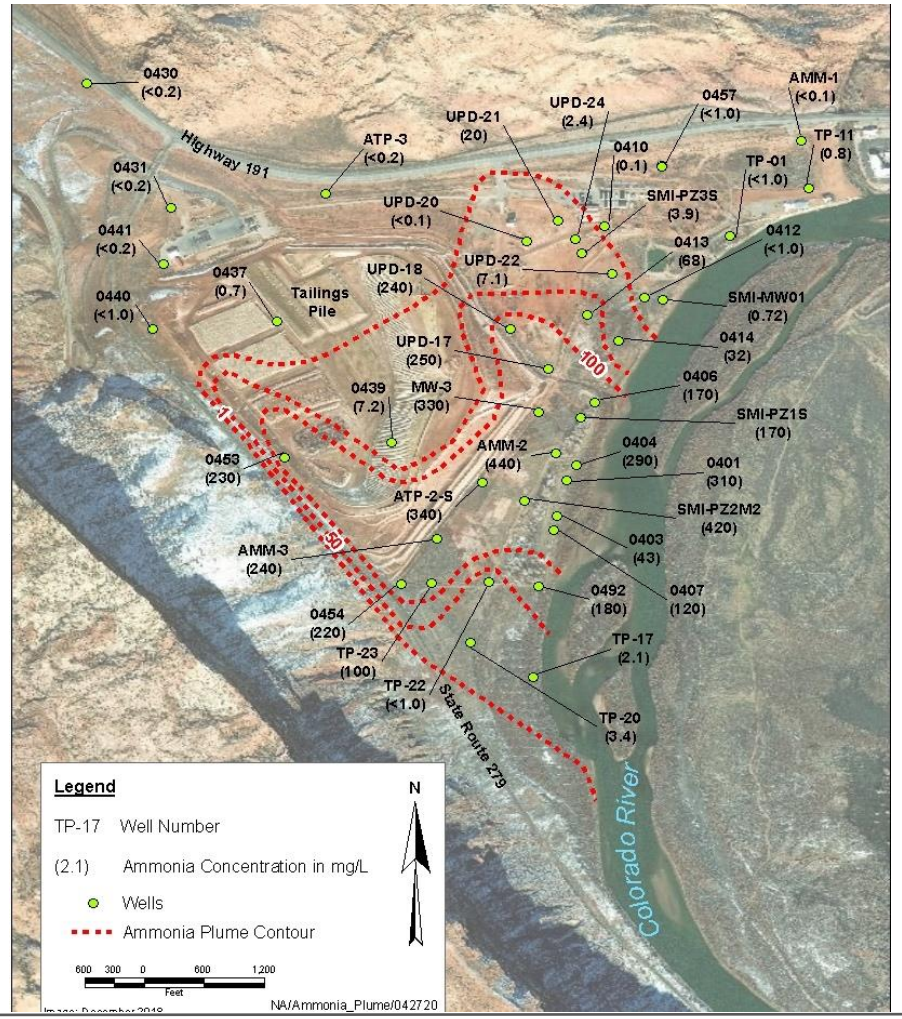


Conceptual Model

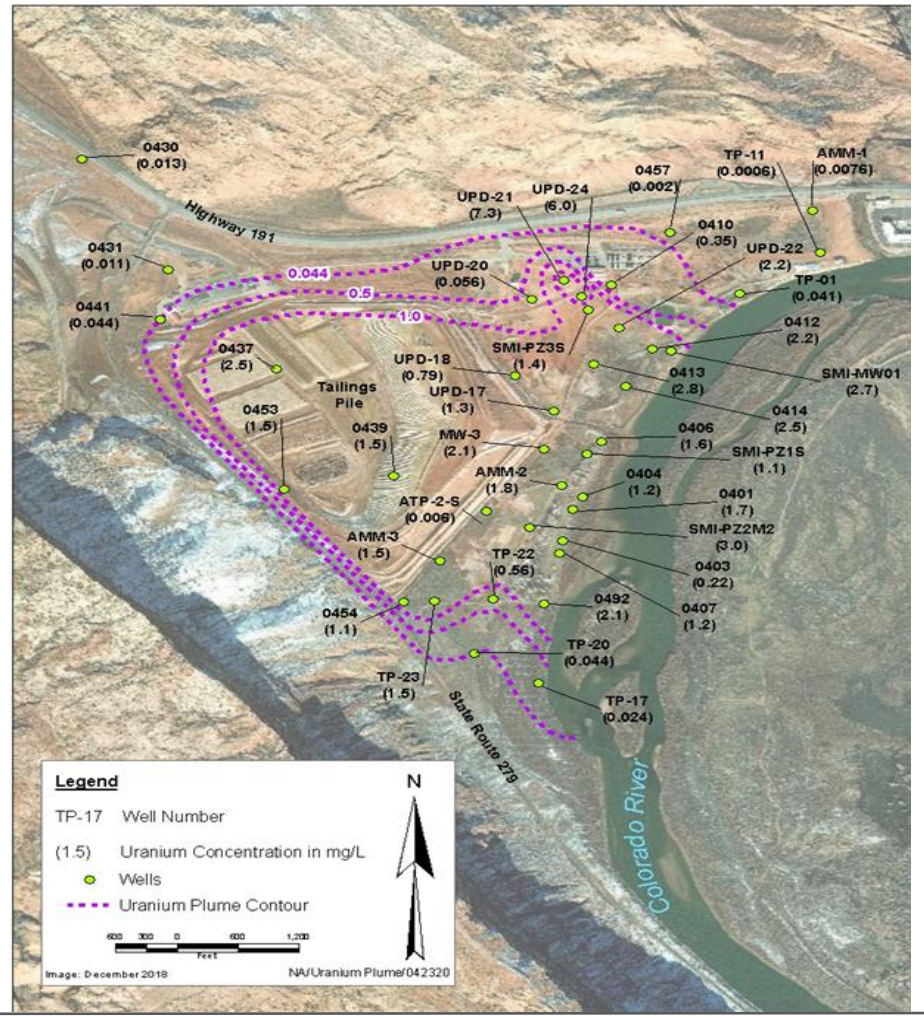
GW/SW Interaction



Recap of Groundwater Issues – Plume Maps



Ammonia



Uranium

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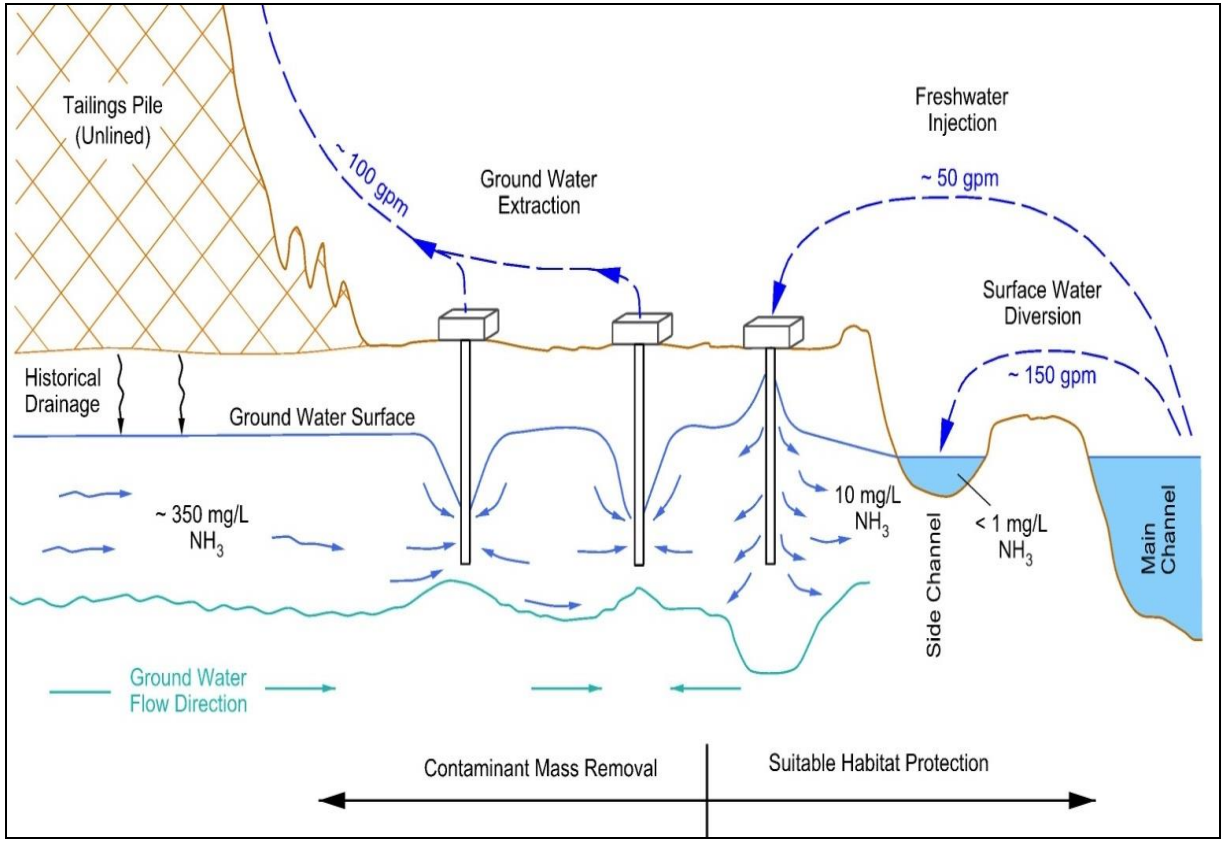
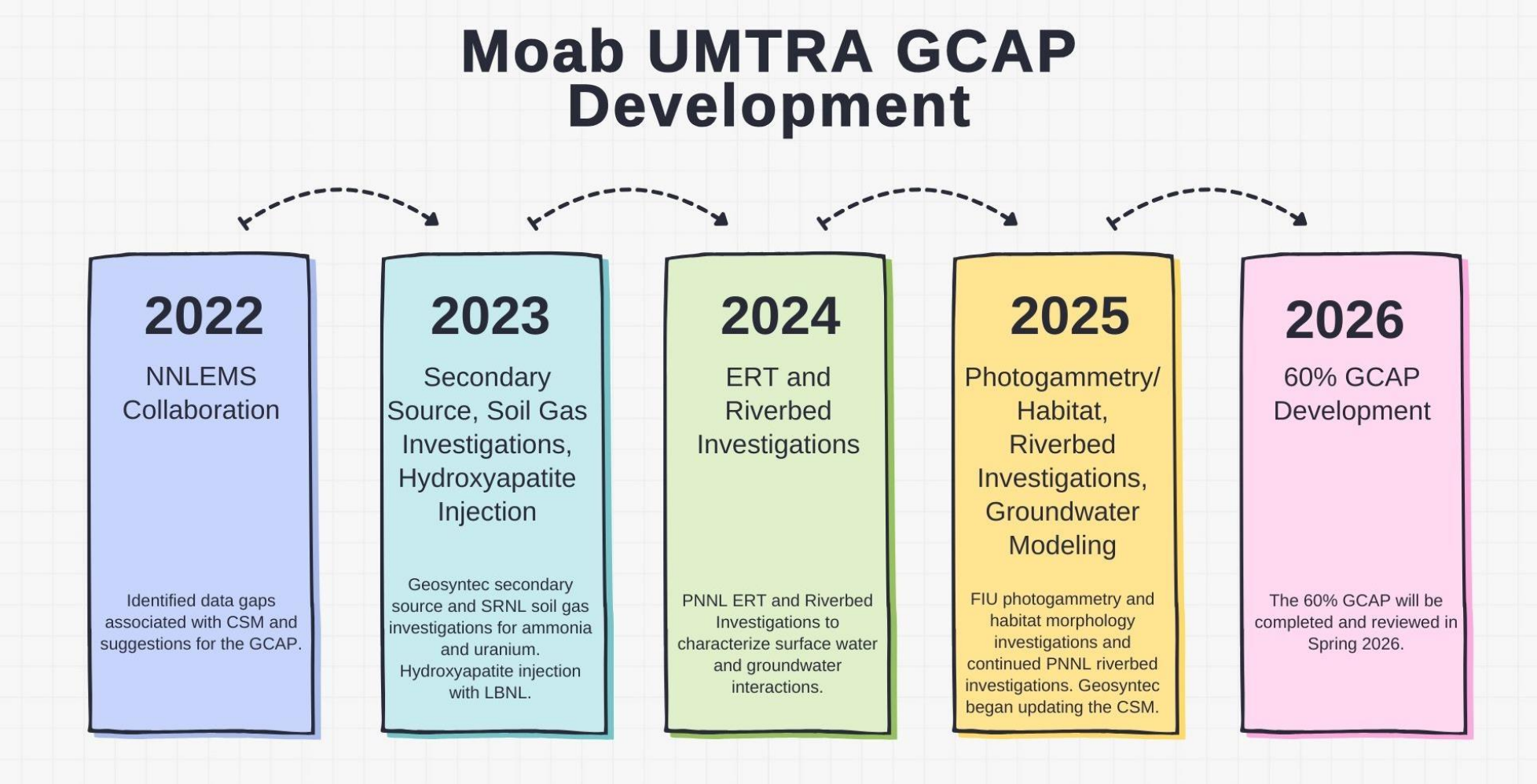
Recap of Groundwater Issues – IA Activities

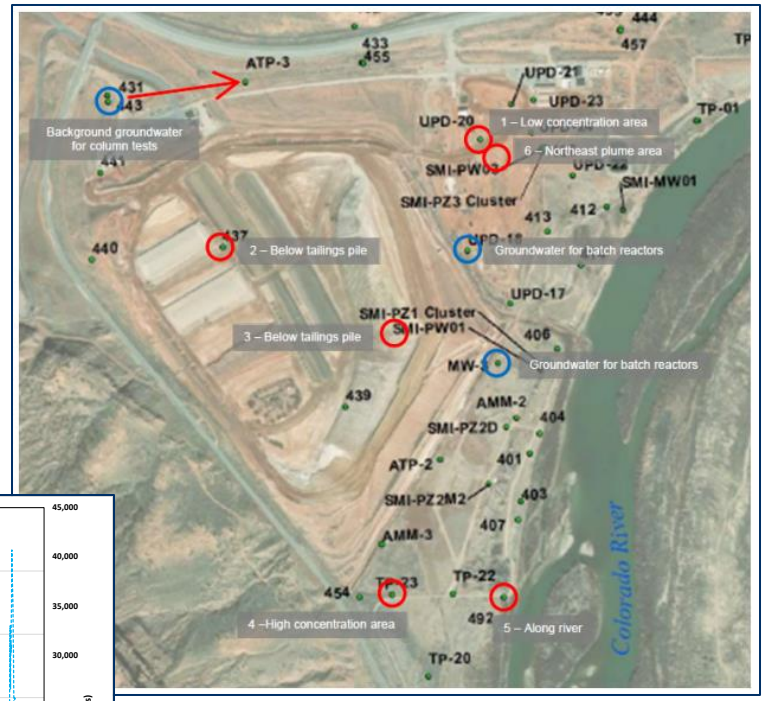


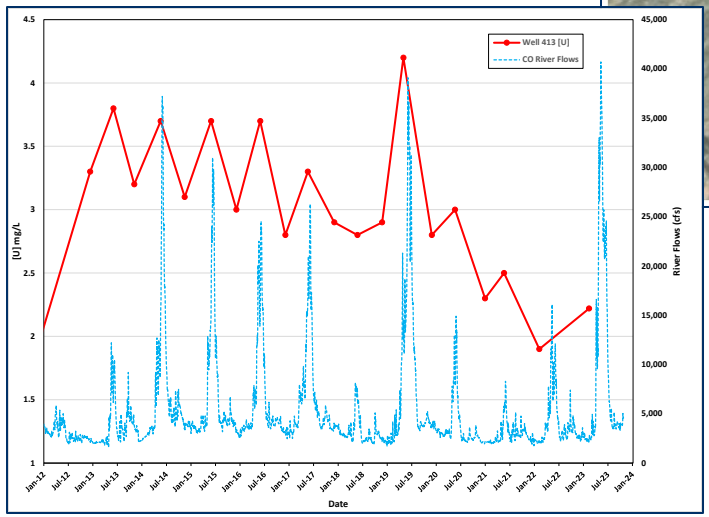
Field Investigations to Support the GCAP



Secondary Source Investigation (Geosyntec)

- Objectives
  - Evaluate uranium and ammonia mineral precipitation based on site groundwater data
  - Perform solid-phase extractions on saturated and vadose zone soil samples to quantify solid-phase uranium speciation
  - Perform column test to determine the number of flushed pore volumes to achieve cleanup goals
  - Perform batch reactor tests to determine if ammonia degradation (nitrification) is occurring





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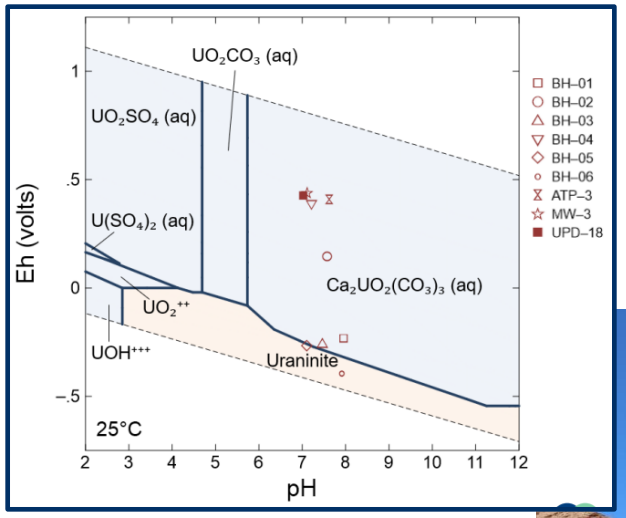
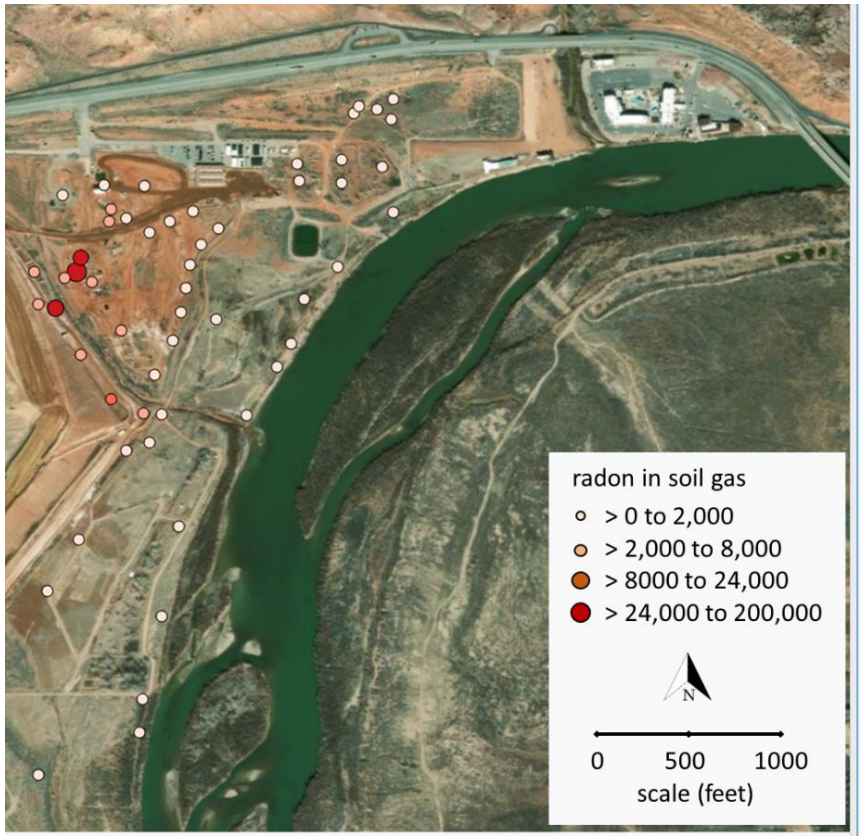
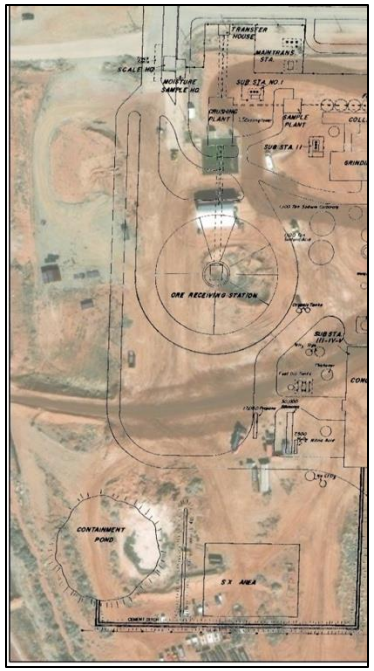
Secondary Source Investigation (Geosyntec) – continued

- Results
  - Groundwater redox conditions ranged from oxidizing to strongly reducing
  - Primary mechanism of uranium sequestration at sampling locations with oxidizing and reducing geochemical conditions was adsorption to iron and manganese (oxy)hydroxides
  - On average, 63% of solid-phase uranium was adsorbed, 23% of solid-phase uranium was associated with iron and manganese (oxy)hydroxides, and 14% of solid-phase uranium was recalcitrant and unlikely to mobilize to groundwater under naturally occurring geochemical conditions
  - The primary mechanism of ammonia sequestration at sampling locations with oxidizing and reducing geochemical conditions was adsorption/cation exchange
  - Evidence of nitrification was observed in one reactor, and may therefore be contributing to attenuation of ammonia in groundwater



Soil Gas Investigation (SRNL)

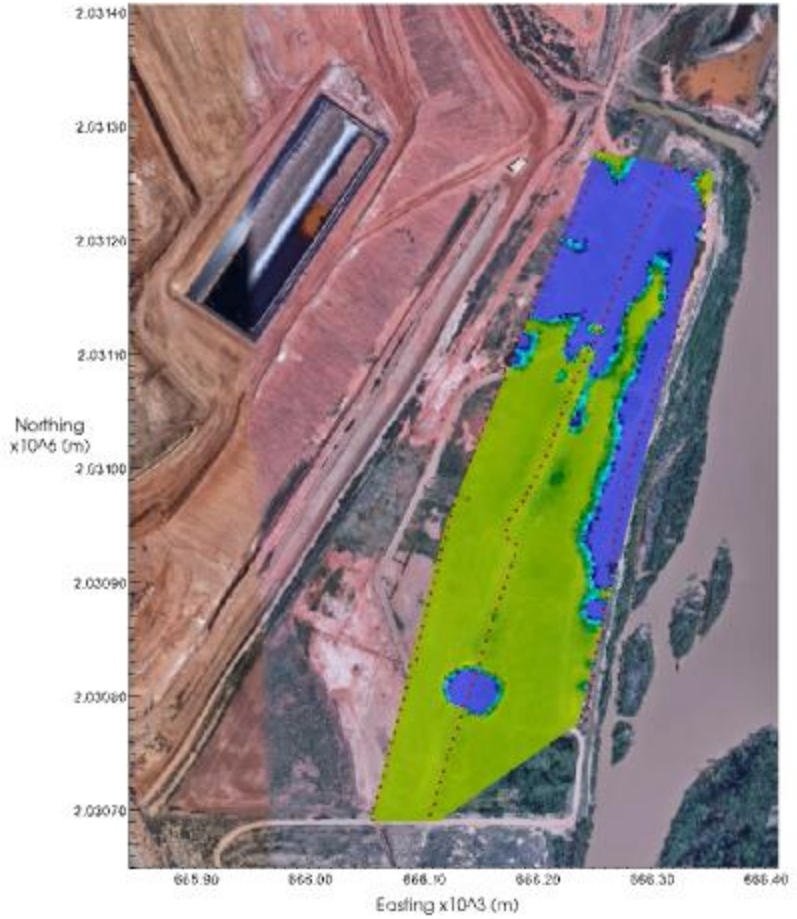




- Objective
  - Confirm, identify, quantify, and refine secondary contaminant source area locations for uranium and ammonium/ammonia in the vadose zone and shallow groundwater
- Preliminary Results
  - Significant variations were measured in the data for radon (4 orders of magnitude), nitrous oxide (> 3 orders of magnitude), carbon dioxide (> 2 orders of magnitude), methane and ammonia (both about 1.5 orders of magnitude)
  - The general biogeochemical soil gas indicators indicated that a significant, sustained, and active subsurface microbial community is present in the area of highest radon
  - Ammonia was elevated in the soil gas at well field sampling locations and near the riverbank, likely resulting from the flushing of ammonium from source areas

Electrical Resistivity Tomography (ERT) (PNNL)

- Objective
  - Use electrical resistivity tomography (ERT) to:
    - Image subsurface structure
    - Monitor stage-driven groundwater-surface water interactions between the Colorado River and the Moab Site.
- Preliminary Results
  - Generally lower conductivity to the north (Moab wash) and east (Colorado River)
  - Conductivity increases with depth
  - Overall high conductivity conditions at Moab decrease sensitivity between ERT lines, making it appear (at times) there are no changes between lines.
  - Intrusion pathway is predominantly to the northwest
  - Southern region is mostly inactive



Riverbed Investigations (PNNL)

- Objective
  - Use streambed sampling and thermal profiling to:
    - Obtain new information to refine the CSM, in particular the roles of deep geologic brines and the Moab fault in the GW/SW system
    - Identify preferential flow paths and interaction between the river and the aquifer
    - Evaluate hydrogeophysical methods for integration into long-term monitoring

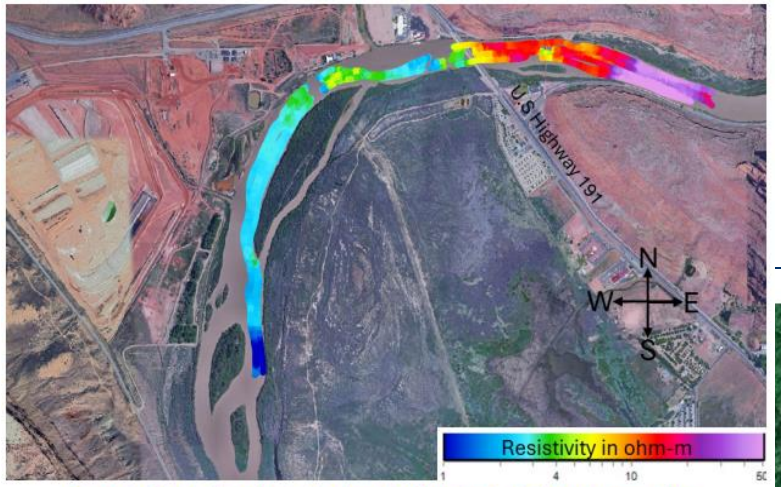
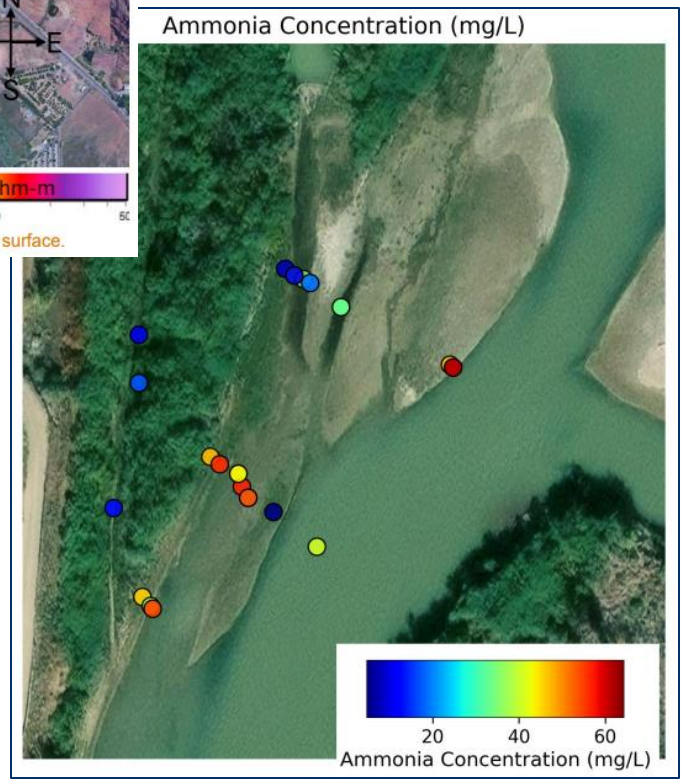


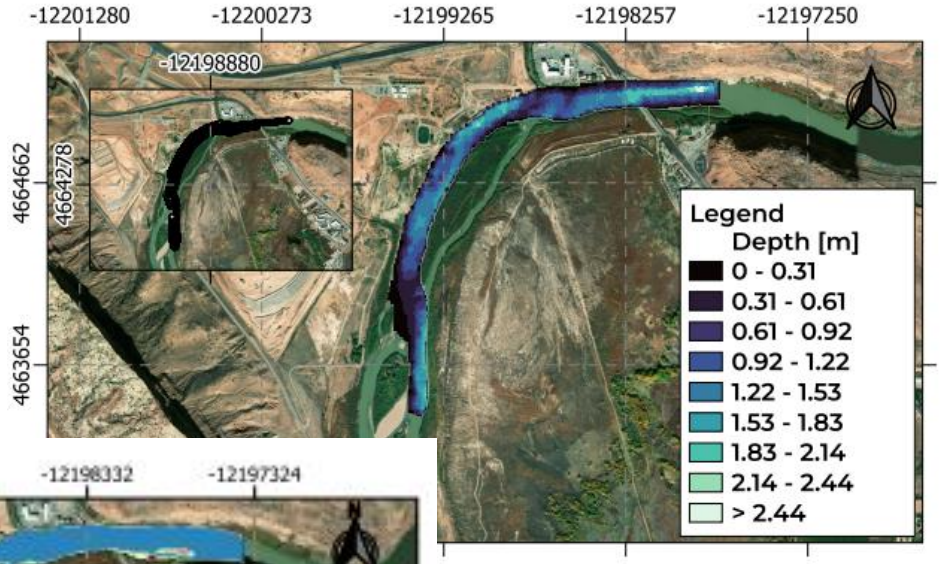
Figure 9. Depth slice of resistivity from 15-20 m depth, relative to water surface.

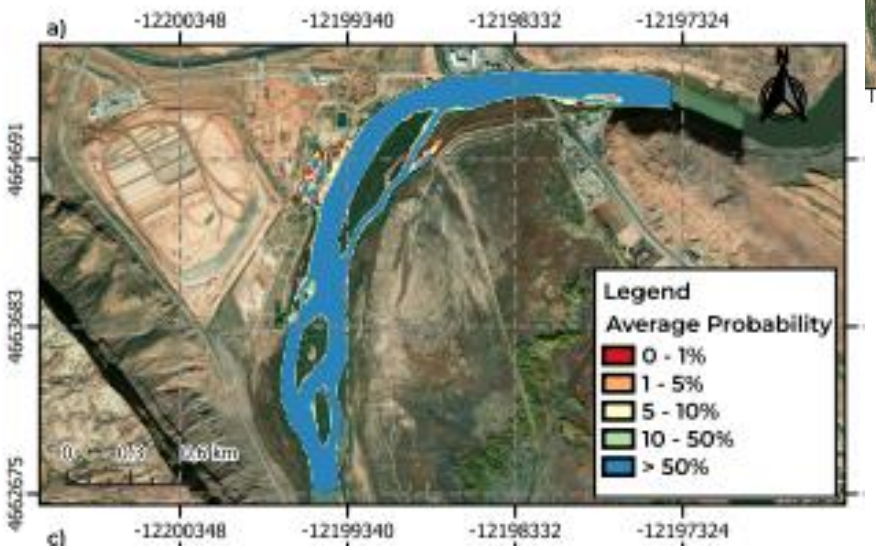


- Results
  - Decreasing resistivity with depth, consistent with increasing salinity of the pore fluids with depth in the streambed
  - The top of a low-resistivity feature lies 15-20 m below water surface
  - Bulk resistivity in the streambed is higher toward the right bank (adjacent to the site) vs. the left (adjacent to the wetland), possibly due to freshwater injections that were ongoing during the field campaign. Southern region is mostly inactive

Photogammetry/Habitat Investigations (FIU)

Bathymetric Map



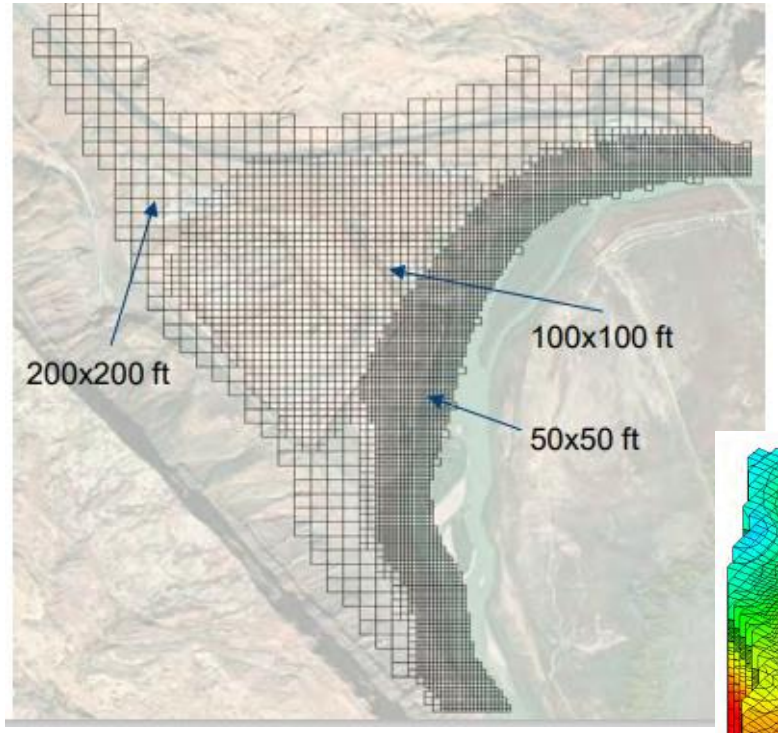


Avg Flood Probability

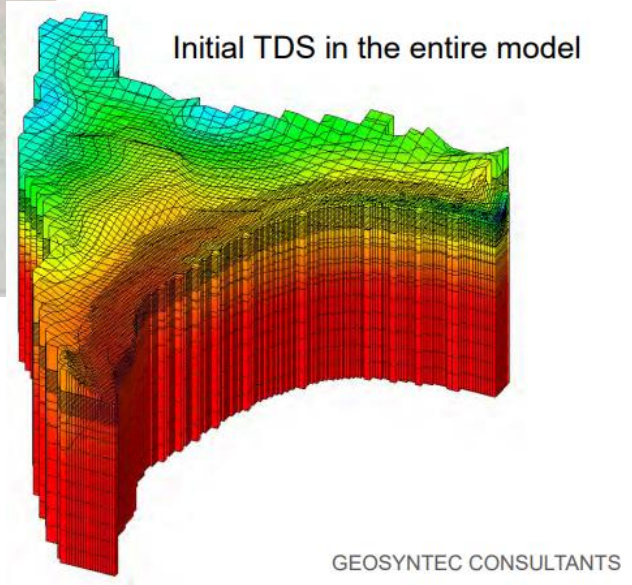
- Objective
  - Evaluate groundwater well observations using ML/AI methods to:
    - Build a model for the shallow subsurface to identify long-term patterns in groundwater flow
    - Understand how spatial and temporal changes in Colorado River flows impacts groundwater interaction and critical habitats
    - Identify the impact of river flow scenarios through a detailed assessment on the shallow groundwater and surface water system
- Preliminary Results
  - Evaluated the variability in flood extent and hydraulic conditions
  - Flood occurrence probability, temporal mean, and standard deviation of inundation depth were computed to characterize flooding

Groundwater Modeling (Geosyntec)

- Objective
  - Develop a Groundwater Fate and Transport Model to:
    - Set up 100-year forward predictive simulations representing future conditions
    - Assess residual and secondary contaminant sources, including vadose zone sources and the deep legacy brine plume
    - Integrate the modeling results into recommendation for groundwater compliance strategy for GCAP development



Model Domain

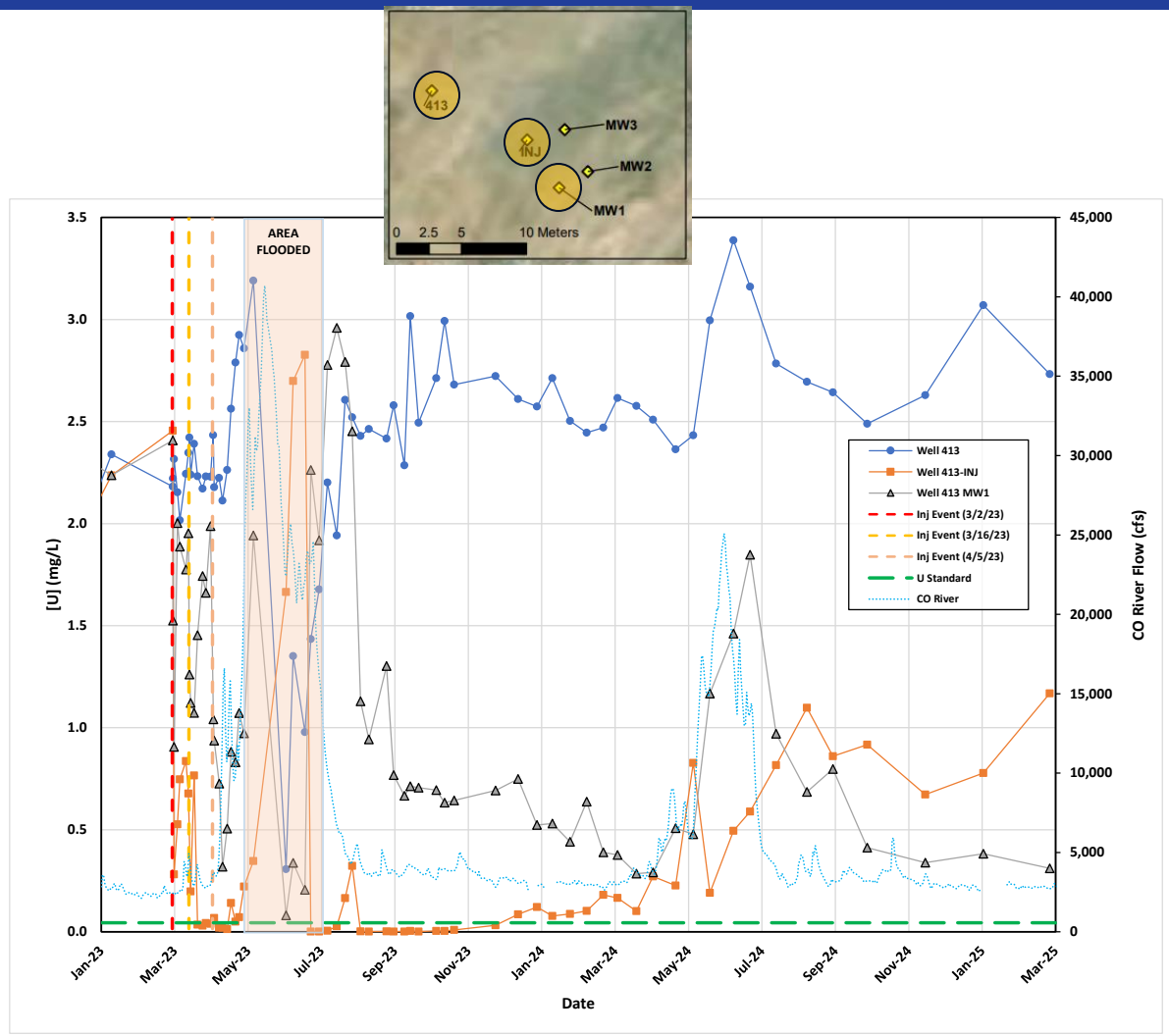


- Preliminary Results
  - Because of the contaminant transport, ammonium and uranium concentrations gradually decrease in the shallow plumes and slightly increase and then decrease afterwards in the deep aquifer
  - Looking into natural flushing timeframes for ammonia and uranium

Hydroxyapatite (LBNL)

- Objective
  - Evaluate the effectiveness of a hydroxyapatite chemical reactive barrier to uptake and remove uranium from the groundwater system

- Preliminary Results
  - Three injection events Mar – Apr 2023
  - Plot displays background (413), injection point (413-INJ), and 5m downgradient (413-MW1) uranium concentrations
  - 413-INJ and 413-MW1 impacted immediately by injection, 413 impacted by 2023 above average CO River spring runoff flows
  - Late June 2023 413-INJ concentrations sharply decreased, and stayed below the 0.044 mg/L standard through late November 2023
  - After 2024 runoff flows, 413-MW1 concentrations have remained below 0.5 mg/L since October 2024, and have gradually increased in 413-INJ



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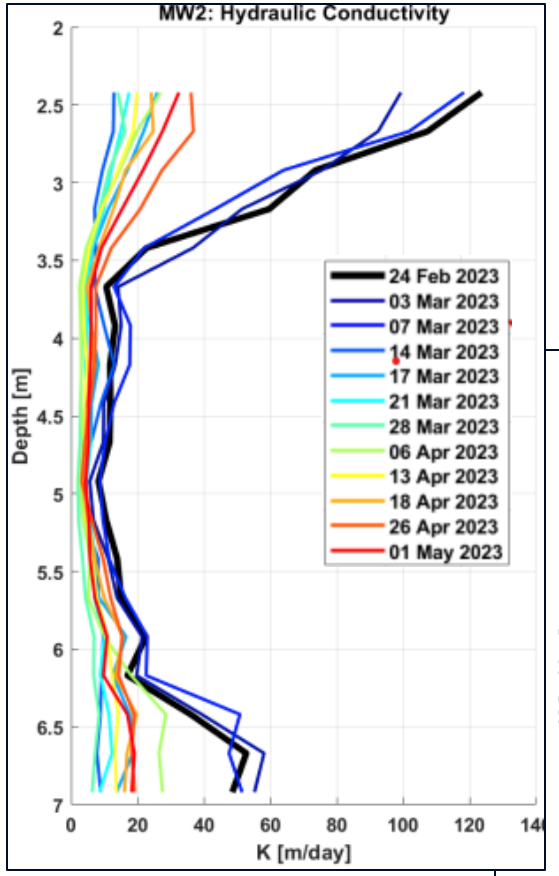
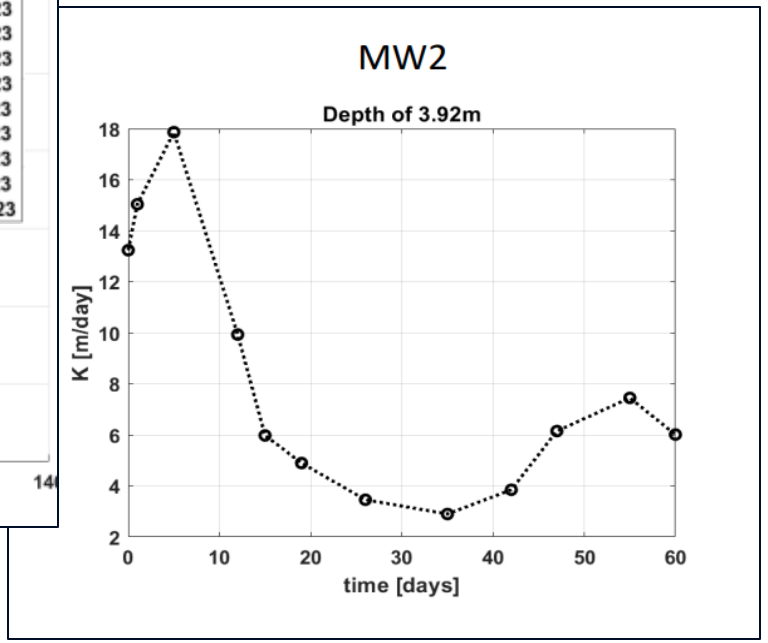
Nuclear Magnetic Resonance (NMR) (Vista Clara)

- Objective
  - Remote monitoring of hydroxyapatite precipitation prior to and after Mar – Apr 2023 subsurface injection events
- Preliminary Results
  - Significant hydraulic conductivity changes 2.5 m bgs (water table), from 120 to 20 m/d within ~20 days, then slight rebound
  - At 3.9 m bgs K decreases from 18 m/d to less than 5 m/d after 2 weeks
  - Significant decrease in free water content and increase in capillary water content was detected between 2.5 to 5 m, associated with precipitation in pores
  - Dramatic hydraulic conductivity decrease was detected





Technical Updates

- Technical and Regulatory Support
  - Regulatory Center of Excellence and SRNL
  - Long-term Monitoring
- Stakeholder Engagement
  - Local and Federal
- Path Forward

Technical and Regulatory Support (SRNL)

Moab UMTRA GCAP Technical Support

NNLEMS Report	"Moab Uranium Mill Tailings Remedial Action Project Site: Collaboration to Support Development of the Groundwater Corrective Action." May 2023
Remedial Strategies	"Development of Recommended Groundwater Compliance Remediation Portfolios for moab UMTRA Project Site." TBD
Recommendations for Expedited Regulatory Acceptance	"Proposed SRNL Technical Assistance Support to Moab: Regulatory Strategic for GCAP Approval Recommendations." July 2024
Strategic Long-Term Monitoring Plan	"Preliminary Recommendations for the Implementation of an Innovative Strategy for Long-Term Monitoring of Groundwater Contamination at the Moab UMTRA Project Site." October 2024

Technical Support

- Baseline Risk Assessment
  - Institutional Controls
  - ACLs
- Supplemental Standards
  - 82% of the aquifer qualifies as limited use due to TDS

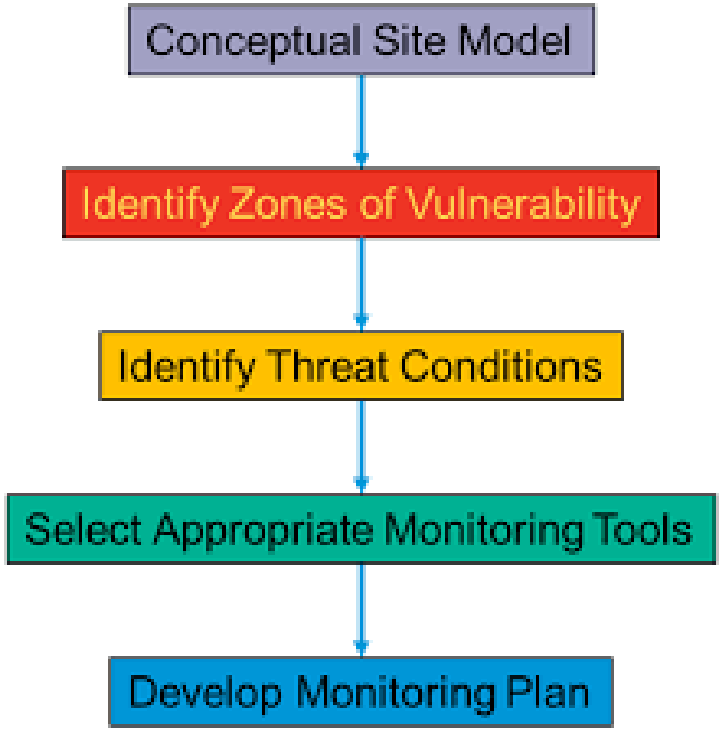
Technical Support

Strategy	Alternative			
	Proposed action	No action[a]	Active remediation to background levels	Passive remediation
Active ground water remediation methods	X		X[b]	
Natural flushing [C]	X			X
No ground water remediation - Sites that qualify for supplemental standards [d] or alternate concentration limits[e].	X			X
- Sites that meet maximum concentration limits or background levels (no impacts).[f]	X			X

Long-Term Monitoring

ALTEMIS

- Detect changes that threaten human health, environment, and timely closure
- Past monitoring data will be used to train AI/ML algorithms to identify anomalous conditions
- Adaptable to end-state land-use conditions
- Accelerates development/deployment of improved lower cost LTM strategies at other sites



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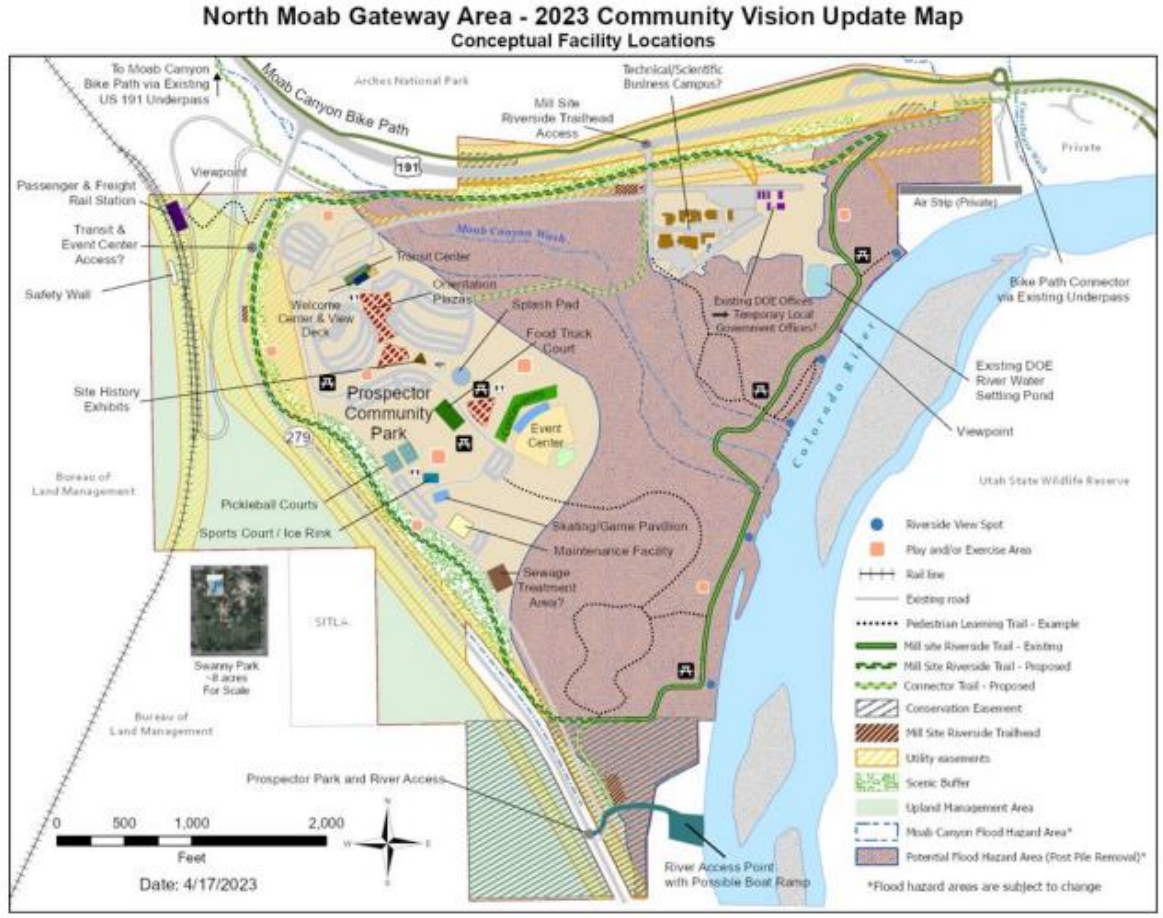
Stakeholder Engagement

- Local Stakeholders
  - Moab UMTRA Steering Committee
  - Site Futures Committee
- DOE- Office of Legacy Management
  - Site Closure IPT
- Nuclear Regulatory Commission
  - Quarterly Meetings
- U.S. Fish and Wildlife
- State of Utah

Path Forward

- GCAP Schedule
- End State of Site
  - S.1321 Moab UMTRA Project Transition Act of 2025
  - Atomic Energy Act 161(g)



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Questions?

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