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Protecting People and the Environment

Characterizing, Modeling, Monitoring and Remediating Radionuclides in the Subsurface

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Overview

- Regulatory Bases for Evaluating the Need for Remediation
- Integrate Modeling with Monitoring
- Conceptual Site Model and Information Needed to Confirm
- Uncertainties in Conceptual Site Models
- Dose Assessment to Determine Need for Remediation
- Range of Remediation Methods Available
- Formulate 3-D Realistic Model to Evaluate Remediation Alternatives and Performance
- Information Sources

Regulatory Bases for Evaluating the Need for Remediation

- ✓ Minimization of contamination required at new nuclear facilities [10 CFR Part 20.1406 (a) (b)]
  - How facility design and operating procedure will minimize to the extend practicable contamination of the facility and the environment
  - Facilitate eventual decommissioning and minimize generation of radioactive waste
- ✓ Existing radionuclide contamination at operating facilities
- ✓ Facilities being decommissioned with residual radionuclides

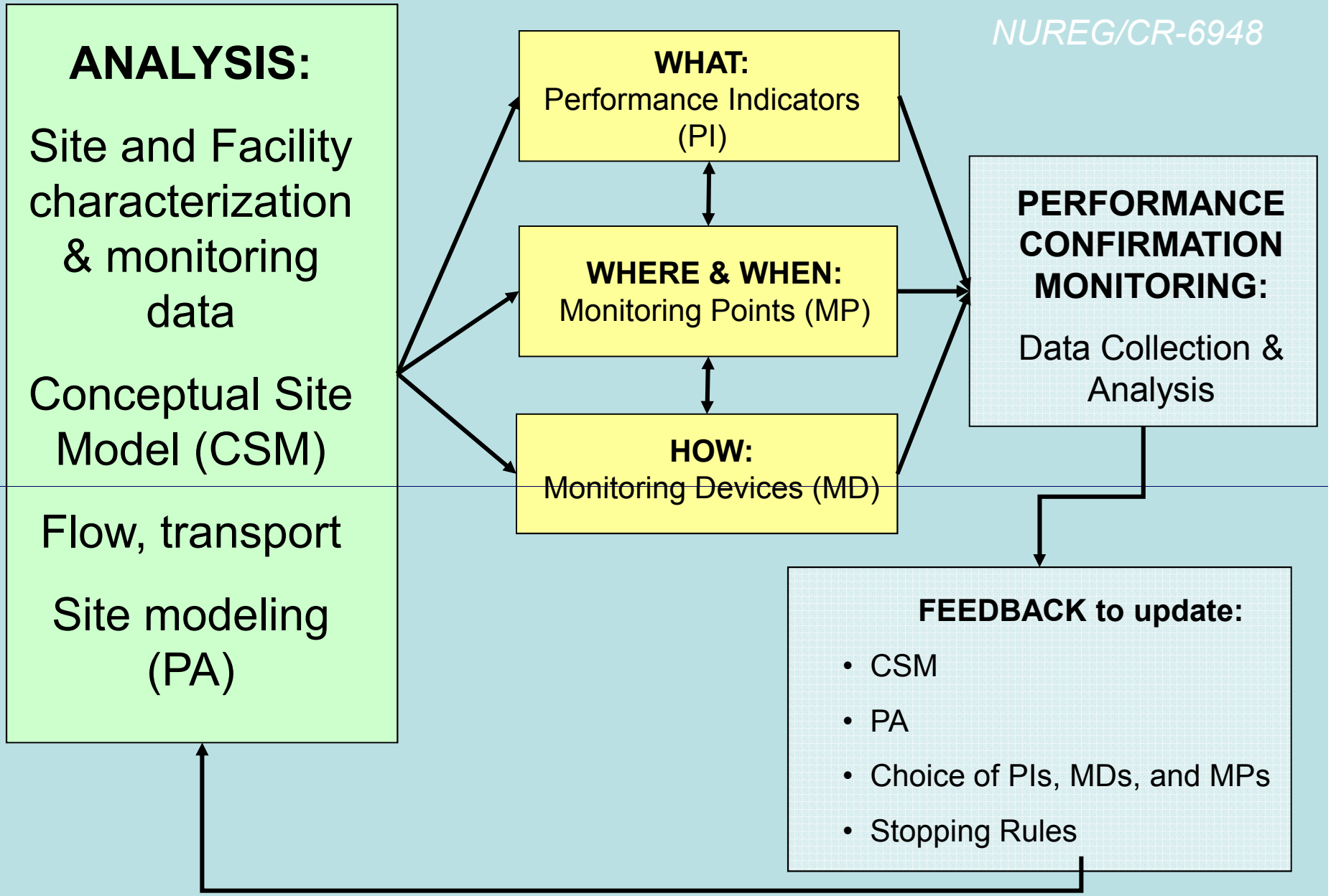
Modeling and monitoring establish technical basis for decision-making on the need for and selection of remediation methods

Integrate Modeling with Monitoring

Site-Specific modeling benefits for evaluating need for remediation:

- ✓ Integrates disparate characterization and monitoring data into a logical framework
- ✓ Reduces uncertainties and optimizes locations for sampling/ monitoring to confirm hydrogeologic system behavior
- ✓ Forecasts impacts (doses due to exposure and uptake)
- ✓ Provides bases for decision-making on the need to remediate
- ✓ Assists in designing and monitoring remediation program (e.g., monitored natural attenuation thru pump-and-treat)
- ✓ Identifies Performance Indicators as measurable quantities for both monitoring and modeling
- ✓ Communicates understanding of the system to the public and facilitates technical interactions

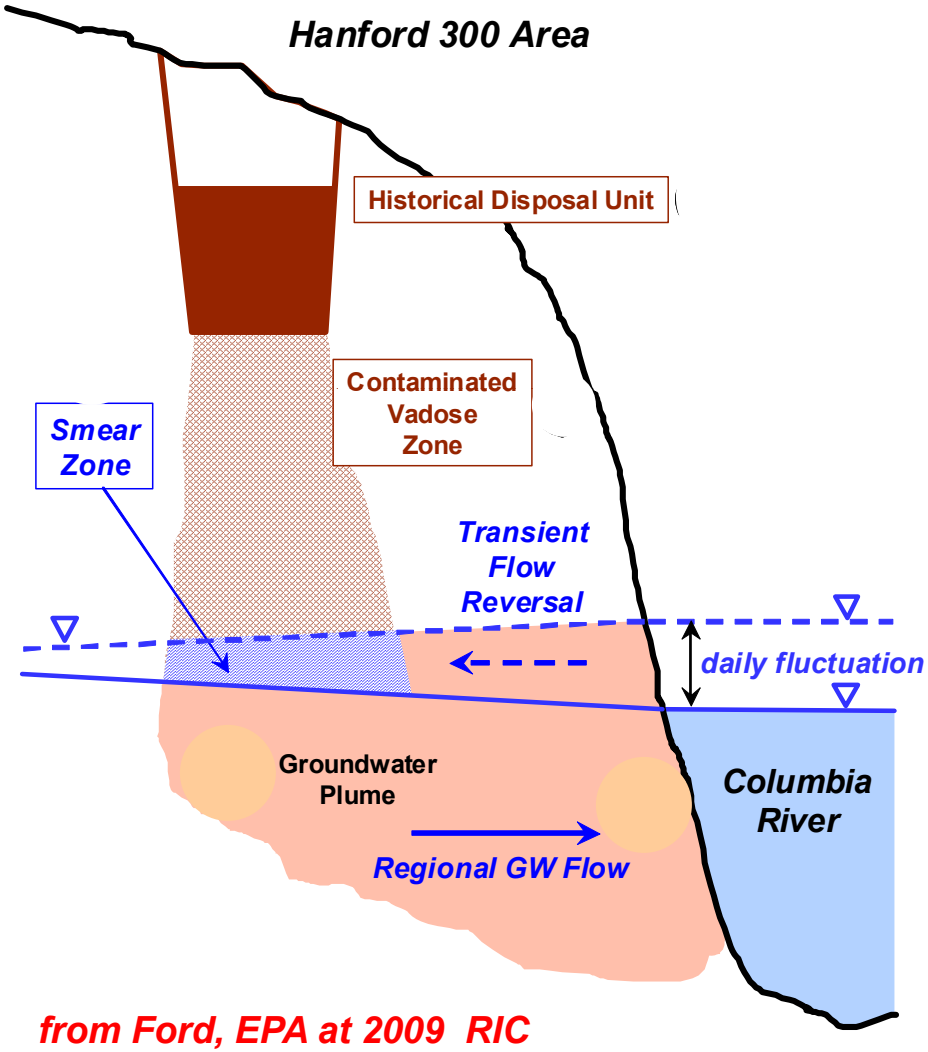
NUREG/CR-6948



[from Price and others, 2007 in NUREG/CR-6948]

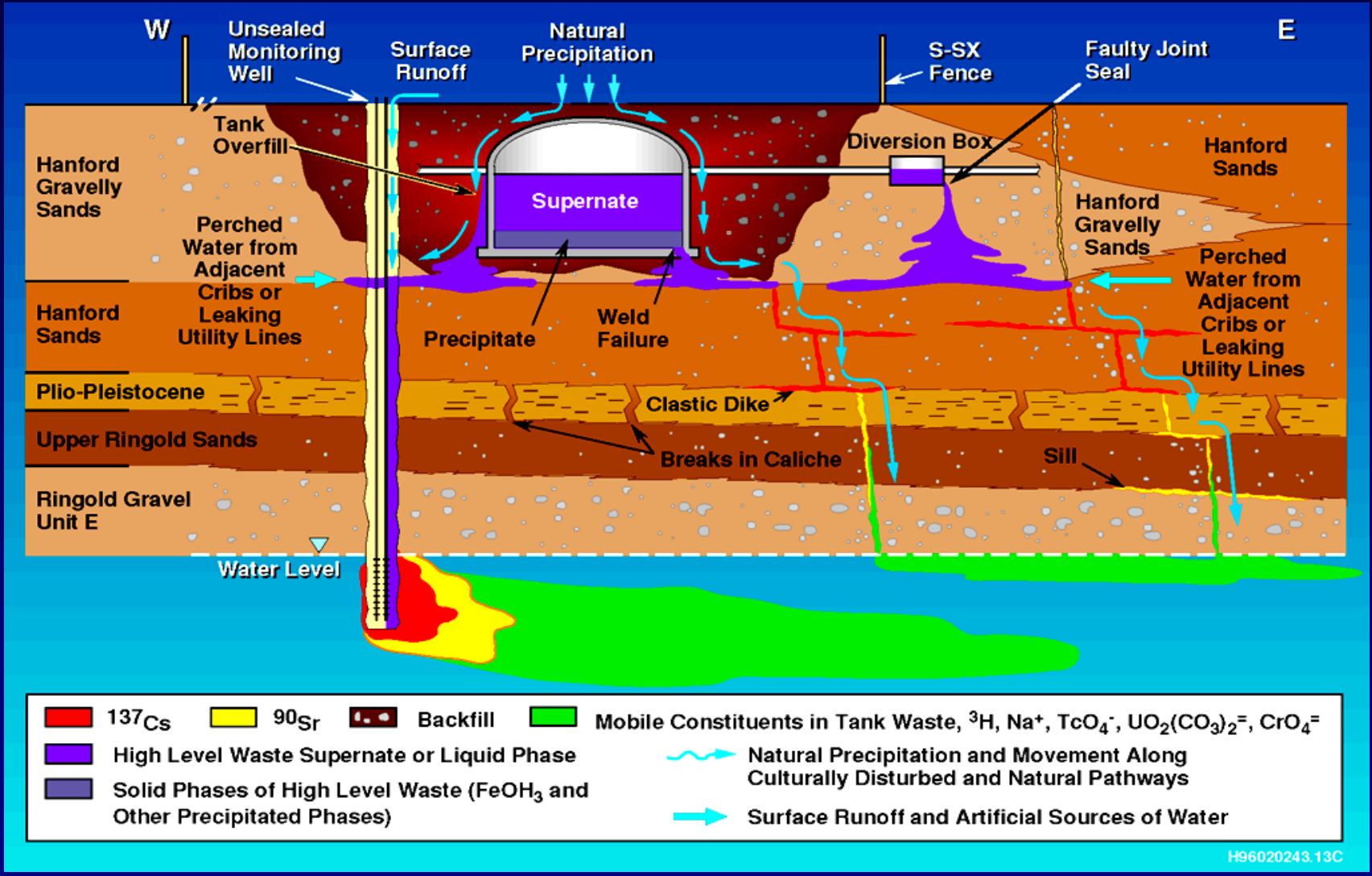
Conceptual Site Model

- Simplified representation of the site with significant FEP's
- Select, organize and communicate information in 3-dimensional visualizations
- Subject to testing with new characterization and monitoring data



from Ford, EPA at 2009 RIC

Conceptual Model of Complex Site with Multiple Sources



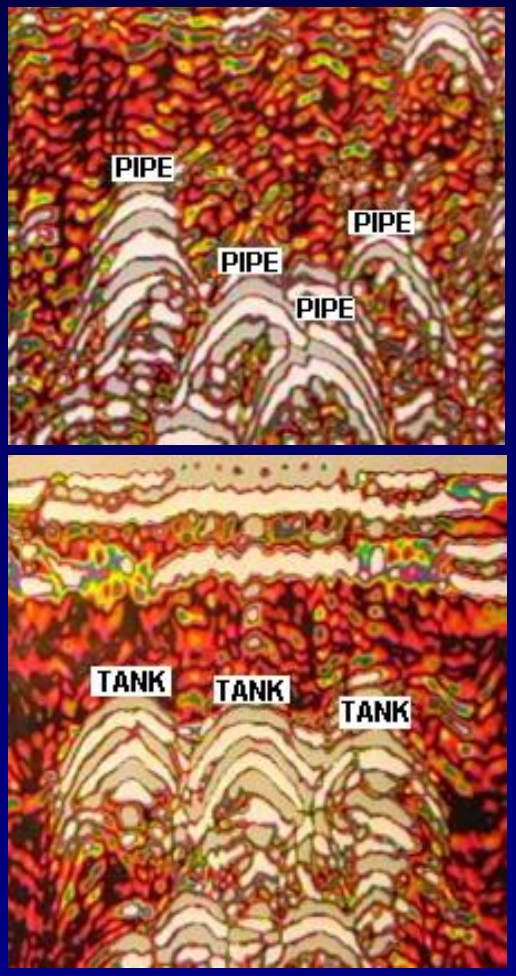
from Ward et al. (1997) after Caggiano et al. (1996)

Information Needed to Confirm Conceptual Site Hydrologic Model

- Natural and engineered features, structures, backfills and soil-rock interfaces, boundary conditions and time-dependent processes
- Potential sources of contaminant releases
- Regional and site hydrologic setting (perched water, aquifers, surface- water bodies, springs, wetlands and drainage systems)
- Local drinking water sources (ground- and surface-water sources)
- Existing ground-water wells and monitoring points onsite and offsite
- Depth to the water table and surface-water body elevations
- Historical details on contaminant releases
- Ground-water gradients, flow directions and velocities

Anthropogenic Features for Considering Alternative Conceptual Site Models

- Pathways for rapid spread of leaking contaminants
  - pipe or cable trenches
  - gravel backfill
- May drive contaminants in directions not predicted by contouring a few data points on a water-table map
- Local precipitation drainage (roof and storm drains)
- Sources of leaks
  - can inject large amounts of water into the vadose zone, sometimes creating perching
  - drive ground water and contaminants in directions not predicted based on water levels from scattered monitoring wells

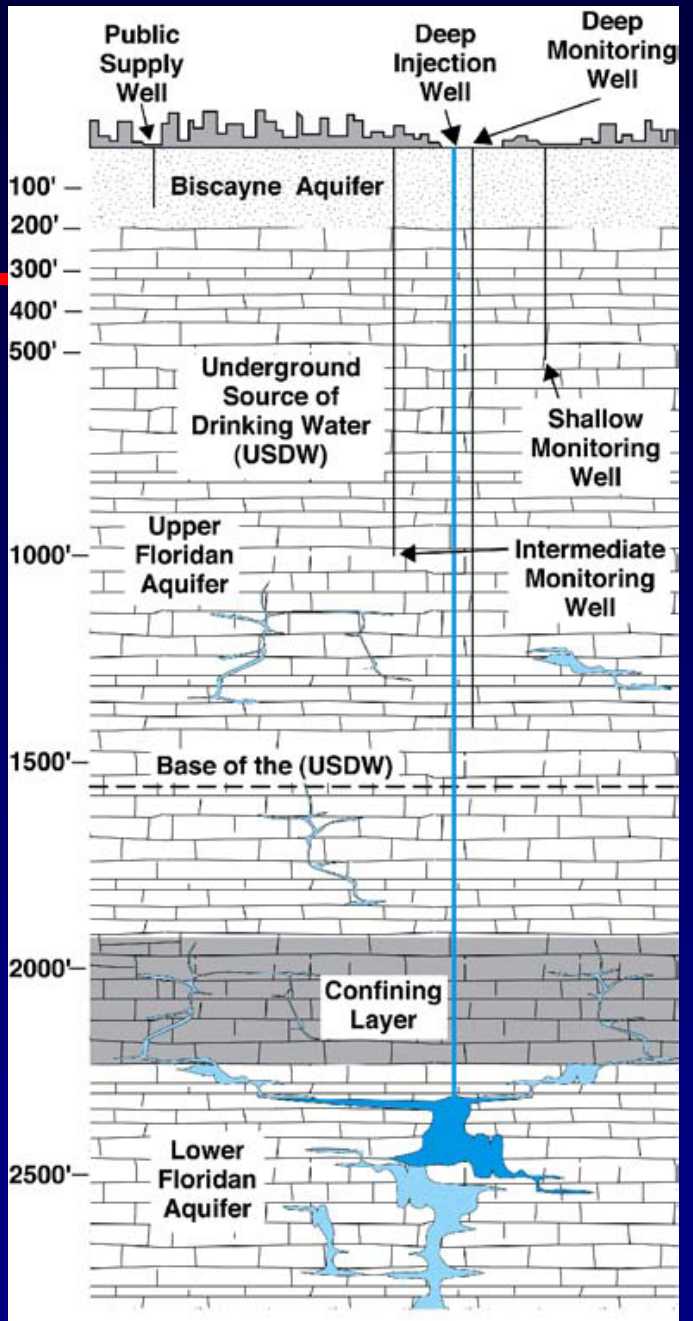


GPR Images

Uncertainties in Conceptual Models

Sources:

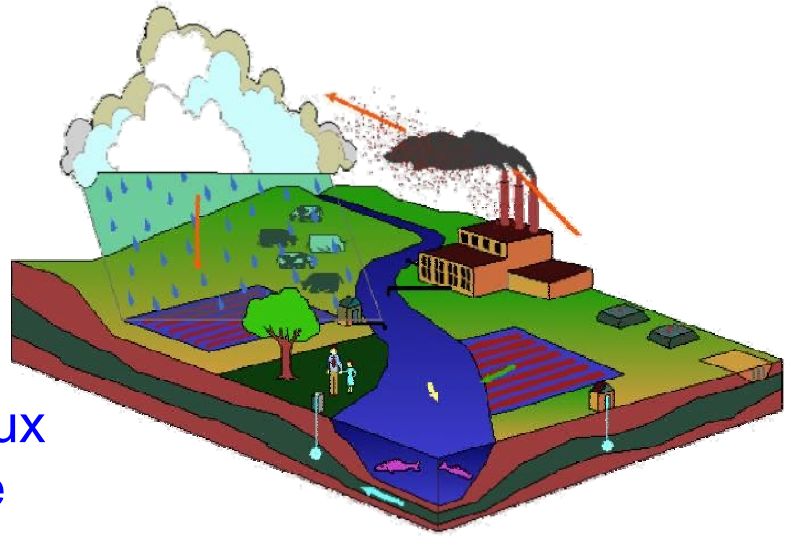
- ✓ Incomplete knowledge of the subsurface system
- ✓ Measurement error in characterizing the system's features, events and processes (FEPs)
- ✓ Natural variability in the system's spatial properties, temporal events and transient external stresses
- ✓ Disparity in scales of sampling, monitoring and simulation relative to actual dimensions of the FEPs
- ✓ Parameter estimation
- ✓ Scenario definition



Hydrogeologic Cross Section in South Florida

Dose Assessment to Determine Need for Remediation

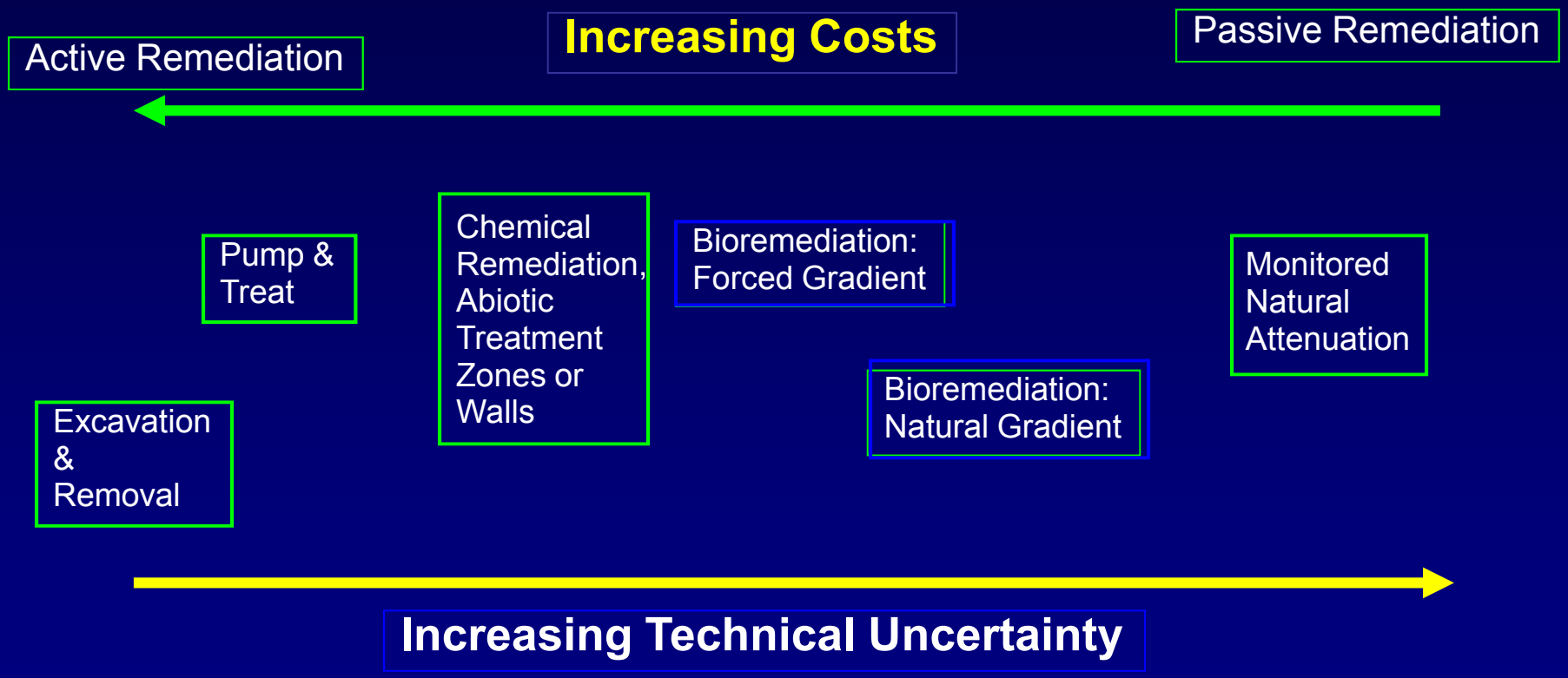
Decision to remediate based upon source and site characterization, monitoring and modeling



- ✓ Identify contaminant sources
- ✓ Determine if releases are continuous or episodic, their radiochemistry and mass flux
- ✓ Collect soil and water samples to estimate contaminant concentrations and properties
- ✓ Identify subsurface pathways to receptors
- ✓ Estimate attenuation and sorption characteristics of subsurface
- ✓ Calculate dose to receptors and compare to dose criteria

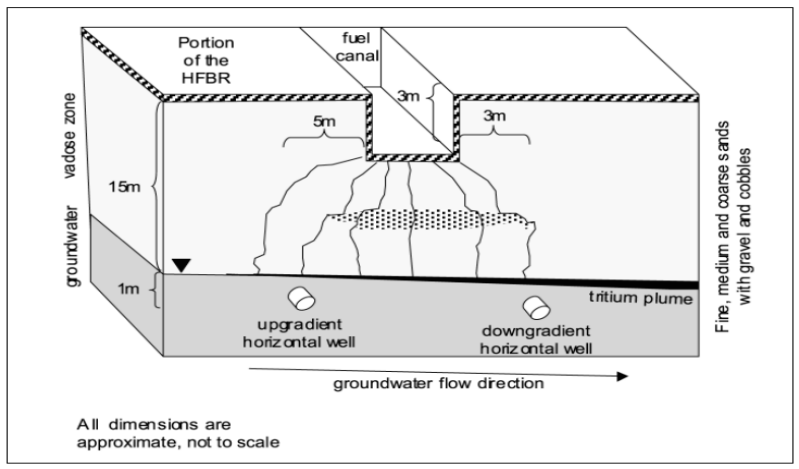
❖ ***If Dose exceeds regulatory criteria consider the need for remediation***

Range of Remediation Techniques



(after Long et al, 2008, NUREG/CR-6973)

Formulate 3-D Realistic Model to Evaluate Remediation Alternatives and Performance



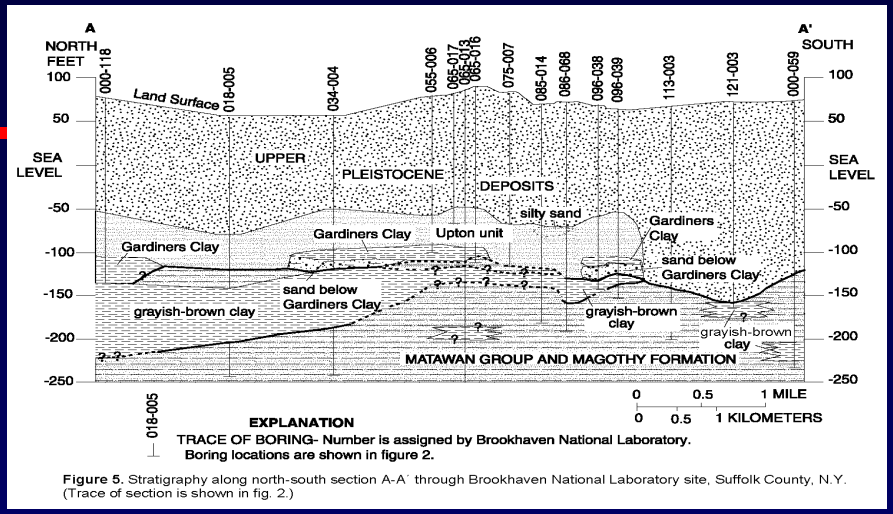
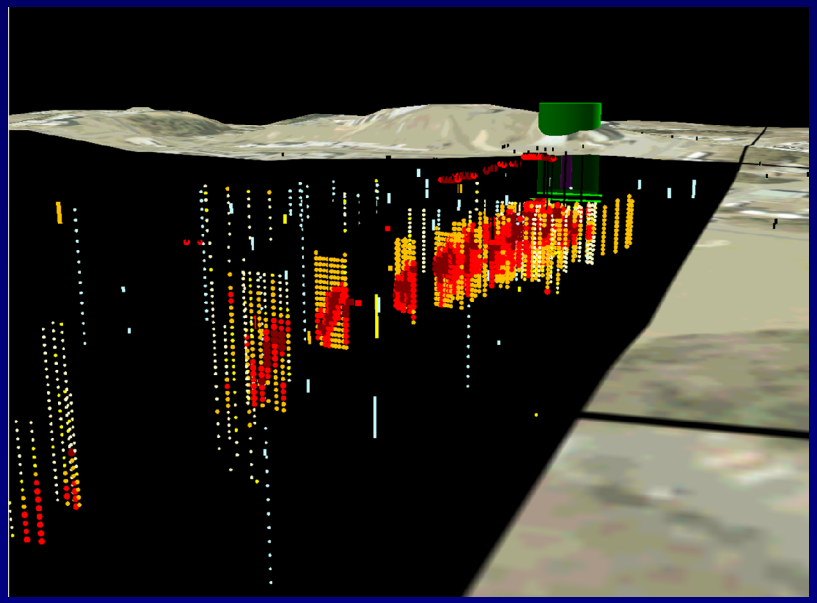


Figure 5. Stratigraphy along north-south section A-A' through Brookhaven National Laboratory site, Suffolk County, N.Y. (Trace of section is shown in fig. 2.)

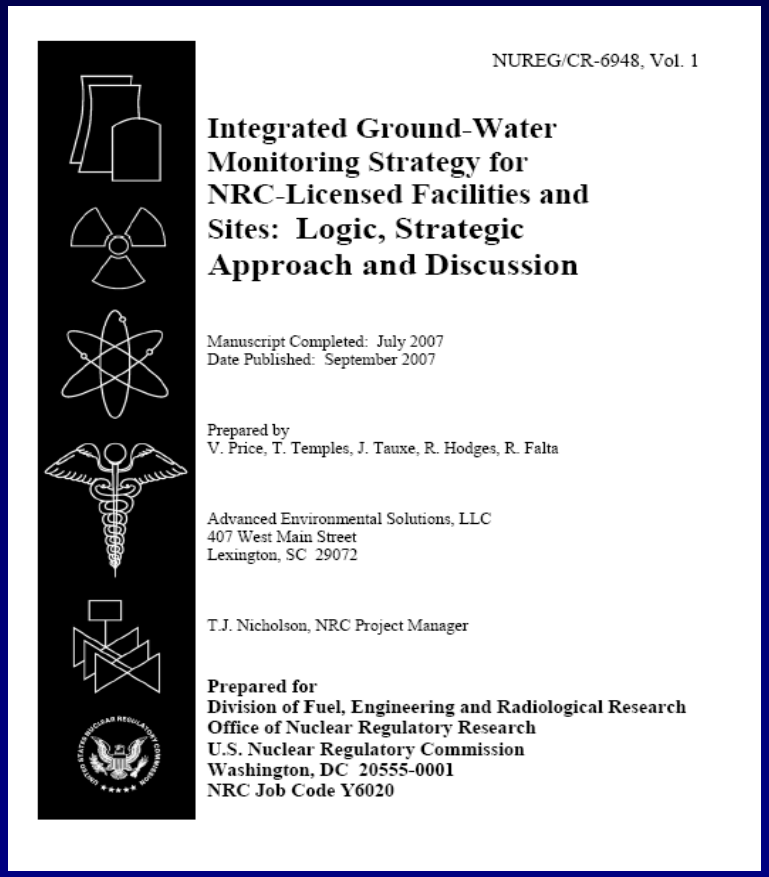
- Combine CSM with flow and transport details (e.g., influence of nearby pumping wells) to generate 3-D visualization of data
- Use flow and transport modeling to confirm CSM reflects observed monitoring data
- Once validated, used flow and transport modeling to evaluate remediation alternatives



from NUREG/CR-6948

Information Source – NUREG/CR-6948

- Technical bases for developing guidance on ground-water monitoring for NRC-licensed sites
- Systematic methodology to integrate monitoring with modeling
- **http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr6948/v1/index.html**



NUREG/CR-6948, Vol. 1

Integrated Ground-Water Monitoring Strategy for NRC-Licensed Facilities and Sites: Logic, Strategic Approach and Discussion

Manuscript Completed: July 2007
Date Published: September 2007

Prepared by
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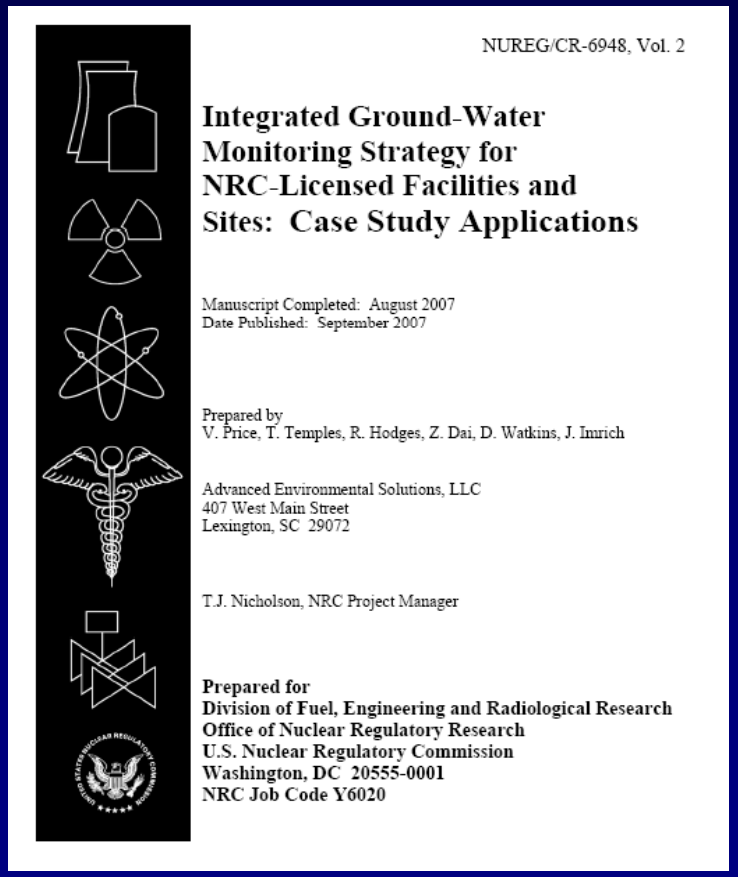
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
NRC Job Code Y6020

Information Source – NUREG/CR-6948

- Lessons-Learned for developing guidance on ground-water monitoring for NRC-licensed sites
- Case Studies which includes Brookhaven radionuclide plume remediation and monitoring
- **http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr6948/v2/index.html**



NUREG/CR-6948, Vol. 2

Integrated Ground-Water Monitoring Strategy for NRC-Licensed Facilities and Sites: Case Study Applications

Manuscript Completed: August 2007
Date Published: September 2007

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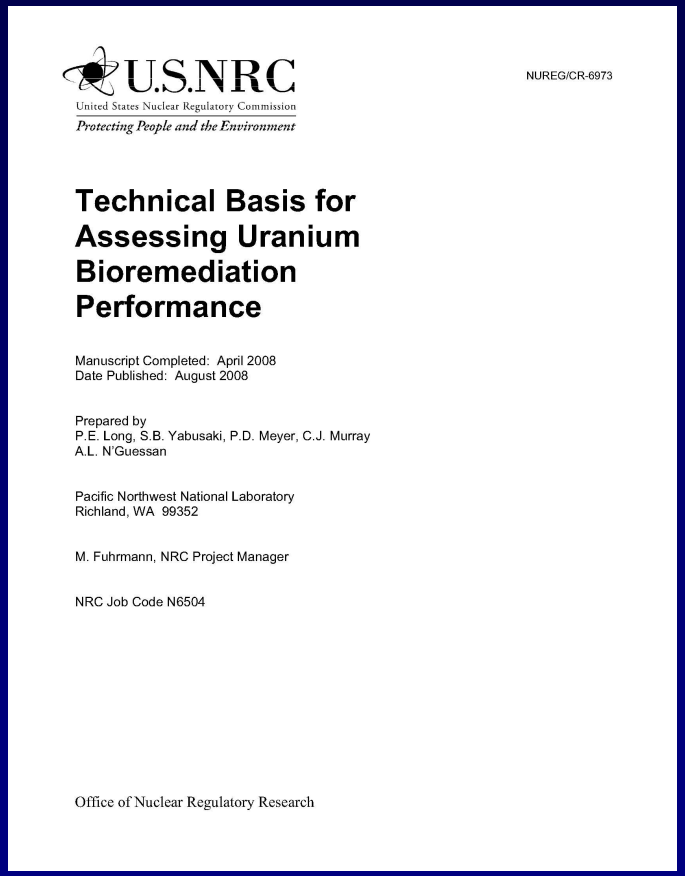
Information Source – NUREG/CR-6973

- Overview of *in situ* uranium bioremediation which identifies and prioritizes field performance indicators for evaluating its effectiveness.
- Performance indicators to be monitored and modeled are based on current biogeochemical understanding of uranium.
- Confirmation monitoring is vital to demonstrating long-term success of U-bioremediation and provides a significant assurance that regulatory goals will be met.
- http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr6973/index.html



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NUREG/CR-6973

Technical Basis for Assessing Uranium Bioremediation Performance

Manuscript Completed: April 2008
Date Published: August 2008

Prepared by
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Monitoring to Determine Efficacy of *In Situ* Bioremediation

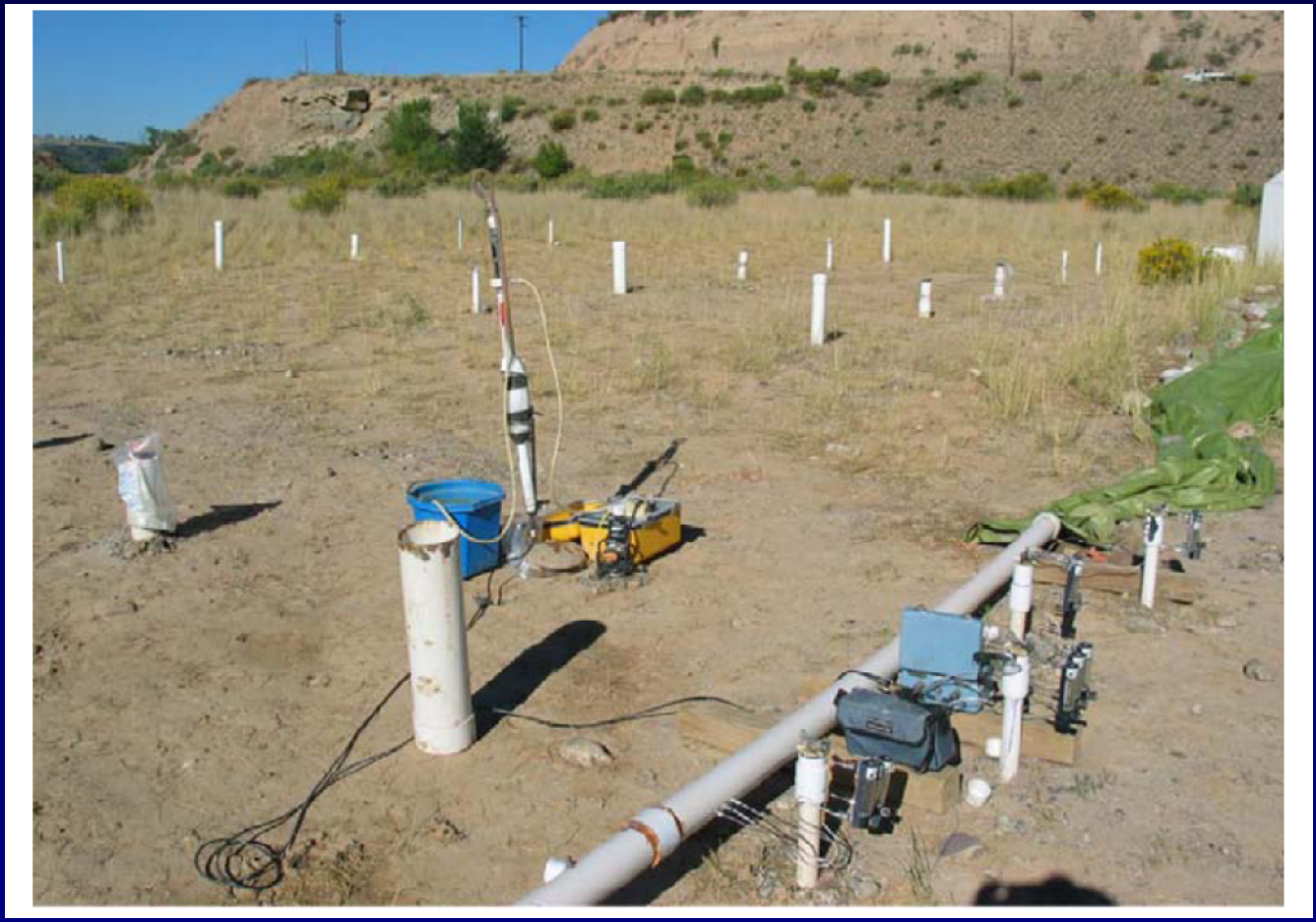

Photo of wells and sampling apparatus including flow cell for measurement of pH, Eh, DO, T, and conductivity during slow purge sampling. Foreground shows injection manifold and stainless steel injection lines to injection wells. [From Long, Yabusaki et al, 2008 (PNNL-17295)]