Oak Ridge Field Research Center

FRC Workshop Tour
October 23, 2006

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http://www.esd.ornl.gov/nabirfrc/

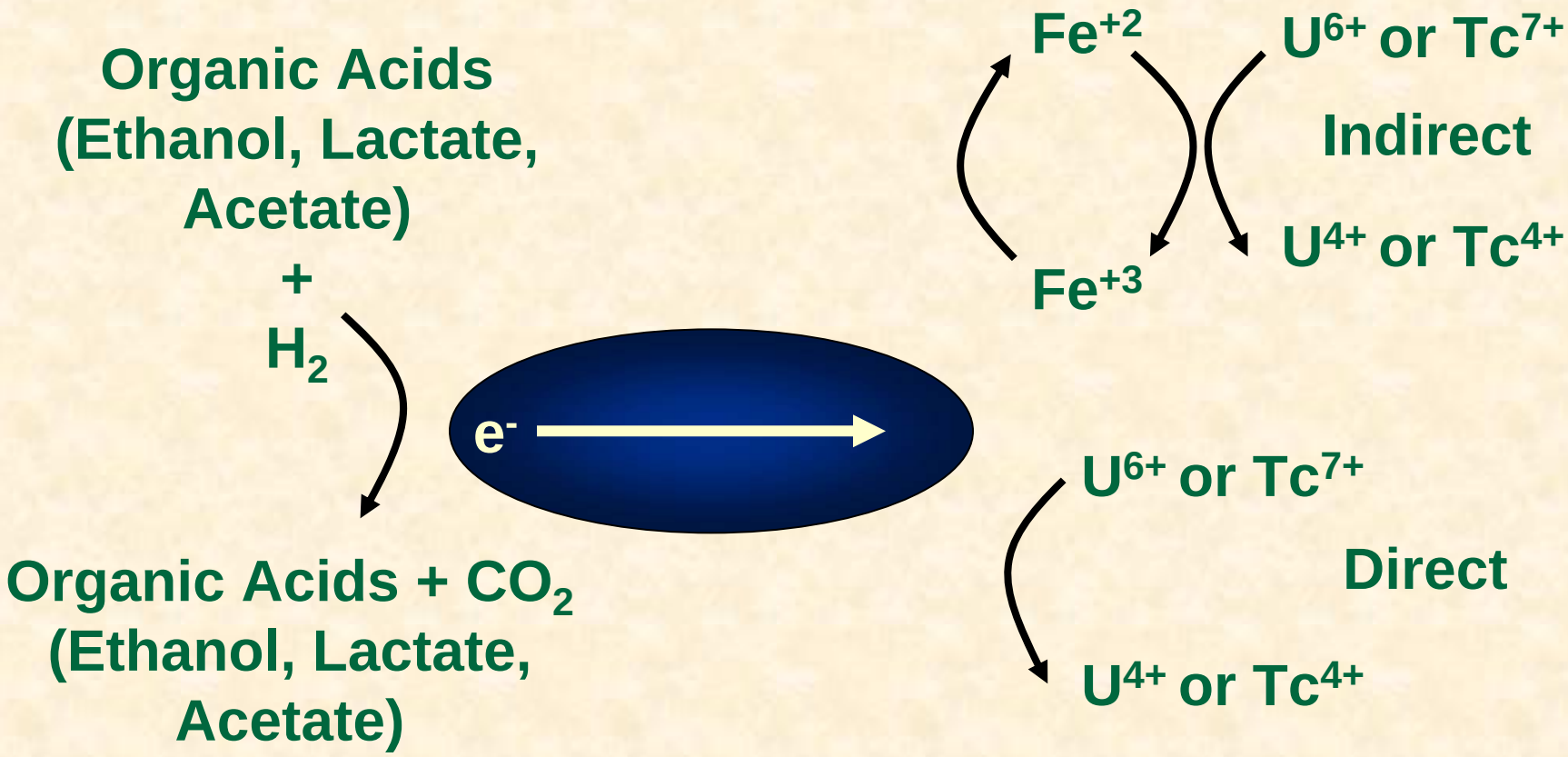
Agenda

- **Overview**
  - **FRC research objectives**
  - **Summary of site setting**
  - **Description of multi-disciplinary *in situ* bioremediation field research projects**
  - **Sources of information**
- **Tour**

Original NABIR FRC Research Focus

- **Objectives**
  - **Understand fundamental biogeochemical processes influencing the use of bioremediation approaches for cleaning up, managing, or understanding fate and transport of metals and radionuclides at DOE's contaminated legacy waste sites**
- **Field Laboratory**
  - **In situ accelerated bioremediation research**
  - **Source of subsurface samples for investigators**
  - **Evaluation of new characterization and monitoring methods, and predictive approaches**
  - **Mercury samples and studies**

Objective is to use microbes to transfer electrons to reduce U (VI) to the less soluble U (IV) form



UT-BATTELLE

Happy bugs = lower risk?

Organic Acids (Ethanol, Lactate, Acetate) + H_2

Organic Acids + CO_2 (Ethanol, Lactate, Acetate)

"This is some mighty fine EtOH"

Fe^{+2}

Fe^{+3}

U^{6+} or Tc^{7+}

Indirect

U^{4+} or Tc^{4+}

U^{6+} or Tc^{7+}

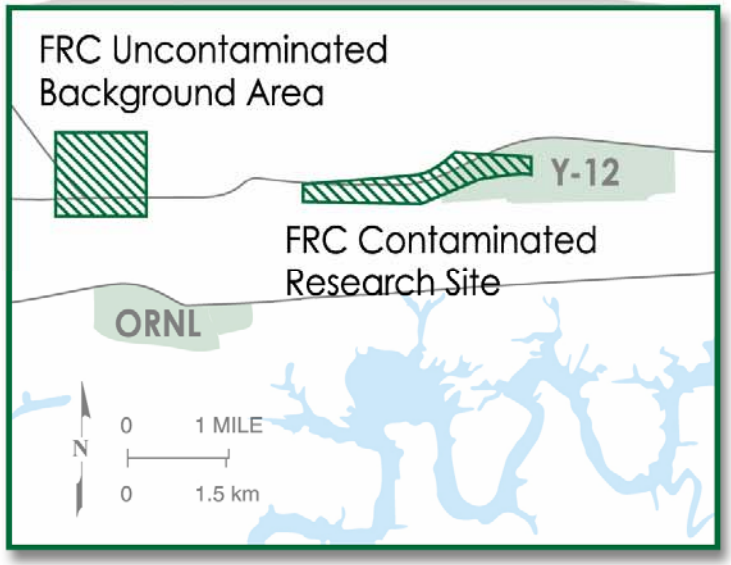
Direct

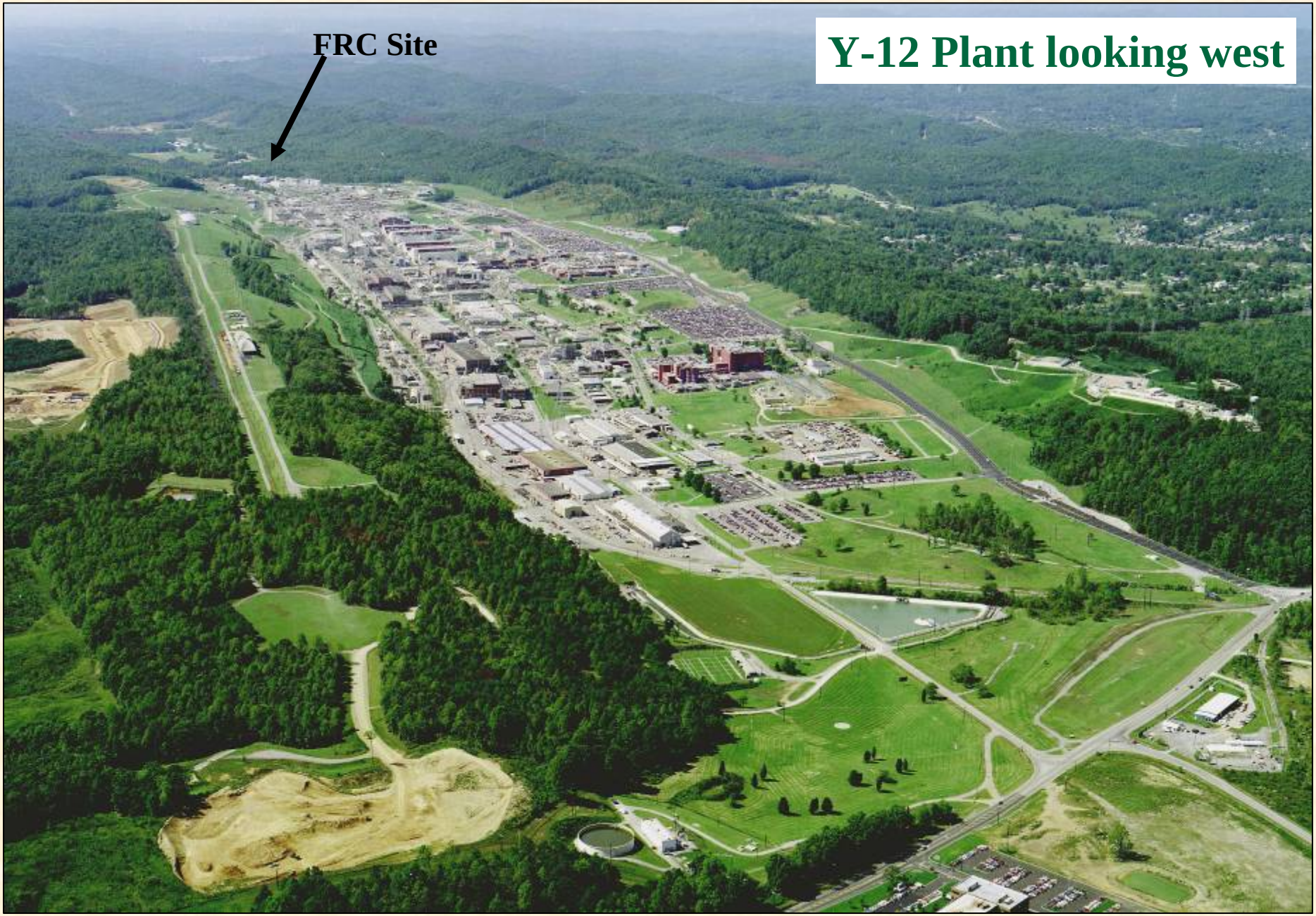
U^{4+} or Tc^{4+}

NABIR FRC Facilities

Glove Bag with 5 ft Airlock at Field Trailer

Drill Rigs



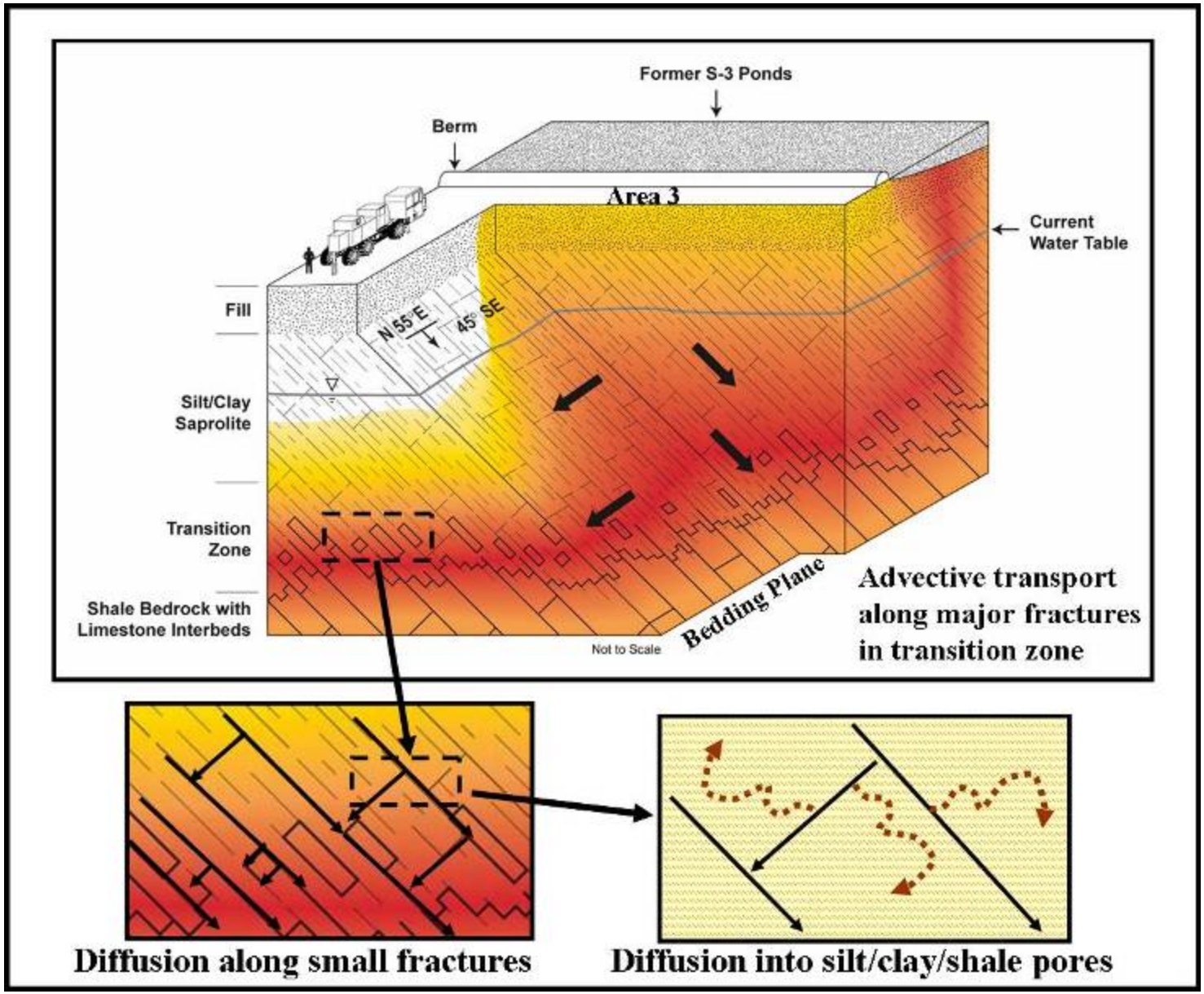

FRC Site
Y-12 Plant looking west

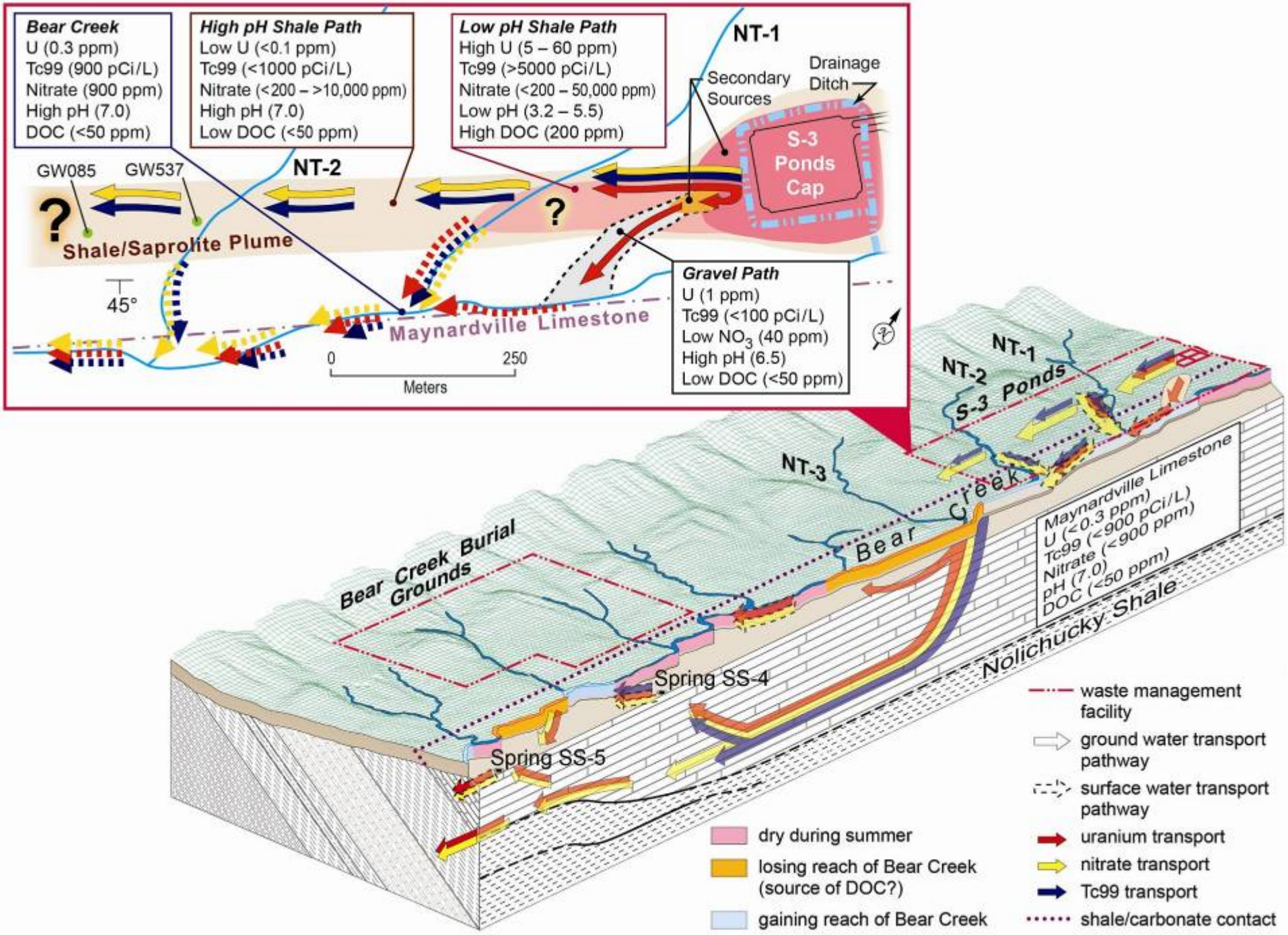
- Operated from 1951 to 1983
- 400 ft x 400 ft x 17 ft deep
- Over 2.5 million gallons waste/year
- Wastes contained nitrate, uranium, Tc-99, metals, VOCs, high TDS, and low pH (<2.0)
- Neutralized in 1984 capped in 1988

Currently a parking lot

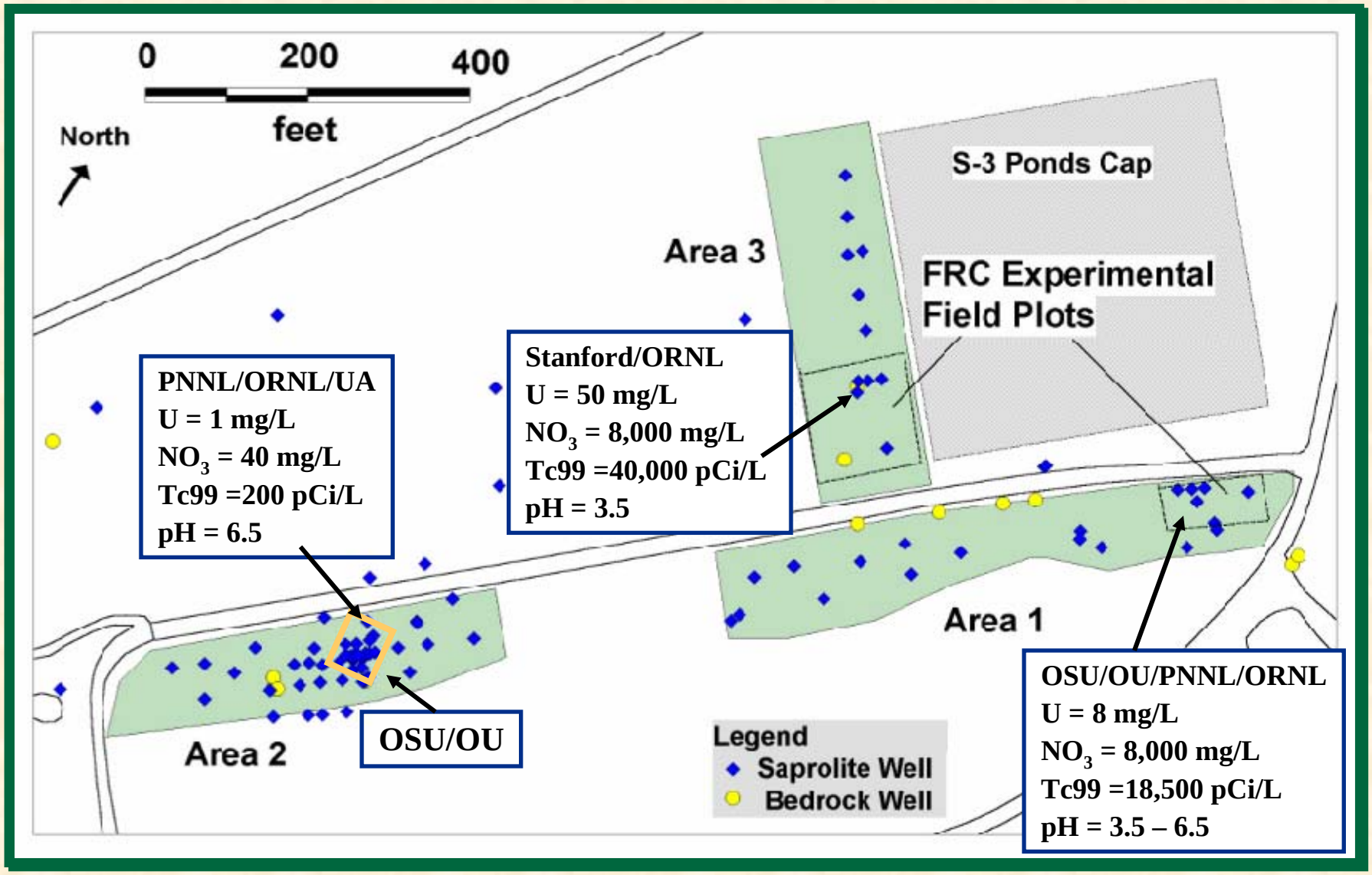
S-3 Disposal Ponds During Denitrification

Conceptual Model of Contaminant Transport at the S-3 Ponds Site and Bear Creek Valley




Bear Creek
U (0.3 ppm)
Tc99 (900 pCi/L)
Nitrate (900 ppm)
High pH (7.0)
DOC (<50 ppm)
High pH Shale Path
Low U (<0.1 ppm)
Tc99 (<1000 pCi/L)
Nitrate (<200 – >10,000 ppm)
High pH (7.0)
Low DOC (<50 ppm)
Low pH Shale Path
High U (5 – 60 ppm)
Tc99 (>5000 pCi/L)
Nitrate (<200 – 50,000 ppm)
Low pH (3.2 – 5.5)
High DOC (200 ppm)
NT-1
Secondary Sources
Drainage Ditch
S-3 Ponds Cap
GW085
GW537
NT-2
Shale/Saprolite Plume
45°
Maynardville Limestone
0
250
Meters
Gravel Path
U (1 ppm)
Tc99 (<100 pCi/L)
Low NO3 (40 ppm)
High pH (6.5)
Low DOC (<50 ppm)
NT-1
NT-2
S-3 Ponds
NT-3
Bear Creek
Bear Creek Burial Grounds
Maynardville Limestone
U (<0.3 ppm)
Tc99 (<900 pCi/L)
Nitrate (<900 ppm)
pH (7.0)
DOC (<50 ppm)
Nolichucky Shale
Spring SS-4
Spring SS-5
waste management facility
ground water transport pathway
surface water transport pathway
uranium transport
nitrate transport
Tc99 transport
shale/carbonate contact
dry during summer
losing reach of Bear Creek (source of DOC?)
gaining reach of Bear Creek

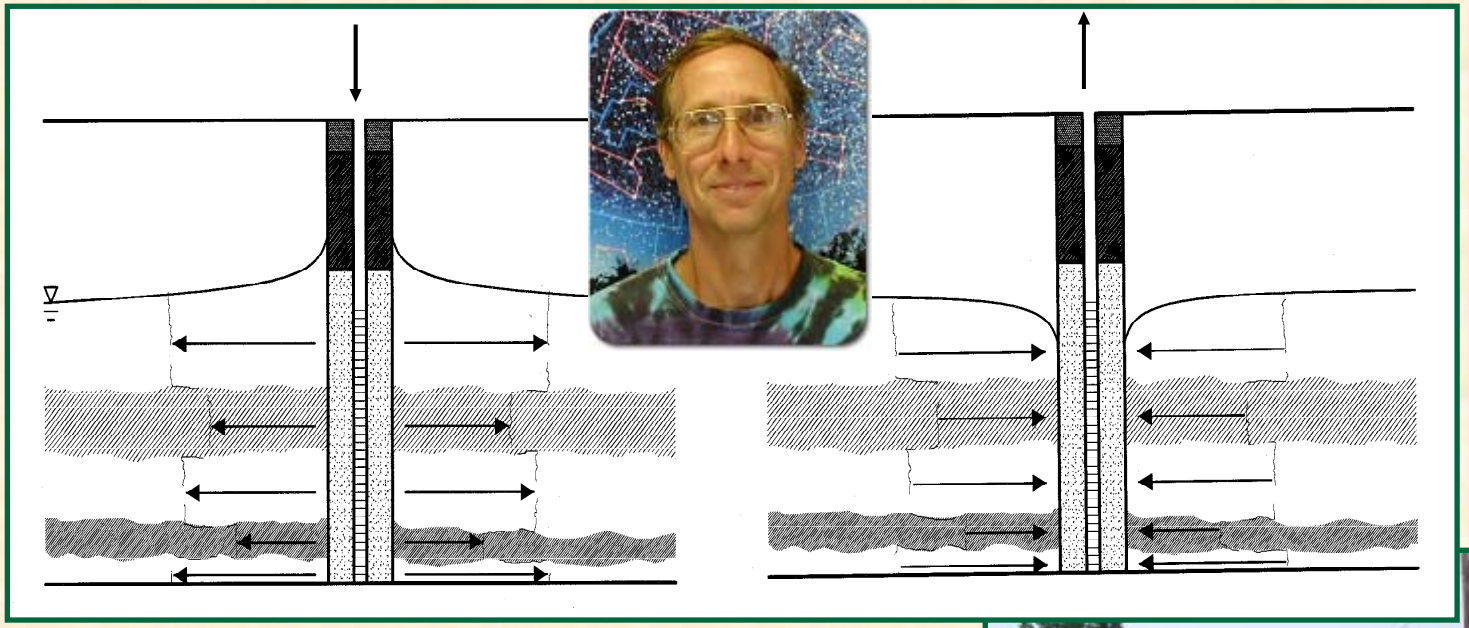
Field Plots in Contaminated Area



Multi-disciplinary in Situ Accelerated Bioremediation Field Research Projects

- ***In situ* uranium reduction experiments using push-pull techniques** (Oregon State University, Oklahoma University, PNNL, ORNL located in Areas 1 and 2)
- ***In situ* immobilization of uranium in structured porous media via biomineralization at the fracture/matrix interface** (PNNL, ORNL, and University of Alabama, located in Area 2)
- **Field-scale bioreduction of uranium** (Stanford and ORNL, located in Area 3)

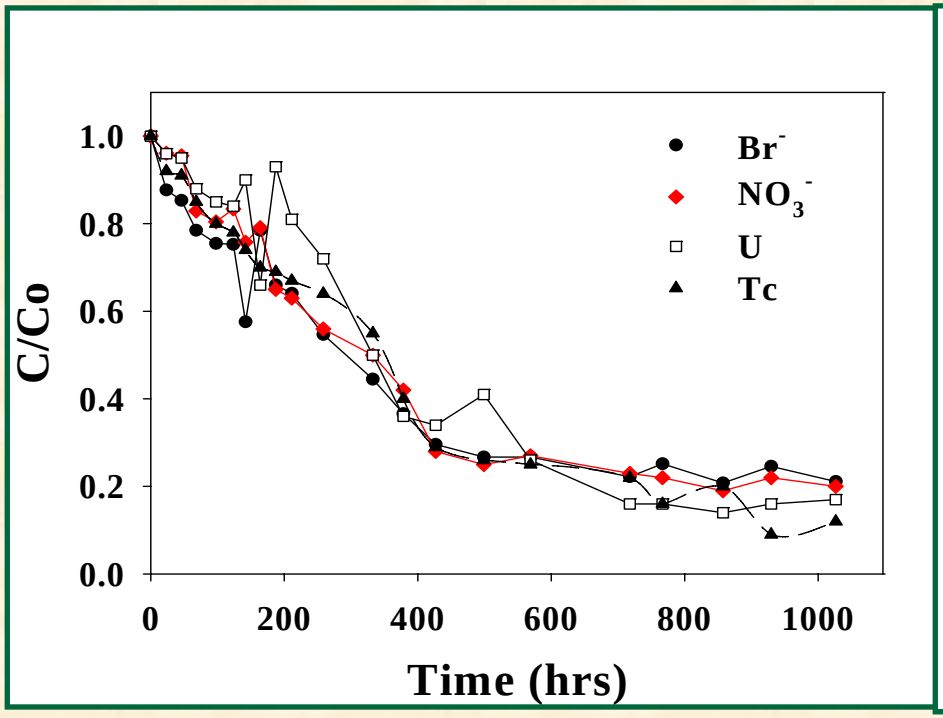
OSU Push-Pull test methodology



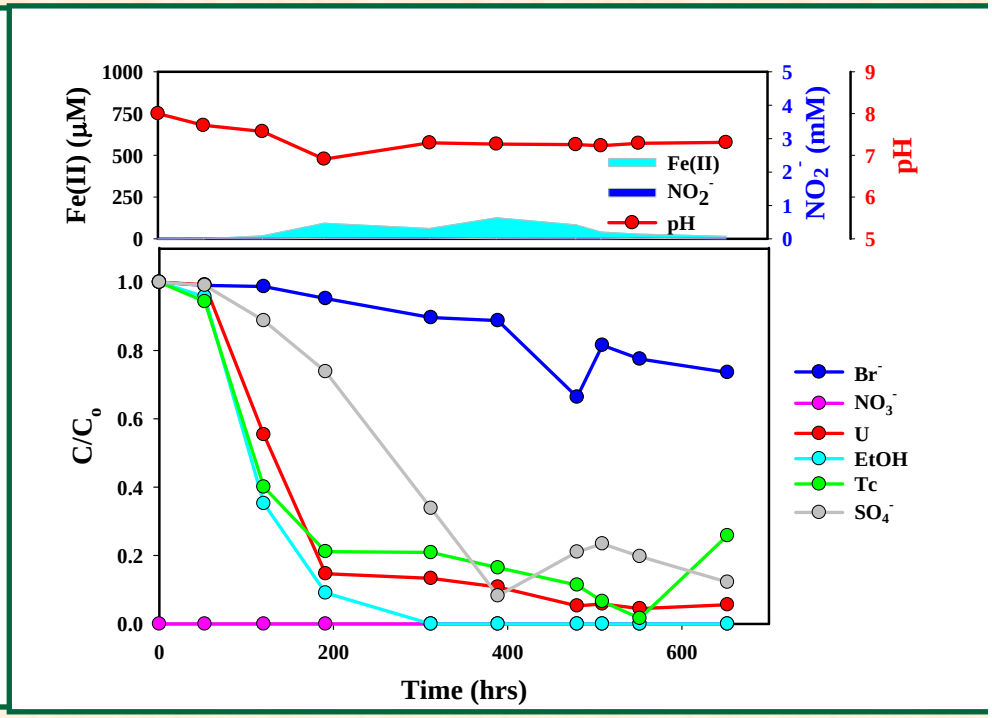
Field push-pull tests (left) injection "push" phase (right) extraction "pull" phase

To test for microbial activity, site groundwater is mixed with tracers and nutrients in drums and injected into monitoring wells. Many tests can be run relatively quickly to test hypothesis.

OSU/OU Push-Pull test results



Control well with no electron donor shows no reaction



Simultaneous uranium (U) and technetium (Tc) immobilization during field push-pull tests with addition of electron donor (ethanol)

PNNL/ORNL/UA *in situ* Experimental Design

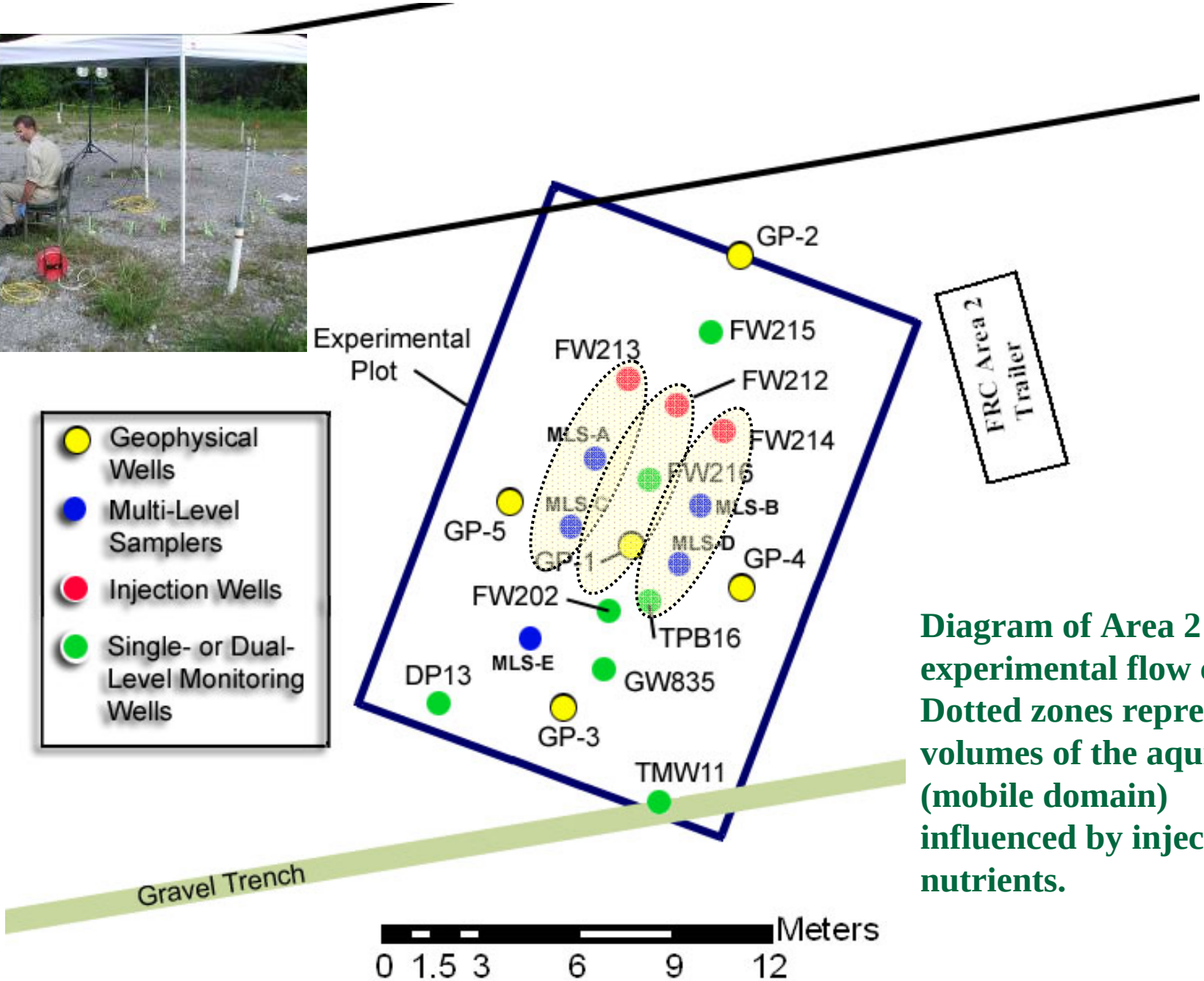
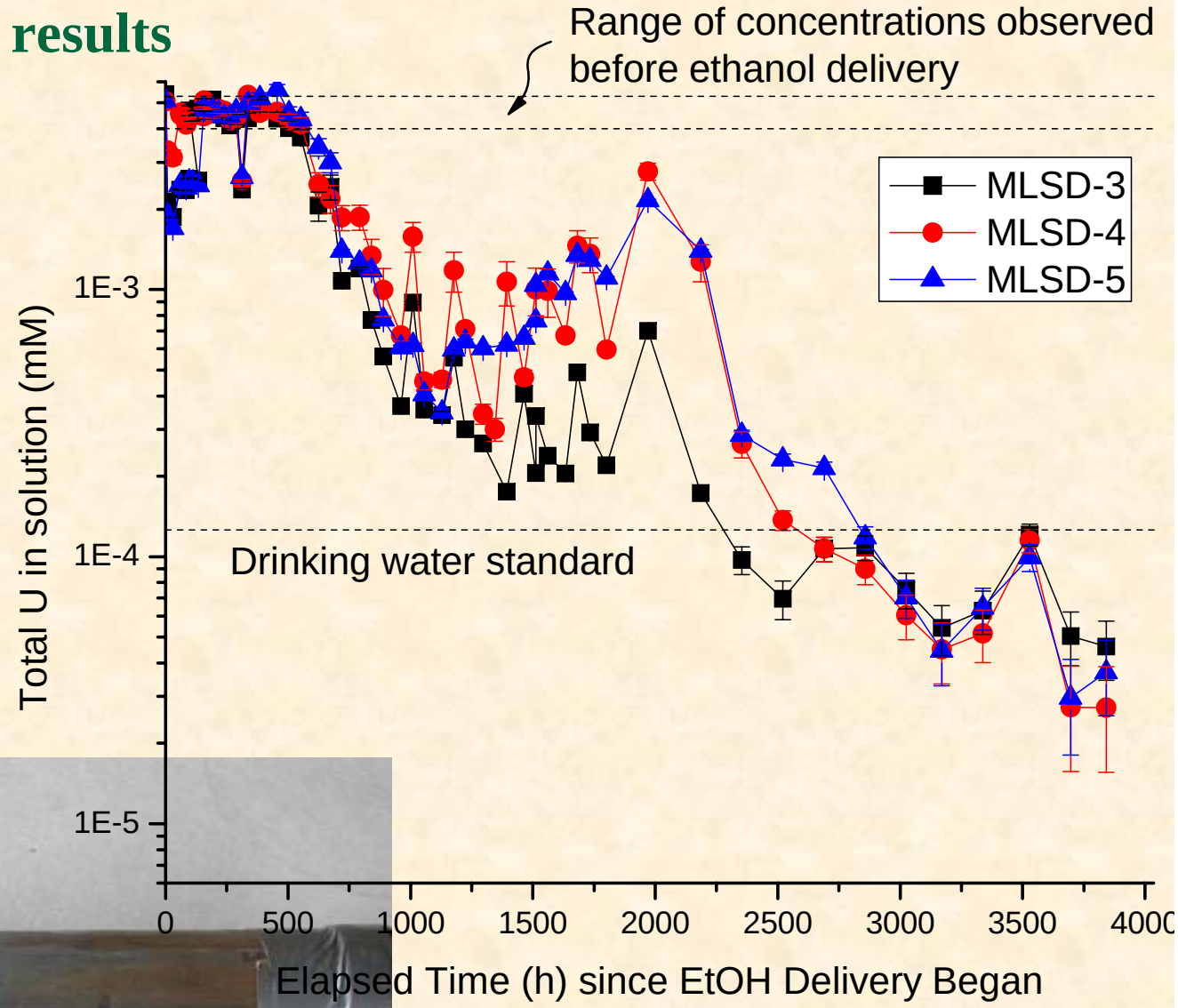
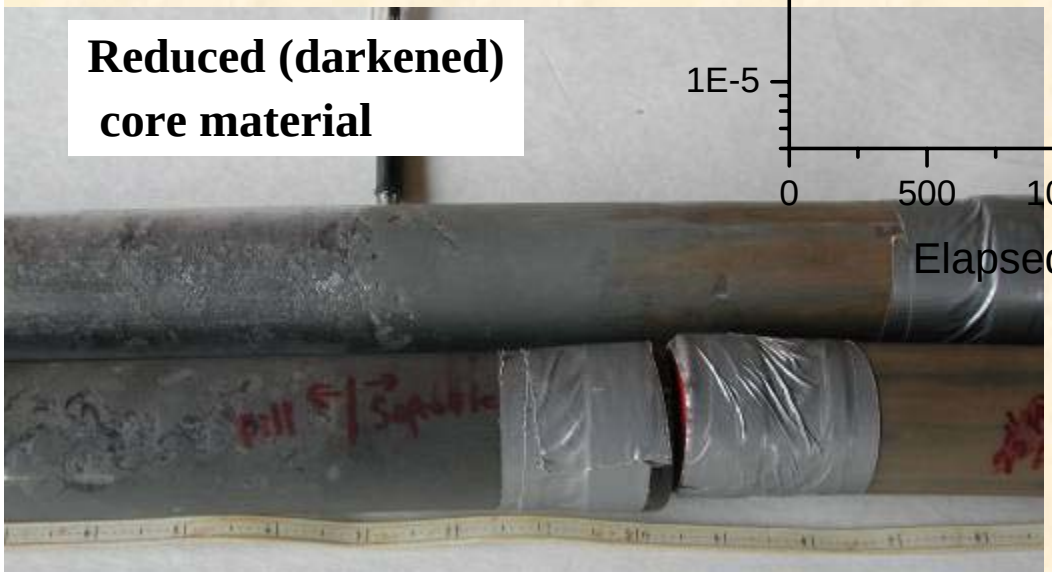


Diagram of Area 2 field experimental flow cell. Dotted zones represent volumes of the aquifer (mobile domain) influenced by injected nutrients.

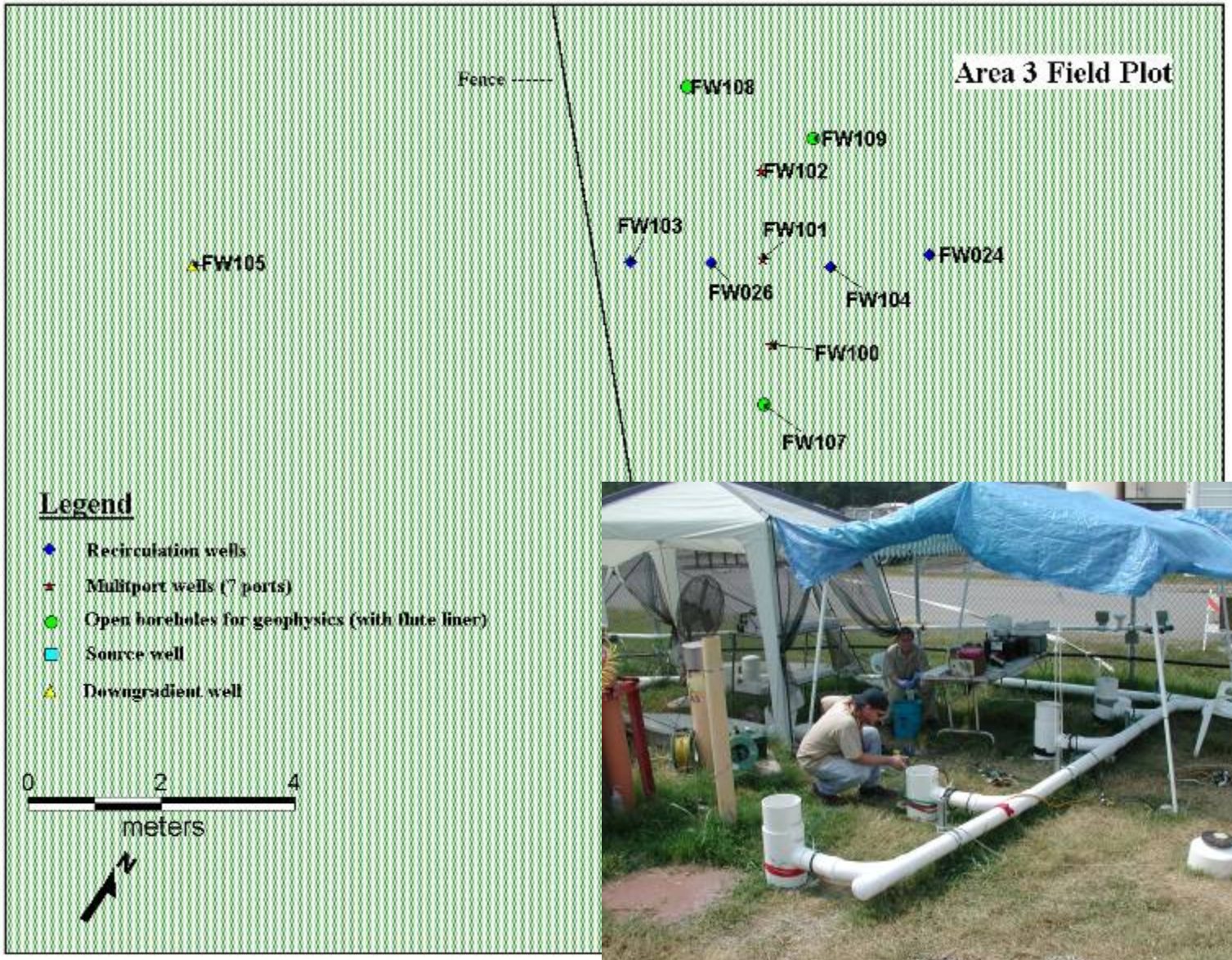
PNNL/ORNL Area 2 results

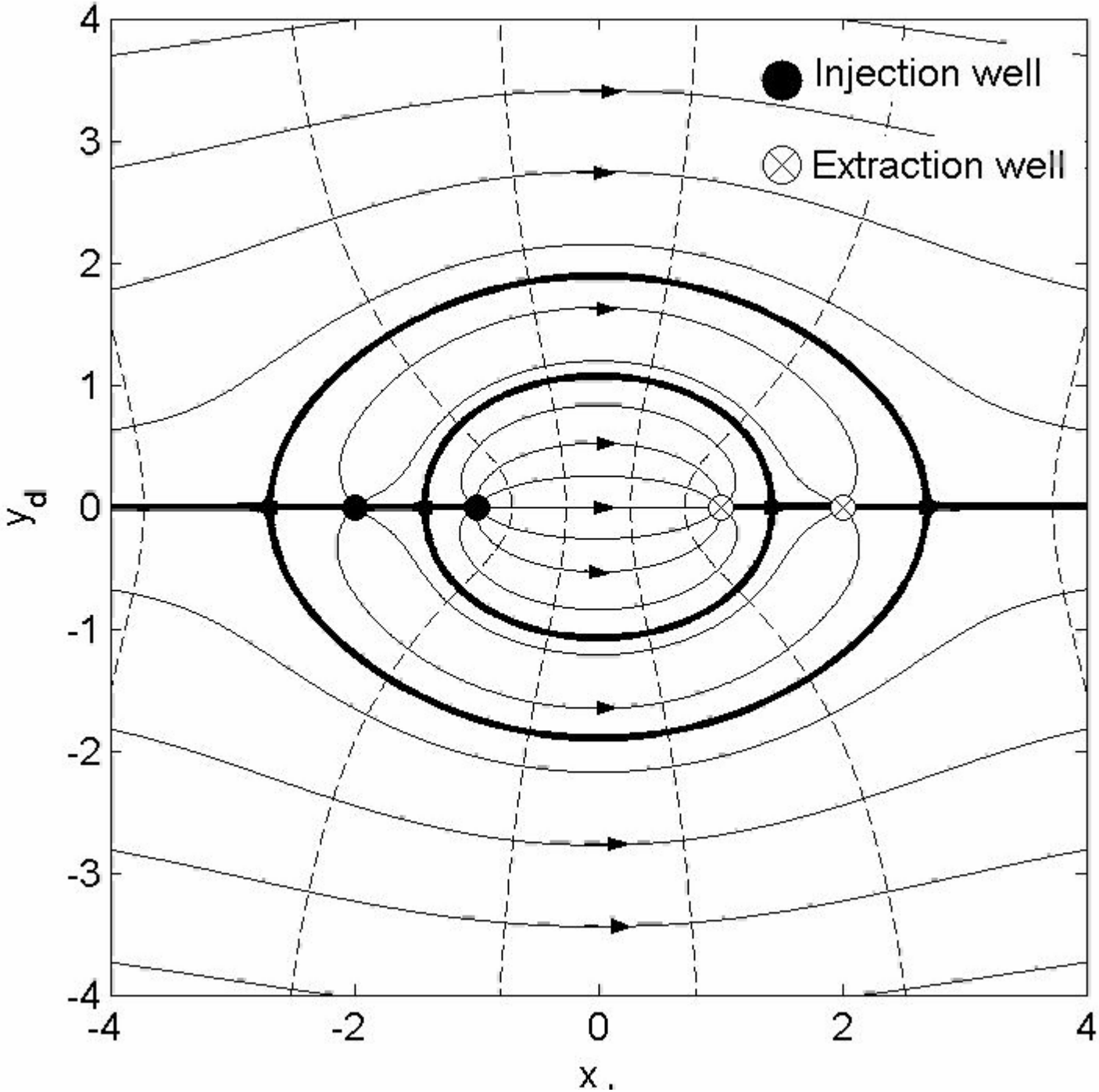
Objective is to use microbes to transfer electrons to reduce U (VI) to the less soluble U (IV) form





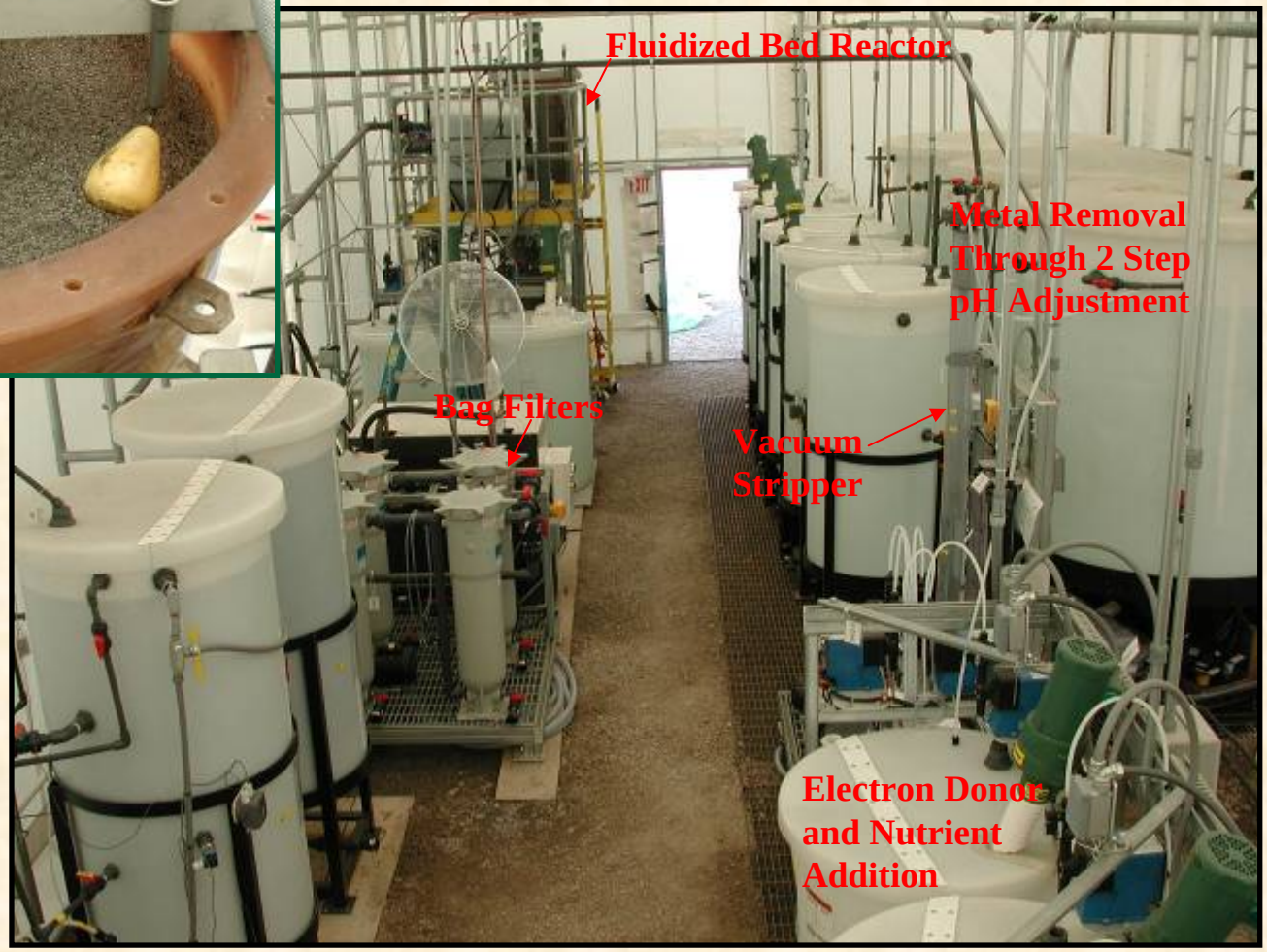
Stanford/ORNL Field Plot in Area 3



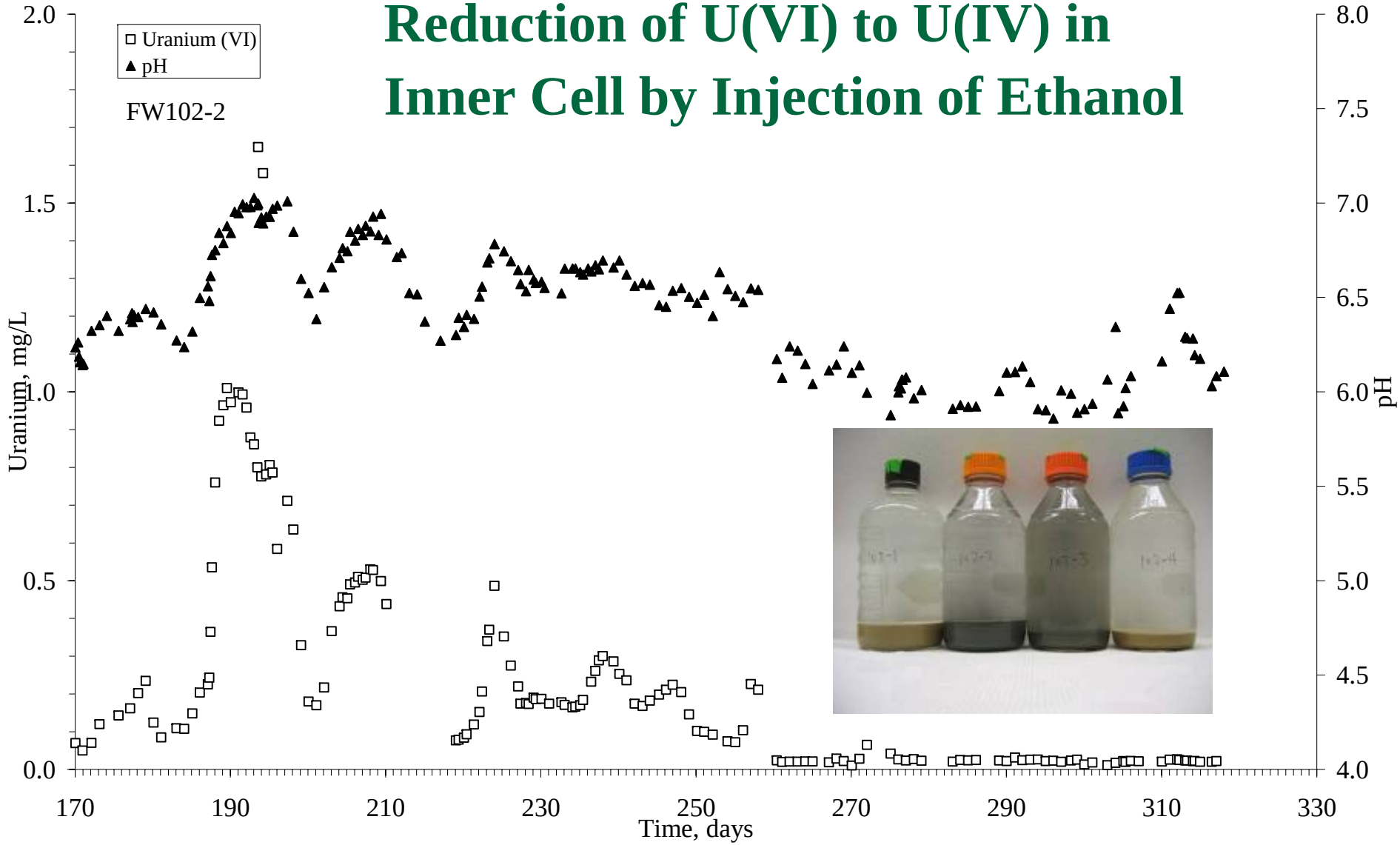

Injection well
Extraction well
4
3
2
1
0
-1
-2
-3
-4
-4
-2
0
2
4
y_d
x_d

Above ground conditioning

Bubbles in FBR indicating microbial activity is consuming ethanol and removing nitrate



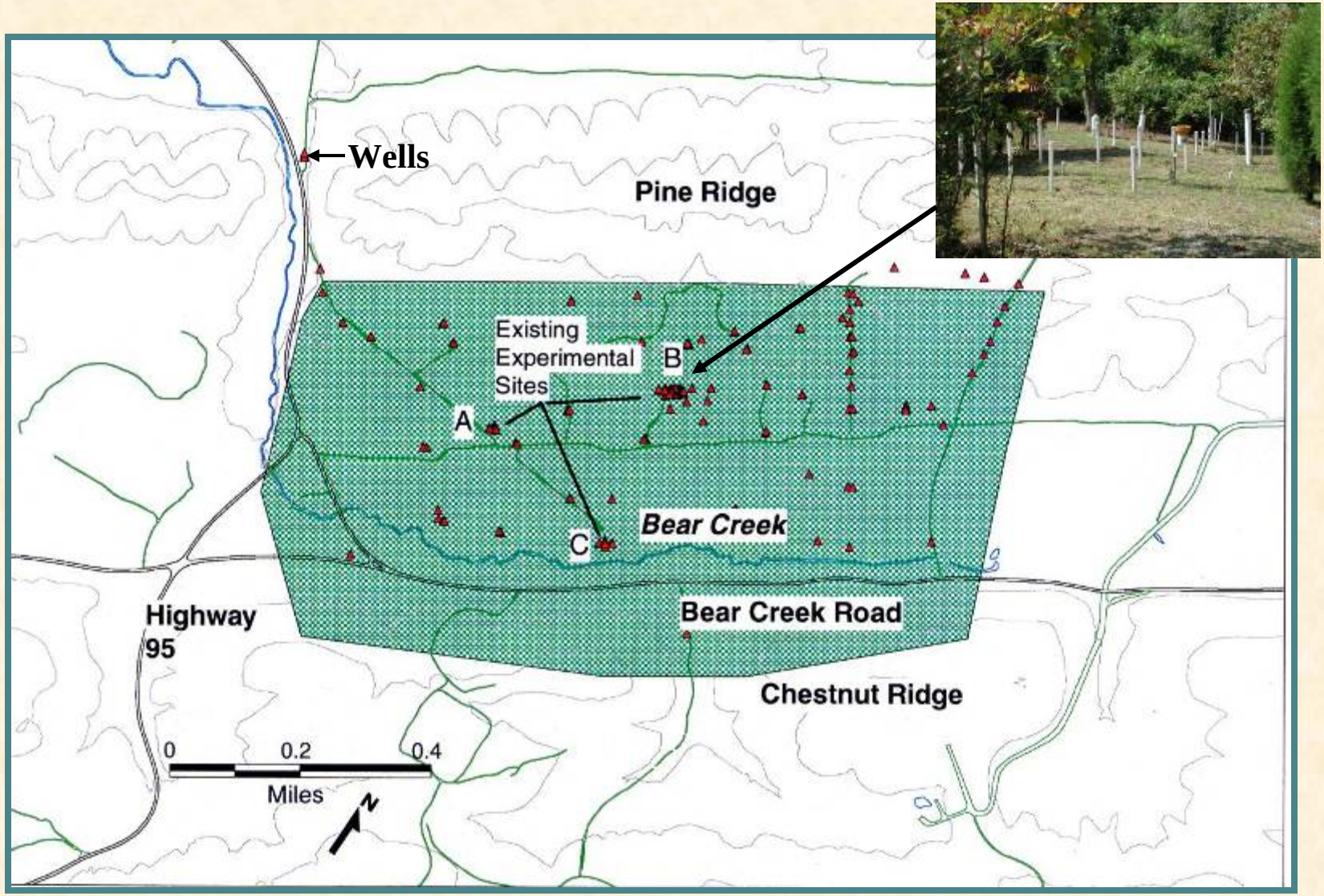
Reduction of U(VI) to U(IV) in Inner Cell by Injection of Ethanol



Conclusions From Research Projects

- **Microorganisms found in subsurface environments can transform radionuclides (e.g., uranium, technetium) and other contaminants into chemical forms that are less mobile or less toxic in groundwater**
- **Introducing naturally occurring humic substances (organic matter found in soil) can accelerate the chemical reduction and immobilization of these contaminants**
- **Co-contaminants in the subsurface (e.g., nitrate) and elevated concentrations of other chemicals (e.g., calcium) can inhibit the chemical reduction process and can reoxidize uranium, making it more mobile**

FRC Background Area



Reference Materials

- **FRC forested soil humics for lab and field tests**
  - **Data from Istok field tests indicate it helps with shuttle of electrons and increases rates of reduction but also increases reoxidation rate**

Humics from FRC Background Soils

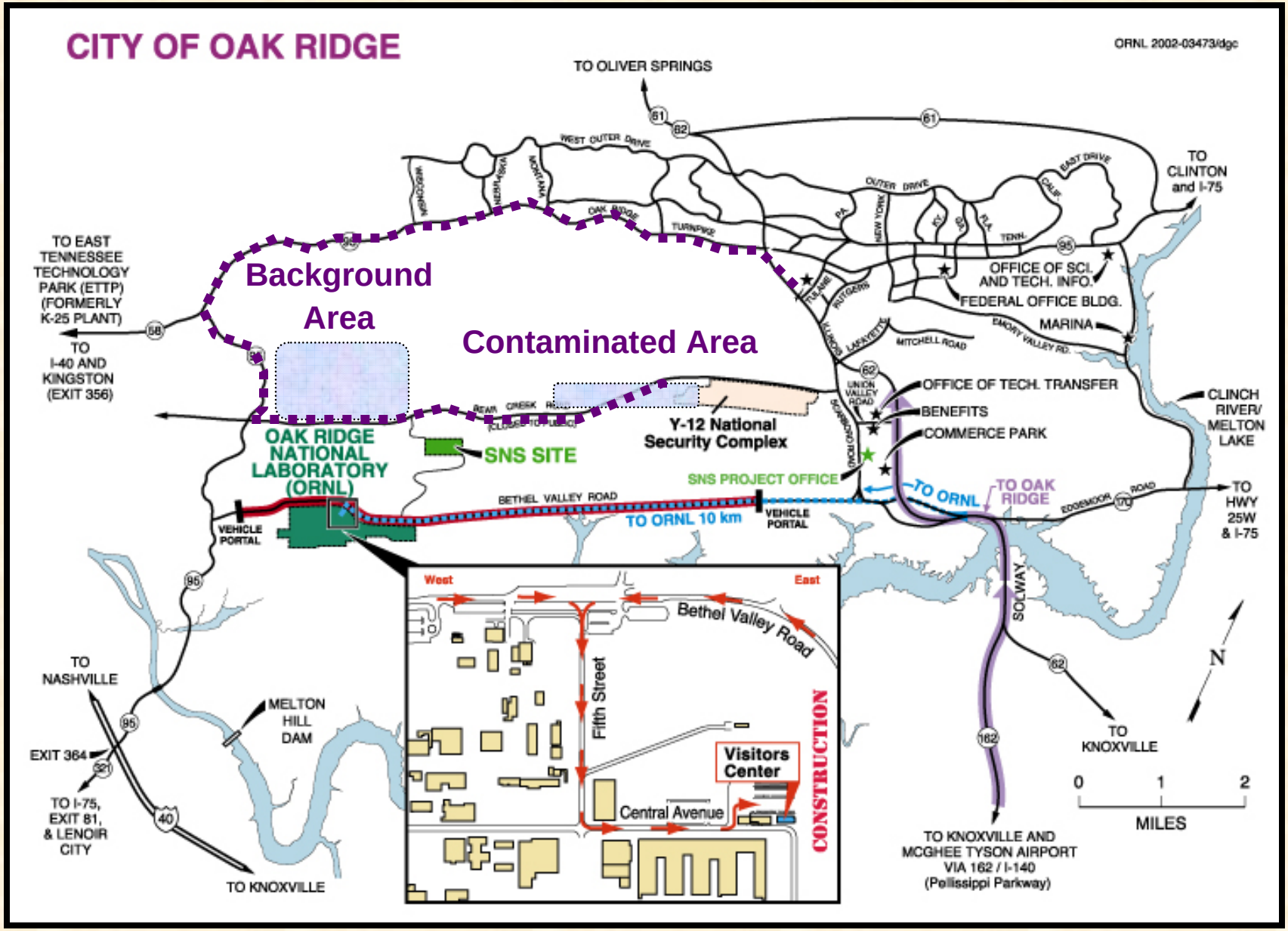
Website

- **Overview of FRC**
- **User's guide and facility description**
- **Background information**
  - **Sites**
  - **Projects**
- **Documents**
- **Working groups**
- **Data retrieval**

Tour

- **Drive past Background Area**
- **S-3 Ponds Parking lot overview**
- **Tour 3 Field Projects (Stanford, Oregon, and PNNL)**
- **Gas tracer test**
- **PELCAPS with XRF**
- **Drilling rigs (Geoprobe & Holegator)**
- **FRC Trailer**
- **Restrictions**
  - **Cells phones must be left behind**
  - **No pictures**

FRC Tour


CITY OF OAK RIDGE
ORNL 2002-03473/dgc
TO OLIVER SPRINGS
TO CLINTON and I-75
TO EAST TENNESSEE TECHNOLOGY PARK (ETTP) (FORMERLY K-25 PLANT)
TO I-40 AND KINGSTON (EXIT 356)
Background Area
Contaminated Area
OFFICE OF SCI. AND TECH. INFO.
FEDERAL OFFICE BLDG.
MARINA
OFFICE OF TECH. TRANSFER
BENEFITS
COMMERCE PARK
CLINCH RIVER/ MELTON LAKE
Y-12 National Security Complex
OAK RIDGE NATIONAL LABORATORY (ORNL)
SNS SITE
SNS PROJECT OFFICE
TO ORNL
TO OAK RIDGE
TO HWY 25W & I-75
BETHEL VALLEY ROAD
TO ORNL 10 km
VEHICLE PORTAL
VEHICLE PORTAL
West
East
Bethel Valley Road
Fifth Street
Visitors Center
Central Avenue
CONSTRUCTION
SOLWAY
TO NASHVILLE
MELTON HILL DAM
EXIT 364
TO I-75, EXIT 81, & LENOIR CITY
TO KNOXVILLE
TO KNOXVILLE
TO KNOXVILLE AND MCGHEE TYSON AIRPORT VIA 162 / I-140 (Pellissippi Parkway)
N
0 1 2
MILES