Oak Ridge Site Specific Advisory Board

Groundwater Strategy

Briefing & Discussion

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U.S. Department of the Interior
U.S. Geological Survey

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U.S. Geological Survey
U.S. Department of the Interior

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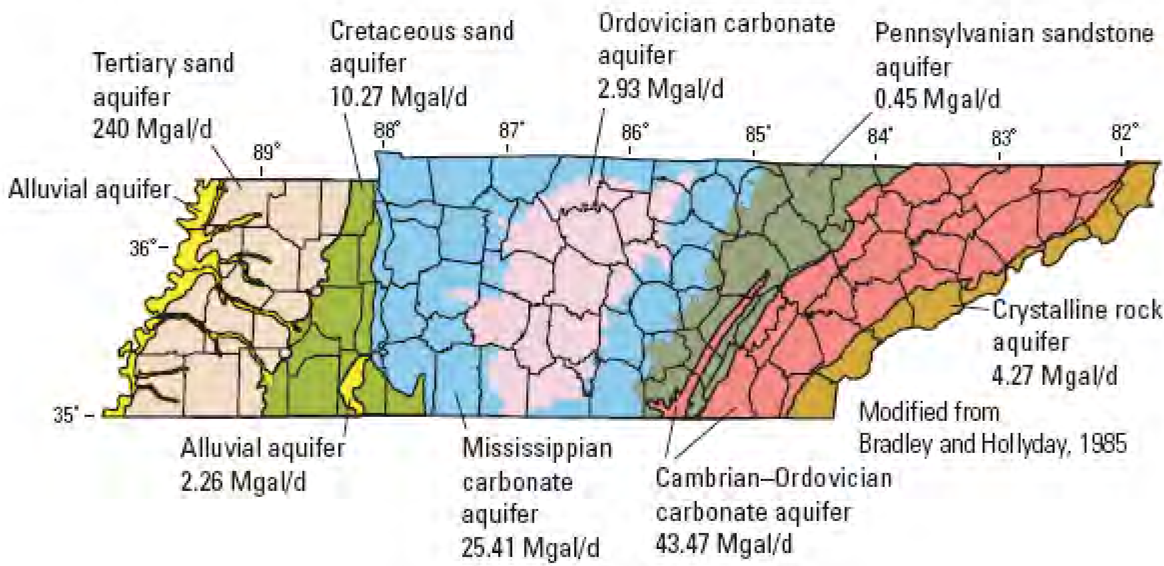
WATER RESOURCES PUBLICATIONS OF THE U.S. GEOLOGICAL SURVEY FOR TENNESSEE, 1906-1987

Glenn, L.C., 1906, Underground waters of Tennessee and Kentucky west of the Tennessee River and of an adjacent area in Illinois: USGS Water-Supply Paper 164.

Recent Reports

Geologic map of the Great Smoky Mountains National Park region, Tennessee and North Carolina
2012, Southworth, Scott; Schultz, Art; Aleinikoff, John N.; Merschat, Arthur J.
USGS Scientific Investigations Map: 2997

Effects of groundwater withdrawals associated with combined-cycle combustion turbine plants in west Tennessee and northern Mississippi
2012, Haugh, Connor J.
USGS Scientific Investigations Report: 2012-5072



Public water-supply systems and associated water use in Tennessee, 2005
2010, Robinson, John A.; Brooks, Jaala M.
USGS Open-File Report: 2010-1226

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Outline

- Strategy Highlights
- Off-site Groundwater Quality Assessment Project
- ORR Groundwater Program
- Plume Rankings
- Off-site Groundwater Use
- Discussion

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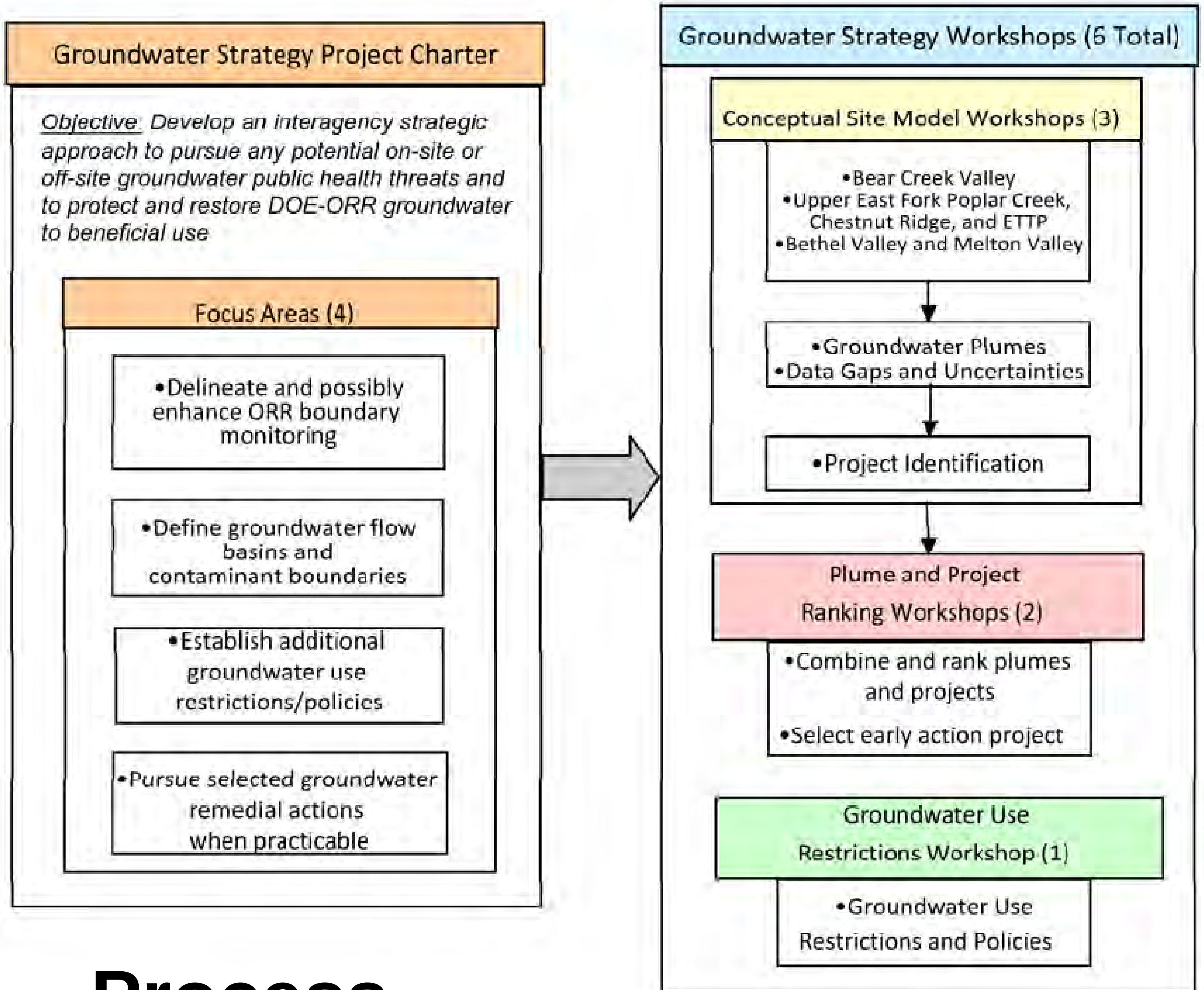

Process

Fig. 1.1. Groundwater strategy project charter and workshops.

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Project Team (primary participants)

- DOE – Elizabeth Phillips
- EPA – Carl Froede Jr. & Bill O’Steen
- TDEC – Randy Young, Gareth Davies, & Wesley White
- UCOR/RSI – Lynn Sims, Dick Ketelle, Craig Rightmire, & Holly Clancy
- SAIC – Samantha Pack, Bob Gelinas, Kevin Jago, & Allen Motley
- USGS – Dan Goode (liaison for ORSSAB / EM Committee, via DOE-USGS IA)

Selection of the Off-site Groundwater Quality Assessment Project

- **Consensus among the FFA parties was reached on key groundwater issues, including:**
  - Additional near-term off-site monitoring is needed to assess potential off-site risks. This need guided selection of the **Off-site Groundwater Quality Assessment Project.**
  - An ongoing **ORR Groundwater Program** to systematically prioritize and investigate groundwater plumes and data gaps is needed.

Groundwater Strategy Recommendations

- “ORR Groundwater Program” Additional baseline DOE funding
- Off-site Groundwater Quality Assessment Project FY2014 – FY2016 (early action $)
- Plume rankings for long-term strategy

Take Home Messages

- **Strategic Planning Process Worked: DOE, EPA, and TDEC participants (Strategy Team) agree on Recommendations**

- **Initial issues raised (to USGS) by ORSSAB EM addressed:**
  - **Uncertainty about potential off-site migration via deep groundwater flow paths**
  - **Can groundwater modeling help?**

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ORR Groundwater Strategy Near-term Steps

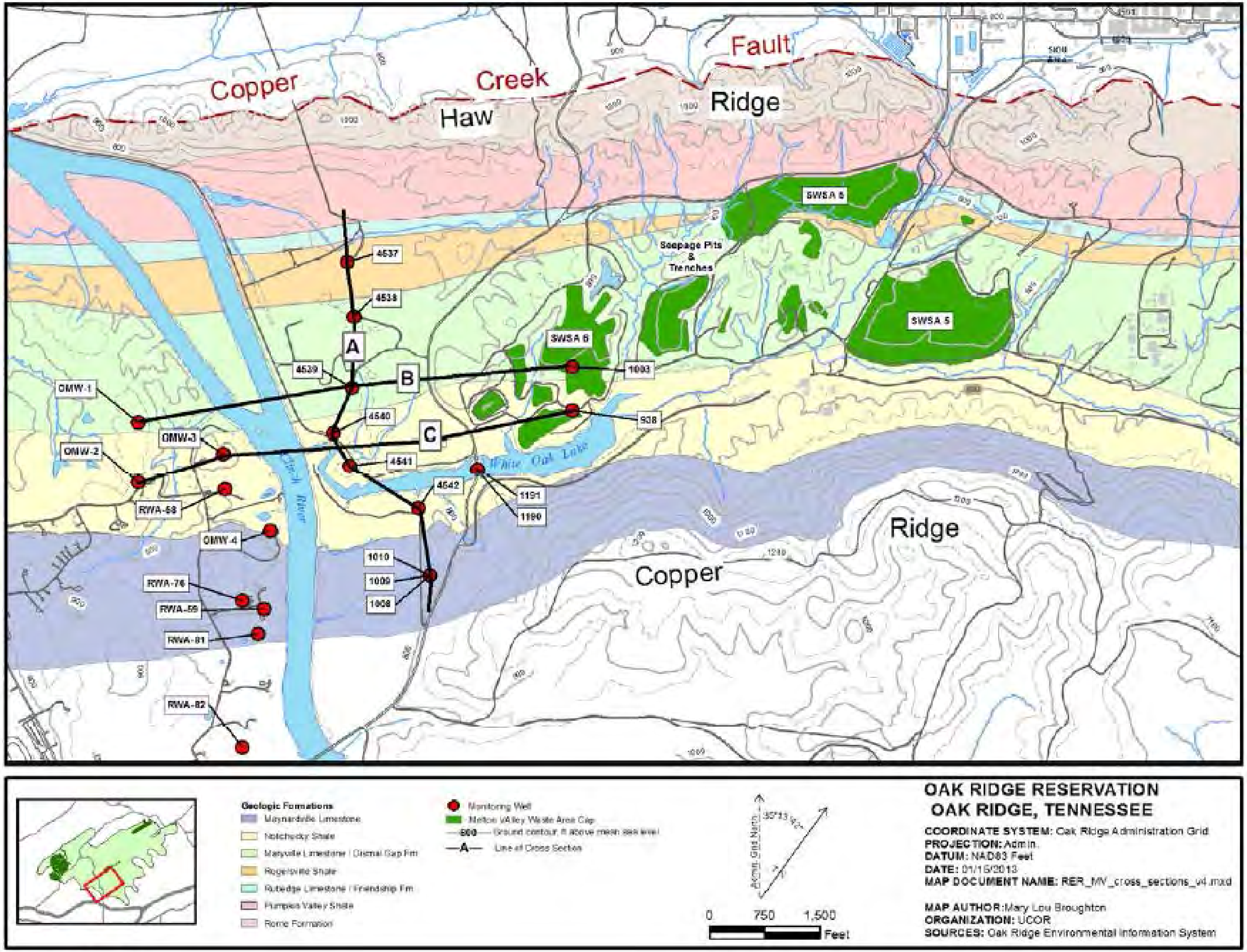
Conduct an Off-site Groundwater Quality Assessment in FY14 through FY16 as the first project under the ORR Groundwater Program.

- The project is consistent with the ORR Groundwater Strategy's ranking efforts and will be the focus of the new ORR Groundwater Program for the first 3 years.
- A Data Quality Objectives approach will be used to sample and analyze off-site groundwater, including residential wells and springs in downgradient areas to determine:
  - if contaminants unique to the DOE Reservation are present
  - if there is a potential public health risk from DOE contaminants off-site
- After data collection is complete, results will be evaluated to determine:
  - if follow-on actions may be needed
  - the next focus areas of the ORR Groundwater Program

Reduce Uncertainty about Potential Off-site Migration and Risks

- **“There have been recent sporadic, low-concentration detections of radionuclides and volatile organic compounds in off-site sampling locations downgradient of the ORR . . . There are no known health impacts from contaminants detected off-site . . . However, in order to minimize groundwater pumping that could draw DOE contaminants off-site, license agreements restricting groundwater use have been put in place for some residents in the area west of the Clinch River across from Melton Valley”**

Source: Sep 2013 ORR Groundwater Strategy D1, V. 1, p. ES-1 (DOE/OR/01-2628/V1&D1)



Source: DOE 2013

Melton Valley Off site

Fig. G.10. Locations of Melton Valley exit pathway wells and off-site monitoring wells.

Bethel & Melton Valley Geology

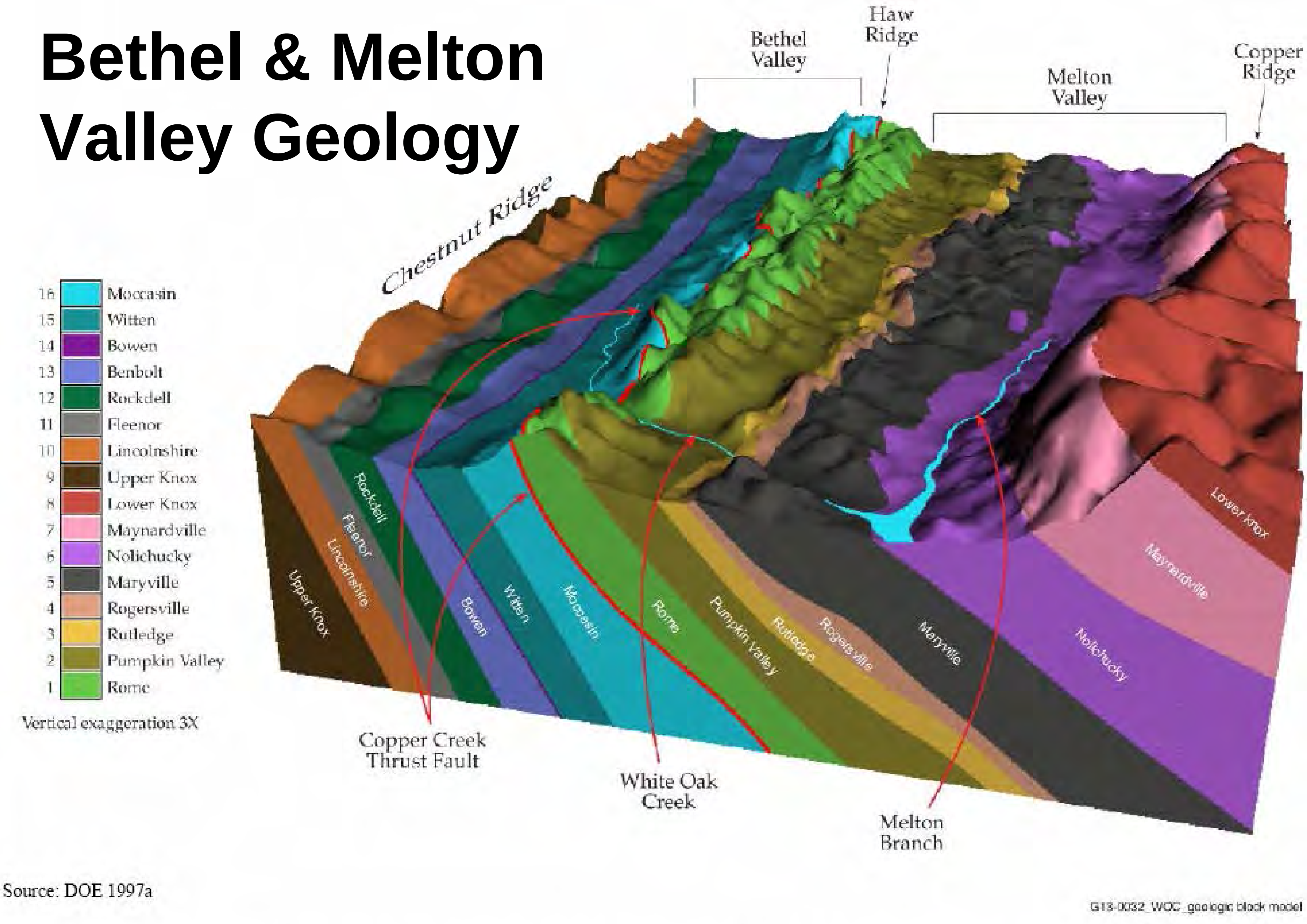


Fig. G.6. 3-D Block diagram of geology in Melton and Bethel Valleys (view up-valley to the east).

“Summary observations from groundwater (DOE 2013) indicate the following for the Picket Wells:

- A number of radionuclides and VOCs [solvents] have been detected periodically at low levels in different monitoring zones on the MV Picket.
- Intermittent detections of metals and VOCs have been observed in off-site wells across (on the west side of) the Clinch. Two detections of ^{90}Sr [strontium] and one of ^{99}Tc [technitium] have been observed.

Source: Sep 2013 ORR Groundwater Strategy D1, V. 2, p. G-49 (DOE/OR/01-2628/V2&D1)

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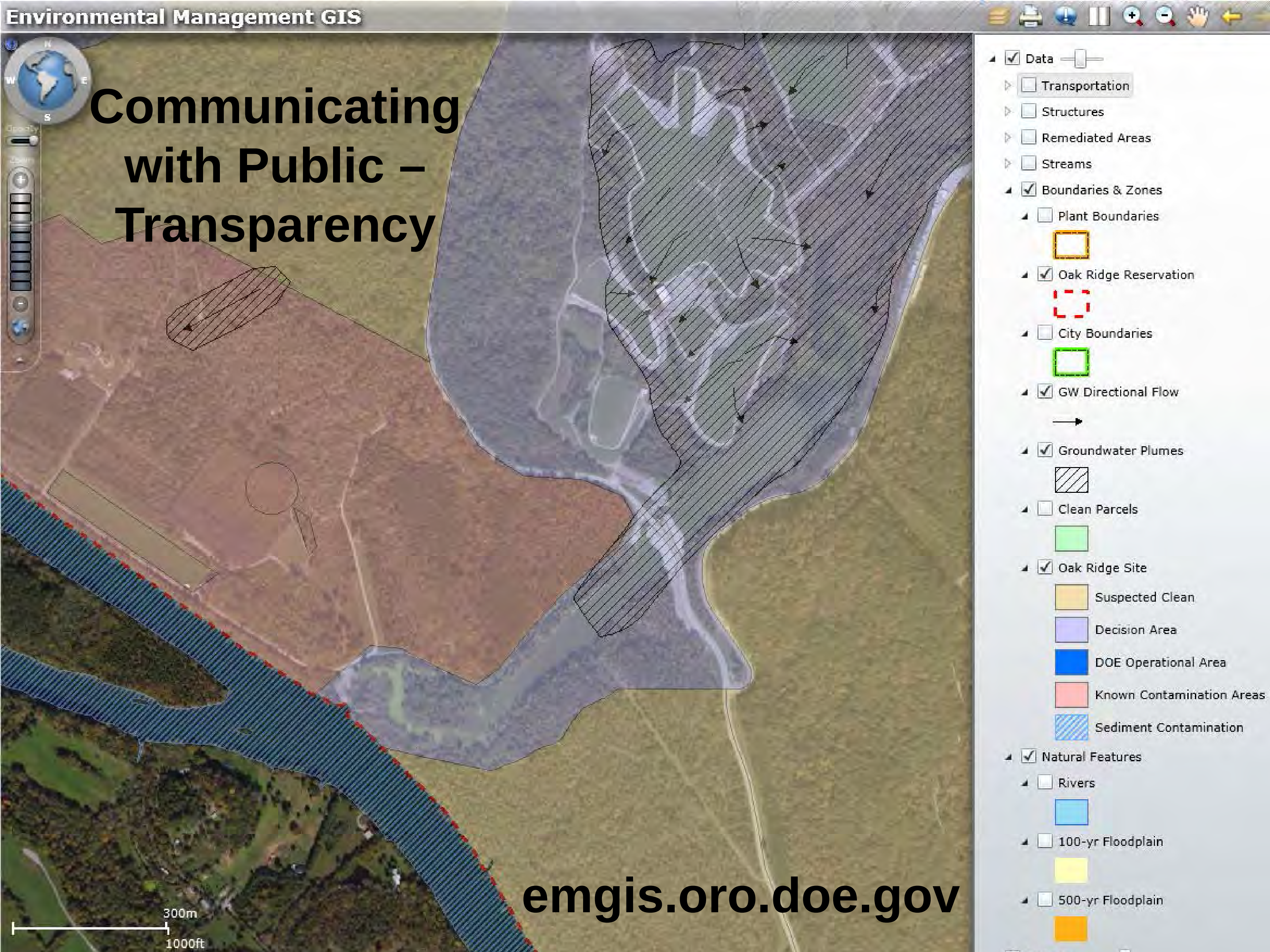
“Summary observations from groundwater (DOE 2013) indicate the following for the Picket Wells: (cont.)

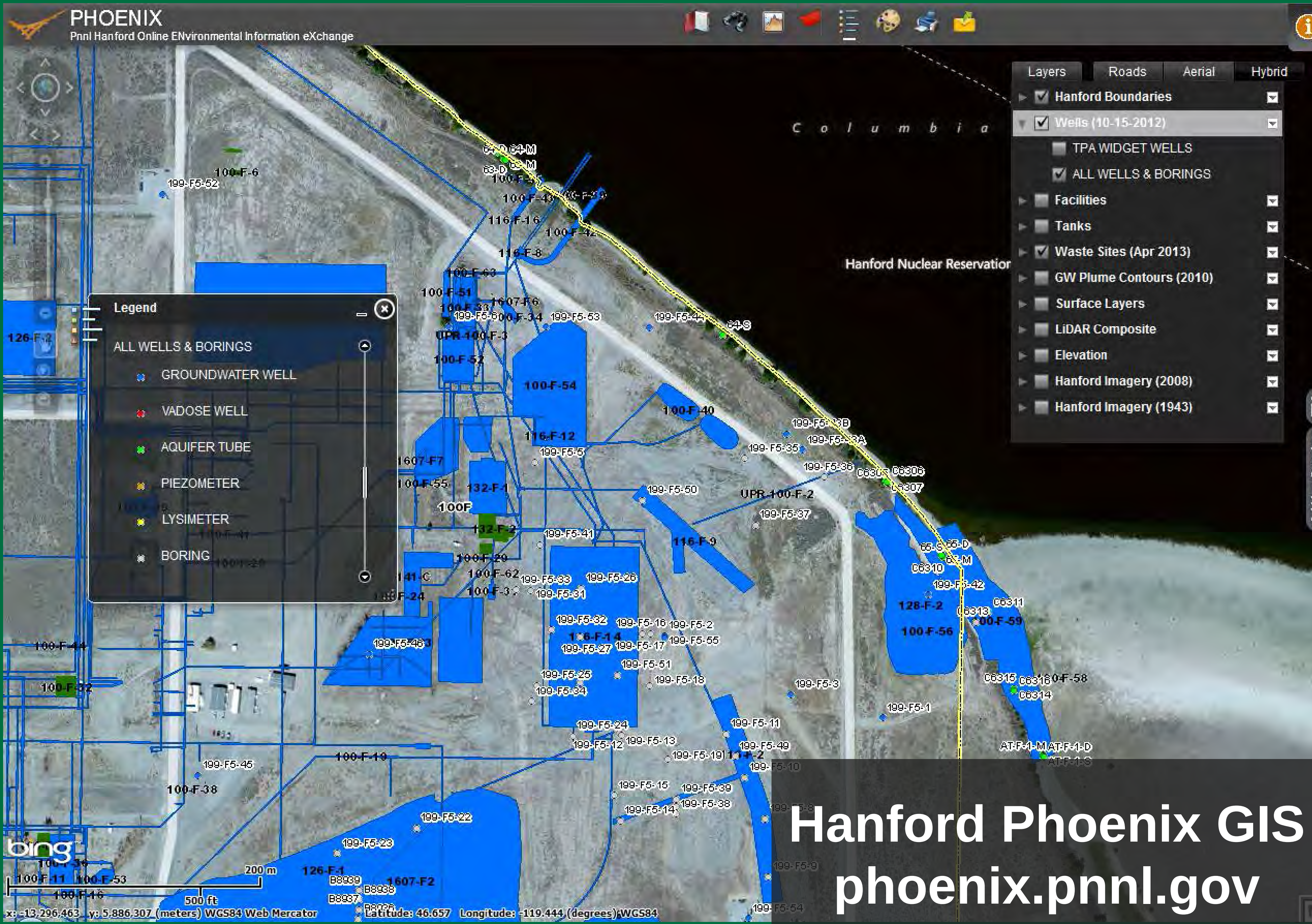
- Natural head gradients indicate groundwater movement toward the Clinch River from both east and west of the river. Alteration of the natural gradients caused by pumping can induce flow through interconnected fractures. This type of gradient alteration has the potential to induce contaminant movement from areas beneath the river to off-site wells.”

Source: Sep 2013 ORR Groundwater Strategy D1, V. 2, p. G-49 (DOE/OR/01-2628/V2&D1)

Communicating with Public – Transparency



emgis.oro.doe.gov

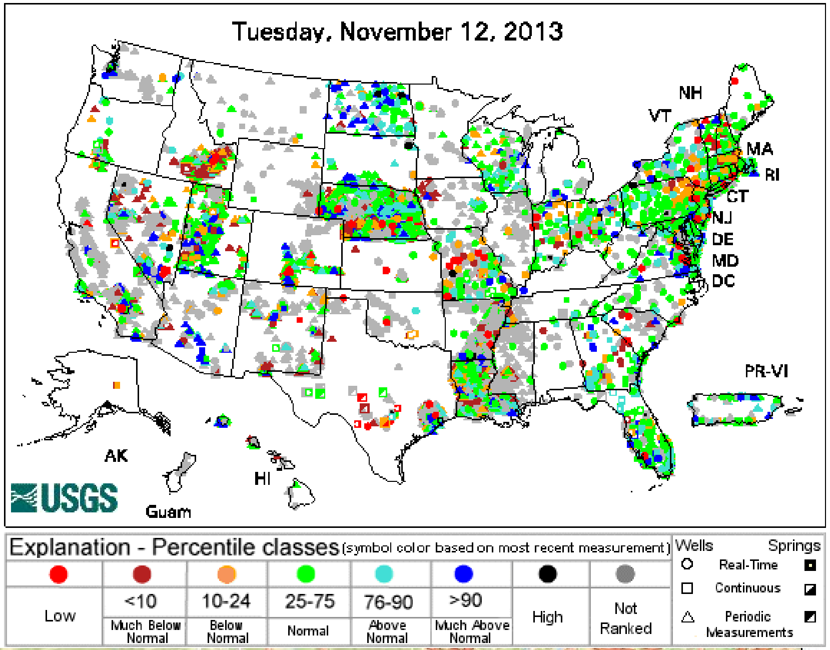


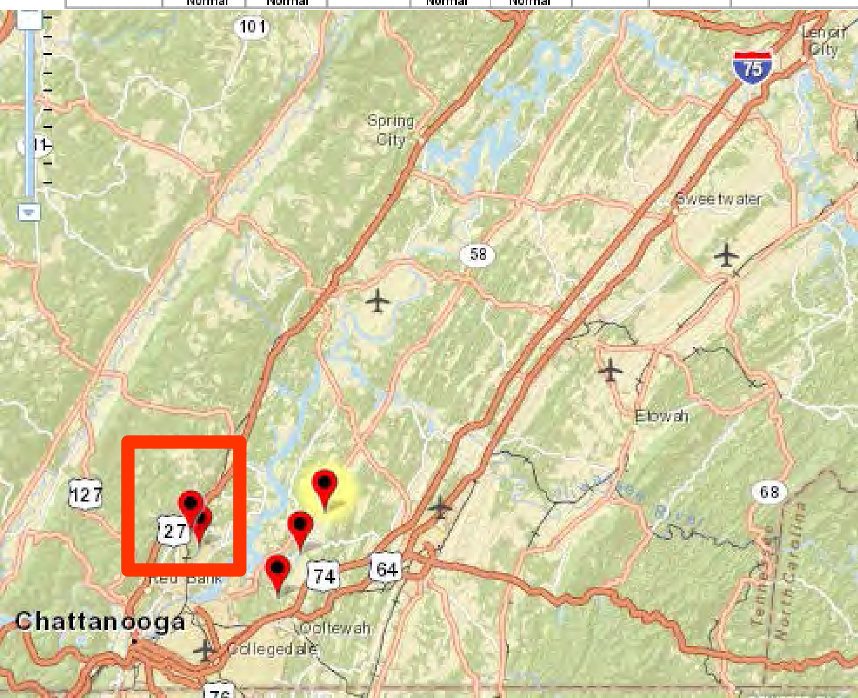
Hanford Phoenix GIS

phoenix.pnnl.gov

Groundwater Watch

Active Groundwater Level Network





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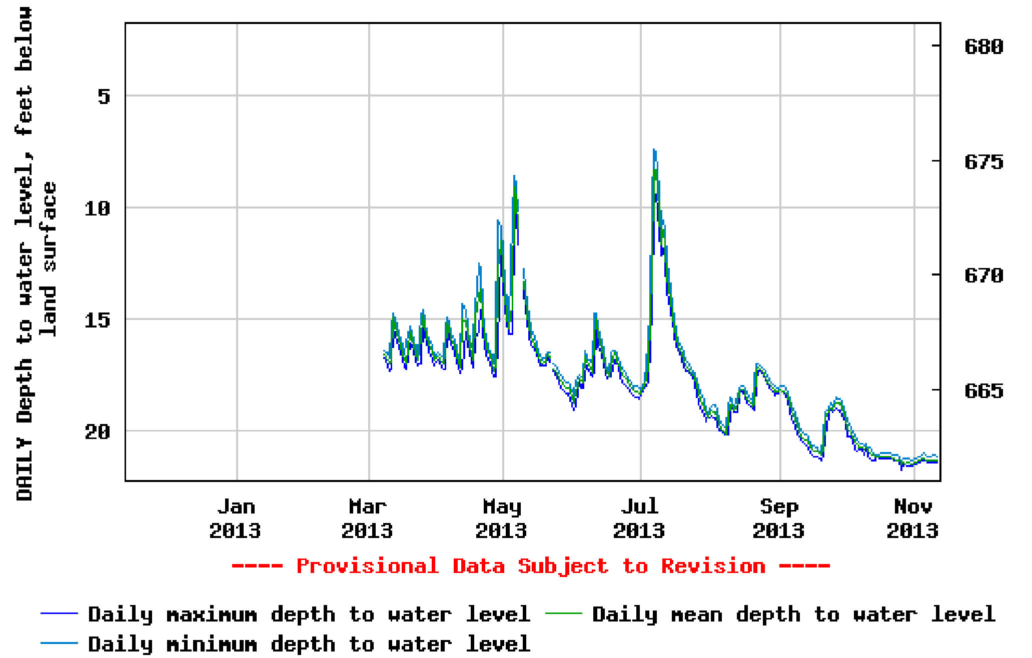

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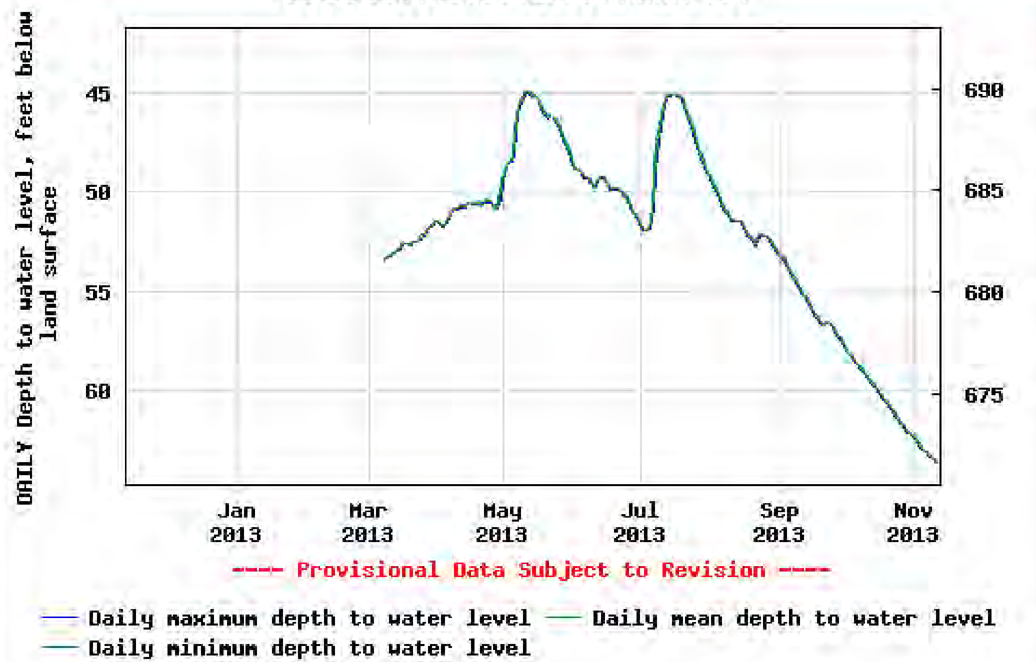

Take Home Messages

- **With the exception of a low VOC detection in one sample in one well in 2010, no results for known DOE contaminants in off-site wells across the Clinch River from Melton Valley have exceeded Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs).**
- **This VOC was not detected in subsequent samples from the same well.**

Take Home Messages

- Consensus that off-site migration via deep paths is plausible, may have occurred in the past, and deserves further investigation.

- ORSSAB could consider recommending that DOE proceed with the Off-site Groundwater Quality Assessment project.

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ORR Groundwater Strategy Near-term Steps (cont.)

Set up an ongoing ORR Groundwater Program based in the Water Resources Restoration Program (WRRP).

- To improve long-term planning, the Program will develop project scopes for consideration and prioritization.
- Selected projects (e.g., investigation, modeling, technology development support) will be integrated with WRRP monitoring to optimize resources.
- The program will provide flexibility to adapt based on investigation findings, cleanup progress, and budgets.
- Project prioritization and resource allocation will follow FFA and EM program budget protocols.
- ORR Groundwater Program findings will be used to:
  - reevaluate and adjust initial plume and project ranking and results
  - identify interim measures that may be warranted
  - support future groundwater decisions and remediation

Revive state-of-the-art Groundwater Investigation at ORR

- **"Many data gaps exist because little groundwater investigation work has been done since the 1990s . . . Groundwater investigation, groundwater modeling, and technology development . . will improve understanding of plume sources and migration . . ."**

Source: Sep 2013 ORR Groundwater Strategy D1, V. 1, p. ES-2 (DOE/OR/01-2628/V1&D1)

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ORNL/TM-12074

Environmental Sciences Division

STATUS REPORT ON THE GEOLOGY OF THE OAK RIDGE RESERVATION

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Geology 1992

Date Published—October 1992

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ORNL/TM–12026

ENVIRONMENTAL SCIENCES DIVISION

STATUS REPORT

A HYDROLOGIC FRAMEWORK FOR THE OAK RIDGE RESERVATION

D. K. Solomon, G. K. Moore,[1] L. E. Toran, R. B. Dreier, and W. M. McMaster[1]

Environmental Sciences Division
Publication No. 3815

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[1]Department of Civil Engineering, The University of Tennessee, Knoxville.

ENERGY SYSTEMS OAK RIDGE HYDROLOGY SUPPORT PROGRAM
(Activity No. 26 45 02 00 0)

Hydrology 1992

May 1992

Prepared for the
Energy Systems Groundwater Program Office

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831

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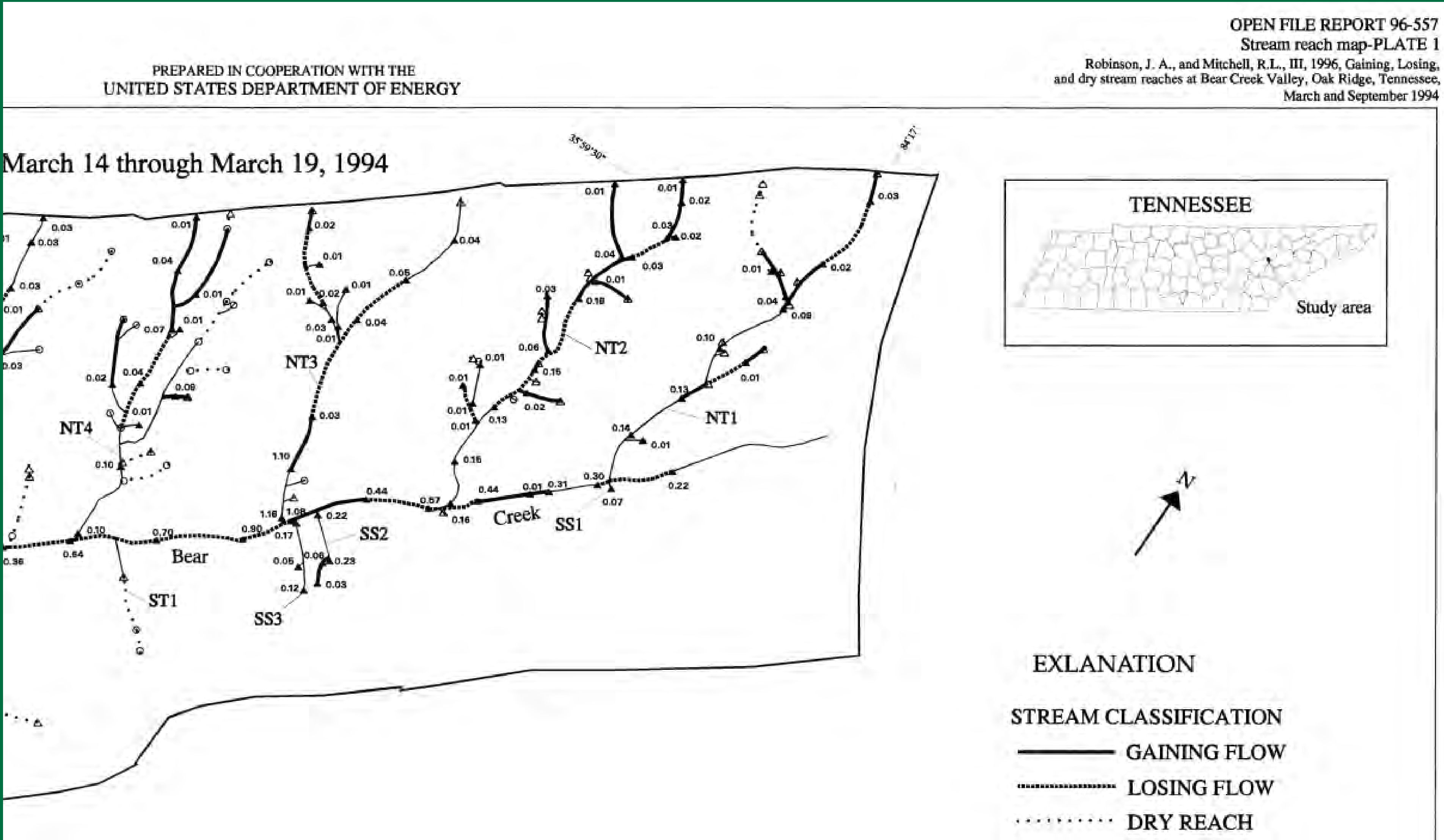
Gain / Losing Streams 1994



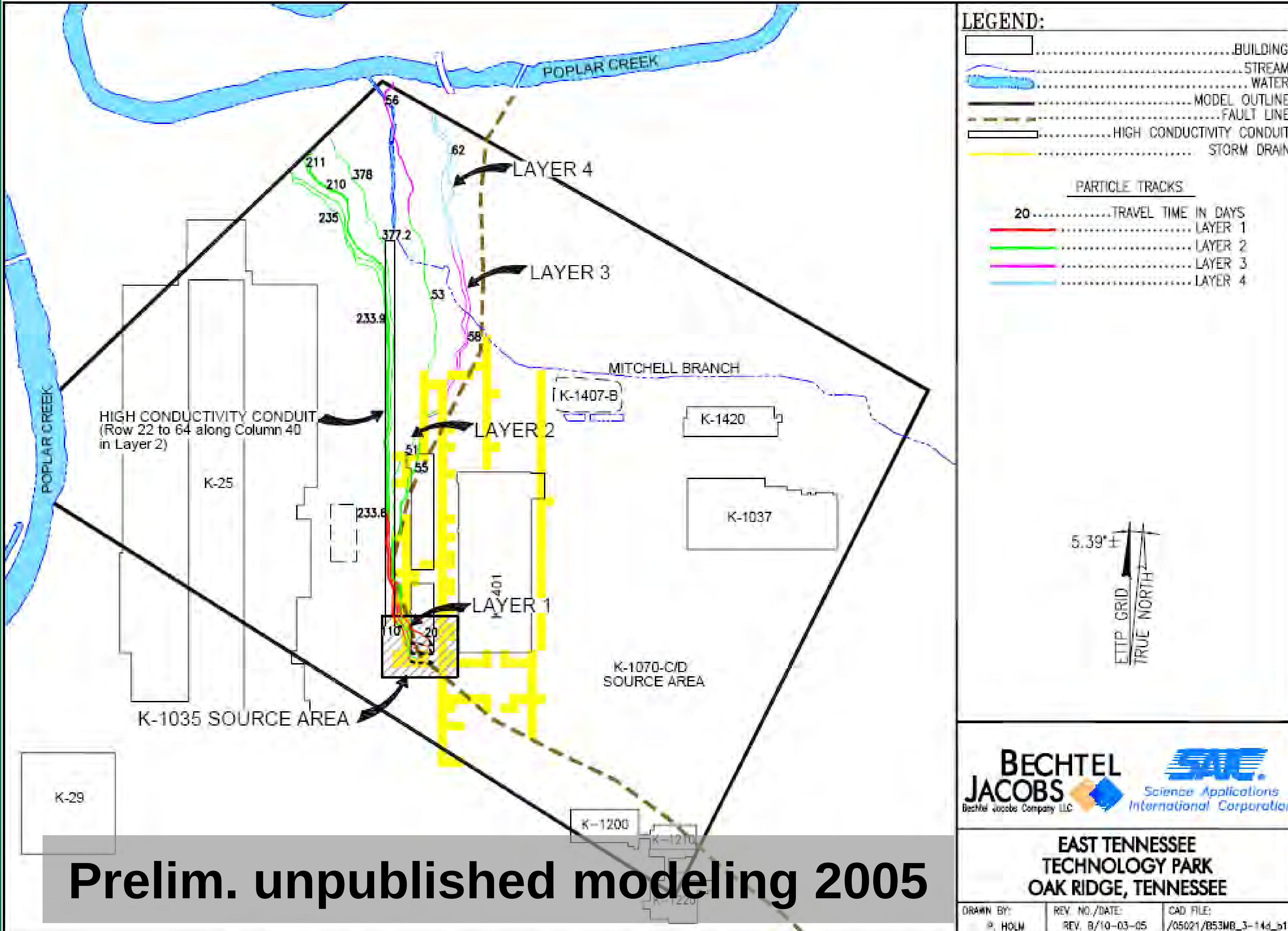


Fig. 3.28. Tracks of particles released in Layer 1 from K-1035 area under sump-on condition for the assumed discrete high conductivity conduit in Layer 2.

groundwater

Estimating Reaction Rate Coefficients Within a Travel-Time Modeling Framework

by R. Gong[1], C. Lu[1], W.-M. Wu[2], H. Cheng[2], B. Gu[3], D. Watson[3], P.M. Jardine[3], S.C. Brooks[3], C.S. Criddle[2], P.K. Kitanidis[2], and J. Luo[1,4]

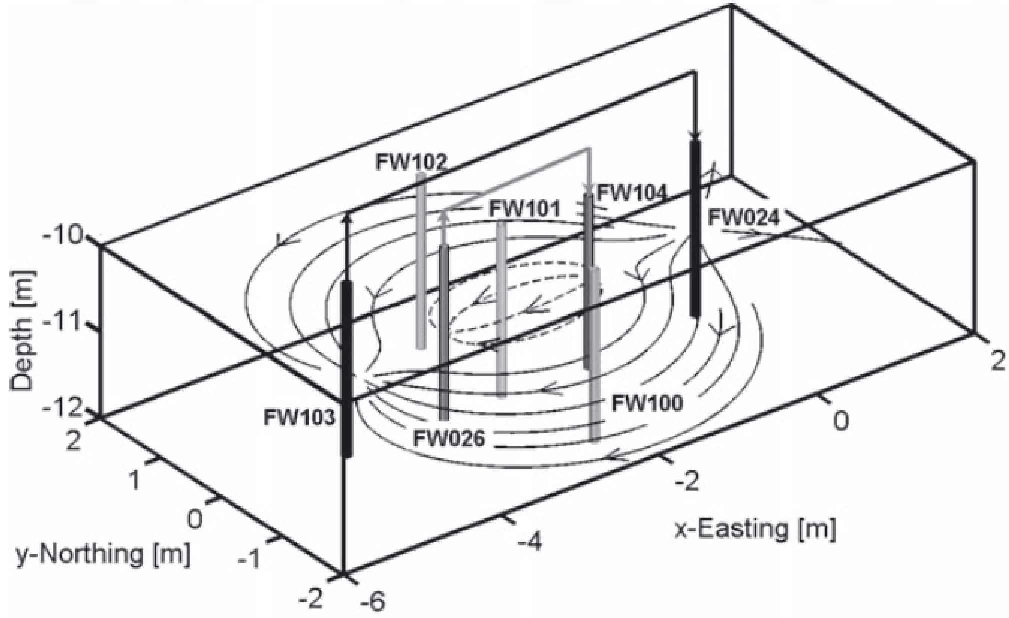


Figure 1. The multiple-well system installed at Oak Ridge, Tennessee, for in situ remediation of U(VI)-contaminated groundwater. The well system includes two injection (FW024 and FW104) and two extraction wells (FW026 and FW103), and three MLS wells. The dashed lines with arrows indicating flow directions are the streamlines within the nested inner cell, and the solid lines are the streamlines in the outer flow cell.

214 R. Gong et al. GROUND WATER 49, no. 2: 209–218 NGWA.org

2011 Ga. Tech, Stanford, ORNL, DOE-funded

Mercury in Water Science at Oak Ridge

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- Site Specific Problem
- Approach
- Current Progress
- Related Websites
- Documents
- Publications and Presentations
- Expertise
- Contacts

Applied Field Research Initiative

Remediation of Mercury and Indu

Research Staff

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Terry Cothron, Y-12 BWXT

Dick Kettelle

Bob Alexander, Tennessee Department of Environment and Conservation

Brian Looney and Carol Eddy-Dilek, SRNL

Ralph Turner

George Southworth and Maryanna Bogle, Retired from ORNL

Scott Brooks, Baohua Gu, Dwayne Elias, Anthony Palumbo and Terry Mathews

Groundwater Modeling – A tool for data analysis & decision making

- "Groundwater modeling will play an instrumental role in the CERCLA RI/FS process in coming years, and for some of the more complex decisions, it may play a role in the long-term monitoring (LTM) phase of CERCLA implementation."

Source: Sep 2013 ORR Groundwater Strategy D1, V. 1, p. 5-12 (DOE/OR/01-2628/V1&D1)

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Groundwater Modeling – A tool for data analysis & decision making

- No further action on residual sources
- Monitored Natural Attenuation (MNA)
- Technical Impracticability (TI) waivers
- Design of active remediation (e.g. well rates & locations)
- Optimization of monitoring programs
- ORR-wide regional flow model needed

Source: Sep 2013 ORR Groundwater Strategy D1, V. 1, p. 5-12 (DOE/OR/01-2628/V1&D1)

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Take Home Messages

- DOE effort since early 1990s has focused on remediation and monitoring
- Scientific advances in characterization and modeling in last 20 yrs.
- ORSSAB could consider recommending that DOE secure additional baseline funding for interpretive analysis, including modeling, to obtain maximum benefit of monitoring data and other information

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Take Home Messages

- **ORSSAB could consider recommending that DOE broaden the technical support team beyond site contractors to include academic and government experts, akin to the scientific groundwater program at Oak Ridge prior to 1993. Such an approach seems to be underway with respect to Mercury at ORR.**

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- Strategy Highlights
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- **Plume Rankings**
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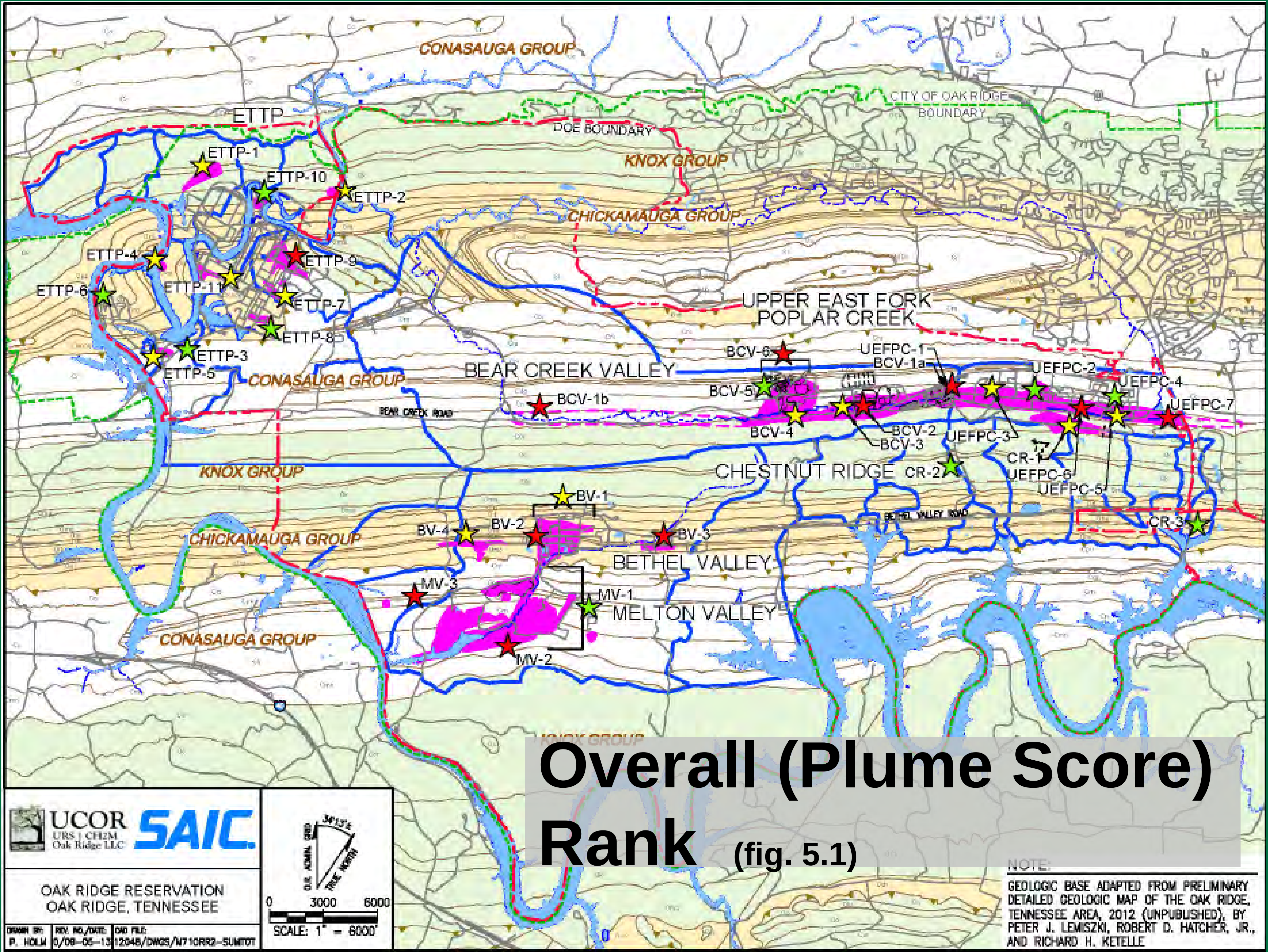
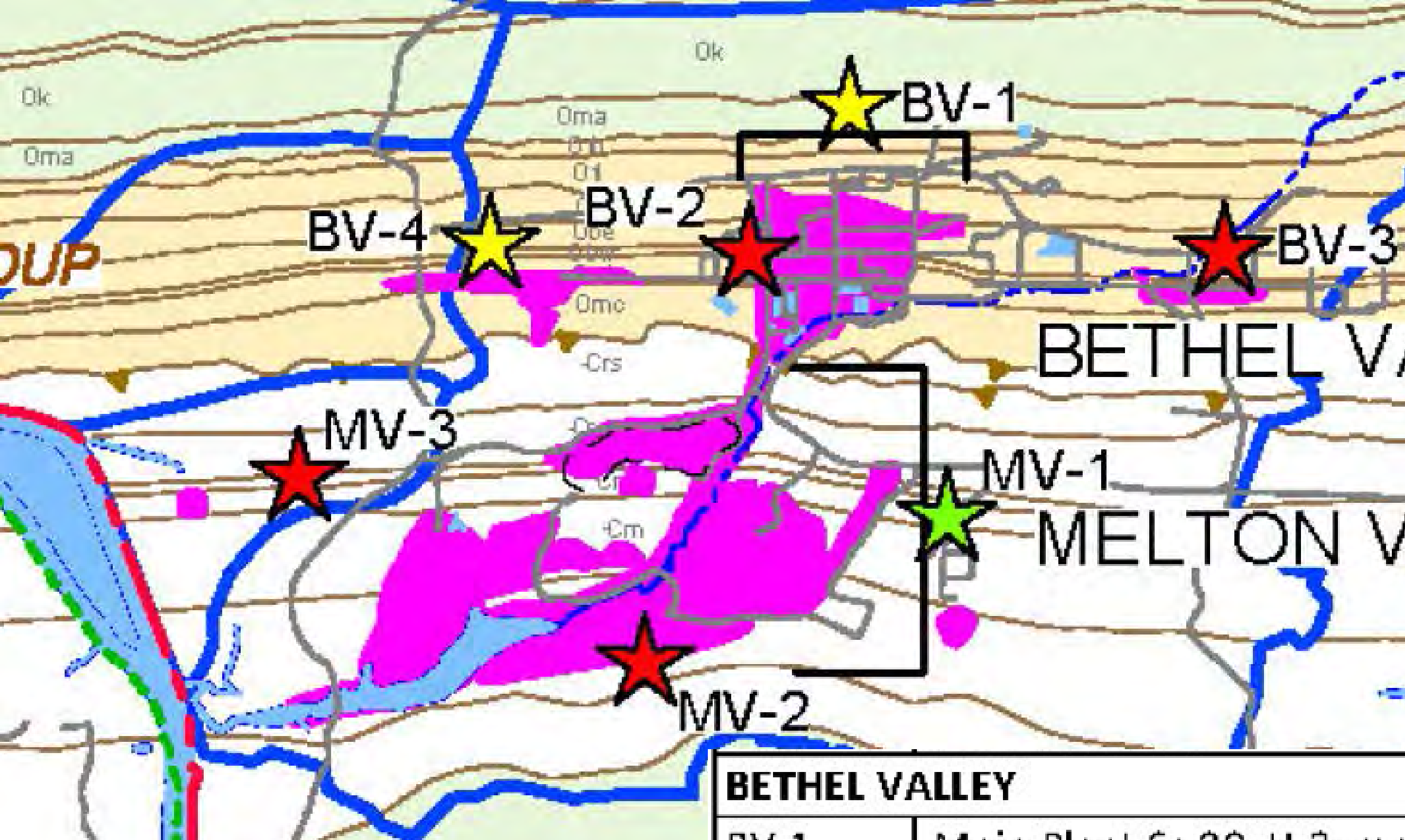
Plume Rankings

- Pathway Score =
  Pathway (0-10) + Receptor (0-10)
- Plume Score = Pathway Score + Hazard Score
- Hazard Score = 0.57 x [Toxicity (0-15) +
- Area (0-10) + Longevity (0-10)]
- Hazard Score weighted by 0.57 = (20/35) to equalize values with Pathway Score
- Table sorted by Pathway Score (not Plume Score)

Source: Sep 2013 ORR Groundwater Strategy D1, V. 1, section 5.1.3 (DOE/OR/01-2628/V1&D1)



Overall (Plume Score) Rank (fig. 5.1)



Overall Rank (Plume Score)

(fig. 5.1)

BETHEL VALLEY	
BV-1	Main Plant Sr-90, H-3, mercury
BV-2	Corehole 8, Sr-90, U, Cs-137
BV-3	7000 Area VOC Plume
BV-4	SWSA 3 Sr-90
MELTON VALLEY	
MV-1	Shallow Groundwater Contamination emanating from buried waste operations overlying the Conasuga Group formations
MV-2	Hyrdofracture Sites
MV-3	Exit Pathway/Picket Wells

Rankings by Pathway & Plume Scores

Table 5.3. Pathway ranking and Overall ranking of ORR groundwater plumes

Plume No.	Groundwater Plume	Hazard Score: Toxicity	Hazard Score: Area	Hazard Score: Longevity	Hazard Score: Weighted Total	Pathway Score: Pathway	Pathway Score: Receptor	Pathway Ranking[a] by Total Pathway Score	Overall Ranking[a] by Total Plume Score
MV-3	Exit Pathway/Picket Wells contamination from undetermined sources	7	5	2	8.0	10	10	20	28
BCV-2	Uranium in the Maynardville Limestone	5	5	10	11.4	10	7	17	28
BCV-1b	S-3 Deep nitrate in Maynardville Limestone	4	10	1	8.6	10	7	17	26
ETTP-1	K-1070-A Burial Ground	7	3	3	7.4	7.5	9	16.5	24
ETTP-2	Contractor's Spoil Area (CSA)	4	3	3	5.7	7.5	9	16.5	22
BV-2	Corehole 8, ^{90}Sr, U, ^{137}Cs	15	5	2	12.6	7.5	7	14.5	27
ETTP-11	K-27/K-29 Area	8	1	6	8.6	7.5	7	14.5	23
ETTP-5	K-720 Fly Ash Pile	5	1	10	9.1	5	9	14	23
BV-4	SWSA 3, ^{90}Sr	6	3	2	6.3	5	9	14	20
ETTP-4	Duct Island/K-1070-F	4	3	3	5.7	5	9	14	20
UEFPC-7	East End VOC Plume	10	10	6	14.9	10	3	13	28
MV-2	Hydrofracture Sites	15	7	10	18.3	5	7.5	12.5	31
UEFPC-1	S-3 Site Eastern Plume/S-2 Site Plume	9	10	10	16.6	7.5	5	12.5	29
BCV-1a	S-3 Shallow Contamination in Nolichucky Shale and Bear Creek (Pathways 1, 2, 3)	12	7	10	16.6	7.5	5	12.5	29
UEFPC-6	Localized Mercury Sources to Groundwater	12	3	10	14.3	7.5	5	12.5	27
ETTP-9	Mitchell Branch Commingled Plumes	15	3	6	13.7	7.5	5	12.5	26
BV-3	7000 Area VOC Plume	12	3	6	12.0	7.5	5	12.5	25
BCV-3	HCDA Shallow/deep VOCs (DNAPL) in Nolichucky and Maynardville	9	5	6	11.4	7.5	5	12.5	24
ETTP-7	K-1200 Area	8	3	3	8.0	7.5	5	12.5	21
CR-1	Chestnut Ridge Security Pits	5	5	3	7.4	7.5	5	12.5	20
ETTP-8	K-1004 Area	4	3	3	5.7	7.5	5	12.5	18
CR-2	United Nuclear Corporation Disposal Site	5	1	2	4.6	7.5	5	12.5	17
ETTP-10	K-1064 Peninsula	2	1	3	3.4	7.5	5	12.5	16
BV-1	Main Plant, ^{90}Sr, ^{3}H, mercury	13	3	2	10.3	5	7	12	22
	Uranium Sources in Maynardville								

Rankings by Pathway & Plume Scores

Table 5.3. Pathway ranking and Overall ranking of ORR groundwater plumes

Plume No.	Groundwater Plume	Hazard Score: Toxicity	Hazard Score: Area	Hazard Score: Longevity	Hazard Score: Weighted Total	Pathway Score: Pathway	Pathway Score: Receptor	Pathway Ranking[a] by Total Pathway Score	Overall Ranking[a] by Total Plume Score
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BV-4	SWSA 3, ^{90}Sr	6	3	2	6.3	5	9	14	20
ETTP-4	Duct Island/K-1070-F	4	3	3	5.7	5	9	14	20
UEFPC-7	East End VOC Plume	10	10	6	14.9	10	3	13	28
MV-2	Hydrofracture Sites	15	7	10	18.3	5	7.5	12.5	31
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ETTP-8	K-1004 Area	4	3	3	5.7	7.5	5	12.5	18
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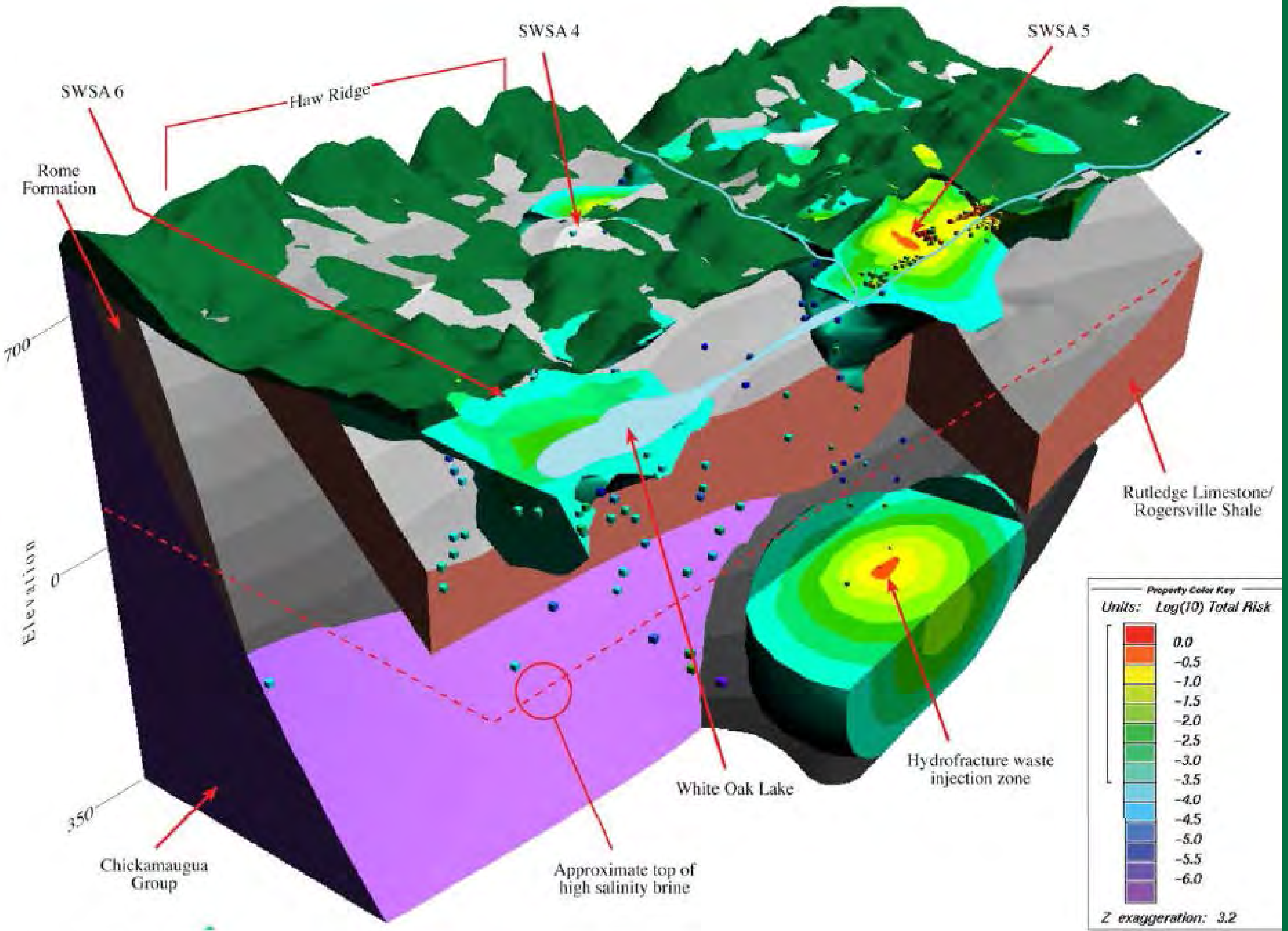
	Uranium Sources in Maynardville								



Source: DOE 1997a

HydroFracture

G13-0032_WOC - silicon

Fig. G.22. Hydrofracture waste injection zone showing relationship to other MV waste units, geology and associated risk.

Take Home Messages

- Team used an explicit multi-step process to rank plumes. However, any ranking process is unavoidably subjective. Final Rankings heavily weight the Pathway Score.
- ORSSAB could consider recommending that DOE adopt the plume rankings for management of site-wide groundwater remediation.

Take Home Messages

- **Hydrofracture disposal has highest Overall Plume score (31), but Pathway score 0.5 points below "High" rank.**
- **ORSSAB could consider recommending that DOE collect, review, and archive records associated with hydrofracture disposal to support long-term stewardship.**
- **Can experience at ORR inform national debate on hydraulic fracturing?**

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Recommendation 4: Off-site Groundwater Use

- **"Utilizing a portion of the annual funding to be budgeted for the ORR Groundwater Program, continue to evaluate and track groundwater use at properties adjacent to and downgradient of the ORR. Set up a DOE interface with TDEC to allow DOE to be notified of new well installation activity. If potential unacceptable risk is identified, consider additional groundwater use restrictions/policies for interim protectiveness until final decisions are reached."**

Source: Sep 2013 ORR Groundwater Strategy D1, V. 1, p. 7-2 (DOE/OR/01-2628/V1&D1)

USGS

Land Use Restrictions

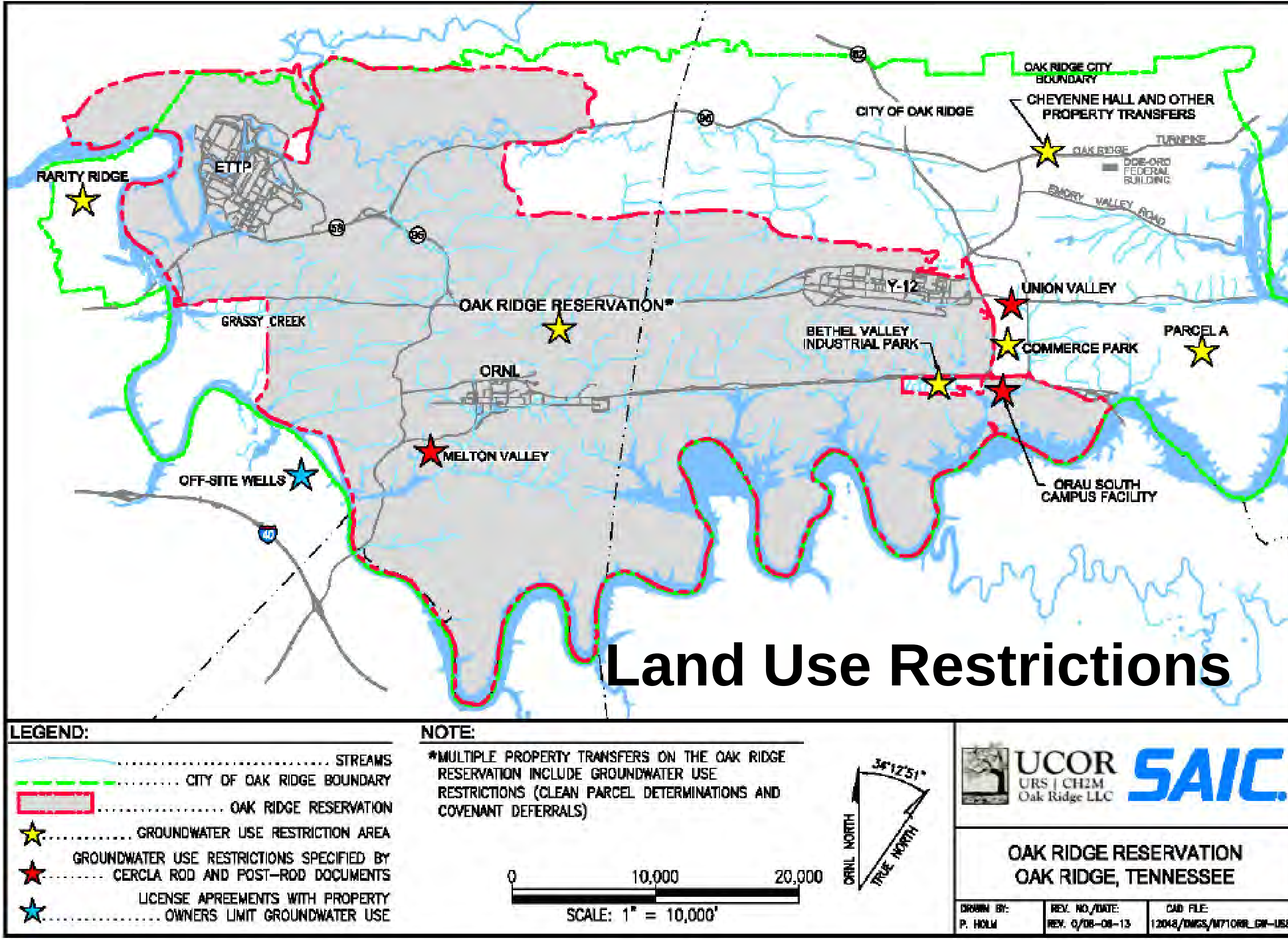

Fig. 5.3. Areas with groundwater use restrictions on and around the ORR.

Outline

- Strategy Highlights
- Off-site Groundwater Quality Assessment Project
- ORR Groundwater Program
- Plume and Project Rankings
- Off-site Groundwater Use
- Discussion