U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

NOTE TO FILE: Document Date

DATE: September 14, 2009

Name : Yolande Norman, Project Manager **/RA/**
Department: Materials Decommissions Branch
Division: DWMEP

Summary: **Package ML092520133 should be added to ADAMS with a date of September 14, 2009**

Meeting Agenda: Thursday, August 27, 2009, 1 p.m. to 5 p.m.

ADAMS Document No.: ML092520131	Mail Control:
License No.: SUB-1435	Docket No.:040-08838

MEETING AGENDA

Thursday, August 27, 2009, 1 p.m. – 5 p.m.
U.S. Nuclear Regulatory Commission (NRC), Headquarters

Meeting to Discuss Site Characterization Progress and Plans for Upcoming Work at the Jefferson Proving Ground Depleted Uranium Impact Area Site

TIME		
1:00 PM	Introductions & Introductory Remarks	NRC/Army
1:15 PM	Meeting Purpose (Cloud)	Army
1:20 PM	Review Project Objectives and Project Status/Major Milestones (Skibinski)	Army's contractor SAIC
1:50 PM	Summarize Preliminary Results of Site Characterization • Penetrator study (Skibinski) • Quarterly sampling results (sediment, surface water, groundwater) (Skibinski) • Soil sampling results (Chambers)	SAIC
2:35 PM (5 min)	Break	
2.40 PM	Summarize Preliminary Results of Characterization – continued • Hydrogeologic investigation update (gain/loss survey and slug testing) (Fox) • Preliminary Ground Water Age Estimates (Buszka)	SAIC
3:40 PM	Plans for Upcoming Work (Skibinski)	SAIC
3.55 PM (5 min)	Break	
4:00 PM	Discussion of Decision Points (Skibinski/Chambers/Fox) • Preliminary recommendations for site characterization • Preliminary recommendations for Revised ERM SOP • Discuss Army/NRC actions for October 2009 Meeting and other future teleconferences	SAIC
4:30 PM	Questions/Comments	Public
5:00 PM	Concluding Remarks	NRC

JPG Status Briefing:

Characterization Progress and Plans for Upcoming Work

U.S. Army – Paul Cloud
U.S. Geological Survey, Indiana Water Science Center – Paul Buszka
SAIC – Joseph Skibinski, Dennis Chambers, and Tad Fox

27 August 2009

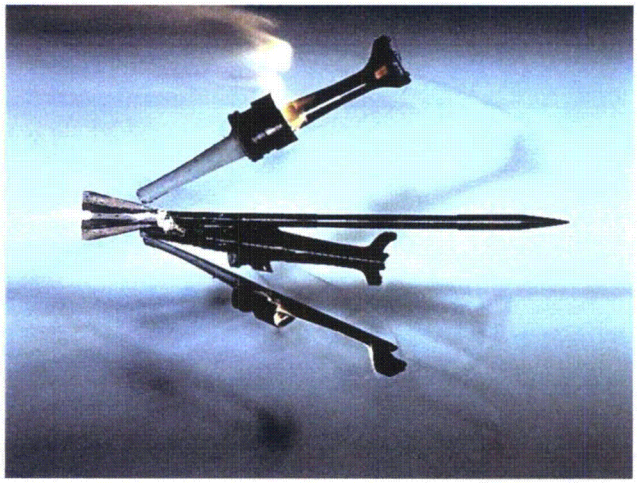
U.S. Nuclear Regulatory Commission Headquarters, Rockville, MD

Agenda

- Review Project Objectives and Status/Major Milestones
- Summarize Preliminary Results of Site Characterization
  - Penetrator study
  - Quarterly sampling results (groundwater, sediment, surface water)
  - Soil sampling results
  - Hydrogeologic investigation update
  - Preliminary ground water age estimates
- Plans for Upcoming Work
- Discussion of Decision Points
  - Preliminary recommendations for site characterization
  - Preliminary recommendations for Revised ERM SOP
  - Discuss Army/NRC actions for October 2009 Meeting and other teleconferences
- Questions from Public

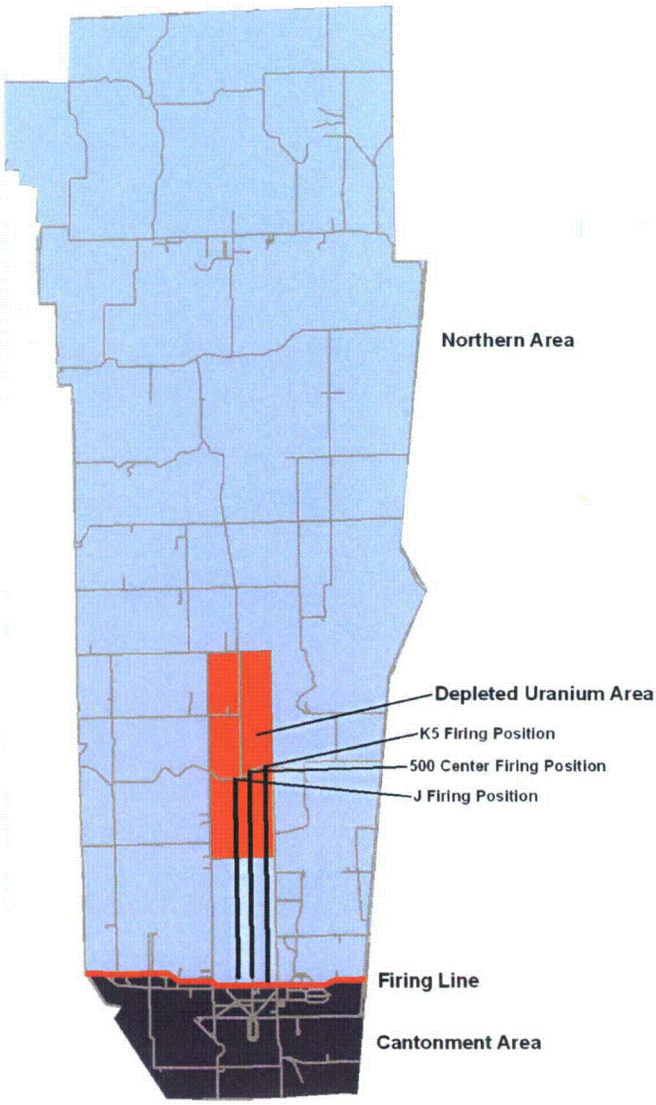
Background – DU Firing

- Targets placed at 1,000-meter intervals starting 1,000 meters from gun position extending to 4,000 meters
- Of 100,000 kg total depleted uranium (DU) fired, approximately 6,600 kg (~7%) fired from J Firing Position, almost 90,000 kg (~89%) fired from 500 Center Firing Position, and 3,888 kg (~4%) fired from K5 Firing Position
- Approximately 33,000 kg of DU was removed; approximately 70,000 kg of DU remains (14,000 to 21,000 individual penetrators – depending on whether fired from 105-mm or 120-mm gun)



DU penetrator loses windshield, sabots and fins in flight

Only the penetrator and fragments remain in DU Impact Area



Background – Suspected Contamination

- Trench formed from repeated firing from 500 Center firing position: 5 to 8 m wide, ~1,200 m long, and ~1 m deep
- Limited evidence of trench formed north of J Firing Position (western-most): less visible
- Scattered penetrators/fragments along and near firing lines that extend north from firing points

Aerial view of 500-Center DU trench (early 1990s)

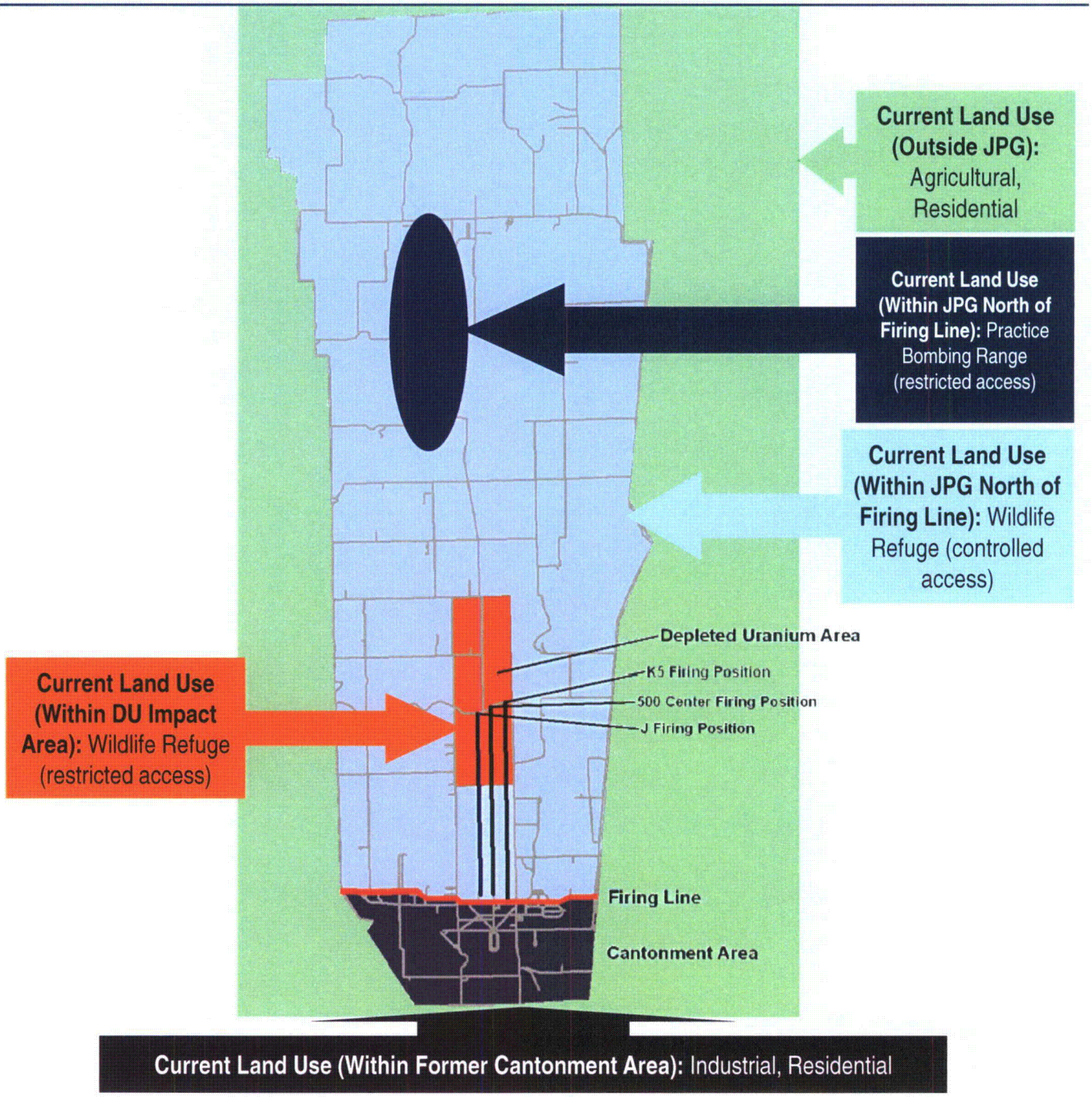
Ground view of 500-Center DU trench (early 1990s)

DU trench from J Firing Position (October 2008)

500-Center DU trench (winter early-2000s)

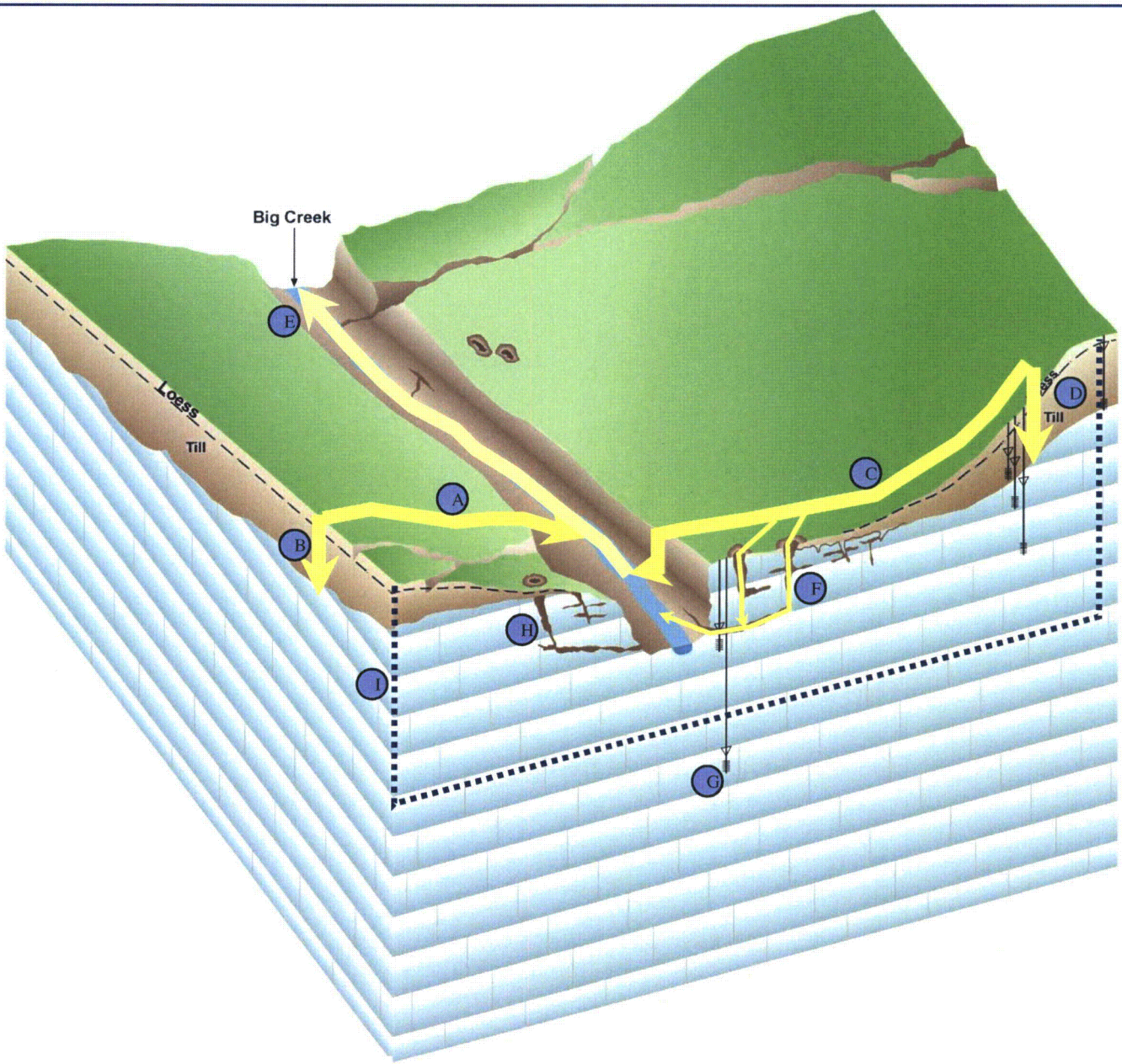
Review Objectives

Conceptual Site Model – Land Use



Future Land Use = Current Land Use
Access restrictions are monitored and enforced by U.S. Fish & Wildlife Service and U.S. Air National Guard through the "Jefferson Proving Ground Firing Range Memorandum Of Agreement (MOA)," which remains in effect for 25 years from signing date in May 2000 and may be renewed for additional 10-year periods upon mutual agreement

Conceptual Site Model – Fate and Transport



- **A** DU corrosion products running from trench in higher elevations into Big Creek
- **B** DU corrosion products transported to subsurface soil and potentially groundwater aquifer
- **C** DU corrosion products running from areas north of Big Creek where penetrators landed in firing lines into Big Creek
- **D** DU corrosion products transported to subsurface soil and potentially groundwater aquifer
- **E** DU corrosion products mixing with surface water and depositing in sediment in Big Creek
- **F** DU corrosion products transported through karst features (sinkholes, caves, fractures, etc.)
- **G** Current data suggests that the shallow bedrock groundwater zone responds to precipitation and discharges to the local surface water, while the deeper bedrock has limited permeability and is not well connected with surface water or responsive to precipitation
- **H** As a result of drilling, field observations and reviewed published reports it appears that karst activity within and immediately surrounding the DU Impact Area is limited in depth and lateral extent (SAIC, March 2008, p.4-6)
- **I** The CSM has been modified to limit the location of shallow karst features (caves and sinkholes) to a narrow plain along Big Creek. Caves and solution features appear to be most commonly above the elevation of Big Creek, and limited to depths of less than 50 feet from the land surface. (SAIC, March 2008)

Project Objectives

- Enhance the understanding of the nature and extent of contamination in the Depleted Uranium (DU) Impact Area and the fate and transport of DU in the environment
- Define and verify the conceptual site model (CSM)
- Provide the basis for modifying the current monitoring program within the next 2 to 3 years and for completing a revised Decommissioning Plan not later than the end of 2011

Phase I: Offsite Migration Potential and Pathways	Phase II: Source and Release Characterization	Phase III: Modeling	Phase IV: Decommissioning
▪ Stream and cave spring gauges ▪ Groundwater wells ▪ Distribution and concentrations of DU corrosion products in groundwater, surface water, sediment, and biota	▪ DU penetrator corrosion analysis ▪ Transport of DU corrosion products ▪ Distribution and concentrations of DU corrosion products in soil	▪ Fate and transport modeling ▪ Dose modeling	▪ Environmental Report ▪ Decommissioning Plan ▪ Revised ERM program

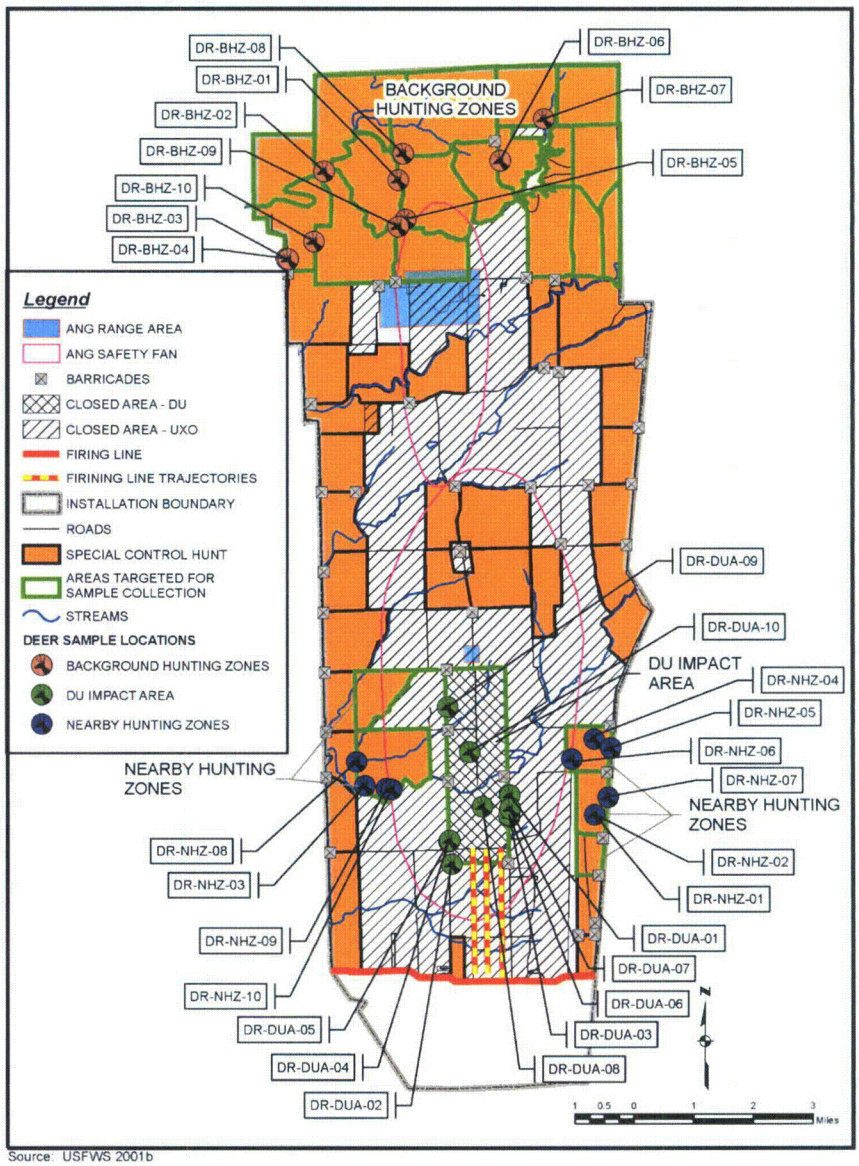
Major Tasks

- Completed Tasks
  - Deer Tissue Sampling
  - Soil Verification
  - Stream and Cave Spring Gauge Installation and Monitoring
  - Fracture Trace Analysis
  - Electrical Imaging (EI) Survey
  - Groundwater Well Installation
  - Public Meetings
- Ongoing Tasks
  - DU Penetrator Corrosion Study
  - Groundwater, Surface Water, and Sediment Sampling and Analysis
  - Soil Sampling and Analysis
  - Ground-Water Age Estimates
  - Slug Testing
- Upcoming Tasks
  - Partition Coefficient (K_d) Study
  - Metal Speciation and Dose Modeling
  - Fate and Transport Modeling
  - Revised Environmental Radiation Monitoring (ERM) Standard Operating Procedure (SOP)
  - Environmental Report
  - Decommissioning Plan

Completed Tasks

Deer Tissue Sampling

- **Objectives:** Collect samples of deer tissue (kidney, liver, bone, muscle) and analyze (total uranium, ^{234}U, ^{235}U, ^{238}U) to evaluate potential human consumption exposure pathway
- **Summary of Work:** Sampled 10 deer each from DU Impact Area, Nearby Hunting Zone (NHZ), and Background Hunting Zone (BHZ) in November/December 2005 and February 2006
- **Documentation:** *Field Sampling Plan Addendum 1* (November 2005) and *Deer Tissue Sampling Results Report* (August 2006)
- **Conclusions:** (1) DU not detected in any of 132 samples; (2) no difference between total uranium levels or uranium isotopic ratios in DU Impact Area samples from samples taken either in the NHZ or BHZ; (3) no additional biological tissue sampling required



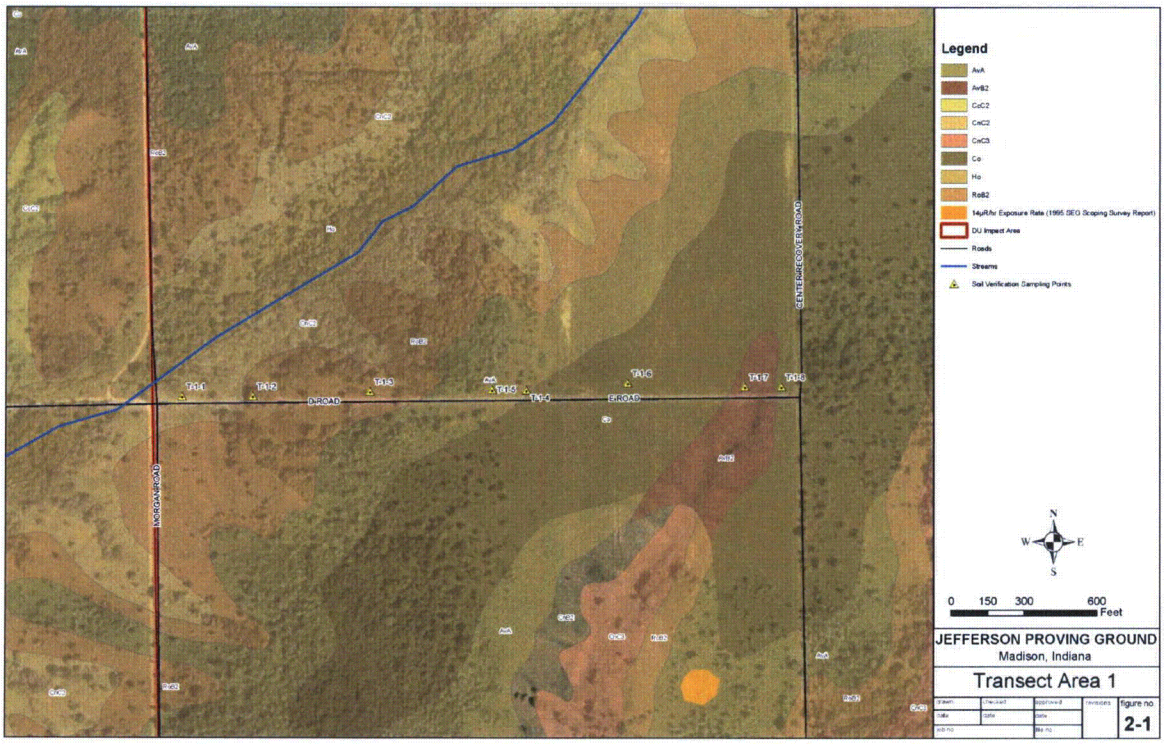
Source: USFWS 2001b

Deer Tissue Sampling Locations

Completed Tasks

Soil Verification

- **Objectives:** Determine if the published soil mapping can be used in the process of defining and completing future soil sampling efforts
- **Summary of Work:** Generated soil mapping units from Jefferson County Soil Survey Geographical Database; mapped soil series in DU Impact Area: Avonburg, Cincinnati, Cobbsfork, Grayford, Holton, Rossmoyne, Ryker; soil scientist observed and described the soil at 22 boring locations along 2 transects in August 2006
- **Documentation:** *Field Sampling Plan Addendum 2* (July 2006) and *Well Location Selection Report* (January 2007)
- **Conclusions:** (1) soil mapping units are reasonably accurate and sufficient for defining sampling efforts/sample locations; (2) mapped soil series can be grouped based on drainage classes/soil conditions; (3) samples for corrosion and Kd studies should be distributed with respect to the soil types



Soil series in the vicinity of Transect 1

Stream and Cave Spring Gauges

- **Objectives:** Collect surface water stage data and manual flow measurements to calculate surface water flows and estimate recharge to the aquifer at the JPG DU Impact Area
- **Summary of Work:** Installed 9 electronic recording gauges and 1 staff gauge in September 2006; collected continuous stage data from September 2006 through present; collected manual measurements of stream flow monthly for first year (September 2006 – August 2007); collected manual measurements during surface water/ sediment sampling; conducted additional quarterly monitoring until 2010; measured stream cross-section collected in February 2008; developed rating curves and hydrographs
- **Documentation:** *Field Sampling Plan Addendum 3* (July 2006), *Well Location Selection Report* (January 2007), and *Well Construction and Surface Water Data Report* (March 2008)
- **Conclusions:** (1) Conditions indicative of hydrologic system with unusually high surface water runoff and unusually low groundwater recharge; (2) preliminary water budget: 56% of annual onsite precipitation returns to atmosphere via evapotranspiration, 36% leaves site as runoff, and 8% infiltrates ground surface to become groundwater; (3) surface water in Big Creek appears to be the greatest avenue of potential DU migration from the DU Impact Area

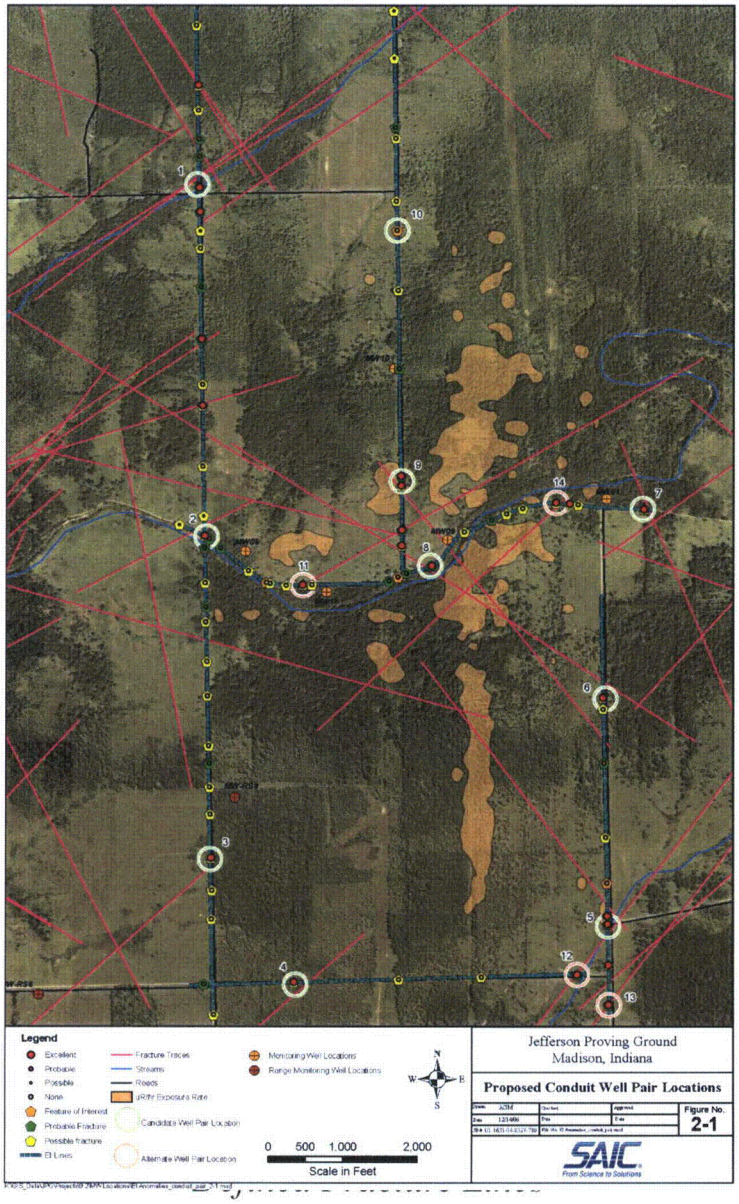
SGS-BC-01

CGS-BC-11

Completed Tasks

Fracture Trace Analysis

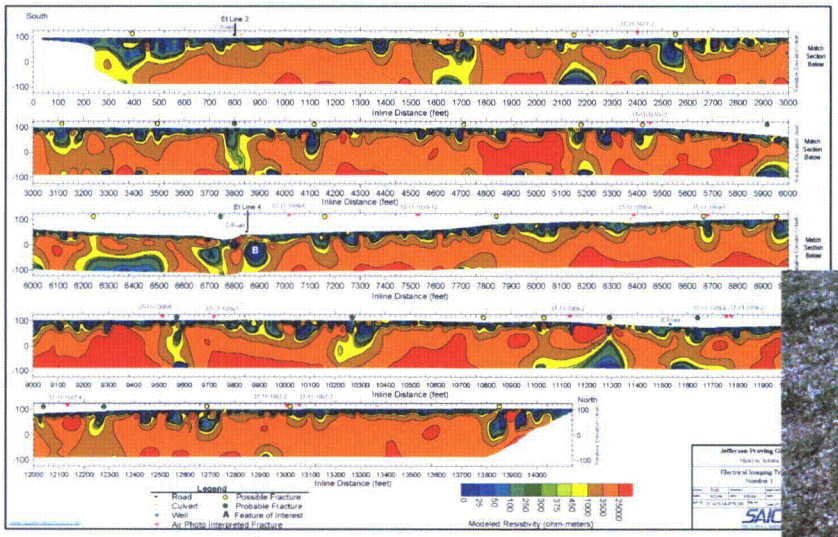
- **Objectives:** Identify and locate preferential groundwater flow pathways in fractures and solution enhanced features or "conduits" in carbonate limestone aquifer in the DU Impact Area
- **Summary of Work:** Obtained stereo-paired aerial photographs from U.S. National Archives and Records Administration (NARA) of site prior to construction of JPG and DU Impact Area (approximately 22 square miles); viewed photographs obliquely and in stereo at various magnifications; mapped and marked features on photographs and digitized into GIS; straight line segments were aligned with mapped fractures on photographs and field verified, grouped, and ranked in July 2006
- **Documentation:** *Well Location Selection Report* (January 2007)
- **Conclusions:** (1) 110 numbered fracture lines were identified; (2) distribution of fracture lines to be used with electrical imaging results to locate wells in zones most likely to transport groundwater

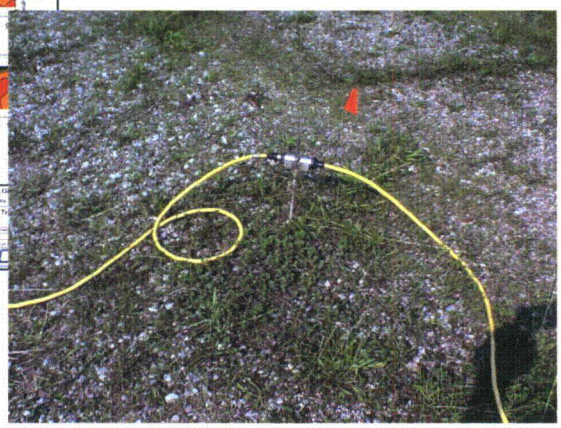


Completed Tasks

EI Survey

- **Objectives:** Refine locations of potential preferred groundwater flow pathways, further characterize the subsurface features, and assist in the selection of proposed monitoring well pair locations and refinement of the conceptual site model
- **Summary of Work:** Collected and analyzed 42,277 feet of data with 78 anomalies identified in July/August 2006; evaluated and indicated anomalies as "possible" or "probable" fractures or features of interest (e.g., potential sediment-filled void, caves)
- **Documentation:** *Field Sampling Plan Addendum 3* (July 2006) and *Well Location Selection Report* (January 2007)
- **Conclusions:** (1) Selected 13 "fracture" or "conduit" and 1 deep overburden locations of well pairs; (2) selected 9 locations for well pairs that provides coverage across DU Impact Area; (3) provided four alternate locations if access was restricted for any of first 9; (4) developed tenth location with a greater than average depth to bedrock

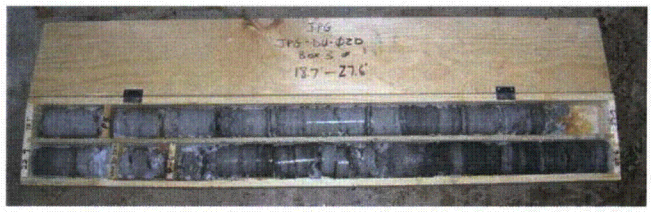




Electrode Used in Electrical Imaging Survey

Completed Tasks

Groundwater Well Installation



Fractured/weathered zones are most prevalent in the top 50 feet

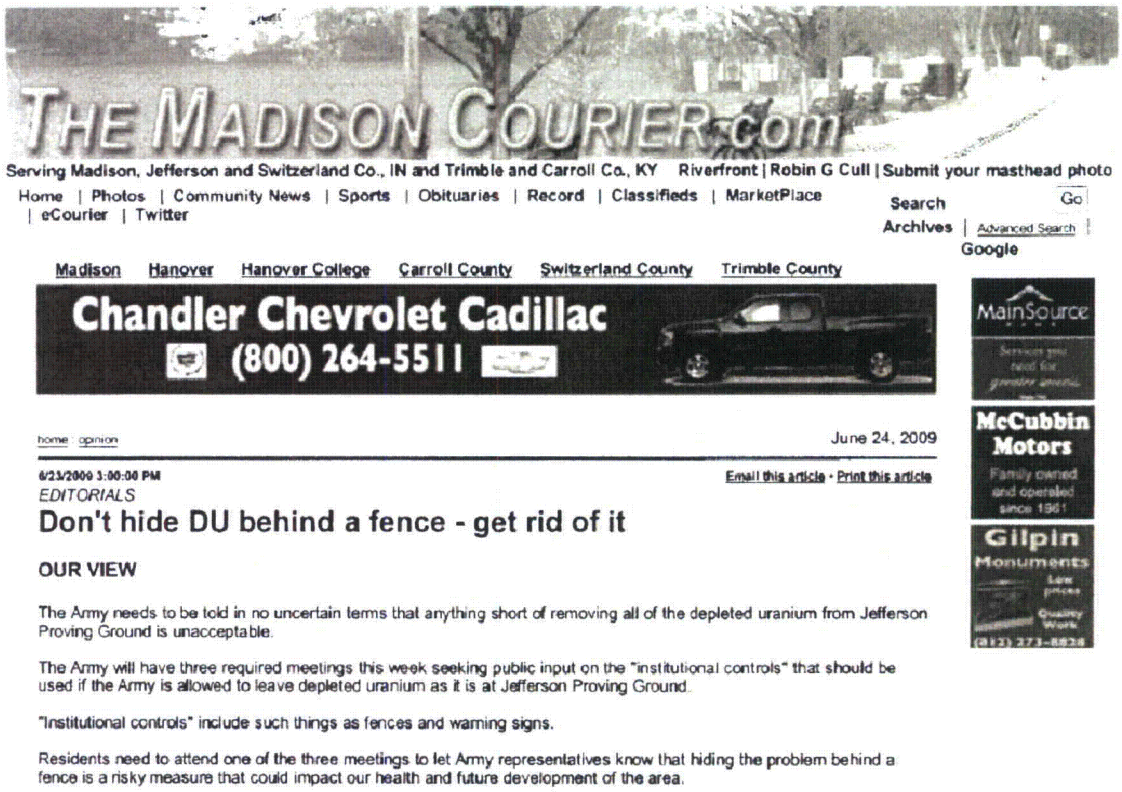
Permeability of deeper aquifer is expected to be extremely low based on lack of fracturing and weathering

- **Objectives:** Expand limited understanding of hydrogeologic system, particularly bedrock, north of JPG firing line: 19 existing groundwater wells, nearly half of existing wells installed in overburden, average depth ~28 feet below ground surface (BGS), deepest ~54 feet BGS, shallowest ~12.5 feet BGS, most have low yields
- **Summary of Work:** Installed 22 wells in May/June and November/December 2007: 19 bedrock wells; 3 overburden wells; average "shallow" bedrock well depth ~ 41 feet BGS; average "deep" bedrock well depth ~106 feet BGS; deepest ~136 feet BGS; shallowest ~29 feet BGS
- **Documentation:** Well Location Selection Report (January 2007 and Well Construction and Surface Water Data Report (March 2008)
- **Conclusions:** (1) Fractured/weathered zones are most prevalent within the top 50 feet of bedrock, (2) based on observation of limited fracturing, limited weathering, and limited karst features, the permeability of the shallow bedrock aquifer is expected to be moderate to low, (3) permeability of the deeper portion of the bedrock aquifer is expected to be very low

Completed Tasks

Public Meetings

- **Objectives:** Seek public input in accordance with requirements specified in 10 Code of Federal Regulations 20.1403(d) for the Army's intent to decommission the Radioactive Materials License SUB-1435 by restricting use of the site
- **Summary of Work:** Held meetings on 28, 29, and 30 October 2008 in Madison (3 attendees), Versailles (0 attendees), and North Vernon (2 attendees), respectively, and on 23, 24, and 25 June 2009 in North Vernon (4 attendees), Versailles (6 attendees), and Madison (23 attendees), respectively
- **Documentation:** Meeting transcripts to be provided with Decommissioning Plan and newspaper articles/editorial
- **Conclusions:** (1) Army fulfilled requirement for seeking public input, (2) most comments not related to institutional controls, (3) no additional meetings are planned



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June 24, 2009

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EDITORIALS

Don't hide DU behind a fence - get rid of it

OUR VIEW

The Army needs to be told in no uncertain terms that anything short of removing all of the depleted uranium from Jefferson Proving Ground is unacceptable.

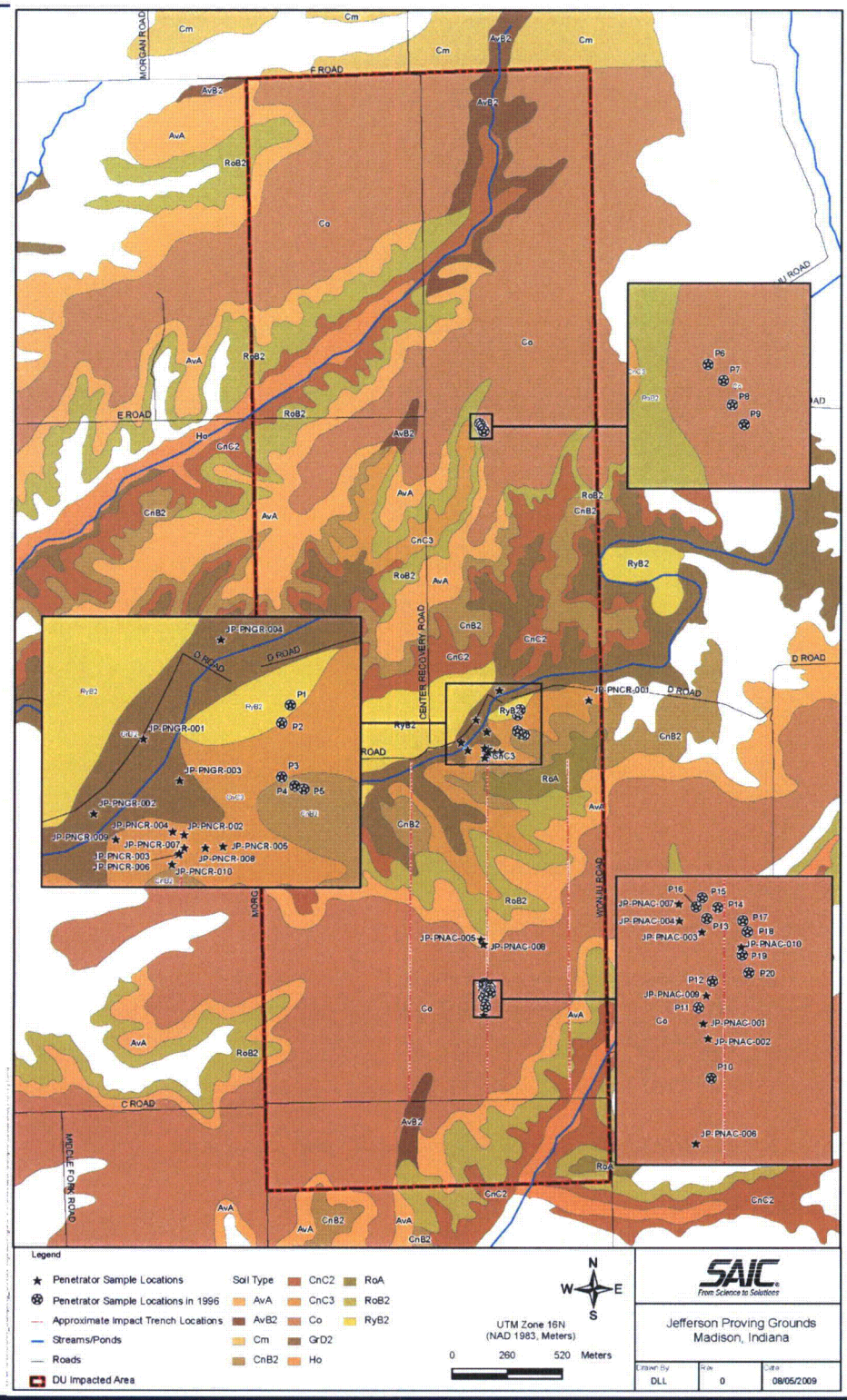
The Army will have three required meetings this week seeking public input on the "institutional controls" that should be used if the Army is allowed to leave depleted uranium as it is at Jefferson Proving Ground.

"Institutional controls" include such things as fences and warning signs.

Residents need to attend one of the three meetings to let Army representatives know that hiding the problem behind a fence is a risky measure that could impact our health and future development of the area.

Ongoing Tasks

Penetrator Collection Locations



20 Penetrators Collected in 1996 and
24 Penetrators Collected in October 2008

DU Penetrator Corrosion Study

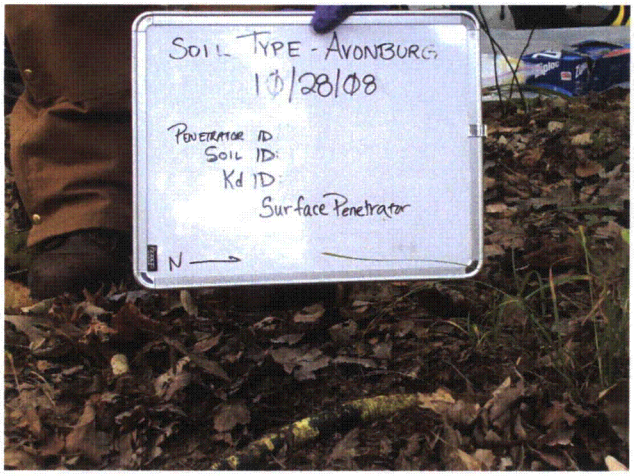
Soil Type	Penetrators
Avonsburg/ Cobbsfork	■ 10 Penetrators collected (JP-PAC-001 to JP-PAC-010) ■ 5 penetrators collected from ground surface (JP-PAC-001, JP-PAC-002, JP-PAC-003, JP-PAC-004, and JP-PAC-005) ■ 5 penetrators collected from subsurface (JP-PAC-006 from 1 to 2" BLS, JP-PAC-007 from 2 to 4" BLS, JP-PAC-008 from 2 to 3" BLS, JP-PAC-009 from 2 to 4" BLS, and JP-PAC-010 at 2" BLS)
Cincinnati/ Rossmoyne	■ 10 Penetrators collected (JP-PCR-001 to JP-PCR-010) ■ 7 penetrators collected from ground surface (JP-PCR-001, JP-PCR-002, JP-PCR-003, JP-PCR-004, JP-PCR-005, JP-PCR-009, and JP-PCR-010) ■ 3 penetrators collected from subsurface (JP-PCR-006 from 0 to 2" BLS, JP-PCR-007 from 0 to 3" BLS, and JP-PCR-008 from 0 to 3" BLS)
Grayford/ Ryker	■ 4 Penetrators collected (JP-PGR-001 to JP-PGR-004) ■ 4 penetrators collected from ground surface (JP-PGR-001, JP-PGR-002, and JP-PGR-003) ■ 1 penetrator collected from subsurface (JP-PGR-004 from 4 to 6" BLS)

24 Penetrators Collected from 3 Soil-type Groups

Ongoing Tasks

Penetrator Collection and Preparation for Testing

Avonsburg/Cobbsfork (JP-PAC-005) – Recommended for Leachability Test



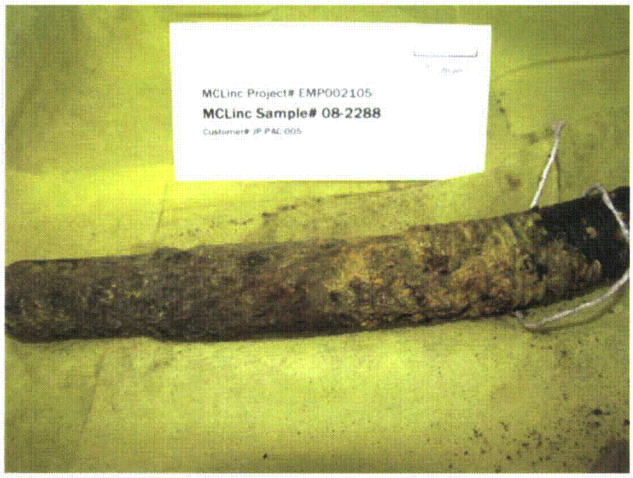
Prior to collection

Packaged for shipment

As received (wide-angle)

As received (tight-angle)

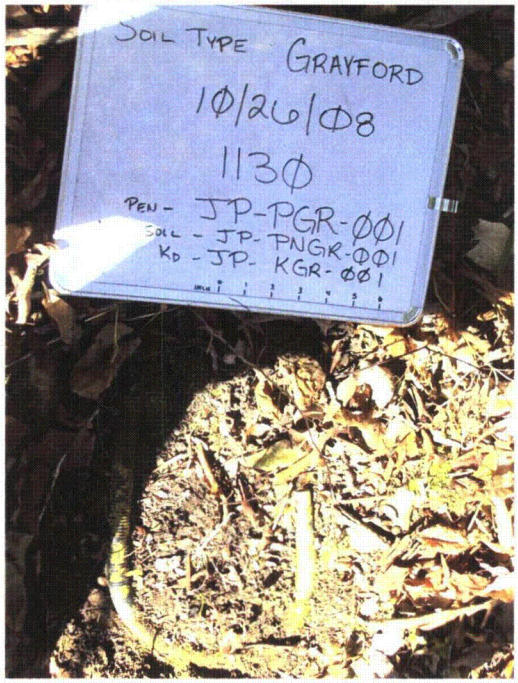
Before scraping



After scraping

Ongoing Tasks

Penetrator Collection (continued)



JP-PGR-001

JP-PCR-008

Penetrator in Tree

Penetrator Stickup

DU Penetrator Corrosion Study

Test Objective	Preliminary Findings
X-Ray Diffraction (XRD)	
Determine the crystalline phases present	■ Major phases determined by dominant peaks, trace phases are just recognizable, and minor phases are recognizable but not dominant ■ Major uranium phase – hydrated uranyl trioxide ($UO_3 \cdot 2H_2O$), minor phase – uranyl dioxide (UO_2), metallic uranium and hydrated uranyl peroxide ($UO_4 \cdot 2H_2O$) also detected ■ Several samples contain several trace-sized and minor-sized peaks unassigned to a phase/not uranium-bearing
Scanning Electron Microscopy with Associated Energy Dispersive X-ray Spectroscopy (SEM-EDS)	
Collect the bulk chemistry to aid in the determination of the phases present	■ Major elements in each sample are uranium (U) and oxygen (O) ■ Silicon (Si) also present in samples as major or minor component ■ Minor and trace elements also present: aluminum (Al), magnesium (Mg), calcium (Ca), titanium (Ti), and iron (Fe)
X-ray Photoelectron Spectroscopy (XPS)	
Examine uranium speciation/phase	■ Each sample contained mixture of uranium in the U^{+6} and U^{+4} oxidation states with good matches to mixture of UO_3 and UO_2 ■ No uranium metal was detected ■ Small shoulder on some samples could be assignable to UO_4

- Summary and Preliminary Conclusions
  - 24 Penetrators analyzed using XRD, SEM-EDS, and XPS
  - UO_2 (uranium dioxide, uraninite) is a black to steely black crystalline powder with tints of brown and is insoluble in water (CRC 1984)
  - UO_3 (uranyl trioxide or uranyl oxide) is a yellow-orange powder and insoluble in water (CRC 1984)
  - $U0_4 \cdot 2H_2O$ (uranioum peroxide) is composed of pale yellow crystals and partially soluble in water (6×10^{-4} g/mL in cold water and 8×10^{-3} g/mL in hot water)
  - UO_2^{+2} ions fluoresce under ultraviolet light

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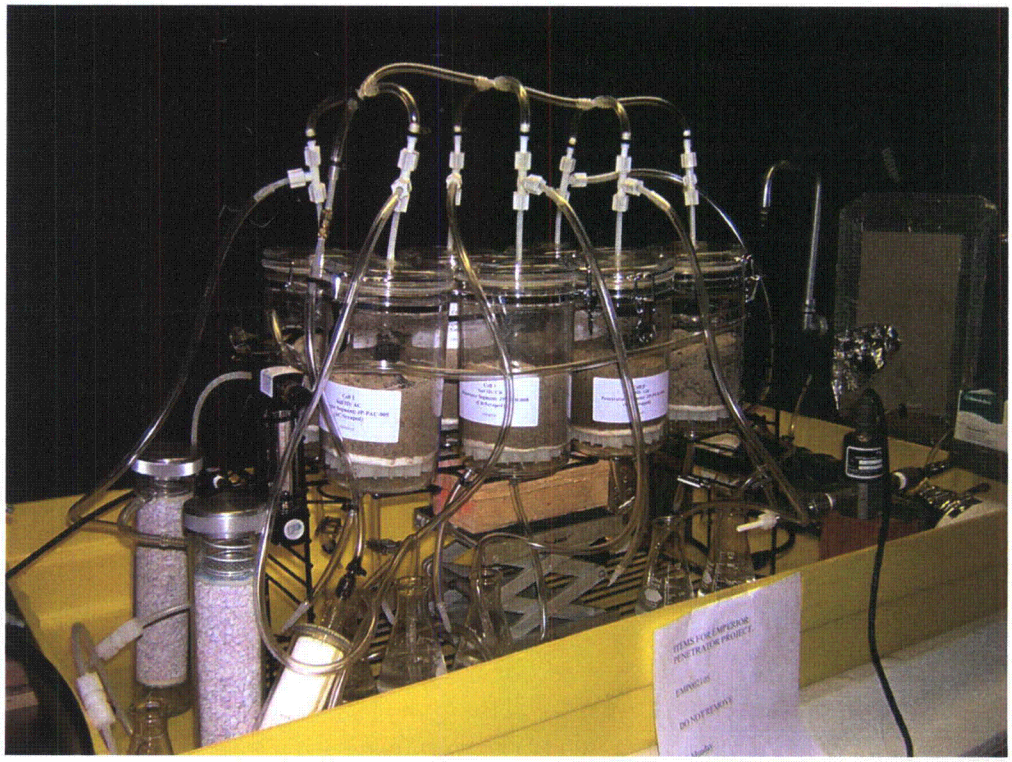
Ongoing Tasks

DU Penetrator Corrosion Study

Accelerated Weathering of Selected Penetrators

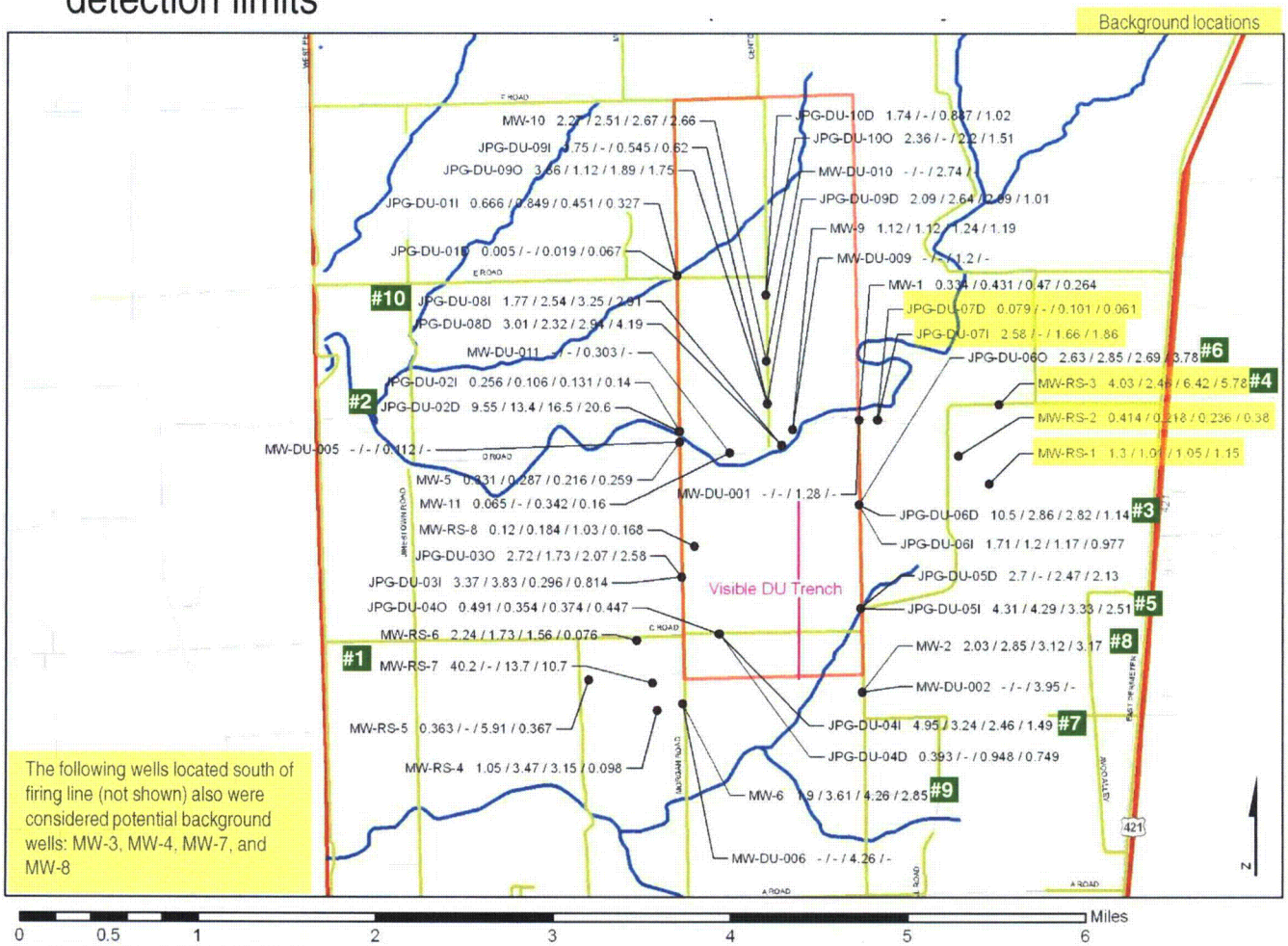
- Accelerated Weathering of Selected Penetrators
  - Modified ASTM D5744-96 method (replaced by D 5744-07)
  - Three segments with site-formed corrosion rinds and three segments from which the surface rinds have been removed
  - At least 10 cycles of environmentally simulated meteorological conditions (flood, drain, dry air, wet air) lasting 3 weeks each in constructed weathering cells/apparatuses
  - After weathering, induced corrosion growth will be characterized and compared to the as-received corrosion rind
  - Rain/flood water leachate will be analyzed for total and isotopic uranium (^{234}U, ^{235}U, and ^{238}U)
  - Results include time-related data that can be compared with observed effects and allow prediction of dissolution rates for penetrators in various corrosion states
  - Used with estimated number of penetrators to assess long-term threat of DU infiltration into groundwater



Weathering Apparatus During a Dry Cycle
(Courtesy MCLinc)

Quarterly Groundwater Sampling

- Collected 328 groundwater samples from 42 wells in April 2008, July 2008, October 2008, and February 2009
- Samples could not be taken from some locations since wells were dry when sampling took place
- Analyzed using alpha spectrometry (ASTM D3972 90M) for lower detection limits



	Unfiltered	Filtered
n	160	168
Min	0.028	0.032
Max	47.1	40.2
Average	2.19	2.03
Std. Dev.	4.42	4.00

Groundwater Action Level for ERM Samples: If ≥ 150 pCi/L, resample. If activity verified, notify NRC and assess results. The findings and recommended corrective actions will be documented for the Army's Radiation Control Committee. The Committee will provide recommendations to the Commander based on its evaluation. If < 150 pCi/L, no corrective action.

Quarterly Groundwater Sampling (cont'd)

- Nomenclature
  - ERM wells = MW-x or MW-DU-xxx
  - Site characterization – overburden wells: JPG-DU-xxO
  - Site characterization – intermediate wells (shallow bedrock): JPG-DU-xxI
  - Site characterization – deep (bedrock) wells: JPG-DU-xxD
  - Range Study wells = MW-RS-x

Overburden		Shallow Bedrock Zone		Deep Bedrock Zone [b]	
Potential Background Wells					
▪ MW-RS1 ▪ MW-RS3		▪ JPG-DU-07I ▪ MW-3 ▪ MW-4	▪ MW-7 ▪ MW-8 ▪ MW-RS2	▪ JPG-DU-07D	
Potential Site Wells					
▪ JPG-DU-03O ▪ JPG-DU-04O ▪ JPG-DU-06O ▪ JPG-DU-09O ▪ JPG-DU-10O ▪ MW-6 ▪ MW-10	▪ MW-RS4 ▪ MW-RS5 ▪ MW-RS6 ▪ MW-RS7 ▪ MW-RS8	▪ JPG-DU-01I ▪ JPG-DU-02I ▪ JPG-DU-03I ▪ JPG-DU-04I ▪ JPG-DU-05I ▪ JPG-DU-06I ▪ JPG-DU-08I	▪ JPG-DU-09I ▪ JPG-DU-10D ▪ MW-1[a] ▪ MW-2 ▪ MW-5 ▪ MW-9 ▪ MW-11	▪ JPG-DU-01D ▪ JPG-DU-02D ▪ JPG-DU-04D ▪ JPG-DU-05D ▪ JPG-DU-06D ▪ JPG-DU-08D ▪ JPG-DU-09D	

[a] Well MW-1 has two separate screen intervals in the limestone and will require additional consideration following additional data collection to determine if the water levels are usable.

[b] None of the existing wells was installed in the Deep Zone.

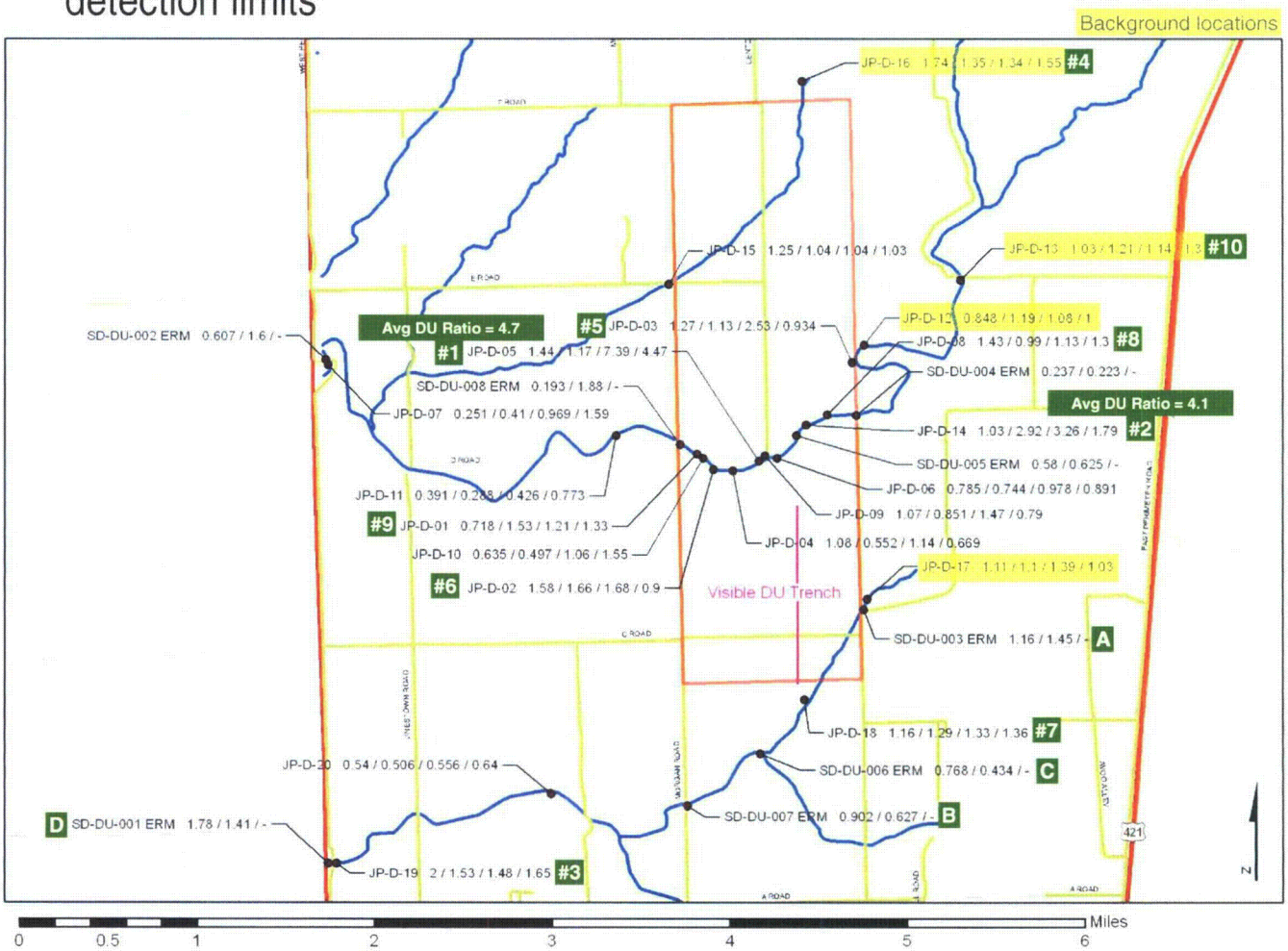
Preliminary Evaluation of Groundwater Sample Results

- Statistical Testing
  - No difference between site and background concentrations
  - No concentration trend observed between quarterly sampling events
  - Site characterization vs. ERM
    - Well JPG-DU-02D is outlier – if removed, Site characterization concentrations = ERM concentrations
    - Well JPG-DU-02D is outlier – if NOT removed
      - Site characterization concentrations >> ERM concentrations (untransformed)
      - Site characterization background concentrations > ERM background concentrations (untransformed)
      - Site characterization concentrations = ERM concentrations (log-transformed)
- Conclusions
  - Although wells were installed on roads around and within DU Impact Area due to explosive safety hazards from UXO, the closest off-post boundary is greater than 2 miles in any direction
  - Wells installed in locations with highest potential for identifying DU
  - All concentrations low with respect to potential radiological doses when groundwater used as drinking water source (e.g., 30 pCi/L Safe Drinking Water Act Maximum Contaminant Level)
  - Low yield of aquifer under site renders groundwater less desirable as a drinking water source
  - No evidence of DU – all $^{238}U/^{234}U$ ratios ≤ 2
  - Most concentration trends in ERM events over time are not discernible (poor linear correlation – $r^2 < 0.5$) because results fluctuate just above detection limits
  - For the few concentration trends that are discernible ($r^2 > 0.5$), the trends are decreasing in concentration over time
  - Additional information for site characterization to include anion/cation evaluation and groundwater age dating results

Ongoing Tasks

Quarterly Sediment Sampling

- Collected 80 sediment samples from 20 locations in April 2008, July 2008, October 2008, and February 2009
- Samples taken from same locations even if location was dry when sampling occurred
- Analyzed using alpha spectrometry (ASTM D3972 90M) for lower detection limits



	Site Char.	ERM
n	80	160
Min	0.251	0.193
Max	7.39	2.801
Average	1.28	0.99
Std. Dev.	0.94	0.56

Sediment Action Level for ERM Samples: If ≥ 35 pCi/g, collect five additional samples in a 1-meter grid. If average activity exceeds 35 pCi/g, decontaminate to 35 pCi/g. If < 35 pCi/g, no corrective action.

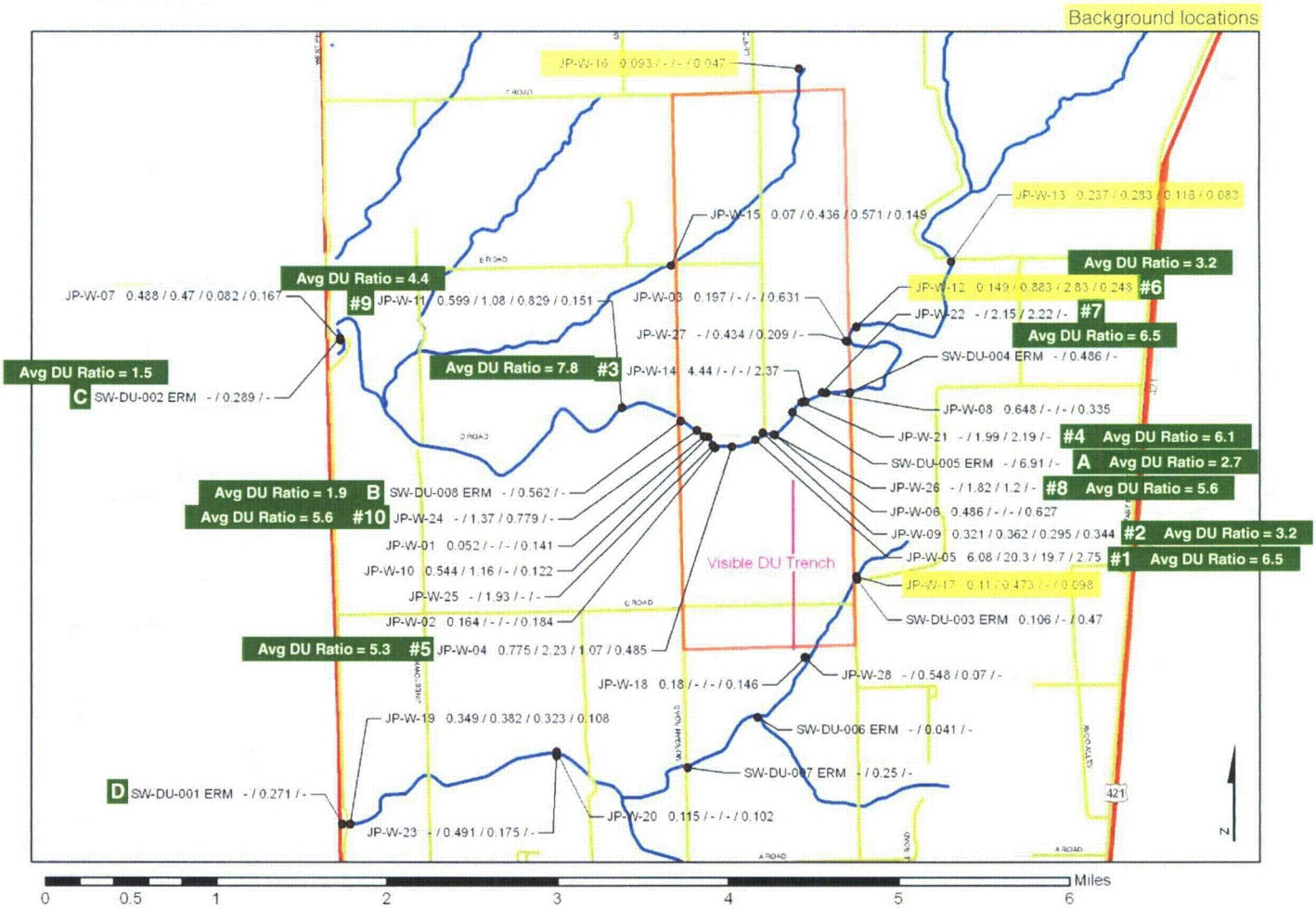
Preliminary Evaluation of Sediment Sample Results

- Nomenclature
  - ERM = SD-DU-xxx (8 locations)
  - Site characterization: JPG-D-xx (20 locations)
- Background (4 locations)
  - ERM: none
  - Site Characterization (4 locations): JP-D-12, JP-D-13, JP-D-16, and JP-D-17
- Statistical Testing
  - Site concentrations significantly lower than background at a statistically significant level ($p < 0.05$)
  - No concentration trend observed between quarterly sampling events
- Conclusion
  - Samples collected upgradient of site, downgradient of highest potential DU sources, and downgradient of site
  - All concentrations low with respect to potential radiological dose (14 pCi/g is the concentration which, based on conservative assumptions, equates to 25 mrem per year)
  - Highest concentrations where runoff expected to enter Big Creek from DU trench
  - Some evidence of DU in JP-D-05 and JP-D-14 (based on elevated $^{238}U/^{234}U$ ratios)
  - All other $^{238}U/^{234}U$ ratios ≤ 2
  - Most concentration trends in ERM events over time are not discernible (poor linear correlation – $r^2 < 0.5$) because results fluctuate just above detection limits

Ongoing Tasks

Quarterly Surface Water Sampling

- Collected 80 surface water samples from 20 locations in April 2008, July 2008, October 2008, and February 2009
- Samples from 7 locations moved since dry when sampling occurred
- Analyzed using alpha spectrometry (ASTM D3972 90M) for lower detection limits



	Unfiltered	Filtered	ERM
n	75	75	77
Min	0.031	0.047	0
Max	63.8	20.3	6.91
Average	2.17	1.29	0.50
Std. Dev.	7.94	3.29	0.46

Surface Water Action Level for ERM Samples: If ≥ 150 pCi/L, resample. If activity verified, notify NRC and assess results. The findings and recommended corrective actions will be documented for the Army's Radiation Control Committee. The Committee will provide recommendations to the Commander based on its evaluation. If < 150 pCi/L, no corrective action.

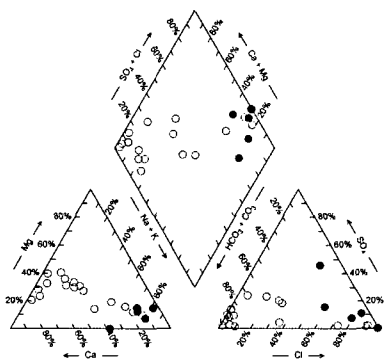
Preliminary Evaluation of Surface Water Sample Results

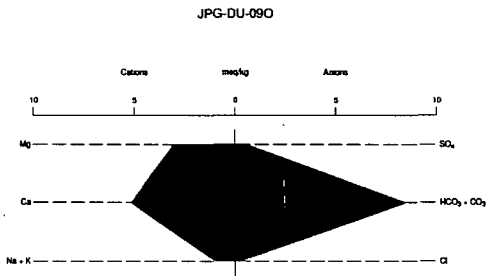
- Nomenclature
  - ERM = SW-DU-xxx
  - Site characterization: JPG-W-xx
- Background (4 locations)
  - ERM: none
  - Site Characterization (4 locations): JP-W-12, JP-W-13, JP-W-16, and JP-W-17
- Statistical Testing
  - Site almost significantly higher than background
  - Trend observed: July/October > April/February (higher concentrations during low-flow periods)
- Conclusion
  - Samples collected upgradient of site, downgradient of highest potential DU sources, and downgradient of site
  - All concentrations low with respect to potential radiological doses when surface water is used as drinking water source (e.g., 30 pCi/L Safe Drinking Water Act Maximum Contaminant Level)
  - Low flow through site and regional agricultural impacts on surface water quality renders surface water less desirable as a drinking water source
  - Highest concentrations where runoff expected to enter Big Creek from DU trench
  - Some evidence of DU in 12 samples (based on $^{238}U/^{234}U$ ratios)
  - All other $^{238}U/^{234}U$ ratios ≤ 2
  - Most concentration trends in ERM events over time are not discernible (poor linear correlation – $r^2 < 0.5$) because results fluctuate just above detection limits
  - Additional information for site characterization includes the anion/cation evaluation

Evaluation of Anions and Cations

- All surface water, cave/seep, and groundwater samples analyzed for major dissolved species were evaluated:
  - Cations – potassium, sodium, calcium, and magnesium
  - Anions – chloride, alkalinity, and sulfate
- Evaluate the geochemical signature of samples from each of the hydrostratigraphic zones
- Evaluate similarities of geochemical signatures between samples in the same hydrostratigraphic zone as well as similarities between samples from different zones
- Aid in the evaluation of the connectivity of the monitored locations based on the mineral saturation
- Aq•QA® software by RockWare, Inc. is being used for the analysis
  - Initially two separate graphic evaluations are being completed and as the evaluation continues additional graphic evaluations will be made and considered
    - Stiff diagrams – graphically shows ion concentrations plotted as percentages with each point representing a chemical analysis to identify geologic units with chemically similar water and define the evolution in water chemistry along the flow path
    - Piper diagrams – polygonal shapes created on four parallel horizontal axes extending on either side of a vertical zero axis to visualize ionically related waters from which a flow path can be determined or, if the flow path is known, to show how the ionic composition of a water body changes over space and/or time
  - The calcite mineral saturation indexes and hydrogeochemical facies are also being determined and evaluated

Deep and Shallow Bedrock Wells





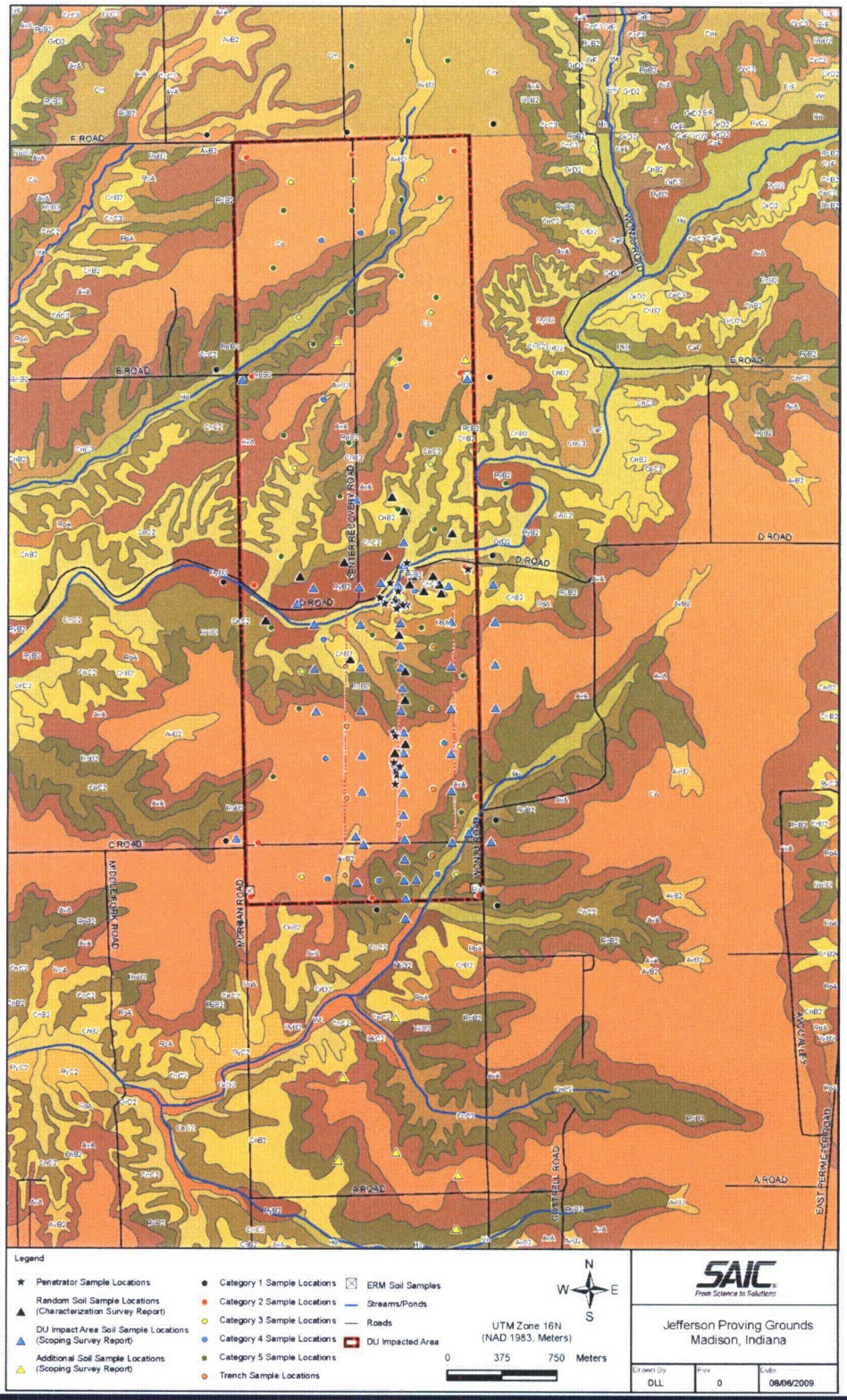
Soil Sampling

- Collected 596 soil samples from 140 locations in October 2008
- Analyzed using alpha spectrometry (ASTM D3972 90M) for lower detection limits and re-analyzed 136 samples with gamma spectrometry
- Sampling depths:
  - Background; Categories 1, 2, and 5; and, Under Penetrators – 0 to 0.5, 0.5 to 1, 1 to 2, and 2 to 4 feet BLS
  - Categories 3, 4, and 6 – 0 to 0.5, 0.5 to 1, 1 to 2, 2 to 4, and 4 to 6 feet BLS
  - Hand auger refusal (roots, stones, etc.) limited depths at some locations

Soil Sample Grouping	Number of Sampling Locations	Overall Results Across All Sampling Depths			
		Number of Samples	Minimum Detect (pCi/g)	Maximum Detect (pCi/g)	Average Detect (pCi/g)
Background – Avonsburg and Cobbsfork	8	36	1.25	1.84	1.53
Background – Cincinnati and Rossmoyne	8	36	1.03	2.13	1.66
Background – Grayford and Ryker	8	33	1.15	3.76	1.79
Category 1 – Outside DU Impact Area Perimeter	12	45	1.25	2.10	1.60
Category 2 – Immediately Inside DU Impact Area	12	48	0.998	2.30	1.62
Category 3 – Midway to DU Impact Area Trenches	12	58	1.16	19.1	1.87
Category 4 – Immediately Outside DU Impact Area Trenches	12	58	1.03	2.10	1.54
Category 5 – Other Nature and Extent Samples	32	127	0.711	2.58	1.56
Category 6 – Trench Locations	12	59	-3.250	142	8.88
Soil Under Penetrators – Avonsburg and Cobbsfork	10	45	15.4	40,694	6,718
Soil Under Penetrators – Cincinnati and Rossmoyne	10	36	85.0	27,497	4,084
Soil Under Penetrators – Grayford and Ryker	4	15	71.6	12,491	2,880
Total	140	596	-3.25	40,694	377

Ongoing Tasks

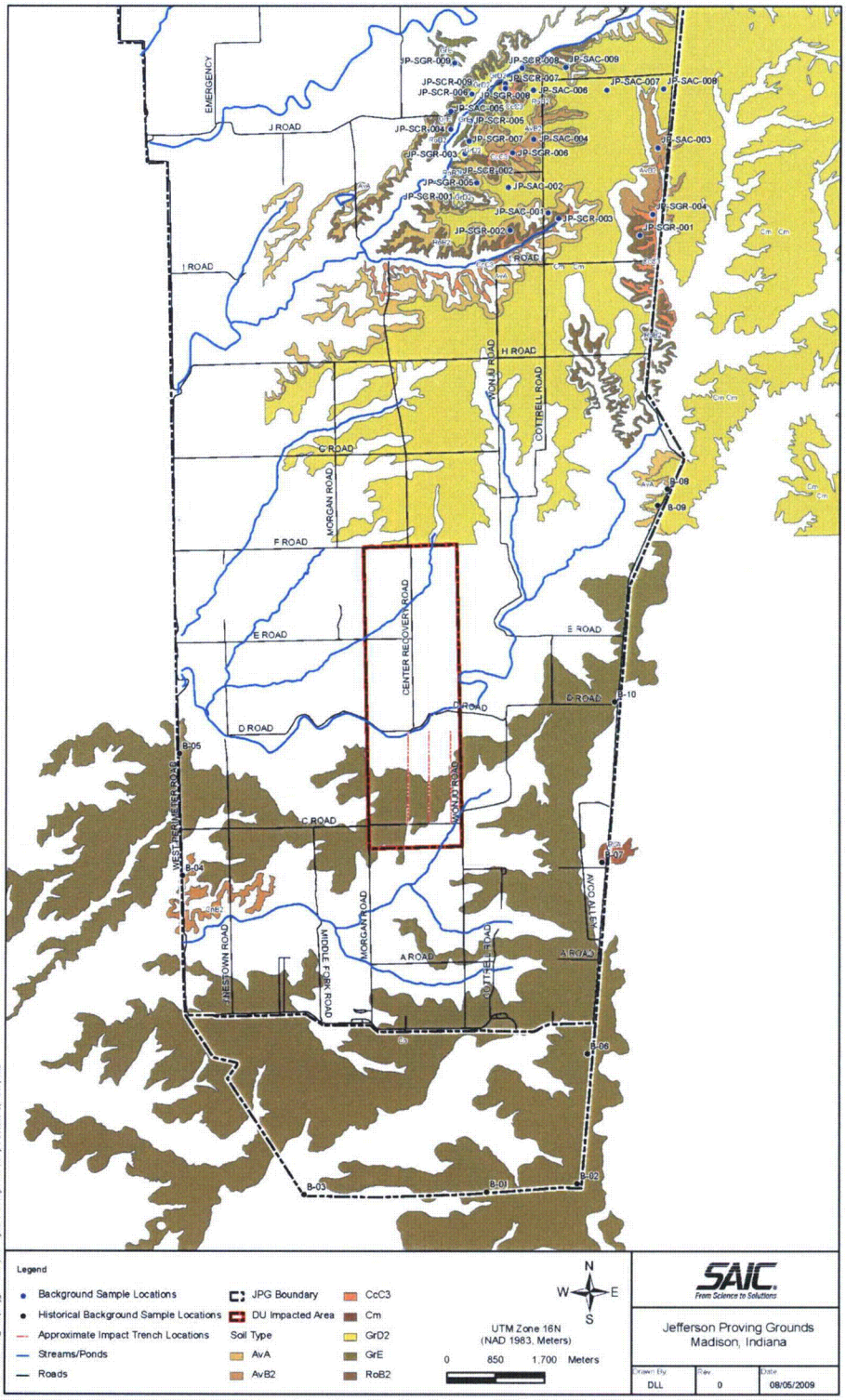
Soil Sampling Locations



596 soil samples from 140 locations in October 2008

Ongoing Tasks

Background Soil Sampling Locations



105 Samples Collected from 24 Background Locations in October 2008

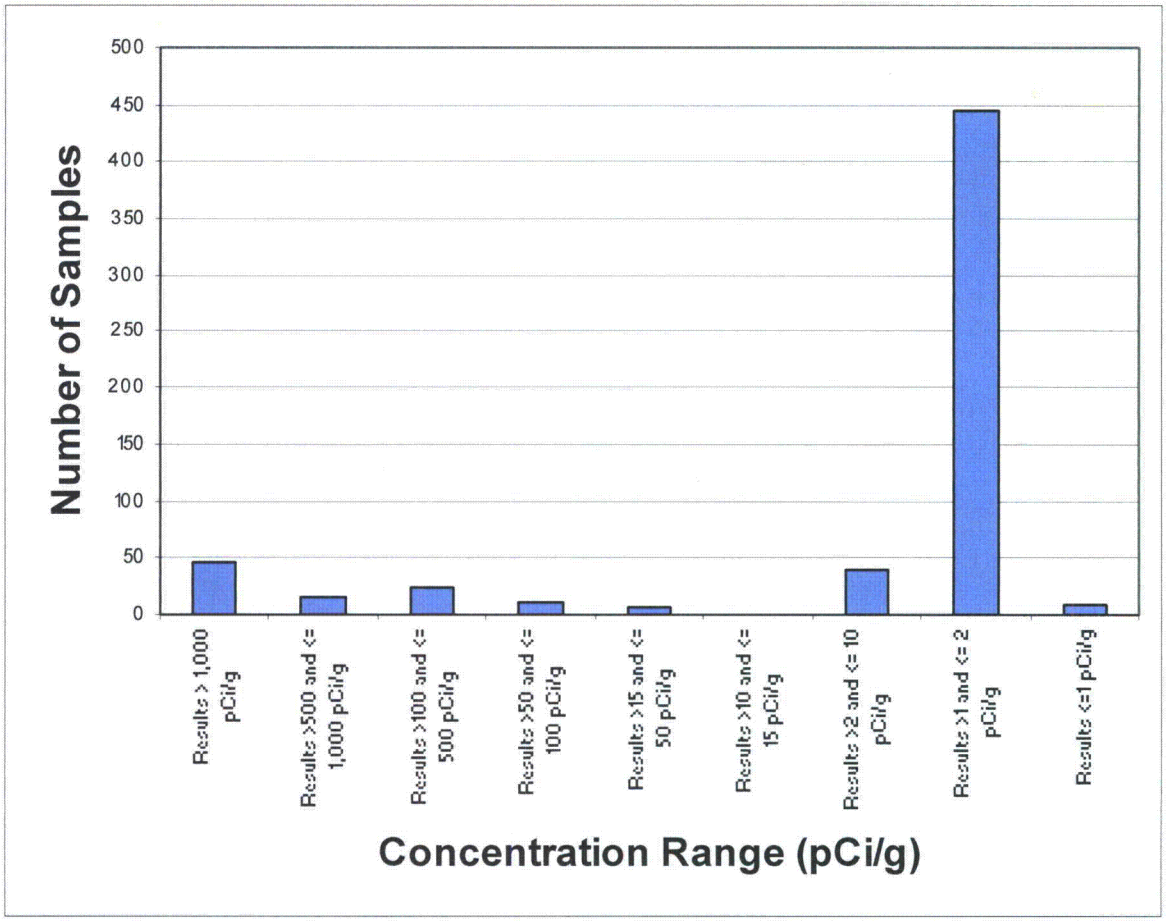
Corrected. 08/27/09

Ongoing Tasks

Soil Sampling

Summary of Ranges of Total Uranium Concentrations

Category	Number of Samples
Results > 1,000 pCi/g	46
Results >500 and <= 1,000 pCi/g	15
Results >100 and <= 500 pCi/g	25
Results >50 and <= 100 pCi/g	10
Results >15 and <= 50 pCi/g	7
Results >10 and <= 15 pCi/g	1
Results >2 and <= 10 pCi/g	39
Results >1 and <= 2 pCi/g	445
Total Number of Samples	**596**



76% of Total Uranium Concentrations ≤ 2 pCi/g

Ongoing Tasks

Soil Sampling

Summary of Ranges of Total Uranium Concentrations

Category	Number of Samples
Results > 1,000 pCi/g	46
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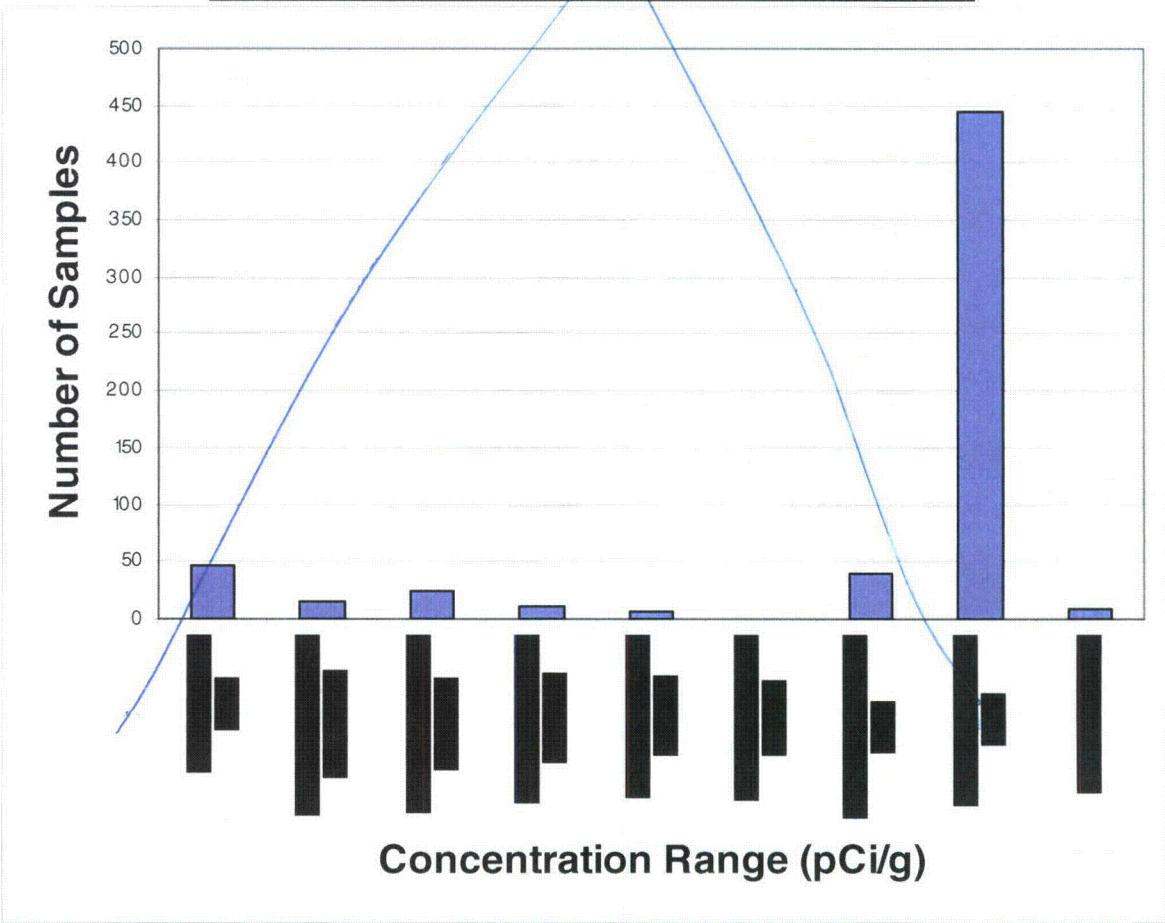
Results >2 and <= 10 pCi/g	39
Results >1 and <= 2 pCi/g	445
Total Number of Samples	**596**



76% of Total Uranium Concentrations ≤ 2 pCi/g

Ongoing Tasks

Soil Sampling Summary

Total Uranium Concentrations Under Penetrators Across Sampling Depths

Under Penetrators – 1996 Characterization

Overall	n = 73
0 to 0.5' BLS	n = 20 Min = 2.9+/-0.6 pCi/g Max = 12,318+/-185 pCi/g Mean = 2,881 pCi/g
0.5 to 1.0' BLS	n = 20 Min = 1.5+/-0.4 pCi/g Max = 547+/-17.7 pCi/g Mean = 79.5 pCi/g
1.0 to 1.5' BLS	n = 20 Min = 1.8+/-0.4 pCi/g Max = 63+/-5 pCi/g Mean = 13.5 pCi/g
1.5 to 2.0' BLS	n = 13 Min = 1.4+/-0.2 pCi/g Max = 11.5+/-0.7 pCi/g Mean = 4.55 pCi/g

36X reduction

6X reduction

3X reduction

Under Penetrators – 2008 Characterization

Overall	n = 96
0 to 0.75' BLS	n = 30 Min = 460+/-43 pCi/g Max = 40,694+/-250 pCi/g Mean = 13,750 pCi/g
0.5 to 1.25' BLS	n = 20 Min = 165+/-5.20 pCi/g Max = 10,858+/-111 pCi/g Mean = 1,988 pCi/g
1.0 to 2.5' BLS	n = 25 Min = 15.4+/-3.1 pCi/g Max = 2,030+/-55.1 pCi/g Mean = 529 pCi/g
2.0 to 4.5' BLS	n = 16 Min = 15.5+/-6.75 pCi/g Max = 670+/-24.8 pCi/g Mean = 233 pCi/g

7X reduction

4X reduction

2X reduction

Additional uranium transport in 12 years between sampling

Ongoing Tasks

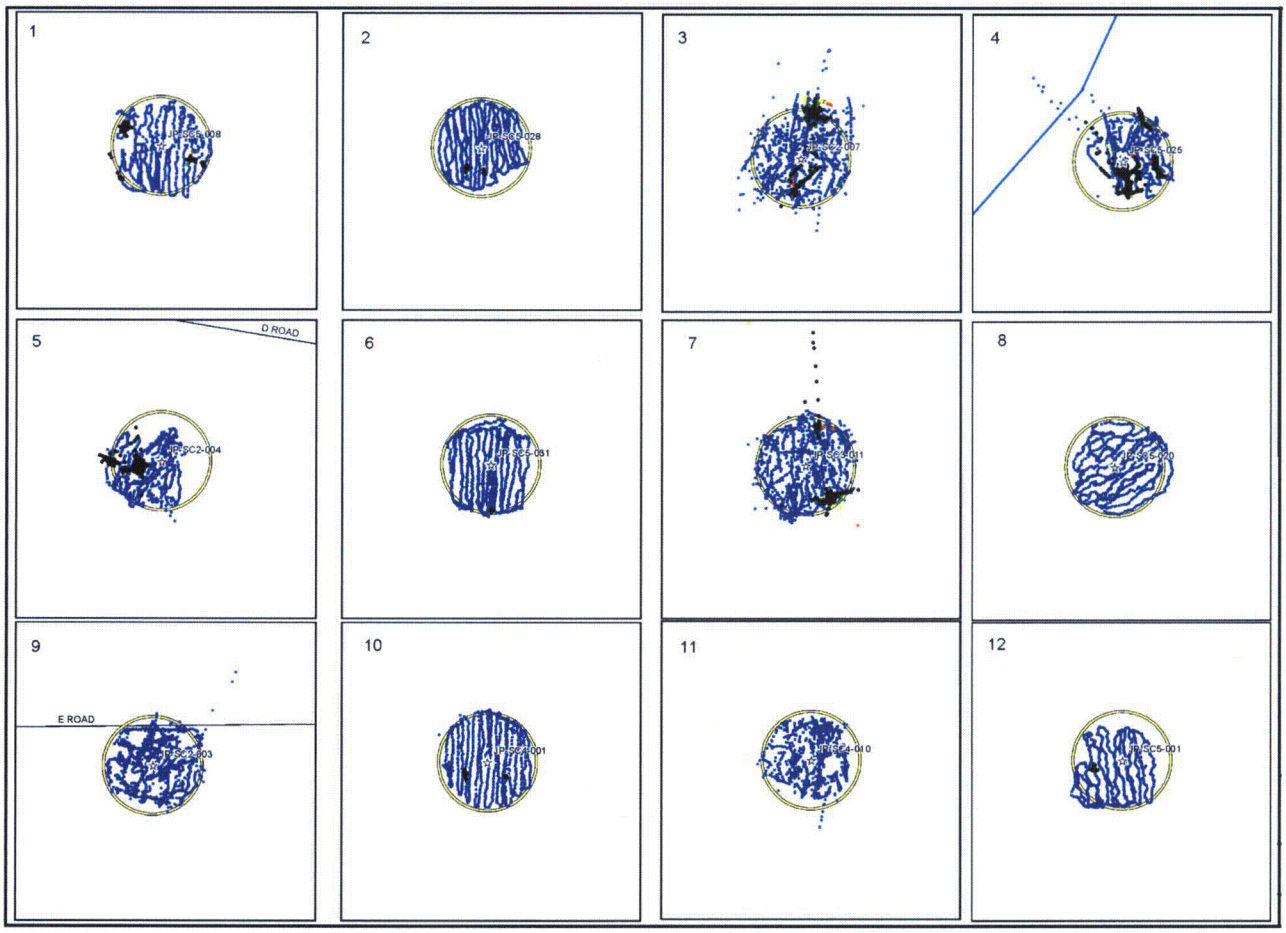
Gamma Walkover Survey

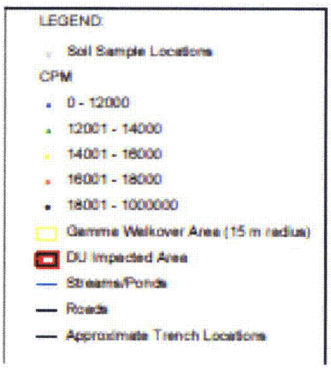
Firing Lines and Nearby Zone

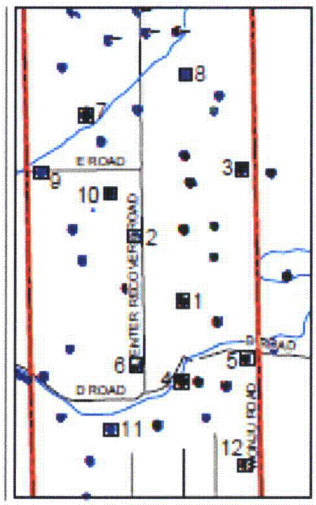
Ongoing Tasks

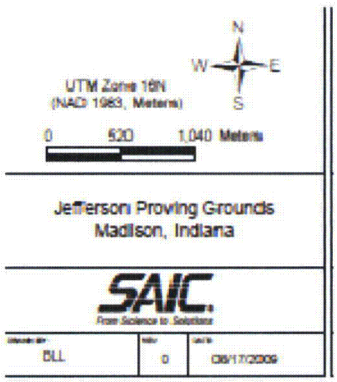
Gamma Walkover Survey

Various Sampling Locations









Preliminary Evaluation of Soil Sample Results

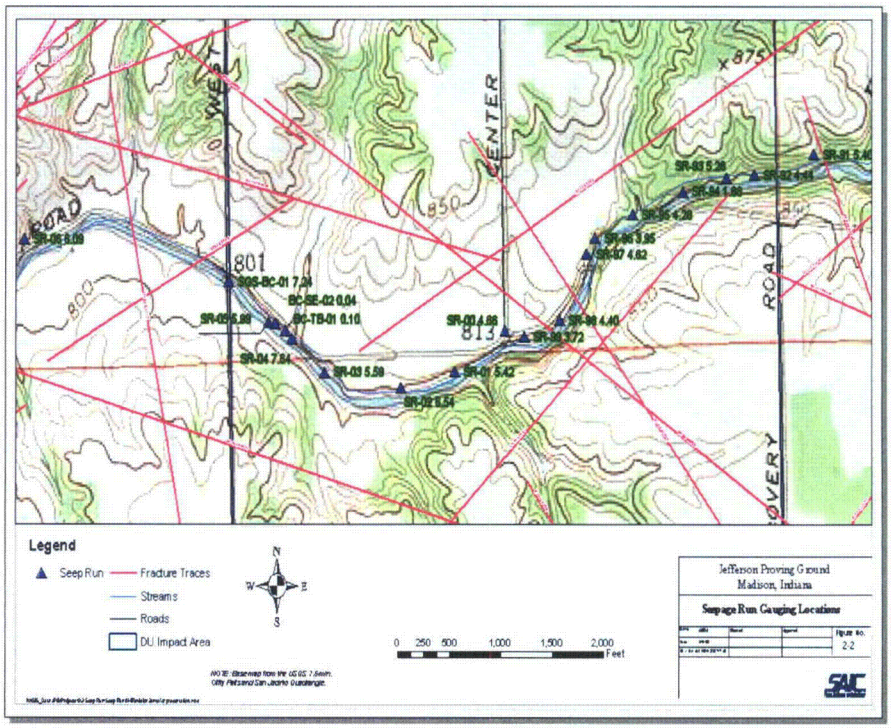
- Statistical Testing
  - In background samples, Cincinnati/Rossmoyne and Grayford/Ryker have significantly higher mean levels of total uranium than Avonsburg/Cobbsfork (between 10 and 20% higher)
  - Data for the soil under/over penetrators has concentrations orders of magnitude higher than background and Categories 1-6
  - In background vs. site analyzed on log scale, mean concentration for categories 1-6 is significantly higher than background for Avonsburg/Cobbsfork, but not for Cincinnati/Rossmoyne and Grayford/Ryker
  - For background, uranium concentrations are significantly higher at depths 1 foot or lower compared to topsoil, but there is no difference in mean concentrations between samples taken at 1 foot and samples taken at 2 feet below ground surface
  - For Categories 1-5, uranium concentrations do not differ by depth
- Conclusion
  - Concentrations in samples collected in Category 1-5 areas are significantly lower than concentrations collected under/over penetrators and within trench (Category 6)
  - DU concentrations under penetrators and within impact trenches are such that the associated radiological doses are expected to correspondingly higher
  - Evidence of DU (based on $^{238}U/^{234}U$ ratios) in samples collected under/over penetrators and within trench – $^{238}U/^{234}U$ ratios > 2 in 107 of 155 samples collected within trench and under penetrators, (including all samples collected under penetrators)
  - With the exception of the surface (0 to 0.5 feet) interval of JP-SC3-005, all $^{238}U/^{234}U$ ratios were less ≤ 2 for samples from Category 1 – 5 locations. (The $^{238}U/^{234}U$ ratio for the surface interval of JP-SC3-005 was 5.9.)
  - Additional information for site characterization includes the corrosion study, leachability testing, and K_d study

Seepage Run (Gain/Loss) Survey

- Goal was to identify gaining and losing stream segments along Big Creek through the DU Impact Area
- Two surveys were conducted in May and April to capture high base flow conditions:
  - May 2008 - Two teams measured stream flow at 17 locations over a distance of 1.7 miles of stream course in one day (5 May 2008)
  - April 2009 - Two teams measured stream flow at 14 locations over a distance of 1.5 miles of stream course in one day (15 April 2009)

Ongoing Tasks

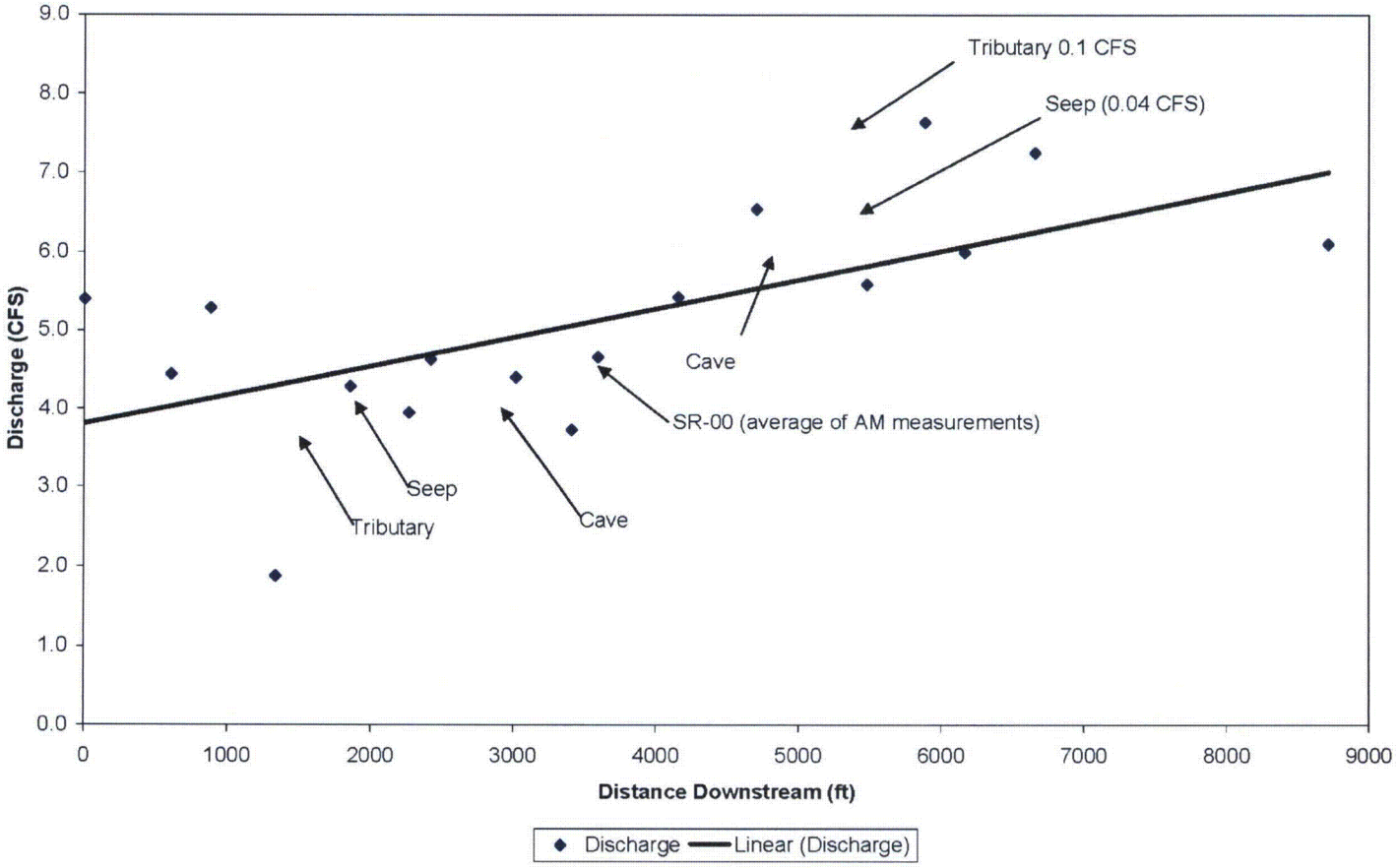
May 2008 Seepage Run Survey Review



- Total flow during May 2008 in stream was low (4 to 5 cfs) due to lack of seasonal precipitation and resulted in the following accuracy considerations:
  - Stream channel extremely variable (affected the accuracy of measurements)
    - Width 10 to 50 feet
    - Depth 0 to 2.7 feet
    - Velocity 0 to 2.5 feet/second
    - Stream bottom gravel, silt, and bedrock
  - Velocity at some stations too low to measure flow accurately

May 2008 Seepage Run Survey Review (cont'd)

Station	Distance Downstream	Discharge	Station	Distance Downstream	Discharge
SR-91	0	5.4	SR-00	3592	4.7
SR-92	608	4.4	SR-01	4155	5.4
SR-93	882	5.3	SR-02	4704	6.5
SR-94	1338	1.9	SR-03	5478	5.6
SR-95	1858	4.3	SR-04	5882	7.6
SR-96	2270	4.0	SR-05	6162	6.0
SR-97	2423	4.6	BC-01	6652	7.2
SR-98	3017	4.4			
SR-99	3411	3.7			
SR-00	3592	4.7			

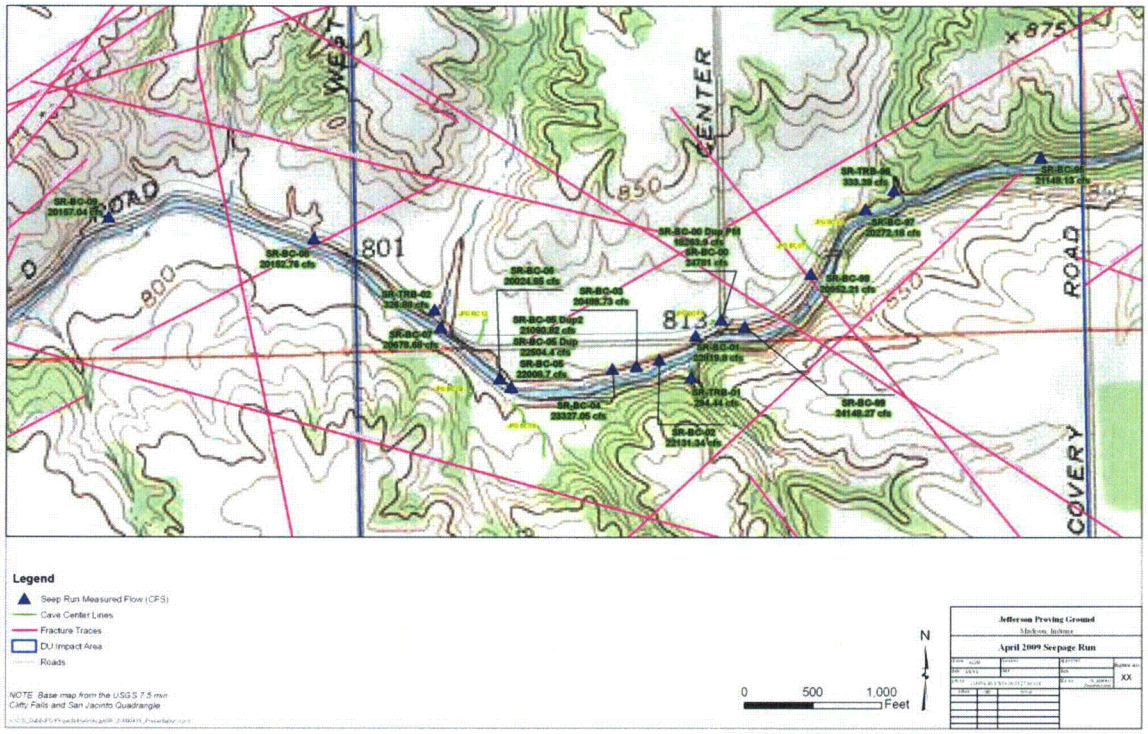


May 2008 Seepage Run Survey Review (cont'd)

- Extremely low stream flow velocities resulted in questionable data quality. Variations of up to 20% flows in adjacent stations were most likely a result of poor method accuracy at low velocities.
- Due to uncertainty, a second seepage run survey was conducted.

Ongoing Tasks

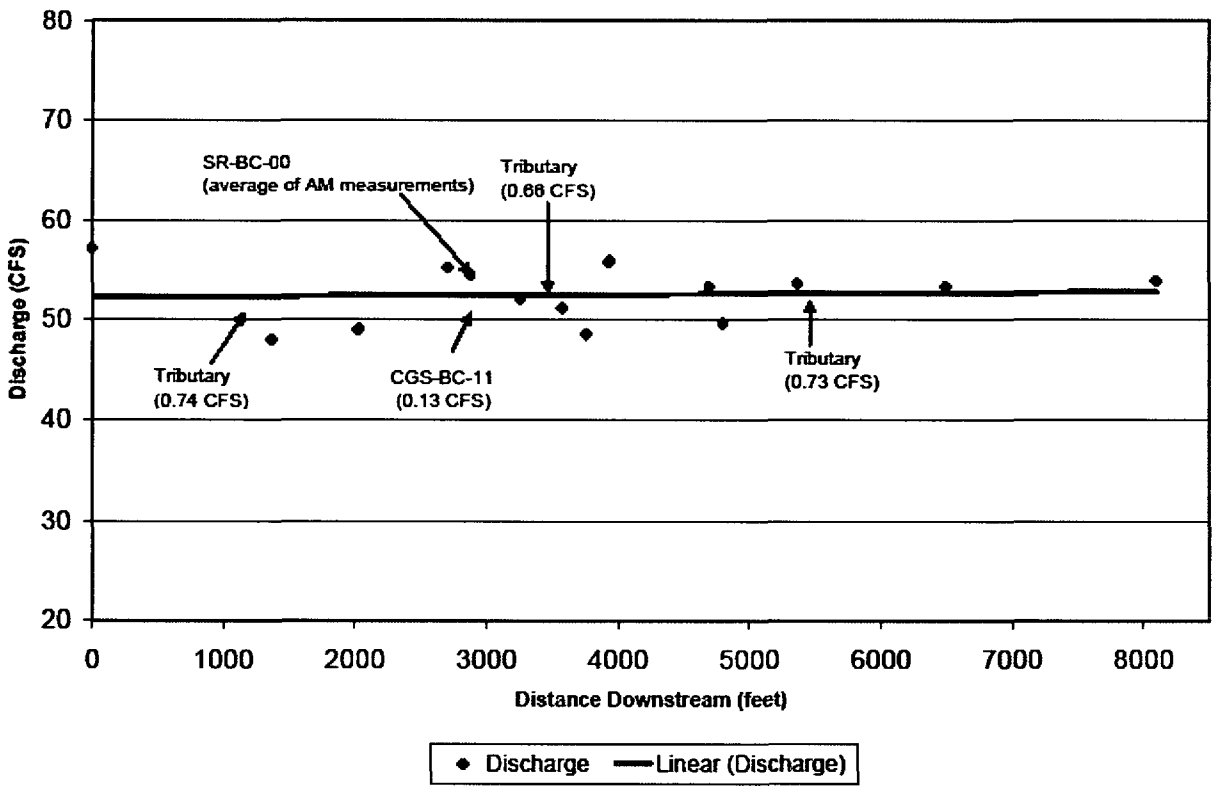
April 2009 Seepage Run Survey Review



- April 2009 stream flow was high (40 to 50 cfs) due to a rain event in the preceding day of approximately 0.5 inch.
  - The stream flows were declining through the period of measurement
  - A correction was made to the stream discharge measurements to account for the measured change in discharge at a duplicated location at the beginning and end of the measurement time period
  - Repeat measurements for quality control and assessment were within 3%

April 2009 Seepage Run Survey Review (cont'd)

Station	Distance Downstream	Discharge
SR-BC-95	0.0	57.1
SR-BC-97	1367.0	48.0
SR-BC-98	2026.1	49.0
SR-BC-99	2704.9	55.2
SR-BC-00	2876.9	54.4
SR-BC-01	3252.6	52.1
SR-BC-02	3571.1	51.2
SR-BC-03	3755.7	48.5
SR-BC-04	3933.1	55.9
SR-BC-05	4693.7	53.3
SR-BC-06	4798.8	49.6
SR-BC-07	5366.6	53.6
SR-BC-08	6497.6	53.3
SR-BC-09	8099.2	53.9



Conclusions from Seepage Run Surveys

- SR-BC-95, up gradient station measurement questioned due to turbulence at measurement location stream
- Discharge volumes approximately 10 times that measured during the May 2008 seepage run
- Repeat Measurements demonstrated a variance of 3%
- The change in flow across the measured section of stream, excluding SR-BC-95, showed 11% increase, 3.5 cfs/mi2.
- Variation in many adjacent stations was relatively small and was close to or within the calculated measurement error of ~3% at repeat measurements locations.
- Variations that were outside the Measurement error could be a result of gain/loss from stream channel
- No significant losing stream sections were identified
- If gain/loss from stream channel, this is expected to be shallow flow, either through gravel in stream bed or very shallow karst features since measurements indicate the flow quickly returns to the stream at downstream locations.
- During times of low precipitation Big Creek often has no flow

Aquifer Testing for Hydraulic Conductivity

- Conditions that determined unsuitability for testing
  - Too short of water column for complete submergence of equipment
  - Non-static water conditions – such as response to recent precipitation
- Several wells were attempted to be tested and had extremely low hydraulic conductivities
  - These wells did not return to static conditions overnight after insertion of the small pressure transducer and would not have recovered from introduction of a slug for days and were not tested
- Following preliminary review and analysis of the slug testing data, fourteen wells were determined to have data sets and conditions suitable for calculating estimates of hydraulic conductivity
  - Four wells completed in the overburden/till
  - Ten wells completed in the shallow bedrock
- The data sets from these wells were imported into Aqtesolv version 4.5 software for analysis

Aquifer Testing for Hydraulic Conductivity (cont'd)

- Wells that were evaluated for testing, but didn't have suitable conditions or extremely low hydraulic conductivity
  - The following wells had water levels that were very slow to recover or did not recover to their initial water levels after water was withdrawn during development and sampling activities and therefore were not considered for slug testing. The hydraulic conductivities are estimated to be extremely low at these wells.
    - JPG-DU-02D
    - JPG-DU-05D
    - JPG-DU-07I
    - JPG-DU-07D
    - JPG-DU08I
    - JPG-DU-08D
  - The following wells didn't recover from the submergence of either the transducer or the initial slug overnight as a result of low hydraulic conductivities that are estimated to be at the low end of the published range for limestone and dolomites or lower.
    - JPG-DU-01D
    - JPG-DU-03I
    - JPGDU-06D
    - JPG-DU-09I
    - JPG-DU-09I
    - JPG-DU-10O
    - JPG-DU-10D
    - MW-10

Aquifer Testing for Hydraulic Conductivity (cont'd)

- Several evaluations were completed to verify the applicability of the conventional theory:
  - Comparison of data sets between the slug in vs. slug out to evaluate if directional dependence is present and if effective screen length is changing
  - Comparison of theoretical slug displacement vs. observed to evaluate appropriate effective casing radii and potential presence of air trapped in filter pack and how to represent water table
  - Comparison of first and last tests of similar displacement size to monitor if conditions changed throughout the test
  - Comparison of data sets for tests with different sized slugs to evaluate for appropriate effective casing radii for large slugs

Ongoing Tasks

Preliminary Hydraulic Conductivity Estimate Results

Overburden/Till Wells

- JPG-DU-09O responded very slowly to head changes and hydraulic conductivity estimate was several orders of magnitude lower
- JPG-DU-03O has possible low conductivity well skin, but hydraulic conductivity estimate in same order of magnitude as others
- Range from 0.000923 to 6.74 gal/day/sq ft
- Average for all Overburden wells 3.51 gal/day/sq ft
- Average with JPG-DU-09O removed is 4.68 gal/day/sq ft

Well	Avg Hydraulic Conductivity	Possible well skin
JPG-DU-03O	2.40	yes
JPG-DU-04O	4.88	
JPG-DU-06O	6.74	
JPG-DU-09O	0.000923	

Preliminary Hydraulic Conductivity Estimate Results

Shallow Bedrock Wells

- The following wells were determined to have a possible low conductivity well skin:
  - MW-2, MW-3, JPG-DU-4I, JPG-DU-05I
  - The average hydraulic conductivity for the wells with well skins is 2.88 gal/day/sq ft

Preliminary Hydraulic Conductivity Estimate Results

- JPG-DU-02I has a six inch void in the screened zone and has the largest estimated hydraulic conductivity average of 23.154 gal/day/sq ft
- Range from 0.037 to 23.154 gal/day/sq ft
- Average for all shallow bedrock wells is 5.29 gal/day/sq ft
- Average with JPG-DU-02I removed is 3.30 gal/day/sq ft
- Average of all wells without well skins is 6.89 gal/day/sq ft
- Average of all wells without well skins and JPG-DU-02I is 3.63 gal/day/sq ft

Well	Avg Hydraulic Conductivity	Possible well skin
JPG-DU-01I	0.037	
JPG-DU-02I (Void)	23.154	
MW-2	0.548	yes
MW-3	0.323	yes
JPG-DU-04I	10.611	yes
MW-5	0.081	
JPG-DU-05I	0.053	yes
JPG-DU-06I	11.353	
MW-7	3.030	
MW-RS2	3.668	

Preliminary Hydraulic Conductivity Estimate Summary

- Overburden/till wells without well skin and JPG-DU-09O
  - Average hydraulic conductivity is 5.81 gal/day/sq ft
  - Published range for glacial till
    - ~10 to 0.00001 gal/day/sq ft (Freeze and Cherry, 1979)
  - Average from tests is on upper end
  - The estimate for JPG-DU-09O is reasonable
- Shallow bedrock wells without well skins and JPG-DU-02I
  - Average hydraulic conductivity is 3.63 gal/day/sq ft
  - Published range for limestone and dolomite
    - ~10 to 0.02 gal/day/sq ft (Freeze and Cherry, 1979)
  - Published range for karst limestone
    - ~5 to 100,000 gal/day/sq ft (Freeze and Cherry, 1979)
    - JPG-DU-02I (23.15 gal/day/sq ft) average hydraulic conductivity in lower end of this range
- All of the "deeper" bedrock wells and several of the shallow bedrock wells have exhibited extremely slow responses to attempts to slug test and dewatering during well sampling
  - These wells would be considered to have very low hydraulic conductivities expected to be at the low end of the range published for limestone and dolomites or lower

Groundwater Age Estimates and Borehole Flowmeter Measurements from Hydrogeologic Units at Jefferson Proving Ground, 2008 data

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