AGENDA
Meeting To Discuss Data Quality Objectives for Sampling At Jefferson Proving Ground
Monday, December 3, 2007, 1 p.m. – 4 p.m.
U.S. Nuclear Regulatory Commission (NRC), Headquarters
11545 Rockville Pike
TWFN T-10A1
Rockville, MD 20852-2738

0100 Introductions (NRC/Army)
0110 Meeting Purpose (Cloud)
0115 Review Project Objectives and Project Status/Major Milestones (Skibinski)
0145 Summarize Results of Characterization Since October 2006 Meeting (Eaby/Snyder)
- Stream and Cave Spring Gauges
- Groundwater Well Installation

0215 Propose Data Quality Objectives (DQOs) (Chambers)
- Analytical Methods (Chambers)
- Surface Water, Sediment, and Groundwater Sampling (Eaby/Snyder)

0300 Discuss Selection of Models (Skibinski)
0320 Summary and Conclusions (Cloud/Skibinski)
0330 Summary of Action Items/Conclusions (NRC)

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Army's Progress in Characterizing JPG and Data Quality Objectives for Sampling

U.S. Army – Paul Cloud
SAIC – Joseph Skibinski, Stephen Snyder, Todd Eaby, Dennis Chambers, and Michael Barta

3 December 2007

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

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Overview

- Review Project Objectives
- Review Project Status/Major Milestones
- Summarize Results of Characterization Since October 2006 Meeting
  - Stream and Cave Spring Gauges
  - Groundwater Well Installation
- Propose Data Quality Objectives (DQOs)
  - Analytical Methods
  - Surface Water, Sediment, and Groundwater Sampling
- Discuss Selection of Models
- Summary and Conclusions

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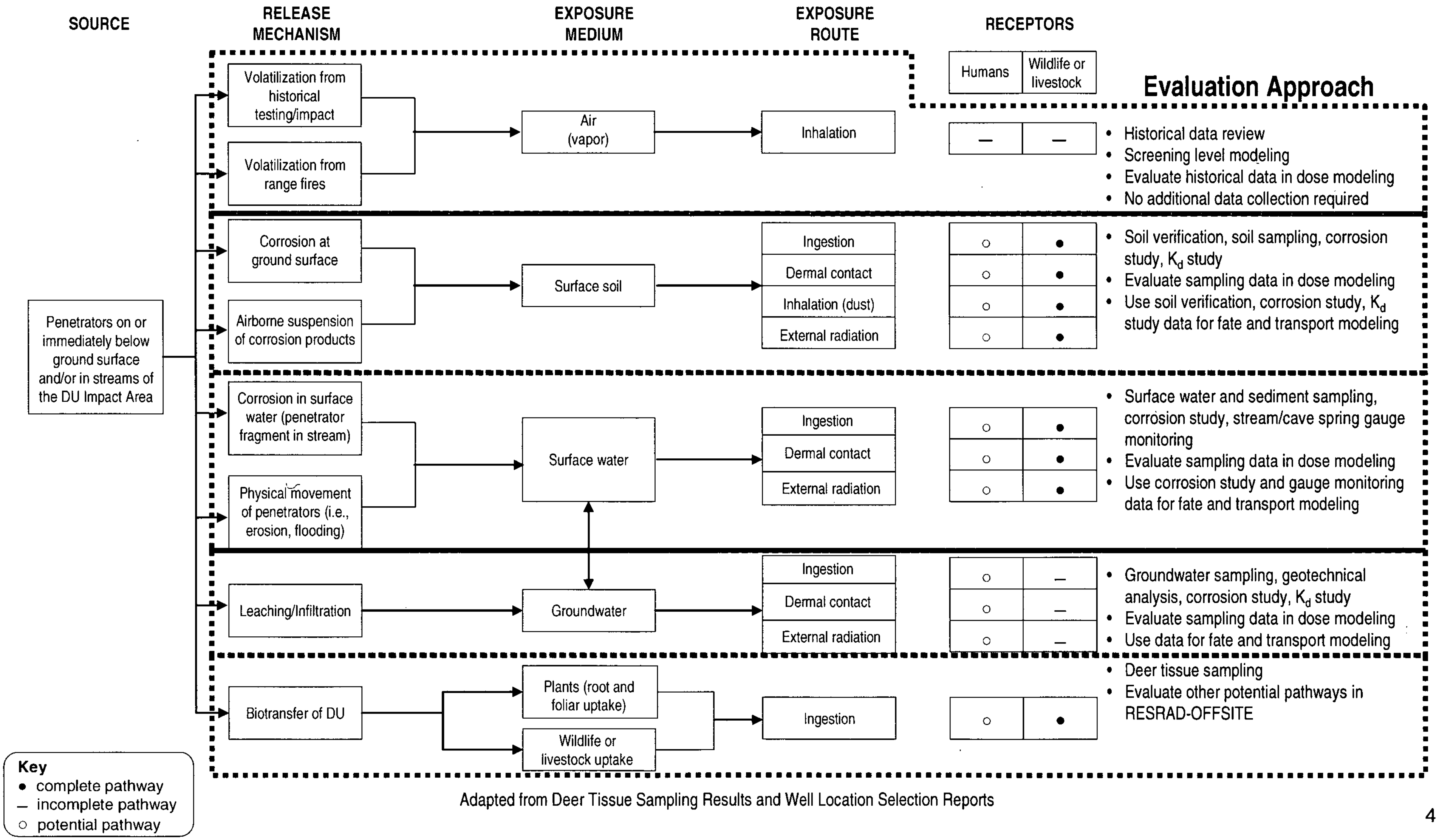
Project Objectives

- 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 in 5 years

CSM and Evaluation Approach Summary



Adapted from Deer Tissue Sampling Results and Well Location Selection Reports

Project Status/Major Milestones

Deliverable/Activity	Date
Field Sampling Plan (FSP)	May 2005
FSP Addendum 1 – Deer Sampling	November 2005
Deer Sampling Field Work	November / December 2005 and February 2006
Fracture Trace Analysis Report	May 2006
Deer Sampling Report	August 2006
Fracture Trace Analysis Field Correlation	July 2006
FSP Addendum 2 – Soil Verification	July 2006
FSP Addendum 3 – Other Monitoring Equipment Installation and Electrical Imaging (EI)	July 2006

Project Status/Major Milestones (cont'd)

Deliverable/Activity	Date
EI Field Work	July / August 2006
Soil Verification Field Work	August 2006
Stream and Cave Spring Gauge Installation	September 2006
Stream and Cave Spring Gauge Monitoring	Monthly: September 2006 – August 2007 Quarterly: October 2007 – 2010
Army/NRC Status Meeting	12 October 2006
FSP Addendum 4 – Monitoring Well Installation	January 2007
Well Location Selection Report	January 2007
Well Installation	May / June 2007 and November / December 2007

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Project Status/Major Milestones (cont'd)

Deliverable/Activity	Date
Army/NRC Status Meeting	3 December 2007
FSP Addendum 5 – DQOs for Groundwater (GW), Surface Water (SW), and Sediment Sampling and Analysis	January 2008
GW, SW, and Sediment Sampling	April, July, and October 2008 and January 2009
Army/NRC Status Meeting	Propose June 2008
FSP Addendum 6 – DQOs for Soil Sampling and Analysis, Kd Study, and Corrosion Study	June 2008
Soil Sampling and Collection of DU Penetrators	Summer 2008

Project Status/Major Milestones (cont'd)

Deliverable/Activity	Date
K_d Study	Summer to Winter 2008
Corrosion Study	Summer to Winter 2008
Metal Speciation and Dosimetry Modeling	2008 – 2010
Decommissioning Plan	Early 2011

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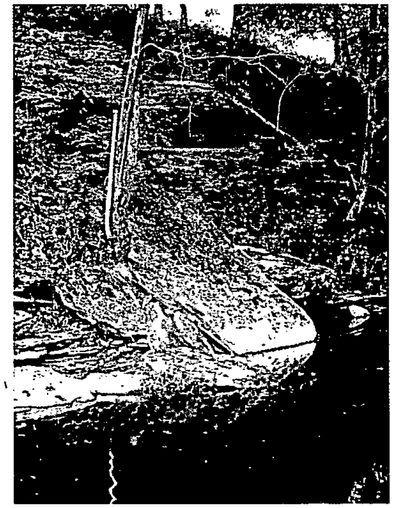
Stream and Cave Spring Gauges

- Objective to collect surface water stage measurements
  - Used to calculate and monitor surface water flows and flow from selected cave streams
  - Used to estimate recharge quantities and characteristics of the aquifer
  - Used to evaluate the interrelationships between precipitation, surface water, and groundwater
- Precipitation data
  - Not collected with the installation of an automated weather station as stated in the FSP (SAIC 2005a), but utilizing an existing recording station at JPG
  - Downloaded from the following website http://www.fs.fed.us/raws/
- Gauging stations
  - Electronic data recorders and pressure transducers installed to continuously and automatically record water levels (or stage) within the stilling wells
  - Each gauging station calibrated by manually measuring stream or spring/cave stream flows using a Gurley® flow meter or equivalent

Stream and Cave Spring Gauges (cont'd)

- Nine electronic recording gauges and one staff gauge installed in September 2006
- Continuous stage data from September 2006 through present
- Manual measurements of stream flow monthly for first year (September 2006 – August 2007)
- First quarterly manual measurement for observing stream channel changes and rating curve confirmation (November 2007)
- Manual measurements to be collected during surface water/ sediment sampling
- Additional quarterly monitoring until 2010



SGS-BC-02

CGS-BC-11

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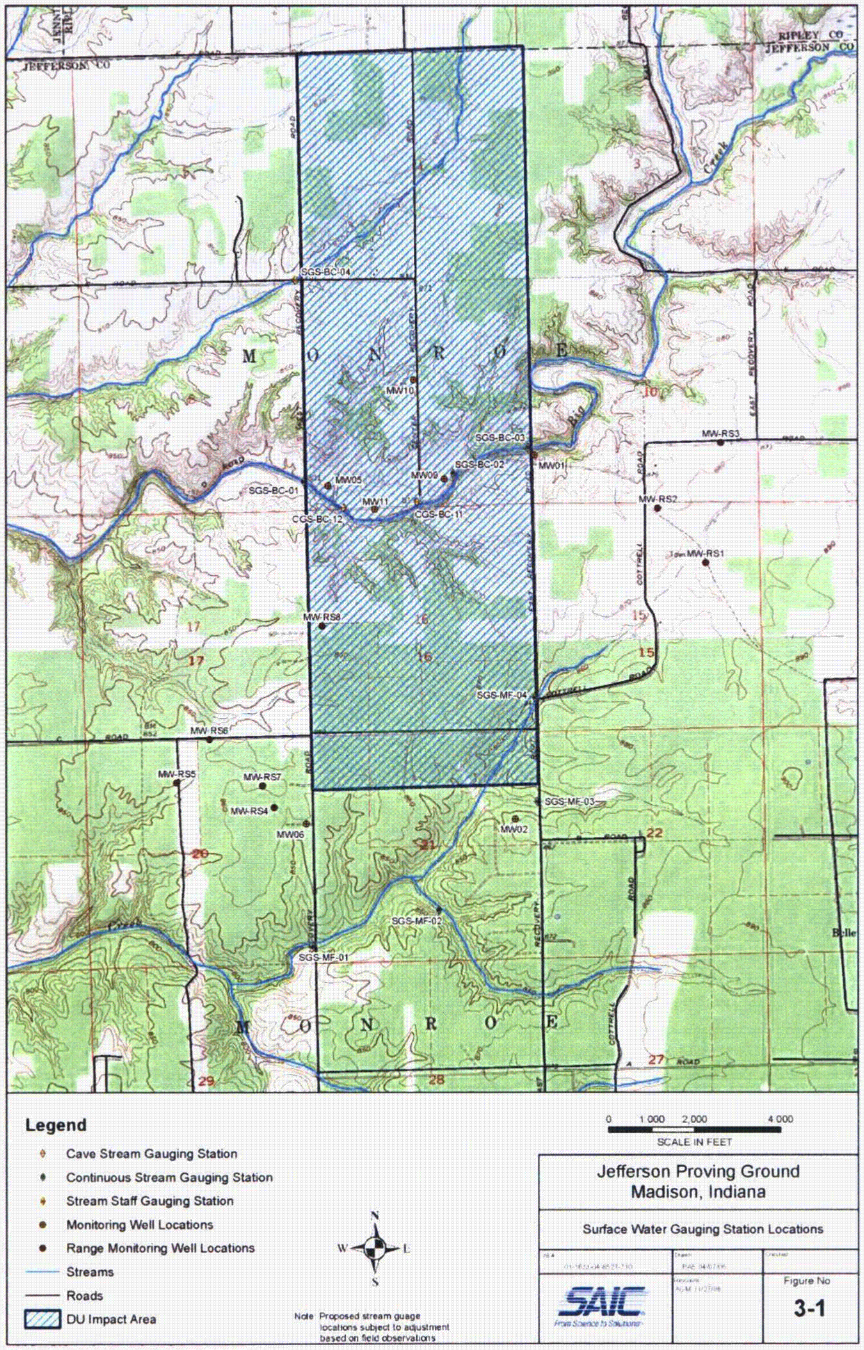
Stream and Cave Spring Gauge Locations

- Number of locations based on water body and flow characteristics
  - Gradient is relatively consistent
  - No permanent standing water bodies entering into/emerging from streams running through the DU Impact Area
  - Number, location, and orientation of tributaries considered
- Big Creek
  - Three recording gauges
  - Staff gauge on a northern tributary to Big Creek
- Middle Fork Creek
  - Four recording gauges
  - Additional location due to number of tributaries in study area
- Cave Springs
  - CGS-BC-11
  - CGS-BC-12



Stream and Cave Spring Data

- Rating curves developed for each gauge using the manual flow measurements and the recorded stage data
- Rating curve used to compute flow data from stage data
- Rating curves may be updated if stream/channel configurations change (e.g., deposition/scouring, construction/destruction of beaver dams)
- Flow data will be used in two U.S. Geological Survey (USGS) computer programs to estimate recharge to the aquifer using stream flow hydrograph analysis methods
  - PART automates the separation of surface water and interflow from groundwater base flow
  - RORA uses a recession-curve displacement method to estimate groundwater recharge from storm periods recorded on the stream flow hydrographs
- Analysis using the computer programs will be completed for the first year based on monthly data then annually thereafter based on quarterly data

Manual Flow Calculation Example Sheet for SGS-BC-02

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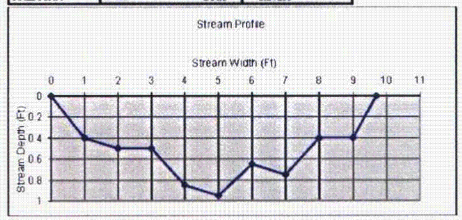
Stream Gauging Data Collection Sheet		Page 1 of 1	
Date: 4-Jun-07		Time : 1355	
Project Name & Location: JPG - Madison, Indiana			
Collected By: TDE	Station Description (circle all that apply)		
Station ID: SGS-BC-02	Stream Bed Description:	Gravelly Sandy Silty Bedrock	
Current Weather Conditions:~75 Cloudy	Flow Description:	Obstructed Turbulent Smooth	
Stream Width (ft): 9.7'	Water Clarity:	Very silty Cloudy Clear	
Instrument Type & ID: Marsh McBirney	Ice:	None Partially frozen Frozen	
Notes:	Heavy Rain in past 7 days	Yes No Unknown	
	Carbonate Area	Yes No Unknown	

Distance from Bank (Ft)	Depth (ft)	Velocity (ft/s)	Area (ft^2)	Flow (ft^3/s)	Comment
			0.2		
1.0	0.40	0.05	0.45	0.0225	
2.0	0.50	0.04	0.5	0.02	
3.0	0.50	0.06	0.675	0.0405	
4.0	0.85	0.07	0.9	0.063	
5.0	0.95	0.07	0.8	0.056	
6.0	0.65	0.05	0.7	0.035	
7.0	0.75	0.05	0.575	0.02875	
8.0	0.40	0.01	0.4	0.004	
9.0	0.40	0.02	0.14	0.0028	
9.7					
Total Flow:	122.32044 GPM		0.27255 ft^3/s		

Trapezoidal Area		
Distance	Depth	Area (ft^2)
		0.2
1	0.4	
1	0.4	0.45
2	0.5	
2	0.5	0.5
3	0.5	
3	0.5	0.675
4	0.85	
4	0.85	0.9
5	0.95	
5	0.95	0.8
6	0.65	
6	0.65	0.7
7	0.75	
7	0.75	0.575
8	0.4	
8	0.4	0.4
9	0.4	
9	0.4	0.14
9.7		
9.7		



Notes:

1. All shaded boxes are automatically populated from values entered in un-shaded areas.
2. Zero values entered will show up as blank cells.
3. Average trapeziodal area calculated by following procedures:

http://www.epa.gov/owow/monitoring/volunteer/stream/vms51.html

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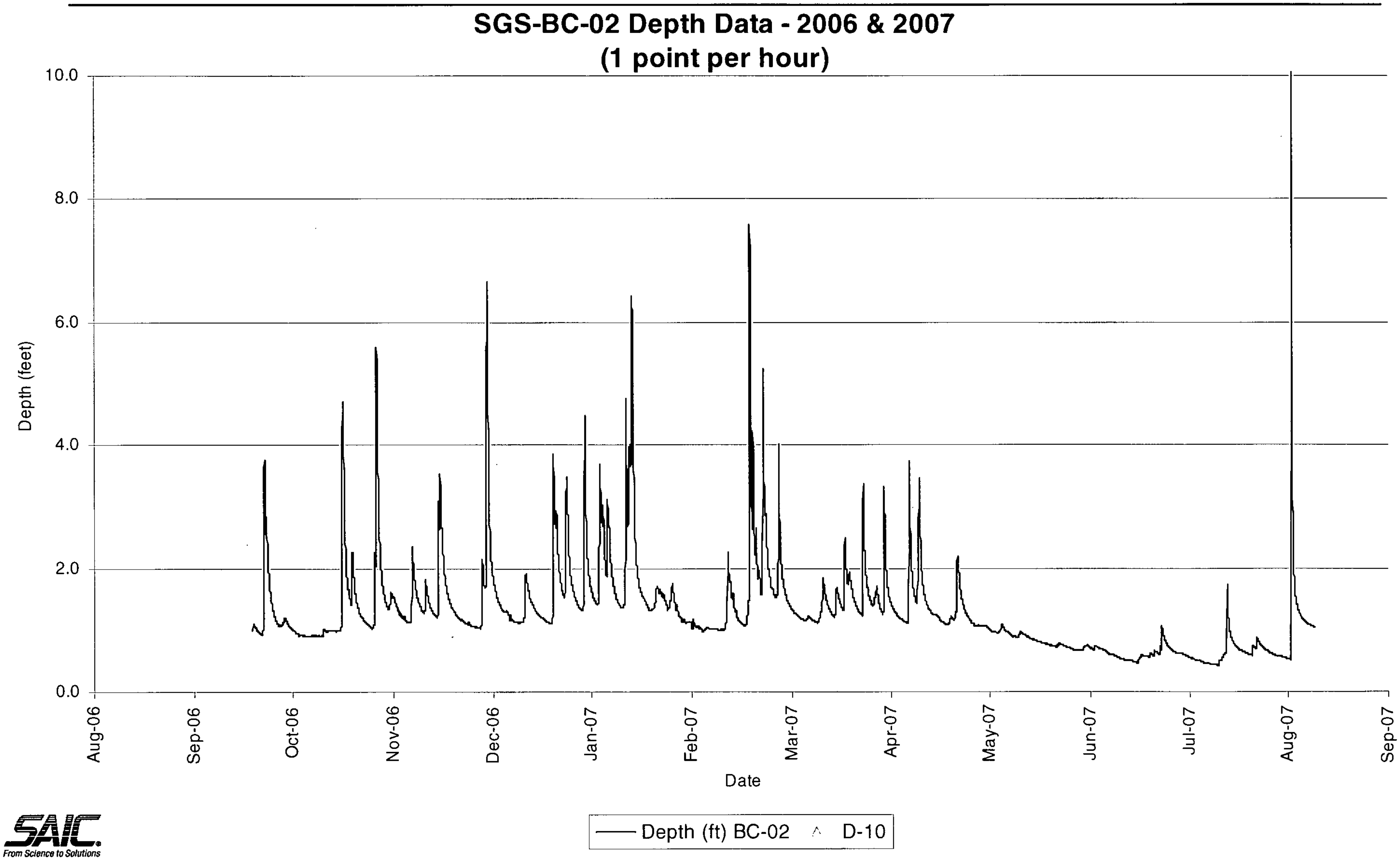
Stream Stage Data



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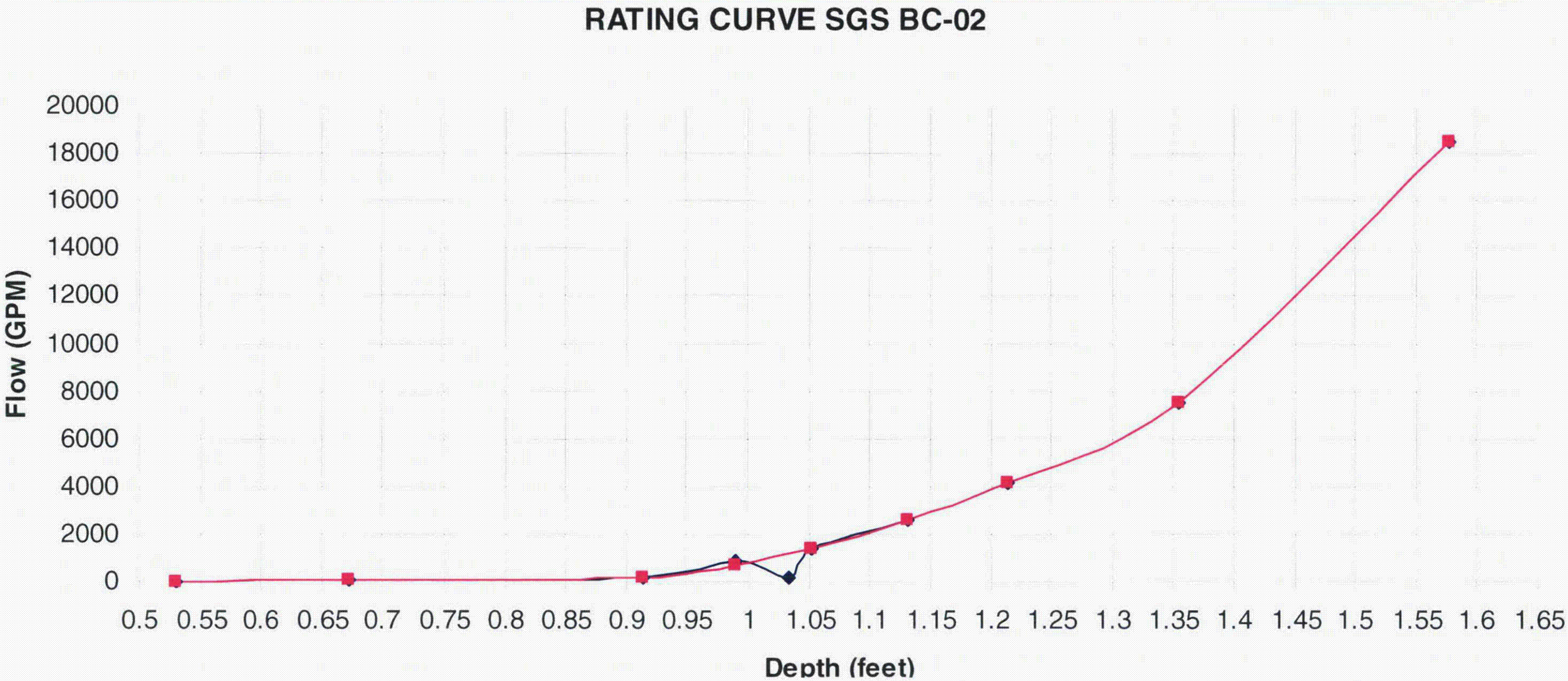
Stream Rating Curve



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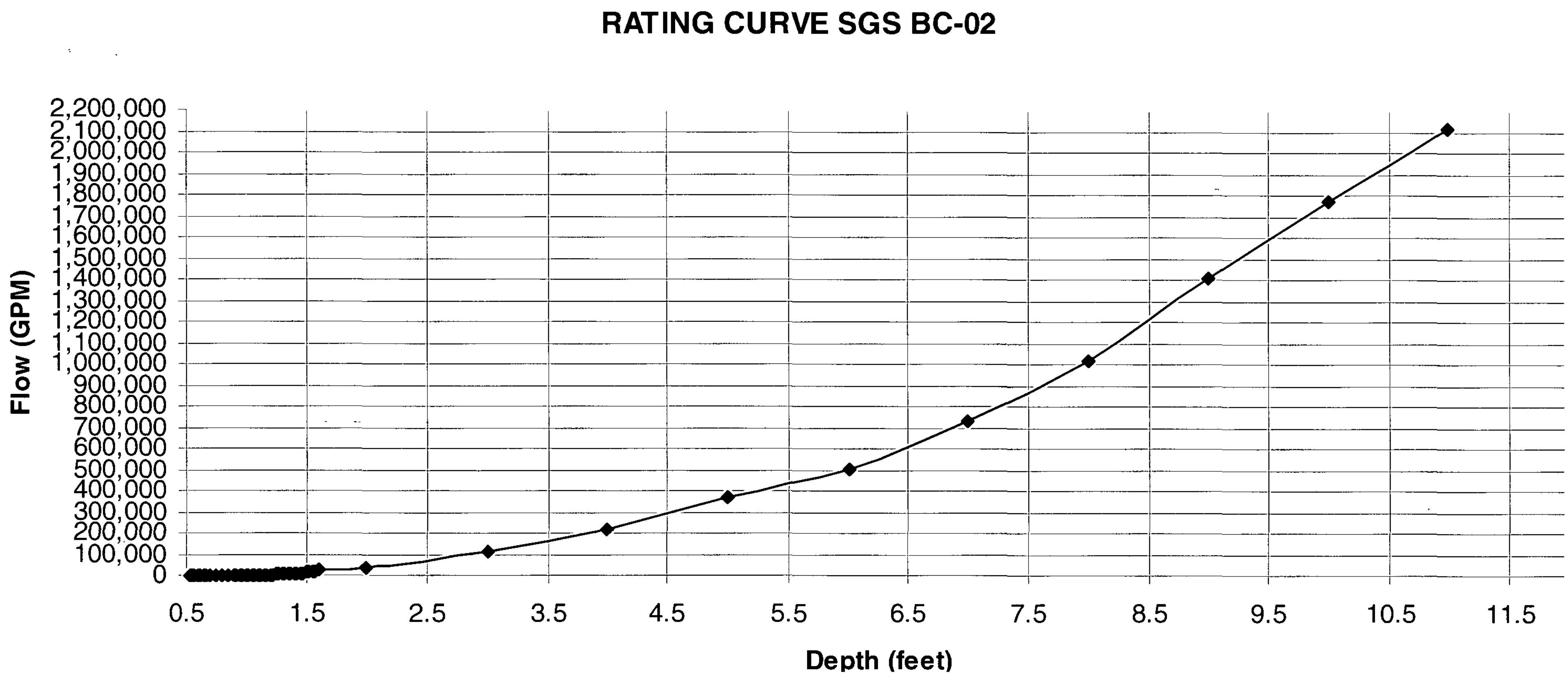
Stream Rating Curve (Extrapolated)



Rating curve extrapolated using USGS method

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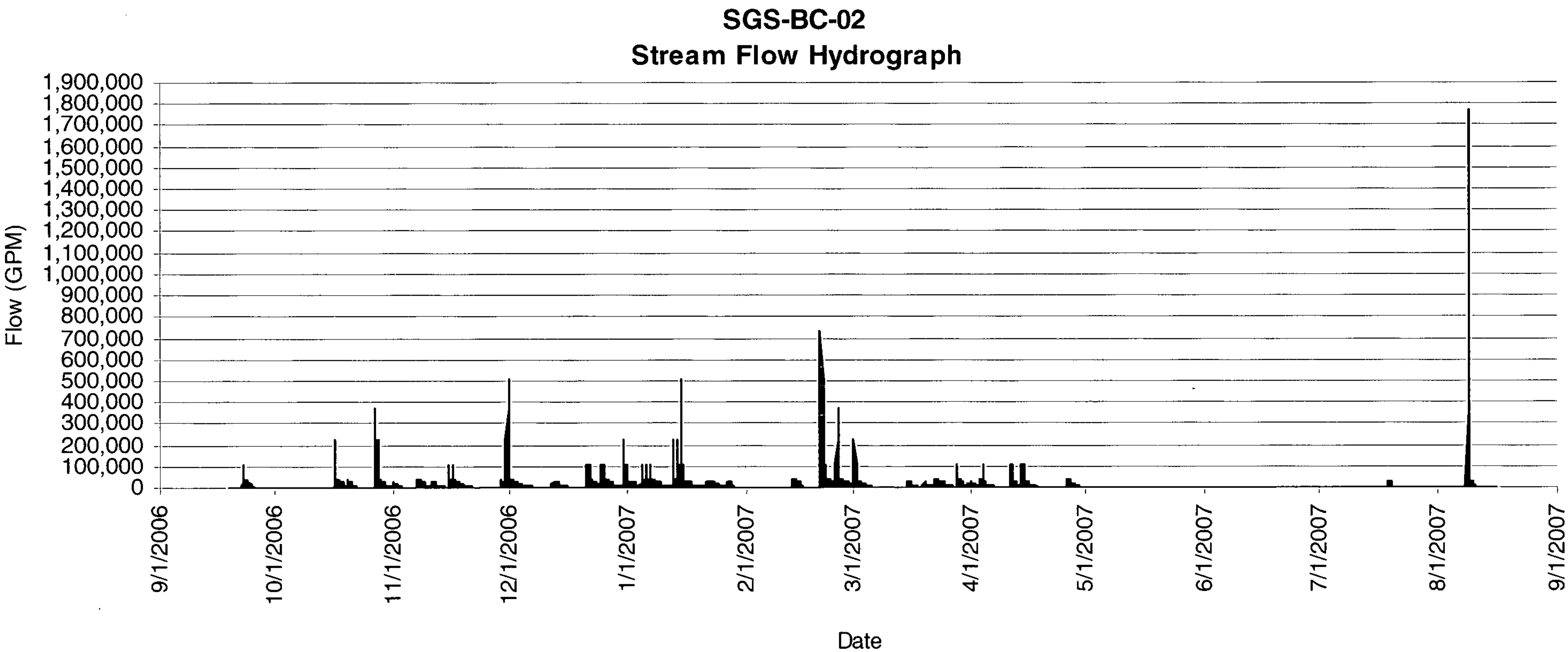
Stream Flow Hydrograph



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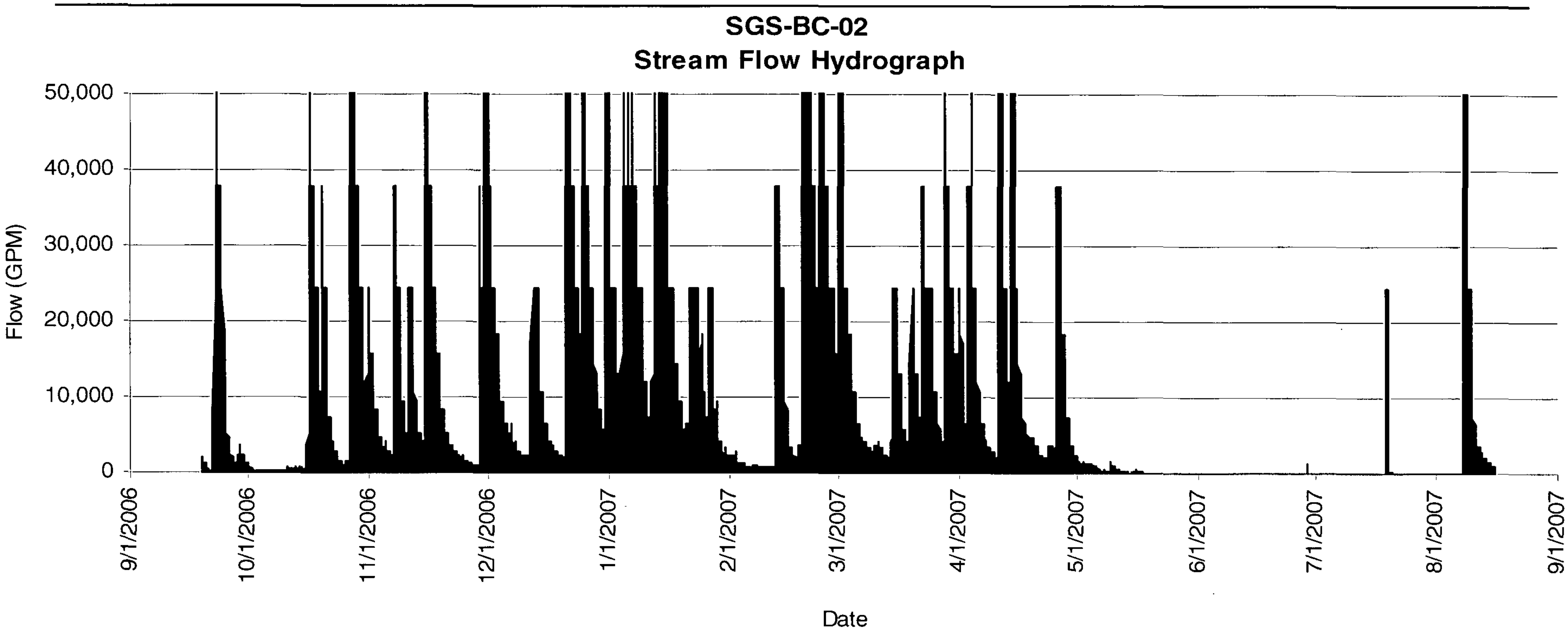
Stream Flow Hydrograph (Zoomed-In)



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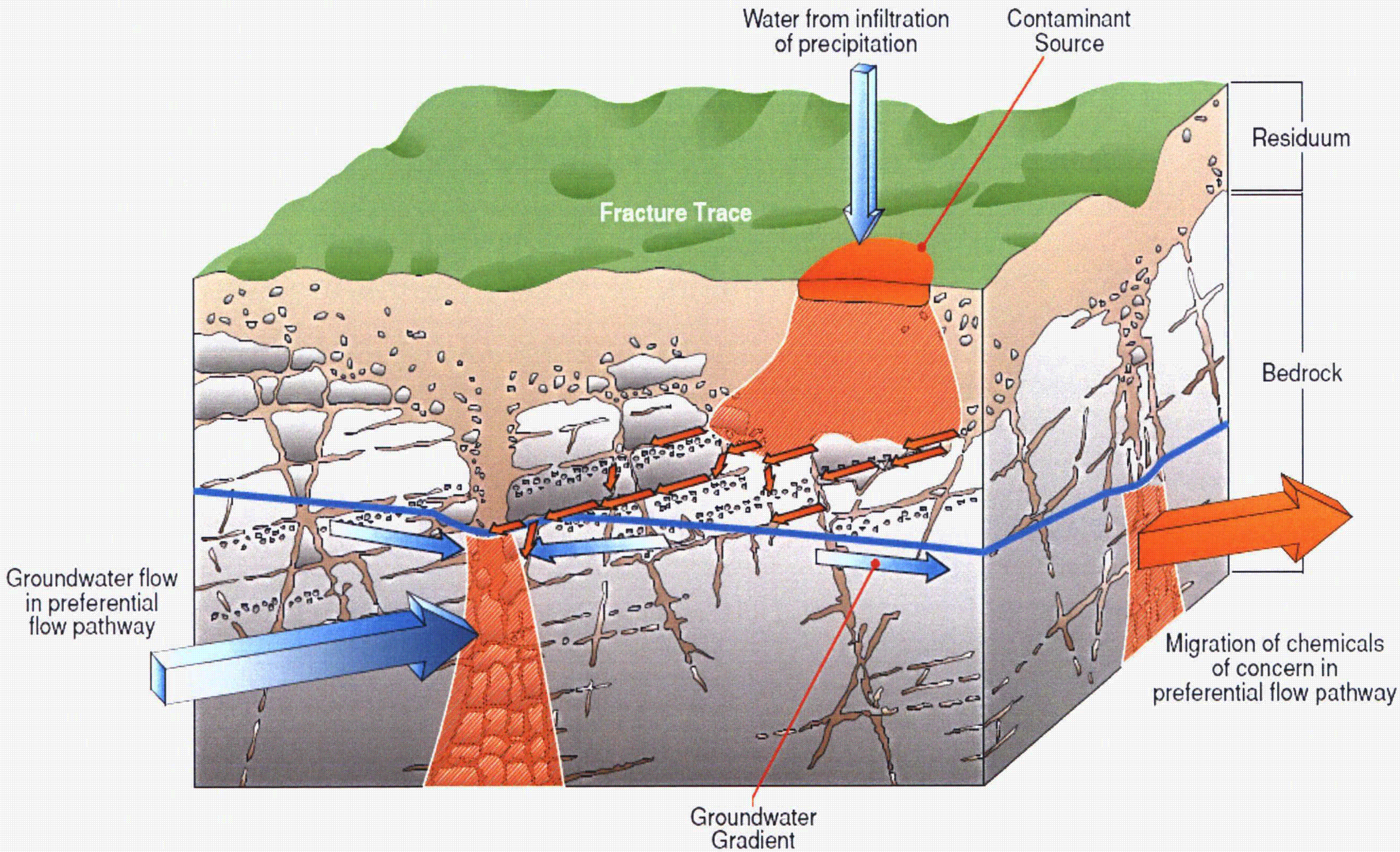
Stream and Cave Spring Status/Planned Events

- Rating curves developed for each gauge and stage data being evaluated
  - Additional observations may be required to investigate unusual readings
  - Ice blockages observed near SGS-BC-01
  - Beaver dam blockage near SGS-MF-03
- Will run PART and RORA computer software to estimate recharge to the aquifer and re-run annually
- Continue automatic stage data monitoring and quarterly manual flow measurements until 2010

Groundwater Well Installation

- Limited understanding of hydrogeologic system (particularly bedrock north of JPG firing line) before characterization began
  - 19 existing groundwater wells
  - Nearly half of existing wells are installed in overburden
    - Average depth ~ 28 feet below ground surface (BGS)
    - Deepest = 53.7 feet BGS/shallowest = 12.5 feet BGS
    - Most have low yields
  - Evidence of karst aquifer (sinkholes, caves)
- Objective to confirm CSM
  - Highly developed shallow bedrock drainage network
  - Groundwater migration occurs in preferential groundwater flow paths (conduits)
  - Wells located in conduits will enable evaluation if site activities have impacted the environment and provide monitoring points for most probable migration pathways

Potential for DU Migration in Karst Aquifer



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Groundwater Well Installation (cont'd)

- Multi-step approach to identify and locate preferential groundwater flow pathways
  - Aerial photos/fracture traces
  - Electrical imaging
  - Drilling-monitoring well installation
  - Water level monitoring
  - Groundwater chemistry
- Well locations selection criteria
  - On a fracture trace
  - Good electrical imaging characteristics
  - Down-gradient from known areas of concentrated DU material
  - Good site coverage

Groundwater Well Installation (cont'd)

- 13 wells installed in May and June 2007
  - 11 bedrock wells
  - 1 deep (~72 feet) overburden well installed at location #10
  - 1 additional overburden well installed in saturated permeable material at location #9
  - Average "shallow" bedrock well depth ~ 41 feet BGS
  - Average "deep" bedrock well depth ~106 feet BGS
  - Deepest = 136.3 feet BGS/shallowest = 28.8 feet BGS
- 9 wells are planned to be installed in November and December 2007
  - 8 bedrock wells
  - 1 overburden well installed in saturated permeable material identified at location #6
  - Additional overburden wells may be added if saturated permeable materials are identified at the remaining well locations - #4

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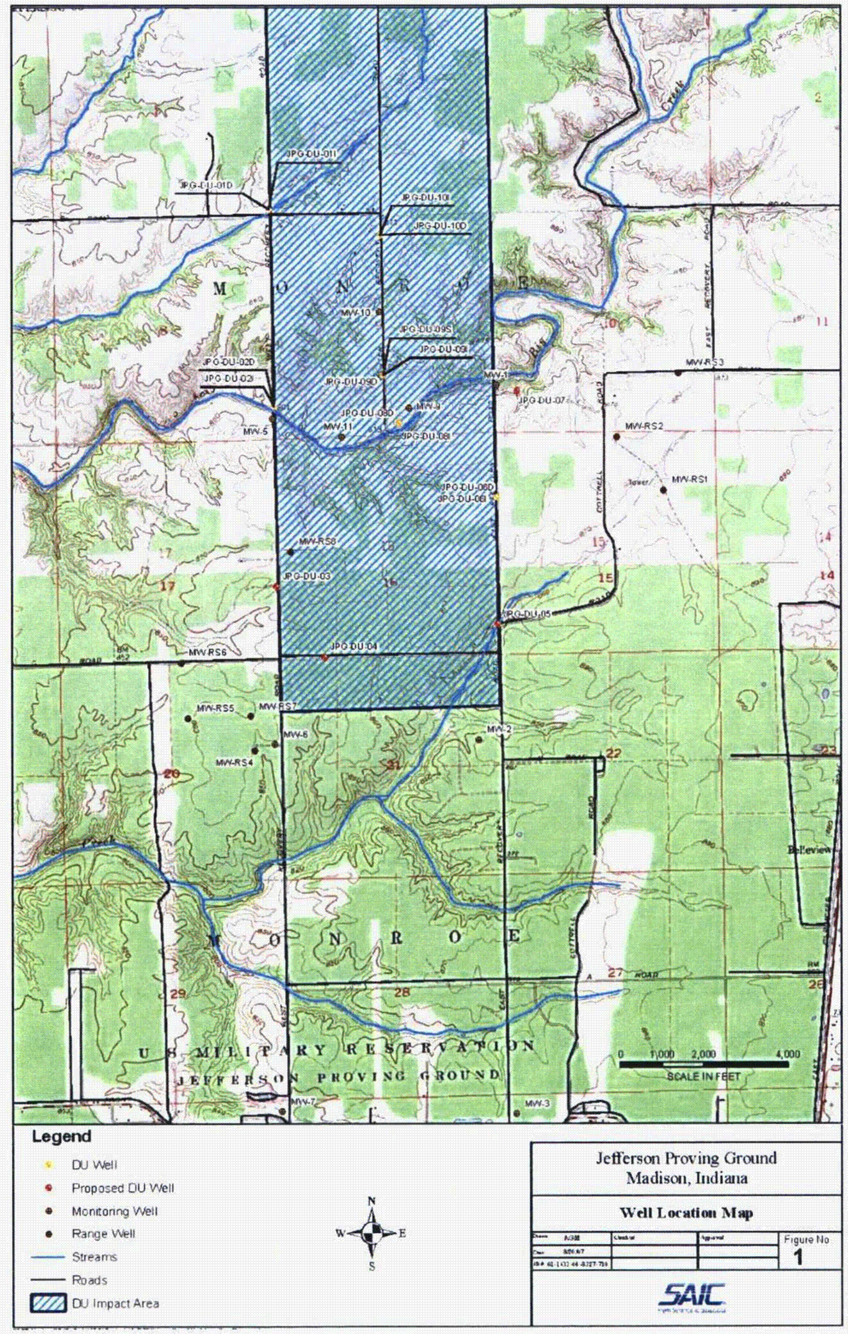
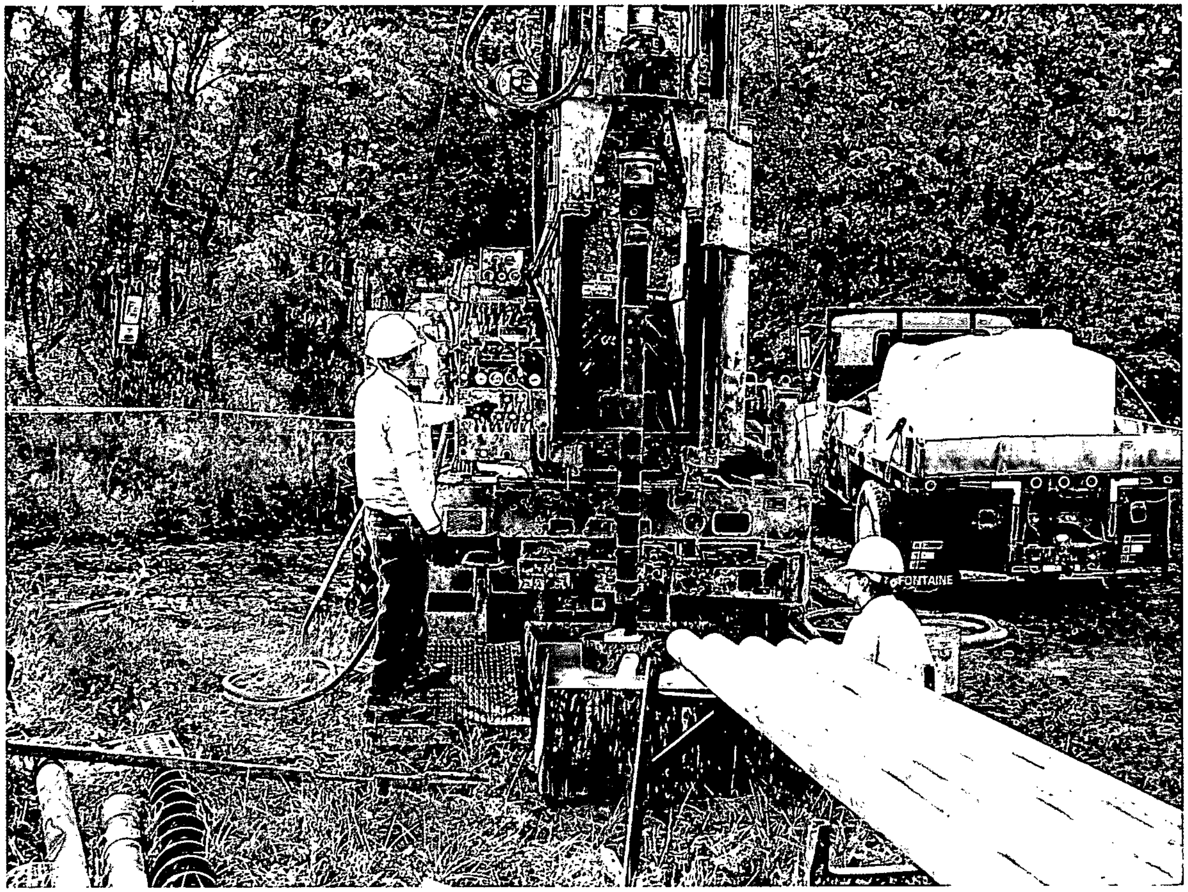
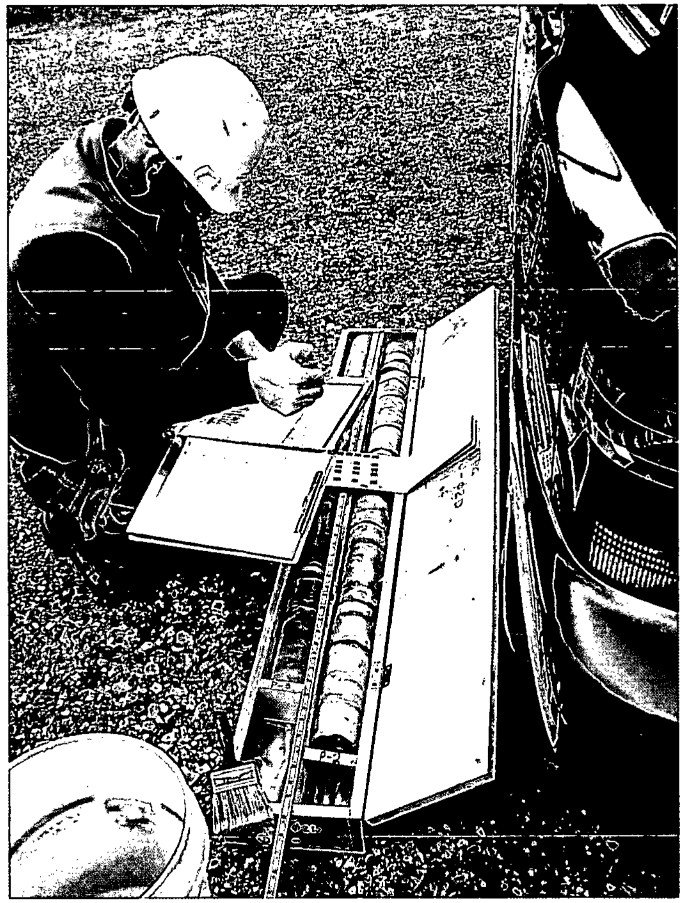
Groundwater Well Locations



Groundwater Well Drilling





19 bedrock wells plus 3 overburden wells will be completed by the end of December 2007

Groundwater Well Drilling Observations

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

Well Installation Key Observations

- Depths to bedrock range from 5 to 72 feet BGS
- Fractured/weathered zones are most prevalent in the top 50 feet
- Saturated permeable overburden encountered in three locations to date and overburden wells were installed in all cases
- Bedrock well depths range from ~30 to 50 feet (shallow wells) and ~83 to 136 feet (deep wells)
- Overburden well depths range from ~20 to 72 feet
- 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
- The permeability of the deeper portion of the bedrock aquifer is expected to be very low

Well Installation Status/Planned Events

- 13 wells installed in May/June 2007 and 9 wells have been or will be installed in November/December 2007
- Permeability testing of each well will be conducted using slug test method
- USGS to measure groundwater-flow directions
  - Colloidal borescope flowmeter during wet climatic conditions for all wells and in dry conditions for selected wells
  - Heat-pulse based flowmeter for up to five wells
- USGS to measure residence time of groundwater
  - Chlorofluorocarbon compounds (Freon-11, Freon-12, Freon-113) for age dating constituent (post-1930's recharge dates through present)
  - Tritium (reporting limit to about 2 pCi/L) for relative age date (either pre- or post-1952 recharge) and for refined tritium/helium-3 age date
  - Helium-3 for refined age date of modern to post-1952 recharge

Project DQOs

- ***Step 1: State the Problem***
  - The Army needs to collect and analyze characterization data to support the decommissioning of the JPG DU Impact Area by the end of 2011 or earlier. The project is structured and phased to address the data gaps outlined in Army and NRC documentation subject to funding availability and adapted based on annual (or more frequent) meetings with NRC.
- ***Step 2: Identify the Decision***
  - Principal Study Question: Is DU or are DU corrosion products present at levels distinguishable from background that could impact the health of average members of the critical group (based on restricted use and if controls fail) or are DU corrosion products migrating off-site at concentrations that could result in potentially unacceptable hazards to human health?
  - Alternative Actions: License Termination (unrestricted or restricted release) or License Amendment and Army/NRC coordination to address pathway(s) of concern
  - Decision Statement: If the total effective dose equivalent (TEDE) from DU exposure is below release criteria, the Army will request the termination of their possession-only NRC license (SUB-1435). If not, the Army will coordinate with NRC to address pathway(s) of concern.

Project DQOs (cont'd)

- ***Step 3: Identify Inputs to the Decision***
  - Direct measurements
    - Distribution and concentrations of DU corrosion products in soil, surface water, sediment, groundwater, and biological tissue
    - Hydrologic and hydrogeologic study results
    - DU penetrator corrosion and K_d studies
  - Modeling results to be developed
    - Concentrations in media up to 1,000 years after planned license termination at points within and outside sampled areas
    - Dose modeling results
  - Release criteria (assumes criteria in § 20.1403(a), (b), and (c) have been satisfied and criteria in § 20.1403(e) will not be used)
    - TEDE from residual radioactivity distinguishable from background to the average member of the critical group will not exceed 25 mrem (0.25 mSv) per year and achieves as low as reasonably achievable (ALARA)
    - TEDE from residual radioactivity distinguishable from background to the average member of the critical group will not exceed 100 mrem/year (if institutional controls fail) and achieves ALARA

Project DQOs (cont'd)

- ***Step 4: Define Study Boundaries***
  - Spatial – Horizontal:
    - DU Impact Area
    - JPG areas outside of the DU Impact Area
    - Area downgradient/downwind of JPG
  - Spatial – Vertical:
    - Maximum depth of DU contamination
  - Temporal:
    - Up to 1,000 years after date of planned license termination
- ***Step 5: Develop a Decision Rule***

Action	Conclusion	Rationale
TEDEs equal or fall below limits of 25 and 100 mrem/year	Terminate Army's Possession-Only License	TEDEs achieve release criteria
TEDEs exceed either limit of 25 or 100 mrem/year	Further action required	TEDEs exceed release criteria

Project DQOs (cont'd)

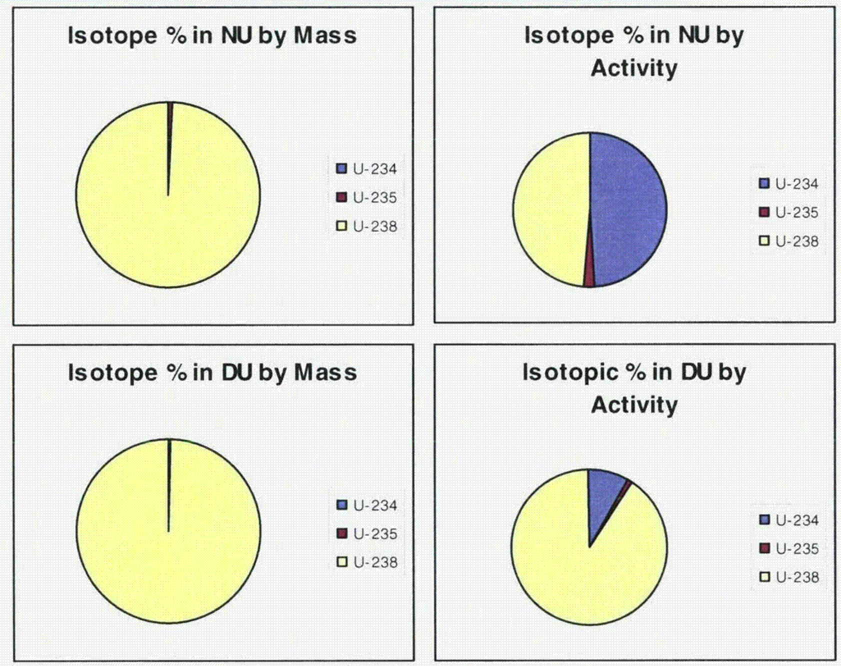
- ***Step 6: Specify Tolerable Limits on Decision Errors***
  - A non-statistical sampling approach will be used for sampling most media (soil sampling only possible exception)
    - Baseline condition or null hypothesis (H_0): The survey unit (DU Impact Area) is contaminated above the release criteria
    - Alternative hypothesis (H_a): The survey unit is not contaminated above the release criteria
  - Type I decision error (H_0 is rejected when it is actually true): The survey unit is not contaminated above the release criteria when it actually is.
  - Type II decision error (H_0 is accepted when it is actually false): The survey unit is contaminated above the release criteria when it actually is not.

Project DQOs (cont'd)

- ***Step 7: Optimize the Design for Obtaining Data***
  - Phase I: Off-site migration potential and pathways
    - Stream and cave spring gauges
    - Groundwater wells
    - Distribution and concentrations of DU corrosion products in groundwater, surface water, sediment, and biota
  - Phase II: Source and release characterization
    - DU penetrator corrosion analysis
    - Transport of DU corrosion products
    - Distribution and concentrations of DU corrosion products in soil
  - Phase III: Modeling
    - Fate and transport modeling
    - Dose modeling
  - Phase IV: Decommissioning Plan

Natural versus Depleted Uranium

- Natural Uranium
  - 99.284, 0.711, and 0.005 percent ^{238}U, ^{235}U and ^{234}U, respectively, by weight
  - 48.6, 2.2 and 49.2 percent ^{238}U, ^{235}U and ^{234}U, respectively, by activity
- Depleted Uranium
  - 99.7990, 0.200, and 0.0010 percent ^{238}U, ^{235}U and ^{234}U, respectively, by weight
  - 90.14, 1.45 and 8.40 percent ^{238}U, ^{235}U and ^{234}U, respectively, by activity
- Natural ratio of ^{238}U to ^{235}U = 137.5 +/- 0.5
- Natural ratio of ^{238}U to ^{234}U can vary more than the ^{238}U to ^{235}U ratio
- Variability of depleted uranium used by NATO



Uranium Analysis Goals

- Analytical goals
  - Locate localized areas of potential contamination using geo-referenced survey tool
  - Detect and quantify uranium at natural levels in various environmental media
  - Quantify uranium isotopes found in natural and depleted uranium (^{238}U, ^{235}U, and ^{234}U)
- Performance and resource requirements for analyses
  - Sample processing and analysis times
  - Commercial availability
  - Limitations due to interferences
  - Detection limits
  - Cost

Analytical Alternatives for Uranium Detection

- Gamma Spectroscopy
  - Well-established analytical protocols
  - Homogeneity
  - Limited use for isotopic ratios due to detection considerations
- Alpha Spectrometry
  - Very low detection limits
  - Well-established analytical protocols
  - Requires separation chemistry; Correction for chemical recovery
  - Detection of ^{235}U may necessitate use of other isotopes for assessments
- Inductively Coupled Plasma – Mass Spectrometry (ICP-MS)
  - Very low detection limits
  - Excellent for water with low solids; Solids require laser ablation or separation chemistry
  - Potential QA/QC and chemical recovery issues
- Recommendation: Continued use of Alpha Spectrometry (ASTM Method D3972-90M) to measure total and isotopic uranium (^{238}U, ^{235}U, and ^{234}U) with Minimum Detectable Concentration (MDC) = 0.1 pCi/L or pCi/g

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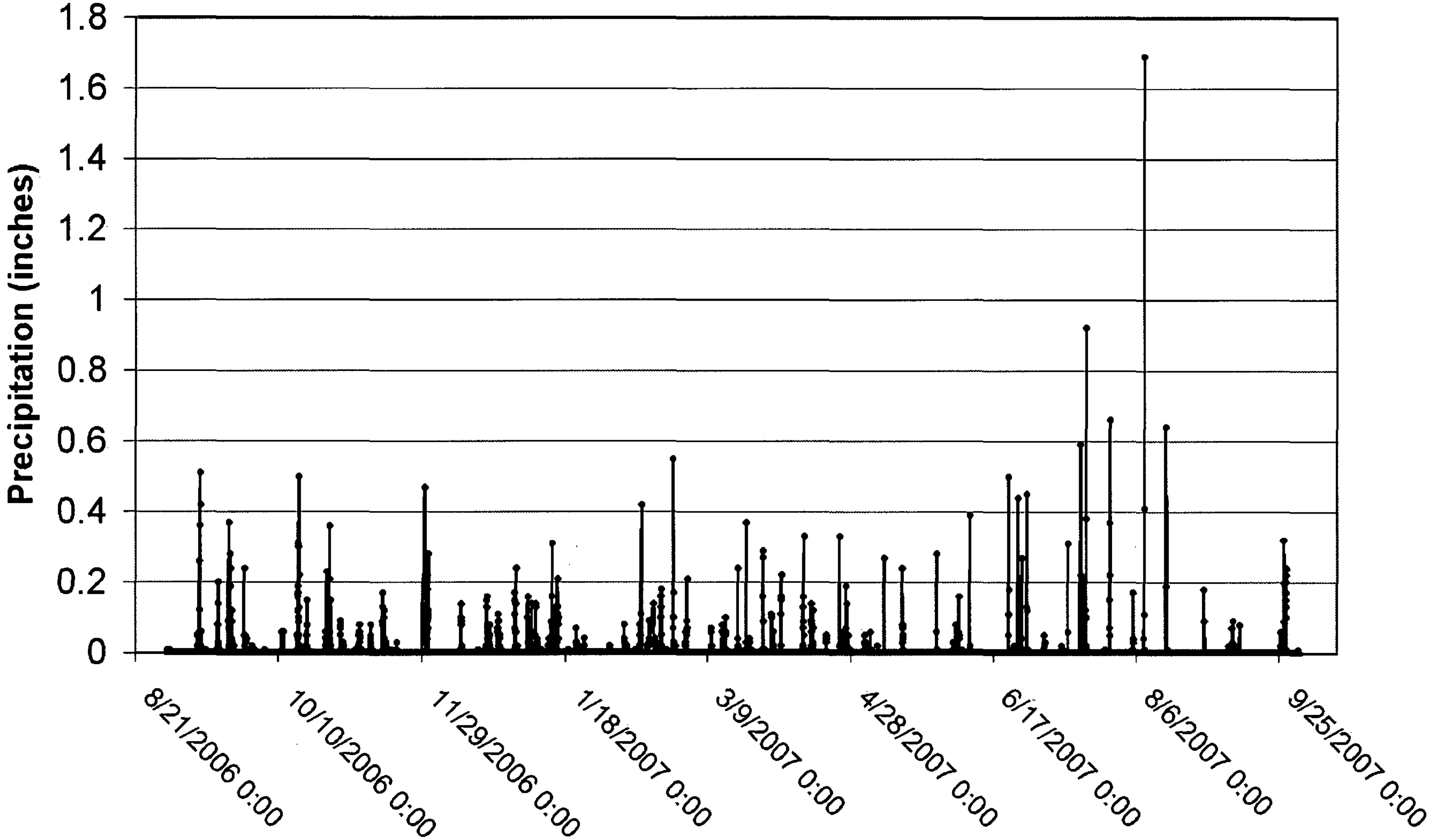
SW and Sediment Sampling

- Samples collected to measure surface water and sediment quality
- Samples collected to address potential for surface water to transport dissolved DU or suspended DU particles outside of the DU Impact Area
- Surface water and sediment sampling augments groundwater characterization (e.g., sampling observed seeps)
- Big Creek and Middle Fork Creek will be surveyed as follows:
  - Areas of where groundwater discharges to the surface as springs or seeps will be identified
  - Areas of sediment deposition will be identified (where the surface water flow is low and/or deposition is most likely such as bends in the creek)
  - Gamma walkover survey will be conducted along the stream corridors
  - All surveys will be digitally recorded and geo-referenced using global positioning system (GPS)

SW and Sediment Sampling (cont'd)

- Surface water sampling points collected from groundwater influx points (springs or seeps) and possibly before surface water tributary convergence points
- Sediment sampling points will be selected where recent deposits are observed
- Additional sediment samples will be collected at areas identified during gamma survey (> 2,000 counts per minute [cpm] above background)
- Field measurements will be recorded (conductivity, dissolved oxygen, flow, oxidation/reduction potential (ORP), pH, salinity, temperature, turbidity)
- Field observations will be recorded (e.g., presence of penetrators, relation to land features, changes in stream configuration, description of stream-bottom)

USFWS Weather Station Data



Sampling evenly spaced throughout hydrologic year with low occurring in October
(first year of sampling planned for April 2008, June 2008, October 2008, January 2009)

SW and Sediment Sampling (cont'd)

- Appropriate sample locations will be selected based on observed conditions within each of the following areas:
  - Five locations on Big Creek (one at western boundary of DU Impact Area on the northern tributary, one at upstream boundary of DU Impact Area, one within, one at downstream boundary of DU Impact Area, and one at the downstream boundary of JPG)
  - Three possible SW sediment sample locations within intermittent tributaries to Big Creek that originate and flow within the DU Impact Area
  - Four locations on Middle Fork Creek (three downstream of the DU Impact Area, and one at the downstream boundary of JPG)
  - Seven locations at cave spring locations along Big Creek within the DU Impact Area
  - Two location at a cave/springs along Middle Fork Creek
- If SW sample locations are dry or not flowing there will be back-up locations selected and prioritized for replacement of dry locations
- Possibility of adding and/or moving sample locations after initial gamma survey

SW and Sediment Sampling Specifications

- Sediment samples collected in 8-ounce glass jars
- Surface water samples collected in 1-L polyethylene bottles
- Sediment and surface water samples analyzed using alpha spectrometry (ASTM Method D3972-90M) for total and isotopic uranium (^{238}U, ^{235}U, and ^{234}U)
- Samples will not be filtered
- Samples will be preserved (pH < 2 with HNO_3) to inhibit biological growth and to leach uranium from the particles in the water
- Duplicate samples collected and analyzed at a rate of one per ten samples (i.e., 10%)
- Surface water samples also will be analyzed for alkalinity, anions (nitrate, chloride, sulfate), cations (calcium, potassium, magnesium, sodium), and dissolved iron

Groundwater Sampling

- Samples from 19 existing wells plus 22 newly installed wells
- Sampling to coincide with surface water and sediment sampling (evenly spaced throughout hydrologic year – April 2008, June 2008, October 2008, January 2009)
- USGS groundwater-flow direction and residence-time measurements to coincide with SAIC sampling events
- Sample collection, handling, and analysis similar to surface water (e.g., analyzed for total and isotopic uranium, no filtering, preservation to pH < 2)
- Well purging practices established for sustainable yielding wells (above the minimal pumping capabilities) and low yielding wells
- Samples also will be analyzed for alkalinity, anions (nitrate, chloride, sulfate), cations (calcium, potassium, magnesium, sodium), and dissolved iron

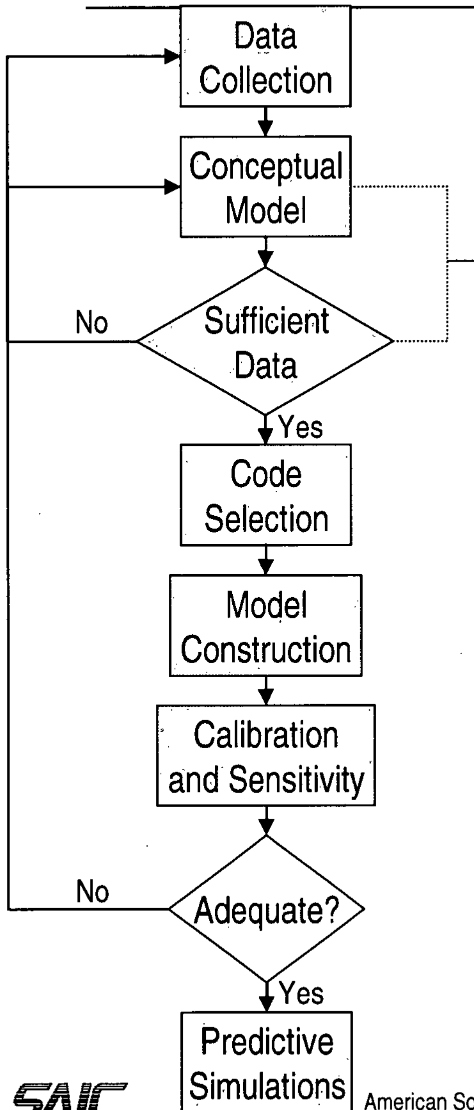
Well Yield-Matched Purge Sampling Technique

- Incorporates some aspects of low-flow or micro-purge sampling techniques
- Reduces “stress” in the aquifer by pumping at a rate equal to or less than well yield
- Reduces well bore mixing after completion of purge by sampling directly from purging equipment
- Reduces turbidity of samples by not stirring up or “stressing” the well
- Purges from the water-bearing zones not causing the filter pack or water-bearing zone to be exposed to air or aerated
- Wells sampled in order from lowest suspected concentrations (sampled first) to well with highest suspected concentrations (sampled last)

JPG Modeling Goals

- Predict concentrations at potential exposure points (soil, groundwater, surface water, sediment, biota) both onsite and offsite for current and future receptors
- Predict uranium aqueous species and include results in transport modeling
- Estimate doses from potential exposures to DU corrosion products (distinguishable from background) for average members of the critical group (based on restricted use and if controls fail)
- Support decommissioning decisions

Modeling Process

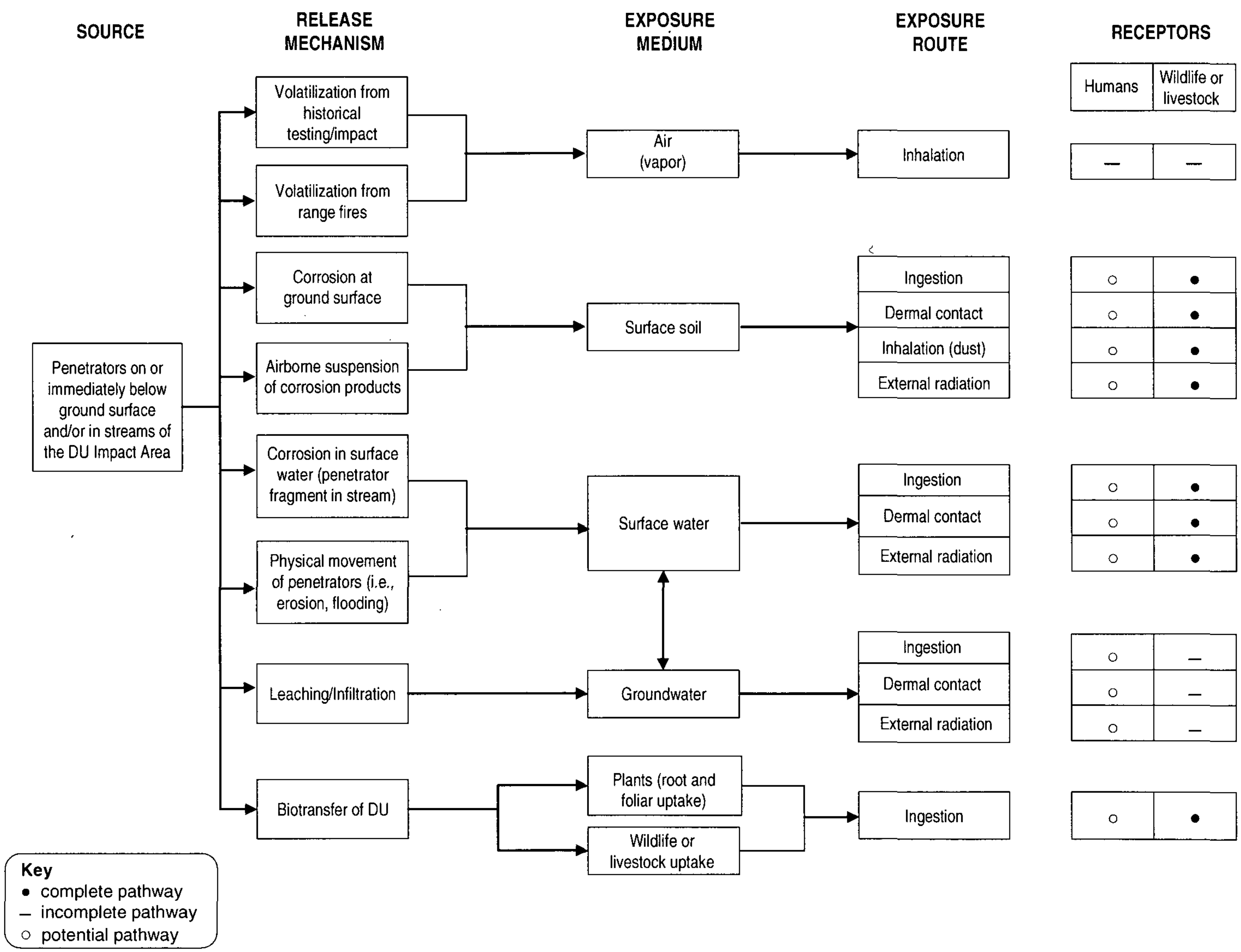


The Army is collecting and evaluating data needed to confirm key aspects of the conceptual model

Levels of Modeling Complexity

- ☐ Rudimentary analytical modeling
- ☐ Model as a simplified dimensionality/system (e.g., 1- or 2-dimensional modeling approaches)
- ☐ Model as integrated 3-dimensional physical system

Potential Pathways for DU Migration/Exposure



Potential Data Needs for GW Transport Models

- Flow system boundaries (for 3-D model, extends beyond boundary of DU Impact Area to surface water features)
- Depths and thicknesses of each geologic unit
- For each geologic unit:
  - Groundwater elevations
  - Recharge rates (based on stream flow hydrograph separation and unit area recharge calculations)
  - Discharge rates (based on flow at cave entrances with gauges)
  - Discharge locations (based on GPS/survey of cave entrances)
  - Hydraulic conductivities (based on slug tests)
  - Effective porosities (geotechnical analysis of soil/rock)
  - Hydraulic conductivity/saturation relationships (for unsaturated materials, geotechnical analysis)
- Constituent-specific data needs

Potential Data Needs for SW Transport Models

- Configuration of branched stream network (GIS topographic data)
  - Elevation, latitude, and slope of each land area
  - Vegetation cover of each land area
- Flow (stream and cave spring gauge data)
  - Flow at upstream boundaries
  - Point inflow or withdrawal
  - Lateral inflows and withdrawals
- Meteorology (downloaded from nearest weather station)
  - Cloud cover
  - Air temperature (dry and wet bulb)
  - Wind speed
  - Barometric pressure
  - Precipitation
  - Dew-point
  - Solar radiation
- Constituent-specific data needs

Constituent-Specific Data Needs

- Initial distribution and concentrations of uranium
  - Groundwater wells – concentrations
  - Surface water – concentrations upstream boundary of DU Impact Area, within, at downstream boundary of DU Impact Area, and at the downstream boundary of JPG
- For each hydrogeologic unit and surface water areas in which transport is simulated:
  - Fluid chemistry (anions, cations, pH, oxidation-reduction potential, etc.)
  - Dispersion coefficients (literature values for soil)
  - Bulk densities (literature values or geotechnical analysis of soil/rock)
- For DU:
  - Corrosion rate (laboratory analysis)
  - Partition coefficient (laboratory analysis)

Available Models Under Consideration

- Integrated multi-media and dosimetry models
  - RESRAD (Residual Radioactivity model) – calculates site-specific RESidualRADioactive material guidelines as well as radiation doses and excess lifetime cancer risks to chronically exposed on-site residents (developed by Argonne National Laboratory)
  - RESRAD-Offsite – extension of RESRAD code to include 3-D dispersion groundwater flow and radionuclide transport model, Gaussian plume model for atmospheric dispersion, and deposition model to estimate the accumulation of radionuclides in offsite locations and in foods (developed by Argonne National Laboratory)
  - DandD Software – developed to provide a simple screening approach for demonstrating compliance with 10 Code of Federal Regulations (CFR) 20, Subpart E (developed by NRC)

Available Models Under Consideration (cont'd)

- Integrated multi-media and dosimetry models (cont'd)
  - GENII-NESHAPS – consists of an atmospheric transport model, an environmental accumulation model, an exposure module, and a dose/risk module (originally developed by the U.S. Department of Energy in 1988 and updated by USEPA in 2002)
  - Multimedia Environmental Pollutant Assessment System (MEPAS) – physics-based environmental analysis code for endpoints such as concentration, dose, or risk using air, groundwater, surface-water, overland, and exposure models (simulates release from the source, transport through air, groundwater, surface water, or overland, and transfer through food chains and exposure pathways to the exposed individual or population) (developed by Pacific Northwest Laboratory)
  - GoldSim Pro with Radionuclide Transport (RT) Module – models complex, real-world multi-media environmental systems and assesses the risk of those environmental systems (includes a specialized element to facilitate simulation of transport in complex fractured rock networks) (developed by the GoldSim Technology Group)

Available Models Under Consideration (cont'd)

- Groundwater Transport
  - Finite Element Heat and Mass Transfer (FEHM)
    - Developed by Los Alamos National Laboratory
    - Numerical simulation code for subsurface transport processes (3-D, time-dependent, multiphase, multicomponent, nonisothermal, reactive flow through porous and fractured media)
    - Model integrated into GoldSim for predicting radionuclide transport in the unsaturated zone at Yucca Mountain
  - University of Texas Chemical Compositional Simulator (UTChem)
    - Developed by University of Texas
    - 3-dimensional, multiphase, multicomponent, compositional, variable temperature, finite-difference numerical simulator

Available Models Under Consideration (cont'd)

- Surface Water Transport
  - QUAL2E (Enhanced Stream Water Quality Model)
    - Developed by USEPA
    - Steady-state, 1-dimensional model to simulate flow and water quality in streams and rivers that can be assumed to be well-mixed
  - HSPF (Hydrological Simulation Program)
    - Jointly developed by USGS and USEPA
    - Simulates hydrologic and associated water quality processes on pervious and impervious land surfaces and in streams and well-mixed impoundments for extended periods of time
  - One-Dimensional Transport with Equilibrium Chemistry (OTEQ)
    - Developed by USGS with equilibrium code based on MINTEQ (USEPA)
    - Mathematical simulation model to characterize the fate and transport of water-borne solutes in streams and rivers

Available Models Under Consideration (cont'd)

- Geochemical Speciation Models
  - MINTEQA2
    - Developed by USEPA
    - Equilibrium speciation model to calculate equilibrium composition of dilute aqueous solutions (mass distribution among dissolved species, adsorbed species, and multiple solid phases under a variety of conditions including a gas phase with constant partial pressures)
  - PHREEQC
    - Developed by USGS
    - Performs low-temperature aqueous geochemical calculations based on an ion-association aqueous model (speciation and saturation-index calculations; batch-reaction and 1-D transport calculations; inverse modeling)

Model Selection Recommendations

- Identify preliminary data needs based on model types and specify data sources (i.e., field/laboratory measurements, literature values, or engineering estimates)
- Use existing data to identify potential models and conduct preliminary trial-runs within next 6 months
  - Run conservative and/or representative simulation for limited area
  - Use simulations to confirms completeness of data collection parameters
  - Present results at next meeting
- Complete characterization to evaluate data sufficiency in conjunction with NRC experts
  - Confirm understanding of conceptual site model
  - Confirm significant transport and exposure pathways
  - Evaluate applicability of preferred models and results of preliminary simulations
- Select appropriate codes, complete model construction, and conduct calibration/sensitivity analyses in conjunction with NRC experts

Summary and Conclusions

- Upcoming milestones
  - Surface water, sediment, and groundwater sampling to be conducted quarterly beginning in April 2008
  - Army to submit FSP Addendum 5 in January 2008 for NRC review
  - Need to schedule next Army/NRC meeting prior to soil sampling, penetrator corrosion study, and K_d study (June 2008)
  - Army to submit FSP Addendum 6 in June 2008 for NRC review
  - Soil sampling, DU penetrator corrosion study, and K_d study (FSP Addendum 6) to begin in summer 2008
- Stream and Cave Spring Gauges
  - Nine continuous electronic recording gauges and one staff gauge installed
  - Manual measurements taken and data downloaded monthly since September 2006 and quarterly since August 2007
  - Will run PART and RORA computer program analysis to estimate recharge to the aquifer and re-run annually

Summary and Conclusions (cont'd)

- Groundwater Well Installation
  - 22 new bedrock and overburden wells installed in May/June and November/December 2007
  - Wells constructed in most permeable zones observed during drilling within "shallow" and "deep" bedrock to characterize most probable flow pathways
  - Fractured/weathered zones occur in the top 50 feet
  - 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
  - The permeability of the deeper portion of the bedrock aquifer is expected to be very low
  - Permeability, flow direction, and residence time tests are planned

Summary and Conclusions (cont'd)

- Analytical Methodology
  - Different options for measuring uranium concentrations
  - Recommend continued use of alpha spectrometry
  - Measure total and isotopic uranium (^{238}U, ^{235}U, and ^{234}U)
  - MDC = 0.1 pCi/L or pCi/g
- Model Selection
  - Discussed modeling goals, ASTM's modeling process, predominant pathways for DU migration, and key factors potentially affecting model selection
  - Discussed general data needs and models currently under consideration
  - Recommended collaborative selection and evaluation process for appropriate codes, construction of models, and conducting calibration/sensitivity analyses in conjunction with NRC experts