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Derivative Classifier: D. B. Moore-Shedrow
D. B. Moore-Shedrow, Section Manager
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**THREE DIMENSIONAL DIGITAL IMAGING
OF ENVIRONMENTAL DATA (U)**

R. L. Nichols
C. A. Eddy

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Authentication: Ralph L. Nichols

Approved by: D. B. Moore-Shedrow
D. B. Moore-Shedrow, Manager
Environmental Sciences Section
Savannah River Laboratory

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WESTINGHOUSE SAVANNAH RIVER COMPANY
SAVANNAH RIVER SITE
AIKEN, SC 29808

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1.0 INTRODUCTION

The Environmental Sciences Section (ESS) of the Savannah River Laboratory has recently acquired the computer hardware (Silicon Graphics Personal Iris Workstations) and software (Dynamic Graphics, Interactive Surface and Volume Modeling) to perform three dimensional analysis of hydrogeologic data.

Three dimensional digital imaging of environmental data is a powerful technique that can be used to incorporate field, analytical, and modeling results from geologic, hydrologic, ecologic, and chemical studies into a comprehensive model for visualization and interpretation.

2.0 TRICHLOROETHYLENE GROUNDWATER CONTAMINATION IN A/M AREA

The A/M Area of SRS is the location of the Savannah River Laboratory, site administration and raw materials processing facilities. Historical area operations have resulted in the use and disposal of industrial solvents (i.e., TCE, PCE). Subsurface transport of solvent waste from waste disposal facilities has resulted in contamination of groundwater with volatile chlorinated organic chemicals.

- Data input consists of TCE (industrial solvent) concentrations measured in samples from more than 350 groundwater monitoring wells.
- The distribution of groundwater contamination is heterogeneous and is controlled by varying aquifer properties and hydrogeologic boundaries (i.e., streams). Figure 2-1 is a plan view of the A/M Area contamination with some of the prominent surface features.
- In the A/M Area, the groundwater flow in shallow sediments is predominantly down. In deeper sediments, the groundwater flow is lateral towards a local discharge boundary. An example of this type of groundwater flow is illustrated by the "southern sector" plume shown at the lower left in Figure 2-2.
- The groundwater contamination depicted in the upper right hand corner of Figure 2-2 is beneath the Savannah River Laboratory.
- Figure 2-3 is a cut away view of the A/M Area plume looking east showing groundwater contamination beneath the M Area Basin.

Figure 2-1: Plan view of the A/M Area. Yellow lines indicate roads and buildings, and the blue lines indicate streams.

A/M Area 3Q90 TCE

Figure 2-2: Oblique angle view of A/M Area groundwater contamination. View is to the west. A block of the model has been removed to reveal the intricate three dimensional geometry of the ground water contamination plume.

A/M Area 3Q90 TCE

Figure 2-3: View of A/M Area groundwater contamination toward the east. The small yellow squares illustrate the location of screened intervals in monitoring wells.

3.0 TRICHLOROETHYLENE AND TETRACHLOROETHYLENE CONTAMINATION OF SEDIMENTS AND GROUNDWATER AT THE INTEGRATED DEMONSTRATION SITE

A DOE sponsored Integrated Demonstration Project designed to evaluate innovative remediation technologies for environmental restoration at sites contaminated with volatile organic contaminants is located within the A/M Area. Extensive environmental characterization of the site was performed in order to evaluate the effectiveness of the technologies tested.

- Three dimensional digital imaging was used to model the distribution of two volatile contaminants, trichloroethylene (TCE) and tetrachloroethylene (PCE), in the sediments, and to model the distribution of bacterial colonies culturable on enriched nutrient media.
- Duplicate analyses from over seven hundred sample locations were used to create the models of the contaminant distribution. Figure 3-1 shows the distribution of TCE in concentrations of 1 ppm or greater in the sediment at the Integrated Demonstration Site. The TCE is localized within zones at elevations of 270, 300, and 325 feet. The sediment at these elevations have a significant component of clay-sized material suggesting that the clay-rich layers concentrate the TCE in the sediment.
- Figure 3-1 shows the distribution of PCE in concentrations of 1 ppm or greater and is shown in the same orientation as Figure 3-1. The PCE is concentrated in the shallow clay layers at 300 and 325 feet but is not widely distributed in the lower clay-rich zones. This is consistent with historical records of solvent use that indicate that PCE was used as a solvent only in the later period of waste disposal. In addition it illustrates the difference in migration rates for PCE verses TCE, i.e., TCE migrates faster than PCE in the subsurface.
- Figure 3-3 shows the distribution of microbial colony forming units at the same site. Microbes are more abundant at the surface, and at and below the water table. This information will be used to determine the effect of nutrient stimulation on indigenous microflora and to control the biodegradative capacity of the environment.

Pretest TCE ($Z=0.001$) at the IDS
Savannah River Laboratory

Figure 3-1: Distribution of TCE in sediment in the vadose zone and upper aquifer zone at the Integrated Demonstration Site. Contamination at levels ≥ 1 ppm in the sediment is shown.

Pretest PCE (Z=0.001) at the IDS
Savannah River Laboratory

0.001 to 0.001 (Z=0.001)

0.001 to 0.001 (Z=0.001)
Azimuth: 100
Inclination: 150

Figure 3-2: Distribution of PCE in the vadose zone and upper aquifer zone sediments at the Integrated Demonstration Site. Figure 3-2 is shown in the same orientation as Figure 3-1. Small yellow squares designate sample locations.

Pretest Bacteria High Nutrient
Savannah River Laboratory

Figure 3-3: Abundance of microbial colony forming units culturable on high nutrient media from sediment samples at the Integrated Demonstration Site. The scale is in log units.

4.0 TRICHLOROETHYLENE CONTAMINATION OF GROUNDWATER IN THE TNX AREA

The TNX Area is a pilot scale test facility for the Savannah River Laboratory. Wastewater from a diverse suite of research activities was disposed of in unlined seepage basins until 1988 and resulted in groundwater contamination throughout the area.

- A three dimensional model of groundwater monitoring data for TNX was prepared to integrate several types of data. Data used in the model includes analytical results from 35 monitoring wells, lithologic and geophysical logs, aquifer performance tests, and potentiometric data.
- Well construction details and historical groundwater monitoring data were compiled into cross sections to show the vertical and lateral distribution of TCE along a given two dimensional plane, see Figure 4-1 for location of the cross sections. The cross sections were then digitized and imported into the environmental workstation.
- Three dimensional digital imaging was used to model the area between the cross sections yielding a more complete understanding of the lateral and vertical extent of groundwater contamination at TNX. Figure 4-2 is a perspective view of the TNX area showing surface topography (shaded brown surface), the unsaturated zone above the water table (light green), and the unconfined aquifer (purple). The unconfined aquifer discharges to the Savannah River and local seeps in the floodplain east of the Savannah River. The concentration of TCE in the groundwater is shown by the shades of green in some of the seeps.
- In Figure 4-3 the unsaturated zone has been removed and a block has been cut out of the contaminated aquifer to illustrate the three dimensional nature of the model. The yellow lines on Figure 4-3 represent screened intervals in the groundwater monitoring wells in the TNX Area.
- This model will be used to estimate the contaminant inventory and to evaluate remediation alternatives.

Figure 4-1: Location of cross sections used to prepare TNX model. Yellow lines indicate the location of the cross sections.

Figure 4-2: Perspective view of TNX model. The topographic surface is shown in shades of brown, the unsaturated zone in light green, and the unconfined aquifer in purple. TCE contamination is shown in some of the seeps in light green.

5.0 TRITIUM CONTAMINATION IN THE GROUNDWATER AT THE GENERAL SEPARATIONS AREA

The General Separations Area (GSA) at the Savannah River Site processes materials that are generated in the reactor areas. In the past wastewater from the GSA was disposed of in unlined seepage basin resulting groundwater contamination.

- A detailed hydrogeologic investigation at the GSA has identified tritium contamination of 3 shallow aquifers. The results of this investigation have been integrated with groundwater monitoring and numerical modeling results using 3 dimensional digital imaging techniques. In Figure 5-1 each of the 3 aquifers is identified with a different color. The tops and bottoms of the aquifers are represented in the model as irregular 2 dimensional surfaces.
- The upper aquifer has been removed in Figure 5-2 to reveal the distribution of tritium in the middle aquifer. Varying tritium concentrations are represented by different colors. The highly irregular surface in the right center of the figure has occurred as a result of the dissolution of underlying carbonate zones followed by subsidence.
- Numerical simulations of groundwater flow in the GSA have been performed to assist scientists and engineers in the design of a remediation system. Results of the numerical simulations have been integrated in the model of tritium concentration in Figure 5-3. The yellow lines indicate the path followed by particles that were released in the numerical model. The particles were released from sources of known contamination and moved laterally and vertically as shown by the figure. Note that some of the particles go downward and then curve up; this indicates that these particles would be captured by a nearby stream that is known to receive groundwater discharges. Some of the particles are not captured by the stream, but instead they migrate into the deepest of the 3 aquifers in the model and begin to move in the opposite direction toward a different discharge point.

Figure 5-1: Three aquifer model of General Separations Area. Each aquifer is represented by a different color.

GSA Tritium (3Q90, z=0.5)

Figure 5-2: Tritium contamination in the middle aquifer at the GSA. The bright yellow squares indicate high concentrations beneath the H Area seepage basin.

GSA Tritium (3Q90, $z=0.5$)

Figure 5-3: Flow paths (yellow lines) for particles released in the groundwater at the H Area seepage basin. The middle aquifer and lower portion of the bottom aquifer have been removed to reveal the flow paths. Note the reverse in the flow direction of some of the particles.

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