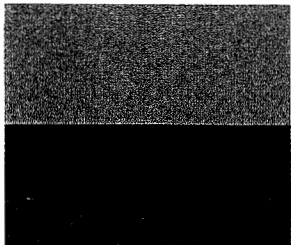




Electric Power  
Research Institute

Keywords:  
Groundwater  
Dispersions  
Transport  
Hydrodynamics  
Leachate migration  
Solid-waste disposal

EPRI TR-102072  
Project 2485-05  
Interim Report  
February 1993



## **Database for the Second Macrodispersion Experiment (MADE-2)**

Prepared by  
Tennessee Valley Authority  
Norris, Tennessee

## Database for the Second Macrodispersion Experiment (MADE-2)

Results from an investigation of the transport of reactive and non-reactive tracers in a saturated, heterogeneous aquifer make up the MADE-2 database. Detailed measurements of site hydraulic characteristics as well as spatial distributions of tracer concentrations throughout the duration of the experiment are contained in this database, which will assist utilities in establishing dispersivity for use with hydrogeochemical models and in understanding the attenuation of reactive organic chemicals.

---

### INTEREST CATEGORIES

Land and water quality—  
hydrogeochemical  
modeling  
Waste and water  
management  
Waste disposal and use  
Risk analysis,  
management, and  
assessment

---

### KEYWORDS

Groundwater  
Dispersions  
Transport  
Hydrodynamics  
Leachate migration  
Solid-waste disposal

---

**BACKGROUND** Dispersive transport is a physical process influencing the migration and distribution of chemicals entering the subsurface environment. Advective and dispersive transport mechanisms influence the movement of dissolved chemicals in the subsurface and consequently play a major role in determining where and when chemical and biological interactions with the ambient minerals and aqueous components will occur. As an integral part of the Solid-Waste Environmental Studies (SWES) project, two field-scale macrodispersion experiments (MADE) were conducted to perform a complete hydraulic characterization of a heterogeneous aquifer and to execute a tracer injection and plume tracking program. The first macrodispersion experiment (MADE-1) was focused on the transport of nonreactive tracers only (EPRI report EN-7363). In MADE-2, nonreactive, reactive, and degrading chemicals were included in the tracers injected.

---

**OBJECTIVE** To create a comprehensive database for developing methods for quantifying both macrodispersion in the saturated subsurface and the biological and chemical processes affecting the transport of dissolved organic chemicals.

---

**APPROACH** Researchers performed field studies at the MADE site to establish the heterogeneous hydraulic character of the aquifer in which the second tracer experiment was conducted. They injected a solution containing five tracers into the aquifer's saturated zone using five wells screened over a depth of 0.6 m. During a 48-hour period, they introduced 9.7 m<sup>3</sup> of solution, producing a finite-duration rectangular source that resulted in the formation of a three-dimensional plume. A sampling network containing 328 multilevel samplers captured the three-dimensional distribution of the tracers in the saturated zone. Synoptic samplings of the plume established the spread of chemicals over time. Sampling was performed more frequently along two rows (fencelines) of the network. Piezometric head measurements were made during the experiment to facilitate interpretation of the tracer migration pathways.

---

**RESULTS** The measurements of hydraulic data and tracer concentration made during the field study have been cataloged to form the MADE-2 database. The data are organized into four directories, one for each of the data types—snapshot tracer concentrations, fenceline tracer concentrations, piezometric head, and hydraulic conductivity. All tracer concentrations and piezometric head data are cross-referenced to spatial coordinates and the elapsed time of the experiment.

---

The hydraulic conductivity data files are indexed by location and contain the hydraulic head at the time of the measurement.

---

**EPRI PERSPECTIVE** The MADE-1 and MADE-2 databases represent a unique and comprehensive set of measurements to characterize chemical plume behavior in a hydraulically heterogeneous saturated subsurface environment. This database has value to electric utility engineers for three primary reasons:

- To demonstrate to regulators and the public the transport and natural attenuation of inorganic and organic chemicals in groundwater.
- To validate models.
- To assess the ability of flow models to predict dispersion characteristics.

In addition, the database will serve the research community in its efforts to develop new theories and approaches for predicting dispersive transport and the attenuation of reactive chemicals.

---

#### **PROJECT**

RP2485-05

Project Manager: Dave McIntosh

Environment Division

Contractor: Tennessee Valley Authority

For further information on EPRI research programs, call  
EPRI Technical Information Specialists (415) 855-2411.

---

# Database for the Second Macrodispersion Experiment (MADE-2)

TR-102072  
Research Project 2485-05

Interim Report, February 1993

Prepared by  
TENNESSEE VALLEY AUTHORITY  
Engineering Laboratory  
Norris, Tennessee 37828

Principal Investigators  
J. M. Boggs  
L. M. Beard  
S. E. Long  
M. P. McGee

UNITED STATES AIR FORCE  
HQ AFCEA/RDV  
Tyndall Air Force Base, Florida 32403-6001

Principal Investigators  
W. G. MacIntyre  
C. P. Antworth  
T. B. Stauffer

Prepared for  
**Electric Power Research Institute**  
3412 Hillview Avenue  
Palo Alto, California 94304

EPRI Project Manager  
D. A. McIntosh

Land and Water Quality Studies Program  
Environment Division

## **DISCLAIMER OF WARRANTIES AND LIMITATION OF LIABILITIES**

THIS REPORT WAS PREPARED BY THE ORGANIZATION(S) NAMED BELOW AS AN ACCOUNT OF WORK SPONSORED OR COSPONSORED BY THE ELECTRIC POWER RESEARCH INSTITUTE, INC. (EPRI). NEITHER EPRI, ANY MEMBER OF EPRI, ANY COSPONSOR, THE ORGANIZATION(S) NAMED BELOW, NOR ANY PERSON ACTING ON BEHALF OF ANY OF THEM:

(A) MAKES ANY WARRANTY OR REPRESENTATION WHATSOEVER, EXPRESS OR IMPLIED, (I) WITH RESPECT TO THE USE OF ANY INFORMATION, APPARATUS, METHOD, PROCESS, OR SIMILAR ITEM DISCLOSED IN THIS REPORT, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, OR (II) THAT SUCH USE DOES NOT INFRINGE ON OR INTERFERE WITH PRIVATELY OWNED RIGHTS, INCLUDING ANY PARTY'S INTELLECTUAL PROPERTY, OR (III) THAT THIS REPORT IS SUITABLE TO ANY PARTICULAR USER'S CIRCUMSTANCE; OR

(B) ASSUMES RESPONSIBILITY FOR ANY DAMAGES OR OTHER LIABILITY WHATSOEVER (INCLUDING ANY CONSEQUENTIAL DAMAGES, EVEN IF EPRI OR ANY EPRI REPRESENTATIVE HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES) RESULTING FROM YOUR SELECTION OR USE OF THIS REPORT OR ANY INFORMATION, APPARATUS, METHOD, PROCESS, OR SIMILAR ITEM DISCLOSED IN THIS REPORT.

ORGANIZATION(S) THAT PREPARED THIS REPORT:

**TENNESSEE VALLEY AUTHORITY**

## **ORDERING INFORMATION**

Requests for copies of this report should be directed to the EPRI Distribution Center, 207 Coggins Drive, P.O. Box 23205, Pleasant Hill, CA 94523, (510) 934-4212. There is no charge for reports requested by EPRI member utilities and affiliates.

Electric Power Research Institute and EPRI are registered service marks of Electric Power Research Institute, Inc.

Copyright © 1993 Electric Power Research Institute, Inc. All rights reserved.

## ABSTRACT

---

The content and organization of the database for the second macrodispersion experiment (MADE-2) are described. The study consisted of a large-scale natural-gradient tracer experiment conducted over a period of approximately 15 months. The tracers used in the experiment included tritium, benzene,  $^{14}\text{C}$  labeled p-xylene, naphthalene, and o-dichlorobenzene. The experimental database includes five, three-dimensional snapshots of the aqueous concentration distribution for each tracer plume. Tracer time-series data are available for selected points aligned along two lateral rows (fences) within the sampling network. In addition to the tracer data, piezometric head measurements recorded during the study and hydraulic conductivity data derived from borehole flowmeter testing conducted prior to the tracer test are presented. The complete database is provided on three diskettes which accompany the report.

## ACKNOWLEDGMENTS

---

The radiological tracer measurements were performed by Tom Kellogg and Jack Greene of the Water Resources Research Institute at Mississippi State University. Lyman Howe and staff of the TVA Environmental Chemistry Laboratory (Chattanooga) provided analyses for the four organic tracers used in the study. Tracer sample collection and hydrological monitoring at the Columbus site were conducted by James Adams, Carl Terry, and other members of TVA's Field Engineering (West) Department (Muscle Shoals).

# CONTENTS

---

Section	Page
<b>1 INTRODUCTION</b>	<b>1-1</b>
<b>2 EXPERIMENTAL METHODS</b>	<b>2-1</b>
Tracers	2-1
Injection Procedure	2-1
Tracer Monitoring	2-3
Analytical Methods	2-4
Piezometric Measurements	2-5
Hydraulic Conductivity Measurements	2-5
<b>3 DATABASE DESCRIPTION</b>	<b>3-1</b>
Spatial Coordinate System	3-1
Tracer Concentration Data	3-1
Piezometric Data	3-2
Hydraulic Conductivity Data	3-4
<b>4 REFERENCES</b>	<b>4-1</b>
<b>DISKETTE A</b>	
Tracer concentration measurements for MADE-2 natural-gradient tracer experiment	
<b>DISKETTE B</b>	
Hydraulic head measurements recorded at test site, June 1990 through September 1991	
<b>DISKETTE C</b>	
Hydraulic conductivity measurements from borehole flowmeter tests at 67 wells	



## SUMMARY

---

The goal of the MADE-2 project was to develop a field database for validating geohydrochemical models used to predict the transport and fate of groundwater contaminants. A large-scale natural-gradient tracer experiment was conducted to acquire detailed data on the transport of tritiated water and four dissolved organic compounds (benzene, naphthalene,  $^{14}\text{C}$  labelled p-xylene, and o-dichlorobenzene) of interest to the utility industry and the military. The study was conducted at Columbus Air Force Base (Mississippi) between June 1990 and September 1991.

The experiment was performed in a shallow alluvial aquifer characterized by a high degree of heterogeneity. Following a two-day pulse injection of  $9.7 \text{ m}^3$  of tracer solution into the saturated zone of the aquifer, the spatial concentration distributions of the tracers were monitored at one- to three-month intervals using an array of over 300 multilevel samplers. A total of five spatial samplings or snapshots of the tracer plumes were performed. Selected points aligned along two rows or fences within the sampling network were sampled more frequently to develop complete tracer time-series data. Radiotracers were analyzed by liquid scintillation counting, while gas chromatography with flame ionization detection was used to quantify the organic tracers. Tracer concentration data from the natural-gradient experiment are presented in digital form on Diskette A.

The hydraulic head field at the experimental site was monitored with a network of 48 piezometers. Sixteen of these piezometers were equipped with continuous groundwater level recorders. The remainder were monitored at monthly intervals during the study. Diskette B contains the hydraulic head data recorded during the study period.

Aquifer characterization under MADE-2 was limited to a series of hydraulic conductivity measurements in the near-field region of the experimental site. Hydraulic conductivity profiles at 11 fully-penetrating piezometers were derived from borehole flowmeter tests performed in April 1990. These data, along with the hydraulic conductivity measurements for 56 wells previously tested under MADE-1, are given on Diskette C.

## INTRODUCTION

---

MADE-2 represents the second large-scale natural-gradient tracer experiment conducted at Columbus Air Force Base (Figure 1-1). The field study was carried out between June 1990 and September 1991, and was jointly sponsored by EPRI and the U.S. Air Force. Detailed field observations of the transport of tritiated water and four organic compounds (benzene, naphthalene,  $^{14}\text{C}$  labeled p-xylene, and o-dichlorobenzene) were performed during the 15-month experiment. The four organic compounds selected for the experiment are common constituents of various fuels and solvents, and represent an important class of groundwater contaminants of concern to the utility industry and the military. The study was intended to improve understanding of the dominant physical, chemical, and biological processes affecting transport of dissolved contaminants, and lead to improved methods for predicting the transport and fate of groundwater contaminants.

The experiment was initiated with a two-day pulse injection of  $9.7 \text{ m}^3$  of tracer solution into the shallow alluvial aquifer at the test site. Three-dimensional snapshots of the tracer concentration distributions were performed at one- to three-month intervals using an extensive multilevel sampling network. In addition, selected points aligned along two rows (or "fences") within the network were sampled more frequently to develop tracer data for time-series analysis. Piezometric head measurements were recorded during the experiment at monitor wells in the test site vicinity to aid in the interpretation of the tracer migration. Aquifer characterization associated with MADE-2 was limited to hydraulic conductivity testing by the borehole flowmeter method at 11 additional sites.

The experimental methods used in acquiring the data are briefly outlined in Section 2. The tracer injection procedures, analytical methods, piezometric head monitoring, and hydraulic conductivity testing are discussed in this section. Section 3 describes the content and organization of the digital experimental database which accompanies this report. The three principal components of the database include the tracer concentration data (Diskette A), the piezometric head measurements recorded during the experiment (Diskette B), and the aquifer hydraulic conductivity data obtained from borehole flowmeter tests (Diskette C). The hydraulic conductivity database includes measurements for 56 test wells reported in the MADE-1 database along with data for 11 new sites tested as part of MADE-2.

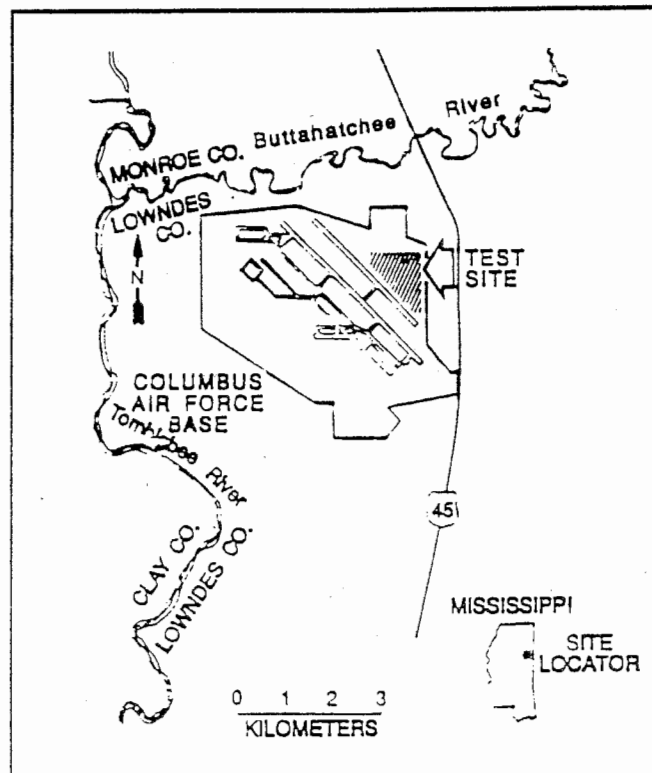


Figure 1-1: Site Location Map

The following is a chronological listing of EPRI publications related to the MADE-1 and MADE-2 field studies:

- \* Macrodispersion Experiment (MADE): Design of a Field Experiment to Investigate Transport Processes in a Saturated Groundwater Zone, EPRI EA-4082, June 1985.
- \* A Review of Field-Scale Physical Solute Transport Processes in Saturated and Unsaturated Porous Media, EPRI EA-4190, August 1985.
- \* Evaluation of Tracer Sampling Devices for the Macrodispersion Experiment, EPRI EA-5816, May 1988.
- \* Estimates of Macrodispersivity Based on Analyses of Hydraulic Conductivity Variability at the MADE Site, EPRI EN-6405, July 1989.
- \* Measuring Hydraulic Conductivity With the Borehole Flowmeter, EPRI EN-6511, September 1989.
- \* Hydrogeologic Characterization of the MADE Site, EPRI EN-6915, July 1990.
- \* Database for the First Macrodispersion Experiment (MADE-1), EPRI EN-7363, June 1991.
- \* Transport of Tritium and Four Organic Compounds During a Natural-Gradient Tracer Experiment (MADE-2), EPRI [in TR-102072], 1992.

## EXPERIMENTAL METHODS

---

### Tracers

The tracers selected for the natural-gradient experiment are listed in Table 2-1 along with their initial concentrations and total injected masses (activities). Tritiated water served as the conservative reference tracer for the experiment. The four organic compounds chosen for the study include benzene, naphthalene, p-xylene, and o-dichlorobenzene (o-DCB). They vary in terms of their mobility in aquifers and in their susceptibility to biotransformation. The p-xylene was labeled with  $^{14}\text{C}$  in order to discern transformation of the p-xylene should it occur during the experiment.

Table 2-1

Initial Tracer Concentrations and Masses (Activities)

Tracer	Mean Aqueous Concentration	Mass Injected
tritium	55,610 pCi/mL	0.5387 Ci
$^{14}\text{C}$ (p-xylene)	2770 pCi/mL	0.0268 Ci
benzene	68.1 mg/L	659.7 g
p-xylene	51.5 mg/L	402.0 g
naphthalene	7.23 mg/L	70.0 g
o-dichlorobenzene	32.8 mg/L	317.7 g

### Injection Procedure

The method of tracer injection was similar to that used in the earlier MADE-1 bromide experiment [Boggs, 1991]. The tracer solution was injected through five wells spaced one meter apart in a linear array (see map inset, Figure 2-1). Each injection well was screened over a 0.6-m interval between elevations 57.5 and 58.1 m. Injection was conducted over a

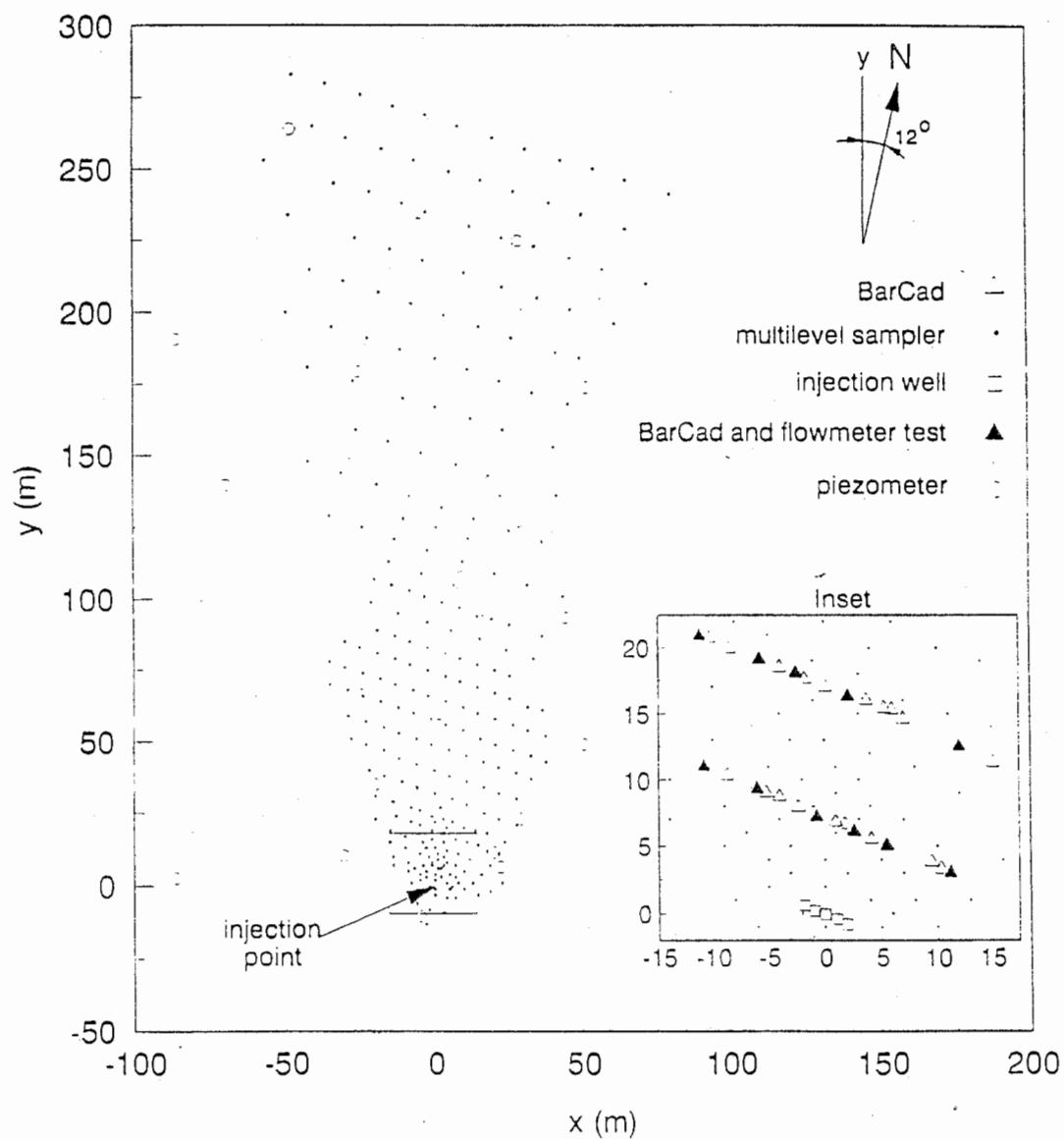


Figure 2-1. Map Showing Tracer Sampling Well Network and Piezometers

period of 48.5 hrs at a uniform rate of 3.3 L/min beginning June 26, 1990. The total volume of solution injected was approximately 9.7 m<sup>3</sup>. The maximum increase in hydraulic head in the injection wells was 0.45 m.

The tracer solution was prepared and stored on-site during injection. Ambient groundwater from a well located approximately 75-m upgradient from the injection point was used to prepare the solution. The tritium and pure-phase organic compounds were mixed and stored in two 2.7 m<sup>3</sup> thermally-insulated tanks equipped with floating lids and a motor-driven impeller mixer. Note that the organic tracers were introduced into the aquifer in the aqueous phase and not as pure product. Samples of the tracer solution were collected at one- to two-hour intervals from the tubes leading to the injection wells. The injected mass (activity) for each tracer was estimated by volume-weighting of the tracer concentration measurements for the samples taken during injection.

### Tracer Monitoring

Figure 2-1 shows the array of 328 multilevel samplers (MLS) used to monitor the tracer plumes in three dimensions during the experiment. Each MLS was equipped with 20 to 30 sampling points spaced 0.38 m apart in the vertical dimension. Groundwater samples from each MLS were simultaneously collected using a mobile sampling cart equipped with three, ten-channel peristaltic pumps. Sampling protocols required purging of 120 mL (approximately four sample tube volumes) of groundwater prior to collection of a 20-mL sample in a glass vial with a Teflon-lined septa cap. Two drops of ten-percent sodium azide solution (a bacteriostat) were added to each sample before sealing. Samples were refrigerated at approximately 4°C in an inverted position (i.e., capped-end down) until analyzed.

Five three-dimensional sampling events or "snapshots" of the tracer plumes were performed at approximately 100-day intervals during the study. General information related to these sampling events is given in Table 2-2. Note that the fifth snapshot, conducted at 440 days, was designed to bound only the organic plumes which were limited to the near-field region of the test site. The more extensive tritium and <sup>14</sup>C plumes were not completely sampled during this event.

**Table 2-2**  
**Tracer Sampling Summary**

Event	Date	Elapsed Time (days)	No. Wells Sampled	Samples Analyzed
F01	Jul 9-11, 1990	13	26	264
S21	Jul 23-27, 1990	27	99	1226
F02	Aug 13-17, 1990	48	31	287
F03	Sep 17-19, 1990	83	53	185
F04	Oct 5-17, 1990	111	39	72
S22	Nov 5-8, 1990	132	111	871
F05	Dec 3-4, 1990	160	29	195
F06	Jan 8-9, 1991	195	25	196
S23	Feb 5-7, 1991	224	190	1976
F07	Apr 3-5, 1991	281	42	387
S24	May 21-23, 1991	328	205	2345
S25	Sep 9-11, 1991	440	79	460

In addition to the MLS network, 56 positive-displacement samplers were installed in the near field along two parallel lines or "fences" oriented normal to the general flow direction (see map inset, Figure 2-1). Rows were spaced approximately 10 m apart, and were located at distances of approximately 6 m and 16 m from the tracer injection point. These samplers were intended to provide reliable concentration time-series data for the volatile organic tracers. As indicated in Table 2-2, the frequency of fence sampling varied from two-week intervals initially to three-month intervals later in the study.

### Analytical Methods

The organic tracers present in the 20-mL groundwater samples were extracted prior to analysis in 5 mL of n-pentane. The resulting extract was analyzed for benzene, naphthalene, p-xylene, and o-DCB by gas chromatography (GC) using a flame ionization detector (FID) system. All samples were extracted and analyzed within 21 days of collection.

The sensitivity of the GC/FID method was 4  $\mu\text{g/L}$  for naphthalene, p-xylene, and o-DCB. A sensitivity of 12  $\mu\text{g/L}$  was initially established for benzene analyses, and was applied to the data for the first snapshot (SNAP1.DAT, Diskette A) and the first two fence sampling events (FENCE1.DAT and FENCE2.DAT, Diskette A). However, subsequent evaluation of the analytical procedures indicated that 50  $\mu\text{g/L}$  was a more appropriate benzene sensitivity. A detection limit of 50  $\mu\text{g/L}$  was applied to all subsequent benzene analyses. Benzene



measurements below 50  $\mu\text{g/L}$  reported in the early snapshot and fence data sets are considered highly uncertain. It is recommended that the higher sensitivity of 50  $\mu\text{g/L}$  be consistently applied in any interpretational studies of benzene transport which involve these early data sets.

Tritium and  $^{14}\text{C}$  present in field samples were measured with a liquid scintillation analyzer in dual isotope mode. Five milliliters of each sample were emulsified in 15 mL of counting cocktail, and held in darkness for at least one hour prior to counting. Samples were counted for 20 minutes or to a one-percent error at the 95 percent probability level, whichever was attained first. Background levels of tritium and  $^{14}\text{C}$  in ambient groundwater at the test site dictated the analytical sensitivity for the experimental measurements, and were approximately 2 and 3 pCi/mL, respectively.

The analytical quality control methods and results for the radiological and non-radiological tracers are presented in Boggs et al. [1992].

### **Piezometric Measurements**

Monitoring of the hydraulic head field in the aquifer at the test site was conducted prior to and during the field tracer experiment using the piezometer network shown on Figure 2-1. Piezometers were constructed of either 5.1-cm or 10.2-cm diameter PVC pipe with either 0.6-m or 1.2-m slotted well screens at the lower end. Piezometers with a suffix letter of A or B represent multistaged piezometers. The type "A" piezometers were screened at an average elevation of 61.1 m, while the type "B" piezometers were screened at an average elevation of 56.3 m. Construction specifications for all piezometers are given in Appendix C of Boggs et al. [1990].

Water levels in the piezometers were manually measured with an electric probe on a monthly basis during the period June 1990 through September 1991. In addition, eight pairs of staged piezometers (P8AB, P27AB, P44AB, P53AB, P54AB, P55AB, P60AB, and P61AB) were equipped with continuous water level recorders.

### **Hydraulic Conductivity Measurements**

The MADE-1 borehole flowmeter hydraulic conductivity database [Boggs, 1991] has been updated to include data for 11 new test wells. Test wells were installed at selected BarCad sampler sites as shown in the map inset on Figure 2-1. Borehole flowmeter testing was performed in April 1991 using the methods described in Rehfeldt et al. [1989]. These additional hydraulic conductivity data were primarily intended for calculating flow-weighting factors for BarCad tracer concentration measurements [Boggs et al., 1992].

## DATABASE DESCRIPTION

---

The structure of the database for MADE-2 is briefly described in this section. In general, data are organized under three categories: (1) concentration measurements for benzene, naphthalene, p-xylene, o-dichlorobenzene, tritium, and  $^{14}\text{C}$ ; (2) piezometric head measurements recorded during the experiment; and (3) hydraulic conductivity data obtained from borehole flowmeter testing. Additional information concerning the organization and format of these data can be found in the READ.ME files contained on the accompanying database diskettes.

### Spatial Coordinate System

One notable difference between the MADE-1 and MADE-2 databases is the reference coordinate system used for each. The MADE-2 spatial measurements are transformed into a reference coordinate system in which the origin lies at the center injection well and the y axis is approximately aligned with the mean tracer plume trajectory. This transformation simplifies the analysis and interpretation of the tracer data. On the other hand, data for MADE-1 are presented in a reference system in which the injection point is located at coordinates [85.2 m, 188.4 m] and the plume trajectory lies at an angle of approximately 26 degrees clockwise from the y axis. The MADE-2 data can be transformed into the MADE-1 coordinate system (or vice versa) using the following transformation formulae and parameters:

$$x = x'\cos\theta - y'\sin\theta + h \quad (3-1)$$

$$y = y'\cos\theta + x'\sin\theta + k \quad (3-2)$$

$$x' = (x-h)\cos\theta + (y-k)\sin\theta \quad (3-3)$$

$$y' = (y-k)\cos\theta - (x-h)\sin\theta \quad (3-4)$$

where x and y designate MADE-1 coordinates, x' and y' designate MADE-2 coordinates, h=85.2 m, k=188.4 m, and  $\theta=-25.68$  degrees.

### Tracer Concentration Data

The tracer concentration measurements are contained in two directories on diskette A. directory \SNAPSHOT contains the three-dimensional tracer distribution data for the five

plume snapshots. A separate file is designated for each snapshot data set. An example of the content and format of the snapshot data files is presented in Table 3-1.

**Table 3-1**  
**Example of Tracer Concentration Data**

Sample ID	Benzene ( $\mu\text{g/L}$ )	Naphthalene ( $\mu\text{g/L}$ )	p-Xylene ( $\mu\text{g/L}$ )	o-DCB ( $\mu\text{g/L}$ )	Tritium (pCi/mL)	Carbon-14 (pCi/mL)	X (m)	Y (m)	Z (m)	Sampling Date	Days Since Injection
S25B60A01	<50.	<4.0	<4.0	<4.0	1.	2.7	-10.8	11.0	53.85	09/09/91	440
S25B60A02	<50.	<4.0	<4.0	<4.0	2.	2.7	-10.8	11.0	58.44	09/09/91	440
S25B60B01	<50.	<4.0	<4.0	<4.0	2.	3.1	-8.7	10.3	56.24	09/09/91	440
S25B61A01	<50.	<4.0	<4.0	<4.0	2.	2.7	-6.0	9.3	58.11	09/09/91	440
S25B61A02	<50.	<4.0	<4.0	<4.0	8.	3.0	-6.0	9.3	53.70	09/09/91	440
S25B61B01	<50.	<4.0	<4.0	<4.0	180.	7.1	-4.0	8.7	55.15	09/09/91	440
S25B61B02	<50.	<4.0	<4.0	<4.0	9.	3.2	-4.0	8.7	60.03	09/09/91	440
S25B62A01	<50.	<4.0	<4.0	<4.0	14.	3.4	-7	7.2	55.11	09/09/91	440
S25B62A02	1400.	210.0	330.0	1600.0	2760.	99.4	-7	7.2	59.71	09/09/91	440
S25B62B01	<50.	<4.0	<4.0	<4.0	130.	7.1	-2.4	7.9	56.66	09/09/91	440
S25B63A01	<50.	<4.0	<4.0	<4.0	2.	3.0	2.6	6.1	53.84	09/09/91	440
S25B63A02	-999.	-999.0	-999.0	-999.0	87.	7.8	2.6	6.1	57.02	09/09/91	440
S25B63B01	-999.	-999.0	-999.0	-999.0	546.	23.4	1.1	6.8	55.46	09/09/91	440
S25B63B02	-999.	-999.0	-999.0	-999.0	1582.	21.9	1.1	6.8	60.04	09/09/91	440
S25B64A01	53.	<4.0	<4.0	8.0	13.	3.3	5.5	5.0	55.08	09/09/91	440
S25B64A02	52.	<4.0	<4.0	17.0	21.	3.7	5.5	5.0	59.66	09/09/91	440
S25B64B01	52.	<4.0	<4.0	<4.0	8.	3.0	4.1	5.6	56.56	09/09/91	440
S25B65A01	<50.	<4.0	<4.0	<4.0	2.	3.1	11.2	3.0	53.79	09/09/91	440

Tracer time-series data associated with the fence samplers (BarCad samplers and selected MLS) are found in directory \FENCE. A separate file is designated for each fence data set. The format of the time-series data is identical to that of the snapshot data (Table 3-1).

### Piezometric Data

Piezometric head measurements recorded during the natural-gradient tracer experiment are provided on diskette B. Manual piezometric measurements performed approximately monthly during MADE-2 are given in directory \MONTHLY of diskette B. One file is provided for each measurement date. Table 3-2 gives an example of the monthly piezometric data.

Table 3-2

## Example of Monthly Piezometric Head Data

Well	x (m)	y (m)	Date	Elapsed Time (days)	Water Level Elevation (m)
P-3	-86.10	2.56	04/04/91	280	63.68
P-40	-11.41	83.28	04/04/91	280	63.43
P-41	1.62	56.17	04/04/91	280	63.41
P-45	-30.84	10.38	04/04/91	280	63.66
P-52	-85.85	190.51	04/04/91	280	63.02
P-8A	95.13	123.75	04/04/91	280	63.51
P-8B	95.13	123.74	04/04/91	280	63.44
P-10A	103.20	5.73	04/04/91	280	65.10
P-10B	101.69	6.15	04/04/91	280	63.80
P-22A	-19.40	-50.16	04/04/91	280	64.36
P-22B	-20.20	-49.01	04/04/91	280	63.98
P-24A	22.61	6.42	04/04/91	280	63.61
P-24B	20.84	6.80	04/04/91	280	63.66
P-25A	-23.30	66.57	04/04/91	280	63.45
P-25B	-24.76	66.37	04/04/91	280	63.44
P-25C	-24.03	66.48	04/04/91	280	63.29

Directory \RECORDER of diskette B contains continuously recorded piezometric data for 16 piezometers. The data for each piezometer is given in a separate file. An example of the continuous piezometric data is presented in Table 3-3.

Table 3-3

## Example of Continuous Piezometric Head Data

Well	x (m)	y (m)	Elapsed Time (days)	Yr	Julian Day	Water Level Elevation (m)
P-53a	-4.9	-10.3	-7.00	90	170	62.44
P-53a	-4.9	-10.3	-6.00	90	171	62.42
P-53a	-4.9	-10.3	-5.00	90	172	62.40
P-53a	-4.9	-10.3	-4.00	90	173	62.39
P-53a	-4.9	-10.3	-3.00	90	174	62.36
P-53a	-4.9	-10.3	-2.00	90	175	62.33
P-53a	-4.9	-10.3	-1.00	90	176	62.31
P-53a	-4.9	-10.3	.00	90	177	62.30
P-53a	-4.9	-10.3	1.00	90	178	62.29
P-53a	-4.9	-10.3	2.00	90	179	62.26
P-53a	-4.9	-10.3	3.00	90	180	62.24
P-53a	-4.9	-10.3	4.00	90	181	62.22
P-53a	-4.9	-10.3	5.00	90	182	62.21
P-53a	-4.9	-10.3	6.00	90	183	62.20
P-53a	-4.9	-10.3	7.00	90	184	62.17
P-53a	-4.9	-10.3	8.00	90	185	62.15
P-53a	-4.9	-10.3	9.00	90	186	62.14
P-53a	-4.9	-10.3	10.00	90	187	62.12

## Hydraulic Conductivity Data

Hydraulic conductivity data for the 67 wells tested by the borehole flowmeter method are provided on diskette C. Data for each test well is given in a separate file with the filename designated by well number. The content and format of each file is illustrated in Table 3-4.

Table 3-4

## Example of Hydraulic Conductivity Data

FLOWMETER WELL K-37 HYDRAULIC CONDUCTIVITY - DEPTH PLOT DATA

WELL COORDINATES: X = -16.24 Y = 104.51

[A] DEPTH BELOW GRADE (M)

[B] DEPTH BELOW GRADE (FT)

[C] ELEVATION ABOVE MEAN SEA LEVEL (M)

[D] ELEVATION ABOVE MEAN SEA LEVEL (FT)

[E] HYDRAULIC CONDUCTIVITY (CM/SEC)

[F] HEAD IN THE AQUIFER (FT ABOVE SEA LEVEL)

[A]	[B]	[C]	[D]	[E]	[F]
3.024	9.920	61.899	203.080	0.1471	207.2
3.176	10.420	61.746	202.580	0.1471	207.2
3.176	10.420	61.746	202.580	0.4009E-02	207.2
3.328	10.920	61.594	202.080	0.4009E-02	207.2
3.328	10.920	61.594	202.080	0.4013E-02	207.2
3.481	11.420	61.442	201.580	0.4013E-02	207.2
3.481	11.420	61.442	201.580	0.4017E-02	207.2
3.633	11.920	61.289	201.080	0.4017E-02	207.2
3.633	11.920	61.289	201.080	0.4151E-02	207.2
3.786	12.420	61.137	200.580	0.4151E-02	207.2
3.786	12.420	61.137	200.580	0.4155E-02	207.2
3.938	12.920	60.984	200.080	0.4155E-02	207.2
3.938	12.920	60.984	200.080	0.1954E-01	207.2
4.090	13.420	60.832	199.580	0.1954E-01	207.2

## REFERENCES

---

- Boggs, J.M., S.C. Young, D.J. Benton and Y.C. Chung, Hydrogeologic Characterization of the MADE Site, *EPRI Topical Rept. EN-6915*, Electric Power Res. Inst., Palo Alto, CA, 1990.
- Boggs, J.M., Database for the First Macrodispersion Experiment (MADE-1), *EPRI Final Rept. EN-7363*, Electric Power Res. Inst., Palo Alto, CA, 1991.
- Boggs, J.M., L.M. Beard, T.B. Stauffer, W. G. MacIntyre, and C. P. Antworth, Transport of Tritium and Four Organic Compounds During a Natural-Gradient Tracer Experiment (MADE-2), *EPRI Rept. [in TR-102072]*, Electric Power Res. Inst., Palo Alto, CA, 1992.
- Rehfeldt, K.R., P. Hufschmied, L.W. Gelhar, and M.E. Schaefer, Measuring Hydraulic Conductivity With the Borehole Flowmeter, *EPRI Topical Rept. EN-6511*, Electric Power Res. Inst., Palo Alto, CA, 1989.

**EPRI**—*Leadership in Science and Technology*

## **ABOUT EPRI**

*The mission of the Electric Power Research Institute is to discover, develop, and deliver advances in science and technology for the benefit of member utilities, their customers, and society.*

Funded through annual membership dues from some 700 member utilities, EPRI's work covers a wide range of technologies related to the generation, delivery, and use of electricity, with special attention paid to cost-effectiveness and environmental concerns.

At EPRI's headquarters in Palo Alto, California, more than 350 scientists and engineers manage some 1600 ongoing projects throughout the world. Benefits accrue in the form of products, services, and information for direct application by the electric utility industry and its customers.

EPRI TR-102072

Database for Second Macrodispersion Experiment



Printed on Recycled Paper  
Printed in USA

Feb 1993