NRC FORM 314
(5-90)
10 CFR 30.36 (if applicable)
10 CFR 40.42 (if applicable)
10 CFR 70.38 (if applicable)

U.S. NUCLEAR REGULATORY COMMISSION

CERTIFICATE OF DISPOSITION OF MATERIALS

INSTRUCTIONS: SEND THE COMPLETED CERTIFICATE TO THE NRC OFFICE SPECIFIED ON THE REVERSE

2. Items M, O, P, R (if applicable) completed on reverse

1. LICENSEE NAME AND ADDRESS

Tennessee Valley Authority, Oliver Basin Laboratory (Formerly
Engineering
Engineering Laboratories)
Building 1010
Norris, TN 37828

LICENSE NUMBER

CONTROL OR DOCKET NO.

THE LICENSEE OR ANY INDIVIDUAL EXECUTING THIS CERTIFICATE ON BEHALF OF THE LICENSEE CERTIFIES THAT:
(Check and/or complete the appropriate item(s) below.)

A. MATERIALS DATA *(Check one and complete as necessary.)*

☐ 1. NO MATERIALS HAVE EVER BEEN PROCURED OR POSSESSED BY THE LICENSEE UNDER THIS LICENSE.

OR

☐ 2. ALL MATERIALS PROCURED AND/OR POSSESSED BY THE LICENSEE UNDER THE LICENSE NUMBER CITED ABOVE HAVE BEEN DISPOSED OF IN THE FOLLOWING MANNER. *(If additional space is needed, use the reverse side or provide attachments.)*

Describe specific material transfer actions and, if there were radioactive wastes generated in terminating this license, the disposal actions, including the disposition of low-level radioactive waste, mixed waste, Greater-than-Class C waste, and sealed sources, if applicable.

For transfers, specify the date of the transfer, the name of the licensed recipient, and the recipient's NRC license number or Agreement State name and license number.

If materials were disposed of directly by the licensee rather than transferred to another licensee, licensed disposal site or waste contractor, describe the specific disposal procedures (e.g., decay in storage).

See attached materials.

B. OTHER DATA

☒ 1. OUR LICENSE HAS NOT YET EXPIRED. PLEASE TERMINATE IT.

2. WAS A RADIATION SURVEY CONDUCTED TO CONFIRM THE ABSENCE OF LICENSED RADIOACTIVE MATERIALS AND TO DETERMINE WHETHER ANY CONTAMINATION REMAINS ON THE PREMISES COVERED BY THE LICENSE? *(Check one)*

☐ NO *(Attach explanation)*

☒ YES, THE RESULTS *(Check one)*

- ☒ ARE ATTACHED, or
- ☐ WERE FORWARDED TO NRC ON *(Date)*

3. THE PERSON TO BE CONTACTED REGARDING THE INFORMATION PROVIDED ON THIS FORM

NAME	TELEPHONE NUMBER
J. Markus Boggs	(423) 632-1894

4. MAIL ALL FUTURE CORRESPONDENCE REGARDING THIS LICENSE TO:

J. Markus Boggs
Tennessee Valley Authority - LAB 1A-N
[illegible] Pine Road
Norris, TN 37828

CERTIFYING OFFICIAL

I CERTIFY UNDER PENALTY OF PERJURY THAT THE FOREGOING IS TRUE AND CORRECT.

SIGNATURE	DATE
	March 27, 1996

PRINTED NAME AND TITLE

Gregory W. Lowe, Manager, River System Operations

WARNING: FALSE STATEMENTS IN THIS CERTIFICATE MAY BE SUBJECT TO CIVIL AND/OR CRIMINAL PENALTIES. NRC REGULATIONS REQUIRE THAT SUBMISSIONS TO THE NRC BE COMPLETE AND ACCURATE IN ALL MATERIAL RESPECTS. 18 U.S.C. SECTION 1001 MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

Enclosure 1 to Form 314

RADIOACTIVE MATERIALS REMAINING IN THE ENVIRONMENT DUE TO THE GROUNDWATER TRACER EXPERIMENT CONDUCTED AT COLUMBUS AIR FORCE BASE, COLUMBUS, MISSISSIPPI, AND ESTIMATIONS OF THEIR DOSES TO THE PUBLIC. BY-PRODUCT LICENSE 41-25047-02

By-product license 41-25047-02, issued to the Tennessee Valley Authority, authorizes the possession of radioactive materials that were used in an experiment conducted almost six years ago. The results of these activities are discussed below.

On June 26 and 27, 1990, an experiment to more accurately determine the characteristics of the flow of organic pollutants in groundwater was begun at Columbus Air Force Base (CAFB) near Columbus, Mississippi. Tritiated water (538.7 milli Ci) was used as a conservative tracer to accurately determine the flow of underground water. Also, 26.8 mCi of C-14 tagged p-xylene, an organic compound used to simulate pollution from leaking underground fuel storage tanks, was injected into the groundwater.

Some of the p-xylene evaporated from the water solution and attached to the equipment used to pump it during the injection process. Over 400 g of stable isotope p-xylene was also injected to act as a carrier. The equipment used in the injection process became contaminated and substantial effort was later spent in decontaminating it. Many parts of the equipment could not be economically decontaminated and were disposed of as radioactive waste and transferred to a licensed broker for ultimate disposal.

Three other nonradioactivly tagged, organic chemicals were also injected, but they are of no interest here.

The experiment was conducted in accordance with the original documents that were included in the application for the license. Details on the results of the experiment and on the subsequent fate of the radioactive material are submitted in enclosure 3 and in the EPRI 1993, Transport of Tritium and Four Organic Compounds During a Natural-Gradient Experiment (MADE-2), Final Report TR-101998, also enclosed.

Thus, 538.7 mCi of H-3 and 26.8 mCi of C-14 was injected into the ground water at CAFB in June of 1990. The initial concentrations of these two isotopes was 0.05561 micro Ci/ml of C-14 and 0.00277 micro Ci/ml of H-3.

As the enclosed reports show, the low-level radioactive material is flowing north-northwesterly toward the Buttahatchee River, approximately 3 km north of the injection point. No one lives in this area. This region is unoccupied by dwellings or significant commercial activities. No agricultural activities take place there. This land is the site of several gravel quarries and a pine forest.

257000

Due to the 12.35 year half of tritium, the total quantity of this isotope remaining is 388.3 milli Ci, 72.1 percent of the original quantity, due to radiological decay for 6.83 years. Because of its long (5730 yr.) half life, the original quantity, 15.6 mCi of C-14, remains.

The maximum concentrations of H-3 and C-14 in ground water, based on monitoring and modeling predictions, are 4 and 0.2 pico Ci/ml, above background. See Figures 4 and 5 in enclosure 1.

These concentrations and quantities of H-3 and C-14 present no hazard from direct radiation or from inhalation of these materials. The only credible hazard that they may present is from ingestion, primarily drinking water that is contaminated by these low level radioactive materials. We present two calculations to demonstrate that these materials are not hazardous to the public.

First, let us assume that an individual consumes 2,000 ml of this water each day for a year. Thus, 730,000 ml would be consumed in one year. If maximally contaminated water were consumed at this rate, then the quantities consumed in one year would be: 4 pico Ci/ml X 7.3×10^5 ml/yr. = 2.92 micro Ci/yr. of H-3 and 0.2 pico Ci/ml X 97.3×10^5 ml/yr. = 0.15 micro Ci/yr. of C-14.

According to EPA Report No. EPA-520/1-88-020 (Federal Guidance Report No. 11), the Annual Limits on Intake for the ingestion of H-3 and C-14 are 80,000 and 2,000 micro Ci, respectively. Each of these quantities, if ingested, would give reference man a committed effective dose equivalent of 5,000 mrem.

This conservative, hypothetical ingestion of the maximal concentration of H-3 for an entire year would result in a total effective dose equivalent (TEDE) of (2.92/80,000) x 5,000 = 0.18 mrem/yr. The hypothetical ingestion of the maximal concentration of C-14 would result in a committed effective dose equivalent of (0.15/2,000) x 5,000 = 0.38 mrem/yr. This would result in a combined TEDE of 0.56 mrem in a year from both radionuclides. We used the above technique to estimate the dose from the drinking water pathway, rather than the factors given in Table A-4 of NUREG 1500, Working Draft Regulatory Guide on Release Criteria for Decommissioning: NRC Staff's Draft Comment. The factors given in that table do not seem to consider the rapid underground flow of this slightly contaminated water.

Second, let us use the dose factors given in Table A-1 of NUREG 1500 to estimate the TEDE from all pathways. We conservatively assume that the density of soil is 1 g/ml so that the above concentrations of radionuclides in water can be taken as concentrations in soil. The use of the factors in Table A-1 assumes that an individual lives on the maximally contaminated soil and that he eats food grown there and ingests radionuclides from various other hypothetical pathways. These factors also include doses from direct radiation. The following table shows the doses calculated for these two radionuclides, using the factors in Table A-1 of NUREG 1500.

Radionuclide	Concentration in Soil pCi/g	Annual TEDE Factor mrem/yr per pCi/g	Total Dose mrem/yr
H-3	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Thus, the total annual dose to a maximally exposed hypothetical individual would be 0.14 + 0.08 = 0.22 mrem/yr., a trivial dose.

The trivial doses calculated using the above two methods are well below all guidelines and standards promulgated by both the Nuclear Regulatory Commission and the Environmental Protection Agency for doses to members of the public.

Enclosure 2 to Form 314

FINAL SURVEYS OF SITES WHERE MATERIAL WAS USED

Direct Radiological Survey and Smear Analysis Data Sheet

Survey No. RS-95-222 Location: CAFB-Miss Survey Date: 11-14-95

NRC License No: 41-28605-25047-01

Survey Purpose: Clean Survey on TLA Equipment before release Survey by: Phil Llewellyn

Item or Location	Direct or Fixed Radioactive Contamination C/M	Transferable Contamination D/M per 100 cm²	Type	Instrument Serial Number	Remarks
Track Hoe/Back Hoe TV-625/40	ND	See MSU Results Attached	β⁻	Bicron 841810	Membrane Smears / See Attached Results #1
Dump Truck #85658	ND		β⁻		#2
Tanker #2	ND		β⁻		#3
Tanker #1	ND		β⁻		#4
Crain - 15 ton Grove	ND		β⁻		#5
Dewatering Well D1	ND		β⁻		#6
D2	ND		β⁻		#7
D3	ND		β⁻		#8
D4	ND		β⁻		#9
Ball Dozer 74854	ND		β⁻		#10
					#11
			β⁻		
				NA	

Reviewed by:

(NA = Not Applicable, ND = Not Detectable, D/M = disintegrations per minute, C/M = counts per minute, BKG background)

EDD-1.pdf

Mississippi State University

attached to 12-15-95

December 6, 1995

Mark Boggs
TVA
Engineering Laboratory
P.O. Drawer E
Norris, TN 37828

Dear Sir,

Enclosed are the radioisotope analysis for the water samples delivered to my laboratory by Phillip Llewellyn on November 30, 1995.

sample number	dpm tritium	dpm carbon-14
W1	27	29
W2	24	29
W3	24	31
W4	28	31
W5	26	29
W6	26	30
W7	26	29
W8	26	32
W9	29	29
MSU	18	28

College of Agriculture & Home Economics • Agricultural & [illegible] Experiment Station
Department of Biochemistry & Molecular Biology • Box 9650 • Mississippi State University, MS 39762 USA
(601) 325-2640 • FAX (601) 325-8664

Attached to
12-5-95-A22

WIPE SAMPLES

1	20	23
2	20	23
3	17	25
4	19	25
5	23	22
6	21	21
7	22	22
8	21	23
9	21	21
10	20	23

The water samples are accurate to a standard deviation of less than 3.0%.

The samples marked "MSU" are laboratory blanks and are expected values for assays of non radioactive substances.

Sincerely,

Thomas K Kellogg

Thomas F. Kellogg
Professor of Biochemistry
and Molecular Biology

RADIOLOGICAL SURVEY

Survey Number RS&C 92-154 Location 401 Bldg Chatt Date 2/24/92

Reason for this survey: Clearance of C-14/43 40-K Area

ITEM OR LOCATION	TIME	DIST.	Dose Rates				Contamination			Instrument Serial No	Remarks	Surveyed By
			Beta mRad/hr	Neutron mRem/hr	Gamma mR/hr	Total mRem/hr	Direct	Transferrable dpm/100 cm²	Type			
Counter Tops Hoods Floor Liquids	1300	CONTACT	NA	NA	<0.1	<0.1	ND	<1000	β	Bicron 552067	See Attached	Sally Hall
	↓	12"	↓	↓	↓	↓						
		GA	↓	↓	↓	↓						
		CONTACT										↓
		CONTACT										
		CONTACT										
		CONTACT					NA					
		CONTACT										
		CONTACT						See Report from R. Maxwell dtd. 2/7/92				Ea
		CONTACT										

NA = Not Applicable ND = Not Detectable
GA = General Area NDA = Nearest Acceptable Area

Reviewed by: [signature]

L91 920831 800

August 31, 1992

R. B. Maxwell, MPB 1B-M

RESULTS OF SURVEY RS&C 92-154 (WATER: CARBON-14/TRITIUM)

Analysis is complete on the subject survey. Due to the cloudiness of the sample, it was filtered before performing the liquid scintillation analysis. The carbon-14 analysis was taken from the filtered sample. The sample was then distilled and once again counted by a liquid scintillation technique. The tritium portion was calculated from this second analysis. The carbon-14 results were not calculated from this run since any carbon-14 present would be volatilized during the distillation process. Attached are the measured values in picocuries per liter.

The filtrate obtained during the filtering process was also counted by liquid scintillation technique. The millipore filter was placed in a liquid scintillation vial and counted for the presence of carbon-14 and tritium. No activity was detected.

If you have any questions, please call me at extension 3769.

Monica H. Cross

Monica H. Cross
Chemist
Radioanalytical Laboratory
WAR 1A-M

MHC:DHS
Attachments
cc: RIMS, MR 2F-C

(836)

	A	B	C	D	E	F	G
1	blank-channel a	9.75	eff a C-14	0.508	0.012	uncertainty	
2	blank-channel b	11.9	eff b C-14	1.223	0.026	uncertainty	
3	cpm c14-channel a	407.8	eff a H-3	0.920	0.020	uncertainty	
4	cpm c14-channel b	970.55	eff b H-3	-0.003	0.001	uncertainty	
5	pCi ..4	783.8					
6	cpm h3-channel a	703.45	VOLUME	0.003			
7	cpm h3-channel b	9.9	count time(min)	20	determinant	-1.1263142	
8	pCi h3	754			uncertainty	0.03426901	
9	1-Jun-91	26-Aug-92	251.40	3	704		
10	cpm a sam	cpm b sam	SAMPLE ID -	pCi C-14/liter	err c 14	pCi H-3/liter	err h 3
11	12.35	11.20	RS&C 92-154	189	293	1046	415
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							
33	REVIEWED BY	W. L. Cross					
34	APPROVED BY	Charles E Goodrich					
35							

blank-channel a	11	eff a C-14	0.241	0.006	uncertainty		
blank-channel b	12.3	eff b C-14	0.529	0.012	uncertainty		
cpm c14-channel a	430.7	eff a H-3	0.446	0.010	uncertainty		
cpm c14-channel b	932.5	eff b H-3	0.000	0.001	uncertainty		
dpm c14	1740						
cpm h3-channel a	709.2	VOLUME	1				
cpm h3-channel b	12.6	count time(min)	10	determinant	0.2358496		
dpm h3	1565			uncertainty	0.00768158		
1-Jun-91	15-Aug-92	558.10	3	15[illegible]			
LSC POSITION #	RS&C 92 ~~150~~ /5✓	~~mr, 8/25/92~~ cpm a sam	cpm b sam	DPM C-14	err c-14	DPM H-3	err h-3
4	1	8.6	13.5	2	3	7	4
CALCULATED BY	W. L. Cross						
REVIEWED BY	W. L. Cross						
APPROVED BY	Charles E. Frederick						

WATER AND SOIL SAMPLE DATA FORM

TYPE OF SAMPLE:

WATER ✓ SOIL _____ OTHER _____

DATE COLLECTED: 7/24/92

LOCATION OF SAMPLE COLLECTED: 401 Bldg Cluster

DATE SUBMITTED TO WARL: 8/3/92

TYPE OF ANALYSIS FOR SAMPLE: C-14, H-3

WARL LAB SAMPLE NUMBER: _____

NOTES:

(DISPOSITION OF SAMPLE SENT TO WARL, DISPOSITION OF CARBOYS OR SEDIMENT SAMPLED, ETC.)

* The above referenced RS+C # (92-154) was not reflected on the sample container the number written on it was RS+C-92-153. M.R. Cross 8-5-92

THIS FORM SHOULD ACCOMPANY EACH SAMPLE RS&C SUBMITS TO WARL FOR ANALYSIS.

_91 920812 800

August 12, 1992

R. B. Maxwell, MPB 1B-M

RESULTS OF SURVEY RS&C 92-154 (TRITIUM/CARBON-14)

Analysis is complete on the subject survey. Tritium and carbon-14 analyses were performed using a liquid scintillation technique. Attached are the measured values.

If you have any questions, please call me at extension 3769.

Monica H. Cross

Monica H. Cross
Chemist
Radioanalytical Laboratory
WAR 1A-M

MHC:DHS
Attachments
cc: RIMS, MR 2F-C

(81a)

3/4K2

RADIOACTIVITY COUNTING RECORD SHEET FOR SMEARS

Date and Time 2 Nov 92 1430

Inst. Eff. BKG

β-ɣ

β

α

Isotope H-3 / C-14

Sampling Information

RSSCP 92-154

Date 7-JC-92

Location 4[illegible] Bldg

Name P Llewellyn Ph. 3778

Address 365 / E MPB

Smear Number	Sampling Location	Analysis	Total Counts	÷ Count Time (mins)	= Total CPM	− Average BKG CPM	= Net CPM	÷ Counter Efficiency	= DPM
BKG		β		10		N/A	N/A	N/A	N/A
		α							
1	See attached sheet - 11-92 - M. B. Cross	β		10					
		α							
2		β		10					
		α							
3		β		10					
		α							
4		β		10					
		α							
5		β		10					
		ɣ							
BKG		β		10		N/A	N/A	N/A	N/A
		α							
6		β		10					
		α							
7		β		10					
		α							
8		β		10					
		α							
9		β		10					
		α							
10		β		10					
		α							
BKG		β		10		N/A	N/A	N/A	N/A
		α							
		β		10					
		α							
		β		10					
		α							
		β		10					
		α							
		β		10					
		α							
		β		10					
		α							
BKG		β		10		N/A	N/A	N/A	N/A
		α							

Counted by M. B. Cross

Checked by Charles E Fredericks

Calculated by M. B. Cross

blank-channel a	10.2	eff a C-14	0.246	0.006	uncertainty		
blank-channel b	9.3	eff b C-14	0.541	0.012	uncertainty		
cpm c14-channel a	439	eff a H-3	0.446	0.010	uncertainty		
cpm c14-channel b	950.6	eff b H-3	0.001	0.001	uncertainty		
dpm c14	1740						
cpm h3-channel a	708.5	VOLUME	1				
cpm h3-channel b	11.1	count time(min)	10	determinant	0.240725		
dpm h3	1567			uncertainty	0.00783403		
1-Jun-91	6-Aug-92	558.10	3	1567			
LSC POSITION #	RS&C 92-154	cpm a sam	cpm b sam	DPM C-14	err c-14	DPM H-3	err h-3
4	1	11.1	11.3	4	3	0	4
5	2	8.6	11.6	4	3	6	3
6	3	7.4	11.2	4	3	8	3
7	4	8.3	10.8	3	3	6	3
8	5	9.2	13.3	7	3	6	3
9	6	7.9	11.8	5	3	8	3
10	7	9.9	12.1	5	3	4	4
11	8	9	11.2	4	3	5	3
12	9	8.6	11.5	4	3	6	3
16	10	9.3	10.8	1	3	4	3
CALCULATED BY	M. H. Cross 8-11-92						
REVIEWED BY	M. H. Cross 8-11-92						
APPROVED BY	Charles E Sudduth 8-11-92						

Enclosure 3 to Form 314

PREDICTED EXPOSURE POINT CONCENTRATIONS FOR TRITIUM AND C-14

1. SITE DESCRIPTION

A brief hydrogeologic description of the groundwater test site at Columbus Air Force Base (CAFB) is presented below. A more comprehensive description may be found in the EPRI [1993] report included with this submittal.

Aquifer Characteristics

The site of the proposed study is underlain by a shallow unconfined aquifer consisting of alluvial terrace deposits. This unit averages approximately 11 m in thickness, and is composed of poorly to well-sorted sandy gravel and gravely sand with variable silt and clay content. Sediments are generally unconsolidated and occur as irregular horizontal or nearly horizontal lenses and layers. The hydraulic conductivity (K) profile and the vertically averaged conductivity map presented on Figure 1 illustrate the extreme heterogeneity of the aquifer. These data were obtained from borehole flowmeter tests conducted at 59 fully screened wells located in and around the test site. Hydraulic conductivities typically range over two to four orders of magnitude at each well test site. The mean hydraulic conductivity along the tracer travel path increases from approximately 10^{-3} cm/s in the vicinity of the tracer injection point to 10^{-2} cm/s or larger in the far field. At the northern extreme of the test site the mean K again decreases to about 10^{-3} cm/s.

Marine sediments belonging to the Eutaw Formation and consisting of clays, silts, and fine-grained sands lie below the alluvial aquifer. Over most of the site the upper surface of the Eutaw consists of dense clay that forms an aquitard beneath the alluvial aquifer. However, a fine-grained sand unit ranging up to 3m in thickness forms the upper Eutaw surface in one subregion of the site. Where present, this sand unit is underlain by the same clay aquitard found elsewhere.

Groundwater Movement

The general direction of groundwater flow at the test site is from southeast to northwest as shown on Figure 2. An important feature of the groundwater flow field is the region of horizontally converging flow indicated by the V-shaped contours in the southern part of the site. This feature is produced by large-scale spatial variations in mean hydraulic conductivity at the test site. The convergent flow zone coincides with the relatively high hydraulic conductivity sediments known to exist in the area downgradient of the injection point.

Based on the observed migration of the conservative tracers in the two previous field experiments, groundwater accelerates upon entering this zone of convergent flow producing a sharp contrast between the near-field and far-field groundwater velocities. Examination of tritium breakthrough curves for 17 selected sampling points in the near field indicated an average velocity of approximately 18 m/yr. The velocity in the far field is estimated to be on the order of ~15 m/yr based on the observed rate of advance of the leading edge of the tritium plume during MADE-2.

Groundwater exiting the test site is expected, based on topographic considerations, to continue to flow in a northwesterly direction, passing through the contiguous Holocene floodplain alluvium which borders the older terrace alluvial deposits to the north, and ultimately discharging into the Buttahatchee River located approximately 3 km north of the site (Figure 3).

Groundwater Chemistry

Groundwater at the test site has a low total dissolved solids content averaging 43 mg/L. The ionic composition of the groundwater is dominated by sodium, silica, and chloride. Total acidity averages 71 mg/L (as $CaCO_3$). Alkalinity averages 9.6 mg/L and is mainly in the form of carbon dioxide and bicarbonate. Because of the low acid neutralizing capacity of the groundwater, dissolved carbon dioxide strongly affects the pH which averages 4.8. Background concentrations of tritium and C-14 in groundwater average 2.0 and 2.8 pCi/ml, respectively.

2. DESCRIPTION OF GROUNDWATER TRACER EXPERIMENT

The tracers selected for the experiment are listed in Table 1 along with the initial concentration and total injected mass (activity) for each tracer. Note that a small portion of the p-xylene was labeled with C-14 to permit the study of biological or chemical transformation of the p-xylene.

Table 1. Initial Tracer Concentrations and Masses (Activities)

Tracer	Initial Concentration	Mass Injected
tritium	55,610 pCi/ml	0.5387 Ci
C-14 (p-xylene)	2,770 pCi/ml	0.0268 Ci
benzene	68.1 mg/L	659.7 g
p-xylene	51.5 mg/L	402.0 g
o-dichlorobenzene	32.8 mg/L	317.7 g
naphthalene	7.23 mg/L	70.0 g

Tracers were mixed with 9700 L of ambient groundwater and injected into the alluvial aquifer through five wells spaced one-meter apart in a linear array (Figure 4). Each well was screened over a 0.6 m interval located in approximately the middle of the aquifer. The

injection was conducted over a 48.5 hr period beginning June 26, 1990, at a uniform rate of 3.3 L/min. Following the injection, tracers were periodically monitored using an array of 328 multilevel sampling wells (Figure 4). Sampling results and interpretation of the experimental data are given in EPRI (1993).

Safeguard monitoring was also performed periodically during and after the experiment to ensure that no local groundwater supply wells were adversely affected by the study. Sampling results for the four private wells monitored are given in Table 2. There was no indication of tritium or C-14 levels significantly above background for any of the samples collected from the private wells.

Table 2. Tritium and Carbon 14 Measurements Local Domestic Wells During and After MADE-2 (Measurements Include Background)

Well Number	Date	Tritium (pCi/ml)	Carbon-14 (pCi/ml)
1	8/90	2.0	2.2
	1/91	2.0	2.8
	5/91	2.5	3.4
	12/91	1.6	3.1
	7/92	1.7	3.1
2	8/90	2.0	2.0
	1/91	2.0	2.8
	5/91	1.8	3.6
	12/91	1.3	2.9
	7/92	1.6	2.8
3	8/90	(a)	(a)
	1/91	2.0	2.6
	5/91	1.4	3.5
	12/91	1.6	2.9
	7/92	1.5	2.9
5	8/90	2.0	2.2
	1/91	2.1	2.8
	5/91	2.0	3.8
	12/91	1.7	2.9
	7/92	1.7	3.1

(a) Well not available in 8/90.

In addition, tracer data were examined for sampling points located along the last row of the multilevel sampling well network to determine the maximum tracer concentrations exiting the test site. Tritium and C-14 results for sampling points exhibiting the highest measured concentrations are given in Figures 5 and 6. It appears that the maximum concentrations for tritium and C-14 were on the order of 13 and 3.6 pCi/ml, respectively. Most of the sampling

points experienced their peak concentrations within 500 to 600 days after tracer injection. Note that the mean concentrations of tritium and C-14 passing the last row of the sampling network were only about 4 and 3 pCi/ml, respectively.

3. EVALUATION OF FUTURE IMPACTS

Methods

A conservative assessment was performed to determine whether concentrations of tritium and C-14 released to groundwater in the MADE-2 field experiment pose any future risk to offsite water users. The extensive knowledge of the local groundwater flow system derived from the two previous groundwater tracer experiments allowed these risks to be evaluated with a high degree of confidence.

Estimates of the future tritium and C-14 tracer concentrations at potential downgradient receptors were made using a three-dimensional groundwater transport model developed by Yeh [1981]. The model accounts for convection, dispersion, and first-order decay of groundwater solutes in a uniform, unidirectional flow field. Because of the presence of two contrasting groundwater velocity zones at the test site, a two-step procedure was followed in conducting the transport analysis. First, the rate of release of the radiotracers from the low-velocity zone occurred to the high-velocity zone which comprises most of the test site was estimated. Release rates were computed from observed changes in the total tritium and total C-14 activity present in the low velocity zone during the experiment (Table 3). For example, the estimated average tritium release rate (q(t)) from the low-velocity zone between days 27 and 132 is,

$$q(t) = -Mo*(m_1 - m_2)/(t_1 - t_2) = 5.39e11*(1.00-0.94)/(27-132) = 3.08e08 \text{ pCi/day}$$

The presumption here (which has been verified by separately integrating the tracer mass in the low and high velocity zones) is that an observed decrease in tracer mass in the low velocity zone between two sampling dates corresponds to an increase in mass within the high velocity zone. In order to extrapolate beyond the experimental period (i.e., 328 days), the observed tritium and C-14 mass data were fit to a negative exponential function. These results are also given in Table 3.

Table 3. Data Used in Estimating Tritium and C-14 Release Rates to High-Velocity Zone

Days Since Injection	Relative Tritium Mass in Low Velocity Zone	Estimated Tritium Release Rate (pCi/day)	Relative C-14 Mass in Low Velocity Zone	Estimated C-14 Release Rate (pCi/day)
0	1.00	--	1.00	--
27	1.00	0.00e00	0.72	2.78e08
132	0.94	3.08e08	0.64	2.04e07
224	0.62	1.86e09	0.36	8.16e07
328	0.38	1.26e09	0.21	3.87e07

Note: Relative mass equals mass divided by initial mass (Mo); initial mass values for tritium and C-14 given in Table 1.

In the second step of the analysis, the tracer release rates from the low-velocity zone were used as influx boundary conditions in the groundwater transport model to predict tracer concentrations at selected downgradient receptors within the high-velocity zone. A groundwater seepage velocity of 425 m/yr. was assumed based on the observed tritium plume movement during the actual experiment. A longitudinal dispersivity of 10 m was used based on spatial moments analysis of the tritium plume [EPRI, 1993], while transverse and vertical dispersivity values of 1m and 0.3 m were assumed for the analysis. The aquifer was assumed to have a saturated thickness of 8 m, and to be of infinite extent in the longitudinal and transverse directions. An effective porosity of 0.25 was applied.

Figure 7 shows a comparison of predicted and observed tritium concentrations for selected sampling points on the last row of the sampling network located approximately 250 m downgradient of the source. Recall that the observed data represent tritium breakthrough curves exhibiting the highest observed peak concentrations for sampling points on the last row. The predicted result is also the maximum value calculated at a longitudinal distance of 250 m. The favorable comparison of the predicted and observed breakthrough histories lends credibility to subsequent tracer concentration predictions for downgradient receptors.

Results

The downgradient receptors selected for analysis include the two existing private wells located north of CAFB (wells 3 and 5 shown on Figure 3), a hypothetical water supply well located near the northern CAFB property line (well 4 of Figure 3), and the Buttahatchee River. For conservatism, the shortest straight-line distance between the tracer source and each receptor was used in the predictions (see Table 4), despite the fact that the two existing wells lie east of the expected trajectory of the tracer plumes. The maximum predicted concentrations at each longitudinal distance were used in the analysis.

Table 4. Predicted Maximum Tritium and C-14 Concentrations at Potential Receptors

Potential Receptor	Approx. Distance from Source (m)	Tritium (pCi/ml)	C-14 (pCi/ml)
Well 3	1250	5.48	2.94
Well 4 (hypothetical)	1250	5.48	2.94
Well 5	2400	4.00	2.88
Buttahatchee River	3000	3.62	2.87

The tritium and C-14 concentration breakthrough histories for each receptor are shown in Figures 8 and 9, and data are tabulated in Table 5. The maximum predicted concentrations at each location are given in Table 4. Results indicate even using conservative assumptions, the concentration of tritium at the nearest receptor is only about three times background, whereas, the predicted increase in C-14 above background is negligible.

4. REFERENCES

Electric Power Research Institute (EPRI), 1993. Transport of Tritium and Four Organic Compounds During a Natural-Gradient Experiment (MADE-2), *Final Report TR-101998*, Palo Alto, CA.

Yeh, G.T., 1981. AT123D: Analytical Transient One- , Two-, and Three-Dimensional Simulation of Waste Transport in the Aquifer System, *Oak Ridge National Laboratory report ORNL-5602*.

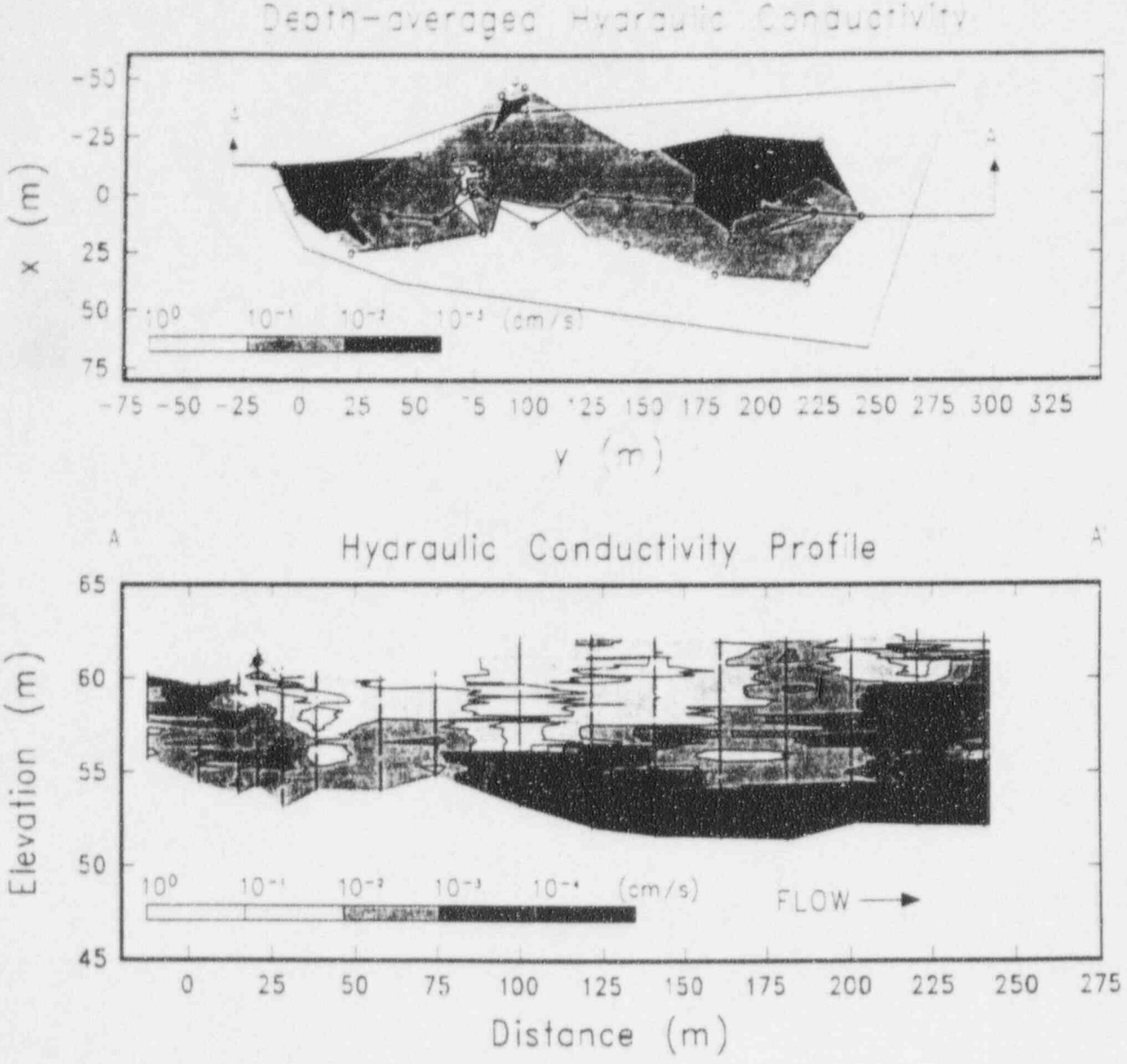

Figure 1. Map of Vertically Averaged Hydraulic Conductivity (Upper Diagram) and Hydraulic Conductivity Profile Along Section A-A' (Lower Diagram)

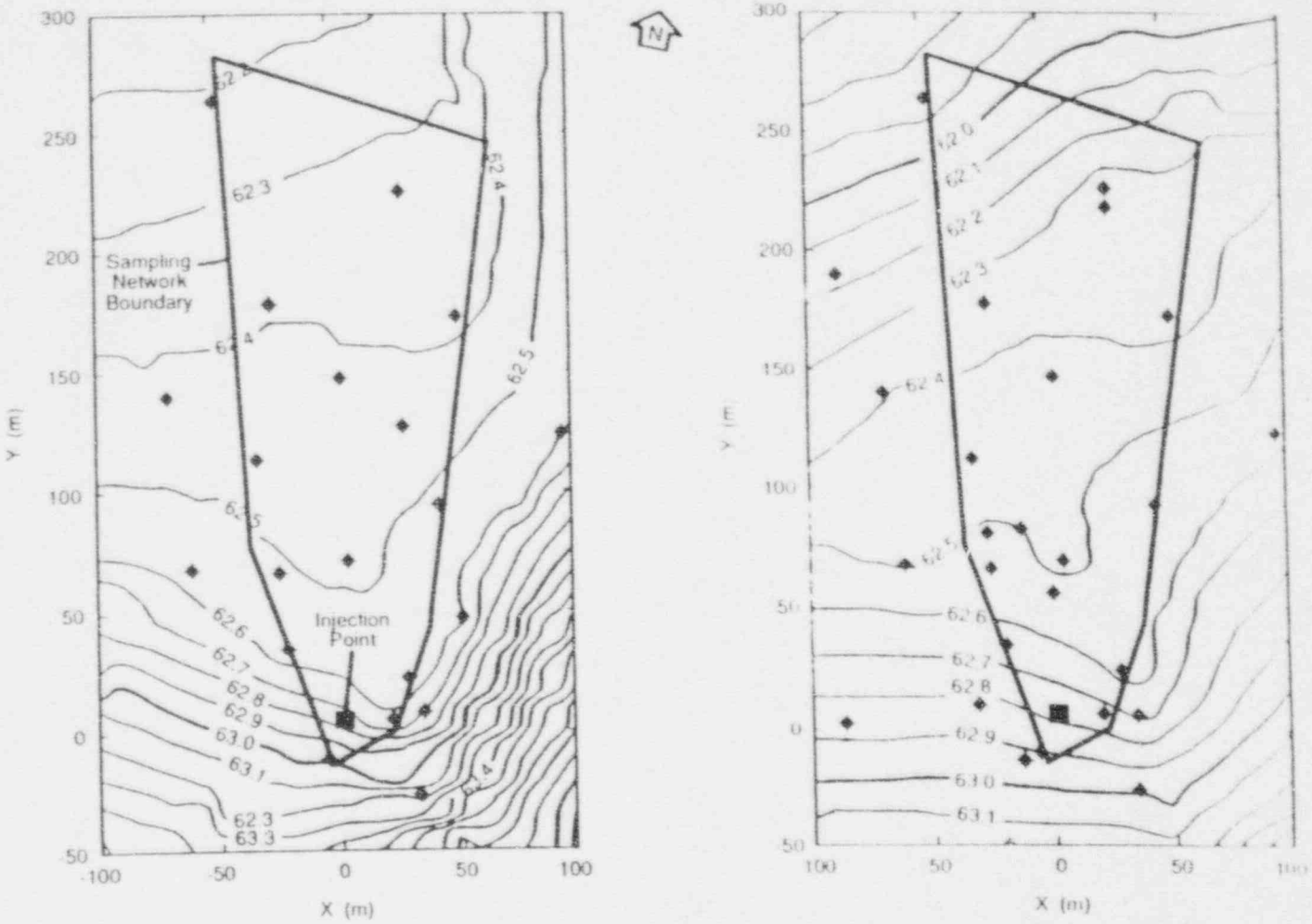

Figure 2 Potentiometric Surface Maps Derived From June 1990 Head Measurements in Shallow (Left) and Deep (Right) Observation Wells

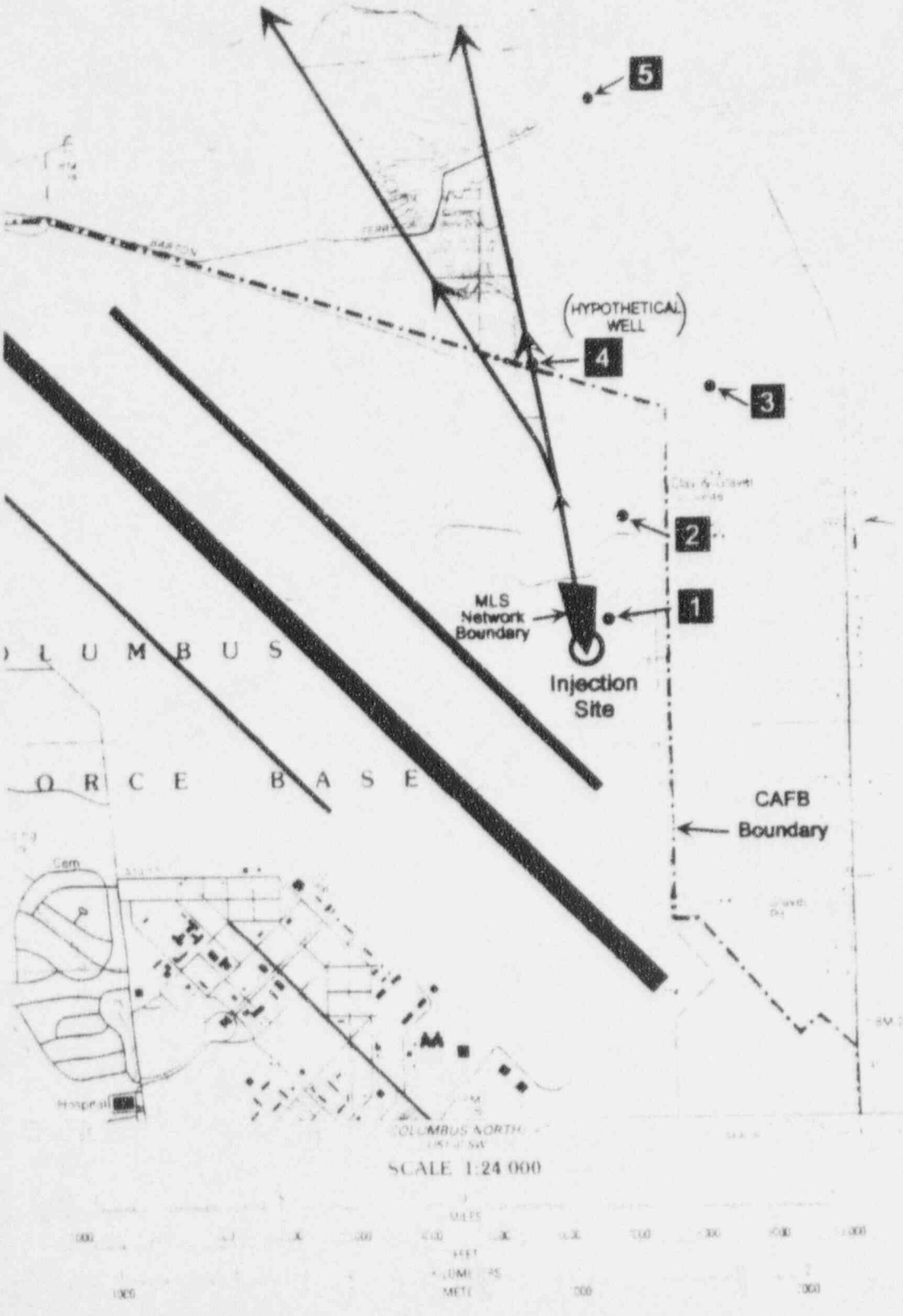

Figure 3. Projected Tracer Plume Pathway in Relation to Local Wells

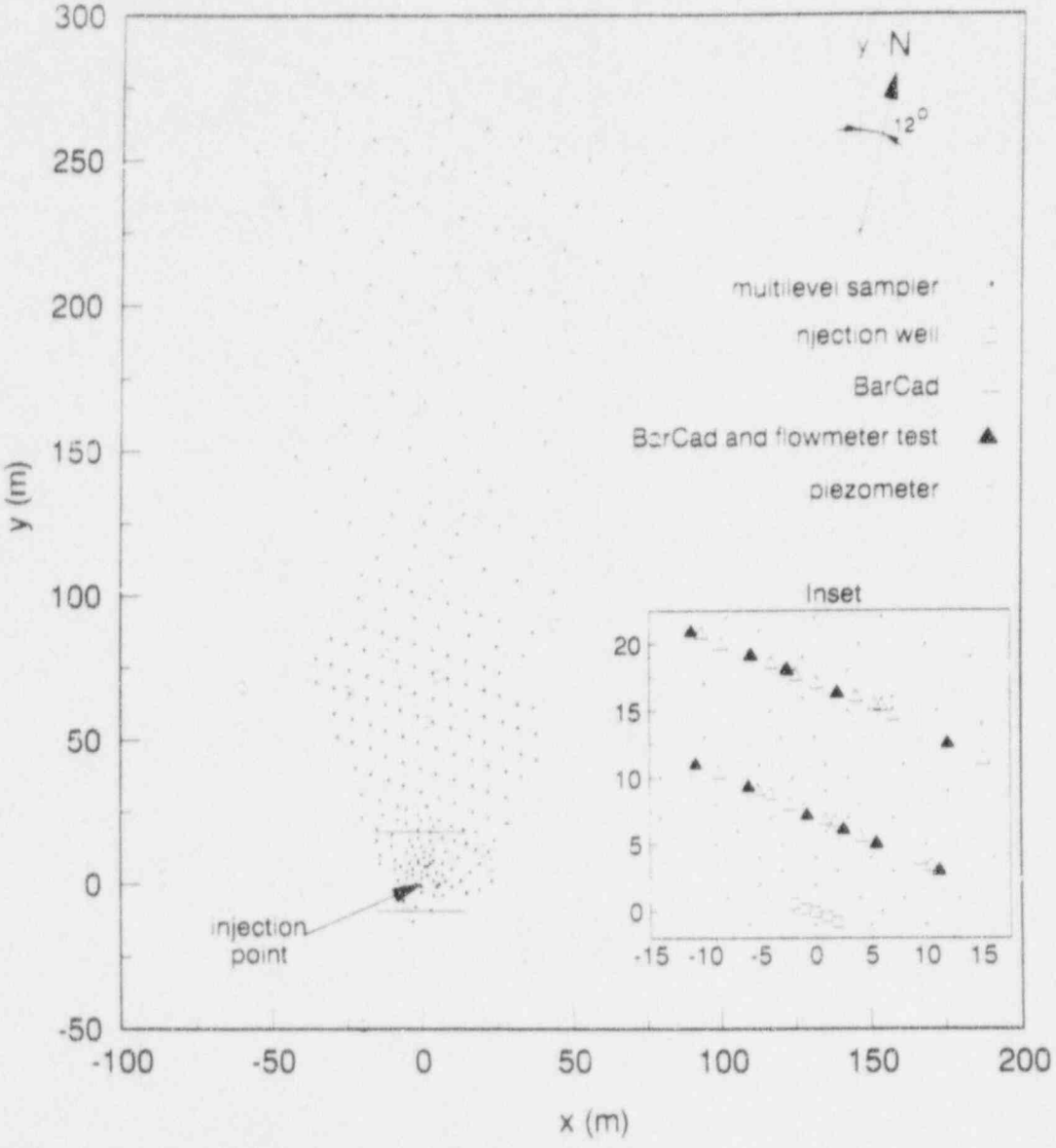

Figure 4 Sampling Well Network Showing Injection Wells, MLS, and BarCad Samplers

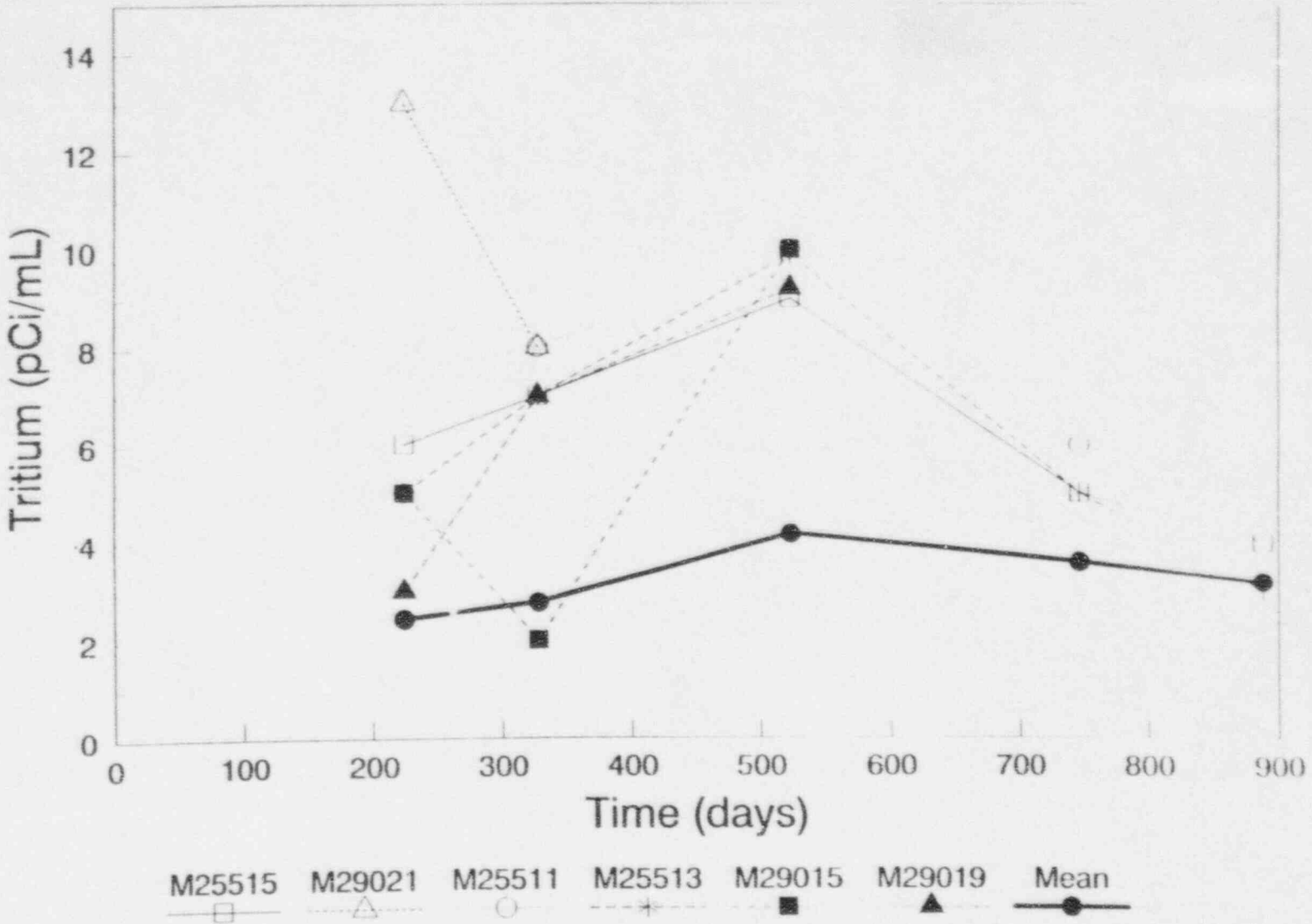

Figure 5. Observed Tritium Concentration Histories for Selected Sampling Points Located In Last Row of Monitoring Network

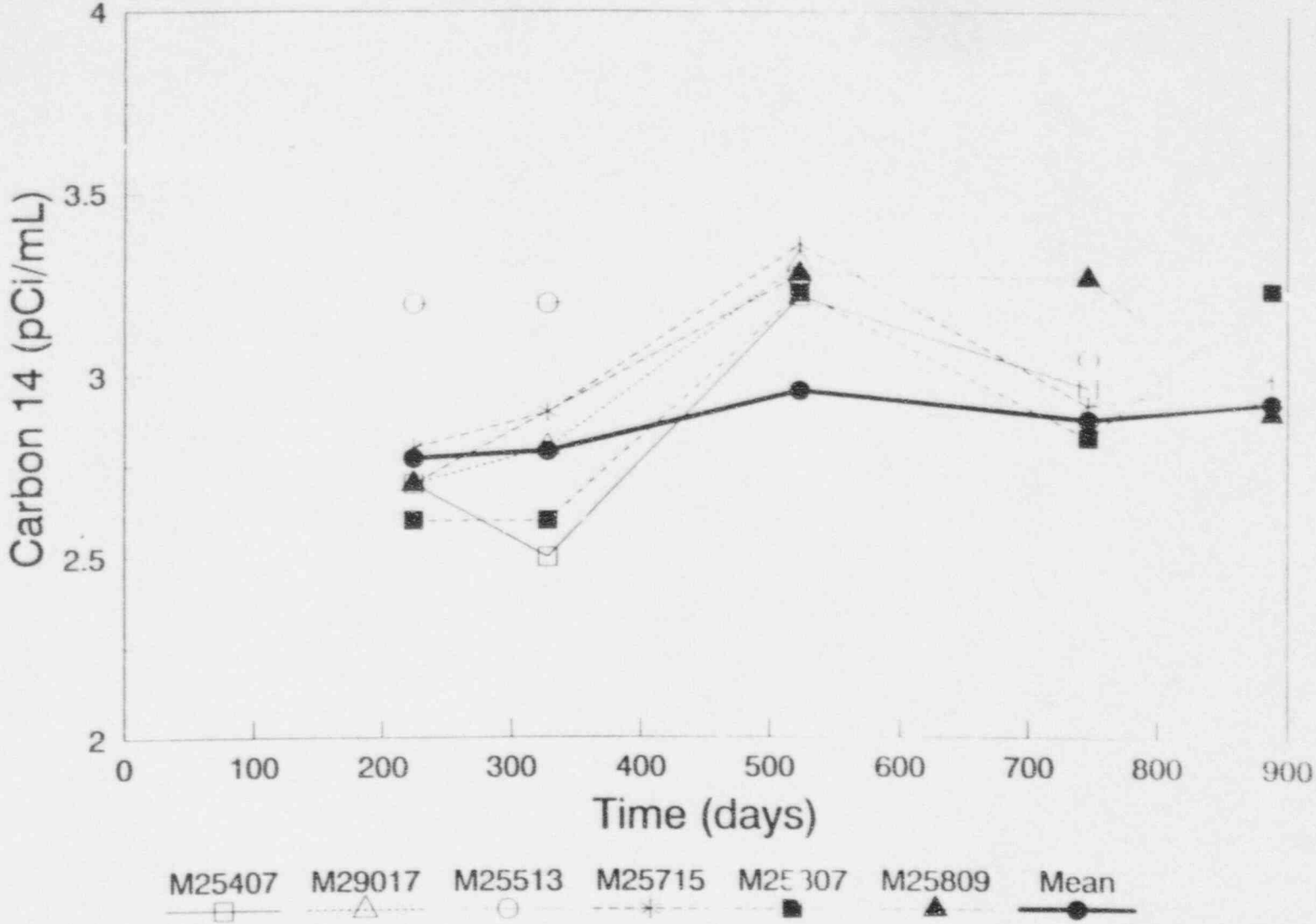

Figure 6. Observed C-14 Concentration Histories for Selected Sampling Points Located In Last Row of Monitoring Network

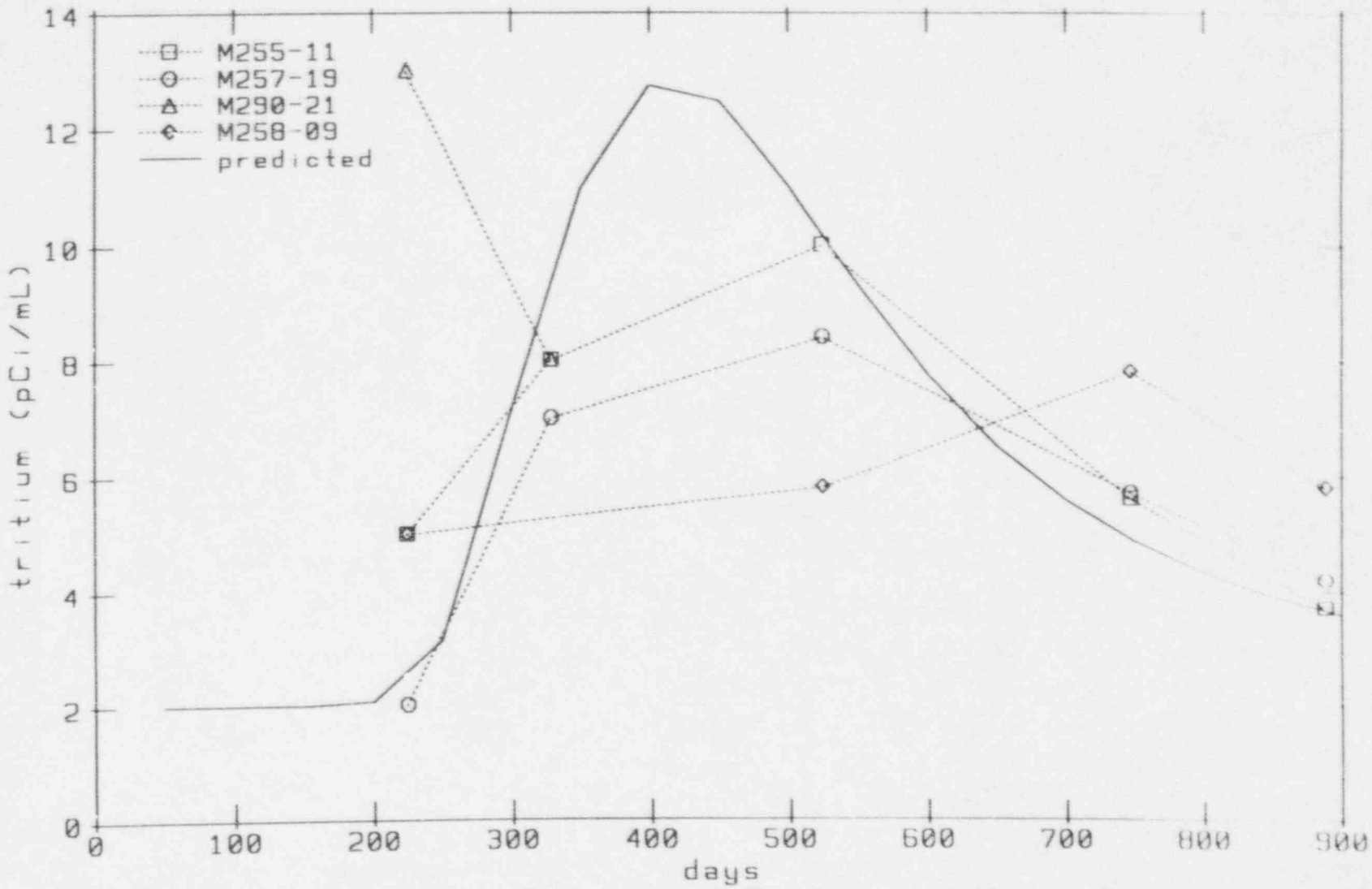

Figure 7. Observed v. Predicted Tritium at Last Row of Network

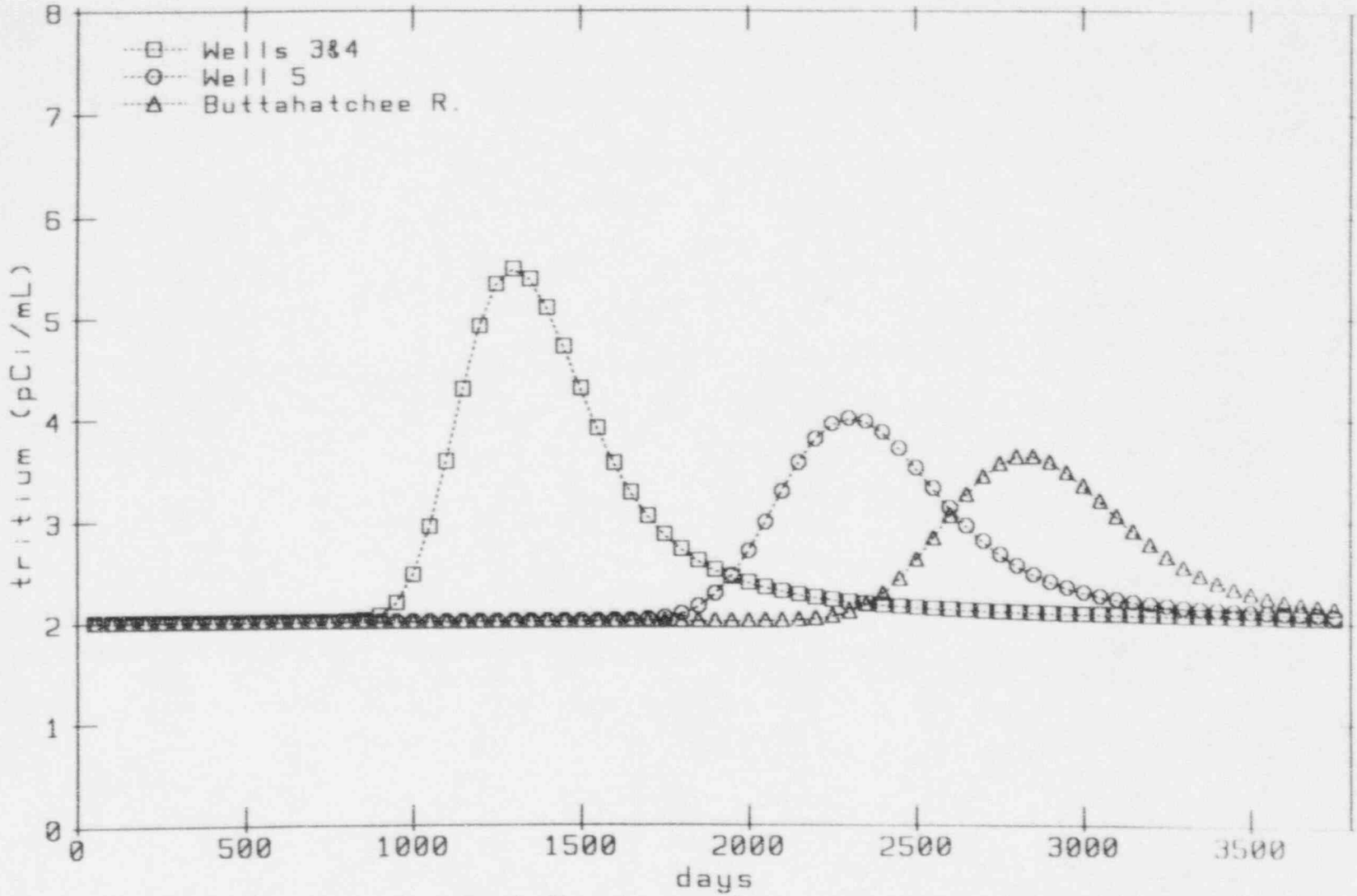

Figure 8. Predicted Tritium Concentrations at Receptors

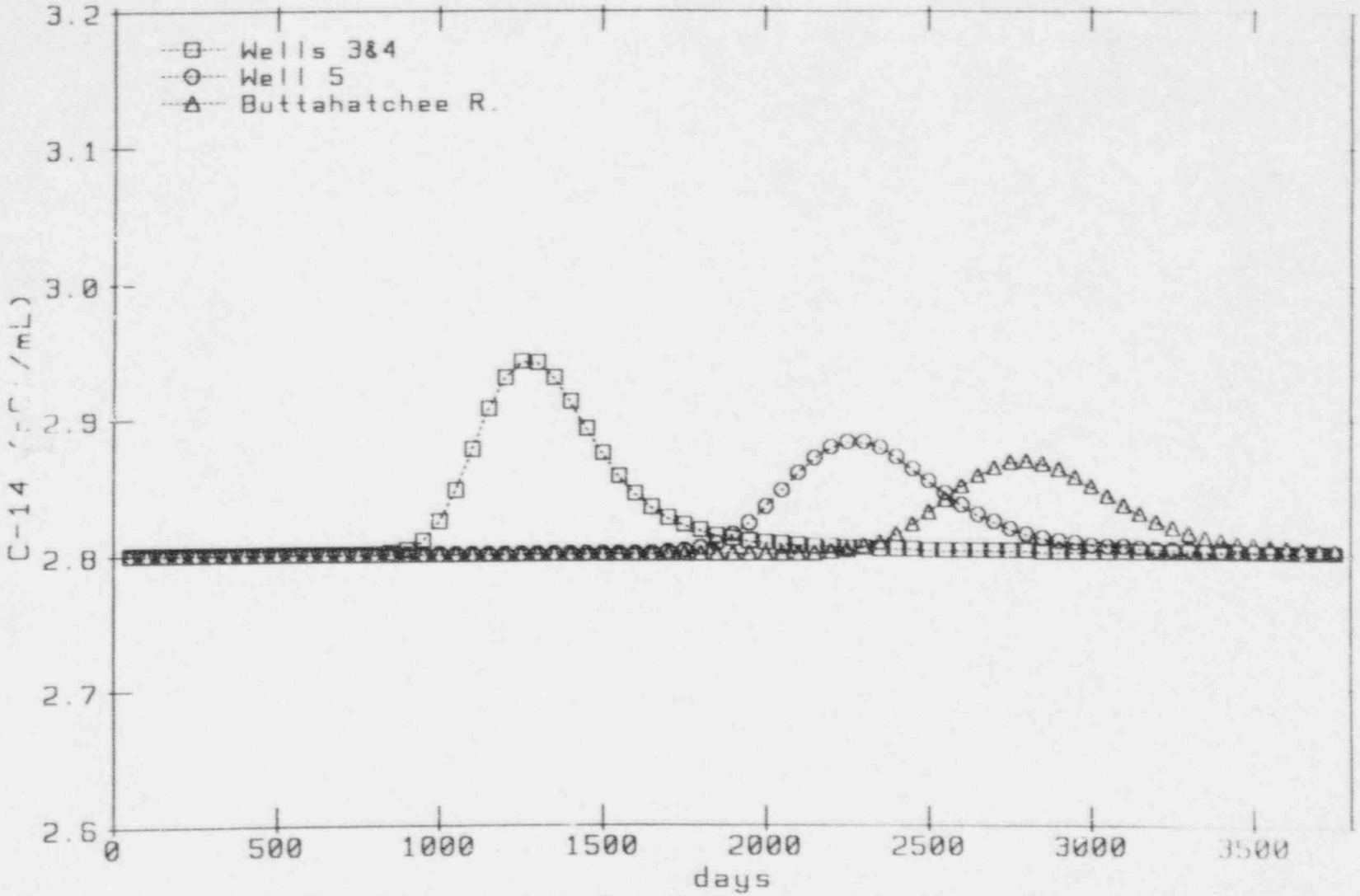

Figure 9. Predicted C-14 Concentrations at Receptors

Tennessee Valley Authority

96 AUG -6 A7:44

July 29, 1996

Mr. Jay Henson
Materials Licensing Section
U.S. Nuclear Regulatory Commission
101 Marietta Street, Northwest
Atlanta, Georgia 30323

Dear Mr. Henson:

REQUEST FOR TERMINATION OF BYPRODUCT LICENSE 41-25047-02, ADDITIONAL INFORMATION

In response to our recent telephone conversations, I submit the following information regarding the letter dated March 27, 1996, from Mr. G. W. Lowe of TVA to Ms. D. Heim of the Nuclear Regulatory Commission.

First, corrections to the first two pages of enclosure 1 to form 314, submitted with the letter of March 27, 1996:

> The last sentence of the second from the last paragraph, first page should read: "The initial concentrations of these two isotopes was 0.05561 micro Ci/ml of H-3 and 0.00277 micro Ci/ml of C-14."
>
> In the last sentence of the fourth paragraph on the second page, the factor 97.3×10^5 should be 7.3×10^5.

Second, figure 5 of enclosure 3 to form 314 of the March 27, 1996 letter was omitted. It is enclosed with this memorandum.

Third, additional data, collected at later dates, on the concentrations of radionuclides in ground water in the area where this field experiment was conducted are enclosed.

If you have any additional questions or comments, please call me at (205) 386-2993.

Jesse H. Coleman, Radiation Safety Officer
Radiation Safety

Enclosures

TABLE 5
PREDICTED TRITIUM AND C-14 CONCENTRATIONS AT DOWNGRADIENT RECEPTORS

Time (days)	Tritium Concentrations* (pCi/mL) Wells 3 & 4	Well 5	At The Buttahatchee River	C-14 Concentrations* (pCi/mL) Wells 3 & 4	Well 5	At The Buttahatchee River
50	2.00	2.00	2.00	2.80	2.80	2.80
100	2.00	2.00	2.00	2.80	2.80	2.80
150	2.00	2.00	2.00	2.80	2.80	2.80
200	2.00	2.00	2.00	2.80	2.80	2.80
250	2.00	2.00	2.00	2.80	2.80	2.80
300	2.00	2.00	2.00	2.80	2.80	2.80
350	2.00	2.00	2.00	2.80	2.80	2.80
400	2.00	2.00	2.00	2.80	2.80	2.80
450	2.00	2.00	2.00	2.80	2.80	2.80
500	2.00	2.00	2.00	2.80	2.80	2.80
550	2.00	2.00	2.00	2.80	2.80	2.80
600	2.00	2.00	2.00	2.80	2.80	2.80
650	2.00	2.00	2.00	2.80	2.80	2.80
700	2.00	2.00	2.00	2.80	2.80	2.80
750	2.00	2.00	2.00	2.80	2.80	2.80
800	2.00	2.00	2.00	2.80	2.80	2.80
850	2.01	2.00	2.00	2.80	2.80	2.80
900	2.06	2.00	2.00	2.80	2.80	2.80
950	2.18	2.00	2.00	2.81	2.80	2.80
1000	2.46	2.00	2.00	2.82	2.80	2.80
1050	2.94	2.00	2.00	2.85	2.80	2.80
1100	3.58	2.00	2.00	2.88	2.80	2.80
1150	4.29	2.00	2.00	2.91	2.80	2.80
1200	4.91	2.00	2.00	2.93	2.80	2.80
1250	5.33	2.00	2.00	2.94	2.80	2.80
1300	5.48	2.00	2.00	2.94	2.80	2.80
1350	5.38	2.00	2.00	2.93	2.80	2.80
1400	5.09	2.00	2.00	2.91	2.80	2.80
1450	4.70	2.00	2.00	2.89	2.80	2.80
1500	4.29	2.00	2.00	2.87	2.80	2.80
1550	3.90	2.00	2.00	2.86	2.80	2.80
1600	3.55	2.00	2.00	2.84	2.80	2.80
1650	3.27	2.00	2.00	2.83	2.80	2.80
1700	3.04	2.01	2.00	2.83	2.80	2.80
1750	2.85	2.03	2.00	2.82	2.80	2.80
1800	2.71	2.07	2.00	2.82	2.80	2.80
1850	2.59	2.14	2.00	2.81	2.81	2.80
1900	2.50	2.27	2.00	2.81	2.81	2.80
1950	2.43	2.45	2.00	2.81	2.82	2.80
2000	2.38	2.69	2.00	2.81	2.83	2.80
2050	2.33	2.97	2.00	2.81	2.85	2.80
2100	2.29	3.27	2.00	2.81	2.86	2.80

TABLE 5. CONTINUED
PREDICTED TRITIUM AND C-14 CONCENTRATIONS AT DOWNGRADIENT RECEPTORS

Time (days)	Tritium Concentrations* (pCi/mL)			C-14 Concentrations* (pCi/mL)		
	Wells 3 & 4	Well 5	At The Buttahatchee River	Wells 3 & 4	Well 5	At The Buttahatchee River
2150	2.26	3.56	2.01	2.81	2.87	2.80
2200	2.23	3.79	2.02	2.81	2.88	2.80
2250	2.21	3.94	2.05	2.80	2.88	2.80
2300	2.19	4.00	2.09	2.80	2.88	2.81
2350	2.17	3.96	2.16	2.80	2.88	2.81
2400	2.16	3.86	2.27	2.80	2.87	2.81
2450	2.14	3.70	2.42	2.80	2.86	2.82
2500	2.13	3.51	2.61	2.80	2.85	2.83
2550	2.12	3.31	2.82	2.80	2.84	2.84
2600	2.11	3.12	3.04	2.80	2.84	2.85
2650	2.10	2.94	3.25	2.80	2.83	2.86
2700	2.10	2.79	3.43	2.80	2.82	2.86
2750	2.09	2.65	3.55	2.80	2.82	2.87
2800	2.09	2.55	3.62	2.80	2.81	2.87
2850	2.08	2.46	3.62	2.80	2.81	2.87
2900	2.08	2.39	3.57	2.80	2.81	2.86
2950	2.07	2.33	3.47	2.80	2.81	2.86
3000	2.07	2.28	3.34	2.80	2.81	2.85
3050	2.06	2.24	3.19	2.80	2.81	2.84
3100	2.06	2.21	3.04	2.80	2.81	2.84
3150	2.06	2.19	2.89	2.80	2.80	2.83
3200	2.06	2.17	2.76	2.80	2.80	2.82
3250	2.05	2.15	2.64	2.80	2.80	2.82
3300	2.05	2.13	2.54	2.80	2.80	2.82
3350	2.05	2.12	2.45	2.80	2.80	2.81
3400	2.05	2.11	2.38	2.80	2.80	2.81
3450	2.04	2.10	2.32	2.80	2.80	2.81
3500	2.04	2.09	2.28	2.80	2.80	2.81
3550	2.04	2.09	2.24	2.80	2.80	2.81
3600	2.04	2.08	2.21	2.80	2.80	2.81

* Listed Concentrations Include Background

Tritium Background is 2.00 pCi/mL
C-14 Background is 2.80 pCi/mL.

Columbas AFB, Concentrations of Radionuclides Remaining in Groundwater
Data Collected Nov. 3, 1993

Well No	Distance From Injection Pt. (m)	Top of Layer (m)	Bottom of Layer (m)	H-3 Av Conc (micro Ci/ml)	C-14 Av Conc (micro Ci/ml)
D018	9.7	4.9	9.5	3.5E-04	5.8E-06
D021	3.3	5.0	10.4	1.1E-04	2.3E-06
M050	13.5	5.9	11.2	8.2E-05	3.1E-06
M066	17.7	4.5	11.3	6.4E-06	6.0E-07
M088	33.8	4.7	11.5	1.7E-06	3.0E-07
M109	48.8	6.0	11.3	2.8E-06	5.0E-07

Data Collected From Nov. 2 to Nov. 10, 1995

Location: Area of Injection Well

	H-3 Av. Conc. Above Background (pCi/ml)	C-14 Av. Conc. Above Background (pCi/ml)
	0.9	0.2
Background (pCi/ml):	2.0	2.8