

**TRITIUM IN GROUND WATER IN MISSISSIPPI,  
1989-90**

**By Larry J. Slack and William T. Oakley**

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**U.S. GEOLOGICAL SURVEY  
Open-File Report 91-177**

**Prepared in cooperation with the**

**MISSISSIPPI DEPARTMENT OF ENVIRONMENTAL QUALITY,  
OFFICE OF POLLUTION CONTROL**



**Jackson, Mississippi  
1991**

**U.S. DEPARTMENT OF THE INTERIOR  
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## CONVERSION FACTORS

<u>Multiply</u>	<u>By</u>	<u>To obtain</u>
foot	25.4	millimeter
gallon per minute	0.06308	liter per second

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## ABSTRACT

*In April 1989 and in April and May 1990, the U.S. Geological Survey collected water samples from 43 shallow wells (less than 500 feet deep) for tritium analyses; the wells are completed in 13 of the 14 principal aquifers in Mississippi. Tritium concentrations ranged from less than 0.3 to 42 picocuries per liter. Tritium concentrations in water from about 40 percent of the wells were greater than 1 picocurie per liter, indicating modern (post-1953) water. The median tritium concentration for wells with modern water was 21 picocuries per liter; the mean, 23 picocuries per liter.*

*The median depth, specific conductance, pH, and alkalinity values were substantially smaller for the wells with modern water than for wells with older (pre-1953) water. Wells with modern water had a median depth of 187 feet; specific conductance, 66 microsiemens per centimeter at 25 degrees Celsius; pH, 5.9; and alkalinity as calcium carbonate, 10 milligrams per liter. Wells with pre-1953 water had a median depth of 277 feet; specific conductance, 339 microsiemens; pH, 7.6; and alkalinity, 158 milligrams per liter.*

## **INTRODUCTION**

As part of the Federal-State Cooperative Program, the U.S. Geological Survey (USGS) collects, on a systematic basis, data needed for the continuing determination and evaluation of the quantity, quality, and use of water resources in the United States, and appraises the availability of ground and surface water through analytical and interpretive investigations. The resulting information forms the foundation for many of the Nation's water-resources management and planning activities and allows for the detection of emerging water problems.

The Mississippi Department of Environmental Quality, Office of Pollution Control (OPC), is the principal agency responsible for the management and protection of ground water in Mississippi. The OPC administers programs and policies to secure, protect, and preserve the right of citizens to unpolluted waters. Together with the Mississippi Department of Agriculture and Commerce, the OPC is developing a comprehensive program to protect aquifers from surface and shallow-source contamination. The USGS, in cooperation with these agencies, is conducting an investigation to describe the relative susceptibility of major aquifers in Mississippi to surface and shallow-source contamination.

### **Purpose and Scope**

One of the objectives of the OPC's ground-water protection programs is to investigate the relative age of ground water in the principal aquifers in Mississippi that are associated with the Well Head Protection Program. In 1989 and 1990, in cooperation with the OPC, the USGS used radioisotope (tritium) dating techniques to assess the relative age of shallow ground water for selected aquifers in the State. This report summarizes the site information, methods of sampling and analysis, and results of the tritium analyses and other selected water-quality data collected as part of that study.

## **Use of Tritium as a Tracer**

Tritium has been used extensively as a hydrologic tracer since the early 1950's and can be used to indicate the relative age of water (pre- or post-1953). Tritium is particularly useful in ground-water studies because it is relatively unaffected by reactions other than radioactive decay. Tritium is a radioactive isotope of hydrogen with an atomic weight of 3 and a half-life of 12.43 years. Tritium is produced naturally and occurs in a small but nearly constant concentration in the atmosphere (Lal and Peters, 1967). Prior to the initiation of atmospheric testing of large thermonuclear weapons in 1953, the natural tritium content of rainwater was about 1 to 5 Tritium Units or 1 to 5 tritium atoms per  $10^{18}$  normal hydrogen atoms (Thatcher, 1962, p. 48). In the 1950's and 1960's, tritium concentrations in precipitation in the northern hemisphere increased substantially and resulted in values of about 50 Tritium Units for surface ocean water and 100's or 1000's of Tritium Units for some continental water (Michel, 1989, p. 2).

## **SITE SELECTION CRITERIA AND SITE INFORMATION**

In April 1989 and in April and May 1990, the USGS collected water samples from 43 shallow wells (less than 500 feet deep) (fig. 1) for tritium analyses; the wells were completed in 17 geologic units in 13 of the 14 principal aquifers in Mississippi (tables 1 and 2). The availability of complete and accurate well-construction information was an essential selection criterion for each site; consequently, first preference was given to public-supply wells for which driller's logs and geophysical logs are available. Other selection criteria included wells that were in use, had turbine or submersible pumps, and had a yield of at least 25 gallons per minute.

## **METHODS OF SAMPLING AND ANALYSIS**

To assure that samples were representative of water from the water-bearing unit, the wells were pumped long enough prior to sampling to

evacuate at least twice the volume of water standing in the casing. Most of the wells sampled were in daily operation, and some were in continuous operation.

Water samples for tritium analysis were collected in a narrow-mouth flint glass bottle with a polyseal cap. The bottle was completely filled, with care taken not to entrain air. The bottle was capped, and the cap was taped to prevent it from loosening during transit.

The samples were shipped to the USGS Water Resources Division National Water Quality Laboratory in Denver, Colorado, where they were recorded, repackaged, and forwarded to the University of Miami Tritium Laboratory. At the Tritium Laboratory, the samples were analyzed by an electrolytic enrichment with gas counting method developed by Ostlund and Werner (1961). It is the most sensitive method of tritium analysis available through the National Water Quality Laboratory. The lower detection limit is 0.3 picocurie per liter.

## RESULTS

Tritium concentrations for the 43 wells (table 3) are in picocuries per liter; for the convenience of the reader, Tritium Units (which were obtained by dividing picocuries per liter by a conversion factor of 3.2) are also shown. Laboratory values for specific conductance, pH, and alkalinity for water from the 43 wells are also included in table 3.

Tritium concentrations less than about 1 picocurie per liter are considered to represent water with natural or background levels of tritium for ground water in Mississippi (R.L. Michel, USGS, oral commun., September 13, 1989). Values greater than 1 picocurie per liter are considered to represent post-1953 water, which is commonly referred to as "modern water" or "bomb tritium water." The limited amount of tritium data obtained during this study precludes drawing conclusions about the typical concentrations for any given aquifer.

Tritium concentrations ranged from less than 0.3 (the lower detection limit) to 42 picocuries per liter (table 3; fig. 2). Tritium concentrations in water from 24 of the wells were less than the lower detection limit. In 17 of the 43 wells (about 40 percent), tritium concentrations were greater than 1 picocurie per liter, indicating modern (post-1953) water. The median

tritium concentration for wells with modern water was 21 picocuries per liter; the mean, 23 picocuries per liter. The largest concentrations of tritium detected in ground water during this study are approximately equal to that in present-day (1991) precipitation in the area, or about 30 to 40 picocuries per liter (R.L. Michel, USGS, written commun., January 26, 1991).

The median depth, specific conductance, pH, and alkalinity values were substantially smaller for the wells with modern water than for wells with older (pre-1953) water (table 4). Wells with modern water had depths ranging from 96 to 360 feet, and a median depth of 187 feet. Water from these modern-water wells had specific conductance values ranging from 20 to 558 microsiemens and a median of 66 microsiemens. Water from these wells had pH values ranging from 5.3 to 7.5, and a median pH of 5.9. Water from these wells had alkalinity values (as calcium carbonate) ranging from 2 to 288 milligrams per liter, and a median of 10 milligrams per liter.

Wells with pre-1953 water had depths ranging from 138 to 483 feet, and a median depth of 277 feet. Water from these wells had specific conductance values ranging from 30 to 938 microsiemens, and a median of 339 microsiemens. Water from these wells had pH values ranging from 6.2 to 8.6, and a median pH of 7.6. Water from these wells had alkalinity values (as calcium carbonate) ranging from 7 to 299 milligrams per liter, and a median of 158 milligrams per liter.

## SUMMARY

In April 1989 and in April and May 1990, the U.S. Geological Survey collected water samples from 43 shallow wells (less than 500 feet deep) for tritium analyses; the wells are completed in 13 of the 14 principal aquifers in Mississippi. Tritium concentrations ranged from less than 0.3 to 42 picocuries per liter. Tritium concentrations in water from about 40 percent of the wells were greater than 1 picocurie per liter, indicating modern (post-1953) water. The median depth, specific conductance, pH, and alkalinity values were substantially smaller for the wells with modern water than for wells with older (pre-1953) water.

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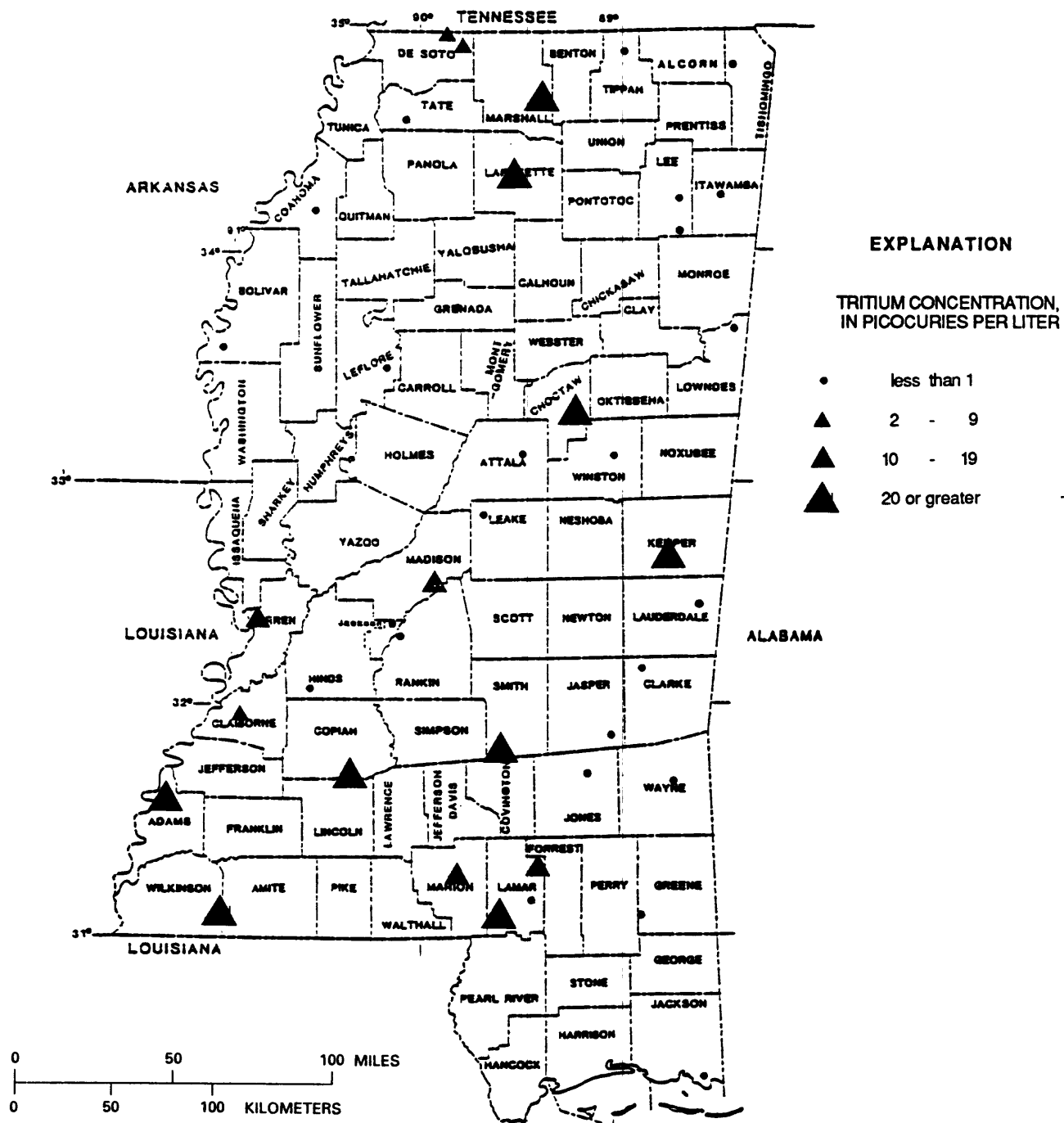


Figure 2.--Tritium concentrations in ground water.

**Table 1. Geologic units and principal aquifers in Mississippi**  
[Modified from Slack and Darden, 1991; only geologic unit codes for units tabulated in table 2 are listed]

Erathem	System	Series	Group	Geologic unit code	Geologic unit	Principal aquifer or aquifer system		
Cenozoic	Quaternary	Holocene and Pleistocene		MRVA	Quaternary alluvium Mississippi River valley alluvium	Mississippi River alluvial aquifer		
		Pleistocene			Loess Terrace deposits			
		Tertiary	Pliocene		CRNL GRMF	Citronelle Formation Graham Ferry Formation	Citronelle aquifers	
	Miocene				Pascagoula Formation Hattiesburg Formation Catahoula Sandstone, upper part Catahoula Sandstone, lower part Deposits of Miocene age	Miocene aquifer system		
			Oligocene	Vicksburg Group	WRBR	Bucaturra Formation Waynesboro sand lentil Byram Formation Glendon Limestone Marianna Formation Mint Spring Formation Forest Hill Formation	Oligocene aquifer system	
	Eocene		Jackson Group		Yazoo Clay Moody's Branch Formation			
			Claiborne Group	CCKF	Cockfield Formation Cook Mountain Formation Sparta Sand Zilpha Clay Winona Sand	Cockfield aquifer		
				SPRT	Tallahatta Formation Neshoba Sand Member Basic City Shale Member Meridian Sand Member	Sparta aquifer		
				TLLT	Meridian Sand Member and Wilcox Group, upper part	Winona-Tallahatta aquifer		
				MUWX	Wilcox Group, upper part Hatchetigbee Formation	Meridian-upper Wilcox aquifer		
			Paleocene	Wilcox Group	WLCXM	Tuscahoma Formation Wilcox Group, middle part Nanafalia Formation Fearn Springs Member	Lower Wilcox aquifer	
					WLCXL	Wilcox Group, lower part		
					Midway Group	Naheola Formation Porters Creek Clay Mathews Landing Marl Member Clayton Formation		
	Mesozoic		Cretaceous	Upper Cretaceous	Selma Group	RPLY	Prairie Bluff Chalk and Owl Creek Formation Ripley Formation Demopolis Chalk Coffee Sand Mooreville Chalk Arcola Limestone Member	Ripley aquifer
		Tuscaloosa Group	EUTW	Eutaw Formation Tombigbee Sand Member Eutaw Formation, lower part	Eutaw-McShan aquifer			
			MCSN GORD	McShan Formation Gordo Formation Coker Formation Massive sand	Tuscaloosa aquifer system			
				Undifferentiated				
Paleozoic				PLZC	Undifferentiated Paleozoic Erathem	Paleozoic aquifer system		

**Table 2. Summary of site information**  
[Util, Utilities; W A, Water Association]

Site number	County	Local well number	Owner or operator	Latitude	Longitude	Depth of well (feet)	Depth to top of open interval (feet)	Geologic unit code (see table 1)
1	ADAMS	D045	BROADMOORE UTIL	31°35'38"	91°21'32"	150	135	MOCN
2	ATTALA	H023	ETHEL	33°07'30"	89°28'01"	210	170	TLLT
3	BOLIVAR	R074	SCOTT	33°35'24"	91°04'37"	483	431	OCKF
4	CHOCTAW	H030	ACKERMAN	33°18'46"	89°10'34"	101	64	WLCXM
5	CLAIBORNE	L079	PORT GIBSON	31°57'19"	90°58'52"	170	110	CTHLL
6	CLARKE	A002	ENTERPRISE	32°10'19"	88°49'09"	250	220	MUWX
7	COAHOMA	J009	CLARKSDALE	34°12'12"	90°34'15"	357	307	SPRT
8	COPIAH	V019	WESSON	31°42'29"	90°23'14"	332	292	CTHLL
9	COPIAH	V025	WESSON	31°42'37"	90°23'10"	360	320	CTHLL
10	DE SOTO	D022	MINERAL WELLS W A	34°59'10"	89°51'30"	272	237	SPRT
11	DE SOTO	H073	FAIRHAVEN W A	34°55'59"	89°47'35"	254	214	SPRT
12	GREENE	N044	MCLAIN	31°05'05"	88°48'58"	180	140	MOCN
13	GRENADA	H010	GRENADA	33°46'43"	89°48'00"	172	132	MUWX
14	GRENADA	H013	GRENADA	33°41'52"	89°43'35"	170	145	MUWX
15	HINDS	H178	BEST WESTERN	32°23'18"	90°08'46"	380	320	OCKF
16	HINDS	S016	UTICA	32°05'40"	90°35'58"	298	258	CTHLL
17	ITAWAMBA	H021	FULTON	34°16'28"	88°23'33"	274	223	GORD
18	JACKSON	Q420	PASCAGOULA	30°22'47"	88°30'29"	346	266	GRMF
19	JASPER	Q002	HEIDELBERG	31°53'35"	88°59'06"	360	300	OCKF
20	JONES	C167	LAUREL	31°42'32"	89°06'52"	322	268	CTHLL
21	KEMPER	N016	KIPLING W A	32°40'51"	88°40'26"	178	138	WLCXL
22	LAFAYETTE	F023	OXFORD	34°21'55"	89°30'40"	96	71	MUWX
23	LAMAR	E209	N LAMAR W A	31°17'30"	89°24'10"	187	147	CRNL
24	LAMAR	J276	N LUMBERTON W A	31°05'14"	89°35'53"	202	160	CRNL
25	LAMAR	L093	PROGRESS W A	31°09'30"	89°25'11"	264	222	MOCN
26	LAUDERDALE	J125	TOOMSUBA W A	32°28'10"	88°31'38"	240	200	WLCXL
27	LEAKE	A006	THOMASTOWN	32°51'56"	89°40'03"	246	206	SPRT
28	LEE	H093	MOORE-RICH W A	34°15'46"	88°36'58"	360	300	EUTW
29	LEE	O115	CASON W A	34°06'24"	88°36'49"	300	250	MCSN
30	LEFLORE	L154	GREENWOOD	33°30'50"	90°11'00"	220	160	SPRT
31	LOWNDES	B030	CALEDONIA	33°41'00"	88°19'30"	323	283	GORD
32	MADISON	U028	DEPT OF WILDLIFE	32°33'50"	89°55'10"	211	171	OCKF
33	MARION	L002	COLUMBIA	31°14'48"	89°48'50"	140	110	MOCN
34	MARSHALL	P065	LAKE CENTER	34°41'20"	89°21'59"	113	83	MUWX
35	RANKIN	F067	REFLECTION APTS	32°19'36"	90°06'33"	350	330	OCKF
36	SMITH	P013	OKATOMA W A	31°47'46"	89°34'26"	241	201	CTHLL
37	TATE	F048	STRAYHORN W A	34°36'06"	90°04'33"	316	276	SPRT
38	TIPPAH	D014	TIPPLERSVILLE W A	34°53'59"	88°54'37"	190	130	RPLY
39	TISHOMINGO	D052	BURNSVILLE	34°50'33"	88°19'22"	280	230	PLZC
40	WARREN	E023	VICKSBURG	32°24'31"	90°53'02"	122	82	MRVA
41	WAYNE	N155	WAYNESBORO	31°39'55"	88°38'45"	138	88	WSBR
42	WILKINSON	O023	CENTREVILLE W A	31°05'14"	91°03'57"	208	168	CRNL
43	WINSTON	F001	BOND W A	33°07'44"	88°57'38"	206	181	WLCXL

**Table 3. Values for tritium and selected water-quality properties and constituents for ground water**

[pCi/L, picocuries per liter; TU, tritium units;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter;  $\text{CaCO}_3$ , calcium carbonate; <, less than]

Site number	Date	Tritium concentration		Specific conductance ( $\mu\text{S}/\text{cm}$ )	pH (units)	Alkalinity (mg/L as $\text{CaCO}_3$ )
		(pCi/L)	(TU)			
1	04-20-89	41	13	558	7.4	288
2	04-20-90	<.3	<.1	80	6.5	28
3	05-03-90	<.3	<.1	340	8.5	168
4	04-18-89	20	6.2	117	5.5	8
5	04-20-89	4.3	1.3	486	7.0	246
6	04-25-90	<.3	<.1	450	8.5	242
7	04-26-89	<.3	<.1	465	7.2	251
8	04-19-89	34	11	61	5.6	7
9	04-19-89	38	12	40	5.6	6
10	04-23-90	2.0	.6	66	7.2	25
11	04-23-90	6.8	2.1	67	7.5	19
12	04-17-90	<.3	<.1	354	8.6	163
13	04-23-90	<.3	<.1	354	7.6	161
14	04-25-89	<.3	<.1	338	7.5	148
15	04-26-90	<.3	<.1	537	8.5	228
16	04-20-89	<.3	<.1	581	7.2	179
17	04-19-89	<.3	<.1	65	6.2	24
18	04-18-89	<.3	<.1	938	7.9	299
19	04-25-90	<.3	<.1	678	8.3	263
20	04-16-90	<.3	<.1	154	7.1	65
21	04-21-89	31	9.7	36	5.3	2
22	04-25-89	42	13	85	5.7	13
23	04-19-89	14	4.4	23	5.7	5
24	04-19-89	31	9.7	20	5.5	3
25	04-19-89	<.3	<.1	30	6.2	11
26	04-25-90	<.3	<.1	245	8.0	113
27	04-20-90	<.3	<.1	80	6.5	14
28	04-24-90	.6	.2	390	8.2	108
29	04-24-90	<.3	<.1	335	8.0	158
30	04-25-89	.9	.3	455	7.2	234
31	04-20-89	<.3	<.1	65	6.2	25
32	04-26-90	13	4.1	145	7.0	36
33	04-19-89	12	3.8	43	5.8	9
34	04-24-90	30	9.4	37	6.7	10
35	04-19-90	<.3	<.1	507	8.4	211
36	04-16-90	28	8.8	53	5.9	4
37	04-25-89	<.3	<.1	91	6.3	38
38	04-18-89	<.3	<.1	370	7.8	192
39	04-19-89	<.3	<.1	61	6.2	20
40	04-20-89	17	5.3	503	7.1	258
41	05-03-90	<.3	<.1	327	8.3	159
42	05-04-90	21	6.6	99	6.4	14
43	04-25-90	<.3	<.1	33	6.6	7

**Table 4. Median values of depth, specific conductance, pH, and alkalinity  
for pre- and post-1953 ground water  
[based on 1989-90 tritium data]**

	<b>Median values</b>			
	Depth (feet below land surface)	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)	pH (standard units)	Alkalinity (milligrams per liter as calcium carbonate)
<b>Post-1953 water</b>	187	66	5.9	10
<b>Pre-1953 water</b>	277	339	7.6	158