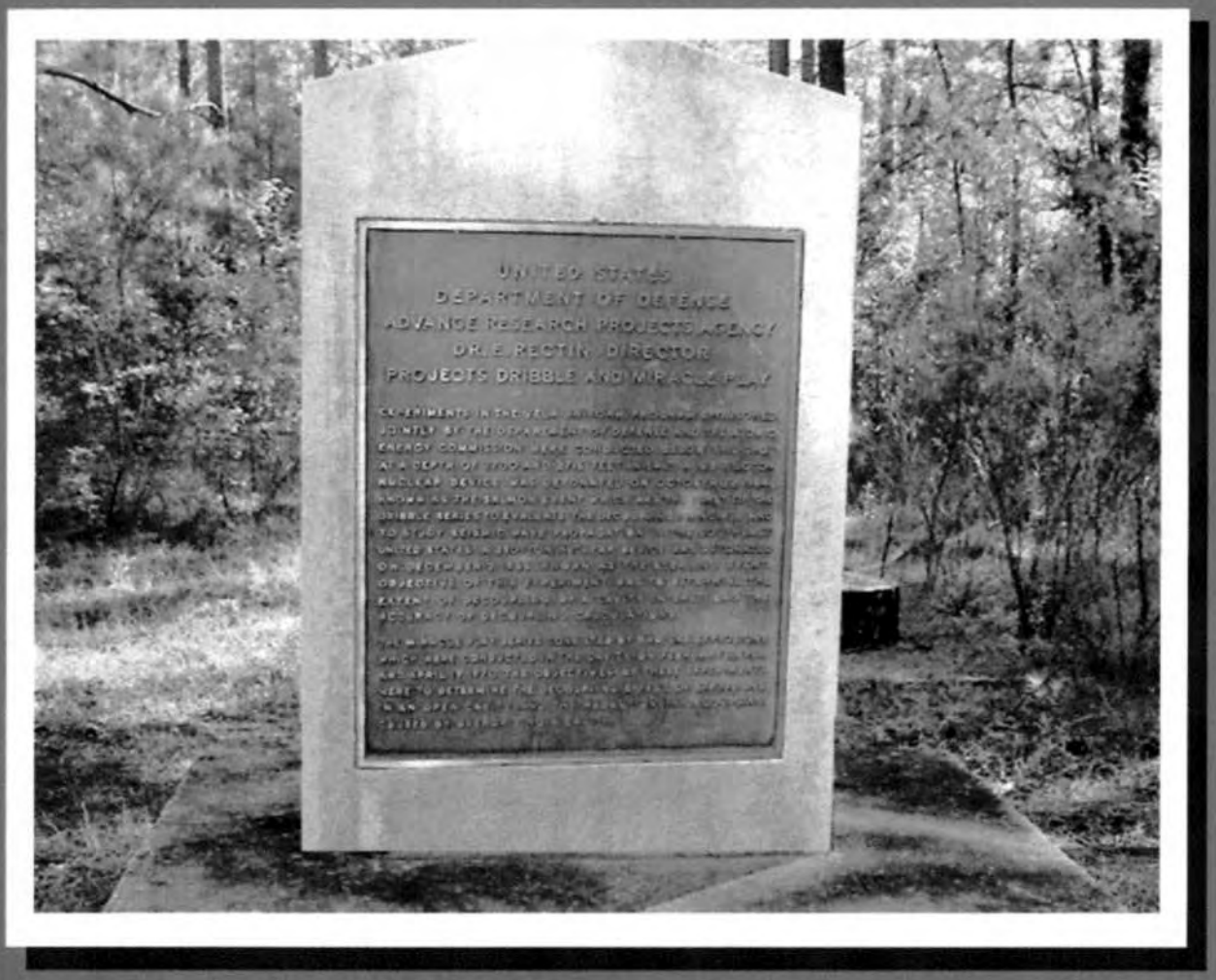

Salmon Test Site Radiological Monitoring

Annual Report 2009

Salmon Test Site
Lamar County, Mississippi

Analytical Results of
Annual Monitoring - April 2009,
and the
Special Study for HMH Series
And Other Surface Samples
January 2009 - December 2009

Includes Comparative Analytical Results
Provided by
EPA
Las Vegas, NV

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May 13, 2011

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7-18-11

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Abbreviations and Notations

AEC	- U.S. Atomic Energy Commission
DOE	- U.S. Department of Energy
ERDA	- Energy Research and Development Administration
EPA	- U.S. Environmental Protection Agency
NCRP	- National Council on Radiation Protection and Measurements
HMC	- Half Moon Creek
HMCOP	- Half Moon Creek Overflow Pond
IT	- International Technologies Corporation
L	- Liter
LLD	- Lower Limit of Detection
LTHMP	- Long-Term Hydrological Monitoring Program
Dup	- Duplicate
NA	- Not applicable
ND	- No data provided
NS	- No sample collected
NSB	- Sample collected by DRH; Broken during shipment to EPA
NSD	- Sample collected by DRH; Broken during transport to DRH
pCi/L	- Picocuries per liter = 10^{-12} curies per liter
PWGZ	- Pond West of Ground zero
SGZ	- Surface Ground Zero
^{3}H	- Tritium
^{137}Cs	- Cesium-137
E-7	- Equipment Well #7
HMH-#	- Hydrological Monitoring Holes-1 through 16
HM-L,L2	- Hydrological Monitoring Well - Local Aquifer
HM-S	- Hydrological Monitoring Well - Surficial Aquifer
HM-1	- Hydrological Monitoring Well - Aquifer 1
HM-2a	- Hydrological Monitoring Well - Aquifer 2a
HM-2b	- Hydrological Monitoring Well - Aquifer 2b
HM-3	- Hydrological Monitoring Well - Aquifer 3
HT-#	- Hydrological Test Well -2c, -4, -5
SA#-##-X	- Source Area 1 to 5 - sequential well number - Aquifer

Preface

This report compiles the data from the April 2009 annual monitoring of the Salmon Test Site (STS), formerly called the Tatum Salt Dome Test Site (TSDTS), in Lamar County, Mississippi. Additionally, it contains data from the year 2009 continuation of the special study of the HMH Series wells. The U.S. Department of Energy (DOE) had representation onsite during the April monitoring period. Many samples were split between the Division of Radiological Health (DRH) and EPA. Duplicate samples collected during the special study of the HMH series were shipped to EPA by DRH. To the extent available, EPA data for the monitoring periods are also reported.

The analytical results identify tritium as the only radionuclide identified above the DRH lower limit of detection and not routinely found at those levels in environmental samples. However, no tritium level above the EPA drinking water standard (20,000 pCi/L) was detected in a potable water source. Additionally, the overall tritium concentration continues to decrease consistent with radioactive decay and dilution in the absence of new sources of significant tritium activity.

Validity of Information

The Division of Radiological Health (DRH) has participated in the DOE/Environmental Measurements Laboratory's (EML) Quality Assurance Program and the Environmental Resource Associates' (ERA) laboratory proficiency testing. As a participant in this program, DRH analyzed unknown, simulated environmental samples provided by ERA and/or EML and reported its results directly to them.

In most cases covered by this report, DRH and EPA shared either duplicate or split samples. Some of the data reflect instances when samples were neither split nor duplicated. In some cases, sample results are less than the Lower Limit of Detection (LLD) for the analytical technique and equipment. For example, for tritium the LLD is approximately 280 picocuries per liter (pCi/L) during routine DRH analysis, and 300 to 700 pCi/L for routine EPA analysis. Concentrations that fall below the LLD are reported "<LLD".

EPA performs some analyses using a "Tritium Enrichment" technique, in which tritium is concentrated by electrolysis. This data can be noted by numbers expressed in quotes; in a fashion similar to: "94.7 ± 6.44", and are generally less than 300 pCi/L.

As a verification of the DRH thermoluminescent dosimetry (TLD) accuracy, the Division twice participated in the International Intercomparison study.

Background Information
The Salmon Test Site, Tritium, and the Role of the Division of Radiological Health

The Salmon Test Site (STS) is located in the piney woods area of the gulf coastal plain near Hattiesburg, Mississippi (Fig. 1). The salt dome at STS is an almost circular dome, 1500 meters (5000 feet) in diameter. The salt is 460 meters (1500 feet) below the ground surface. The salt in the dome is 90% NaCl (commonly called halite) and 10% $CaSO_4$ (commonly called anhydrite).

Project Dribble and Project Miracle Play

During the 1960's the Department of Defense through the U.S. Atomic Energy Commission (AEC) conducted Projects Dribble and Miracle Play in the geological structure known as the Tatum Salt Dome in Lamar County, Mississippi. Project Dribble consisted of two nuclear detonations, and the Miracle Play series consisted of two methane and oxygen gas explosions. All four of the shots were a part of the Department of Defense's Vela-Uniform Project. The STS test cavity contains fission and activation products from the detonations (Fig. 2).

Detonations, Nuclear

The first detonation at STS was known as the Salmon Event. It occurred on October 22, 1964. Its yield was estimated at the time to be 5.3 ± 0.5 kilotons. Note: Some intra-office correspondence indicates a yield closer to 8 kilotons which may have been determined from later calculations. A search of the scientific literature has not confirmed this higher value. The device was detonated at 826 meters (2710 feet) below grade level at surface ground zero (SGZ) and created a cavity in the salt 17 meters (55 feet) in radius.

The second detonation was the Sterling Event; originally to be detonated in a mined cavity on the site. However, failure of two separate attempts to set a large diameter casing to the salt forced a change in plans. The device was placed in the cavity formed by the Salmon Event, and detonated on December 3, 1966. It was calculated to have a 380-ton yield.

Detonations, Non-Nuclear

Two methane/oxygen gas detonations were exploded in the original Salmon/Sterling cavity. These were called, collectively, "Miracle Play." The first shot, February 2, 1969, was called Diode Tube and was estimated to have a 315-ton TNT-equivalence. The second shot, Humid Water, was detonated April 19, 1970, and also had a 315-ton TNT-equivalence.

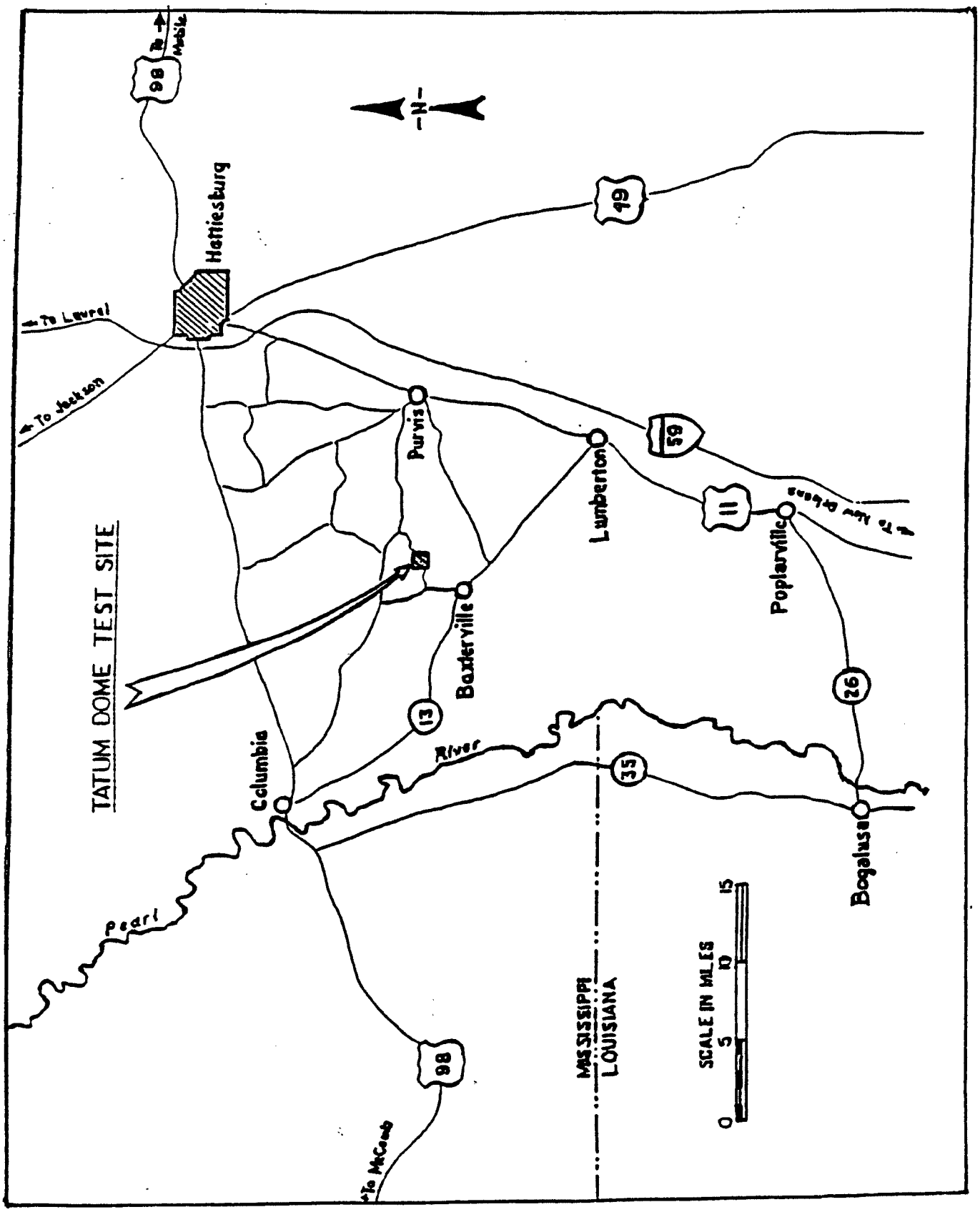

Figure 1, Location Map

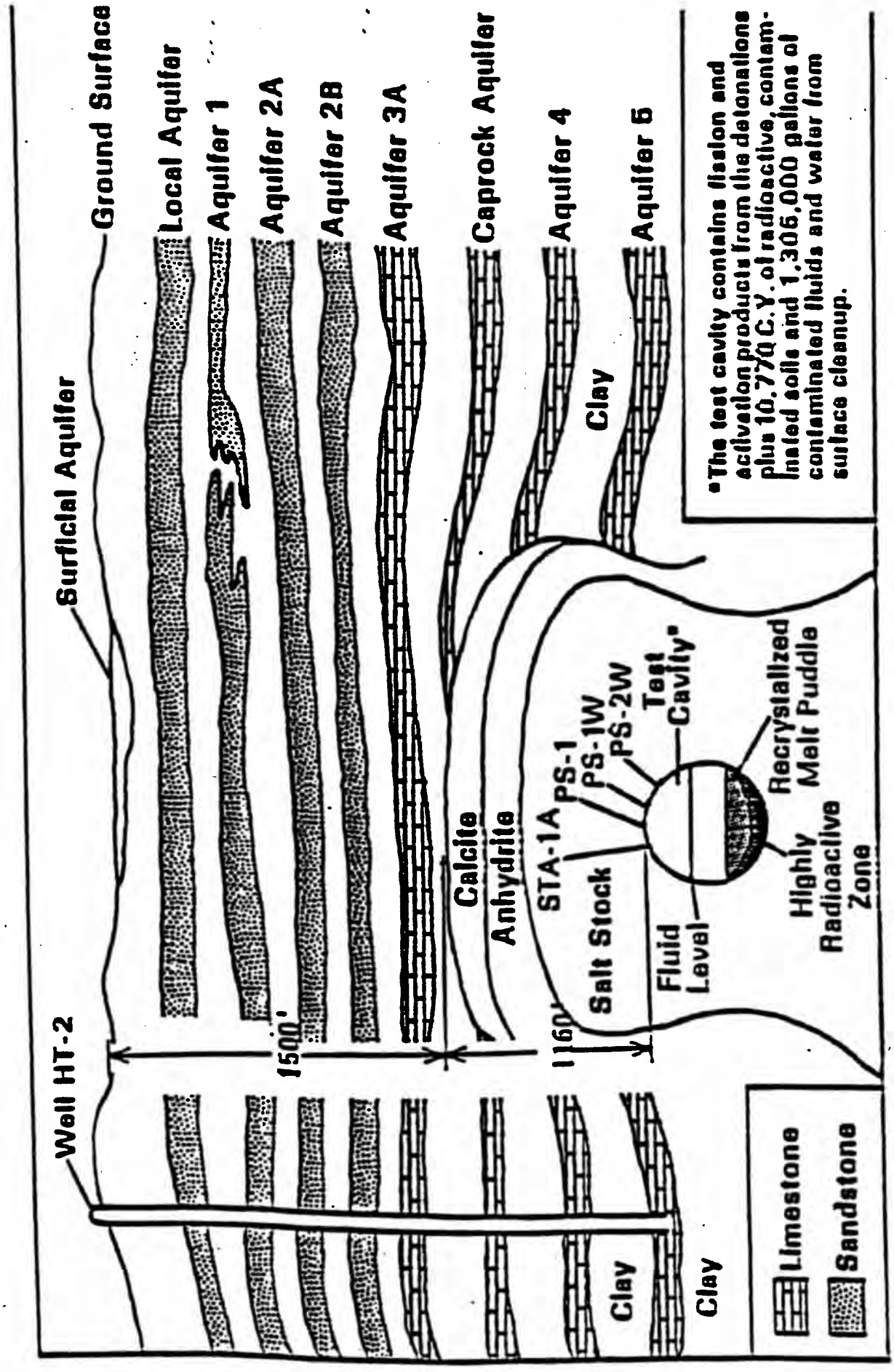

Figure 2, Test Cavity and Aquifers at the Salmon Test Site

Other Site Activities

In preparation for the second nuclear shot and the following gas shots, a plant to process and store radioactive liquids, gases, and solids was built onsite near SGZ. It was known as the Bleeddown Plant. Some soil and drilling mud, and all liquids and gases were processed through this facility.

From March through July of 1965, Aquifer 5 was injected with 7600 liters (2000 gallons) of 15% hydrochloric acid in water solution through Well HT-2 (Fig. 2). This acidic solution effectively dissolved the formation within the Cook Mountain Limestone aquifer in the vicinity of the wellbore, allowing more efficient injection of the waste water. Following this, 1,279,000 liters (337,900 gallons) of contaminated water were injected. At sampling, this water contained 38 curies of beta-gamma emitters and 3253 curies of tritium. A last injection of 340,700 liters (90,000 gallons) of fresh water was made at 414 kPa (60 psi).

Site Decommissioning/Decontamination Limits

The site cleanup was conducted from May 1971 through June 1972 by AEC contractors from Las Vegas, Nevada. Reports indicated that even though the clean-up effort was hampered by locally inclement conditions, the site was left radiologically "clean," consistent with the following limits imposed by the AEC as final clean up criteria:

Surface Water	300,000	pCi/liter tritium
Soil	1,000	pCi/gram tritium
	10	pCi/gram beta-gamma emitter
	1	pCi/gram alpha emitters

The Division of Radiological Health of the Mississippi State Department of Health has been directly involved with STS projects of the Atomic Energy Commission, the Energy Research and Development Administration (ERDA) and the Department of Energy since early 1974.

The reason for the involvement of the Division was the potential for accidental release of waste injected into deep formations (note the fact that radioactively contaminated water had begun surfacing from AEC monitoring well HT-2m). Division activities also address our concerns regarding the potential impact by man-made or natural incursions into the cavity on groundwater onsite and offsite. The isotope of concern has been tritium. In September 1974, an *ad hoc* committee was formulated at the request of the Division to assist in the evaluation of U. S. Government activities at the then Tatum Salt Dome Test Site. That committee was known as the Tatum Salt Dome Advisory Committee.

The Division has been involved only with the radiological matters at the STS. It has also acted as a state clearinghouse for distribution of information received from the various federal agencies involved with the Salmon Project. Unofficially, the Division has acted as the coordinator for Mississippi's involvement at the STS. In 1990, the Mississippi Department of Environmental Quality (MDEQ) became the official coordinator for clean-up activities at STS, and in 2000, that responsibility was officially transferred to the Mississippi State Department of Health.

Due to the possibility of further radiological contamination from HT-2m, the Division had personnel assigned onsite during the HT-2m plugback in August 1975, and the reconditioning of wells HT-1 and Ascot Oil Co. No. 2 Bass Well near Baxterville. The Division also performed tritium analyses on sample splits taken by EPA during the 1975 Salmon operations. An increased sampling frequency was established after the HT-2m plugback.

During the April 1977 sample collection period, the EPA collected some special soil and water samples in the area east of surface ground zero (SGZ) and west of the Half Moon Creek Overflow. The Division did not receive samples from that particular soil and water sampling. In July 1977, the Division was apprised of the fact that significant levels of tritium had been detected in the samples collected in April. A monitoring program was developed to determine the areal and vertical extent, and magnitude of the tritium contamination. Since that time, radiological samples collected by EPA or the Division have been, with few exceptions, splits or duplicates shared with the other agency.

During September and October 1977, representatives of the Division and the Mississippi State Geological Survey (now incorporated into MDEQ) assisted EPA in the collection of soil and water samples from some 130 hand-augered holes in the area of SGZ. The Division of Radiological Health analyzed splits of the water samples.

After the data was analyzed, members of the Tatum Salt Dome Advisory Committee and other interested members of state government determined that additional hand-augered wells should be drilled and a series of shallow water table monitoring holes emplaced. One hole was to be drilled and a well completed in the local aquifer in the SGZ area. Water samples and soil samples collected during the drilling of PS-3 were split with the Division and analyzed for tritium. For various reasons, monitor well PS-3 was never completed.

In September 1978, a Tatum Salt Dome Advisory Committee meeting was called to discuss NVO-200, "Special Study-Tatum Dome Test Site-Final Report," and the role of the Department of Energy, Nevada Operations Office, with respect to future activities at STS.

The Committee determined that the incomplete PS-3 was of no use and should be completed or preferably replaced.

In October 1978, the Mississippi Mineral Resources Institute (MMRI), at the request of State Senator Dale Ford, asked that the Division prepare a synopsis of DRH activities and radioassay results relative to the Tatum Salt Dome (TSD). The information supplied by DRH and Mississippi State Geological Survey (MSGS) and compiled by MMRI showed the geohydrology of the TSD was highly uncertain. There was a question concerning the dome's integrity and the cavity status itself was in doubt.

A Technical Advisory Committee to Senator Ford and the Senate Oil and Gas Committee had a DRH staff member as a representative. Representatives from MSGS and MMRI constituted the remainder of the committee. The input of the DRH representative concerned only radiological matters. Several meetings between the DOE and the Technical Committee were conducted between December 6, 1978, and January 19, 1979. On January 19, 1979, the DOE committed to performing an extensive re-evaluation of the status of the STS in general, with a focus on water and game pathways to man.

Surface Ground Zero (SGZ) Well Depths

In 1979, a group of wells reaching the aquifers (Fig. 2) above the dome were drilled, developed, and pumped. One of the original SGZ wells, PS-3 at 43.3 meters (142 feet), was plugged. Current well depths are as follows:

HM-S	Surficial Aquifer	9 meters (30 ft.)
HM-L	Local Aquifer	62.2 meters (204 ft.) [aquifer extends from 46 to 76 meters]
HM-L2	Local Aquifer	61 meters (200 ft.)
HM-1	Aquifer 1	126 meters (415 ft.)
HM-2a	Aquifer 2a	164 meters (537 ft.)
HM-2b	Aquifer 2b	213 meters (700 ft.)
HM-3	Aquifer 3	267 meters (875 ft.)

REECo Pit

Between 1977 and 1979, during the augering program to collect soil samples and their subsequent analyses, the results indicated notable levels of tritium near the SGZ area. At that time, another area onsite was also identified which had not previously been shown to contain tritium. This location was some 640 meters (2100 feet) from SGZ (Fig. 3). A literature search indicated that this location had been a disposal pit for the Reynolds Electrical and Engineering Company (REECo). It was added to the Long Term

Hydrologic Monitoring Program at that time. Three monitoring points within the old pit were established.

Tritium levels at this pit were unremarkable until 1983. At that time the level increased from the 1000-2000 pCi/L range to approximately 12,000 pCi/L at one location. In 1984, levels returned to the previous range of values.

A request to the U.S. Department of Energy about the use of the pit was made in January 1984. Their response identified the pit as a borrow pit, originally used to fill in other excavations and then for storage of drilling mud. During decommissioning and site cleanup, the pit was used for the disposal of noncombustible materials and uncontaminated tools and equipment. They described the pit as having been filled to capacity, the area was then filled-in and grass planted.

Over the years, this pit has eroded and now has a gully 3.7 to 4.6 meters (12 to 15 feet) deep in places. Bricks and concrete fill have been exposed in areas. Water flows through the pit during high rainfall months. A natural spring is present at one end of this pit; based upon continued sampling, it does not appear to have been contaminated by tritium. Cows and wildlife have been observed using this spring for water. Water flows through the pit, emptying into a small brook somewhat distant from the pit; it also appears to be uncontaminated, beyond any contribution from the pit water.

Senator Trent Lott's Requests

During the fall of 1989, Senator Trent Lott asked DOE to address concerns regarding security needs at SGZ and assess contaminants at the REECo pits. The department was asked to perform an epidemiological cancer study in Lamar County, and evaluate the adequacy of their exchange of information with residents in the STS area.

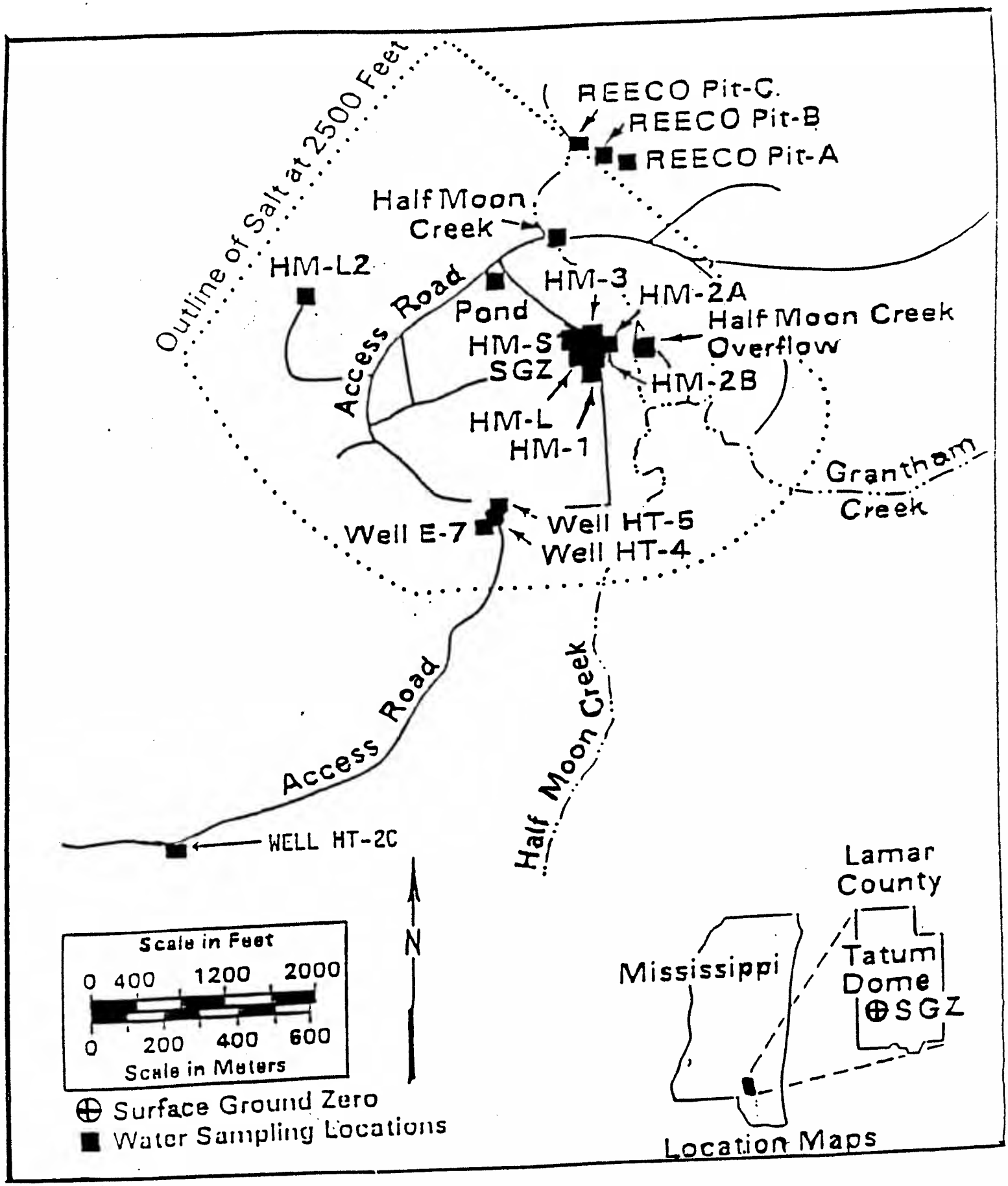

Figure 3, SGZ Downhole Wells and Other Onsite Sample Locations

New Wells on the Salmon Test Site

From the late summer 1995 until January 1997, 29 new wells were drilled, 15 shallow wells (less than 18 meters [59 feet]) and 14 deep wells of varying depth (50.3 to 640 m [165 to 2100 ft]). These wells were drilled both to detect contamination and to characterize the direction of water flow in the aquifers in the vicinity of the Tatum Salt Dome. These wells are designated as the SA# series wells and are a part of the annual sampling. During the 1998 annual sampling of the shallow wells, SA1-1-H well produced tritium analyses results greater than 30,000 pCi/L. This well samples the Half Moon Creek alluvium and is not a potable water source. In December 1998, 70 shallow holes were direct-pushed to repeat the September/October 1977 special study. Duplicate water samples were taken by Division staff and IT Corporation.

In early 2002, four more wells were drilled while many of the earlier wells were plugged and abandoned as part of the Restoration Plan. This left the Long Term Hydrological Monitoring Program (LTHMP) with 28 wells (12 shallow and 16 deep) and six surface water sampling points. In late 2007 all but the two deepest wells were converted to low flow pumps.

Private Wells, Community Water Supplies and Offsite Monitoring

Since March 1980, the annual joint sampling by the U.S. Environmental Protection Agency and the Division of Radiological Health has included private and public supply wells (Fig. 4). The specific public water supplies sampled are Baxterville, Lumberton, Purvis, and Hub Water Association. The approximate locations, relative to SGZ, of the private wells are also shown in Fig. 4.

During the 1990 annual joint sampling of private wells, the offsite monitoring was expanded to include, not only water, but meat, milk, vegetables and other food products for human consumption. Its intent was to examine the various pathways by which tritium, as well as other radionuclides, could be ingested.

During the 2002 Annual joint sampling, residents were notified that the EPA and DRH would no longer collect individual private well samples. This was due to the fact that the DOE had provided assistance to the county for the installation of public water lines to supply all area residents. The offsite sampling will be reduced to the collection of samples from area creeks, ponds and public water suppliers (Table 2).

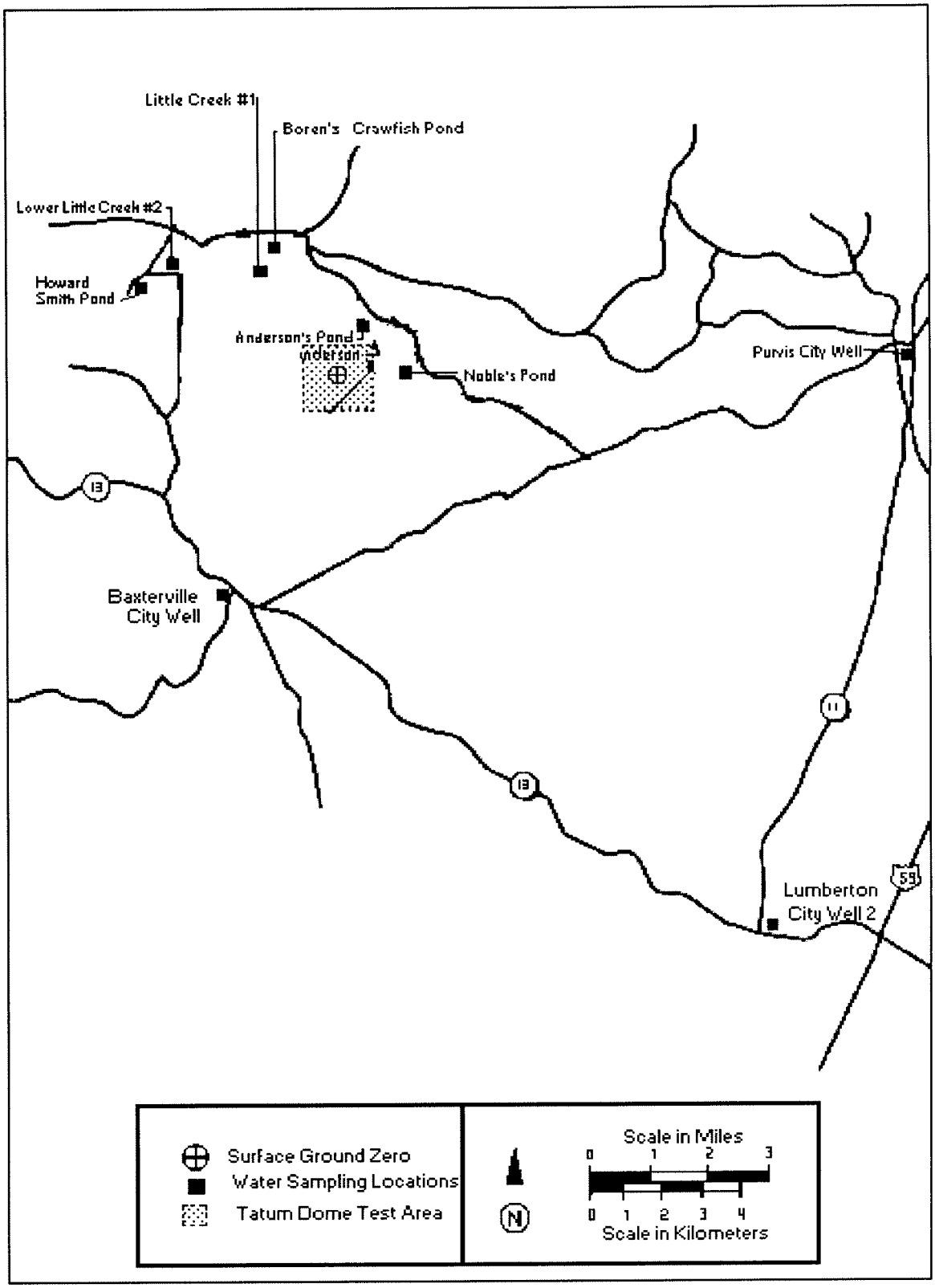

Figure 4, Some of the Offsite Sampling Locations

The "Special Study" Currently Underway At Salmon

During the November 1983 annual sampling, a number of monitored locations had elevated levels of tritium. A number of explanations were discussed, including the most likely explanation that it was due to the dry conditions onsite. Tritium concentration tends to be high during drier months of the year (usually summer and fall) due to less water saturation by rainfall. To evaluate this hypothesis, or assist in the development of a more effective one, an automated rain gauge was installed near the site on February 12, 1992 to accurately measure rainfall. Rainfall was measured by either DRH or EPA into the year 2000. Weather monitoring has been discontinued at the site, the eight years of data having confirmed the theory sufficiently.

After the April 1984 sampling, a "special study" was begun by the Division of Radiological Health with the concurrence of DOE. This study focused on the HMH Series, the Overflow Pond near SGZ, Half Moon Creek, the Pond West of Ground Zero (Beaver Pond), HM-S, and the REECo Pit (Fig. 3 and 5). Samples would be collected monthly in an ongoing study of tritium levels.

Results of this program have been quite consistent, with a definite trend downward for tritium concentrations (Fig. 6). A reduction in sampling frequency to quarterly was instituted when the April 1990 cooperative sampling results did not show a reversal of this trend.

In February of 2002, the HMH series were plugged and abandoned as part of the Site Restoration Plan. Three of these holes were replaced with more reliable wells and several had already been made redundant by the SA# series wells.

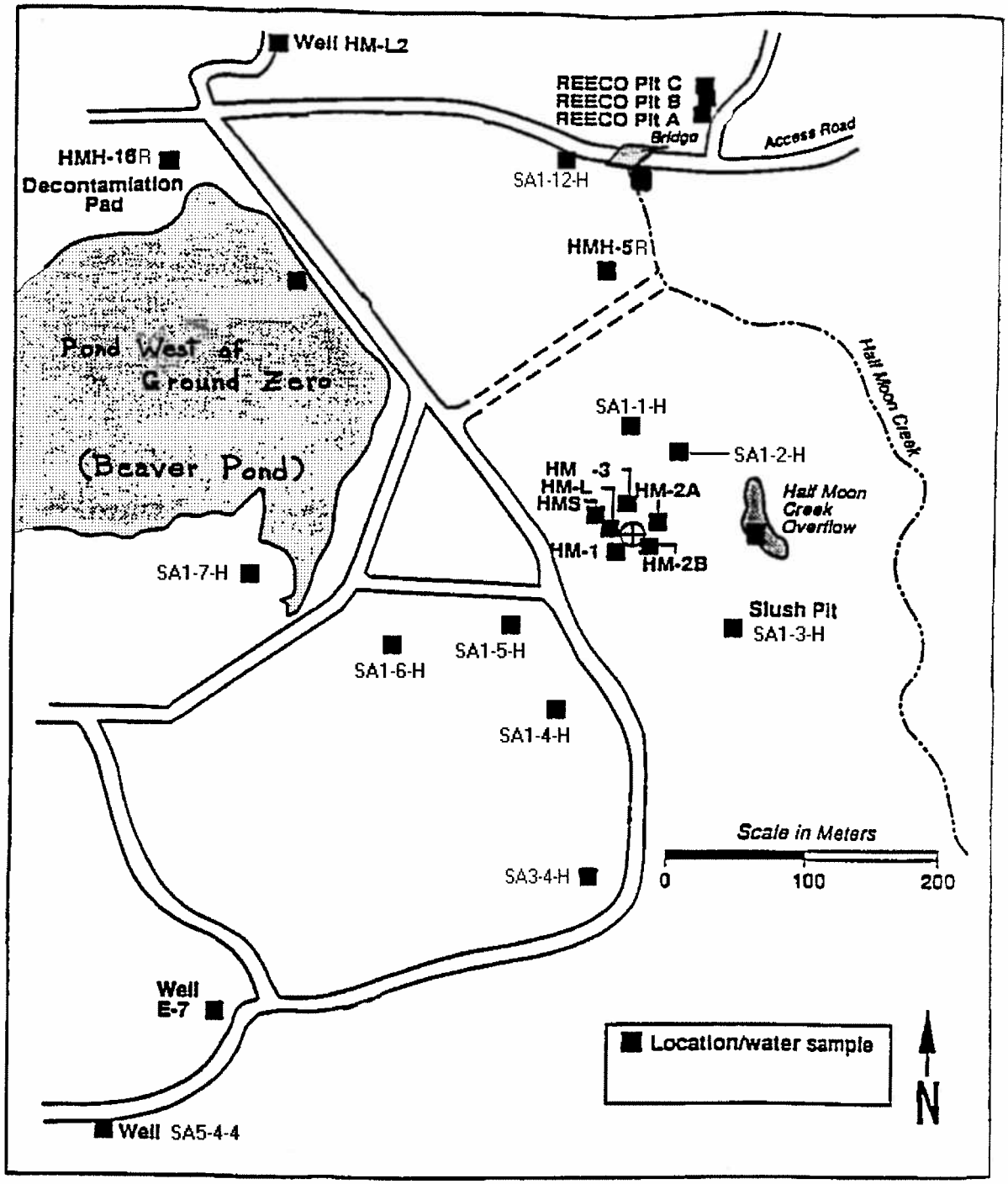

Figure 5, Onsite Sampling Locations

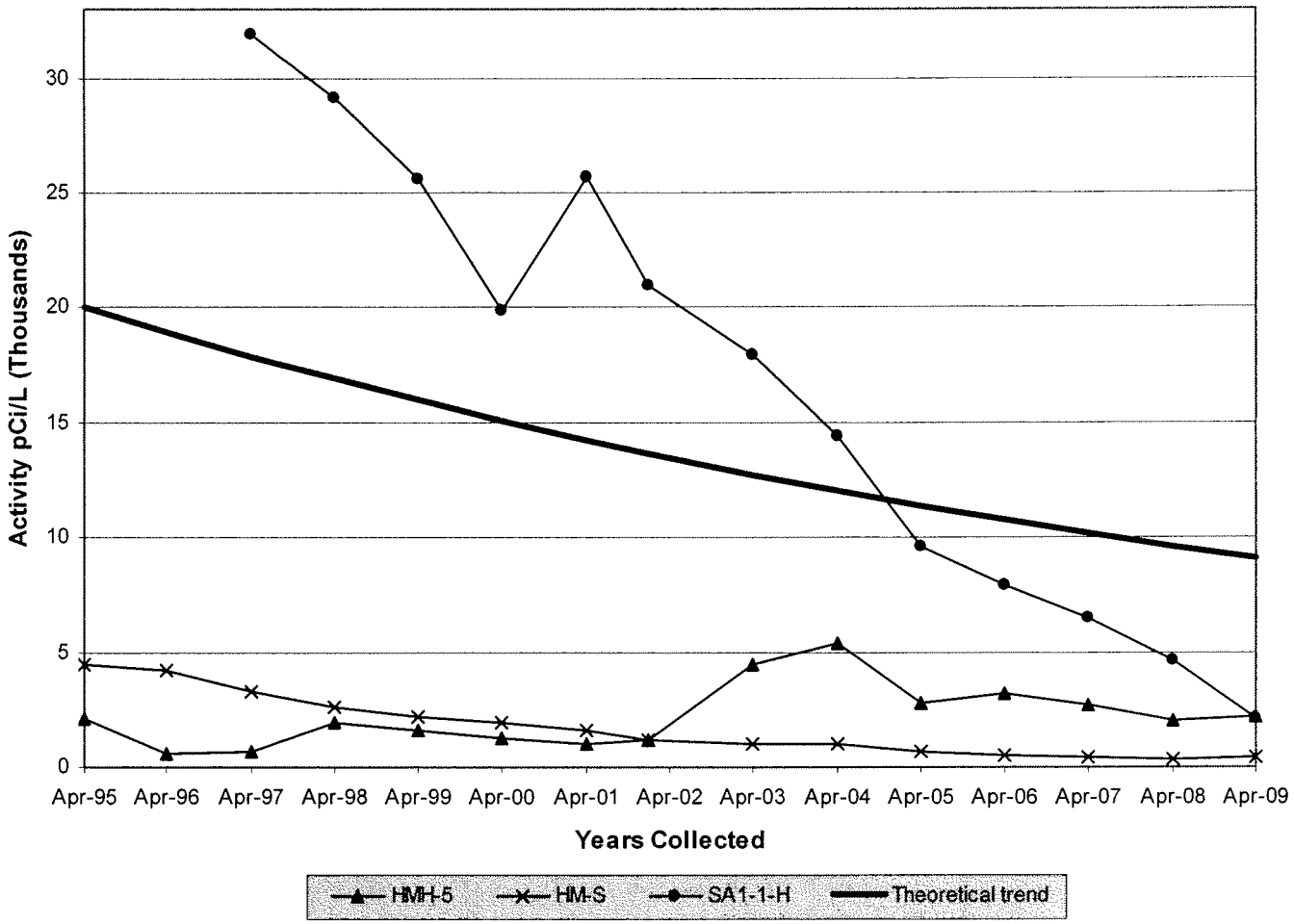

Figure 6, Tritium Trend Chart for Selected Sample Points. NOTE: The spike in the HMH-5 data at April 2003 is from the replacement well HMH-5R which is 20 ft deeper than the original 10ft hole.

Tritium

Since the start of the STS environmental monitoring program, following the Salmon and Sterling nuclear detonations of 1964 and 1966, tritium has been the principal radionuclide of concern.

Tritium is a radioactive isotope of hydrogen. An isotope is one of several alternate physical forms an atom of a chemical element may have while retaining its chemical properties. The most abundant form of hydrogen is radiologically stable, and has one electron in its outer shell and one proton in its nucleus. The next isotope of hydrogen is also stable, and called deuterium. Deuterium has one electron in its outer shell and one proton and one neutron in its nucleus. Deuterium when chemically combined with oxygen to form water is called "heavy water." The last isotope of hydrogen, tritium, also has one electron in its outer shell and one proton in its nucleus; however, in addition to the proton, it has two neutrons in the nucleus, the second neutron causes it to be radioactive. Tritium decays with a half-life of 12.35 years. Note: After a half-life has passed, the radioactive atoms present have decayed to half the number present at the beginning of the half-life.

Despite a short half-life tritium occurs naturally in the environment because it is generated by cosmic radiation in the upper atmosphere. The production rate in the atmosphere is about six million curies per year, which through rainfall causes a tritium inventory in the oceans and other surface waters of the world of about one hundred million curies.[1]

The curie is the unit for radioactivity. One curie is the activity of a sample whose radioactive atoms are undergoing 2.22×10^{12} disintegrations per minute (dpm) or, 2.22 trillion nuclear transformations per minute.

Before the natural tritium concentration in our lakes and oceans had been accurately determined, large quantities of tritium were released from weapons tests which completely overshadowed the natural inventory. Since the nuclear testing through 1963 added 1900 megacuries (1 megacurie = 1 million curies) to the northern hemisphere, the natural radioactivity has been completely masked[2], the equilibrium inventory in each hemisphere is estimated to be 14 megacuries. The results from STS sample analyses are reported in picocuries (10^{-12} curies, one-trillionth of a curie, or 1/1,000,000,000,000 of a curie).

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[1] U.S. Atomic Energy Commission Report "Sources of Tritium and Its Behavior Upon Release to the Environment." D.G. Jacobs, TID-24635, 1968.

[2] NCRP Report #45 "Natural Background Radiation in the United States." National Council on Radiation Protection and Measurements, November 15, 1975, page 33.

Safe Drinking Water Standards for Radioactive Materials

The United States Environmental Protection Agency has established maximum contaminant levels in the Safe Drinking Water Regulations: "The average annual concentration of beta particle-emitting man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than four millirem per year." Twenty thousand picocuries per liter (20,000 pCi/L) of tritium in "finished" drinking water if taken internally at the rate of two liters per day for a year, equals the average annual concentration assumed to produce a total body dose equivalent of four millirem per year.

The groundwater in some aquifers at the STS is non-potable (i.e., due to its brackish nature not suitable for drinking or cooking); therefore, this standard does not apply directly to them. However the Mississippi Department of Environmental Quality does apply the potable water standard to all Mississippi water sources, regardless of potability.

In the absence of any other more appropriate standards, it has also been applied to tritium concentrations in game, fish and vegetation samples. The part that naturally-occurring tritium plays in this report is difficult to determine. Members of the DRH staff have estimated that any amount of tritium that might possibly be detected in offsite wells will be quite small, and has probably been produced from natural causes and/or the atmospheric testing of nuclear weapons.

The Mississippi State Department of Health and other regulatory agencies continue to urge the responsible federal agencies to establish standards for such other environmental components and contaminants which have not yet been promulgated.

2009 STS Environmental Monitoring

The Division of Radiological Health and the U.S. Department of Energy contractor, Stoller, began the 2009 annual monitoring for the STS on April 14, 2009. Federal and State personnel present during the 2009 sampling included:

Name	Affiliation
Tom Welton	Stoller
Tim Zirbes	Stoller
Jack Duray	Stoller
Mark Plessinger	Stoller
Jeff Walters	Stoller
Karl Barber	MSDH/DRH
Danny Brantley	MSDH/DRH

Chronology of Sampling Events

After the 2007 sampling EPA, Las Vegas lost the sampling contract for the Salmon Test Site, but continues to run samples for radiological constituents. The DOE contractor Stoller has taken over the primary sampling responsibility during the annual sampling.

Stoller rented diesel electric generators to power the air pumps for the low flow sampling system and the electric pumps in SA5-4-4 and SA5-5-4 on April 13, 2009. The sampling of wells started around surface ground zero in the afternoon of the 14th and continued through April 17. Pumping of Well HM-L was begun about 1:30 p.m., April 14, 2009. All wells were pumped until field chemistry data (temperature, conductivity, and pH) stabilized to ensure the sample was representative of the aquifer. On April 15, post-sampling specimens of surface water (i.e., PWGZ, HMC and HMCOP) were taken.

Wells SA5-4-4 and SA5-5-4 were pumped down and sampled on April 17. DOE discontinued the sampling of private ponds and city wells offsite in favor of sampling streams as they entered and left the site. DRH was taken off guard by this move and did not have time to contact the public suppliers or property owners in the area prior to the event.

Other areas sampled included Pond West of Ground Zero (Beaver Pond), Half Moon Creek (at three points), Half Moon Creek Overflow Pond, Hickory Hollow Creek, Grantham Creek, and water flowing into and through the old REECo Pit.

Radiological data detailing tritium and gamma isotopic concentrations onsite and offsite can be found on the following pages.

Tritium Analysis

During the April 2009 Annual Monitoring, onsite and offsite locations were sampled for tritium analyses. These analyses identified locations onsite that were above background. No offsite locations showed tritium levels above background. EPA used enrichment techniques only on selected samples.

Table 1. Onsite Sample Tritium Analysis

Location	Date/Time	DRH ANALYSIS Activity ± Error (pCi/L)	EPA ANALYSIS Activity ± Error (pCi/L)
Surface Ground Zero Wells			
HM-1 (Aquifer 1)	04-15 1032	<LLD	"6.47±3.09"
HM-2A (Aquifer 2A)	04-14 1750	<LLD	<LLD
HM-2B (Aquifer 2B)	04-15 1142	<LLD	<LLD
HM-3 (Aquifer 3)	04-14 1831	<LLD	<LLD
HM-L (Local Aquifer)	04-14 1402	824±165	898±114
HM-L2 (Local Aquifer)	04-16 1442	<LLD	<LLD
Other Deep Wells			
E-7 (Caprock)	04-15 1755	<LLD	<LLD
SA1-8-L	04-15 1025	<LLD	<LLD
SA1-11-3	04-15 1300	<LLD	<LLD
SA2-1-L	04-16 1245	<LLD	<LLD
SA2-2-L	04-16 1105	<LLD	<LLD
SA2-4-L	04-16 1540	<LLD	<LLD
SA3-11-3	04-15 1605	<LLD	<LLD
SA4-5-L	04-16 1651	<LLD	<LLD
SA5-4-4	04-17 1405	<LLD	<LLD
SA5-5-4	04-16 1855	<LLD	<LLD

Table 1. Onsite Sample Tritium Analysis (Contd.)

Location	Date/Time	DRH Analysis Activity ± Error (pCi/L)	EPA Analysis Activity ± Error (pCi/L)
Surficial Aquifer Wells			
SA1-1-H	04-14 1530	2064±378	2110±135
SA1-2-H	04-14 1640	635±184	332±103
SA1-3-H	04-14 1800	358±156	"284±5.8"
SA1-4-H	04-15 1521	<LLD	<LLD
SA1-5-H	04-15 1251	<LLD	<LLD
SA1-6-H	04-15 1610	<LLD	<LLD
SA1-7-H	04-15 1817	<LLD	<LLD
SA1-12-H	04-16 1047	<LLD	<LLD
SA3-4-H	04-15 1625	<LLD	<LLD
HMH-5R	04-15 1906	2207±399	2060±135
HMH-16R	04-16 0951	<LLD	"22.0±2.9"
HM-S	04-14 1610	405±162	"366±7.2"
Surface Water			
Half Moon Creek (HMC)	04-15 1005	<LLD	<LLD
HMC Entry	04-16 0907	<LLD	<LLD
HMC Leaving Site	04-15 1115	<LLD	<LLD
Half Moon Ck. Overflow (HMCOP)	04-15 0921	<LLD	<LLD
Pond West of Ground Zero	04-15 0950	<LLD	<LLD
Grantham Creek	04-15 1618	<LLD	<LLD
Hickory Hollow Creek	04-16 1433	<LLD	<LLD

Table 2. Offsite Sample Tritium Analysis

Location	Date/Time	DRH Analysis Activity ± Error (pCi/L)	EPA Analysis Activity ± Error (pCi/L)
Public Water Supplies			
Baxterville		NS	NS
Hub Water Assoc. (collected from the Thompson Store)		NS	NS
N.Lumberton W.A.		NS	NS
Purvis		NS	NS
Other Samples			
Anderson's Pond	4-17-09 0915	<LLD	NS
Lower Little Ck #1		NS	NS
Lower Little Ck #2		NS	NS

Gamma Isotopic Analysis

During the April 2009 Annual Monitoring, onsite and offsite locations were sampled for gamma isotopic analyses. These analyses identified naturally occurring radionuclides, whose sample concentrations were negligible. No other radionuclides were detected. Samples taken for evaluation are detailed on the following pages.

The Lower Limit of Detection (LLD) for Cs-137 for the Mississippi State Department of Health is 8 pCi/L. The LLD for gamma spectroscopy by EPA is generally 6 pCi/L for most common radionuclides in routine milk and water samples, in a simple spectrum.

Table 3. Onsite Sample Gamma Analysis

Surface Ground Zero Wells

Location	Date/Time	DRH Analysis Activity ± Error (pCi/L)	EPA Analysis Activity ± Error (pCi/L)
HM-1	4-15-09 1032	<LLD	<LLD
HM-2A	4-14-09 1750	<LLD	<LLD
HM-2B	4-15-09 1142	<LLD	<LLD
HM-3	4-14-09 1831	<LLD	<LLD
HM-L	4-14-09 1402	<LLD	<LLD
HM-L2	4-16-09 1442	<LLD	<LLD
Other Deep Well			
E-7 (Caprock)	4-15-09 1755	<LLD	<LLD
SA1-8-L	4-15-09 1025	<LLD	<LLD
SA1-11-3	4-15-09 1300	<LLD	<LLD
SA2-1-L	4-16-09 1245	<LLD	NSB
SA2-2-L	4-16-09 1105	<LLD	<LLD
SA2-4-L	4-16-09 1540	<LLD	<LLD
SA3-11-3	4-16-09 1605	<LLD	NSB
SA4-5-L	4-16-09 1651	<LLD	<LLD
SA5-4-4	4-17-09 1405	<LLD	<LLD
SA5-5-4	4-16-09 1855	<LLD	<LLD

Table 3. Onsite Sample Gamma Analysis (Contd.)

Location	Date/time	DRH Analysis Activity ± Error (pCi/L)	EPA Analysis Activity ± Error (pCi/L)
Surface Water and Surficial Aquifer			
HM-S	4-14-09 1610	<LLD	<LLD
Half Moon Creek (HMC)	4-15-09 1005	<LLD	<LLD
HMC Entry	4-16-09 0907	<LLD	<LLD
HMC Exit	4-15-09 1115	<LLD	<LLD
Half Moon Ck. Overflow (HMCOP)	4-15-09 0921	<LLD	<LLD
Pond West of Ground Zero (PWGZ)	4-15-09 0950	<LLD	<LLD
Grantham Creek	4-15-09 1618	<LLD	<LLD
Hickory Hollow Creek	4-16-09 1433	<LLD	<LLD

Table 4. Offsite Sample Gamma Analysis

Location	Date/Time	DRH Analysis Activity ± Error (pCi/L)	EPA Analysis Activity ± Error (pCi/L)
Public Water Supplies			
Baxterville		NS	NS
Hub Water Assoc. (collected from the Thompson Store)		NS	NS
N. Lumberton		NS	NS
Purvis		NS	NS
Other Samples			
Anderson's Pond	4-17-09 0915	<LLD	NS
Lower Little Creek #1		NS	NS
Lower Little Creek #2		NS	NS

Field Chemistry Taken during Pumping of Wells

Chemical parameters were measured during sampling of the all wells for tritium and gamma isotopic analyses to ensure the final sample was formational water from the Aquifer. Thus, in pumping the wells, it was important that the chemistry of the water stabilized before the final sample was taken. The wells were pumped long enough to clear the pump line before the first chemistry sample was taken. Conductivity, pH and water temperature were measured at three minute intervals.

Table 5. Field Chemistry

This data is no longer available. Samples were only taken when the chemistry stabilized, which was captured only on a Stoller laptop.

Special Study of the HMH Series and Surface Water

During the April 1985 routine sampling, representatives of EPA, DOE, and DRH decided to continue the special study that began in April 1984 and was to be terminated in October of 1985. Beginning with the April 1986 data, the DRH has continued this sampling study of the HMH Series, sharing split or duplicate samples with EPA. Also included in this study are other samples: from the HM-S Well, Half Moon Creek, Half Moon Creek Overflow Pond, and Pond West of Ground Zero, and three sampling points along the REECo borrow pit gully. By agreement with DOE many of the HMH-# wells were discontinued as of April 1999 and will no longer be sampled. In February 2002, the HMH-# wells were plugged and abandoned. HMH-5 and 16 were replaced with HMH-5R and 16R, and SA1-1-H is added to the quarterly sampling to make up for HMH-1 and 2.

The REECo pit sample points may not be available due to lack of water during dry months. Analytical results are detailed on the following pages.

Table 6. Special Study of the HMH Series and Surface Water

HMH Series

(All Results Are in pCi/L ± 2 Sigma Error for Tritium)

Date	HMH-5R	HMH-16R	HM-S	SA1-1-H
01-09-09	1343±326	ns	423±171	1323±358
	1530±125	ns	249±101	1490±125
04-15-09	2207±399	<LLD	405±162	2064±378
	2060±135	"22.0±2.9"	"357±6.3"	2110±135
07-02-09	1258±178	ns	ns	7196±686
	1350±122	ns	ns	7550±205
11-02-09	1528±462	ns	<500	6531±654
	1650±127	ns	"360±6"	6670±195

NOTE: The Division of Radiological Health data is listed first, and data from EPA-Nevada Las Vegas, where available, is listed second.

Table 6. Special Study of the HMH Series and Surface Water

Surface Water

(All Results Are in pCi/L ± 2 Sigma Error for Tritium)

Date	REECo Pit Point A	REECo Pit Point B	REECo Pit Point C
01-09-09	<LLD	<LLD	<LLD
	"7.52±2.38"	<LLD	"33.2±3.0"
04-15-09	<LLD	<LLD	<LLD
	<LLD	<LLD	<LLD
07-02-09	dry	dry	dry
11-02-09	<LLD	<LLD	<LLD
	"13.2±2.8"	<LLD	"97.7±4.1"
Date	HMC	HMCOP	PWGZ
01-09-09	<LLD	317±248	<LLD
	"9.16±2.46"	<LLD	<LLD
04-15-09	<LLD	<LLD	
	<LLD	<LLD	<LLD
07-02-09	<LLD	<LLD	dry
	"8.25±3.02"	"85.6±4.7"	dry
11-02-09	<LLD	<LLD	<LLD
	<LLD	"64.9±3.9"	"10.3±2.3"

Thermoluminescent Environmental Dosimetry

Thermoluminescent dosimeters (TLDs) were placed at 25 locations both onsite and offsite. They are exchanged on a quarterly basis with a fresh set. TLDs measure direct radiation. The NCRP has estimated that the average exposure per year in the United States to be 80 millirem, this translates into roughly 20 milliroentgens per quarter. The TLDs are housed in "cricket cages" and attached to a 2-inch PVC pipe. The pipe is driven into the ground so the TLD is approximately 3 feet above the ground. In locations where PVC pipe could not be used, the TLDs are attached to a tree or pole. TLD results, in milliroentgen, for all quarters of 2009 are listed in Table 7 which follows these notes.

Table 7. Thermoluminescent Dosimetry

Placement	1st QTR	2nd QTR	3rd QTR	4th QTR
HMH-1	10.0	9.3	14.7	10.6
HMH-2	12.3	8.9	11.4	9.9
HMH-5R	11.4	8.9	15.5	11.2
HMH-10	9.8	9.1	12.8	9.2
SA1-3-H	10.4	9.3	14.2	*
HMH-16R	11.6	8.8	20.6	11.9
HM-S	12.2	10.2	14.5	12.0
HMCOP	*	8.5	12.0	9.4
WSW of SGZ	10.1	9.5	13.0	9.8
SE of SGZ	11.2	9.5	13.4	10.8
Flowing Knoll	11.1	8.9	12.2	10.3
Halfmoon Creek	11.0	9.1	11.5	9.1
SA5-4-4	11.3	9.4	15.7	10.7
Well E-7	12.3	11.9	17.0	12.7
HT-4 & 5	12.4	9.7	13.9	12.0
REECo PIT A-B	12.5	10.3	15.2	11.6
REECo PIT B-C	11.4	11.0	15.6	11.0
Deer Stand	13.6	10.6	16.6	11.4
Hunt Club	13.5	9.6	13.5	10.5
H. Anderson's	12.3	9.3	15.6	11.0
R.L. Anderson's	11.8	9.0	14.5	10.5
Bay Creek Store	12.2	8.4	13.3	9.5
Little River	10.3	*	13.7	9.5
Reinshagen's	13.4	10.5	15.6	11.5

*TLD missing or damaged.
NOTE: The third quarter went long due to a reader issue, causing the numbers to look high.

Appendix

Questions or comments concerning information contained in this report should be sent to the following address:

Mississippi State Department of Health
Division of Radiological Health
P.O. Box 1700
Jackson, MS 39215-1700

MISSISSIPPI STATE DEPARTMENT OF HEALTH
www.HealthyMS.com
1-866-HLTHY4U
(1-866-458-4948)