LMS/SAL/S06288

Post-Closure Inspection, Sampling, and Maintenance Report for the Salmon, Mississippi, Site

Calendar Year 2009

October 2010

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U.S. DEPARTMENT OF ENERGY | Legacy Management

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Abbreviations

AEC	U.S. Atomic Energy Commission
COC	contaminant of concern
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ft	feet/foot
GEMS	Geospatial Environmental Mapping System
LM	(DOE) Office of Legacy Management
MCL	maximum contaminant level
MDC	minimum detectable concentration
pCi/L	picocurie(s) per liter (1×10^{-12} Ci/L)
SOARS	System Operation and Analysis at Remote Sites
TCE	trichloroethene
TRG	State of Mississippi target remediation goal
VOC	volatile organic compound

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1.0 Introduction

This report summarizes the annual inspection, sampling, and maintenance activities performed on and near the Salmon, Mississippi, Site in calendar year 2009. The draft *Long-Term Surveillance and Maintenance Plan for the Salmon Site, Lamar County, Mississippi* (DOE 2007) specifies the submittal of an annual report of site activities and the results of sample analyses. This report complies with the annual report requirement.

The Salmon, MS, Site is located in Lamar County, MS, approximately 12 miles west of Purvis, MS, and about 21 miles southwest of Hattiesburg, MS (Figure 1–1). The site encompasses 1,470 acres and is not open to the general public. The U.S. Department of Energy (DOE), a successor agency to the U.S. Atomic Energy Commission (AEC), is responsible for the long-term surveillance and maintenance of the site. The DOE Office of Legacy Management (LM) was assigned responsibility for the site effective October 1, 2006.

During the 1960s, AEC used the Tatum Salt Dome beneath the site (Figure 1–2) for nuclear testing related to seismic signatures from explosions. Between 1964 and 1970, two underground nuclear tests and two chemical explosive tests were conducted in the Tatum Salt Dome. The first nuclear test, code name Salmon, created a cavity 2,710 feet (ft) below ground surface. The second nuclear detonation, Sterling, and the two subsequent chemical detonations were conducted within the Salmon cavity. No radioactivity was released to the surface during testing. Residual radioactivity from the subsurface testing is safely contained within the salt cavity.

The site was cleaned up and decommissioned in 1972. During the cleanup, most of the soil and drilling mud contamination from drill-back operations were slurried and injected into the cavity. Some of the contaminated liquids were injected into Aquifer 5, a briny aquifer used for disposal by the oil and gas industry. The injection borehole, located in the southwest corner of the site, was sealed (i.e., plugged and abandoned) after injection. Near ground zero, residual volatile organic compounds (VOCs) and metals from a rathole (used for vertical storage of drill pipe) and a drilling-mud pit could not be removed completely, effectively, and safely. The rathole is located beneath concrete that supports the concrete base of the monument at ground zero. The mud pit is located nearby (178 ft E73.5°S from ground zero) and covered with clean fill.

Laboratory analyses of tritium by EPA of surface water and groundwater samples collected annually since 1972 show that this shallow contamination is attenuating naturally as expected. Current surface water sample points and monitoring well locations are shown in Figure 1–2.

Contamination remaining at the site is centered within the deep cavity. Shallow contamination due to drill-back operations consists of radioactive materials (tritium), VOCs, and metals. The potential sources of contamination of the surface water and groundwater at the site are:

- The rathole and drilling-mud pit.
- The cavity and the now-plugged boreholes that were drilled into the cavity.
- The wastes injected into Aquifer 5 and the borehole used to inject the wastes.

All test and injection boreholes were plugged and abandoned in accordance with the requirements of the State of Mississippi.

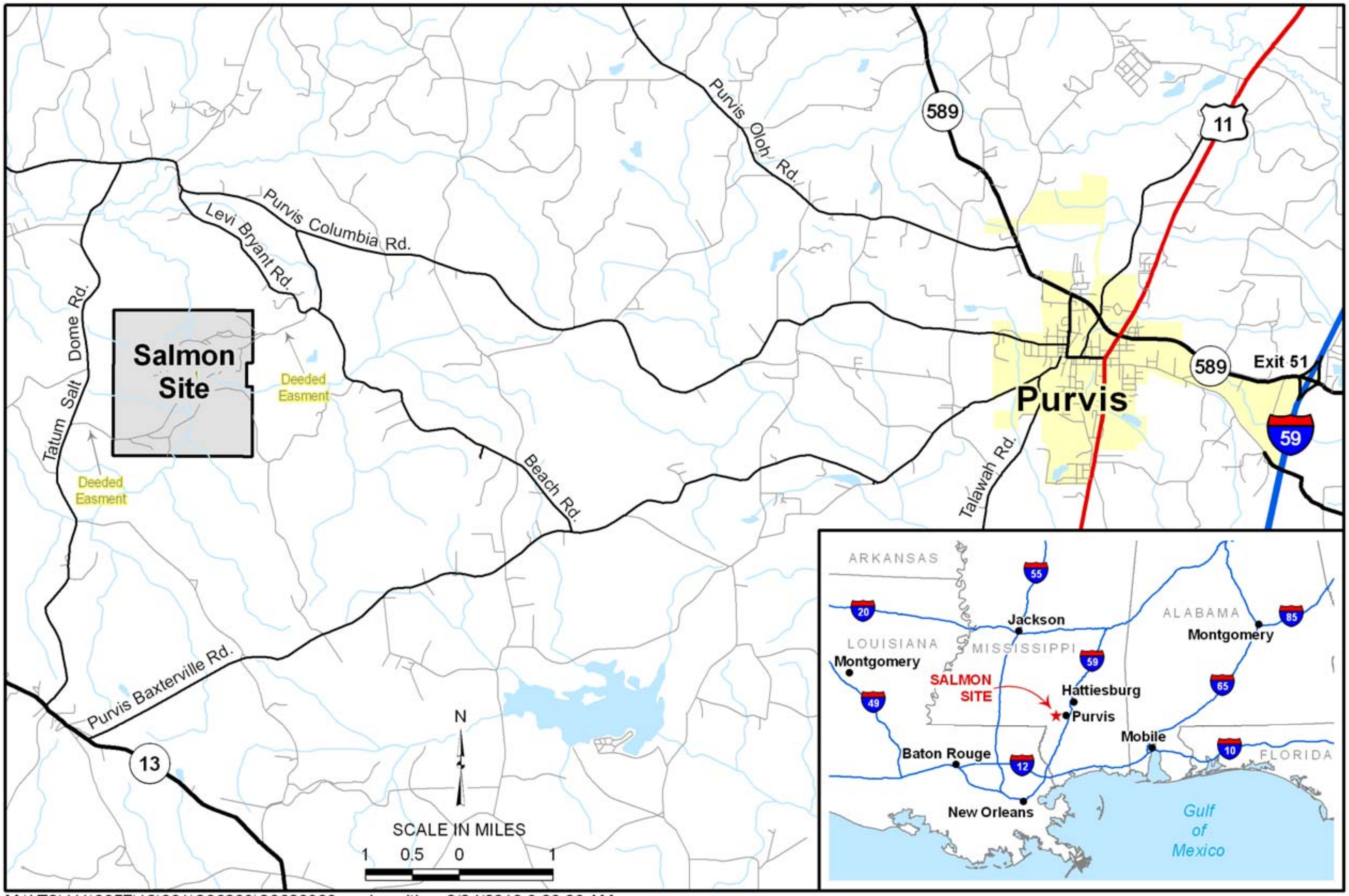

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Figure 1–1. Regional Location Map for the Salmon, Mississippi, Site

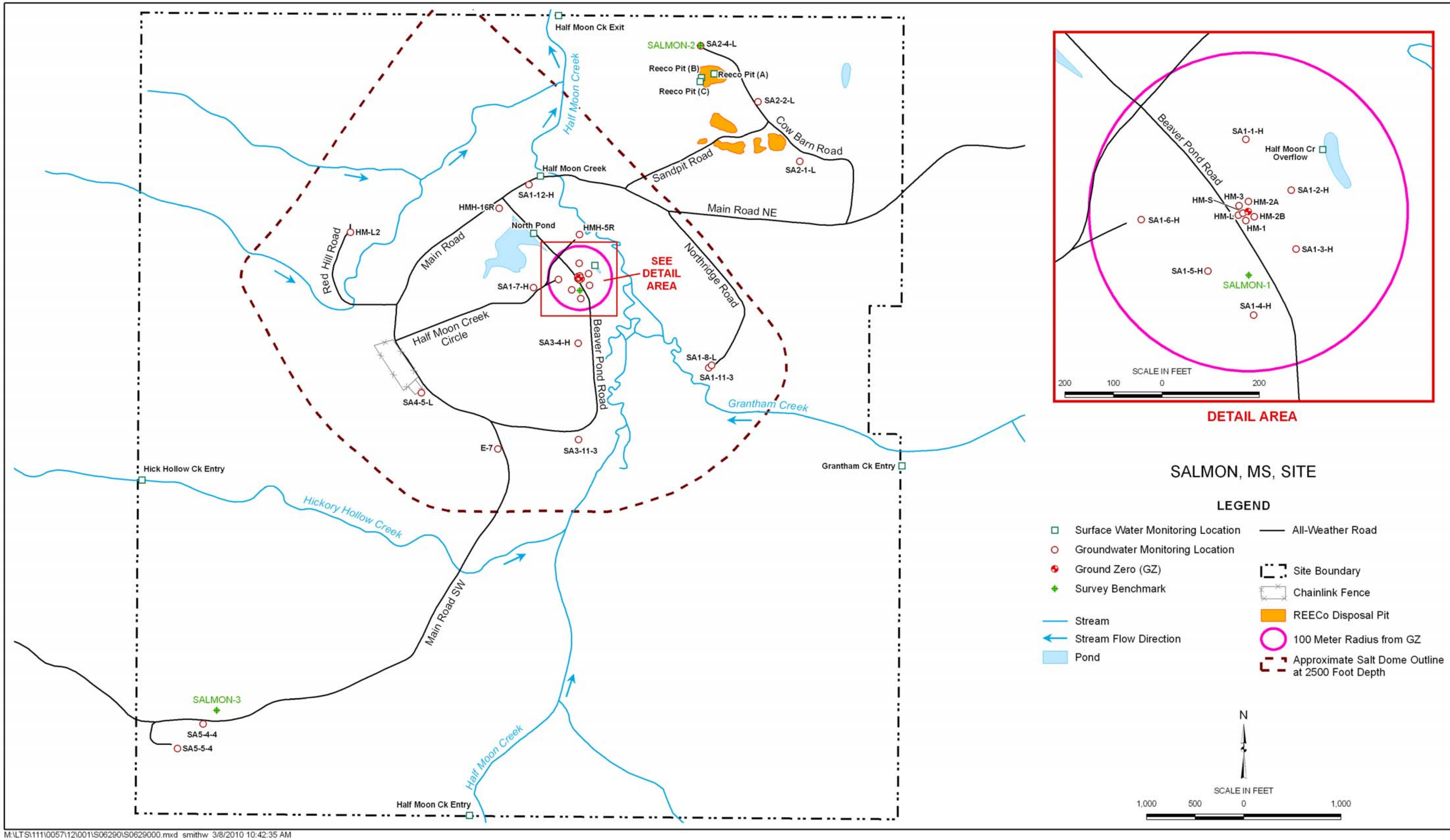

Figure 1–2. Sampling Locations at the Salmon, Mississippi, Site

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The contaminants of concern (COCs) for the site are tritium, arsenic, chromium, and trichloroethene and one of its degradation products, *cis*-1,2-dichlorethene. Historically, some concentrations of COCs have exceeded either the drinking water maximum contaminant level (MCL) (EPA 2004) or the Mississippi target remediation goal (TRG) (MDEQ 2006).

The determination of VOCs and metals as COCs was based on concentrations detected in groundwater samples collected in 2005 and 2006. Although tritium is a COC, it has not been detected above the MCL since 2002. The source of the arsenic is unknown and may be unrelated to DOE activities. Methylene chloride has been detected above the MCL and naphthalene has been detected above the risk based screening level (EPA 2004); however, the detections are sporadic. Since naphthalene is a common solvent and methylene chloride is a common laboratory contaminant, these compounds are not believed to be due to DOE activities at the site.

The surveillance and maintenance objectives shown in Table 1–1 are used as guidance for annual site inspections and sampling events.

Table 1–1. Long-Term Surveillance and Maintenance Objectives for the Salmon, Mississippi, Site

Surveillance and Maintenance Objective	Strategies to Achieve Objective
Prevent exposure to radioactive materials contained in the salt dome	• Monitor groundwater and evaluate results • Monitor and maintain institutional controls
Control exposure to contaminated groundwater	• Monitor groundwater and evaluate results • Monitor institutional controls
Maintain the physical integrity of the site surface	• Conduct regular inspections • Perform needed maintenance • Maintain access controls
Prevent loss of knowledge	• Comply with DOE requirements of mandatory surveillance and maintenance program • Communicate with regulators and stakeholders regularly (including public education, outreach information, and notices) • Record site institutional controls in Lamar County with real property records and management agencies • Comply with National Archives and Records Administration records management requirements • Maintain local records collection and make annual reports available

In April 2009, the annual site inspection and water sampling of surface and groundwater were performed. Three maintenance-related site visits were made in July, September, and December. Selected digital images from the site visits are included in Appendix A. Analytical sample results are tabulated in Appendix B.

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2.0 Inspection and Maintenance Activities

2.1 Institutional, Engineering, and Physical Controls

2.1.1 Deed Restrictions and Ground Zero Monument

No action on the deed restriction on file with the Lamar County, Mississippi, Chancery Office was required. The discrepancy between the deed restriction language and the plaque language mounted on the ground zero monument was reported to DOE.

A review of site access easements on private roads between Lamar County roads and the site was completed. The review confirmed perpetual access.

2.1.2 Fences

The Salmon site fence is not functional except for a private fence on the eastern perimeter between the Main Road NE gate and Grantham Creek. Dense vegetation inhibits site access along most of the perimeter.

The chainlink fence surrounding the lay-down area remains in good condition.

2.1.3 Gates and Locks

The two site gates and locks are in good condition.

A private road between the Tatum Salt Dome Road and the southwest gate provides secondary access to the site. DOE has a permanent easement to use the private road and shares the gate with the landowner and the landowner's lessee. DOE's and the landowner's padlocks were removed from the shared gate by person or persons unknown. The landowner replaced their padlock and provided DOE with a copy of their key.

2.1.4 Signs

All posted signs at the gate and the northwest corner are in good condition. A federal "No Trespassing" sign was observed on the south boundary where Half Moon Creek enters the site (see Photo A−7).

2.2 Physical Site Conditions

2.2.1 Roads and Roadwork

Five road segments were damaged by erosion from unusually heavy spring rains. The total damage is about a quarter mile of roadway. Repair is scheduled for 2010. The damaged road segments are shown in Figure 2–1.

An inventory and assessment of on-site culverts was conducted in April 2009. Thirty-one culverts were identified at that time. The culvert invert (or bottom half) was observed to have eroded completely from most of the culverts (see Photo A−2). The failure is caused by water that undermined the base of the culverts and accelerated rusting. In two locations, the road has slumped and formed hazardous sink holes due to the culvert failure (see Photo A−3). Culvert locations are shown in Figure 2–1.

Engineering personnel evaluated the identified culvert invert failures to design repairs. Concurrently, a local surveyor provided survey coordinates at about 8 to 12 locations per culvert for design purposes. Survey control points (hubs) were also established at each location for culvert replacement and road restoration.

Twenty culverts are to be replaced and six culverts repaired. The plan includes adding riprap at nine inlet or outlet pools.

The design was reviewed by the U.S. Army Corps of Engineers during a site visit in December. The USACE concluded the culvert work would fall under 404 Nationwide Permit # 3, Paragraph (a), "Maintenance," if there was no change to the wetlands or, in other words, the installation of riprap is limited to the roadway shoulder (berm). Otherwise, the work would fall under Paragraph (b), which requires a wetlands study for a Pre-Construction Notification Permit due to the new construction work off the roadway.

The general replacement design plan is to replace the old culvert with the same length and diameter culvert, add flared ends where appropriate, and protect culvert inlets and outlets at the road shoulder with riprap. At all inlets and outlets, a 20-ft by 20-ft area of brush smaller than 6 inches in diameter will be removed with the restriction that this surface is not to be permanently disturbed by vehicles on tires or tracks or by grubbing; stumps must remain.

Figure 2–1 shows the location of all culverts, including the 20 culverts planned for replacement and the 6 culverts to be repaired. The culvert work is planned for the spring of 2010.

2.2.2 Trespassing/Site Disturbances

DOE does not permit trespassing on the Salmon site.

The day following the conclusion of the April annual inspection and sampling, five flat tires were replaced, and flat tires were repaired on one rental vehicle and two General Services Administration vehicles that supported the activity. Tires were also repaired on the State of Mississippi vehicle used to support state water sampling. A check of the site after the tires were repaired, revealed various size roofing nails had been deliberately scattered on about 400 feet of the Main Road SW from well SA5-4-4, extending to the turnoff road to well SA5-5-4. A malicious mischief report was filed with the Lamar County, Mississippi, Sheriff's Department on 18 April 2009. Advisory calls or e-mails were made to site key holders to warn them of the hazard.

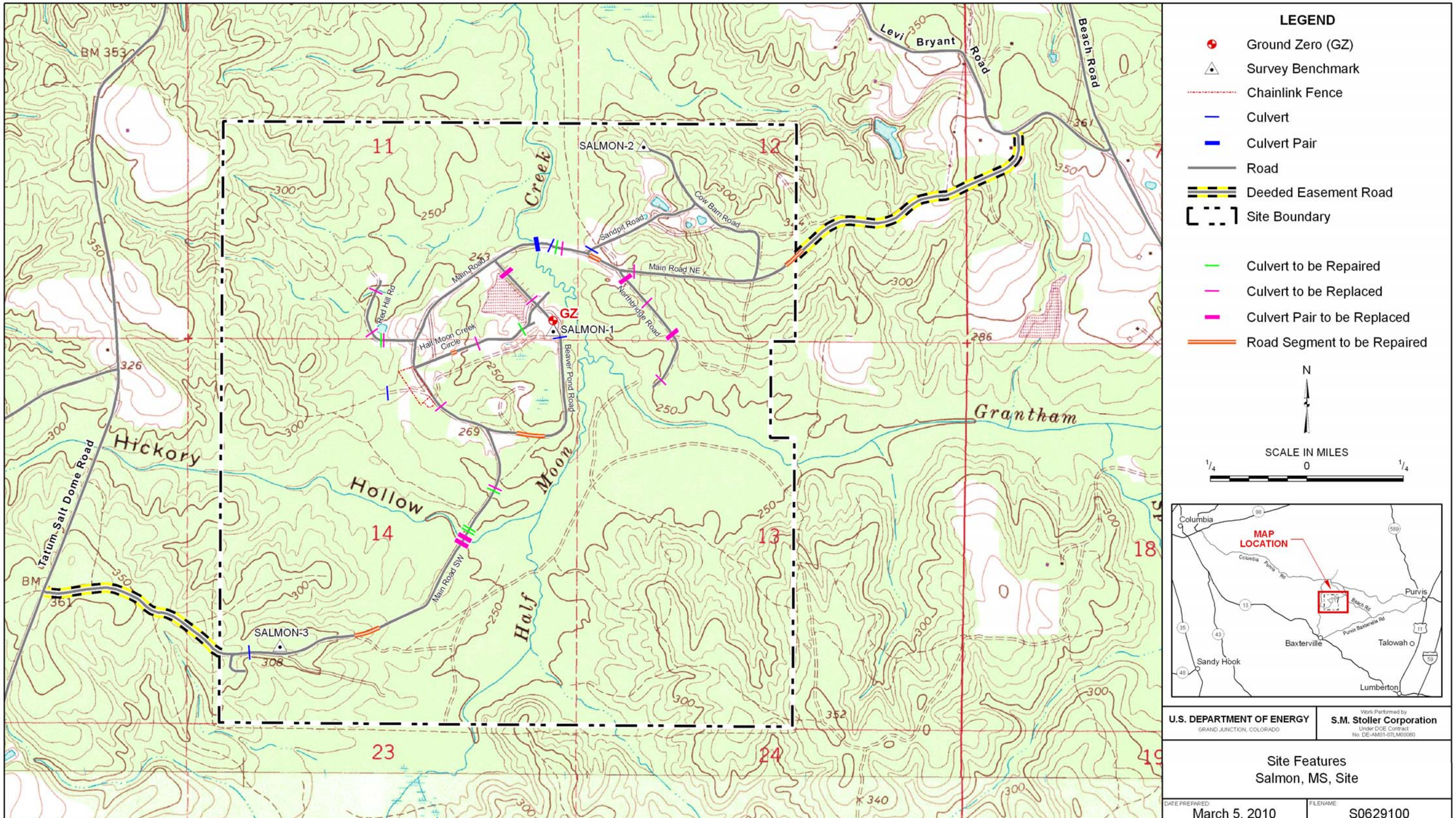

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Figure 2–1. Topographic Map Showing Culverts and Road Repairs Scheduled for Winter 2010

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During two subsequent site visits, the nails were removed with a rented magnetic nail sweeper by making repeated traverses along the road from road shoulder to road shoulder. Before the last nail sweep, the pine straw was raked off the roadway. Raking had the added benefit of scarifying the road, which loosened the small imbedded nails for the nail sweeper. A rented metal detector was ineffective because it registered too many false positives.

2.2.3 Other Site Conditions

Water levels in wells SA1-7-H and HMH-5R are monitored continuously by transducers powered by solar panels. The data are sent to the LM office in Grand Junction by mobile telephone. The modem at the base station, well SA1-7-H, was replaced because of intermittent transmissions. The transmitted data are monitored by the System Operation and Analysis at Remote Sites (SOARS) system in Grand Junction.

The transducers in the base-station well and the remote-station well, HMH-5R, were lowered about 5 ft. Old desiccant packages were removed, and fresh desiccant packages were inserted in each electrical cabinet before the cabinets were closed and locked.

Dead trees devoid of branches (snags) along Beaver Pond Road, south of ground zero near the South Pond area, threaten the road. Several have fallen on the road and had to be cut and removed. During the 2010 winter maintenance, the snags threatening the road will be cut so they fall away from the road.

2.3 Monitoring Wells

There are 28 active groundwater monitoring wells on the Salmon site. The wells are used for monitoring groundwater in aquifers below ground zero, especially the Alluvial Aquifer, the Local Aquifer, and Aquifer 5.

Dedicated bladder pumps are installed in 26 of the wells, and dedicated submersible Grundfos electric pumps are installed in the 2 deep wells in the southwest corner that monitor Aquifer 5.

Seven wells are employed to monitor the Local Aquifer. Water level transducers and data loggers were installed in five monitoring wells in the Local Aquifer: HM-L, SA2-4-L, SA1-8-L, SA4-5-L, and HM-L2. Well SA2-2-L already has a transducer/data logger installed; well SA2-1-L does not.

During the field download of water level data recorded by the Troll 500 data logger in well SA2-2-L, the water level showed an increase of about 0.8 ft since the data logger was initialized in March 2008. The download was terminated and a new test started.

The bladder pump in well SA2-4-L was raised to about 150 ft below the top of the well casing, and 70 ft of drop tube was installed to improve the purge rate. The pump had been set at 220 ft below the top of the casing.

Purge water from well HMH-5R (about 1 gallon) was containerized for shipment to the Environmental Sciences Laboratory in Grand Junction for treatment (aeration) and disposal according to guidance from the Environmental Compliance group.[1] Although this purge water is not regulated, it likely exceeds the U.S. Environmental Protection Agency (EPA) drinking water MCL for TCE based on the previous 2008 sample analysis (EPA 2004). Consequently, this purge water is not discarded on site like other purge water. Regrettably, the container of purge water never reached the Environmental Sciences Laboratory in Grand Junction. Despite an intense effort, the container was never found.

All wells are in good condition except for the cover cap of well SA1-2-H. Both hinges on the cap are broken and will be replaced during the winter 2010 maintenance.

During 2009 site visits, the locks on the well caps were lubricated.

2.4 Site Ecology Conditions

2.4.1 Timber

The *Timber Management Plan for the U.S. Department of Energy's Salmon Tract Lamar County, Mississippi* (October 2008) prepared by Wildlife Mississippi was shared with the Mississippi Forestry Commission.

2.4.2 Other Vegetation

Four areas of the noxious weed cogongrass have previously been located on site and sprayed with the herbicide recommended by the State of Mississippi[2]. One area is at ground zero, two areas are west of the lay-down area, and one area is in the southwest corner. This was the second herbicide application except for the area in the southwest corner, which was not sprayed in November 2008 due to inaccessibility. The applications have been successful. No cogongrass appears to be growing. One final application is planned in 2010.

2.4.3 Gopher Tortoise Habitat

No active gopher tortoise burrows were found in 2009. Ideal gopher tortoise habitat is well-drained, open areas, preferably in longleaf pine forests. There are no open areas on site due to the dense tree canopy.

The gopher tortoise is a federally listed threatened species and listed by the State of Mississippi as endangered.

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1 Management of Purge Water for the Annual Sampling at the Salmon Site: Note to File, D. DePinho, Environmental Compliance Specialist, 4 April 2009.

[2]The herbicide mix is 2 percent glyphosate with 1.5 percent imazapyr.

2.4.4 Beavers

The U.S. Department of Agriculture Animal and Plant Health Inspection Service Wildlife Services is responsible for on-site beaver management. USDA APHIS conducted two site inspections during 2009. At the end of 2009, some new beaver activity was noted. A small dam was observed partially blocking the culvert that drains the North Pond and at a rill that flows into the pond.

Beaver management activities are planned for 2010.

2.5 Cultural Resource Conditions

No activities that affected cultural resources were performed.

2.6 Public Information Access

The *Post-Closure Inspection, Sampling, and Maintenance Report for the Salmon, Mississippi, Site Calendar Year 2008* was posted on the LM webpage (http://www.lm.doe.gov/salmon/Sites.aspx). Other documents were added to the webpage during 2009.

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3.0 Analytical Results and Interpretation

During April 2009, DOE collected groundwater samples from each of the 28 active wells. Surface water samples were also collected from 10 on-site locations and one off-site location.[3] All samples collected at the 39 locations were analyzed for tritium. Selected surface water and groundwater samples were analyzed for VOCs or metals or gamma-emitting radionuclides or some combination.

Temperature, pH, turbidity, and conductivity were measured before each well was sampled.

Samples were analyzed by ALS Paragon (Fort Collins, CO) for metals (RCRA metals—arsenic, barium, cadmium, chromium, lead, selenium, silver, and mercury—plus antimony, beryllium, nickel, and zinc). The U.S. Environmental Protection Agency Laboratory in Las Vegas, Nevada, performed the tritium, enriched tritium, and high-resolution gamma analyses.

Tritium was detected by the standard tritium analysis method in groundwater samples collected from six wells: five wells were in the Alluvial Aquifer, and one well was in the Local Aquifer. Twenty-five percent of the wells are analyzed by the more sensitive enriched tritium method. In two wells, tritium results were above the detection limit for the enriched method. The largest tritium result by the standard analysis was 2,110 picocuries per liter (pCi/L) which is about 11 percent of the 20,000 pCi/L EPA drinking water MCL for water (EPA 2004). No tritium was detected in the 11 surface water samples. No gamma-emitting elements were detected in any sample tested. Tritium results above the laboratory minimum detectable concentration are shown in Appendix B, Table B−1 for groundwater.

Analytical VOC and metal results above the laboratory detection limits are shown in Appendix B, Table B−2 for VOCs and Table B−3 for metals.

2009 is the first year that the three creeks flowing into the site were sampled. Metals above the detection limit are present in surface water samples collected at the three creek entry locations and listed in Table 3–1.

Table 3–1. Metals Detected at Concentrations above the Detection Limit in Creeks Flowing into and out of the Site

Location	Metals (mg/L)							
	Antimony	Barium	Cadmium	Chromium	Lead	Nickel	Zinc	pH
Grantham Ck Entry	0.000028	0.034	0.00014	ND	ND	0.0012	ND	6.30
Half Moon Ck Entry	0.000026	0.040	ND	0.00220	ND	0.0013	0.01	6.92
Hick Hollow Ck Entry	ND	0.039	ND	0.00089	0.0018	0.0010	ND	5.12
Half Moon Ck Exit	0.000032	0.032	ND	ND	ND	0.0012	ND	4.89

mg/L = milligrams per liter
ND = not detected

[3] The Mississippi Department of Health also collected a sample at each location.

3.1 2009 Sample Results Greater Than the EPA MCL or the Mississippi TRG

There were 181 unique results above the detection limit. Of these, five met or exceeded the MCL or State of Mississippi TRG. These results are listed in Table 3–2.

Table 3–2. 2009 Analytical Results Exceeding the MCL or TRG

Location	Date	Analyte	Result	MCL or TRG	Units
HM-3	14-Apr-09	Chromium	0.11	0.1	mg/L
SA1-3-H	14-Apr-09	Arsenic	0.014	0.01	mg/L
SA4-5-L	16-Apr-09	Barium	2.7	2.0	mg/L
HMH-5R	15-Apr-09	Trichloroethene	170	5	µg/L
HMH-5R	15-Apr-09	*cis*-1,2-Dichloroethene	76	70	µg/L

mg/L = milligrams per liter (1×10^{-3} grams per liter)
µg/L = micrograms per liter (1×10^{-6} grams per liter)

3.2 Contaminant Concentration Trends

Historical results through 2009 are plotted in Appendix B, Figures B−1 through B−4, for tritium in groundwater and grouped by location or aquifer for comparison of the trends. Tritium in precipitation is also plotted (Lehr and Lehr 2000) along with a pair of tritium decay trend lines. The half-life of tritium is 12.32 years and is described by an exponential decay curve. When exponential decay is plotted on a logarithmic scale, the concentration trend is a straight line.

Historical VOC data for TCE and *cis*-1,2-dichloroethene detected in the Alluvial Aquifer are plotted in Appendix B, Figures B−5 and B−6.

Historical metals data detected in groundwater are plotted in Appendix B, Figures B−7 through B−10, for arsenic, barium, chromium, and lead. Lead was not detected above its MCL in 2009.

All trends, except for tritium in well HM-L and barium in well SA4-5-L, appear to be decreasing with time, as expected. Tritium in well HM-L and barium in well SA4-5-L have increased over the last 3 years. Barium is a component of drilling mud, but the reason for its appearance only in well SA4-5-L is not known.

3.3 2009 Water Level Measurements

Water levels were measured during five site visits. The Mississippi Department of Health Division of Radiologic Health and LM personnel made the water level measurements. The reference elevations were made by a level loop survey performed in 2008.

The purpose of these data is eventual use in the evaluation of the groundwater monitoring well network.

4.0 Recommendations

The following actions are recommended for the Salmon site:

- Repair or replace culverts that are failing.
- Inspect the railroad flatcar bridge over Half Moon Creek.
- Use businesses from nearby communities for 2010 maintenance whenever possible.
- Continue the interagency agreement for beaver control.
- Continue the current on-site water sampling plan that includes sampling of:
    - Resource Conservation and Recovery Act metals plus antimony, barium, beryllium, chromium, mercury, nickel, and zinc.
    - VOCs.
    - Tritium and appropriate gamma-emitting radionuclides.

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5.0 References

DOE (U.S. Department of Energy), 2007. *Long-Term Surveillance and Maintenance Plan for the Salmon Site, Lamar County, Mississippi*, Draft, DOE-LM/1447-2007, Rev. 1, Office of Legacy Management, Grand Junction, Colorado, April.

DOE (U.S. Department of Energy), 2008. *Post-Closure Inspection and Monitoring Report for the Salmon, Mississippi, Site, Calendar Year 2007*, LMS/SAL/S04251, Office of Legacy Management, Grand Junction, Colorado May.

EPA (U.S. Environmental Protection Agency), 2004. *2004 Edition of the Drinking Water Standards and Health Advisories*, EPA 822-R-04-005, Winter.

Lehr, J.H., and J.K. Lehr, 2000. *Standard Handbook of Environmental Science, Health, and Technology*, Figure 4.7.9, The McGraw-Hill Companies, July 27, p. 4.70

MDEQ (Mississippi Department of Environmental Quality), 2006. Subpart 11, *Risk Evaluation Procedures for Voluntary Cleanup and Redevelopment of Brownfield Sites*, "Open Element," http://www.deq.state.ms.us/MDEQ.nsf/pdf/GARD_brownfieldrisk/$File/Proced.pdf, accessed December 28, 2006.

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Appendix A

2009 Site Photographs

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Photo A−1. Water Damage of Main Road NE Caused by a Blocked Culvert Located on the Main Road NE at the Intersection with Northridge Road

Photo A−2. Typical Culvert Invert Failure

Photo A−3. Sink Hole in Main Road SW Due to Culvert Invert Failure at Location C031

Photo A−4. North Pond; the View Is to the South

Photo A−5. Annual Collection of Water Samples at Well E-7

Photo A−6. Collection of Water Sample where Half Moon Creek Enters the Site

Photo A−7. No Trespassing Sign Posted at the Half Moon Creek Entry

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Appendix B

Analytical Results
April 2009

Table B−1. Tritium Detected above the minimum detectable concentration in groundwater samples collected in April 2009. Tritium was not detected in any surface water sample.

Location	Date	Analyte	Result	Units	Lab Qualifiers
HM-L	14-Apr-09	Tritium	898	pCi/L	
HM-S	14-Apr-09	Enriched Tritium	357	pCi/L	
HM-S (dup)	14-Apr-09	Enriched Tritium	366	pCi/L	
HM-S	14-Apr-09	Tritium	337	pCi/L	
HM-S (dup)	14-Apr-09	Tritium	361	pCi/L	
SA1-1-H	14-Apr-09	Tritium	2110	pCi/L	
SA1-2-H	14-Apr-09	Tritium	332	pCi/L	
SA1-3-H	14-Apr-09	Enriched Tritium	277	pCi/L	
SA1-3-H (dup)	14-Apr-09	Enriched Tritium	284	pCi/L	
SA1-3-H	14-Apr-09	Tritium	311	pCi/L	
SA1-3-H (dup)	14-Apr-09	Tritium	328	pCi/L	
HM-1	15-Apr-09	Enriched Tritium	6.47	pCi/L	
HMH-5R	15-Apr-09	Tritium	2060	pCi/L	
HMH-16R	16-Apr-09	Enriched Tritium	22	pCi/L	

Results shown are greater than the minimum detectable concentration (MDC) plus 2 times the total propagated uncertainty.

Statistics

14 tritium results above the MDC
4 duplicate results (dup)
10 unique tritium results exceeding MDC
4 enriched tritium results

Table B−2. Volatile Organic Compounds and Metals Detected above the Detection Limit in Groundwater Samples Collected in April 2009. Results above the MCL or TRG Are Shown in Bold.

Location	Date	Analyte	Result	Units	Lab Qualifiers	MCL or TRG
E-7	15-Apr-09	Toluene	0.32	µg/L	J	
HM-3	14-Apr-09	Antimony	0.000058	mg/L	B	
HM-3	14-Apr-09	Arsenic	0.0005	mg/L		
HM-3	14-Apr-09	Barium	0.19	mg/L		
HM-3	**14-Apr-09**	**Chromium**	**0.11**	**mg/L**		**0.100**
HM-L	14-Apr-09	Arsenic	0.00093	mg/L		
HM-L	14-Apr-09	Barium	0.44	mg/L		
HM-L	14-Apr-09	Chromium	0.0027	mg/L		
HM-L	14-Apr-09	Nickel	0.0012	mg/L	B	
HM-L	14-Apr-09	Zinc	0.0016	mg/L	B	
HM-L2	16-Apr-09	Barium	0.086	mg/L		
HM-L2	16-Apr-09	Zinc	0.0022	mg/L	B	
HM-S	14-Apr-09	Acetone	3.4	µg/L	J	
HM-S	14-Apr-09	Antimony	0.00004	mg/L	B	
HM-S	14-Apr-09	Barium	0.031	mg/L		
HM-S	14-Apr-09	Benzene	0.22	µg/L	J	
HM-S (dup)	14-Apr-09	Benzene	0.23	µg/L	J	
HM-S	14-Apr-09	Cadmium	0.000047	mg/L	B	
HM-S	14-Apr-09	Chromium	0.00089	mg/L	B	
HM-S	14-Apr-09	Trichloroethene	1.7	µg/L		
HM-S	14-Apr-09	Zinc	0.0018	mg/L	B	
HM-S	14-Apr-09	*cis*-1,2-Dichloroethene	3.8	µg/L		
HM-S (dup)	14-Apr-09	*cis*-1,2-Dichloroethene	3.9	µg/L		
HM-S	14-Apr-09	*trans*-1,2-Dichloroethene	0.49	µg/L	J	
HMH-16R	16-Apr-09	Barium	0.43	mg/L		
HMH-16R	16-Apr-09	Chromium	0.0008	mg/L	B	
HMH-16R	16-Apr-09	Nickel	0.0026	mg/L	B	
HMH-16R	16-Apr-09	Zinc	0.0045	mg/L	B	
HMH-5R	15-Apr-09	1,1-Dichloroethene	0.45	µg/L	J	
HMH-5R	15-Apr-09	Antimony	0.000036	mg/L	B	
HMH-5R	15-Apr-09	Arsenic	0.0019	mg/L		
HMH-5R	15-Apr-09	Barium	0.28	mg/L		
HMH-5R	15-Apr-09	Chromium	0.00093	mg/L	B	
HMH-5R	15-Apr-09	Nickel	0.0012	mg/L	B	
HMH-5R	**15-Apr-09**	**Trichloroethene**	**170**	**µg/L**		**0.005**
HMH-5R	**15-Apr-09**	***cis*-1,2-Dichloroethene**	**76**	**µg/L**		**0.070**
HMH-5R	15-Apr-09	*trans*-1,2-Dichloroethene	4.5	µg/L		
SA1-1-H	14-Apr-09	Arsenic	0.0036	mg/L		
SA1-1-H	14-Apr-09	Barium	0.2	mg/L		
SA1-1-H	14-Apr-09	Beryllium	0.00058	mg/L	B	
SA1-1-H	14-Apr-09	Nickel	0.0017	mg/L	B	
SA1-1-H	14-Apr-09	Trichloroethene	1.5	µg/L		
SA1-1-H	14-Apr-09	Zinc	0.004	mg/L	B	
SA1-1-H	14-Apr-09	*cis*-1,2-Dichloroethene	3.1	µg/L		
SA1-1-H	14-Apr-09	*trans*-1,2-Dichloroethene	0.9	µg/L	J	

Table B−2 (continued). Volatile Organic Compounds and Metals Detected above the Detection Limit in Groundwater Samples Collected in April 2009. Results above the MCL or TRG Are Shown in Bold.

Location	Date	Analyte	Result	Units	Lab Qualifiers	MCL or TRG
SA1-12-H	16-Apr-09	Barium	0.37	mg/L		
SA1-12-H	16-Apr-09	Chromium	0.0034	mg/L		
SA1-12-H	16-Apr-09	Nickel	0.0096	mg/L	B	
SA1-12-H	16-Apr-09	Zinc	0.0051	mg/L	B	
SA1-2-H	14-Apr-09	Antimony	0.000027	mg/L	B	
SA1-2-H	14-Apr-09	Arsenic	0.0078	mg/L		
SA1-2-H	14-Apr-09	Barium	0.066	mg/L		
SA1-2-H	14-Apr-09	Beryllium	0.00017	mg/L	B	
SA1-2-H	14-Apr-09	Cadmium	0.000037	mg/L	B	
SA1-2-H	14-Apr-09	Nickel	0.0017	mg/L	B	
SA1-2-H	14-Apr-09	Tetrachloroethene	0.47	µg/L	J	
SA1-2-H	14-Apr-09	Trichloroethene	0.81	µg/L	J	
SA1-2-H	14-Apr-09	Vinyl chloride	0.66	µg/L	J	
SA1-2-H	14-Apr-09	Zinc	0.0045	mg/L	B	
SA1-2-H	14-Apr-09	*cis*-1,2-Dichloroethene	10	µg/L		
SA1-2-H	14-Apr-09	*trans*-1,2-Dichloroethene	0.79	µg/L	J	
SA1-3-H	14-Apr-09	Antimony	0.000034	mg/L	B	
SA1-3-H (dup)	14-Apr-09	Antimony	0.000078	mg/L	B	
SA1-3-H	**14-Apr-09**	**Arsenic**	**0.014**	**mg/L**		**0.010**
SA1-3-H (dup)	14-Apr-09	Arsenic	0.017	mg/L		
SA1-3-H	14-Apr-09	Barium	0.059	mg/L		
SA1-3-H	14-Apr-09	Benzene	0.75	µg/L	J	
SA1-3-H (dup)	14-Apr-09	Benzene	0.77	µg/L	J	
SA1-3-H	14-Apr-09	Beryllium	0.00031	mg/L	B	
SA1-3-H	14-Apr-09	Cadmium	0.000054	mg/L	B	
SA1-3-H (dup)	14-Apr-09	Cadmium	0.000084	mg/L	B	
SA1-3-H (dup)	14-Apr-09	Chromium	0.0023	mg/L		
SA1-3-H	14-Apr-09	Chromium	0.0038	mg/L		
SA1-3-H	14-Apr-09	Lead	0.00048	mg/L	B	
SA1-3-H	14-Apr-09	Nickel	0.0012	mg/L	B	
SA1-3-H	14-Apr-09	Trichloroethene	1.1	µg/L		
SA1-3-H	14-Apr-09	Vinyl chloride	0.77	µg/L	J	
SA1-3-H (dup)	14-Apr-09	Vinyl chloride	0.78	µg/L	J	
SA1-3-H	14-Apr-09	Zinc	0.0078	mg/L	B	
SA1-3-H	14-Apr-09	*cis*-1,2-Dichloroethene	32	µg/L		
SA1-3-H	14-Apr-09	*trans*-1,2-Dichloroethene	14	µg/L		
SA1-4-H	15-Apr-09	Arsenic	0.00037	mg/L		
SA1-4-H	15-Apr-09	Barium	0.32	mg/L		
SA1-4-H	15-Apr-09	Beryllium	0.00019	mg/L	B	
SA1-4-H	15-Apr-09	*cis*-1,2-Dichloroethene	0.29	µg/L	J	

Table B−2 (continued). Volatile Organic Compounds and Metals Detected above the Detection Limit in Groundwater Samples Collected in April 2009. Results above the MCL or TRG Are Shown in Bold.

Location	Date	Analyte	Result	Units	Lab Qualifiers	MCL or TRG
SA1-5-H	15-Apr-09	Antimony	0.000031	mg/L	B	
SA1-5-H	15-Apr-09	Arsenic	0.00035	mg/L		
SA1-5-H	15-Apr-09	Barium	0.024	mg/L		
SA1-5-H	15-Apr-09	Beryllium	0.00025	mg/L	B	
SA1-5-H	15-Apr-09	Cadmium	0.000075	mg/L	B	
SA1-5-H	15-Apr-09	Nickel	0.0016	mg/L	B	
SA1-5-H	15-Apr-09	Trichloroethene	0.21	µg/L	J	
SA1-5-H	15-Apr-09	Zinc	0.01	mg/L	B	
SA1-5-H	15-Apr-09	*cis*-1,2-Dichloroethene	7.6	µg/L		
SA1-5-H	15-Apr-09	*trans*-1,2-Dichloroethene	1.3	µg/L		
SA1-6-H	15-Apr-09	Arsenic	0.00026	mg/L		
SA1-6-H	15-Apr-09	Barium	0.024	mg/L		
SA1-6-H	15-Apr-09	Cadmium	0.000043	mg/L	B	
SA1-6-H	15-Apr-09	Zinc	0.0014	mg/L	B	
SA1-7-H	15-Apr-09	Arsenic	0.01	mg/L		
SA1-7-H	15-Apr-09	Barium	0.33	mg/L		
SA1-7-H	15-Apr-09	Beryllium	0.00028	mg/L	B	
SA1-7-H	15-Apr-09	Cadmium	0.000058	mg/L	B	
SA1-7-H	15-Apr-09	Nickel	0.0018	mg/L	B	
SA1-7-H	15-Apr-09	Zinc	0.0032	mg/L	B	
SA1-7-H	15-Apr-09	*cis*-1,2-Dichloroethene	0.8	µg/L	J	
SA1-8-L	15-Apr-09	Arsenic	0.0068	mg/L		
SA1-8-L	15-Apr-09	Barium	0.24	mg/L		
SA1-8-L	15-Apr-09	Cadmium	0.00004	mg/L	B	
SA1-8-L	15-Apr-09	Zinc	0.027	mg/L		
SA2-1-L	16-Apr-09	Antimony	0.00011	mg/L	B	
SA2-1-L	16-Apr-09	Arsenic	0.0092	mg/L		
SA2-1-L	16-Apr-09	Barium	0.063	mg/L		
SA2-1-L	16-Apr-09	Zinc	0.0077	mg/L	B	
SA2-2-L	16-Apr-09	Antimony	0.0013	mg/L		
SA2-2-L	16-Apr-09	Arsenic	0.00045	mg/L		
SA2-2-L	16-Apr-09	Barium	0.81	mg/L		
SA2-2-L	16-Apr-09	Beryllium	0.00023	mg/L	B	
SA2-2-L	16-Apr-09	Chromium	0.013	mg/L		
SA2-2-L	16-Apr-09	Lead	0.011	mg/L		
SA2-2-L	16-Apr-09	Zinc	0.012	mg/L	B	
SA2-4-L	16-Apr-09	Antimony	0.000086	mg/L	B	
SA2-4-L	16-Apr-09	Arsenic	0.0097	mg/L		
SA2-4-L	16-Apr-09	Barium	0.12	mg/L		
SA2-4-L	16-Apr-09	Cadmium	0.000038	mg/L	B	
SA2-4-L	16-Apr-09	Lead	0.00063	mg/L		
SA2-4-L	16-Apr-09	Zinc	0.01	mg/L	B	

Table B−2 (continued). Volatile Organic Compounds and Metals Detected above the Detection Limit in Groundwater Samples Collected in April 2009. Results above the MCL or TRG Are Shown in Bold.

Location	Date	Analyte	Result	Units	Lab Qualifiers	MCL or TRG
SA3-4-H	15-Apr-09	Barium	0.36	mg/L		
SA3-4-H	15-Apr-09	Beryllium	0.00026	mg/L	B	
SA3-4-H	15-Apr-09	Cadmium	0.00005	mg/L	B	
SA3-4-H	15-Apr-09	Chloromethane	0.26	µg/L	J	
SA3-4-H	15-Apr-09	Lead	0.00036	mg/L	B	
SA3-4-H	15-Apr-09	Nickel	0.0013	mg/L	B	
SA3-4-H	15-Apr-09	Zinc	0.0027	mg/L	B	
SA4-5-L	16-Apr-09	Antimony	0.00055	mg/L		
SA4-5-L	**16-Apr-09**	**Barium**	**2.7**	**mg/L**		**2.0**
SA4-5-L	16-Apr-09	Beryllium	0.00024	mg/L	B	
SA4-5-L	16-Apr-09	Cadmium	0.00012	mg/L	B	
SA4-5-L	16-Apr-09	Chromium	0.042	mg/L		
SA4-5-L	16-Apr-09	Lead	0.0059	mg/L		
SA4-5-L	16-Apr-09	Zinc	0.2	mg/L		

Results shown are greater than the detection limit or 5 times the reported concentration in the method blank.

Lab qualifiers
B: If the analyte is inorganic, the result is less than the contract required detection limit.
If the analyte is organic, the analyte is found in the method blank.
J: Estimated

141 results above the MDC
8 duplicate analyses (dup)
133 unique lab results
5 results greater than MCL
4 sample locations greater than MCL

Table B−3. Metals Detected above the detection limit in surface water samples collected in April 2009

Location	Date	Analyte	Result	Units	Lab Qualifier	MCL or TRG
Grantham Ck Entry	15-Apr-09	Antimony	0.000028	mg/L	B	
Grantham Ck Entry	15-Apr-09	Barium	0.034	mg/L		
Grantham Ck Entry	15-Apr-09	Cadmium	0.00014	mg/L	B	
Grantham Ck Entry	15-Apr-09	Nickel	0.0012	mg/L	B	
HALFMOON CREEK	15-Apr-09	Antimony	0.000034	mg/L	B	
HALFMOON CREEK	15-Apr-09	Barium	0.032	mg/L		
HALFMOON CREEK	15-Apr-09	Chromium	0.0012	mg/L	B	
HALFMOON CREEK	15-Apr-09	Nickel	0.0012	mg/L	B	
HALFMOON CREEK	15-Apr-09	Zinc	0.0067	mg/L	B	
HALFMOONCRKOVERFLOW	15-Apr-09	Arsenic	0.00072	mg/L		
HALFMOONCRKOVERFLOW	15-Apr-09	Barium	0.051	mg/L		
HALFMOONCRKOVERFLOW	15-Apr-09	Chromium	0.003	mg/L		
HALFMOONCRKOVERFLOW	15-Apr-09	Nickel	0.0015	mg/L	B	
HALFMOONCRKOVERFLOW	15-Apr-09	Zinc	0.0074	mg/L	B	
Half Moon Ck Entry	16-Apr-09	Antimony	0.000026	mg/L	B	
Half Moon Ck Entry	16-Apr-09	Barium	0.04	mg/L		
Half Moon Ck Entry	16-Apr-09	Chromium	0.0022	mg/L		
Half Moon Ck Entry	16-Apr-09	Nickel	0.0013	mg/L	B	
Half Moon Ck Entry	16-Apr-09	Zinc	0.01	mg/L	B	
Half Moon Ck Exit	15-Apr-09	Antimony	0.000032	mg/L	B	
Half Moon Ck Exit	15-Apr-09	Barium	0.032	mg/L		
Half Moon Ck Exit	15-Apr-09	Nickel	0.0012	mg/L	B	
Hick Hollow Ck Entry	16-Apr-09	Barium	0.039	mg/L		
Hick Hollow Ck Entry	16-Apr-09	Chromium	0.00089	mg/L	B	
Hick Hollow Ck Entry	16-Apr-09	Lead	0.0018	mg/L		
Hick Hollow Ck Entry	16-Apr-09	Nickel	0.001	mg/L	B	
HickHCrTSD-East	15-Apr-09	Barium	0.031	mg/L		
Pond West of GZ	15-Apr-09	Antimony	0.000042	mg/L	B	
Pond West of GZ	15-Apr-09	Arsenic	0.00071	mg/L		
Pond West of GZ	15-Apr-09	Barium	0.062	mg/L		
Pond West of GZ	15-Apr-09	Chromium	0.0058	mg/L		
Pond West of GZ	15-Apr-09	Nickel	0.0029	mg/L	B	
Pond West of GZ	15-Apr-09	Zinc	0.03	mg/L		
Reeco Pit (A)	15-Apr-09	Barium	0.03	mg/L		
Reeco Pit (A)	15-Apr-09	Chromium	0.0012	mg/L	B	
Reeco Pit (A)	15-Apr-09	Nickel	0.0012	mg/L	B	
Reeco Pit (A)	15-Apr-09	Zinc	0.0045	mg/L	B	
Reeco Pit (B)	15-Apr-09	Antimony	0.000029	mg/L	B	
Reeco Pit (B)	15-Apr-09	Arsenic	0.00023	mg/L		
Reeco Pit (B)	15-Apr-09	Barium	0.026	mg/L		
Reeco Pit (B)	15-Apr-09	Chromium	0.0051	mg/L		
Reeco Pit (B)	15-Apr-09	Nickel	0.0025	mg/L	B	
Reeco Pit (B)	15-Apr-09	Zinc	0.0061	mg/L	B	

Table B−3 (continued). Metals Detected above the detection limit in surface water samples collected in April 2009

Location	Date	Analyte	Result	Units	Lab Qualifier	MCL or TRG
Reeco Pit (C)	15-Apr-09	Arsenic	0.00024	mg/L		
Reeco Pit (C)	15-Apr-09	Barium	0.025	mg/L		
Reeco Pit (C)	15-Apr-09	Chromium	0.0032	mg/L		
Reeco Pit (C)	15-Apr-09	Nickel	0.0024	mg/L	B	
Reeco Pit (C)	15-Apr-09	Zinc	0.0084	mg/L	B	

Results shown are greater than the detection limit or 5 times the reported concentration in the method blank.

Lab qualifiers
B: If the analyte is inorganic, the result is less than the contract required detection limit.
If the analyte is organic, the analyte is found in the method blank.

48 results
0 duplicate analyses
48 unique lab results

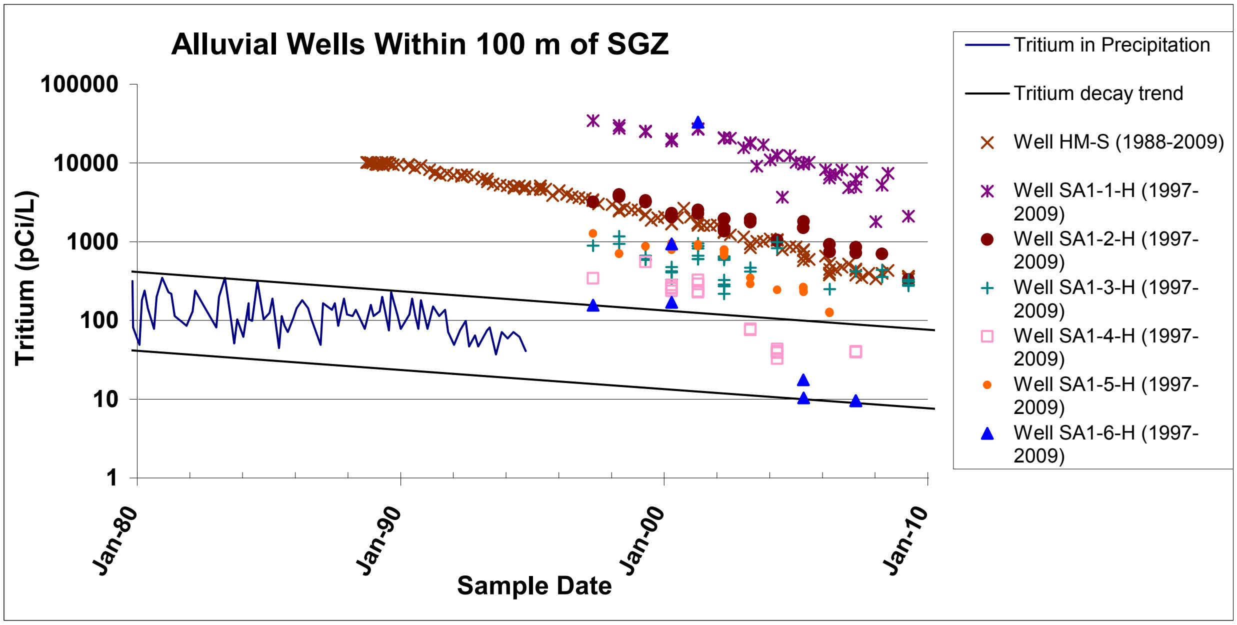

Figure B–1. Concentration Trend of Tritium Detected in Groundwater Samples versus Time. The samples were collected from Alluvial Aquifer monitoring wells located within 100 meters of ground zero. Only results above the MDC are plotted. Measured tritium in rainfall is shown for 1980 through 1995. Tritium decays with a half-life of 12.32 years. The tritium decay trend is a straight line when plotted on a logarithmic scale (vertical axis) versus time (horizontal axis).

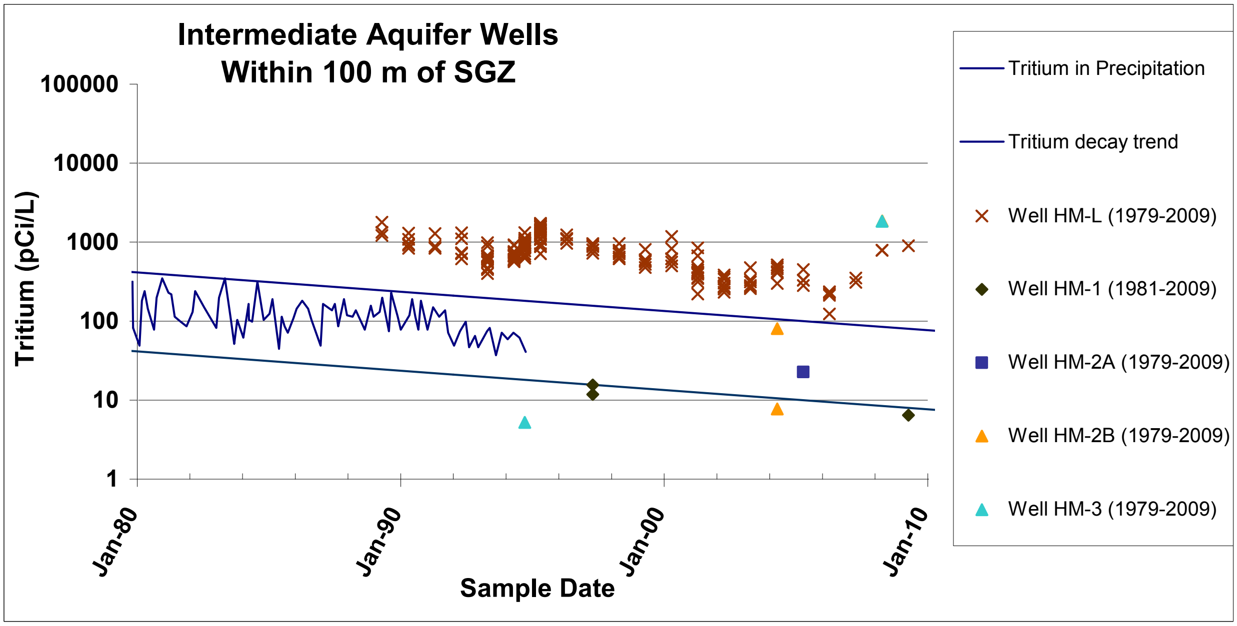

Figure B–2. Concentration Trend of Tritium Detected in Groundwater Samples versus Time. The samples were collected from wells that monitor aquifers spaced above the salt dome. The detonation point is 2,710 feet below the surface in the salt. Only results above the MDC are plotted. Measured tritium in rainfall is shown for 1980 through 1995. Tritium decays with a half-life of 12.32 years. The tritium decay trend is a straight line when plotted on a logarithmic scale (vertical axis) versus time (horizontal axis).

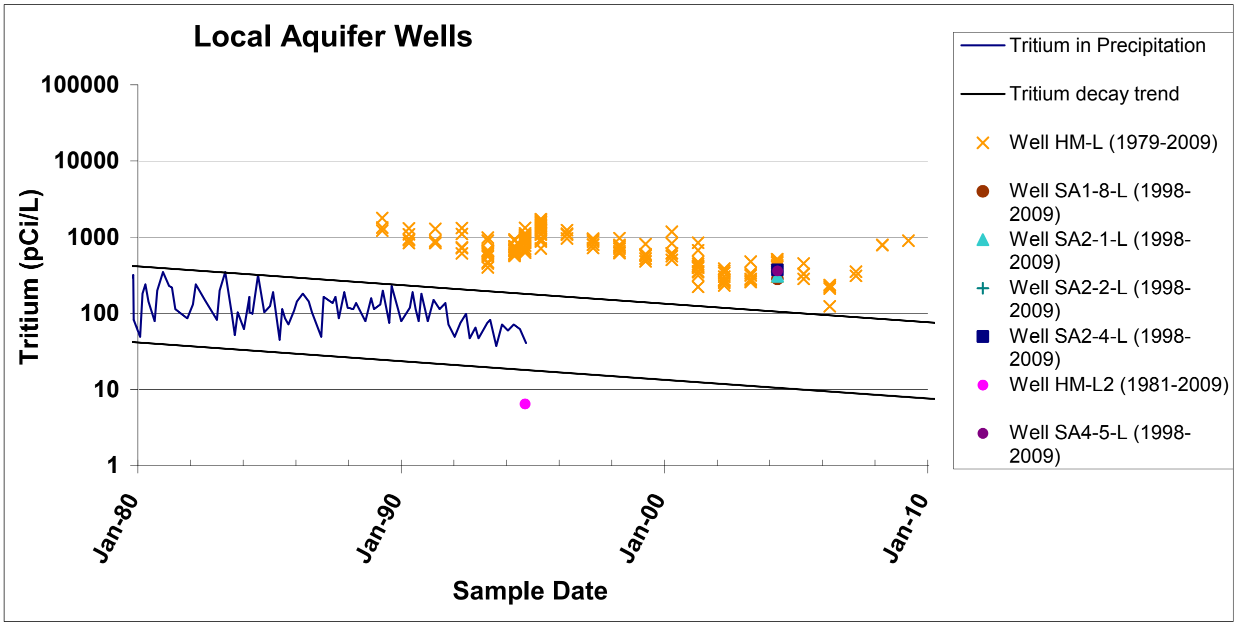

Figure B–3. Concentration Trend of Tritium Detected in Groundwater Samples versus Time. The samples were collected from monitoring wells within the Local Aquifer. Only results above the MDC are plotted. Measured tritium in rainfall is shown for 1980 through 1995. Tritium decays with a half-life of 12.32 years. The tritium decay trend is a straight line when plotted on a logarithmic scale (vertical axis) versus time (horizontal axis).

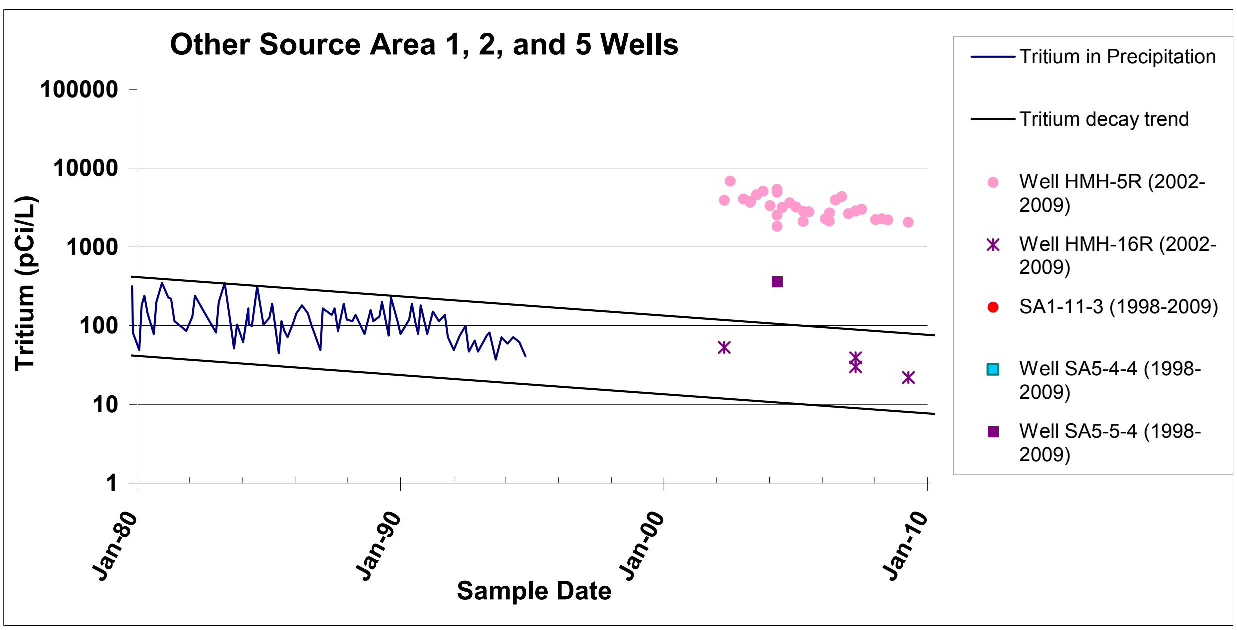

Figure B–4. Concentration Trend of Tritium Detected in Groundwater Samples versus Time. The samples were collected from various monitoring wells. The SA5 wells monitor Aquifer 5, which was injected with radioactive liquids during the testing The other three wells listed in the legend monitor the Alluvial Aquifer. Only results above the MDC are plotted. Measured tritium in rainfall is shown for 1980 through 1995. Tritium decays with a half-life of 12.32 years. The tritium decay trend is a straight line when plotted on a logarithmic scale (vertical axis) versus time (horizontal axis).

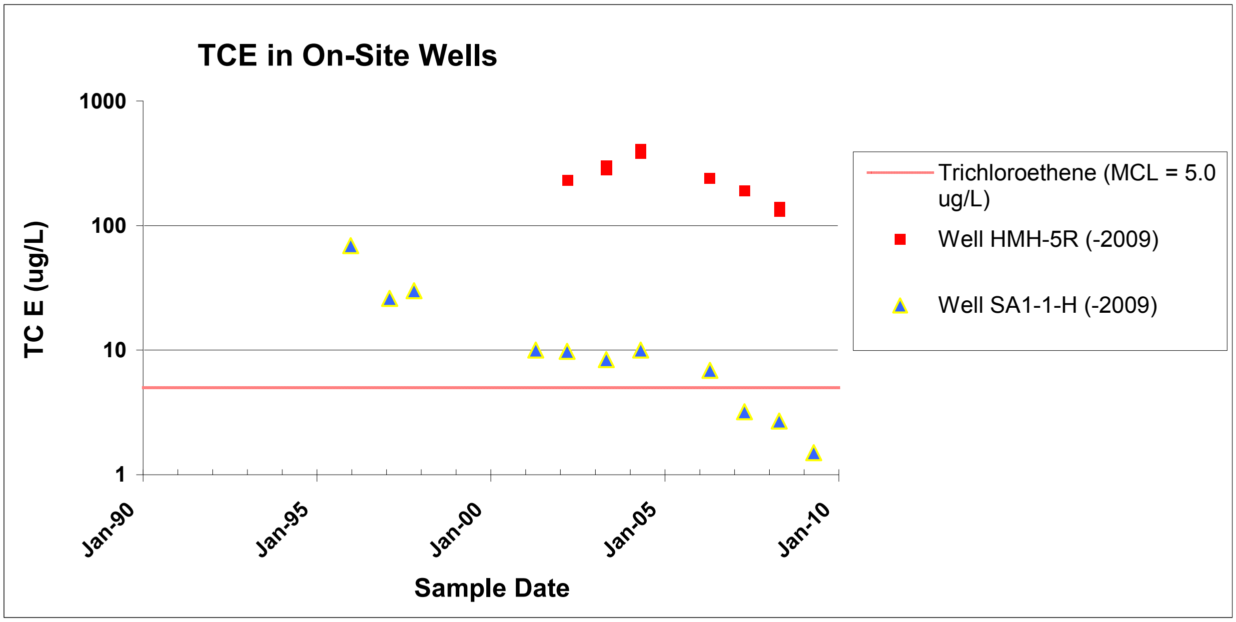

Figure B–5. Concentration Trend of Trichloroethene (TCE) Detected in Groundwater Samples versus Time. The samples were collected from monitoring wells in the Alluvial Aquifer. Only results above the detection limit are plotted. The TCE is from a drilling mud additive used as a lubricant during drilling for the test detonations. The MCL for TCE is plotted in red. The vertical axis is the logarithm of TCE concentration. The horizontal time axis is linear.

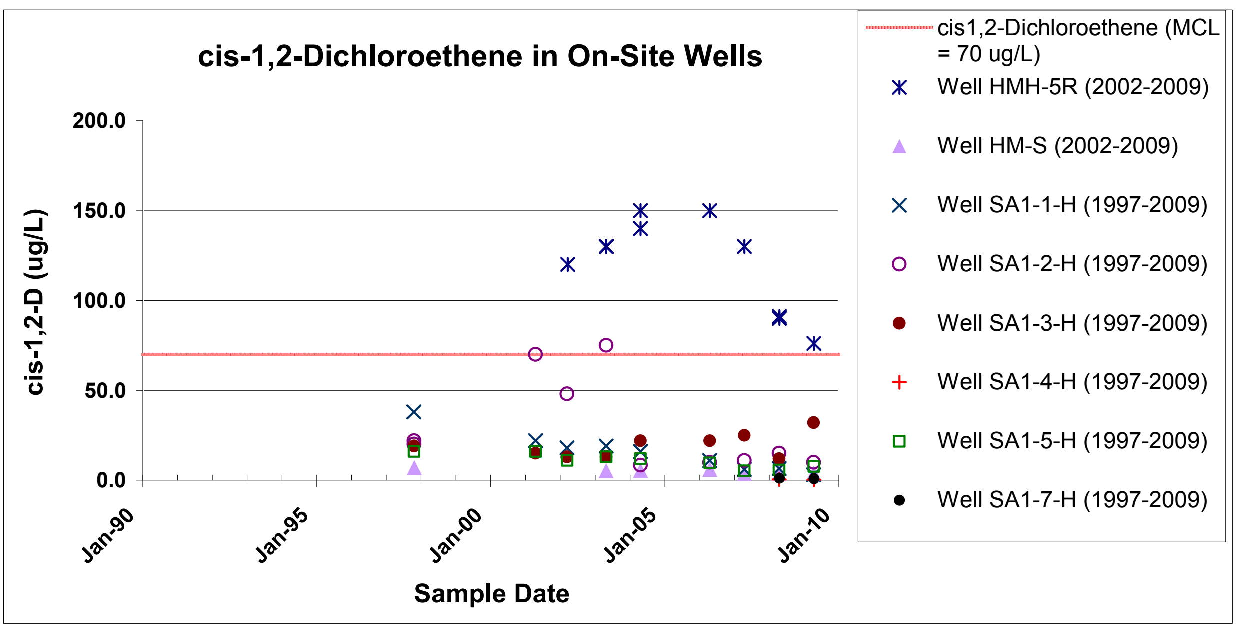

Figure B–6. Concentration Trend of cis-1,2-Dicloroethene Detected in Groundwater Samples versus Time. The samples were collected from monitoring wells in the Alluvial Aquifer. Only results above the detection limit are plotted. This contaminant is from a drilling mud additive used as a lubricant during drilling for the test detonations. The MCL is plotted in red. The vertical axis is the logarithm of cis-1,2-dicloroethene concentration. The horizontal time axis is linear.

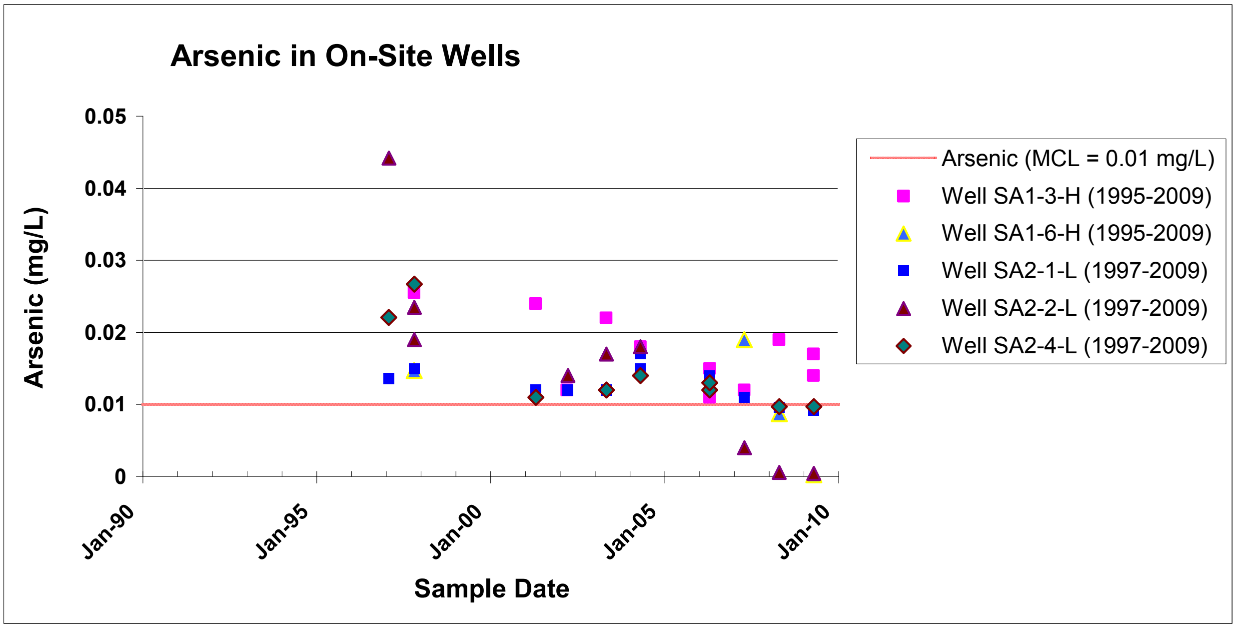

Figure B–7. Concentration Trend of Arsenic Detected in Groundwater Samples versus Time. The samples were collected from monitoring wells in the Alluvial and Local Aquifers. Only results above the detection limit are plotted. The source of the arsenic has never been established. The arsenic MCL is plotted in red. The vertical axis is the logarithm of arsenic concentration. The horizontal time axis is linear.

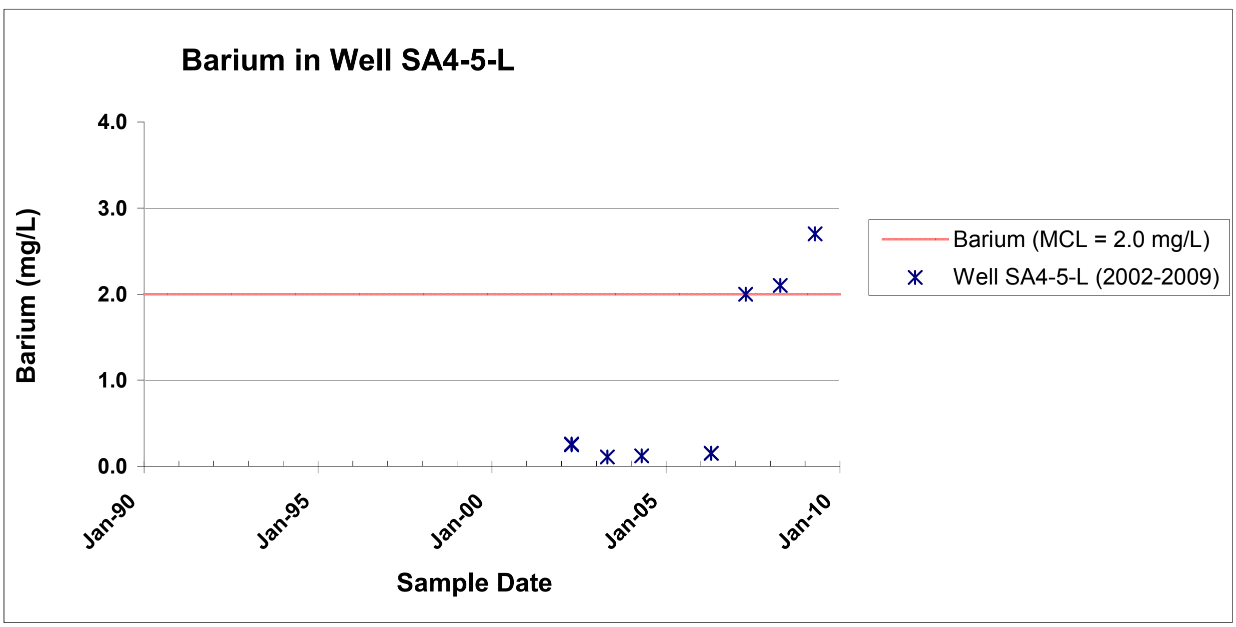

Figure B–8. Concentration Trend of Barium Detected in Groundwater Samples versus Time. The samples were collected from monitoring wells in the Local Aquifer. Only results above the detection limit are plotted. Barium is a major component of drilling mud. The barium MCL is plotted in red. The vertical axis is the logarithm of barium concentration. The horizontal time axis is linear.

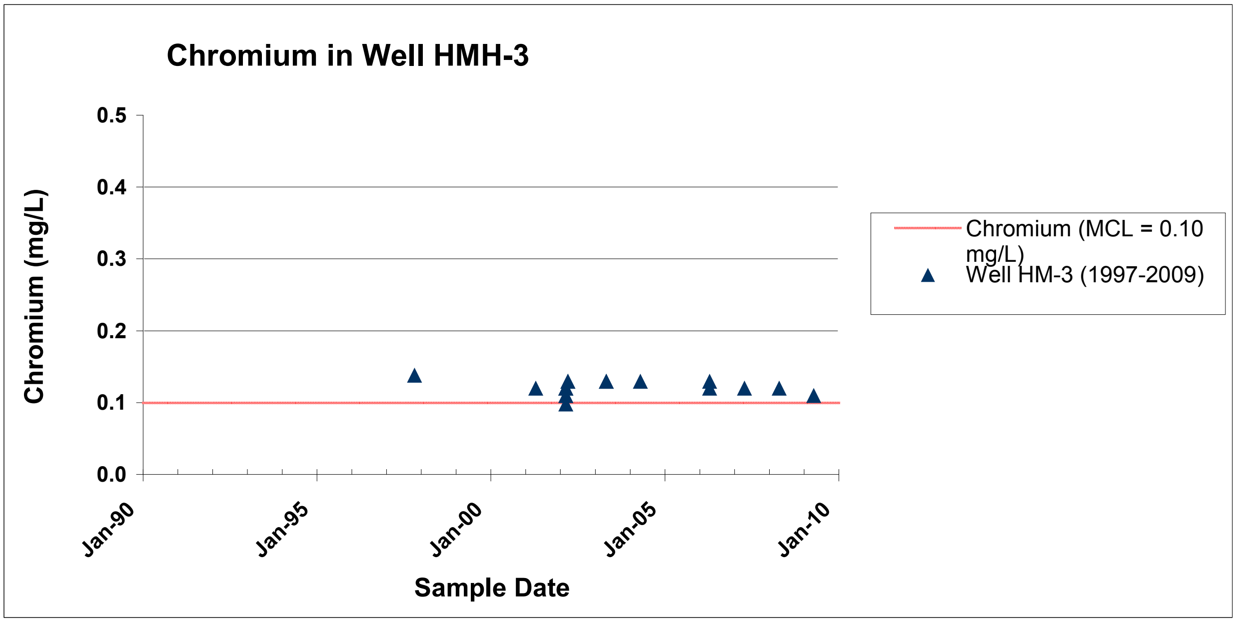

Figure B–9. Concentration Trend of Chromium Detected in Groundwater Samples versus Time. The samples were collected from Aquifer 3. Only results above the detection limit are plotted. The chromium may be from a drilling mud additive. The chromium MCL is plotted in red. The vertical axis is the logarithm of chromium concentration. The horizontal time axis is linear.

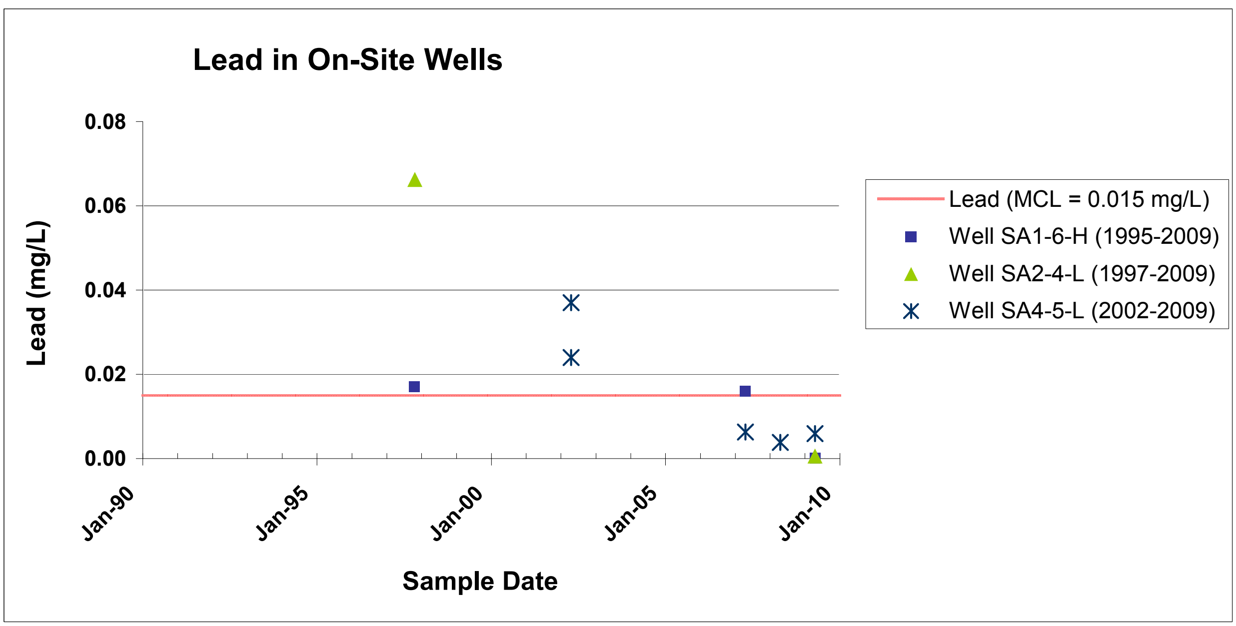

Figure B–10. Concentration Trend of Lead Detected in Groundwater Samples versus Time. The samples were collected in three wells. Only results above the detection limit are plotted. Lead was not detected in 2009. The lead MCL is plotted in red. The vertical axis is the logarithm of lead concentration. The horizontal time axis is linear.

Table B−4. 2009 Water Level Elevations (Feet Above Mean Sea Level)

Aquifer	Monitoring Well	Depth-to-Water-Level Measurement Date				
		9-Jan-09[a]	16-Apr-09[b]	2-Jul-09[a]	28-Jul-09[b]	2-Nov-09[a]
Alluvial	HMH-16R	NA	238.66	232.33	231.87	235.03
Alluvial	HMH-5R	NA	235.85	NA	231.84	230.92
Alluvial	HM-S	237.06	236.77	NA	233.1	235.83
Alluvial	SA1-1-H	236.86	236.55	232.1	232.63	235.48
Alluvial	SA1-2-H	236.81	236.48	232.31	232.87	235.5
Alluvial	SA1-3-H	236.69	236.42	NA	233.03	235.63
Alluvial	SA1-4-H	237.56	237.55	NA	233.46	236.49
Alluvial	SA1-5-H	237.65	237.43	233.22	233.6	236.65
Alluvial	SA1-6-H	NA	237.73	233.55	233.72	236.62
Alluvial	SA1-7-H	NA	237.42	NA	234.12	NA
Alluvial	SA1-12-H	NA	235.16	231.21	230.53	232.63
Alluvial	SA3-4-H	NA	239.09	NA	234.12	237.28
Local	HM-L	152.14	152.39	NA	152.35	NA
Local	HM-L2	NA	155.71	NA	154.61	NA
Local	SA1-8-L	156.66	156.89	NA	NA	NA
Local	SA2-1-L	156.89	157.01	NA	NA	156.9
Local	SA2-2-L	NA	156.95	NA	NA	NA
Local	SA2-4-L	157.21	157.33	NA	NA	NA
Local	SA4-5-L	NA	154.81	NA	155.65	NA
1	HM-1	NA	146.38	NA	146.12	146.36
2	HM-2A	NA	128.16	NA	127.33	NA
2	HM-2B	NA	119.19	NA	118.89	NA
3	HM-3	121.39	121.69	NA	121.34	121.22
3	SA1-11-3	118.36	118.76	118.64	NA	118.57
3	SA3-11-3	117.32	117.77	117.63	117.42	117.66
4	SA5-4-4	NA	201.2*	NA	193.07	NA
4	SA5-5-4	139.68	139.64	NA	191.58*	138.69
cap	E-7	NA	121.17	NA	120.91	NA

[a] Water level measurements made by the Mississippi Department of Health Division of Radiologic Health
[b] Water level measurements made by LM
NA = not available
* Probable measurement error

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