

# Groundwater Sampling and Analysis Report Salmon, Mississippi, Site Calendar Year 2013

March 2014

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# Contents

Abbreviations .....	iii
Executive Summary .....	v
1.0 Introduction .....	1
2.0 Site Location and Background .....	1
3.0 Geologic and Hydrologic Setting .....	6
3.1 Geologic Setting .....	6
3.2 Hydrologic Setting .....	6
4.0 Monitoring Objectives and Activities .....	8
4.1 Metals Monitoring .....	8
4.2 Metals Results .....	12
4.2.1 Alluvial Aquifer Metals Results .....	12
4.2.2 Local Aquifer Metals Results .....	14
4.2.3 Aquifer 3a Results .....	17
4.2.4 Surface Water Metals Results .....	19
4.3 Metals Analysis .....	24
4.4 VOC Monitoring .....	24
4.5 VOC Results .....	24
4.6 VOC Analysis .....	27
4.7 Radiological Monitoring .....	29
4.8 Radiological Results and Analysis .....	29
4.8.1 Tritium Results .....	29
4.8.2 Tritium Analysis .....	30
4.8.3 Gamma Spectroscopy Results and Analysis .....	31
4.8.4 Chlorine-36 Results .....	31
4.8.5 Chlorine-36 Analysis .....	31
4.9 Water Level Monitoring .....	32
4.10 Water Level Results .....	34
4.10.1 Alluvial Aquifer .....	34
4.10.2 Local Aquifer .....	36
4.10.3 Aquifer 3a .....	37
4.10.4 Aquifer 4 .....	38
4.10.5 SGZ Wells .....	38
5.0 Supplemental Site Activities .....	39
5.1 Inspection Activities .....	39
5.2 Maintenance Activities .....	39
6.0 Summary and Recommendations .....	40
7.0 References .....	42

## Figures

Figure 1. Salmon Site and Surrounding Region .....	2
Figure 2. Salmon Site Features and Monitoring Well Locations .....	3
Figure 3. Cross-Sectional Depiction of the Shot Cavity .....	5
Figure 4. Conceptual Model of the Relationship of the Dome, Shot Cavity, and SGZ Well Cluster .....	7

Figure 5.	Site Features and Surface Water Sampling Locations .....	9
Figure 6.	Alluvial Aquifer Arsenic Concentration 2007–2013 .....	12
Figure 7.	Alluvial Aquifer Barium Concentration 2007–2013 .....	13
Figure 8.	Alluvial Aquifer Chromium Concentration 2007–2013 .....	13
Figure 9.	Alluvial Aquifer Lead Concentration 2007–2013 .....	14
Figure 10.	Local Aquifer Arsenic Concentration 2007–2013 .....	15
Figure 11.	Local Aquifer Barium Concentration 2007–2013 .....	15
Figure 12.	Local Aquifer Chromium Concentration 2007–2013 .....	16
Figure 13.	Local Aquifer Lead Concentration 2007–2013 .....	16
Figure 14.	Aquifer 3a Arsenic Concentration 2007–2013 .....	17
Figure 15.	Aquifer 3a Barium Concentration 2007–2013 .....	18
Figure 16.	Aquifer 3a Chromium Concentration 2007–2013 .....	18
Figure 17.	Aquifer 3a Lead Concentration 2007–2013 .....	19
Figure 18.	Onsite Surface Water Arsenic Concentration 2007–2013 .....	20
Figure 19.	Streams Entering and Exiting the Site Arsenic Concentration 2007–2013 .....	20
Figure 20.	Onsite Surface Water Barium Concentration 2007–2013 .....	21
Figure 21.	Streams Entering and Exiting the Site Barium Concentration 2007–2013 .....	21
Figure 22.	Onsite Surface Water Barium Concentration 2007–2013 .....	22
Figure 23.	Streams Entering and Exiting the Site Chromium Concentration 2007–2013 .....	22
Figure 24.	Onsite Surface Water Lead Concentration 2007–2013 .....	23
Figure 25.	Streams Entering and Exiting the Site Lead Concentration 2007–2013 .....	23
Figure 26.	Wells with TCE Concentrations 2007–2013 .....	25
Figure 27.	Wells with cis-1,2 Dichloroethene Concentrations 2007–2013 .....	25
Figure 28.	Wells with trans-1,2 Dichloroethene Concentrations 2007–2013 .....	26
Figure 29.	Wells with Vinyl Chloride Concentrations 2007–2013 .....	26
Figure 30.	Exponential Curve Fit of TCE in HMH-5R .....	28
Figure 31.	Linear Regression Curve Fit of TCE in HMH-5R .....	28
Figure 32.	Time-Concentration Trends for Tritium .....	30
Figure 33.	Conceptual Model of the SGZ Well Cluster .....	33
Figure 34.	Alluvial Aquifer Hydrographs .....	34
Figure 35.	Local Aquifer Hydrographs .....	36
Figure 36.	Transducer Data from Local Aquifer Wells Indicating Seasonal Fluctuations .....	37
Figure 37.	Aquifer 3a Hydrographs .....	37
Figure 38.	Aquifer 4 Hydrographs .....	38
Figure 39.	Historical Water Levels in SGZ Wells .....	39

## Tables

Table 1.	Water-Sampling Plan Changes at the Salmon, Mississippi, Site 2013 .....	11
Table 2.	Average ORP and DO in Wells with Detectable VOC Concentrations .....	27
Table 3.	Tritium Concentrations Observed in 2013 .....	29
Table 4.	Chlorine-36 Ratios Observed in 2013 .....	31
Table 5.	Status of Pressure Transducers for Recording Water Levels .....	32
Table 6.	Construction and 2013 Water Level Elevations for Wells in the Salmon Site Monitoring Network .....	35
Table 7.	Water-Sampling Plan, Salmon, Mississippi Site October 2014 .....	41
Table 8.	Proposed Sampling Schedule .....	42

## Abbreviations

As	arsenic
Ba	barium
Ca <sup>2+</sup>	calcium
Cl <sup>-</sup>	chloride
CO <sub>3</sub> <sup>2-</sup>	carbonate
Cr	chromium
DCE	dichloroethene
DO	dissolved oxygen
DOE	U.S. Department of Energy
ft	feet (foot)
K <sup>+</sup>	potassium
LM	Office of Legacy Management
MCL	maximum contaminant level set by the U.S. Environmental Protection Agency
Mg <sup>2+</sup>	magnesium
µg/L	micrograms per liter
mg/L	milligrams per liter
Na <sup>+</sup>	sodium
ORP	oxidation-reduction potential
Pb	lead
pCi/L	picocuries per liter of water (about 1/27 radioactive disintegrations per second per liter)
SGZ	surface ground zero
SO <sub>4</sub> <sup>2-</sup>	sulfate
TCE	trichloroethene
VOCs	volatile organic compounds

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## Executive Summary

This report focuses on groundwater data and sampling objectives, and it replaces the annual *Post-Closure Inspection, Sampling, and Maintenance Report for the Salmon, Mississippi, Site*.

The U.S. Department of Energy (DOE) transferred the Salmon site property to the State of Mississippi, and the State is responsible for maintenance of the site surface features. DOE's Office of Legacy Management (LM) is responsible for the monitoring wells, the monument at surface ground zero (SGZ), and the subsurface real estate including minerals and contamination remaining from past underground testing. DOE's inspection and maintenance activities are limited to the real property assets, which are the monitoring wells and the monument at SGZ. A condition assessment of these assets is required to be conducted every 5 years. This assessment was conducted as part of the 2013 sampling event.

LM is responsible for the subsurface real estate, which includes contamination from past U.S. Atomic Energy Commission and DOE activities at the site and any contamination that may migrate from the shot cavity or the waste injected into Aquifer 5.

LM sampled 28 wells and 10 surface locations in 2013. Target analytes were metals, volatile organic compounds (VOCs), and tritium. Analytes monitored for possible contaminant migration from the shot cavity and Aquifer 5 are fission and natural radionuclides, chlorine-36, and tritium. Analytical results indicate that contaminant concentrations at the site continue to attenuate, and that there is no indication of any contaminant migration from the shot cavity or Aquifer 5.

LM will implement the following actions for the October 2014 sampling event and future sampling at the site:

- Conduct sampling every 18 months through October 2017, then conduct monitoring every 5 years to coincide with the condition assessment.
- Collect samples for metals analysis at the same locations as the April 2013 event to look for seasonal variability, and then reduce the number of sampling locations to only those where analyte concentrations exceed Safe Drinking Water Act maximum contaminant levels.
- Collect samples for tritium analysis at all locations to look for seasonal variability; analyze by the enriched tritium method only at locations where a lower detection limit is needed (rather than randomly on 25 percent of the samples). After the 2014 sampling, reduce tritium analysis to only Alluvial Aquifer wells, streams entering and exiting the site, and indicator wells (HM-S, HM-L, HM-1, HM-2A, HM-2B, HM-3, E-7, SA5-4-4, and SA5-5-4).
- Analyze for VOCs only in samples from Alluvial Aquifer wells and well HM-L for the October 2014 event and all future monitoring.
- Analyze no samples by gamma spectroscopy in 2014; analyze by this method only for samples collected during April sampling events.
- Continue chlorine-36 analysis for the indicator wells; add this analysis to samples from streams entering and exiting the site. Establish a background location for chlorine-36.
- Analyze for major ions ( $\text{Cl}^-$ ,  $\text{HCO}_3^-$ ,  $\text{CO}_3^{2-}$ ,  $\text{SO}_4^{2-}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ) at the same locations as chlorine-36 analysis to aid in interpretation of the data.

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## **1.0 Introduction**

This report presents the 2013 groundwater monitoring results for samples collected by the U.S. Department of Energy (DOE) Office of Legacy Management (LM) for the Salmon, Mississippi, Site. The State of Mississippi (the State) owns the surface real estate at the site, and the deed to the property includes certain restrictions related to subsurface penetration. The State is the surface operator; the Mississippi Forestry Commission is its agent. The federal government owns the monitoring wells, the monument at surface ground zero (SGZ), and the subsurface real estate including minerals and contamination remaining from former underground nuclear tests. LM has responsibility for the long-term surveillance of the subsurface real estate, shares right-of-entry easements with the State, and retains rights related to subsurface monitoring.

## **2.0 Site Location and Background**

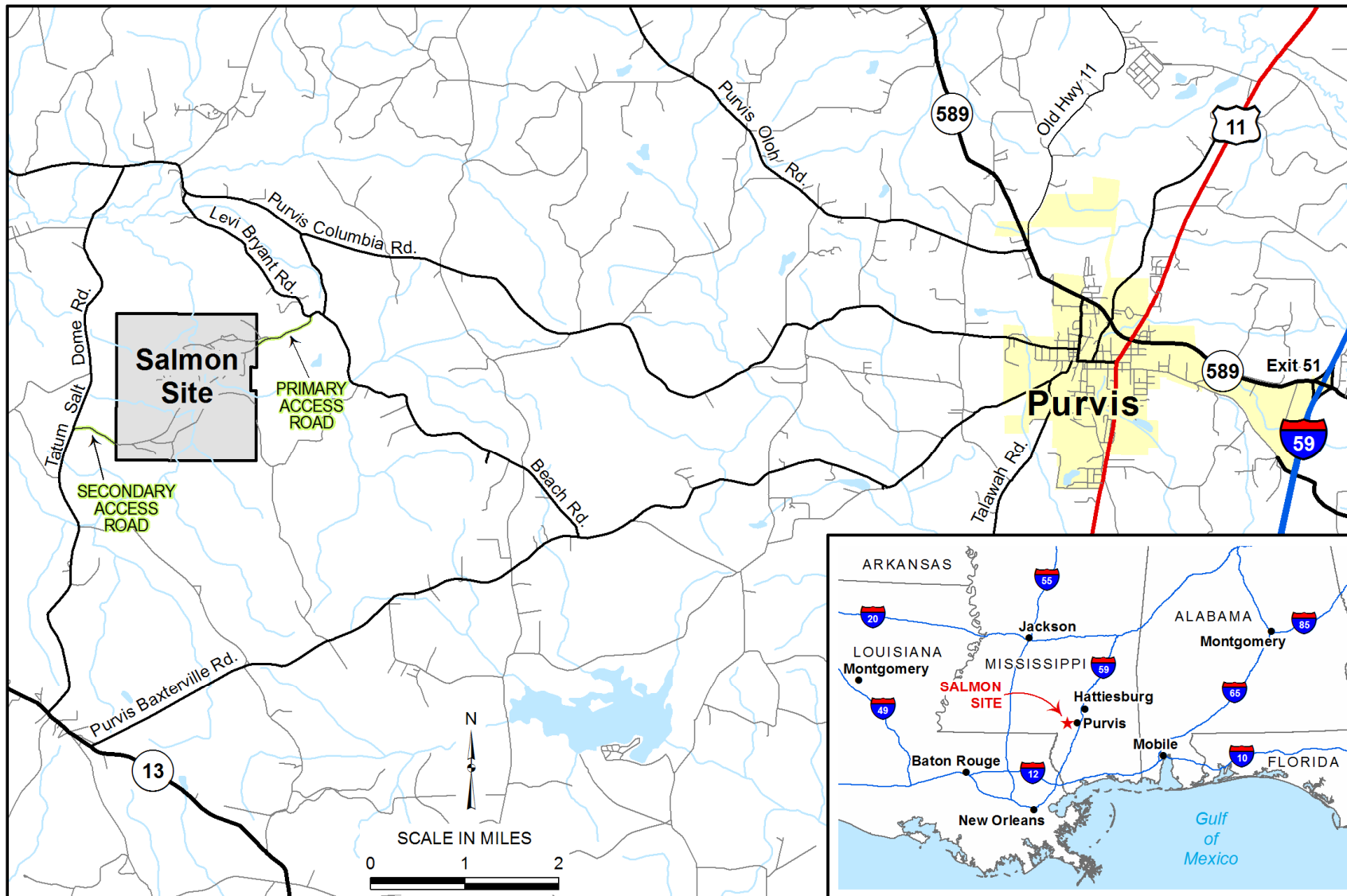
The Salmon site consists of 1,470 acres in Lamar County, Mississippi, approximately 10 miles west of Purvis, Mississippi, and about 21 miles southwest of Hattiesburg, Mississippi (Figure 1).

The U.S. Atomic Energy Commission, a predecessor agency to DOE, conducted a series of underground detonations in the Tatum Salt Dome beneath the site to study seismic signatures. Figure 2 shows an outline of the salt dome at about 2,500 feet (ft) below ground surface. Two nuclear tests (Project Dribble) and two gas-explosive tests (Project Miracle Play) were conducted in the salt dome between 1964 and 1970. Salmon, the first nuclear test, was detonated on October 22, 1964, and created a cavity 2,710 ft below ground surface (Figure 3). The second nuclear test, Sterling, was detonated on December 3, 1966. The Sterling test and the two gas explosions—Diode Tube on February 2, 1969, and Humid Water on April 19, 1970—were all detonated in the cavity created by the Salmon test. No radioactivity was released to the surface during the four tests, although tritium contamination was brought to surface during drill-back operations. Residual radioactivity from Project Dribble is contained within the cavity walls and the cavity itself. The plasticity and impermeability of the surrounding salt formation provide sufficient geologic isolation.

Radioactive liquid waste derived from drill-back operations was injected into Aquifer 5 from March to July 1965. The injection well (HT-2), located in the southwest corner of the site, was plugged during site cleanup operations. The oil industry has used Aquifer 5 for brine injection since 1950 at Baxterville field 6 miles southwest of the Salmon site.

The site was cleaned up and decommissioned in 1972. During cleanup, most of the soil contaminated with drilling fluids from drill-back operations was converted to a slurry and injected into the cavity. All test boreholes for emplacement, drill-back, and injection, and other wells were plugged and abandoned in accordance with State of Mississippi requirements.

During the Remedial Investigation/Feasibility Study (DOE 1993) the site was divided into source areas (SAs) based on the historical activities conducted in the different areas of the site. Figure 2 shows the historical areas where site activities were conducted and the six SAs.



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Figure 1. Salmon Site and Surrounding Region



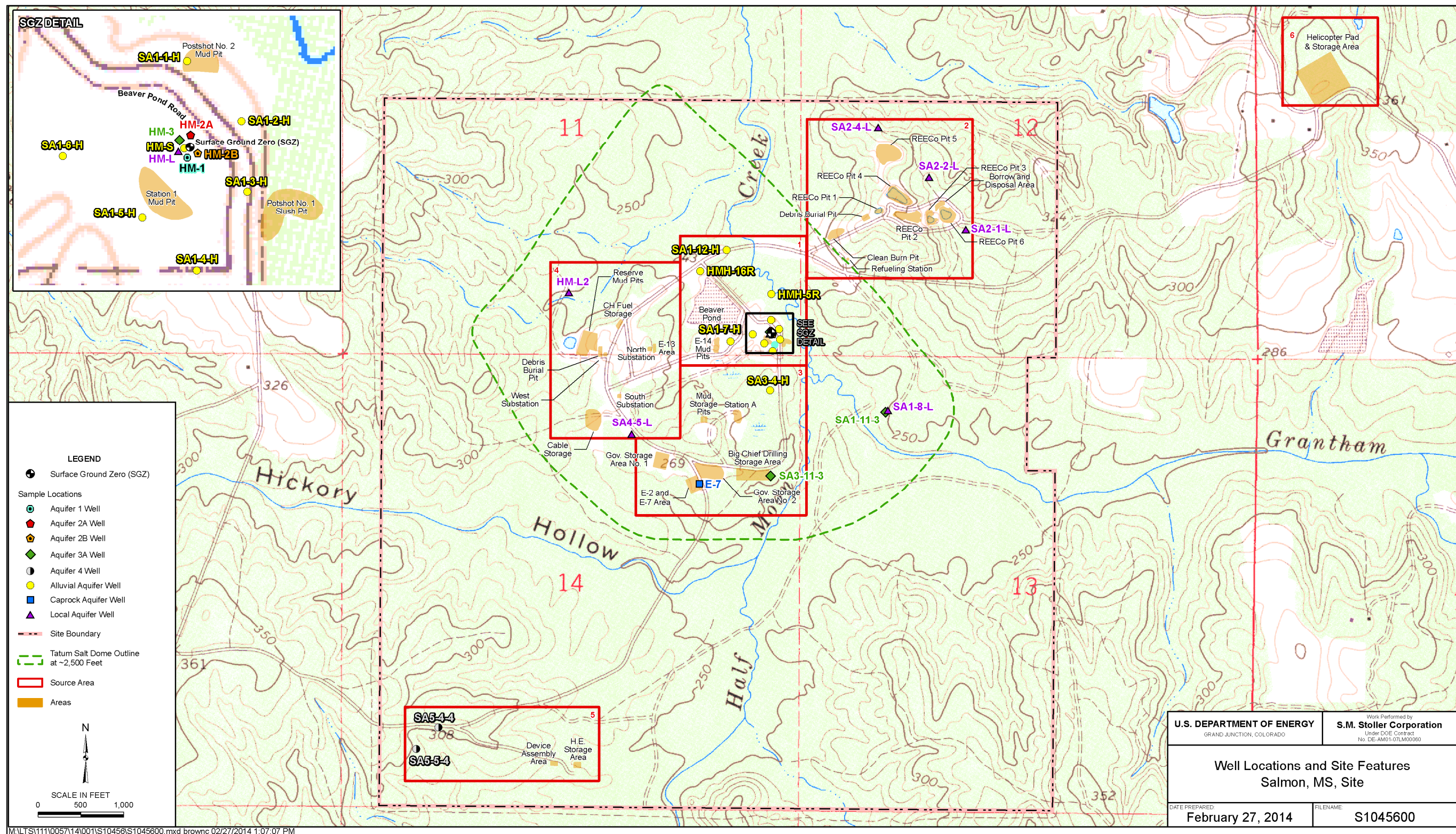


Figure 2. Salmon Site Features and Monitoring Well Locations



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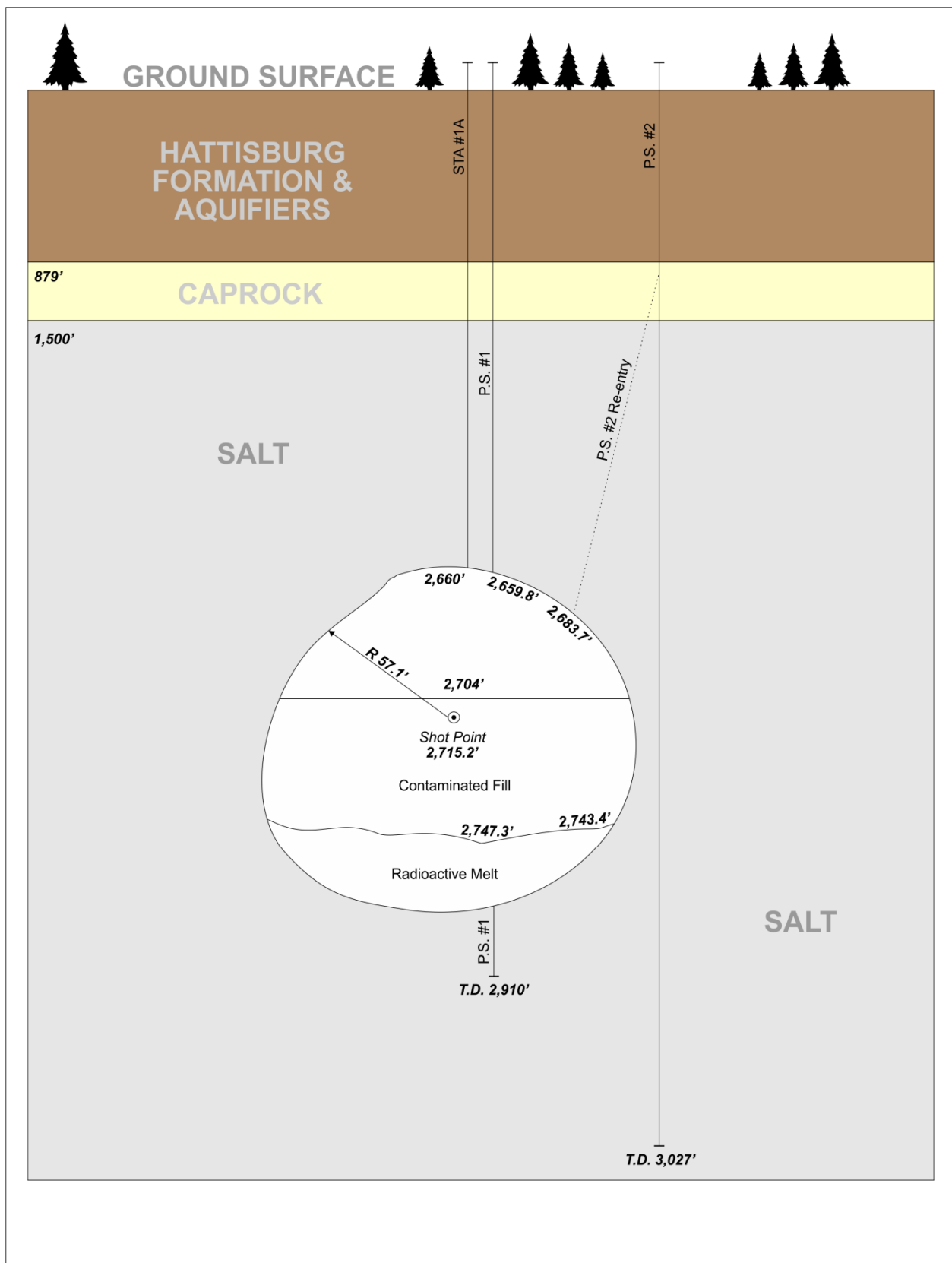


Figure 3. Cross-Sectional Depiction of the Shot Cavity

## **3.0 Geologic and Hydrologic Setting**

### **3.1 Geologic Setting**

Tatum Dome is a salt dome within the Mississippi Interior Salt Basin. The dome consists of a salt core overlain by anhydrite and limestone cap rock (Figure 4). The salt core is roughly circular with a flat top at about 1,500 ft below ground surface. The salt consists of roughly 90 percent halite (sodium chloride) and 10 percent anhydrite (calcium sulfate). The anhydrite cap rock is 450 to 600 ft thick and extends upward to about 1,000 ft below ground surface. The cap rock is overlain by the Catahoula Sandstone of Oligocene age; the Catahoula is 100 to 200 ft thick and is overlain by the Pascagoula-Hattiesburg clays of Miocene age (Hattiesburg Formation), which crop out regionally in the lower stream valleys and also extend across the dome. The Hattiesburg Formation is 550 to 750 ft thick. The surficial material at the Salmon site is the Citronelle Formation, terrace deposits, and alluvium of Pliocene-Pleistocene-recent age. They consist of gravel, sand, and silty clay about 150 ft thick. The Citronelle crops out on the slopes and tops of the hills in the site area. The Cook Mountain limestone and the overlying Vicksburg Group are stratigraphic units below the Catahoula sandstone, and are both pierced by the dome. The Tatum Dome appears to have no topographic expression.

### **3.2 Hydrologic Setting**

Aquifers containing freshwater extend from near the surface to about 1,400 ft below sea level in the Tatum Dome area; however, the salt dome has locally modified the water quality so that freshwater over the dome extends only to about 700 ft below sea level (Figure 4). Thus, some aquifers that contain saline water on the dome contain freshwater away from the influence of the dome. There are multiple freshwater aquifers: two surficial aquifers; the Alluvial Aquifer and surficial waters in the Citronelle formation, six deeper aquifers (Local, 1, 2a, 2b, 3a, and 3b), one brackish aquifer (4), and at least one underlying saline aquifer (5) in the strata surrounding the Tatum Salt Dome (Figure 4). Fresh, brackish, and saline waters are defined as waters containing total dissolved solids concentrations of less than 1,000 milligrams per liter (mg/L), 1,000 to 5,000 mg/L, and more than 5,000 mg/L, respectively. The freshwater surficial aquifers and Local Aquifer are discontinuous. The deeper freshwater aquifers (1, 2a, 2b, 3a, and 3b) are horizontally extensive, although they may be locally offset or interrupted by faults near the dome (USGS 1971). Many water supply wells in Lamar County use groundwater from one or more of these deeper freshwater aquifers. Water is also present in fractures in the cap rock and is referred to as the Caprock Aquifer. Wells in the current monitoring network (Figure 2) monitor most of the freshwater aquifers as well as Aquifer 4 and the Caprock Aquifer. Twelve wells are completed in the Alluvial Aquifer; seven in the Local Aquifer; one in each of Aquifers 1, 2a, and 2b; three in Aquifer 3a; two in Aquifer 4; and one in the Caprock Aquifer. No wells are completed in Aquifer 5, Aquifer 3b, or the Citronelle Formation.



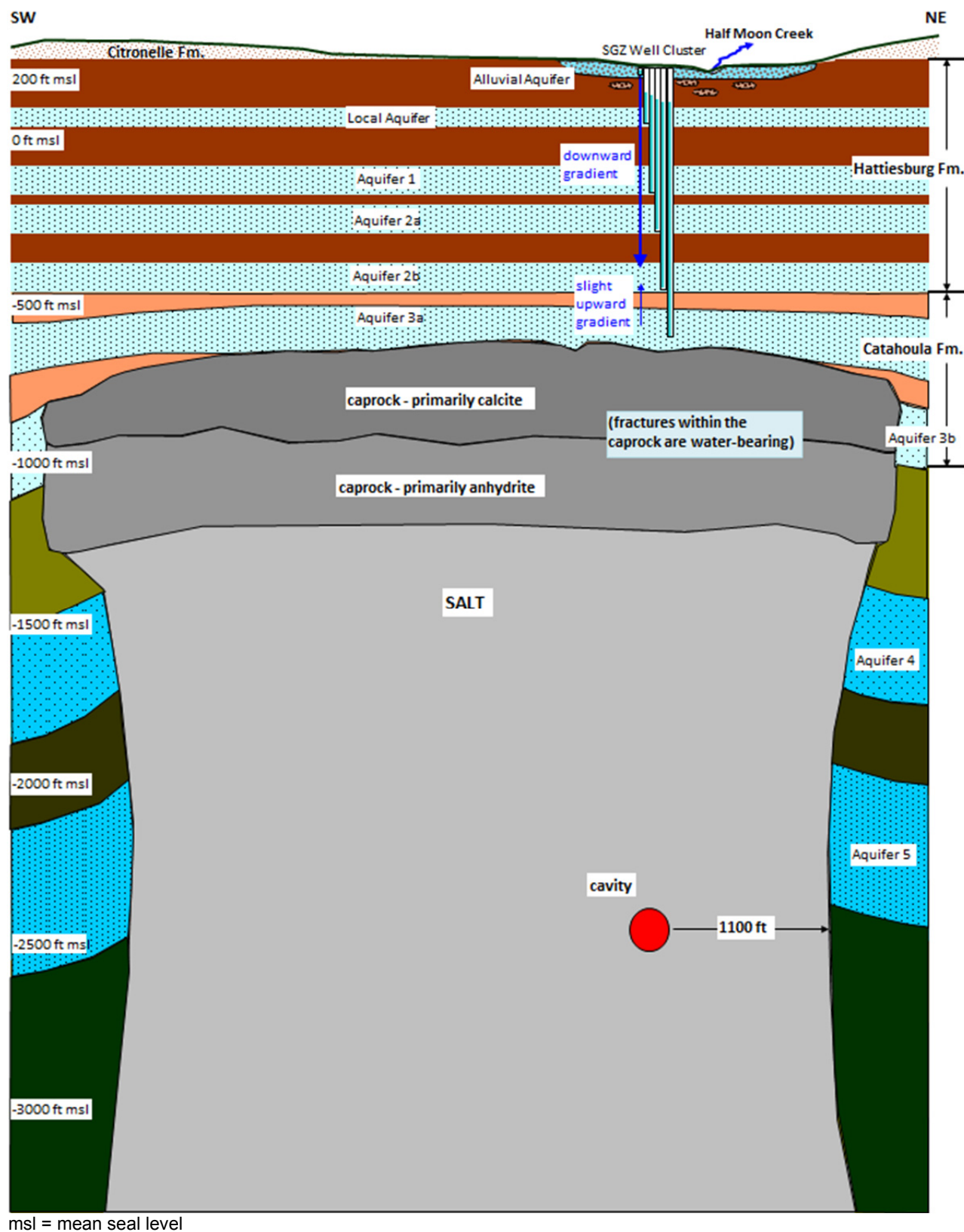


Figure 4. Conceptual Model of the Relationship of the Dome, Shot Cavity, and SGZ Well Cluster

## 4.0 Monitoring Objectives and Activities

Groundwater monitoring has been conducted at the Salmon site since it was decommissioned in 1972. LM has conducted groundwater and surface water monitoring at the site since 2007. The sampling program is designed to monitor residual contamination near the surface and to monitor the potential migration of contamination from the shot cavity and from the Aquifer 5 injection site. The monitoring network consists of 28 monitoring wells (Figure 2) and 13 surface water locations (Figure 5). The onsite wells are completed in multiple aquifers. Historically, samples were collected annually and analyzed for radionuclides, metals, and a suite of volatile organic compounds (VOCs), including trichloroethene (TCE), *cis*- and *trans*-1,2-dichloroethene (DCE), and vinyl chloride.

LM conducted an analysis of the monitoring network in 2012 (DOE 2013a) (network analysis) to evaluate if the well coverage and analyte suite were sufficient to provide an understanding of contaminant distribution at the site and to verify that site conditions are protective of human health and the environment. The following changes were made to sampling conducted in 2013 as a result of the network analysis:

- Metals analysis was reduced to the four metals that have exceeded their respective U.S. Environmental Protection Agency maximum contaminant level (MCL) at one or more locations since 2007 (arsenic, barium, chromium, and lead).
- Radionuclide analysis by gamma spectroscopy was reduced to the locations that overlie a potential radionuclide contaminant source (i.e., the shot cavity and the Aquifer 5 injection site).
- Chlorine-36 analysis was added as a potential long-term indicator isotope to the same locations where samples were collected for gamma spectroscopy analysis.
- VOC analysis was added to Local Aquifer wells and selected surface locations.
- Difficult-to-access surface locations were replaced.

Table 1 shows the changes in sampling implemented in 2013.

It was also recommended that the sampling frequency be adjusted to an 18-month cycle to determine if concentrations vary with seasonal fluctuations in water levels. The next sampling event is scheduled for October 2014.

### 4.1 Metals Monitoring

Metals were analyzed in samples collected from the Alluvial Aquifer wells, the Local Aquifer wells, surface locations, and Aquifer 3a well HM-3 located at SGZ. Metals monitoring was added to two additional Aquifer 3a wells for 2013, as metals have been detected in well HM-3. Metals analysis was reduced to four metals (arsenic, barium, chromium, and lead). These metals were chosen because they had been detected more frequently or have exceeded their MCL from 2007 through 2012. Metals contamination is likely from historical drilling activities and waste disposal in the former mud pits and debris pits on site. However, metals occur naturally in soils in the area, and these natural sources also contribute to the metals concentrations observed in samples from the site.



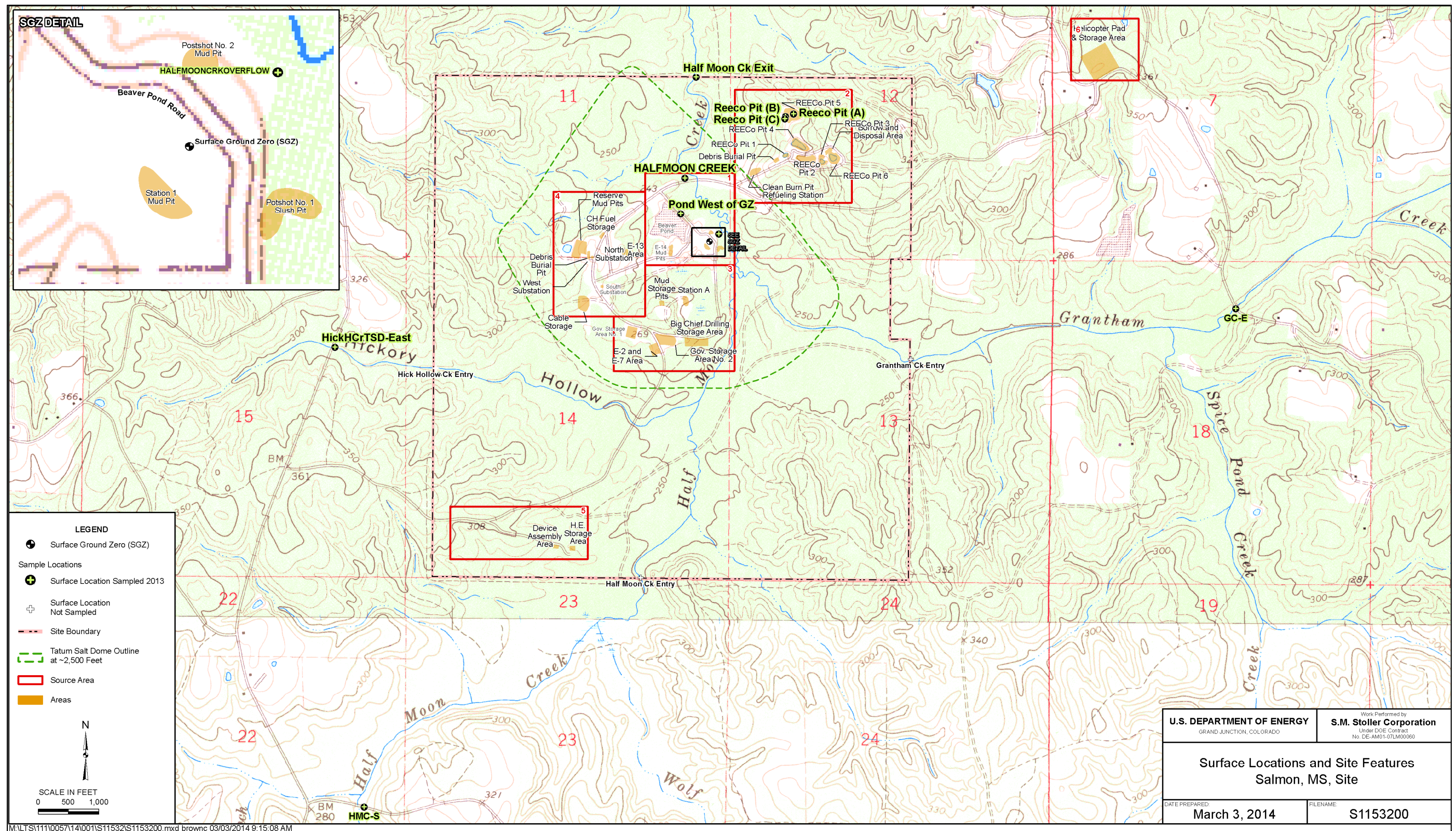


Figure 5. Site Features and Surface Water Sampling Locations



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Table 1. Water-Sampling Plan Changes at the Salmon, Mississippi, Site 2013

Source Area	Well Name	Aquifer	TD (ft)	VOC	Metals <sup>a</sup>	Tritium <sup>b</sup>	Gamma Spec	CI-36	Water Level
SA1	SA1-1-H	Alluvial	30	X	X	X			X
	SA1-2-H	Alluvial	30	X	X	X			X
	SA1-3-H	Alluvial	30	X	X	X			X
	SA1-4-H	Alluvial	30	X	X	X			X
	SA1-5-H	Alluvial	30	X	X	X			X
	SA1-6-H	Alluvial	23	X	X	X			X
	SA1-7-H	Alluvial	30	X	X	X			X
	SA1-12-H	Alluvial	30	X	X	X			X
	HMH-5R	Alluvial	30	X	X	X			X
	HMH-16R	Alluvial	30	X	X	X			X
	HM-S	Alluvial	30	X	X	X	X	X	X
	SA1-8-L	Local	195	X <sup>c</sup>	X	X	O		X
	HM-L	Local	204	X <sup>c</sup>	X	X	X	X	X
	HM-1	1	415			X	X	X	X
	HM-2A	2a	537			X	X	X	X
	HM-2B	2b	700			X	X	X	X
	HM-3	3a	875		X	X	X	X	X
	SA1-11-3	3a	924		X	X	O		X
SA2	SA2-1-L	Local	349	X <sup>c</sup>	X	X	O		X
	SA2-2-L	Local	340	X <sup>c</sup>	X	X	O		X
	SA2-4-L	Local	250	X <sup>c</sup>	X	X	O <sup>d</sup>		X
SA3	SA3-4-H	Alluvial	30	X	X	X			X
	E-7	Caprock	934	O		X	X	X	X
	SA3-11-3	3a	861		X	X	O		X
SA4	HM-L2	Local	200	X <sup>c</sup>	X	X	O		X
	SA4-5-L	Local	180	X <sup>c</sup>	X	X	O		X
SA5	SA5-4-4	4	2099			X	X	X	X
	SA5-5-4	4	2081			X	X	X	X
Surface Location Name									
SA1	HALFMOON CREEK	NA			X	X	O		
	HALFMOONCRKOVERFLOW	NA		X <sup>c</sup>	X	X	O		
	Pond West of GZ	NA		X <sup>c</sup>	X	X	O		
SA2	REECo Pit (A)	NA		X <sup>c</sup>	X	X			
	REECo Pit (B)	NA		X <sup>c</sup>	X	X			
	REECo Pit (C)	NA		X <sup>c</sup>	X	X			
	Grantham Cr Entry	NA			O	O	O		
	Half Moon Cr Entry	NA			O	O	O		
	Hick Hollow Cr Entry	NA			O	O	O		
	Half Moon Cr Exit	NA			X	X	O		
	HickHCr.tsd_East	NA			X	X	O		
	GC-E (Grantham Cr East)	NA			X	X			
	HMC-S (Half Moon Cr South)	NA			X	X			

Notes: Changes are shown in Red (O indicates a location that will no longer be sampled)

<sup>a</sup> Metals = As, Ba, Cr, Pb

<sup>b</sup> Analyze 25% of the tritium samples by the enriched tritium method

<sup>c</sup> If a nondetect, then discontinue

<sup>d</sup> Sampled in 2013 to confirm detection of radionuclides in 2012 results

## 4.2 Metals Results

The four metals analyzed for were detected at all locations sampled. Concentrations exceeded MCLs at SA1-3-H, SA1-7-H, SA4-5-L, and HM-3. The following sections present the historical trends and recent results of the metals monitoring.

### 4.2.1 Alluvial Aquifer Metals Results

Metals concentrations were below the MCLs for all Alluvial Aquifer wells except arsenic in wells SA1-3-H (0.015 mg/L) and SA1-7-H (0.012 mg/L) (Figure 6), both of which slightly exceeded the MCL (0.01 mg/L). Figure 6 through Figure 9 show the concentrations of the four metals in the Alluvial Aquifer for 2007–2013.

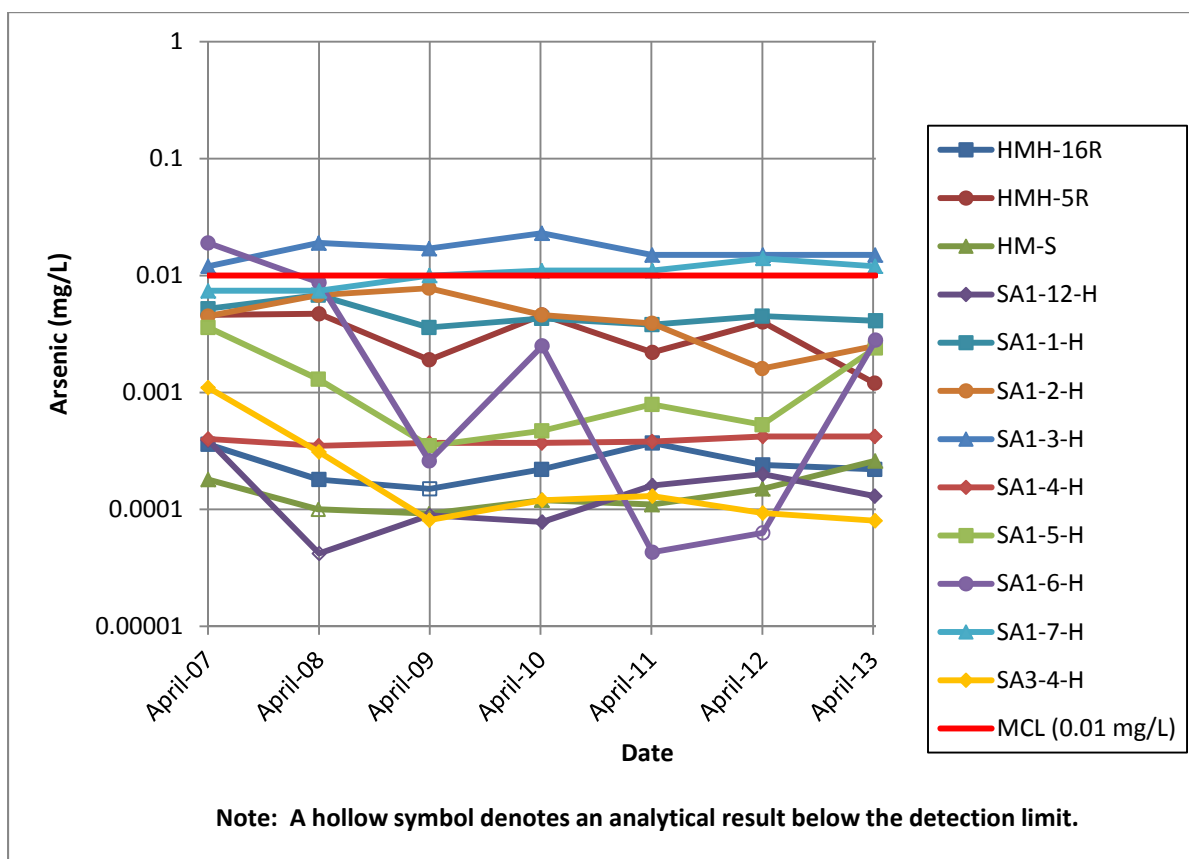


Figure 6. Alluvial Aquifer Arsenic Concentration 2007–2013

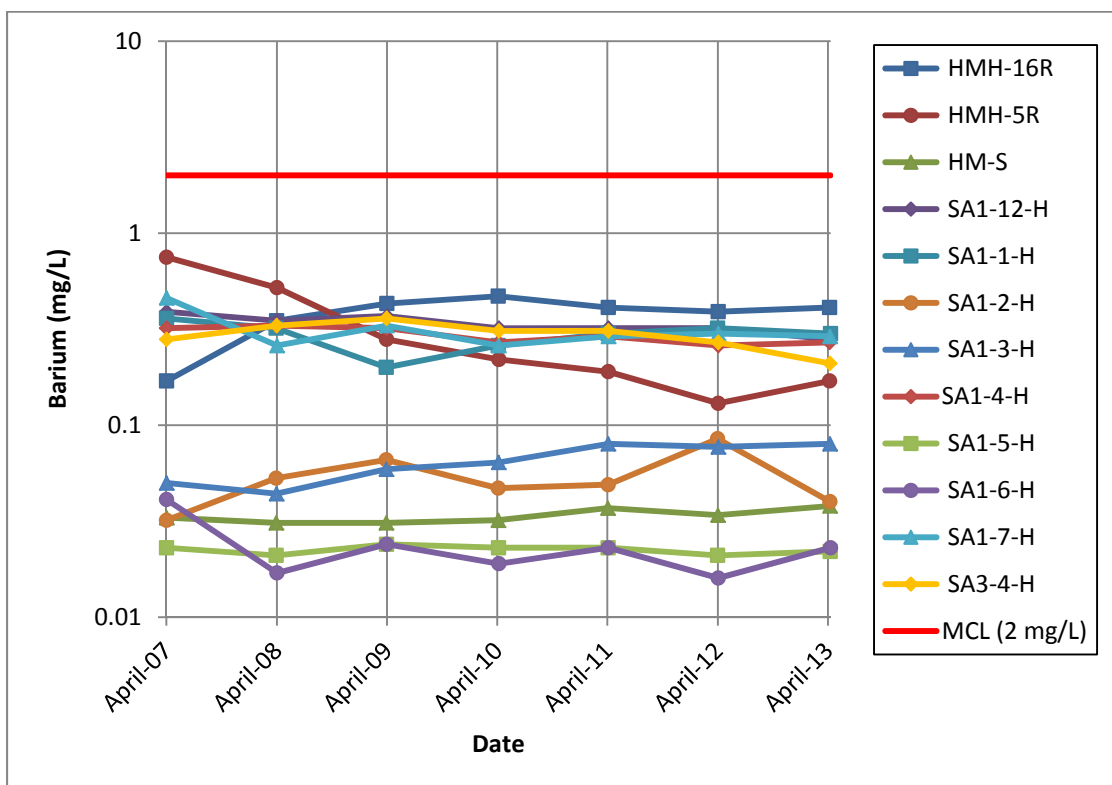


Figure 7. Alluvial Aquifer Barium Concentration 2007–2013

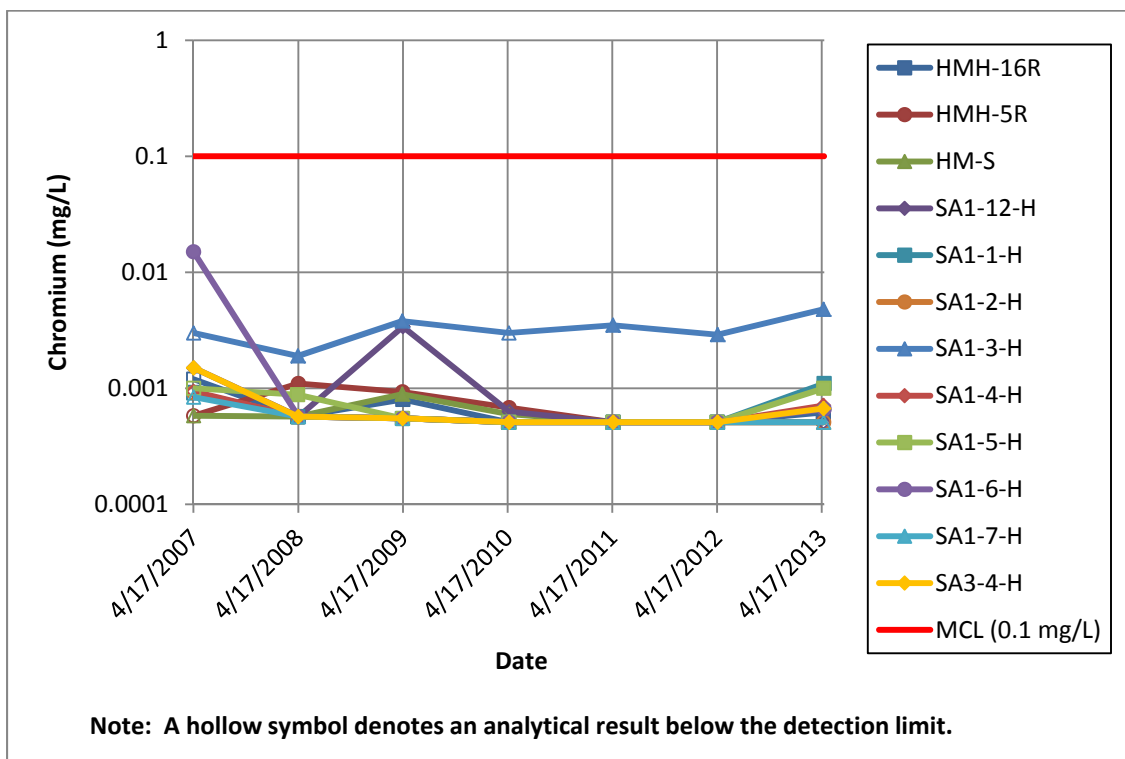


Figure 8. Alluvial Aquifer Chromium Concentration 2007–2013

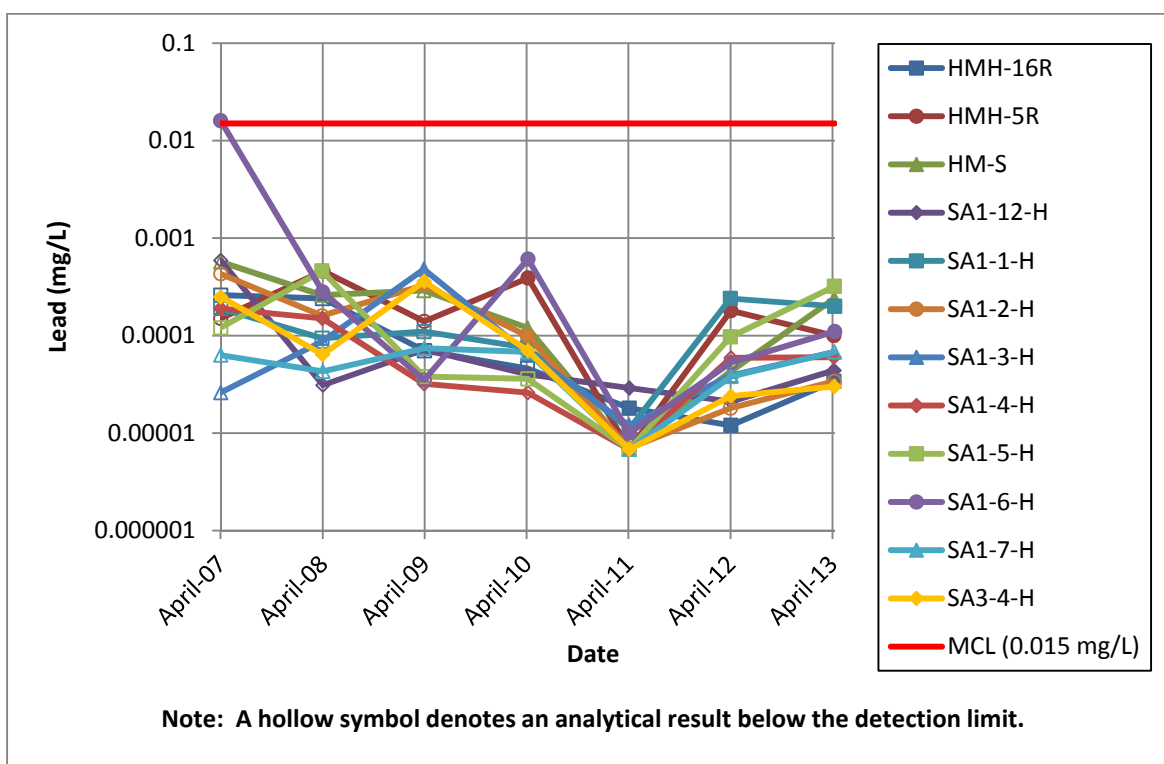


Figure 9. Alluvial Aquifer Lead Concentration 2007–2013

#### 4.2.2 Local Aquifer Metals Results

Metals concentrations were below the MCL for all Local Aquifer wells except for barium in well SA4-5-L (Figure 11), which has consistently exceeded the MCL of 2.0 mg/L (2.6–2.7 mg/L) since 2009. The arsenic concentrations are at the MCL in well SA2-1-L and just below the MCL in well SA2-4-L (0.092 mg/L) (Figure 10). The arsenic concentrations in both of these wells have been at or close to the MCL since 2007. Figure 10 through Figure 13 show the results of the four metals in the Local Aquifer for 2007–2013.



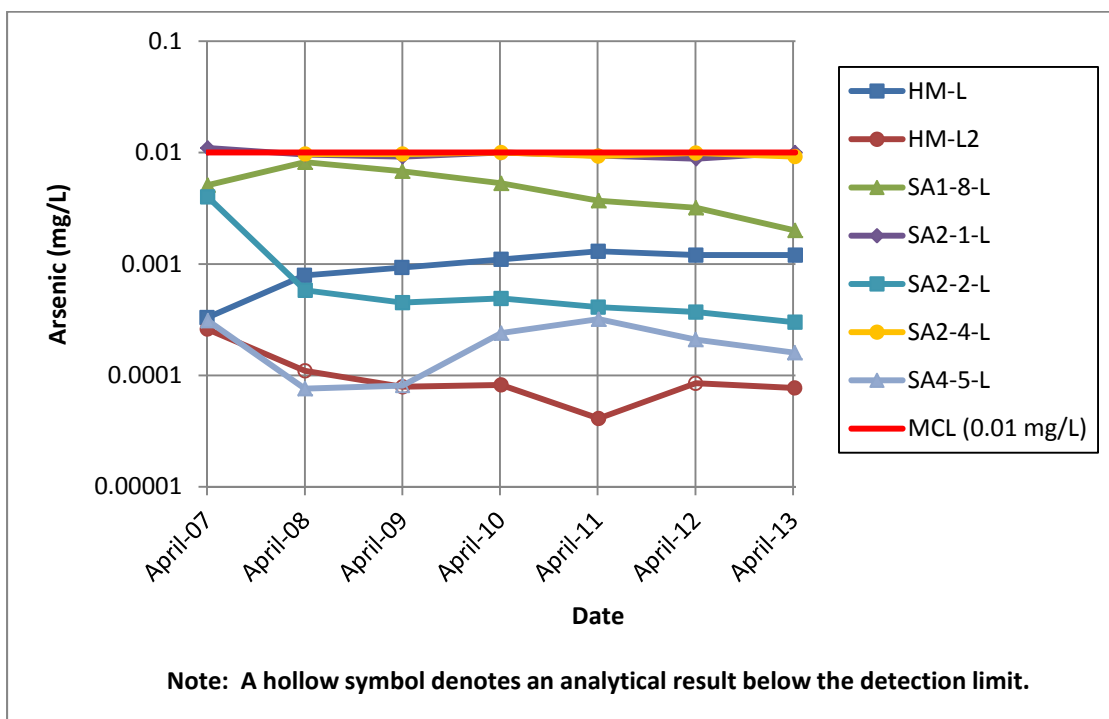


Figure 10. Local Aquifer Arsenic Concentration 2007–2013

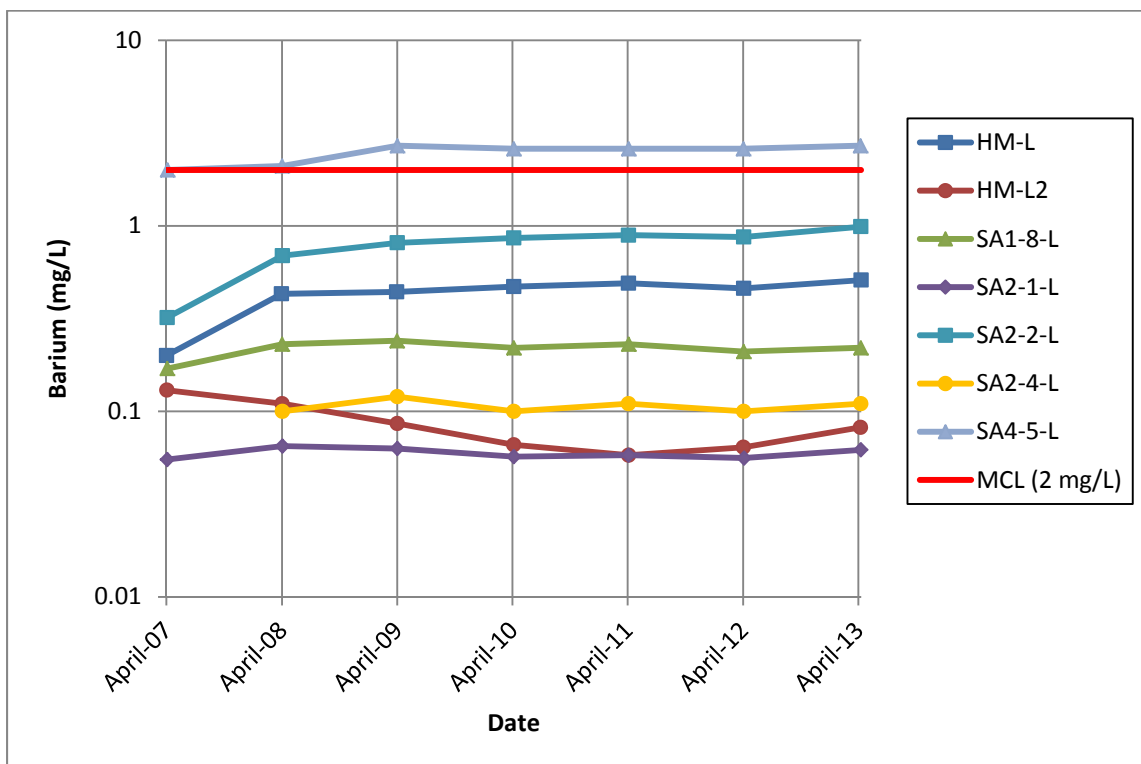


Figure 11. Local Aquifer Barium Concentration 2007–2013

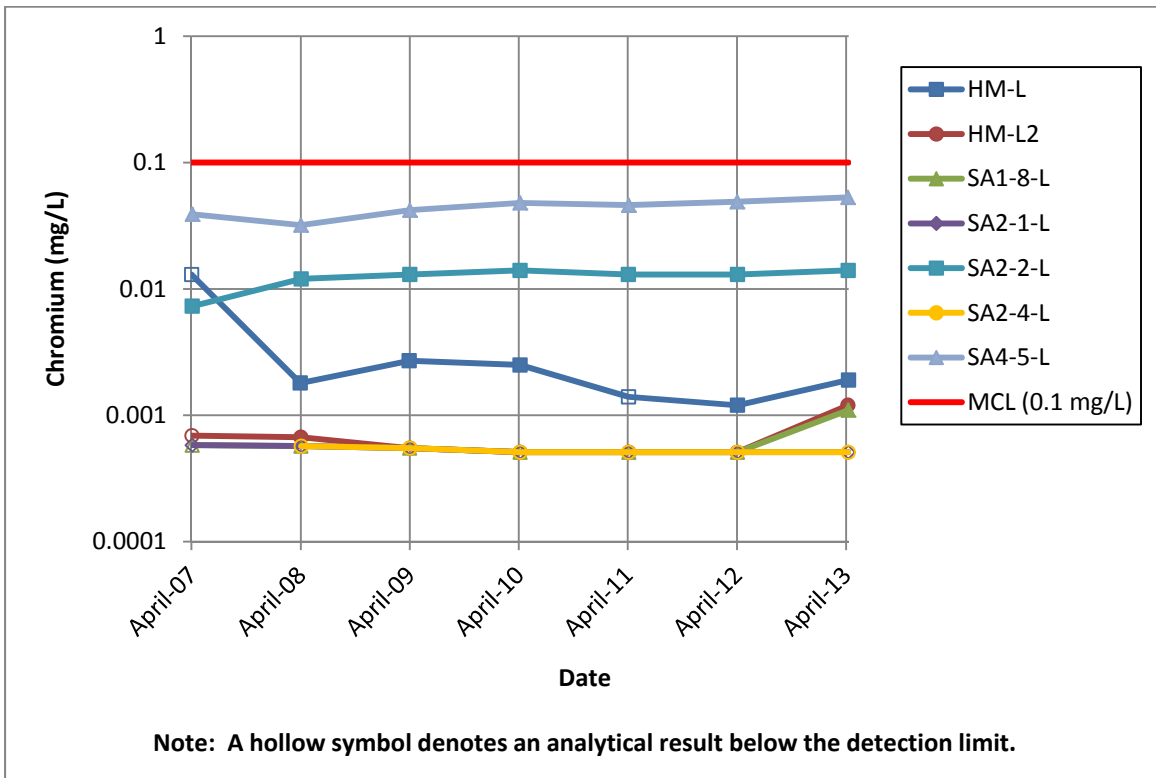


Figure 12. Local Aquifer Chromium Concentration 2007–2013

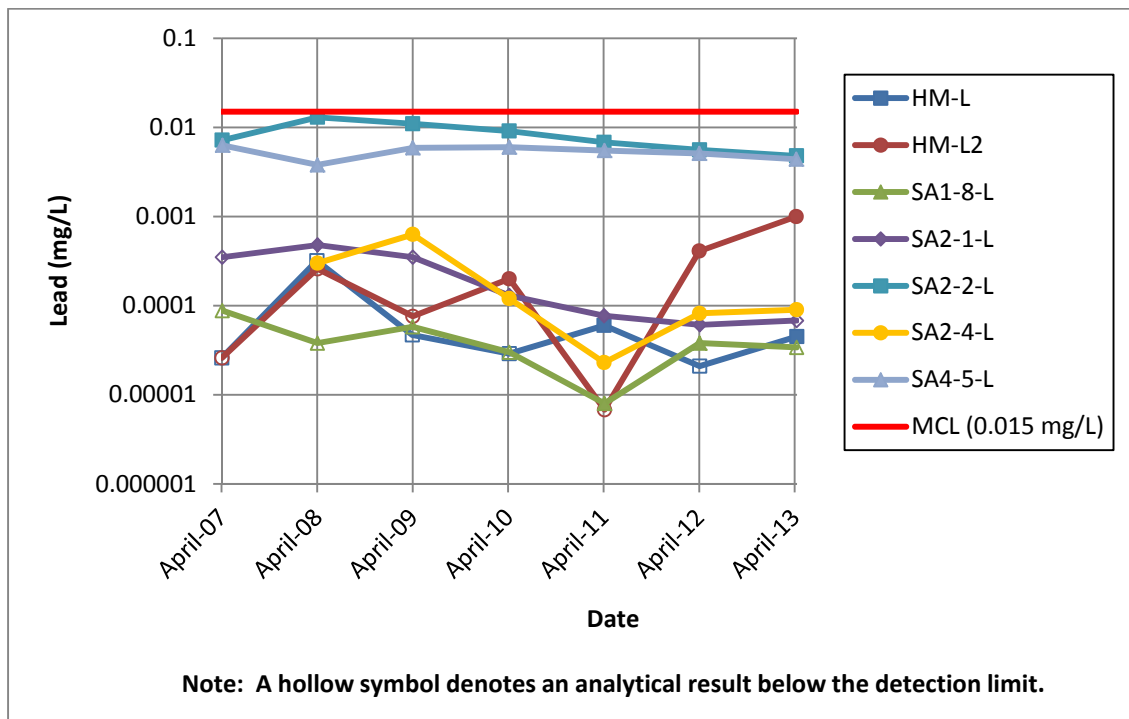


Figure 13. Local Aquifer Lead Concentration 2007–2013

### 4.2.3 Aquifer 3a Results

Metals concentrations were below the MCL for all Aquifer 3a wells except chromium in well HM-3 (Figure 16), which has consistently been slightly above the MCL of 0.1 mg/L (0.11–0.12 mg/L) since 2007. Two additional Aquifer 3a wells (SA1-11-3 and SA3-11-3) were sampled in 2013. All four metals were detected in these wells; however, the concentrations were all lower than the concentrations in HM-3. Figure 14 through Figure 17 show the results of the four metals in Aquifer 3a for 2007–2013.

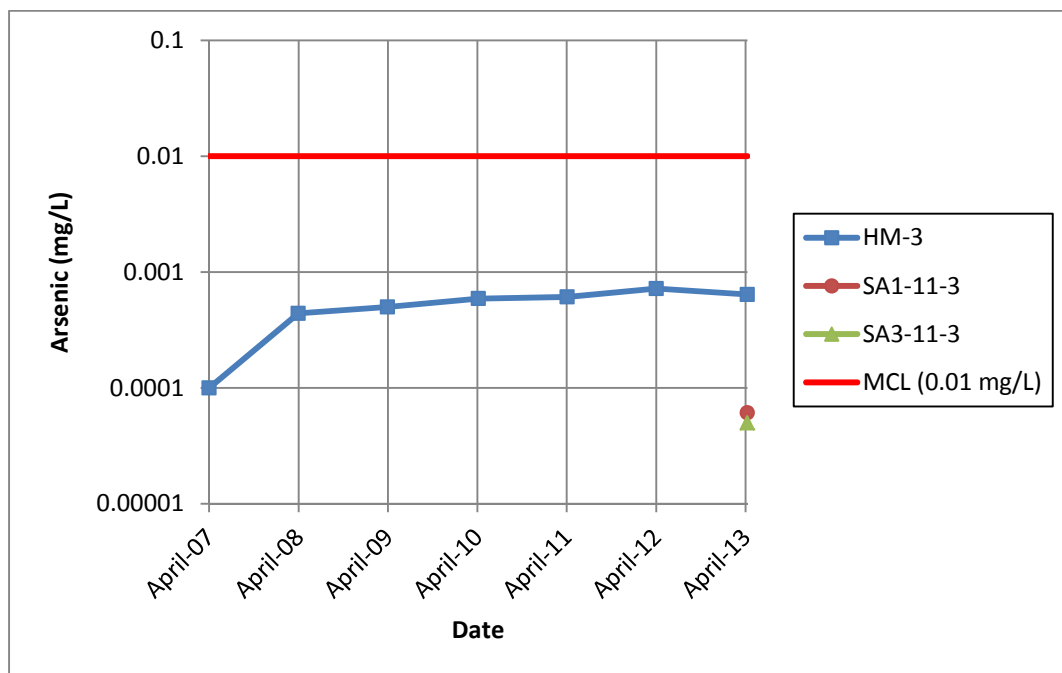


Figure 14. Aquifer 3a Arsenic Concentration 2007–2013

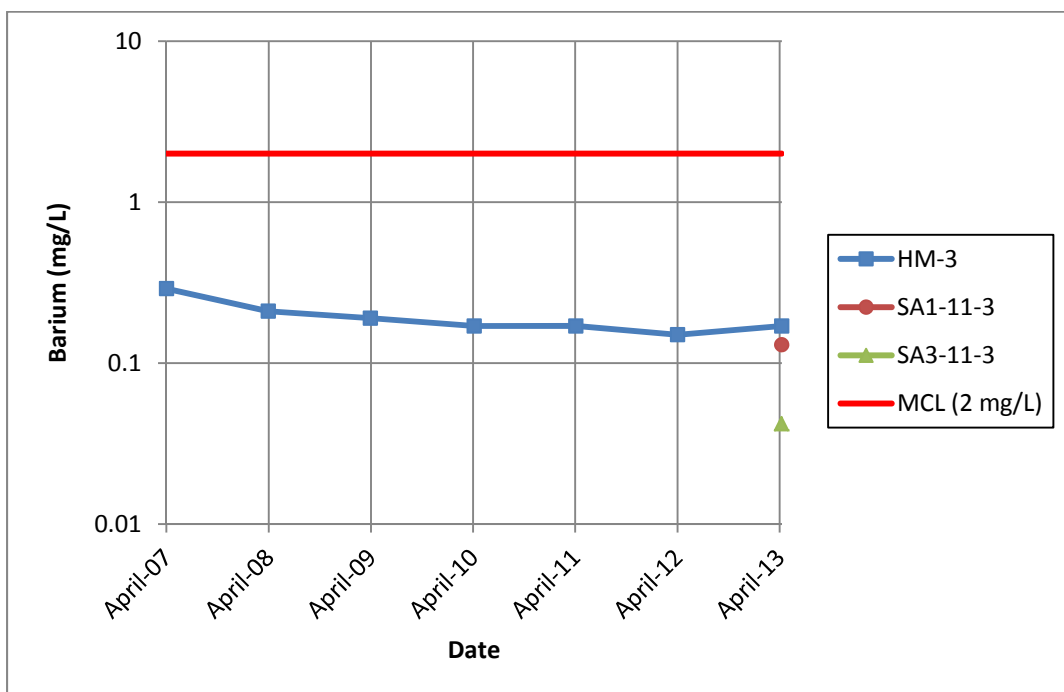


Figure 15. Aquifer 3a Barium Concentration 2007–2013

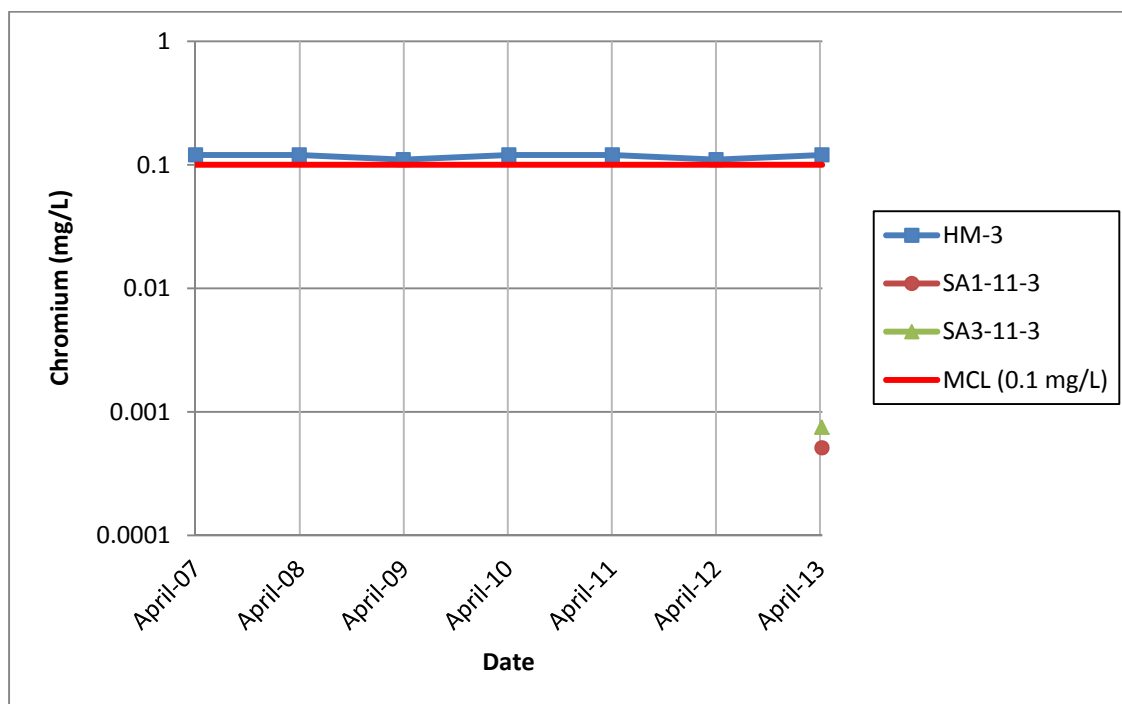


Figure 16. Aquifer 3a Chromium Concentration 2007–2013

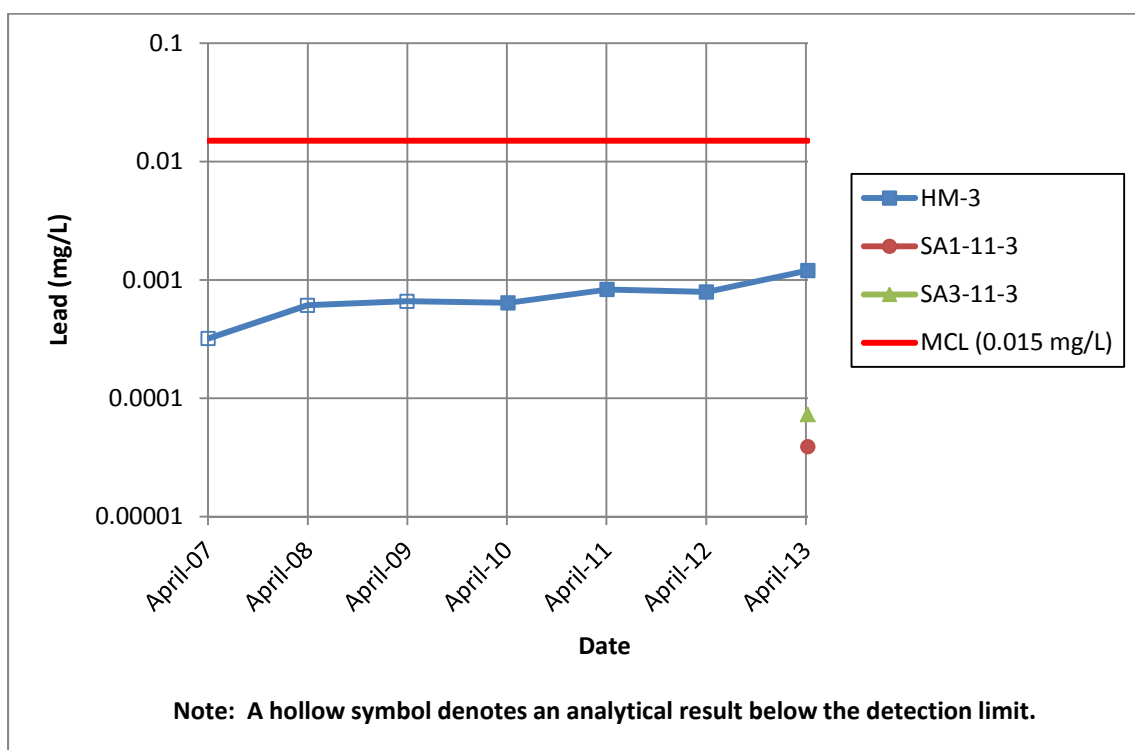


Figure 17. Aquifer 3a Lead Concentration 2007–2013

#### 4.2.4 Surface Water Metals Results

Metals concentrations were below MCLs for all surface water locations. Onsite locations had higher concentrations than offsite locations; however, concentrations in the streams entering the site were equivalent to concentrations in the creek exiting the site. This shows that the metals concentrations onsite are not affecting the quality of the water leaving the site. Two new surface water locations were sampled in 2013, replacing two former locations, and one location that was redundant was discontinued. Location GC-E (Grantham Creek East) replaced Grantham Creek Entry; HMC-S (Half Moon Creek South) replaced Half Moon Creek Entry; and Hick Hollow Creek Entry was not sampled, as it was redundant with HickHCr TSD-East (Figure 2). Figure 18 through Figure 25 show the results of the four metals in the surface water for 2007–2013.

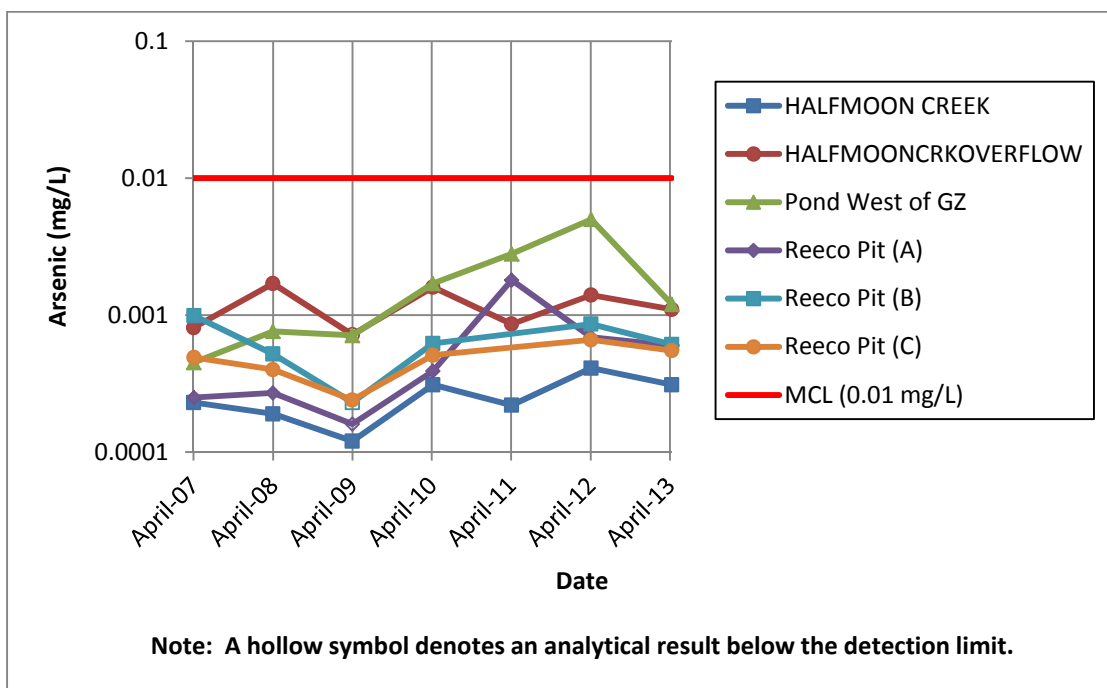


Figure 18. Onsite Surface Water Arsenic Concentration 2007–2013

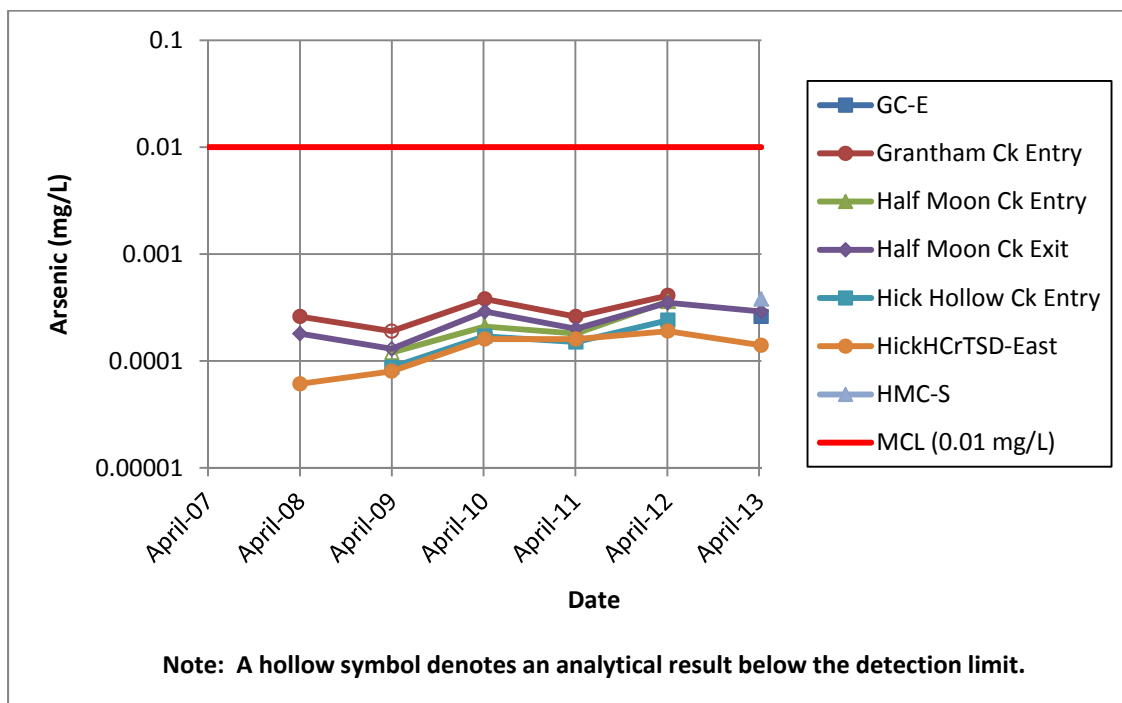


Figure 19. Streams Entering and Exiting the Site Arsenic Concentration 2007–2013

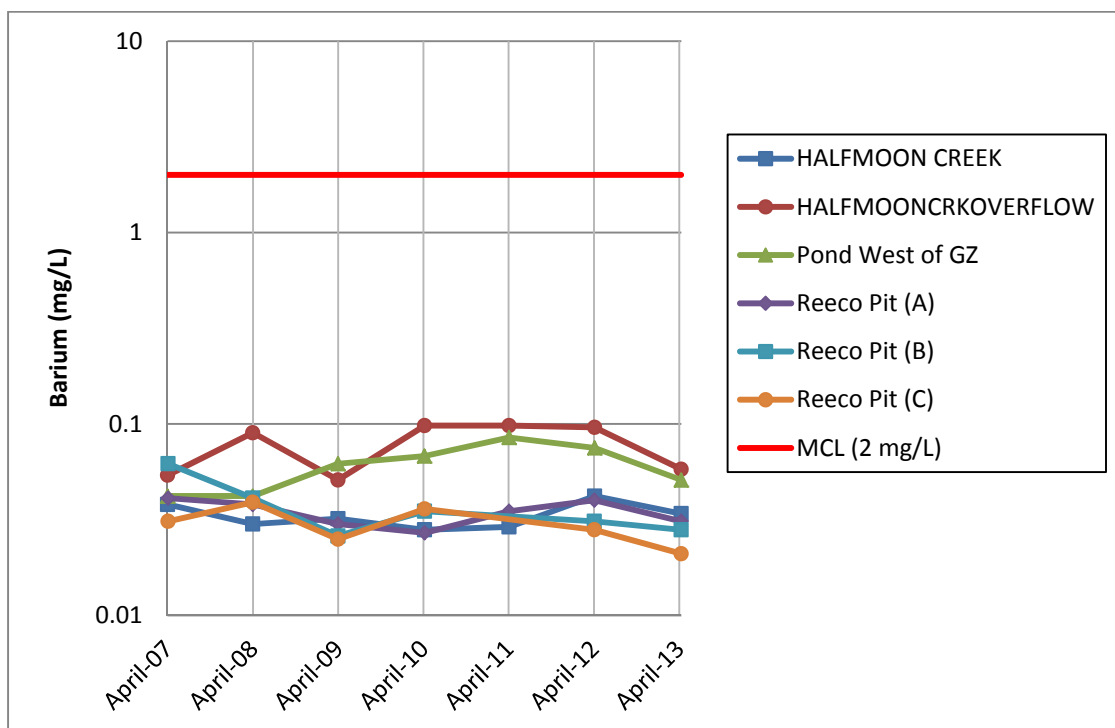


Figure 20. Onsite Surface Water Barium Concentration 2007–2013

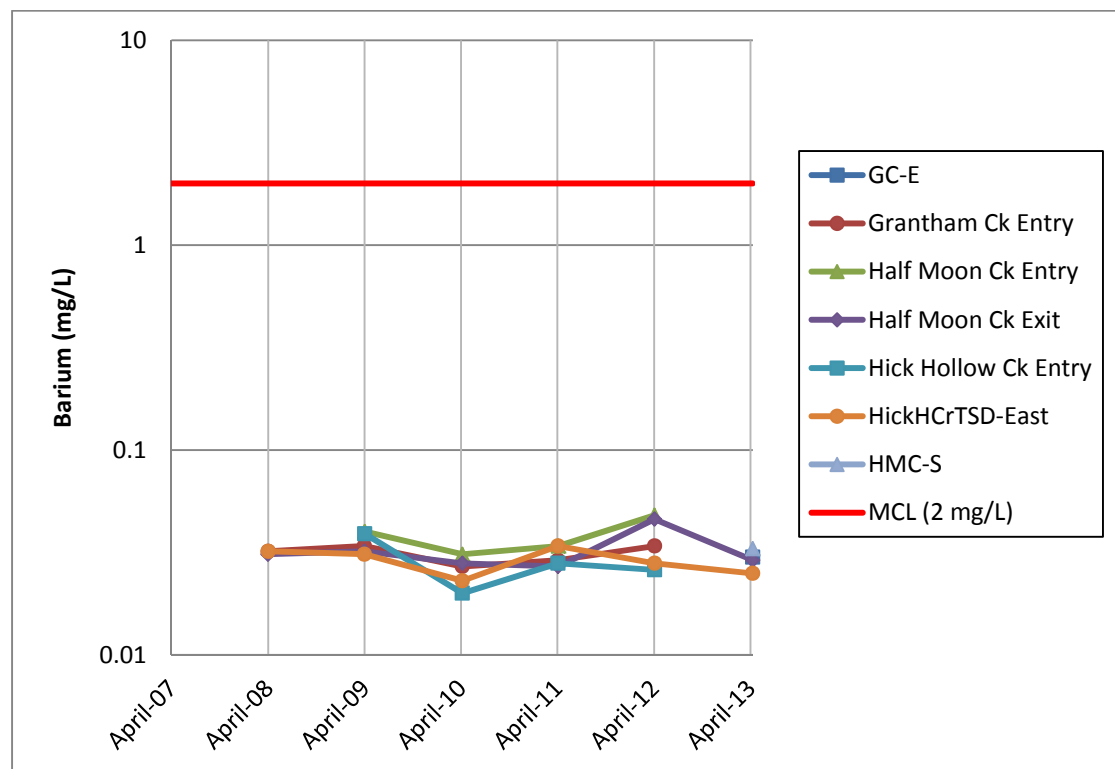


Figure 21. Streams Entering and Exiting the Site Barium Concentration 2007–2013

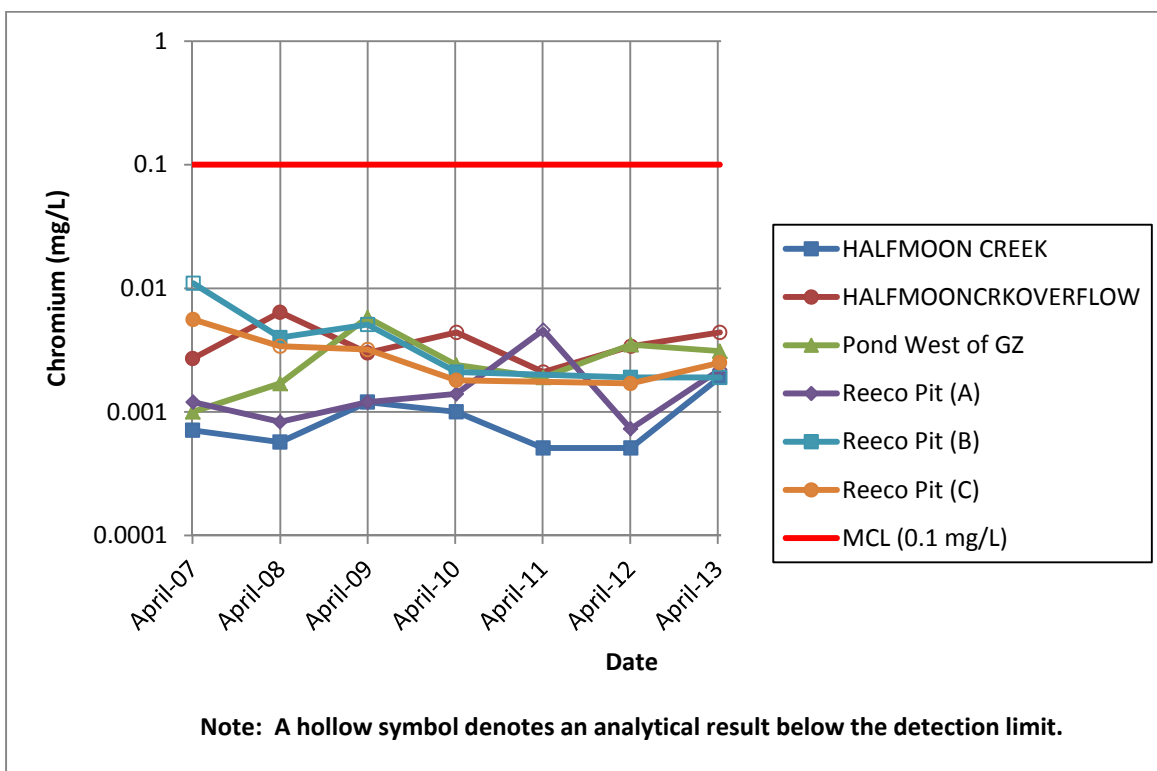


Figure 22. Onsite Surface Water Barium Concentration 2007–2013

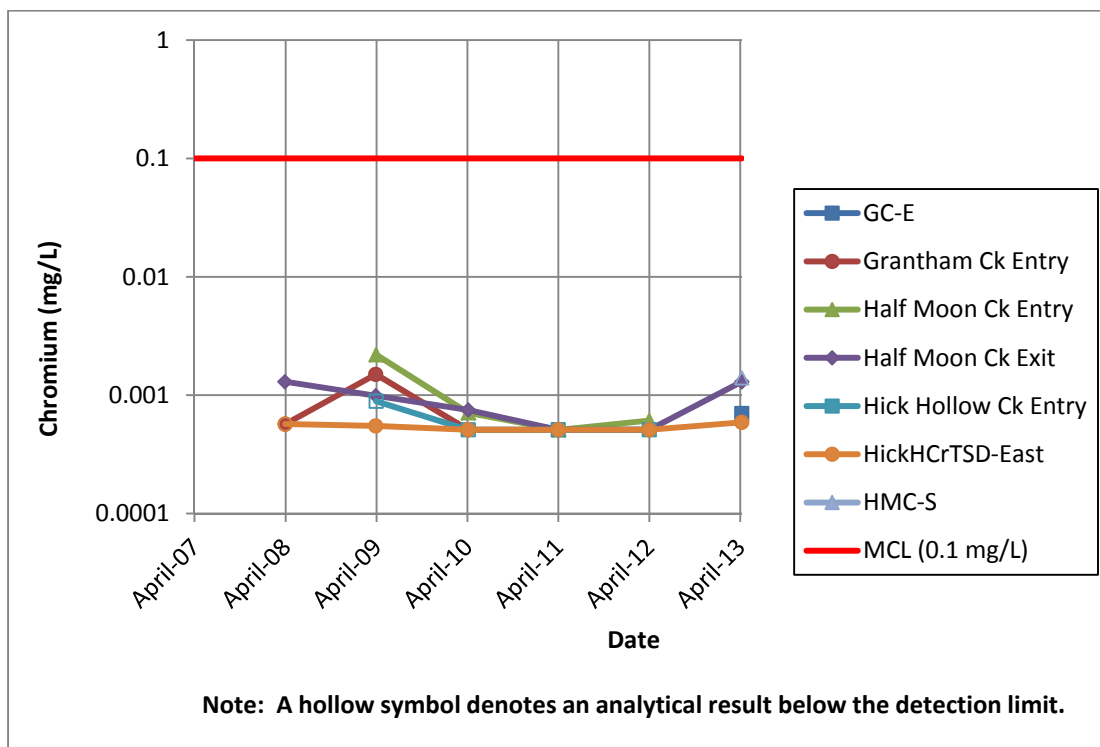


Figure 23. Streams Entering and Exiting the Site Chromium Concentration 2007–2013



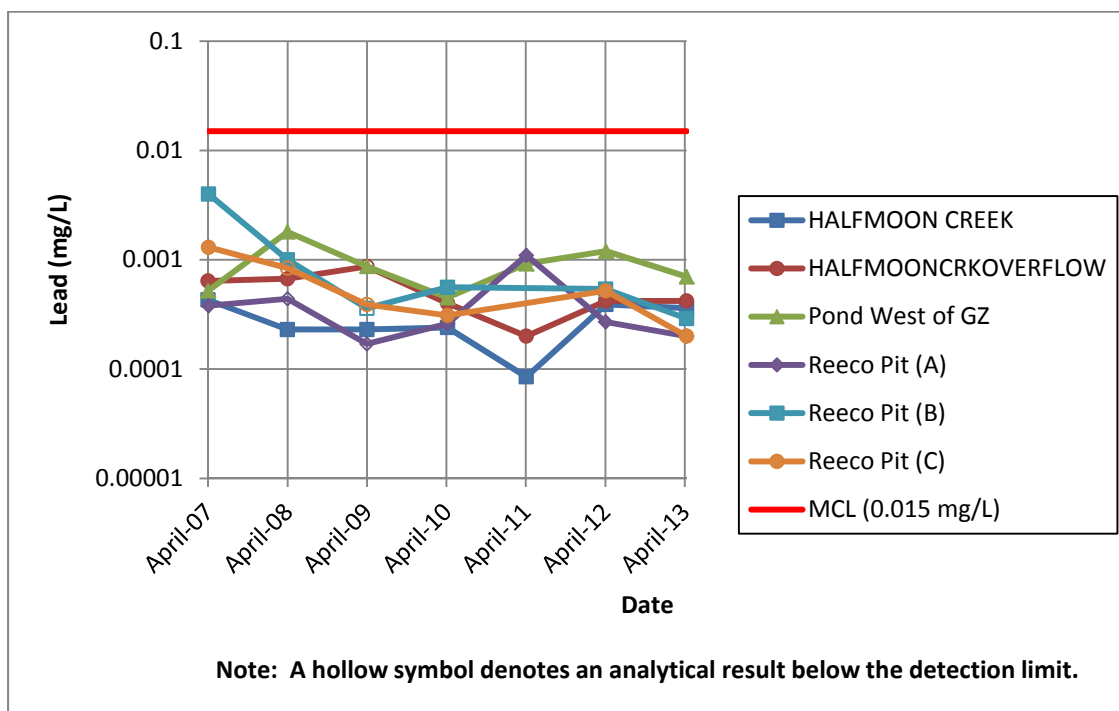


Figure 24. Onsite Surface Water Lead Concentration 2007–2013

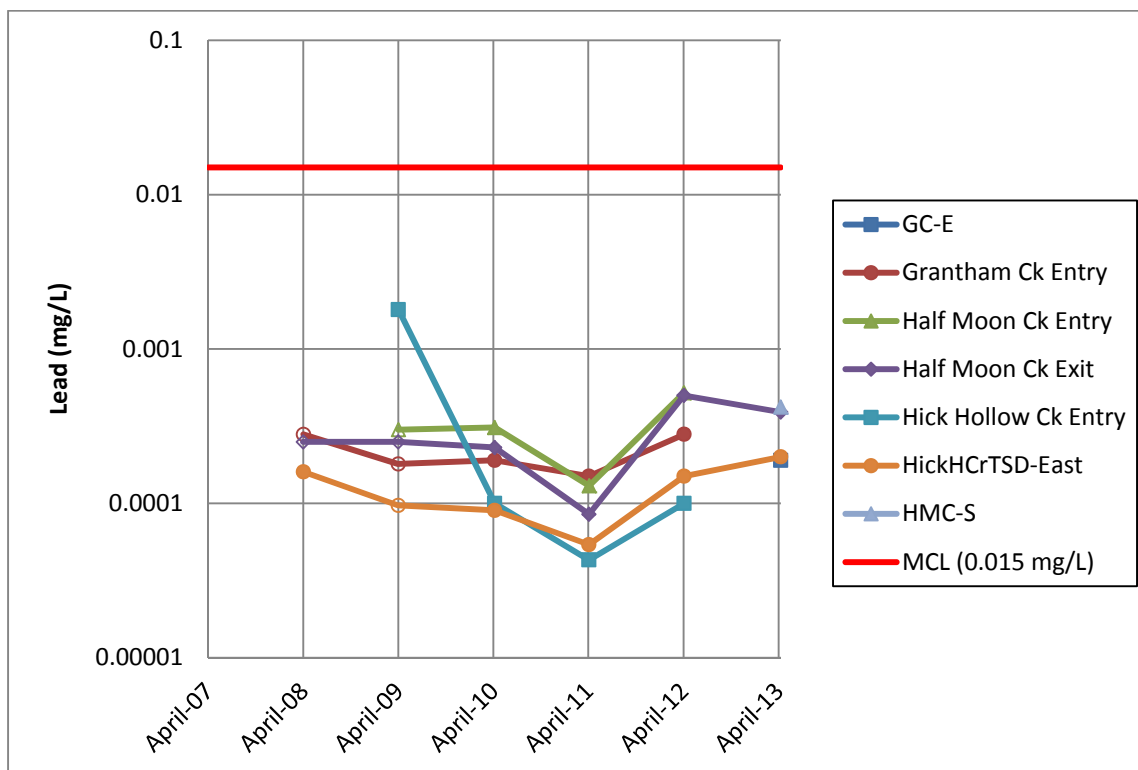


Figure 25. Streams Entering and Exiting the Site Lead Concentration 2007–2013

### 4.3 Metals Analysis

Metals concentrations at the site have remained stable, with only a few locations having concentrations that exceed an MCL. At those locations, concentrations have been only slightly above the MCL and have shown stable trends. Surface water passing through the site is not adversely affected. Of the aquifers with MCL exceedances, only Aquifer 3a is possibly continuous and used offsite. The only well screened in Aquifer 3a with concentrations above an MCL is HM-3 at SGZ, where the chromium concentration has been just slightly above the MCL and stable since 2007. The chromium concentrations in the other Aquifer 3a wells are much lower, indicating that the elevated chromium in Aquifer 3a is isolated to the SGZ area and is not likely to migrate offsite. Observed concentrations of metals are consistent with natural concentrations in the site soil, the data trends are stable, and onsite concentrations are not affecting surface water quality and are not likely to migrate offsite through the aquifers. Therefore, it is recommended that the frequency of metals monitoring be decreased and eventually discontinued. The October 2014 event will include samples for metals analysis to assess whether concentrations vary with seasons; thereafter, the number of locations will be reduced to only those with MCL exceedances.

### 4.4 VOC Monitoring

VOC monitoring has historically been conducted only in the Alluvial Aquifer wells. VOC monitoring was added to the Local Aquifer wells because the network analysis indicated a possible downward flow path from the Alluvial Aquifer to the Local Aquifer, primarily at SGZ, where five wells penetrate the confining unit separating the Alluvial and Local Aquifers. Several surface locations were also added because the network analysis identified, on the basis of data from a 1993 remedial investigation, additional areas on the site that might have VOC contamination, specifically the REEC pits area. Samples are collected for a large suite of VOCs analysis; however, only TCE and its degradation products *cis*- and *trans*-1,2-DCE and vinyl chloride have been detected. TCE was likely used on the site for degreasing and washing equipment and could have been spilled on the site or disposed of in the onsite disposal and mud pits.

### 4.5 VOC Results

Of the wells sampled for VOCs, only one had a constituent that exceeded an MCL. TCE in well HMH-5R had a concentration of 78 micrograms per liter ( $\mu\text{g/L}$ ), which exceeds the TCE MCL of  $5\mu\text{g/L}$  (Figure 26). VOCs in all the Local Aquifer wells were below detection limits except in well HM-L at SGZ, where TCE ( $1.3\mu\text{g/L}$ ), *cis*-1,2-DCE ( $7.7\mu\text{g/L}$ ), and *trans*-1,2-DCE ( $0.51\mu\text{g/L}$ ) were detected. These concentrations are well below the respective MCLs, but the detection of these analytes in HM-L is evidence of a transport path from the Alluvial Aquifer to the Local Aquifer, probably along the wellbores at SGZ. The results from surface locations where samples were analyzed for VOCs in 2013 were all nondetects. Figure 26 through Figure 29 show the VOC results for 2007–2013 at wells that have had VOC concentrations above the detection limit.

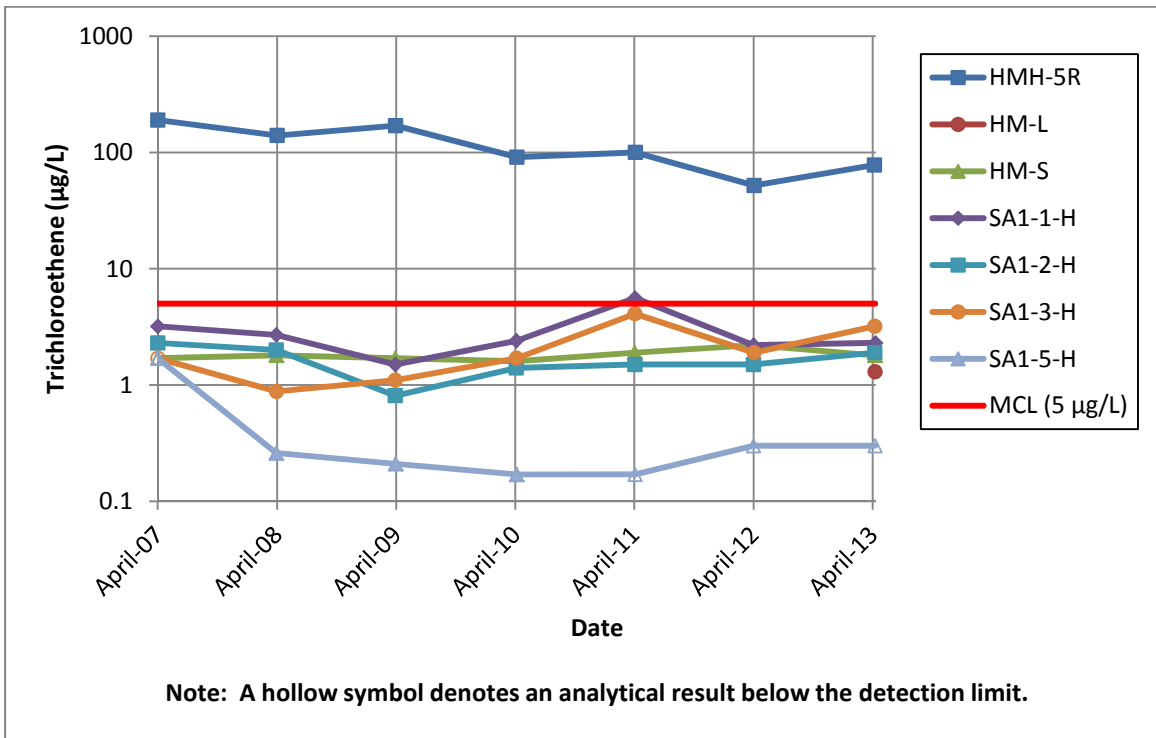


Figure 26. Wells with TCE Concentrations 2007–2013

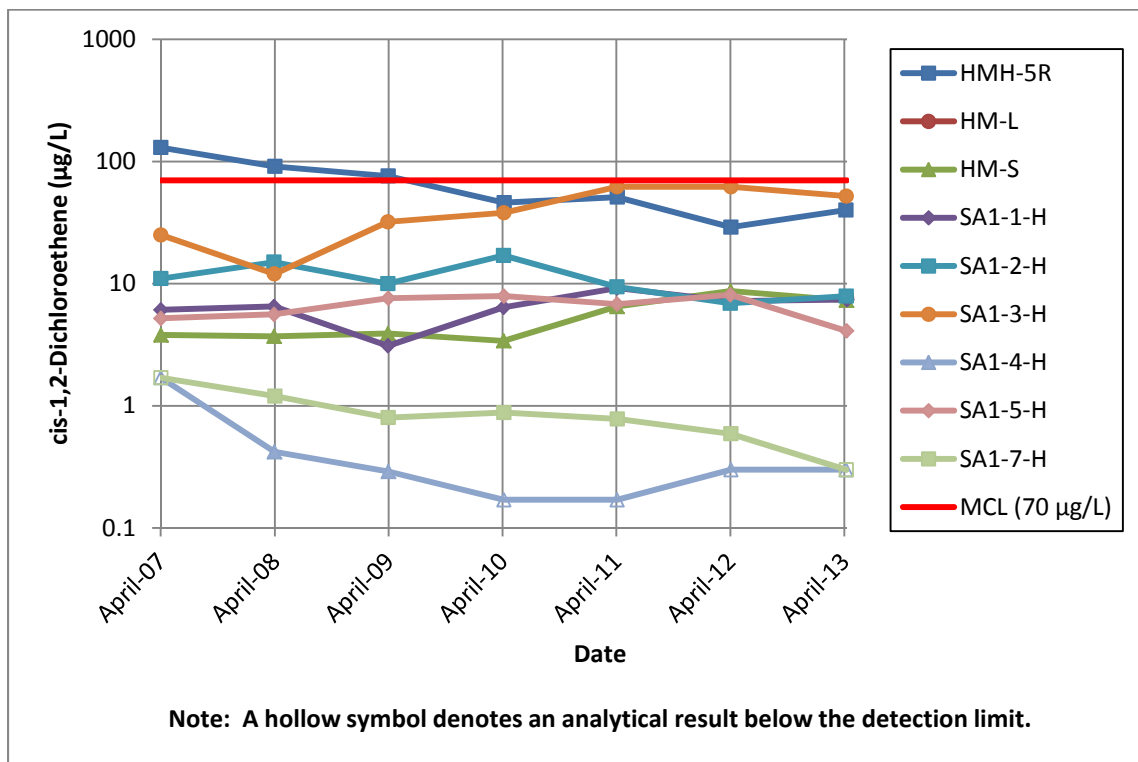


Figure 27. Wells with cis-1,2 Dichloroethene Concentrations 2007–2013

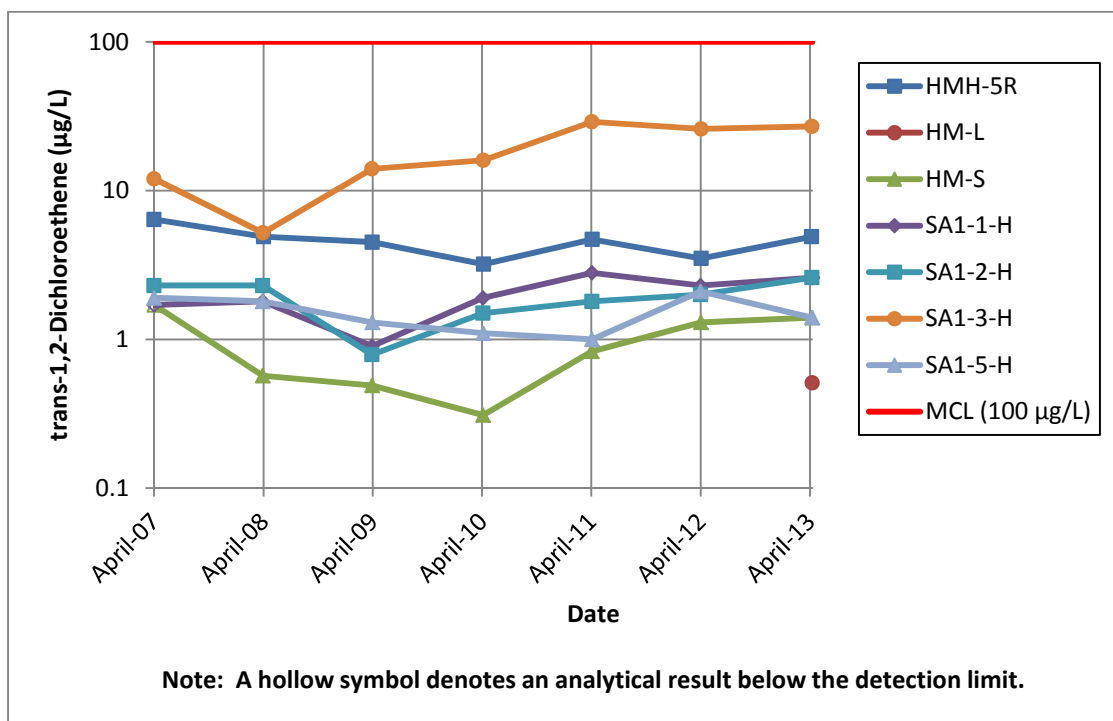


Figure 28. Wells with trans-1,2 Dichloroethene Concentrations 2007–2013

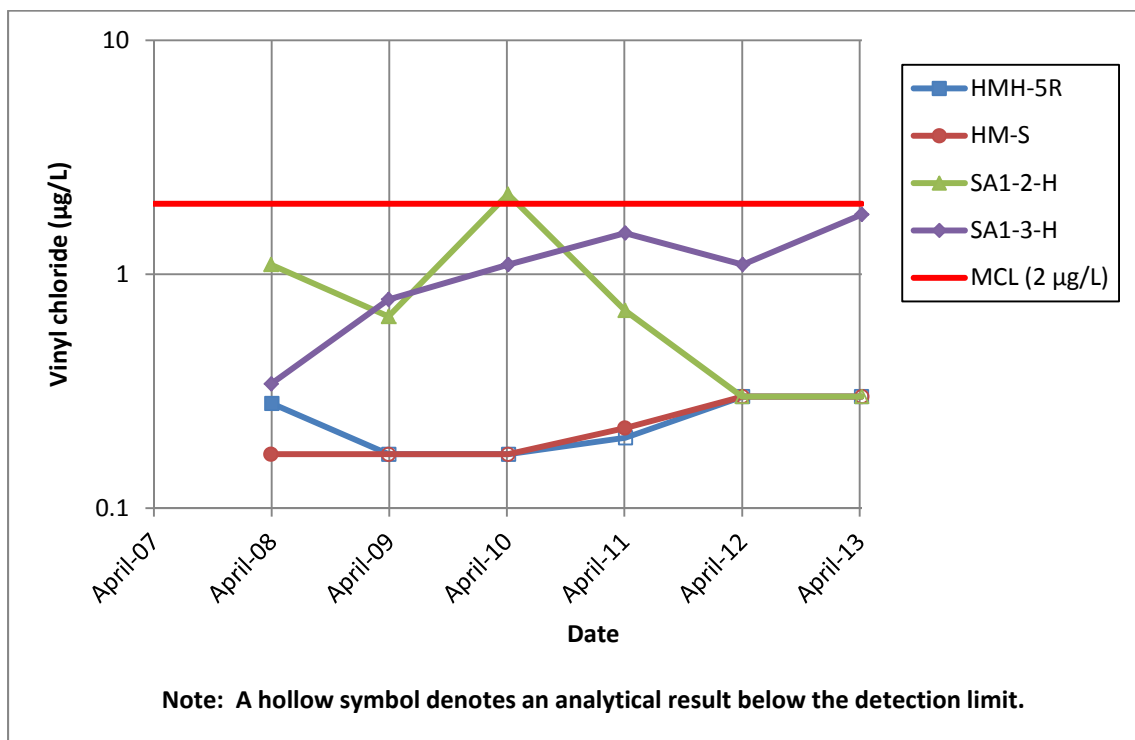


Figure 29. Wells with Vinyl Chloride Concentrations 2007–2013

## 4.6 VOC Analysis

If conditions are favorable, TCE will degrade by reductive dehalogenation to the cis and trans isomers of 1,2-DCE, which will degrade to vinyl chloride, then to ethene, and finally to carbon dioxide and water. Reducing conditions and an electron donor are required for this degradation pathway to proceed, as well as bacterial species such as *Dehalococcoides mccartyi*. Degradation can also proceed by oxidative transformations, which are more favorable for the compounds with a reduced carbon oxidation state such as vinyl chloride. The DCE isomers fall in the midrange of being equally reactive in either oxidizing or reducing conditions. Measurements of oxidation-reduction potential (ORP) and dissolved oxygen (DO) suggest a range of oxidation states. Table 2 shows the average ORP and DO measurements obtained during well purging in 2013.

Table 2. Average ORP and DO in Wells with Detectable VOC Concentrations

Location	Average ORP (mV)	Average DO (mg/L)	Number of Measurement
HM-L	-99.7	0.5	3
HM-S	-5.7	0.4	9
HMH-5R	33.3	3.3	11
SA1-1-H	59.9	3.0	3
SA1-2-H	-14.3	0.34	5
SA1-3-H	-40.6	0.2	4
SA1-4-H	-2.8	1.7	6
SA1-5-H	-15.6	1.4	6
SA1-7-H	-2.7	0.4	8

mV = millivolts

TCE concentrations in well HMH-5R are the only MCL exceedance. The groundwater in this well has higher ORP and DO values than most other groundwaters. TCE degradation can proceed; however, degradation of TCE to DCE will be less favorable than in reducing conditions. Degradation of DCE and vinyl chloride should be more favorable in this well. Time-concentration trends (Figure 26 through Figure 29) show that the concentrations of TCE and its degradation products are trending downward, likely as a result of degradation. Mann-Kendall trend analysis of the TCE data and an exponential regression curve fit show that TCE levels in HMH-5R should be below the MCL in 10–15 years (Figure 30). A linear regression curve fit of the TCE data indicates that TCE levels in HMH-5R could be below the MCL by 2016 (Figure 31). It is recommended that VOC sampling continue in the Alluvial Aquifer wells and Local Aquifer well HM-L until concentrations drop below MCLs. All surface locations added to the VOC analysis in 2013 were nondetects and will no longer be monitored.

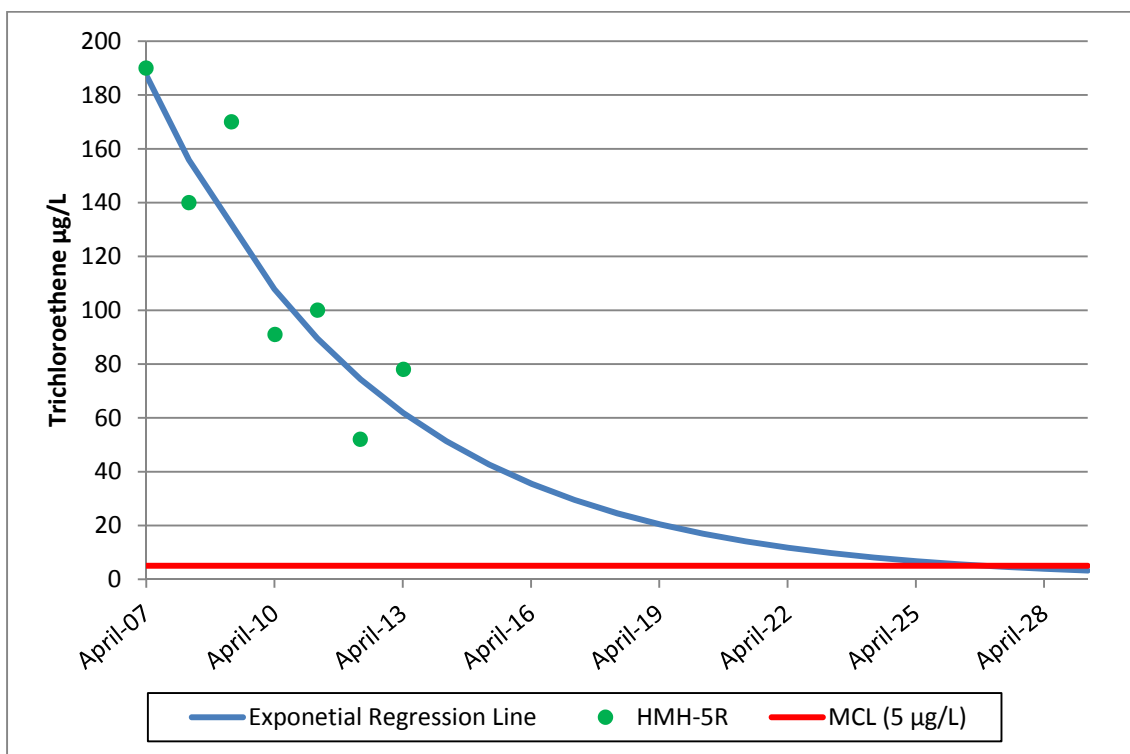


Figure 30. Exponential Curve Fit of TCE in HMH-5R

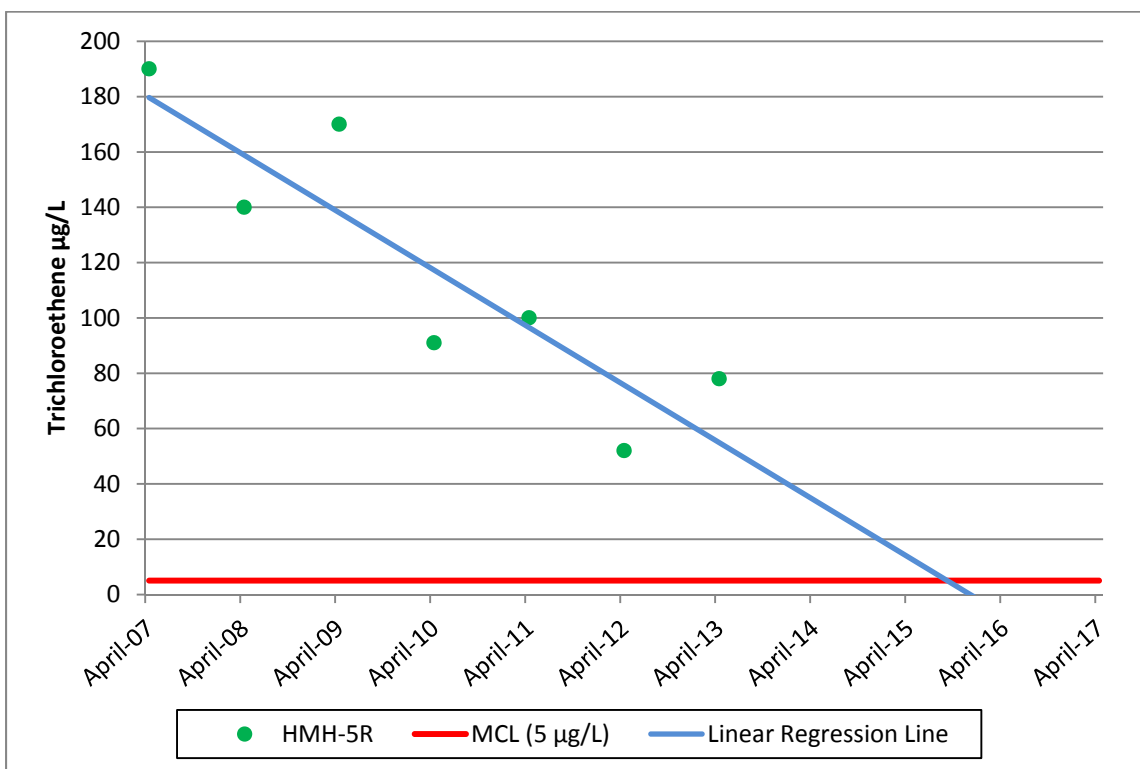


Figure 31. Linear Regression Curve Fit of TCE in HMH-5R

## 4.7 Radiological Monitoring

The only radionuclide that historically has been detected in site waters is tritium, which was brought to the surface during post-shot drilling activities. Tritium monitoring is conducted at all sampled locations. Nineteen other radionuclides, both naturally occurring and fission-related, are analyzed by gamma spectroscopy. Gamma spectroscopy analysis was reduced in 2013 to only the locations that that overlie a potential radionuclide contaminant source (indicator wells). The wells that are monitored by gamma spectroscopy are the six SGZ wells (HM-S, HM-L, HM-1, HM-2A, HM-2B, and HM-3), Caprock Aquifer well E-7 (although it is not directly over the cavity, it is the only well in the Caprock Aquifer), and the Aquifer 4 wells. Chlorine-36 was also analyzed in samples from the indicator wells in 2013 to determine if it could be useful as an early indicator of radionuclide migration after tritium produced by the detonation has decayed. Tritium is a good conservative tracer for monitoring; however, with a half-life of 12.3 years, tritium remaining in the cavity and in Aquifer 5 will be less than 1 curie in 100 years. At that level, tritium would no longer be a good indicator of contaminant migration because with dilution, detection in site waters would be unlikely. Chlorine-36 is a fission product, and since the detonations were conducted in a salt dome, it is possible that chlorine-36 is abundant in the cavity. Chlorine-36 has a half-life of 301,000 years, making it a good analyte for long-term monitoring of contaminant migration from the cavity and Aquifer 5 injection site.

## 4.8 Radiological Results and Analysis

### 4.8.1 Tritium Results

Tritium analysis was conducted at all locations in April 2013, with 25 percent of the locations analyzed by the enriched method. The enriched method has a lower detection limit (3–4 picocuries per liter [pCi/L]) than the standard method (300–400 pCi/L). Tritium was only detected in six wells; five Alluvial Aquifer wells: SA3-4-H (enriched method), SA1-1-H, SA1-2-H, SA1-3-H, HMH-5R, and one Local Aquifer well, HM-L. None of the locations had tritium concentrations that exceeded the MCL of 20,000 pCi/L. Table 3 shows the results of tritium analyses in 2013, and Figure 32 shows the time-concentration trends in the wells with tritium levels detectable by the standard method.

*Table 3. Tritium Concentrations Observed in 2013*

Location	Method	Tritium (pCi/L)
SA3-4-H	Enriched Tritium	6.15
SA1-3-H	Tritium	280
SA1-2-H	Tritium	605
HM-L	Tritium	828
HMH-5R	Tritium	946
SA1-1-H	Tritium	2,790

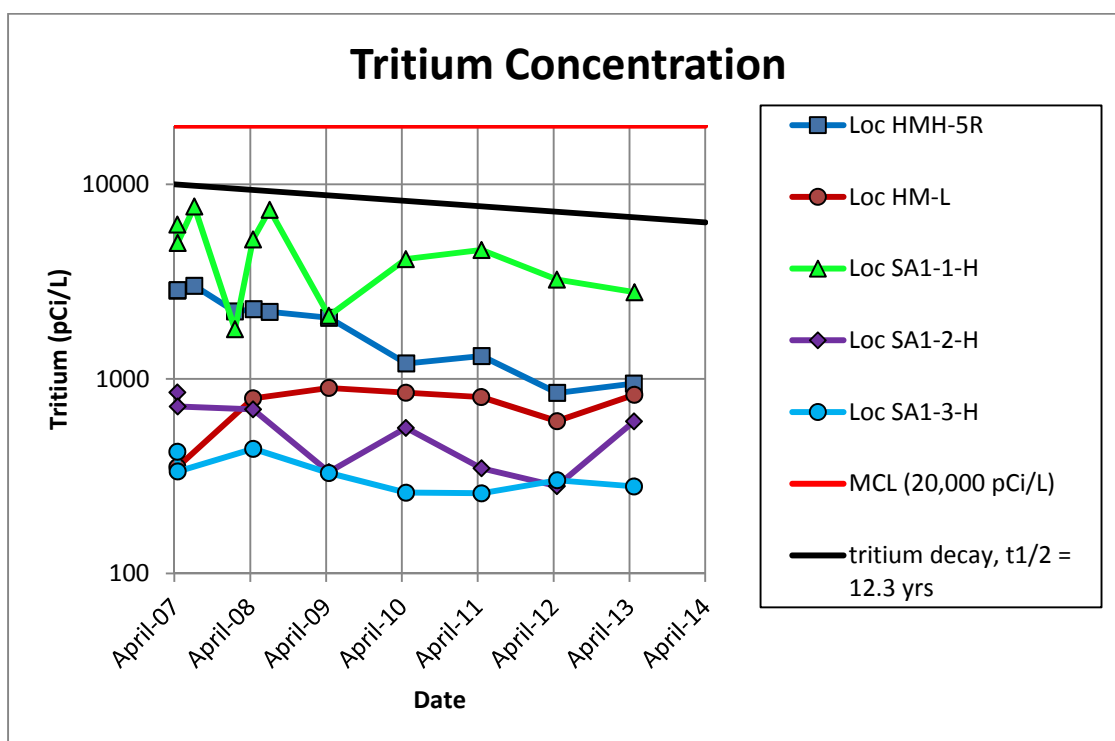


Figure 32. Time-Concentration Trends for Tritium

#### 4.8.2 Tritium Analysis

Tritium is monitored at the site to (1) confirm that tritium levels in materials brought to the surface during drill-back operations do not pose a risk and are declining as expected and (2) to monitor for the possibility of contaminant migration from the cavity and from the injection well site. Tritium concentrations in all site wells are below the MCL of 20,000 pCi/L and show decreasing trends similar to the tritium decay rate (Figure 32). The one exception is well HM-L, which is located at SGZ and is screened in the Local Aquifer. It has neither an increasing nor decreasing trend. Tritium concentrations in this well first appeared in response to a pumping test in the summer of 1979. This test pulled contamination from the overlying Alluvial Aquifer into the Local Aquifer. HM-L was the pumping well, and it is believed that contamination migrated along the emplacement hole casing and that no significant tritium was in the Local Aquifer prior to the summer of 1979 (DOE 1980). Tritium levels as high as 6817 pCi/L were measured from HM-L discharge water on July 31, 1979. The tritium level was 828 pCi/L in the most recent sample taken from HM-L in April 2013.

The highest current tritium value in any well at the site, 2790 pCi/L in Alluvial Aquifer well SA1-1-H, is almost an order of magnitude below the MCL. Near-surface tritium contamination onsite does not pose a human health risk. Tritium is also monitored as an indicator of contaminant migration from the cavity and from the waste injection well. It is recommended that tritium be analyzed by the enriched method on the indicator well samples as well as the surface waters entering and leaving the site. The much lower detection limit of the enriched method would enable earlier detection of tritium migration from the cavity or the waste injection area and would also provide more effective monitoring for any offsite influences. All locations will be analyzed for tritium in October 2014 to see if tritium concentrations vary seasonally.



After that, it is recommended that tritium analysis be reduced to the Alluvial Aquifer wells, the indicator wells, and the streams entering and leaving the site.

#### 4.8.3 Gamma Spectroscopy Results and Analysis

Samples from the indicator wells and well SA2-4-L were analyzed by gamma spectroscopy for selected radionuclides. None of the radionuclides were detected. Well SA2-4-L was sampled because the 2012 results for that well detected cesium-137 at slightly above the minimum detectable concentration. Another sample was taken in 2013 to determine if the previous result was anomalous. No cesium-137 was detected in the 2013 sample, and this well will no longer be monitored by gamma spectroscopy. In the future, only samples from the indicator wells will be analyzed by gamma spectroscopy and only during every other sampling event (April events), as described in the network analysis (DOE 2013a).

#### 4.8.4 Chlorine-36 Results

Samples from the indicator wells were analyzed for chlorine-36 for the first time in 2013. As expected, this isotope was detected in all samples. Chlorine-36 occurs naturally in groundwater as a result of cosmic radiation interacting with atmospheric gases, and anthropogenic, non-site-related chlorine-36 remains from historical atmospheric nuclear testing (Davis 1998). Results are reported as the ratio of chlorine-36 to chlorine-35 times  $10^{-15}$  ( $^{36}\text{Cl}/^{35}\text{Cl} \times 10^{-15}$ ). Table 4 shows the results.

Table 4. Chlorine-36 Ratios Observed in 2013

Location	Chlorine-36 Ratio ( $^{36}\text{Cl}/^{35}\text{Cl} \times 10^{-15}$ )	Location	Chlorine-36 Ratio ( $^{36}\text{Cl}/^{35}\text{Cl} \times 10^{-15}$ )
HM-S	56.6	HM-3	17.3
HM-L	159.7	E-7	19.8
HM-1	28.5	SA5-4-4	12.9
HM-2A	23.9	SA5-5-4	97.0
HM-2B	23.3		

#### 4.8.5 Chlorine-36 Analysis

Chlorine-36 could be a good indicator of contaminant migration from the cavity and the Aquifer 5 injection site because of its long half-life (301,000 years) and its mobility in groundwater. To identify anomalous values, it will be important to first determine the range of background values that can be expected for groundwater at the site. After several sampling events, variations from established trends could indicate contaminant migration from the cavity or injection well if chlorine-36 concentrations begin to rise. Literature values for natural background ratios ( $^{36}\text{Cl}/^{35}\text{Cl} \times 10^{-15}$ ) of chlorine-36 in the groundwater measured in samples from two wells in Hattiesburg are 160 and 50 (Davis 1998). The site results are less than these values. The site values may be from background, but some of the higher values in HM-S and HM-L may be from contamination from drill-back activities. Since tritium was brought to the surface during those activities, it is possible that  $^{36}\text{Cl}$  was brought to the surface as well. It is uncertain whether the difference in levels in Aquifer 4 wells SA5-5-4 (97) and SA5-4-4 (13)

represents background conditions or results from site contamination. The groundwater is briny, and high natural variation in an aquifer that is derived from dissolution of salt with variable amounts of the  $^{36}\text{Cl}$  isotope could explain the difference in the results. Tritium has not been detected in this well even by the enriched method, so it is more likely that the observed chlorine-36 levels are within the range of site background. Samples for chlorine-36 analysis should be collected again during the October 2014 sampling event to better evaluate its origin. Total chloride concentrations should also be determined because they are useful in interpreting chlorine-36 results. It is also recommended that chlorine-36 analysis be added to samples from the creeks entering and exiting the site to determine background levels in surface water and levels in water leaving the site. The sampling program should also identify nearby offsite wells to sample as background rather than rely on a comparison of onsite results to data from the Hattiesburg wells, which are 21 miles away, and the samples were collected in 1998.

## 4.9 Water Level Monitoring

Water levels are monitored in site wells to estimate horizontal and vertical flow directions within and between aquifers at the site. During each sampling event, water levels are measured manually at each of the 28 monitoring wells at the site before sample collection. Pressure transducers continuously measure water levels in 12 wells identified in the network analysis (Table 5). These include all six SGZ wells to determine the water level variability of each aquifer and to what degree seasonal trends affect each aquifer. The wells at SGZ are screened in successively deeper aquifers from the surficial Alluvial Aquifer to Aquifer 3a (Figure 33). A transducer is also installed in well SA5-4-4, southwest of SGZ, which is screened in the lowest monitored aquifer at the site, Aquifer 4. The water levels in Aquifer 4 well SA5-5-4 will no longer be monitored with a transducer because they closely track those in nearby well SA5-4-4.

*Table 5. Status of Pressure Transducers for Recording Water Levels*

Well	Aquifer	Location	Transducer Model	Transducer Status
HM-S	Alluvial	SGZ	TROLL 300, 100 psi	Added in 2013
HM-L	Local	SGZ	TROLL 300, 100 psi	Replaces TROLL 4000
HM-1	1	SGZ	TROLL 300, 100 psi	Added in 2013
HM-2A	2a	SGZ	TROLL 300, 100 psi	Added in 2013
HM-2B	2b	SGZ	TROLL 300, 100 psi	Moved from SA5-5-4
HM-3	3a	SGZ	TROLL 300, 100 psi	Added in 2013
SA2-2-L	Local	2,500 ft NE of SGZ	TROLL 500, 30 psi, vented direct read cable	No change
SA1-8-L	Local	1,600 ft SE of SGZ	TROLL 300, 100 psi	Replaced TROLL 4000
SA4-5-L	Local	2,000 ft SW of SGZ	TROLL 300, 100 psi	Added in 2013
HM-L2	Local	2,400 ft W of SGZ	TROLL 300, 100 psi	Replaced TROLL 4000
SA5-4-4	4	6,000 ft SW of SGZ	TROLL 300, 100 psi	No change
SA2-4-L	Local	2,700 ft NNE of SGZ	TROLL 300, 30 psi	Replaced TROLL 4000

psi = pounds per square inch

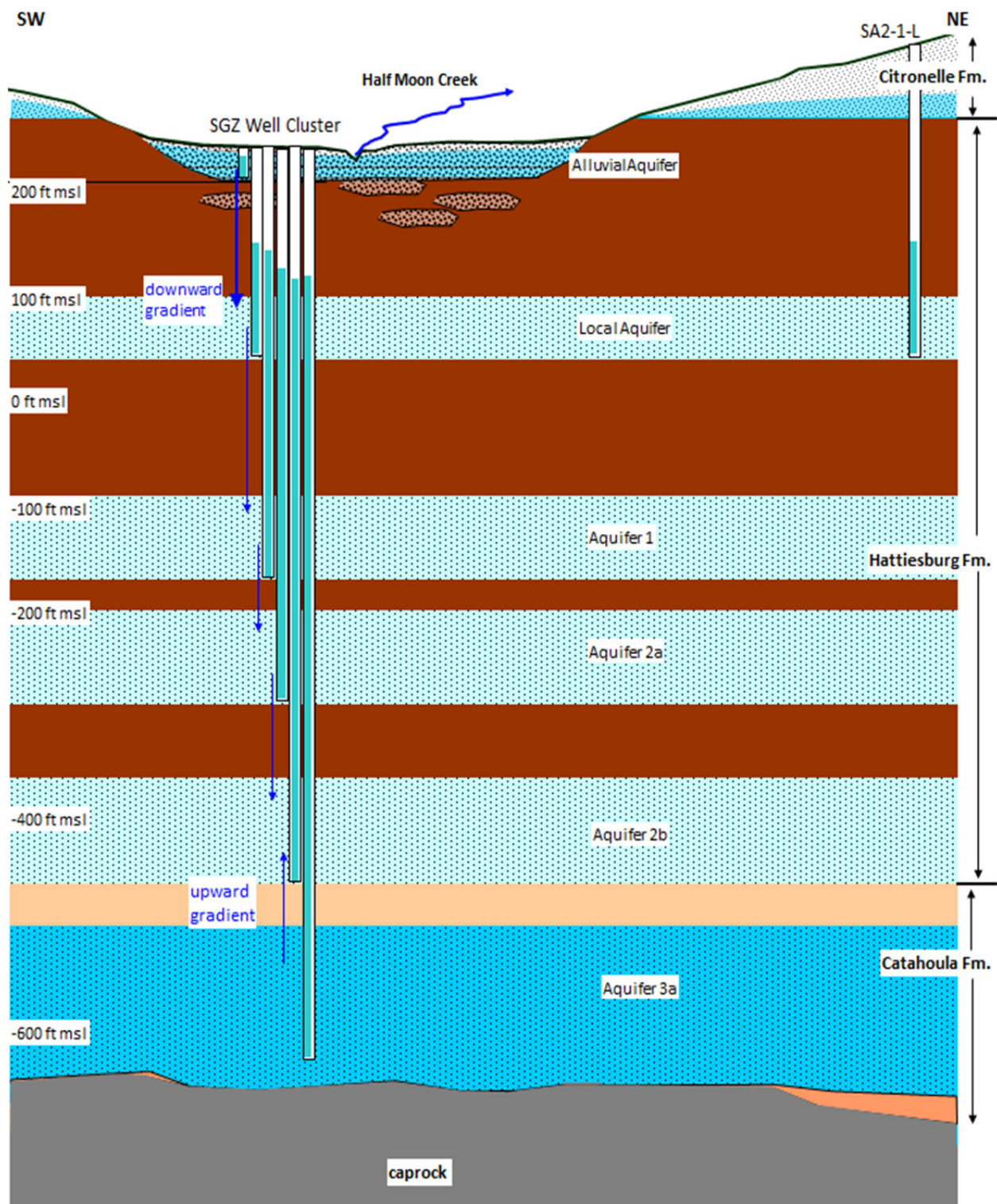


Figure 33. Conceptual Model of the SGZ Well Cluster

The remaining transducers are in Local Aquifer wells to evaluate water level variability and the stability of flow directions in the uppermost offsite aquifer (the Local Aquifer is discontinuous but extends offsite). Transducers were added to some wells, and older TROLL 4000 transducers with failed batteries were replaced with new TROLL 300 transducers during the April 2013 sampling event. Table 5 lists the wells equipped with transducers and lists the status of each transducer. The majority of the transducers in the network read absolute pressure, pressure from the water column above the transducer plus the atmospheric pressure. A BaroTROLL data logger in well HM-2B at SGZ collects atmospheric pressure readings, which are subtracted from the absolute pressure readings. A rain gage was placed at well HMH-5R in April 2013 to assess effects of precipitation on groundwater levels.

## 4.10 Water Level Results

Table 6 lists the most recent water level data (April 2013) from site wells, along with the screened interval elevations and the screened aquifer. Figure 34 through Figure 39 present hydrographs of the hydraulic head data. The hydrographs are provided for selected Alluvial Aquifer wells, Local Aquifer wells, Aquifer 3a wells, and Aquifer 4 wells. A combined hydrograph of the six SGZ wells, screened in successively deeper aquifers, shows the direction of the vertical gradient between aquifers at SGZ.

### 4.10.1 Alluvial Aquifer

Twelve wells at the site are screened in the unconfined Alluvial Aquifer. The hydraulic head at each of these wells is strongly influenced by their proximity to Half Moon Creek and by the surface elevation at the well location. Figure 34 shows water elevations over time for four wells located on the western side of Half Moon Creek. Water levels in all of these wells vary seasonally from highs in the winter and spring to lows in the summer and fall. Wells HMH-5R and SA1-12-H are at slightly lower elevations near the creek. Water levels in well HMH-16R, located near the northern end of the former beaver ponds, fluctuate as much as 7 ft between the wet and dry seasons. Well HM-S was equipped with a transducer in April 2013 and will provide data to document both seasonal effects and the effect of individual precipitation events.

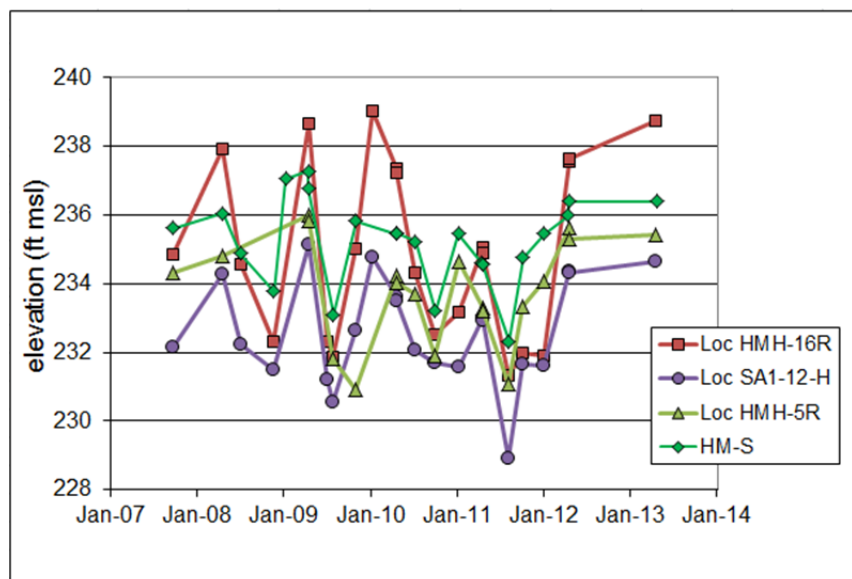


Figure 34. Alluvial Aquifer Hydrographs

Table 6. Construction and 2013 Water Level Elevations for Wells in the Salmon Site Monitoring Network

Well/ Piezometer	TSZ Elevation <sup>a</sup> (ft)	BSZ Elevation <sup>a</sup> (ft)	Aquifer	TOC Elevation <sup>a</sup> (ft)	Water Level Date	Water Depth (ft)	Water Level Elevation <sup>a, b</sup> (ft)
HM-S (SGZ)	102.15	38.15	Local Aquifer	244.02	4/24/2013	91.32	152.7
HM-L (SGZ)	-87.75	-172.75	Aquifer 1	243.56	4/24/2013	96.61	146.95
HM-1 (SGZ)	-198.04	-295.04	Aquifer 2a	243.54	4/23/2013	115.2	128.38
HM-2A (SGZ)	-357.89	-457.89	Aquifer 2b	243.48	4/24/2013	124	119.45
HM-2B (SGZ)	-497.67	-630.67	Aquifer 3b	243.62	4/23/2013	122.8	120.78
HM-3 (SGZ)	226.56	216.66	Alluvial Aquifer	243.56	4/22/2013	4.8	238.76
HMH-16R	217.78	208.38	Alluvial Aquifer	239.45	4/22/2013	4.03	235.42
HMH-5R	230.34	210.84	Alluvial Aquifer	242.3	4/25/2013	5.62	236.68
SA1-1-H	217.64	210.14	Alluvial Aquifer	241.43	4/22/2013	6.79	234.64
SA1-12-H	231.2	211.7	Alluvial Aquifer	243.08	4/23/2013	7.22	235.86
SA1-2-H	231	211.5	Alluvial Aquifer	241.97	4/23/2013	5.77	236.2
SA1-3-H	230.03	210.53	Alluvial Aquifer	242.17	4/22/2013	5.14	237.03
SA1-4-H	228.7	212.15	Alluvial Aquifer	243.53	4/24/2013	6.54	236.99
SA1-5-H	237.03	217.53	Alluvial Aquifer	241.97	4/25/2013	4.55	237.42
SA1-6-H	231.12	211.62	Alluvial Aquifer	243.08	4/23/2013	5.91	237.17
SA1-7-H	230.4	210.9	Alluvial Aquifer	242.3	4/23/2013	4.24	238.06
SA3-4-H	74.49	64.49	Local Aquifer	253.73	4/22/2013	97.86	155.87
HM-L2	104.71	64.71	Local Aquifer	251.44	4/23/2013	94.53	156.91
SA1-8-L	55.1	-4.9	Local Aquifer	335.69	4/23/2013	178.6	157.1
SA2-1-L	48.74	-11.26	Local Aquifer	325.73	4/23/2013	168.7	157.06
SA2-2-L	88.51	48.51	Local Aquifer	290.6	4/23/2013	133.2	157.36
SA2-4-L	107.03	97.03	Local Aquifer	267.96	4/22/2013	112.9	155.08
SA4-5-L	-483.3	-586.8	Aquifer 3a	253.44	4/22/2013	135.6	117.82
SA3-11-3	-594.17	-654.17	Aquifer 3a	250.06	4/23/2013	131.2	118.91
SA1-11-3	-674.1 <sup>c</sup>	-674.1 <sup>c</sup>	Caprock	260.43	4/22/2013	140.1	120.3
E-7	-1497.31	-1777.21	Aquifer 4	302.93	4/25/2013	169.1	133.85
SA5-4-4	-1498.86	-1739.46	Aquifer 4	301.04	4/24/2013	165.4	135.62
SA5-5-4	102.15	38.15	Local Aquifer	244.02	4/24/2013	91.32	152.7

<sup>a</sup> All elevations reported in units of feet relative to mean sea level

<sup>b</sup> No directional surveys available for the deeper wells

<sup>c</sup> No screen zone; casing is open at bottom with no endcap

BSZ = bottom of open interval/screen zone

TOC = top of casing

TSZ = top of open interval/screen zone

#### 4.10.2 Local Aquifer

Six site wells are screened in the Local Aquifer. The Local Aquifer is separated from the overlying Alluvial Aquifer by a 100–150 ft thick confining unit. Figure 35 shows water elevations over time for the six wells. The manual measurements provide some insight into the variability of water levels in individual wells and indicate that water level elevations vary in individual wells but the relative difference in water elevation between wells is consistent, suggesting that the horizontal flow direction in the Local Aquifer is relatively stable. The lowest hydraulic head elevations are in well HM-L at SGZ, suggesting a possible basin effect in the Local Aquifer at SGZ. The readings from the transducer installed in well SA2-2-L in 2008 show short-term variability that is not captured in the quarterly to yearly manual measurements. Figure 36 provides the water level elevations of the four Local Aquifer wells equipped with transducers. Seasonal fluctuations of up to 1 ft do occur in the Local Aquifer over the short record of transducer data. All Local Aquifer wells were equipped with transducers as of the April 2013 sampling event. Troll 4000 transducers with failed batteries were replaced with new transducers, and transducers were added to Local Aquifer wells that previously were not equipped with transducers (Table 5).

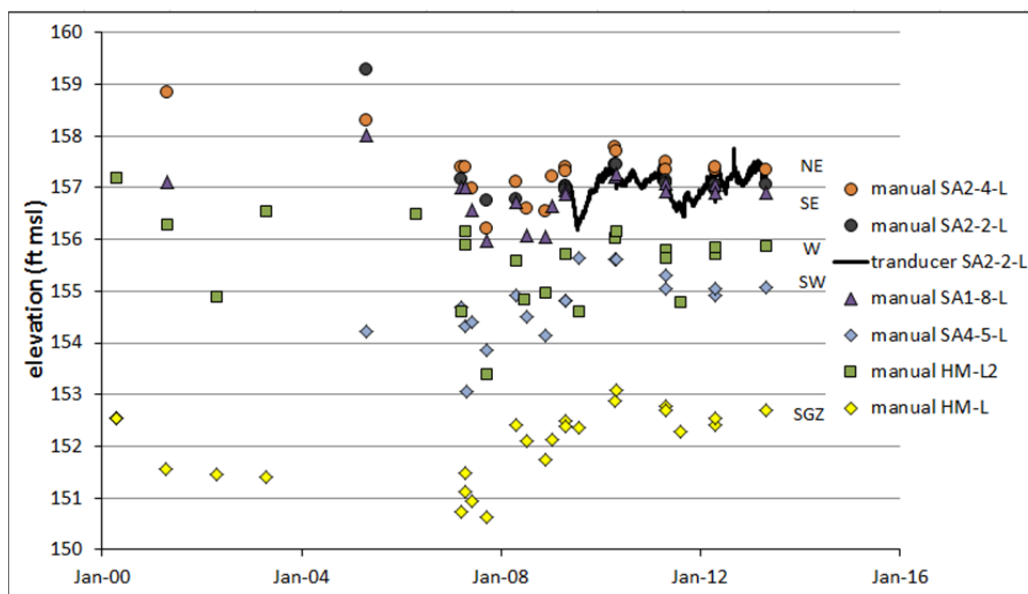


Figure 35. Local Aquifer Hydrographs

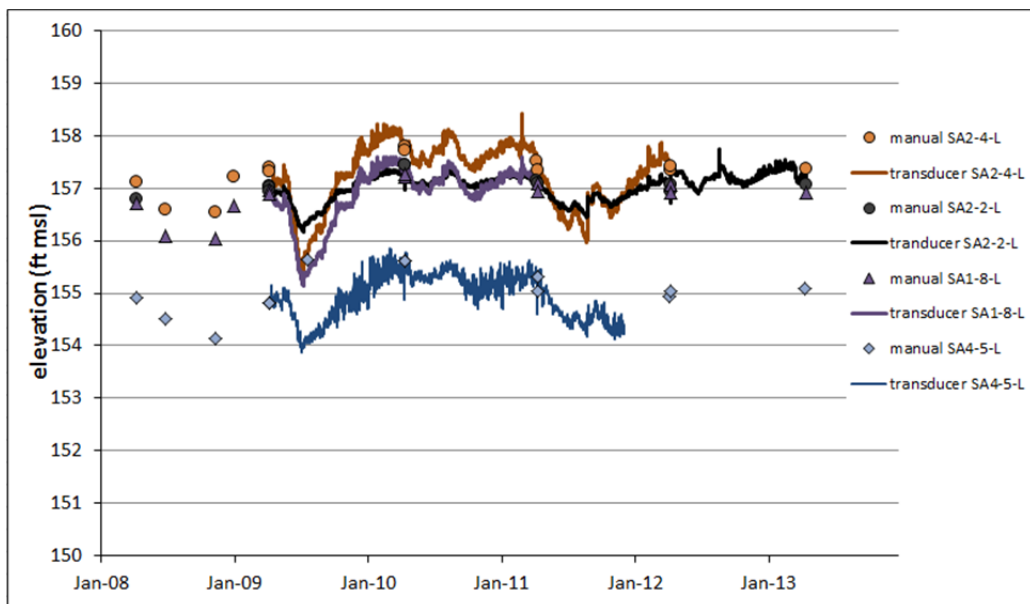


Figure 36. Transducer Data from Local Aquifer Wells Indicating Seasonal Fluctuations

#### 4.10.3 Aquifer 3a

Three site wells are screened in Aquifer 3a: HM-3 at SGZ, SA1-11-3 to the southeast, and SA3-11-3 to the south. The highest Aquifer 3a water level elevations (Figure 37) are near the top of the dome in well HM-3 (at SGZ).

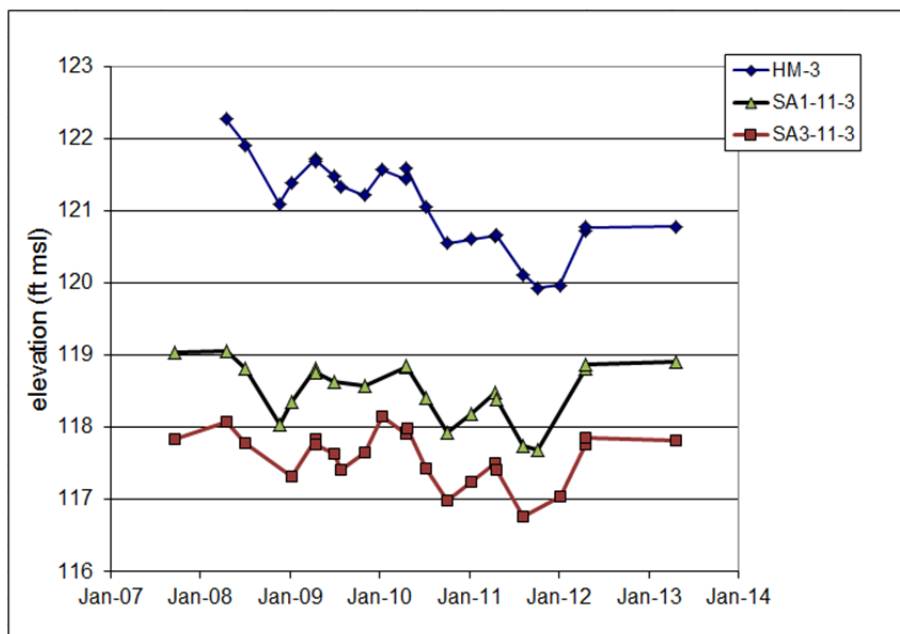


Figure 37. Aquifer 3a Hydrographs



#### 4.10.4 Aquifer 4

The two site wells screened in Aquifer 4 (SA5-4-4 and SA5-5-4) are located about 1.2 miles southwest of SGZ. Aquifer 4 is not present over the dome. These wells monitor the potential migration of contamination injected into underlying Aquifer 5. Both wells are sampled with dedicated submersible pumps and have been equipped with transducers since 2011. The declining water levels in both wells since 2007 appear to be stabilizing over the past few years (Figure 38). Each well has an inflatable packer above the screened interval, and it is not known whether the packers are inflated. Any interpretation of anomalous water levels in these wells should consider the possible influence of the packers. The water elevations in the Aquifer 4 wells are higher than those in Aquifer 2a, 2b, and Aquifer 3a at SGZ.

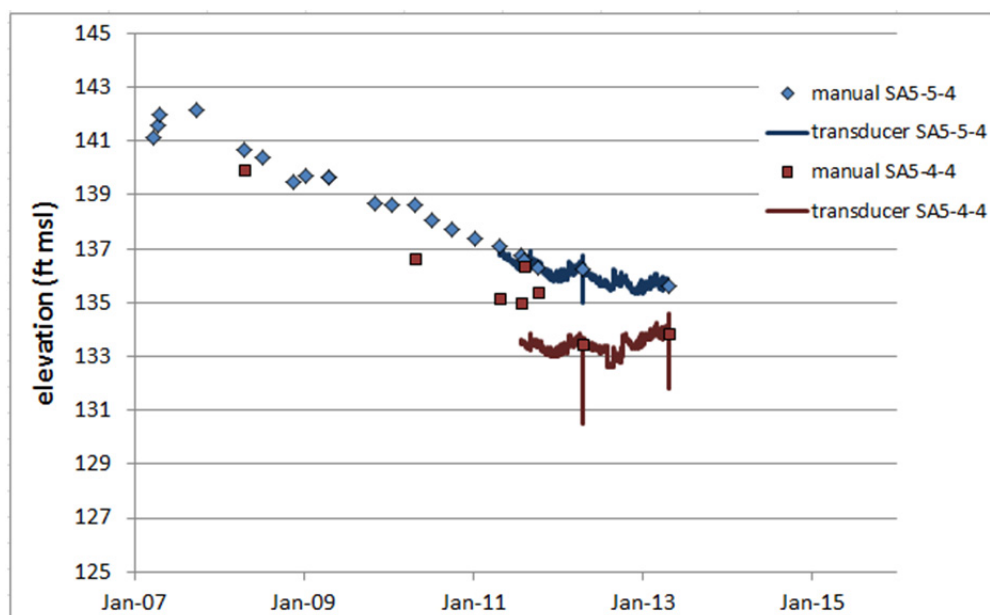


Figure 38. Aquifer 4 Hydrographs

#### 4.10.5 SGZ Wells

The six wells at SGZ are screened in successively deeper aquifers: the Alluvial Aquifer, the Local Aquifer, Aquifer 1, Aquifer 2a, Aquifer 2b, and Aquifer 3a. They monitor for potential upward migration of contamination from the cavity. Water levels in these wells provide vertical flow directions between aquifers at SGZ and, in combination with confining unit thicknesses, can be used to calculate vertical gradients. The primary vertical flow direction between aquifers at SGZ is downward. There is a slight reversal to an upward gradient at the base of the monitored section, from Aquifer 3a to the overlying Aquifer 2b (the lowest head level at SGZ).

The graphs of water levels with time (Figure 39) have been relatively stable. The strong downward gradient from the Alluvial Aquifer to the Local Aquifer (an 85 ft head difference) is probably contributing to the low-level detections of tritium and TCE in well HM-L. Migration of near-surface contamination along imperfections in casing-grout and grout-formation contact of wells that cross the confining unit at SGZ is the probable transport path (DOE 1980). The stability of heads in these aquifers indicates that flow and transport along the wellbores is not significant.



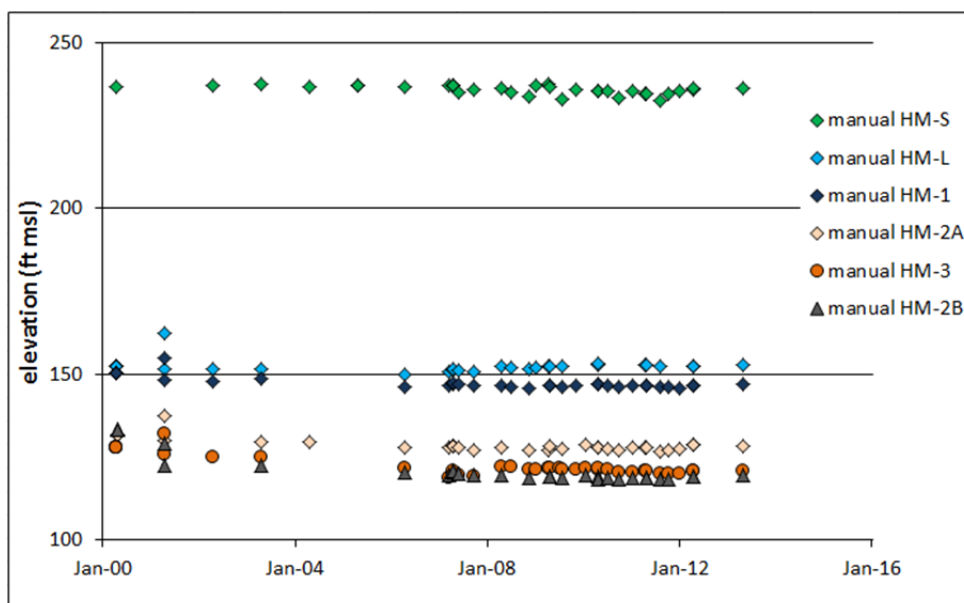


Figure 39. Historical Water Levels in SGZ Wells

## 5.0 Supplemental Site Activities

The following supplemental site activities were conducted during the April 2013 sampling event.

### 5.1 Inspection Activities

Inspectors conducted a condition assessment of the real property assets (monitoring wells and the SGZ monument). This condition assessment verified the existence and condition of the 28 wells and the monument at SGZ and is required every 5 years. All wells and the monument were in good condition, and a report (DOE 2013b) was prepared for the Facilities Information Management System.

### 5.2 Maintenance Activities

All of the locks on the wells and entrance gates were replaced with 3359 locks. Well development was conducted on five wells: HM-S, SA1-1-H, SA1-2-H, SA1-5-H, and SA1-6-H. Bladder pump cap assemblies were replaced on two wells—HM-L2, and SA1-4-H—because the old caps were leaking air.

The attachment for the pump riser pipe to connect to a hose for well SA5-4-4 was missing. Both Aquifer 4 wells need to have better attachments installed before the October 2014 sampling event.

The storage unit that was rented in Purvis was broken into in March 2013, and most of the equipment stored there was stolen. The unit was cleared out, and the rental contract was canceled.

## 6.0 Summary and Recommendations

Sampling at the site is conducted to monitor the residual surface contamination left from site activities (metals, VOCs, and tritium) and the potential for contamination to migrate from the shot cavity and the Aquifer 5 injection site (tritium, a suite of radionuclides analyzed by gamma spectroscopy, and chlorine-36). Surface contamination is attenuating. Metals contaminant levels are stable and not all are related to site activities. TCE and its degradation products trend downward, and only one well has a VOC (TCE in well HMH-5R) at a concentration that exceeds an MCL. Tritium continues to decay and will be undetectable by the standard method in site water samples between 2050 and 2060.

Metals sampling is recommended to be phased out following the October 2014 event. Sampling should be reduced to only the locations where concentrations exceed an MCL and possibly discontinued after the 2017 event, depending on results.

VOC sampling should be conducted until the TCE in well HMH-5R is below the MCL, which Mann-Kendal trend analysis predicts could be in 10 to 15 years.

After the October 2014 sampling event, samples collected for tritium analysis should be reduced to the Alluvial Aquifer wells, the indicator wells, and the streams entering and exiting the site.

Once the surface contamination has attenuated sufficiently, the only monitoring needed at the site is for potential radionuclide migration from the shot cavity and Aquifer 5. Because it is unlikely that migration of radionuclides will occur, and baseline data have been collected since site cleanup in 1972, monitoring by gamma spectroscopy and for tritium could switch to every 5 years to coincide with the condition assessment of the site wells and SGZ monument. If chlorine-36 is found to be useful for monitoring radionuclide migration from the shot cavity and Aquifer 5, it could also be analyzed every 5 years.

Based on the results of the 2013 sampling event and the network analysis, four new monitoring wells are recommended to be installed at the site before the October 2014 sampling event. Two Local Aquifer wells (SA1-12-L and SA3-4-L) will be paired with existing Alluvial Aquifer wells SA1-12-H and SA3-4-H, and a Local and Alluvial pair (SA2-6-H and SA2-6-L) will be installed north of SGZ between Half Moon Creek and the SA2 wells. The purpose of the new wells is to provide further understanding of the horizontal flow direction within the Local Aquifer; the wells will also be monitored for tritium and VOCs during the 2014 event.

It is recommended that sampling continue on an 18-month schedule and then switch to every 5 years after the October 2017 sampling event. If VOCs are not attenuated sufficiently at that time, they will also be included at the 5-year sampling events. Table 7 shows the proposed sampling for the 2014 event, and Table 8 shows the recommended sampling schedule going forward based on 2013 results.

Table 7. Water-Sampling Plan, Salmon, Mississippi Site October 2014

Source Area	Well Name	TD (ft)	VOC	Metals <sup>a</sup>	Tritium	Enriched Tritium	Chlorine-36	Major Ions <sup>b</sup>	Water Level
SA1	SA1-1-H	30	X	X	X				X
	SA1-2-H	30	X	X	X				X
	SA1-3-H	30	X	X	X				X
	SA1-4-H	30	X	X	X				X
	SA1-5-H	30	X	X	X				X
	SA 1-6-H	23	X	X	X				X
	SA1-7-H	30	X	X	X				X
	SA1-12-H	30	X	X	X				X
	HMH-5R	30	X	X	X				X
	HMH-16R	30	X	X	X				X
	HM-S	30	X	X	X	X	X	X	X
	SA1-8-L	195		X	X				X
	HM-L	204	X	X	X	X	X	X	X
	SA1-12-L	TBD ~200	X		X				X
	HM-1	415			X	X	X	X	X
	HM-2A	537			X	X	X	X	X
	HM-2B	700			X	X	X	X	X
	HM-3	875		X	X	X	X	X	X
	SA1-11-3	924		X	X				X
SA2	SA2-6-H	TBD ~30	X		X				X
	SA2-1-L	349		X	X				X
	SA2-2-L	340		X	X				X
	SA2-4-L	250		X	X				X
	SA2-6-L	TBD ~200	X		X				X
SA3	SA3-4-H	30	X	X	X				X
	SA3-4-L	TBD ~200	X		X				X
	E-7	934			X	X	X	X	X
	SA3-11-3	861		X	X				X
SA4	HM-L2	200		X	X				X
	SA4-5-L	180		X	X				X
SA5	SA5-4-4	2099			X	X	X	X	X
	SA5-5-4	2081			X	X	X	X	X
Surface Location Name									
	HALFMOON CREEK	NA		X	X				
	HALFMOONCRKOVERFLOW	NA		X	X				
	Pond West of GZ	NA		X	X				
	REECO Pit (A)	NA		X	X				
	REECO Pit (B)	NA		X	X				
	REECO Pit (C)	NA		X	X				
	Half Moon Cr Exit	NA		X	X	X	X	X	
	HickHCr.tsd_East	NA		X	X	X	X	X	
	GC-E (Grantham Cr East)	NA		X	X	X	X	X	
	HMC-S (Half Moon Cr South)	NA		X	X	X	X	X	

<sup>a</sup> As, Ba, Cr, Pb<sup>b</sup> Cl<sup>-</sup>, HCO<sub>3</sub><sup>-</sup>, CO<sub>3</sub><sup>2-</sup>, SO<sub>4</sub><sup>2-</sup>, Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>

TBD = to be determined

Table 8. Proposed Sampling Schedule

Year	Month	Analytes	Notes
2013	April	Tritium: all locations Metals: Alluvial Aquifer wells, Aquifer 3a wells, & surface water VOCs: Alluvial Aquifer wells, Local Aquifer wells, & selected surface water Cl-36 and gamma spectroscopy: indicator wells	Results indicate metals analysis can be reduced or discontinued pending 2014 results. VOCs were only detected in one of the additional locations (HM-L) in 2013.
2014	October	Tritium: all locations Metals: Alluvial Aquifer wells, Aquifer 3a wells, & surface water VOCs: Alluvial Aquifer wells, HM-L, & new Local Aquifer wells Cl-36, major ions: indicator wells, site entrance & exit surface water, & TBD background wells	If VOC's are not detected in the new Local Aquifer wells then discontinue.
2016	April	Tritium: Alluvial Aquifer wells Enriched tritium: indicator wells & site entrance & exit surface water Metals: wells with MCL exceedances VOCs: Alluvial Aquifer wells & HM-L Cl-36: indicator wells, & site entrance & exit surface water Radionuclides by gamma spectroscopy: indicator wells	Analysis of major ions will be added if needed for chlorine-36 interpretation.
2017	October	Tritium: Alluvial Aquifer wells Enriched tritium and Cl-36: indicator wells, & site entrance & exit surface water VOCs: Alluvial Aquifer wells & HM-L Metals: wells with MCL exceedances	If VOCs are not below MCL, continue monitoring at 5-year events. If metals results remain stable, then discontinue.
2022	April	Enriched tritium and Cl-36: indicator wells, & site entrance & exit surface water Radionuclides by gamma spectroscopy: indicator wells	
2027 <sup>a</sup>	April	Enriched tritium and Cl-36: indicator wells, & site entrance & exit surface water Radionuclides by gamma spectroscopy: indicator wells	

Indicator Wells: HM-S, HM-L, HM-1, HM-2A, HM-2B, HM-3, E-7, SA5-4-4, SA5-5-4.

<sup>a</sup> Pattern continues with DOE visiting the site every 5 years for inspection, maintenance, and limited sampling.

## 7.0 References

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