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2015 Groundwater Monitoring and Inspection Report Gnome-Coach, New Mexico, Site

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U.S. DEPARTMENT OF ENERGY | Legacy Management

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Abbreviations

bgs	below ground surface
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ft	feet
GEMS	Geospatial Environmental Mapping System
LM	Office of Legacy Management
LTHMP	Long-Term Hydrologic Monitoring Program
NMED	New Mexico Environment Department
USGS	U.S. Geological Survey

Executive Summary

The Gnome-Coach, New Mexico, Site was the location of a 3-kiloton-yield underground nuclear test in 1961 and a groundwater tracer test in 1963. The U.S. Geological Survey conducted the groundwater tracer test using four dissolved radionuclides—tritium, iodine-131, strontium-90, and cesium-137—as tracers. Site reclamation and remediation began after the underground testing and was conducted in several phases at the site. The New Mexico Environment Department (NMED) issued a Conditional Certificate of Completion in September 2014, which documents that surface remediation activities have been successfully completed in accordance with the Voluntary Remediation Program. Subsurface activities have included annual sampling and monitoring of wells at and near the site since 1972. These annual monitoring activities were enhanced in 2008 to include monitoring hydraulic head and collecting samples from the onsite wells USGS-4, USGS-8, and LRL-7 using the low-flow sampling method. In 2010, the annual monitoring was focused to the monitoring wells within the site boundary. A site inspection and annual sampling were conducted on January 27–28, 2015. A second site visit was conducted on April 21, 2015, to install warning/notification signs to fulfill a requirement of the Conditional Certificate of Completion that was issued by the NMED for the surface.

Analytical results from the 2015 sampling event indicate that concentrations of tritium, strontium-90, and cesium-137 were consistent with historical results. This includes no detections in the sample from well USGS-1, which has a submersible electric pump and is used to provide water for livestock belonging to area ranchers (water right C01901). Hydraulic head data from this well indicate that the frequency and rate of pumping increased in late November 2013. This is evident by an increase in the amount of drawdown and the recovery time of water levels of approximately 5 feet (ft) when the pump cycles on and off. Historically, water levels in this well varied only about 2 ft between pump cycles. The hydraulic head data continue to show that pumping in well USGS-1 produces a drawdown response in wells USGS-4 and USGS-8, which also increased in late November 2013. The increased magnitude of drawdown and the corresponding recovery of water levels during pump cycles are the result of a new dedicated pump installed in USGS-1 by the area ranchers and an increase in the frequency of pumping. Hydraulic head data from well LRL-7, which monitors the Coach drift, indicate that water levels have nearly recovered from the last sampling event in January 2011. Manual water level measurements collected from re-entry well DD-1, which monitors the detonation cavity, confirmed that the transducer in this well had failed and that the transducer data obtained from June 2011 through February 2014 were in error.

This report is available on the LM public website at http://www.lm.doe.gov/gnome/Sites.aspx, and copies are sent to the individuals on the distribution list in Appendix B. Data collected during this and previous monitoring events (analytical and water levels) are available on the GEMS (Geospatial Environmental Mapping System) website at http://gems.lm.doe.gov/#site=GNO.

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1.0 Introduction

This report presents the groundwater monitoring data collected by the U.S. Department of Energy (DOE) Office of Legacy Management (LM) at the Gnome-Coach, New Mexico, Site (Figure 1). The site was the location of a 3-kiloton-yield underground nuclear test and radioisotopic groundwater tracer test in the 1960s that resulted in residual contamination at the site. Groundwater monitoring consisted of collecting groundwater samples, measuring depth to groundwater, and downloading pressure transducer data from selected wells at the site. This report summarizes the results of the monitoring, site inspection, and site visits conducted during fiscal year 2015 and is available on the LM public website at http://www.lm.doe.gov/gnome/Sites.aspx. Data collected during this and previous monitoring events (sample analytical and water levels) are available on the GEMS (Geospatial Environmental Mapping System) website at http://gems.lm.doe.gov/#site=GNO.

2.0 Site Location and Background

The Gnome-Coach site is approximately 25 miles southeast of Carlsbad in Eddy County, New Mexico (Figure 1). The U.S. Atomic Energy Commission (predecessor agency to DOE) acquired the site through a land withdrawal from the U.S. Bureau of Land Management in the early 1960s for underground nuclear testing through the Plowshare Program (AEC 1962). The Plowshare Program was a research and development initiative started in 1957 to determine the technical and economic feasibility for peaceful applications of nuclear energy. The withdrawal comprises two parcels of land containing approximately 680 acres. The larger parcel (640 acres) is where the underground nuclear test occurred and consists of Section 34, Township 23 South, Range 30 East. The smaller parcel (40 acres) was used for observation during the underground test and is in Section 10, Township 23 South, Range 30 East. The focus of this report is the 640-acre parcel identified as the Gnome-Coach site, where the underground nuclear test and radioisotopic tracer test occurred. Figure 1 shows the two parcels that compose the land withdrawal.

The purpose of the underground nuclear test, identified as Project Gnome, was to study the possibility of converting the energy from nuclear detonations into electricity, investigate the production and retrieval of radioisotopes, measure neutron activation cross-sections of specific isotopes, collect data on the characteristics of nuclear explosions in salt formations, and collect data for use in future Plowshare programs (AEC 1962). Preparation for the test began in 1958 and involved multiple agencies. The U.S. Geological Survey (USGS) installed several wells and boreholes to assess the geologic and hydrologic conditions at the site. The site was determined suitable for the experiment, and a 10-foot (ft)-diameter vertical emplacement shaft was excavated to a depth of 1,216 ft below ground surface (bgs) (Figure 2). A horizontal drift was mined, extending from the bottom of the shaft 1,116 ft to the northeast and ending in a hook shape. The hook shape was designed for placement of the nuclear device and was intended to be self-sealing following the detonation. The nuclear test was performed at a depth of 1,184 ft bgs in a bedded salt formation identified as the Salado Formation on December 10, 1961 (Figure 3). The device had a reported yield of 3 kilotons. Immediately following the detonation, close-in stemming materials failed, and gases from the detonation cavity vented to the atmosphere via the horizontal drift and emplacement shaft (AEC 1962). The cavity that resulted from the detonation has dimensions that are well documented because scientists entered the cavity 5 months after the

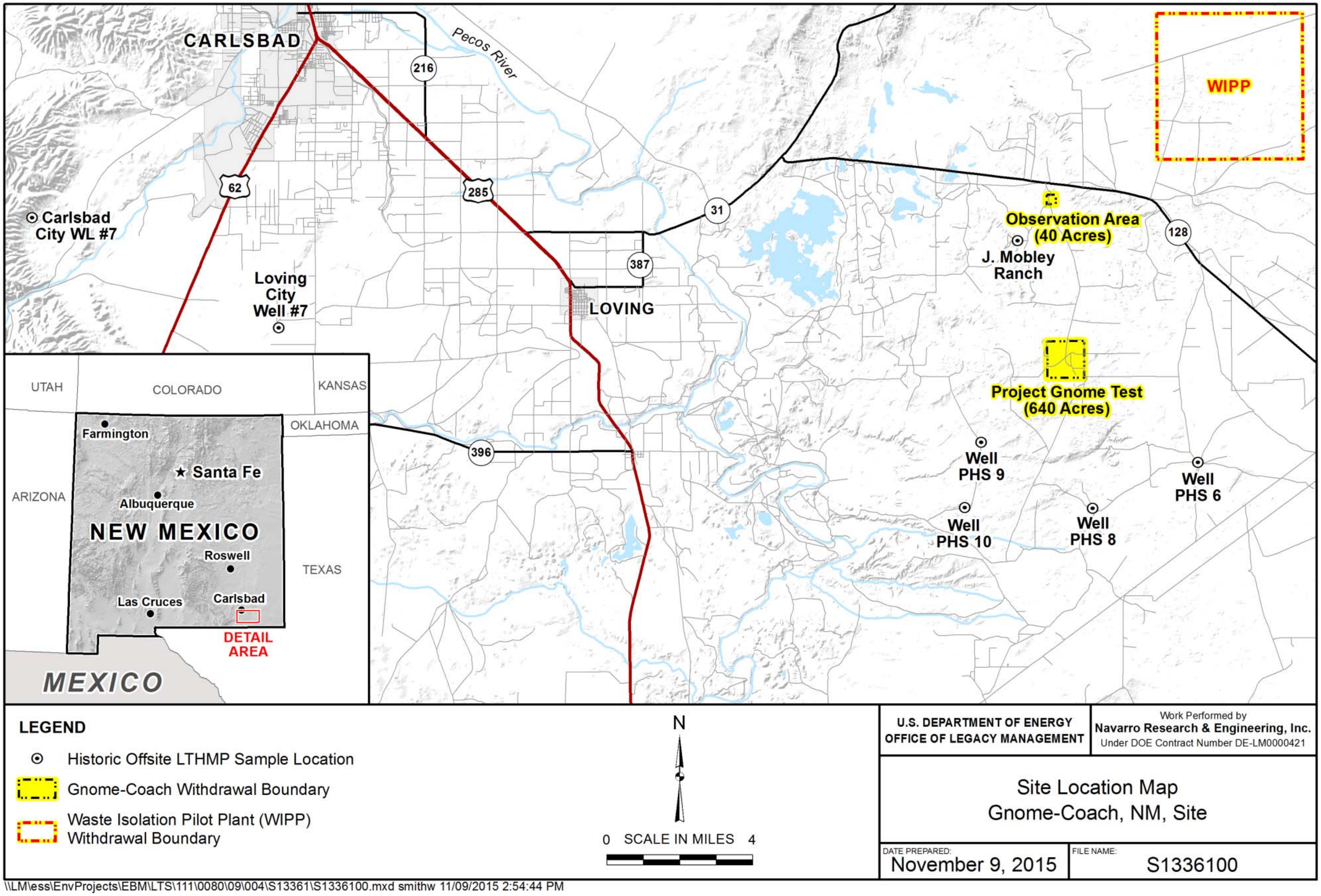

Figure 1. Location Map for the Gnome-Coach, New Mexico, Site

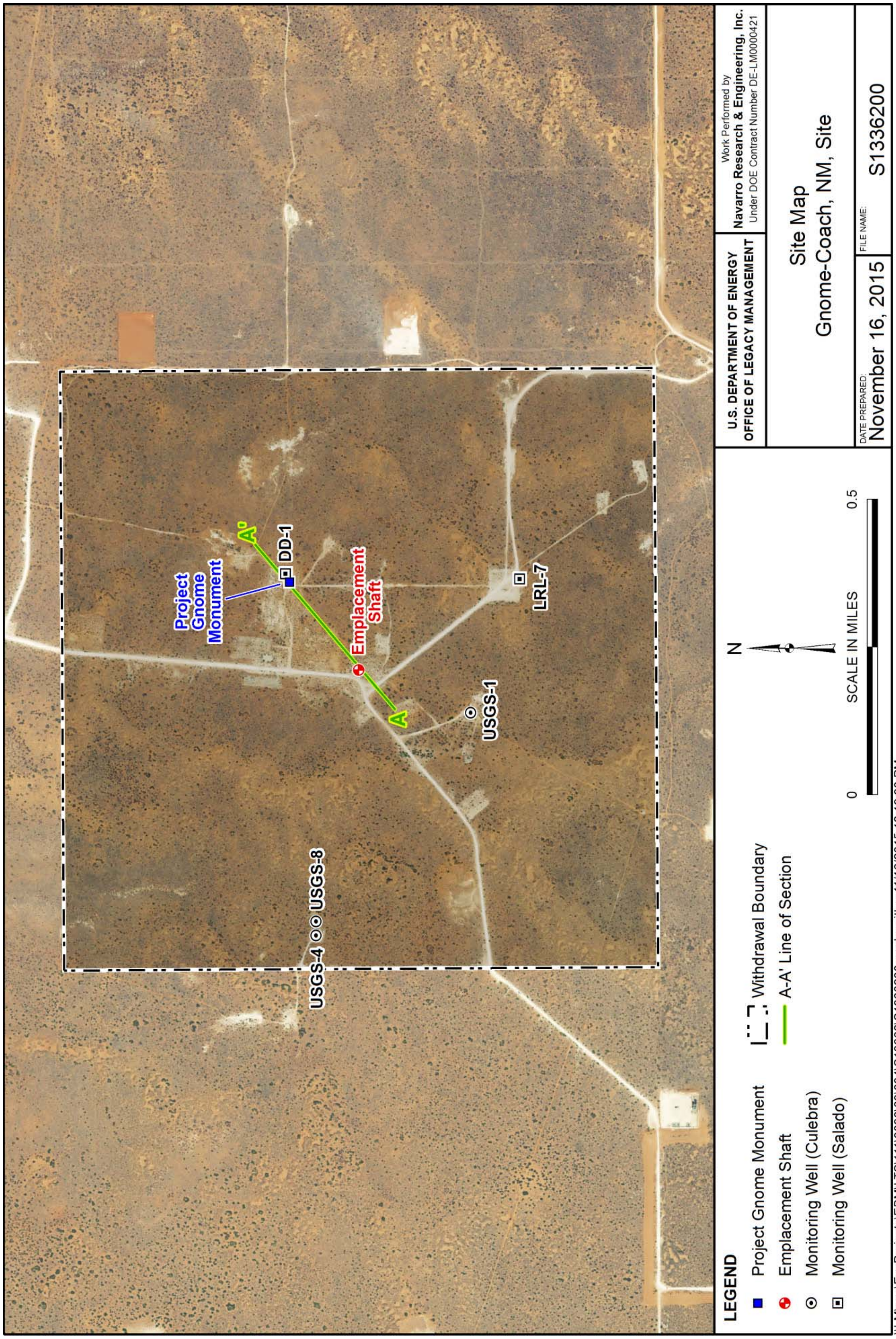

Figure 2. Site Features at the Gnome-Coach Site

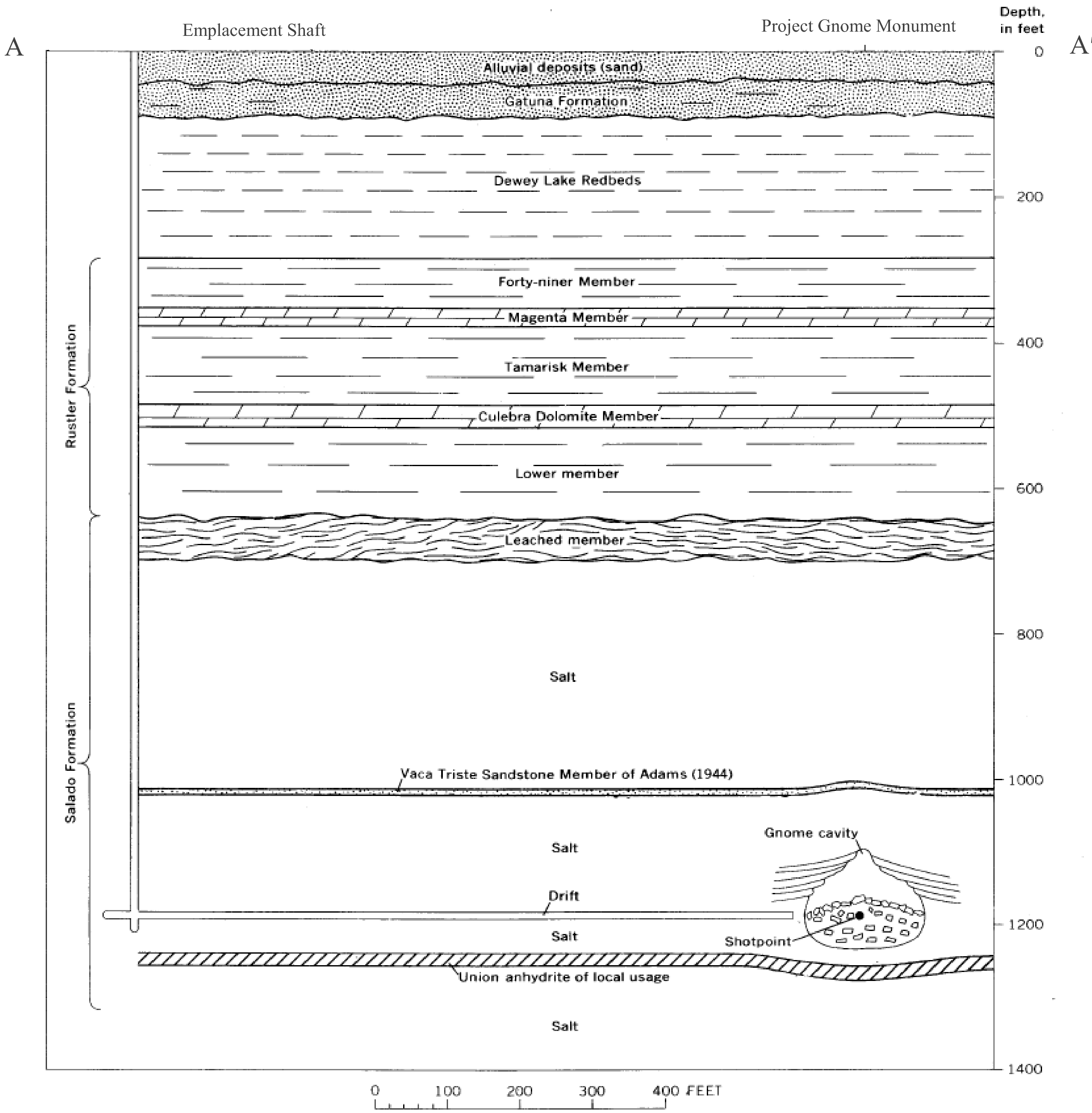

Figure 3. Stratigraphic Cross-Section at the Gnome-Coach Site

test in May 1962. Post-test drilling operations and preparations for another underground nuclear test, identified as Project Coach, began shortly after the Gnome test. The emplacement shaft was restored and deepened to a depth of 1,284 ft bgs, and a second horizontal drift was mined 1,945 ft southeast from the shaft (AEC 1969). The Coach experiment was initially scheduled for 1963 but was canceled and never executed.

No additional underground nuclear detonations occurred at the site, but in 1963 the USGS conducted a groundwater tracer test between wells USGS-4 and USGS-8 using four dissolved radionuclides (tritium, iodine-131, strontium-90, and cesium-137) as tracers. Wells USGS-4 and

USGS-8 are completed in the Culebra Dolomite and are approximately 3,100 ft west of the Project Gnome monument located at surface ground zero (Figure 2). The tracer test experiment was performed using USGS-4 as the extraction well and USGS-8 as the injection well. The extracted groundwater was mixed with the radioisotope tracer solution and injected into well USGS-8 at the same rate as the extraction to create a steady-state flow field between the wells. The Culebra Dolomite is a fractured carbonate aquifer and is the most prolific aquifer near the site. The purpose of the tracer test was to estimate the dispersion coefficient and effective porosity of the Culebra for use in evaluating the potential movement of radionuclides (Beetem and Angelo 1964).

2.1 Summary of Reclamation and Remediation Activities

Cleanup of the surface and shallow subsurface contamination resulting from the underground nuclear testing, post-test drilling, and groundwater tracer test was conducted in 1968 and 1969. A second major cleanup was conducted from 1977 to 1979 (REECO 1981). During this phase of the cleanup, liquid waste was pumped into the cavity through existing vent holes; contaminated material was dumped into the emplacement shaft and Coach drift through existing drill holes; uncontaminated equipment was moved offsite; and drill holes were plugged except those retained for use as groundwater monitoring wells (AEC 1969). While conducting a survey and sampling event in 1994, the U.S. Environmental Protection Agency (EPA) identified radiological contamination on the surface and in the shallow subsurface. The DOE National Nuclear Security Administration Nevada Site Office conducted a corrective action investigation to assess the extent of contamination at the site. The field investigations were performed from February through June 2002 and in May 2003. Contamination identified during the field investigation was excavated and disposed of offsite. A post-remediation surface radiological survey identified areas having radiological concentrations above background, but none of the concentrations were above the action levels determined to be safe for the public. The Corrective Action Investigation Report (DOE/NNSA 2004) summarizes the results of the investigation. After discussions with the State of New Mexico, it was decided that the site would be administered under the Voluntary Remediation Program. DOE prepared a Completion Report in accordance with the Voluntary Remediation Program (DOE/NNSA 2005), and a Conditional Certificate of Completion documents that surface remediation activities have been successfully completed in accordance with the Voluntary Remediation Program.

Subsurface activities have consisted of annual sampling and monitoring of groundwater as part of the Long-Term Hydrologic Monitoring Program (LTHMP). EPA began the LTHMP in 1972 (EPA 1972) and conducted the sampling until 2008, when LM assumed responsibility for sampling. Since 1972, locations used for long-term sampling have changed: some locations were abandoned or replaced, and new locations have been added. Samples collected from these locations have generally been analyzed for gamma-emitting radionuclides (using high-resolution gamma spectrometry), strontium-90, and tritium (using conventional and electrolytic enrichment methods). LM evaluated the LTHMP and the associated monitoring network after assuming responsibility for the sampling in 2008. The purpose of the evaluation was to determine the effectiveness of the current monitoring network and to determine future monitoring at the site. The evaluation considered potential transport pathways for contaminant migration from the detonation zone and tracer test to surrounding receptors. Analytical results from more than 30 years of monitoring indicate that groundwater at sample locations outside the land-withdrawal boundary (Figure 1) were not impacted by nuclear-test-related contamination. For this reason, in 2010 the monitoring was focused to the monitoring wells within the site boundary.

Low-flow bladder pumps were installed in wells USGS-4, USGS-8, and LRL-7 in June 2008 to enhance monitoring at the site. The dedicated bladder pumps were installed to replace the previous sampling method that used a depth-specific bailer and to allow the collection of more representative samples using the low-flow sampling method. Pressure transducers were also installed in the onsite monitoring wells in 2008, 2009, and 2010 to collect hydraulic head data for evaluating groundwater flow directions. Geophysical well logging was conducted in onsite wells USGS-1, USGS-4, and USGS-8 in April 2010. The well logging was conducted to obtain borehole deviation data from wells USGS-1 and USGS-4, natural gamma data from wells USGS-4 and USGS-8, and downhole video logs from wells USGS-4 and USGS-8. The borehole deviation data allow measured depths to be corrected to true vertical depths to support the calculation of hydraulic head at site wells that deviate from vertical. The gamma ray logs provide geologic information that can be used to correlate with other wells in the area. The video log images suggest that the well casings are generally in good condition. The 2010 Groundwater Monitoring and Inspection Report (DOE 2011) summarizes the well-logging results.

A seismic reflection survey was conducted at the site in early 2011. Seven seismic reflection profiles totaling approximately 13.9 miles were acquired to assist in the interpretation of subsurface conditions (geology and hydrogeology) at and near the site. The survey was designed to image the upper few thousand feet of the section, which includes the Culebra Dolomite (at a depth of about 450 ft bgs at wells USGS-4 and USGS-8) and the detonation (at a depth 1,184 ft bgs) within the Salado Formation. A check shot survey was acquired in well USGS-4 to calibrate the seismic profiles to the subsurface lithology. Significant features identified that would influence groundwater flow were areas of collapse in the evaporites overlying the Salado Formation and possible faults that cross the site. The 2012 Groundwater Monitoring and Inspection Report (DOE 2013) summarizes the seismic survey results.

Well boxes were installed at USGS-4, USGS-8, LRL-7, and DD-1 in 2012 and 2013 to improve wellhead security at the site. This resulted in modifications to the USGS-4 and USGS-8 wellheads. The USGS-1 wellhead was also modified in 2013 to repair damage received from a water truck (DOE 2013). The wellhead modifications established new measuring points on the top of casing for measuring depth to groundwater in these wells. To account for these modifications, the monitoring wells were surveyed by a registered land surveyor in 2014 to provide northings and eastings with new top-of-casing elevations. These 2014 wellhead survey data are summarized in the 2014 Groundwater Monitoring and Inspection Report (DOE 2015).

3.0 Geology and Hydrology

The site is in the northwestern part of the Delaware Basin, a deep, oval, sedimentary basin 75 miles wide and 135 miles long in southeastern New Mexico. The geology and hydrology of this basin are well studied because of oil and gas exploration, mining, and operation of the Waste Isolation Pilot Plant approximately 8.5 miles north-northeast of the site (measured from the approximate center of each withdrawal boundary). The basin deposits generally dip gently to the east and southeast, although in places the bedding is almost flat. During the late Permian Period, a warm, shallow sea in the region provided an ideal environment for reef development, which blocked seawater circulation. Brines formed as the seawater began to evaporate, and crystalline salts precipitated and accumulated on the basin floor. As a result, the site area is underlain by several thousand feet of limestone, dolomite, gypsum, halite, anhydrite, and potassium salts (potash) (USGS 1962).

Figure 3 is a cross-section showing the stratigraphy at the site, the emplacement shaft and drift, and the detonation cavity that resulted from the underground test. The Salado Formation, in which the Gnome detonation took place, is a 1,500 ft thick bed of halite that formed during the Permian Period. Immediately overlying the Salado Formation are five thin-bedded members of the Rustler Formation (USGS 1968). This formation includes the Culebra Dolomite Member, which is the subject of extensive study as part of the operation of the Waste Isolation Pilot Plant. Below the Culebra Dolomite and above the Leached Member of the Salado Formation is the Lower Member that is now referred to as the Los Medaños Member. Above the Culebra Dolomite is the Tamarisk Member, which is overlain by the Magenta Member. The uppermost member of the Rustler Formation is the Forty-Niner Member, a mixture of gypsum and anhydrite. The youngest Permian sequences in the site area are the thin, red, sedimentary rocks of the Dewey Lake Redbeds Formation. The Gatuna Formation and alluvial sand deposits overlie the Dewey Lake Redbeds Formation.

The Culebra Dolomite, in which the groundwater tracer test took place, contains the most prolific aquifer at the site. It is a fractured carbonate aquifer that is widespread, laterally continuous, and approximately 30 ft thick. It is encountered at depths ranging from 460 to 515 ft bgs at the site. Water levels are monitored in the Culebra by the onsite wells USGS-1, USGS-4, and USGS-8 (Figure 2). Water level data from these wells indicate that Culebra is confined. The groundwater in the Culebra is of poor quality because of high concentrations of dissolved solids (Mercer 1983); despite the poor water quality, it is a source of water for ranchers who maintain livestock throughout the area. The Salado Formation is characterized as a regional aquiclude because of the hydraulic properties of the bedded halite salt within the formation (DOE 2012). The plastic nature of salt under pressure of its own weight and that of overlying units results in movement over time that closes openings (fractures and void spaces) within the deposit, making any continuous movement of water through the formation highly unlikely. However, the contact between the Rustler and Salado Formations (Leached Member) has been observed as water-bearing, though it is not continuous in the region around the site (DOE 2012). Fluid levels in the detonation cavity are monitored by the re-entry well DD-1 and in the Coach drift by LRL-7, both of which are in the Salado Formation.

4.0 Groundwater Monitoring and Inspection Results

The annual groundwater monitoring and site inspection were conducted on January 27 and 28, 2015. The field activities consisted of a site inspection, downloading pressure transducers data, measuring depth-to-groundwater, and collecting groundwater samples. A site visit was also conducted on April 21, 2015, and data from pressure transducers were downloaded again in late-August 2015. The *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (LMS/PRO/S04351) provides the procedures used to guide the quality assurance/quality control of the annual sampling and monitoring program. These procedures incorporate standards and guidance from EPA, DOE, and ASTM International. The analytical results obtained from the annual sampling were validated in accordance with the "Standard

Practice for Validation of Environmental Data" section in the *Environmental Procedures Catalog* (LMS/POL/S04325). Samples were analyzed using accepted procedures that were based on the specified methods. The laboratory radiochemical minimum detectable concentration reported with these data is an estimate of the predicted detection capability of a given analytical procedure, not an absolute concentration that can or cannot be detected. A copy of the data validation package is maintained in LM records and is available upon request. It can also be accessed on the LM Public Website at http://www.lm.doe.gov/gnome/Sites.aspx. The Sampling and Analysis Plan can be accessed on the LM public website at http://energy.gov/sites/prod/files/2015/02/f19/S04351_SAP.pdf.

4.1 Site Inspection Results

The annual site inspection was conducted on January 27–28, 2015. The inspection included evaluating roads and inspecting the wellheads and the Project Gnome monument for signs of damage, natural deterioration from weather, or vandalism. The site inspection also included repairs to the DD-1 wellhead and installation of a totalizing flow meter at well USGS-1. Repairs to the re-entry well DD-1 were necessary because of vandalism that occurred in July 2014 (DOE 2015). Well USGS-1 has a submersible electric pump, and a totalizing flow meter was installed to monitor total gallons removed from the well. The U.S. Bureau of Land Management has used this well since the 1980s as a point of diversion to provide water for livestock belonging to area ranchers under water right C01901. The flow meter data will help assess any impacts the groundwater extraction has on water levels at the site.

The site visit on April 21, 2015, included the installation of signs that inform the public that ground-disturbing activities are not allowed at the site without permission from LM. These signs were installed near the emplacement shaft, near well USGS-1, and around the perimeter of the site to fulfill a requirement of the Conditional Certificate of Completion that was issued by the New Mexico Environment Department (NMED). The roads, wellheads, and monument were all in good condition at the time of the annual site inspection and site visit.

4.2 Hydraulic Head Monitoring and Results

Pressure transducers in site monitoring wells USGS-1, USGS-4, USGS-8, and LRL-7 recorded water levels every hour. The transducer data were downloaded and water levels were measured manually in the site wells on January 27–28 and on April 21, 2015. The transducer data were downloaded again on August 26, 2015. Manual water level measurements were used to convert the transducer data to depth-to-water measurements. Transducer data were corrected for the different specific gravity of water for each screened unit. The specific gravity of water in Culebra-screened wells is approximately 1.0035, and the specific gravity of water from Salado-screened wells is approximately 1.15. Table 1 presents the water level data and measured groundwater elevations obtained in April 2015, along with the top of casing elevations, the top and bottom screen-zone elevations, and the hydrostratigraphic unit monitored for the wells.

Table 1. Gnome-Coach Site Water Levels

Well	Date	DTW (ft)[a]	TOC Elevation (ft amsl)	TSZ Elevation (ft amsl)	BSZ Elevation (ft amsl)	Formation/Unit Monitored	Groundwater Elevation (ft amsl)
USGS-1	4/21/2015	441.58[c]	3,426.60	2,907[b]	2,875[b]	Culebra Dolomite	2,987[b]
USGS-4	4/21/2015	429.11	3,413.72	2,940[b]	2,907[b]	Culebra Dolomite	2,991[b]
USGS-8	4/21/2015	421.95	3,411.25	2,947[b]	2,915[b]	Culebra Dolomite	2,991[b]
LRL-7	4/21/2015	461.98	3,442.52	2,653[d]	2,127[d]	Salado Formation	2,979[d]
DD-1	4/21/2015	986.70	3,397.49[e]	2,259[d]	NM	Salado Formation	2,411[d]

Notes:
The TOC elevations are provided in U.S. State Plane, Zone New Mexico East, coordinate system, with vertical data based on the National Geodetic Vertical Datum of 1929 (NGVD 29) (DOE 2015).
[a] Depth to water has not been corrected for true vertical depth.
[b] Elevation has been corrected for true vertical depth. (At the water level depth, the deviation correction for USGS-1 is 0.09 ft; the deviation correction for USGS-4 is 4.90 ft; and no correction is required for USGS-8 because it did not deviate from vertical.)
[c] Well USGS-1 has a dedicated submersible pump that was operating at the time of the water level measurement.
[d] Elevations for LRL-7 and DD-1 have not been corrected for true vertical depth because borehole deviation corrections are not available for these wells.
[e] TOC elevation is estimated because of repairs to the wellhead after the well was vandalized in July 2014.

Abbreviations:
amsl = above mean sea level
BSZ = bottom of screen zone, uncased/open interval, or perforated interval in feet above mean sea level
DTW = depth to water (all measurements obtained from north top of casing)
NM = not measured or unknown (the construction and open intervals of re-entry well DD-1 are unknown)
TOC = top of casing elevation in feet above mean sea level (NGVD 29)
TSZ = top of screen zone, uncased/open interval, or perforated interval in feet above mean sea level

The hydraulic head monitoring began in July 2008; hydrograph data are shown in Figure 4 and Figure 5. The hydrographs are grouped according to each well's open interval and formation monitored. Head data from manual water-level tape measurements are shown as individual symbols, and transducer data appear as lines. Hydraulic head data from wells USGS-1 and USGS-4 have been corrected to true vertical depth. No correction is required for well USGS-8 because the well did not deviate from vertical. Borehole deviation data are currently not available for DD-1 and LRL-7, so groundwater elevations depicted in Figure 5 are approximate.

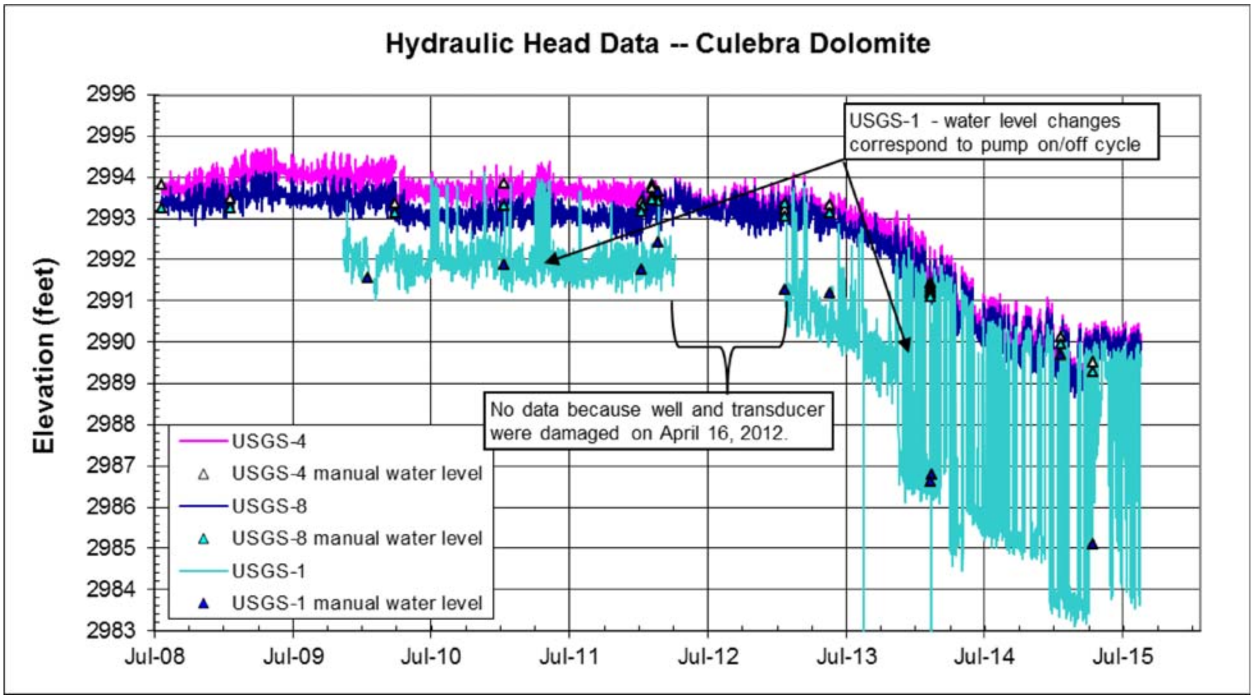

Figure 4. Hydrograph Showing Water Elevations in Wells USGS-1, USGS-4, and USGS-8

Figure 4 shows the hydrographs for the wells (USGS-1, USGS-4, and USGS-8) completed in the Culebra Dolomite. A submersible electric pump in well USGS-1 is used to provide water for livestock belonging to area ranchers (water right C01901). The pump cycles on and off to fill a nearby water tank. The hydraulic head data indicate that the frequency and rate of pumping increased in late November 2013. Prior to that time, water levels varied about 2 ft between pump cycles. Since then, water levels have varied about 5 ft between pump cycles (Figure 4). Water levels in wells USGS-4 and USGS-8 have also responded to the increased water extraction from USGS-1. The hydraulic head in these wells has declined from a stable long-term elevation of about 2,993.5 ft to 2,990 ft since 2013. The decrease in water levels within the Culebra wells may also be the result of drilling and pumping from additional water supply wells in the area.

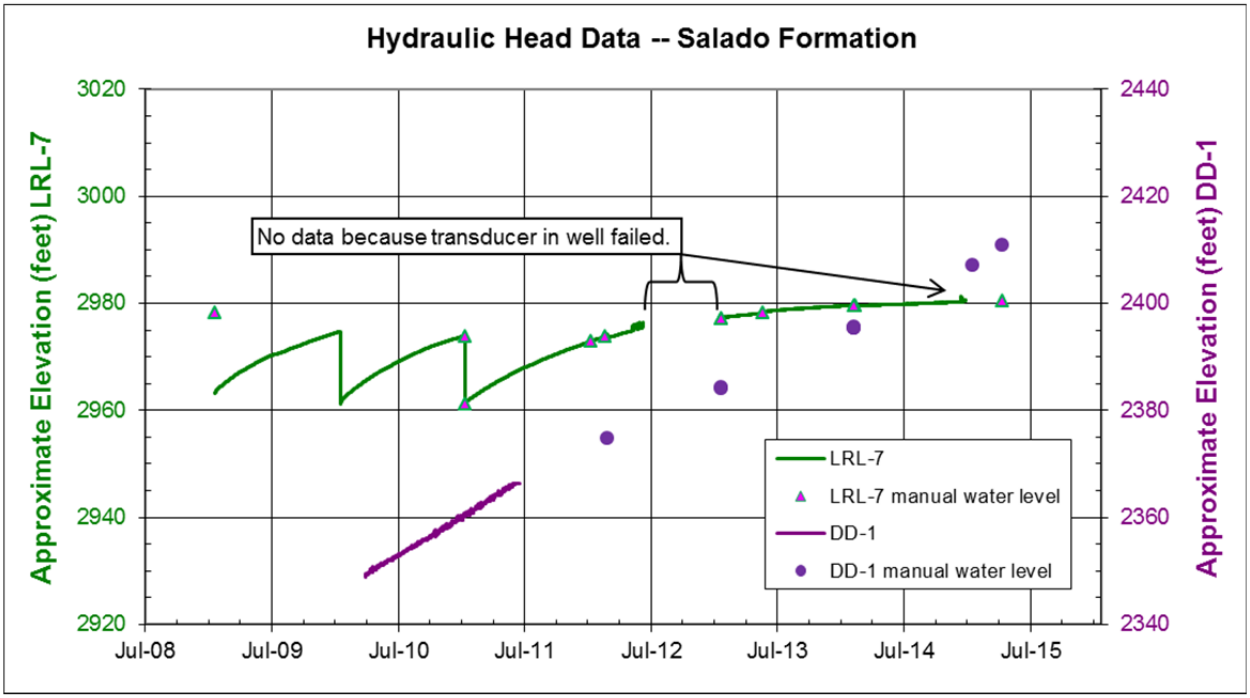

Figure 5. Hydrograph Showing Water Elevations in the Re-entry Wells DD-1 and LRL-7

Figure 5 shows the hydrographs for wells (DD-1 and LRL-7) completed in the Salado Formation. Water levels are monitored in the re-entry well DD-1 and LRL-7, which are completed in the detonation cavity and Coach drift, respectively. Water levels in these wells may be influenced by remnant pressure effects associated with the detonation and disposal activities and may not be representative of the Salado Formation. The transducer in LRL-7 failed in late 2014. The transducer data and subsequent manually measured water level indicate that the rate of water level recovery since LRL-7 was last sampled in January 2011 continues to decrease and that water levels may be nearing static conditions. The transducer in re-entry well DD-1 was removed during the January 2015 sampling event because manual water level measurements confirmed that the transducer had failed and that transducer data from June 2011 through February 2014 were in error. Manual water level measurements have historically been difficult to obtain from this well because of the well's small-diameter construction, depth-to-groundwater, and contamination associated with the detonation cavity. Previous reports said the transducer data might be unreliable, but additional manual water level measurements were needed to confirm this (DOE 2015). Figure 5 has been modified from last year's report to include the manual water level measurements that reflect this determination.

4.3 Groundwater Sampling and Results

Groundwater samples were collected from wells USGS-1, USGS-4, and USGS-8 on January 27, 2015. Monitoring wells USGS-4 and USGS-8 were sampled using dedicated low-flow submersible bladder pumps. The tubing inlets of the bladder pumps are located in the screened or open interval to allow water to be collected directly from the adjacent geologic formation. The sample from well USGS-1 was collected as a grab sample because the dedicated pump was filling the nearby stock tank at the time of the sampling. Samples were analyzed for gamma-emitting radionuclides (using high-resolution gamma spectrometry), strontium-90, and tritium (using conventional methods). An additional sample was collected from well USGS-1 for tritium analysis using the electrolytic enrichment method.

Table 2 presents a summary of radiochemical analytical results from 2008 through 2015 for comparison. LM has performed the sampling at the site since 2008. Prior to 2008, EPA had conducted the sampling and, until the 2012 sampling event, had also analyzed the samples. GEL Laboratories in Charleston, South Carolina, has analyzed all samples collected since the 2011 sampling event. Radiochemical analytical results obtained from the 2015 monitoring event were consistent with previous analytical results (Table 2). The radionuclide concentrations in wells USGS-4 and USGS-8 are the result of radionuclides injected during the tracer test in 1963. Concentrations are higher in well USGS-8 because it was used as the injection well for the tracer test; (well USGS-4 was used as the extraction well during the tracer test). Analytical results of the sample from well USGS-1 indicate no detection of radionuclides above the laboratory minimum detectable concentration (Table 2).

Charts 1 through 7 in Appendix A show temporal plots of radionuclide concentrations (1972 through 2015) in samples collected at wells LRL-7, USGS-4, and USGS-8. Well USGS-1 is not included because concentrations of tritium (using conventional methods), strontium-90, and cesium-137 have not been detected above the laboratory minimum detectable concentration. Concentrations are plotted on a semi-logarithmic scale. All sample results, including nondetects, are plotted. As indicated in the charts, many results from sampling events before the late 1980s had no reported detection limit. For interpretation purposes, relatively high concentrations (i.e., concentrations significantly higher than detection limits associated with subsequent sampling) should be considered detections. The natural decay rates for tritium (12.3 years), strontium-90 (28.8 years), and cesium-137 (30.2 years) have been included on the charts, as needed. The increases in tritium concentrations in samples collected from well LRL-7 (Chart 1) and cesium-137 concentrations in samples collected from wells USGS-8 and LRL-7 (Chart 4 and Chart 6) after the 2007 sampling event are attributed to changes in the sampling method. Prior to 2008, EPA collected samples using a depth-specific bailer, and after 2007, LM collected samples from dedicated bladder pumps using the low-flow sampling method. Tritium concentrations in samples collected from well USGS-4 (Chart 1) also appear to be decreasing at a rate that is greater than the natural decay rate for tritium.

Table 2. Radiochemical Analytical Results 2008 through 2015

Sample Location	Collection Date	Tritium (pCi/L)	Tritium Enriched Method (pCi/L)	Cesium-137 (pCi/L)	Strontium-90 (pCi/L)	Formation/Unit Monitored
USGS-1	7/30/2008	<169	NA	<5.0	NA	Culebra Dolomite
	1/27/2009	<154	NA	<4.94	<1.8	
	1/26/2010	<146	7.6	<2.1	<0.89	
	1/26/2010[a]	<146	<3.4	<1.4	<1.9	
	1/19/2011	<150	NA	<2.2	<3.6	
	1/19/2011[a]	<150	NA	<2.4	<1.1	
	1/18/2012	<240	<2.33	<5.69	<0.728	
	1/18/2012[a]	<243	NA	<6.82	<0.794	
	1/29/2013	<371	<2.18	<4.68	<0.909	
	1/29/2013[a]	<371	NA	<5.97	<0.716	
	2/19/2014	NA	<2.4	<5.68	<0.987	
	2/19/2014[a]	<298	NA	<4.81	<1.08	
	1/27/2015	NA	<2.24	<6.77	<0.722	
USGS-4	7/30/2008	22,300	NA	<4.59	NA	Culebra Dolomite
	1/27/2009	16,800	NA	<4.99	2,980	
	1/26/2010	13,200	NA	<1.4	2,540	
	1/19/2011	11,300	NA	<2.4	2,650	
	1/18/2012	9,110	NA	<5.62	884	
	1/30/2013	10,200	NA	<5.33	987	
	2/19/2014	7,680	NA	<5.85	1,780	
	1/27/2015	6,030	NA	<4.85	1,740	
USGS-8	7/30/2008	30,000	NA	154	NA	Culebra Dolomite
	1/27/2009	28,800	NA	163	3,440	
	1/27/2010	25,500	NA	181	3,320	
	1/19/2011	21,200	NA	150	3,650	
	1/18/2012	21,700	NA	154	1,400	
	1/29/2013	20,900	NA	174	1,580	
	2/19/2014	18,400	NA	176	1,640	
	1/27/2015	17,400	NA	123	2,650	
	1/27/2015[a]	16,400	NA	128	2,480	
LRL-7	7/30/2008	4,070	NA	126	NA	Salado Formation
	1/28/2009	4,870	NA	139	<24	
	1/26/2010	4,350	NA	129	<33	
	1/19/2011	3,910	NA	134	<29	
	1/18/2012	NA	NA	NA	NA	
	1/30/2013	NA	NA	NA	NA	
	2/19/2014	NA	NA	NA	NA	

Notes:
[a] = Indicates a field duplicate sample

Abbreviations:
NA = not analyzed
pCi/L = picocuries per liter

5.0 Conclusions

The annual site inspection on January 27–28, 2015, included final repairs to the DD-1 wellhead. These repairs were necessary because of vandalism that occurred at the site in July 2014 (DOE 2015). The site visit in April included installation of notification signs. These signs were installed near the emplacement shaft, near well USGS-1, and around the perimeter of the site to fulfill a requirement of the Conditional Certificate of Completion that was issued by NMED. The roads, wellheads, and monument were all in good condition at the time of the inspection and site visit.

The annual sampling was conducted in January 2015. Analytical results from this sampling event indicate that concentrations of tritium, strontium-90, and cesium-137 were consistent with historical results. This includes no detections in the sample from well USGS-1, which has a submersible electric pump that is used to provide water for livestock belonging to area ranchers (water right C01901). Hydraulic head data from this well indicate that the frequency and rate of pumping increased in late November 2013. This is evident by an increase in the amount of drawdown and the recovery of water levels of approximately 5 ft when the pump cycles on and off. Historically, water levels in this well varied only about 2 ft between pump cycles. The hydraulic head data continue to show that pumping in well USGS-1 produces a drawdown response in wells USGS-4 and USGS-8, which also increased in late November 2013. The increased magnitude of drawdown and the corresponding recovery of water levels during pump cycles are the result of a new dedicated pump installed in USGS-1 by the area ranchers and an increase in the frequency of pumping. Hydraulic head data from well LRL-7, which monitors the Coach drift, indicate that water levels have nearly recovered from the last sampling event in January 2011. Manual water level measurements from the re-entry well DD-1, which monitors the detonation cavity, confirmed that the transducer in this well had failed and that the transducer data obtained from June 2011 through February 2014 were in error.

This report is available on the LM Public Website at http://www.lm.doe.gov/gnome/Sites.aspx, and copies are sent to the individuals on the distribution list in Appendix B. Data collected during this and previous monitoring events (analytical and water levels) are available on the GEMS website at http://gems.lm.doe.gov/#site=GNO.

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Appendix A

Well Concentration Plots

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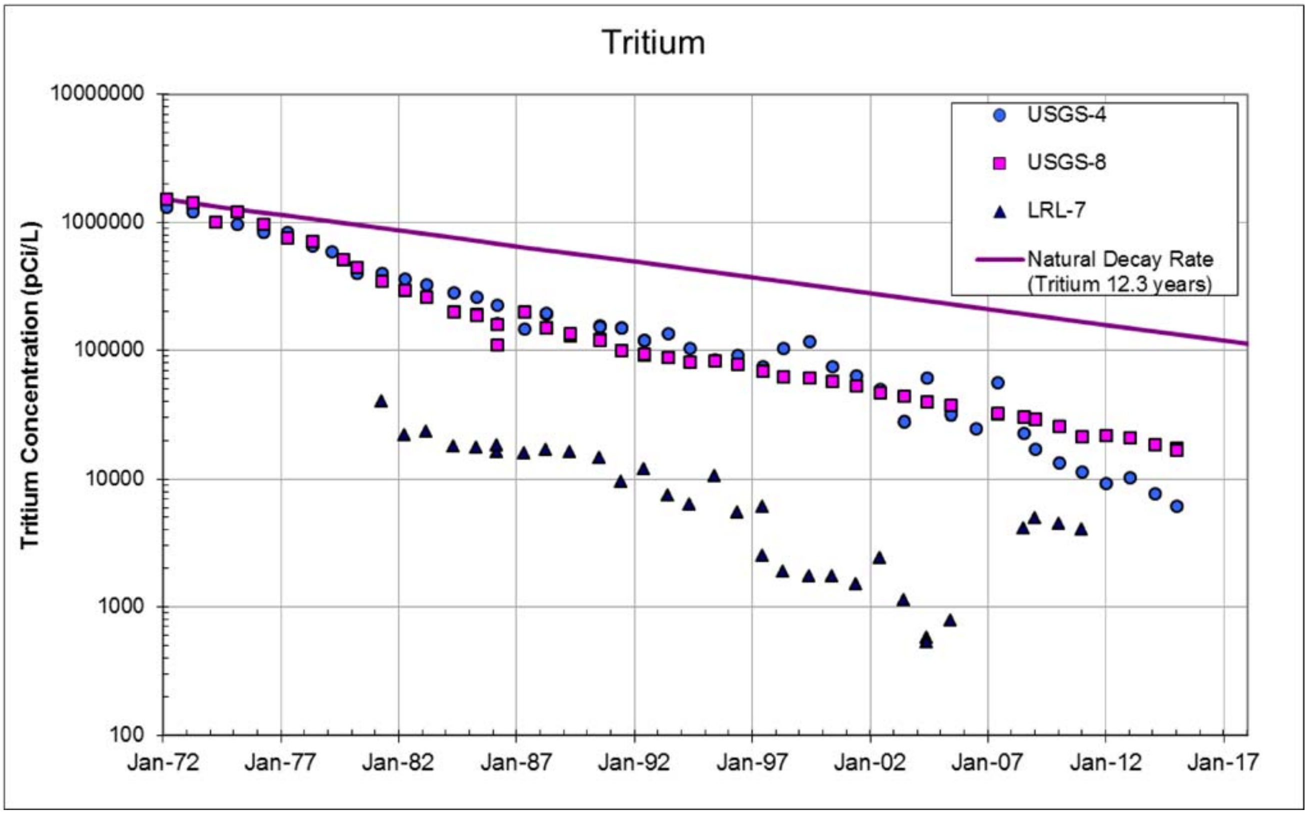

Chart 1. Tritium Concentrations at Wells USGS-4, USGS-8, and LRL-7

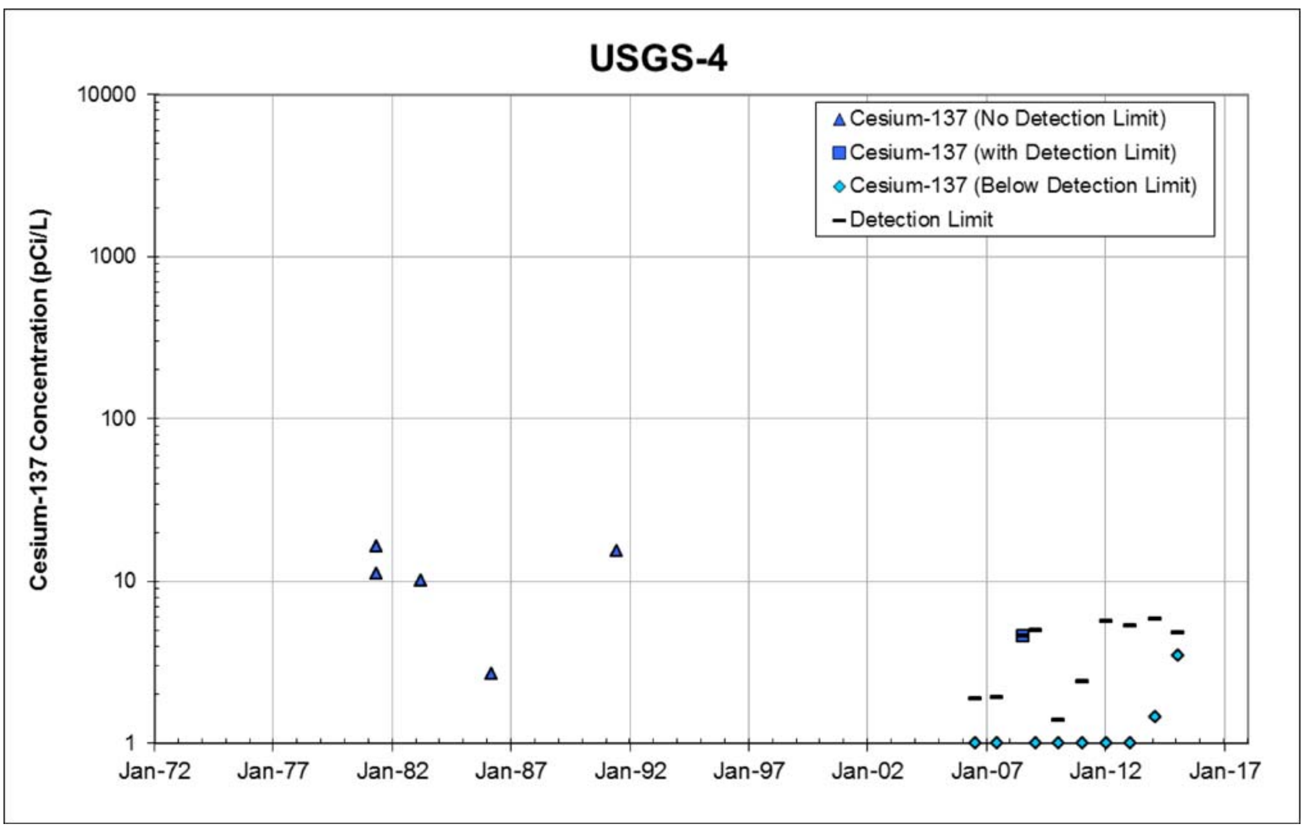

Chart 2. Cesium-137 Concentrations at Well USGS-4

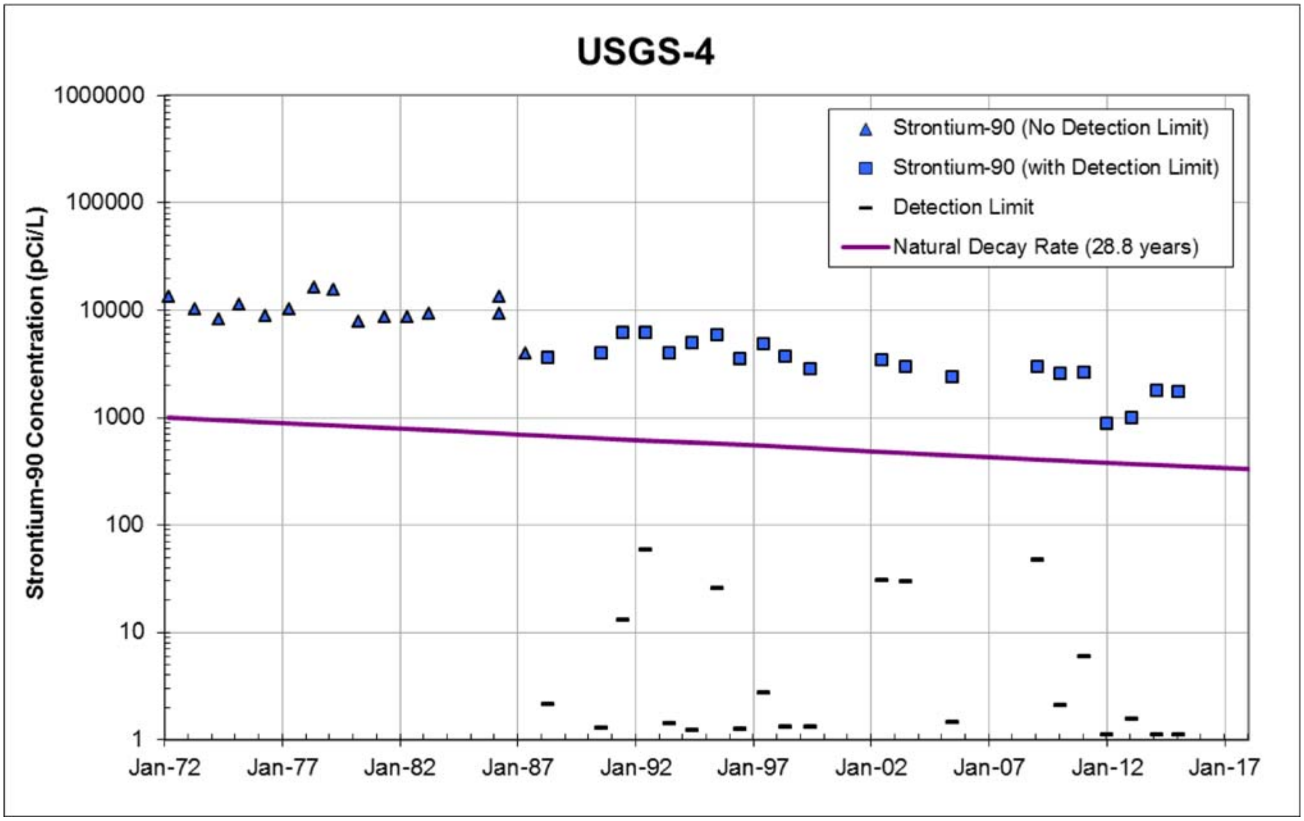

Chart 3. Strontium-90 Concentrations at Well USGS-4

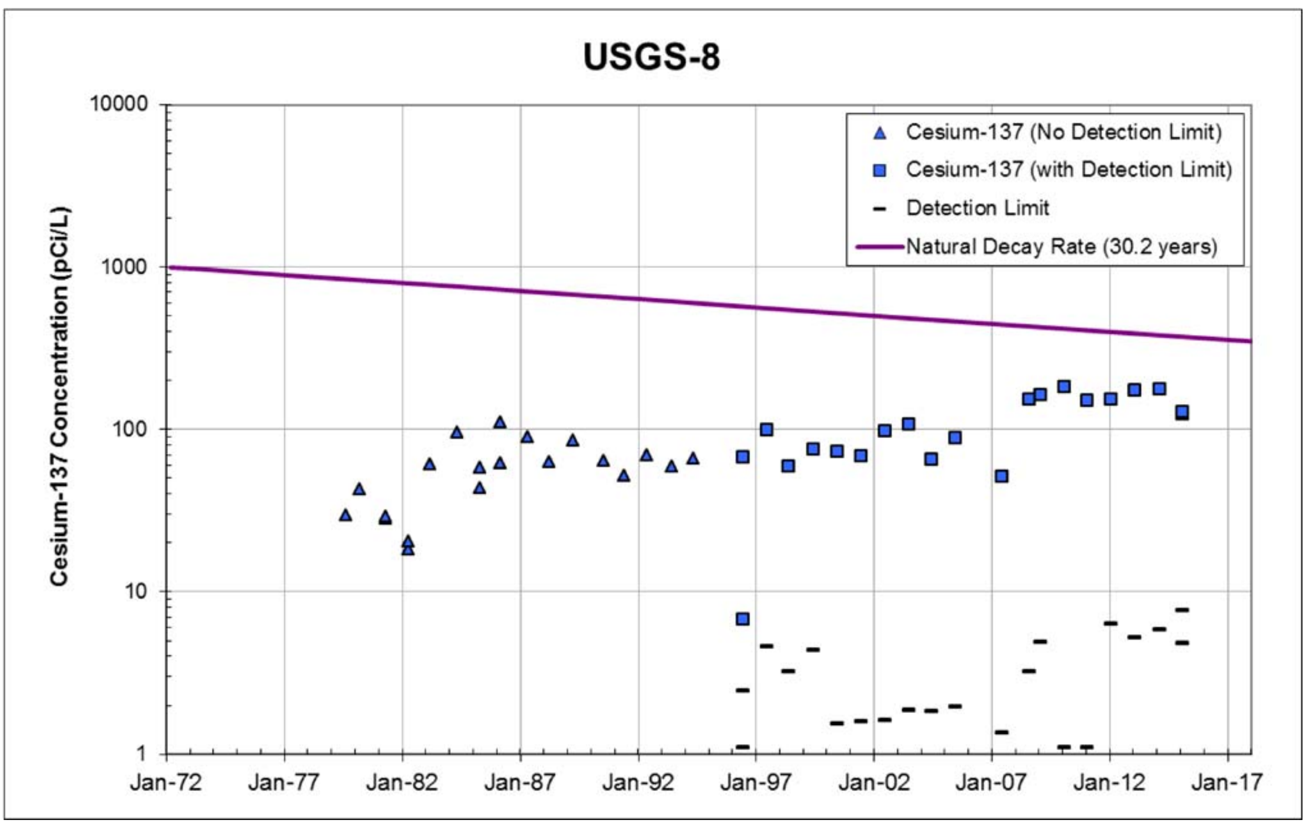

Chart 4. Cesium-137 Concentrations at Well USGS-8

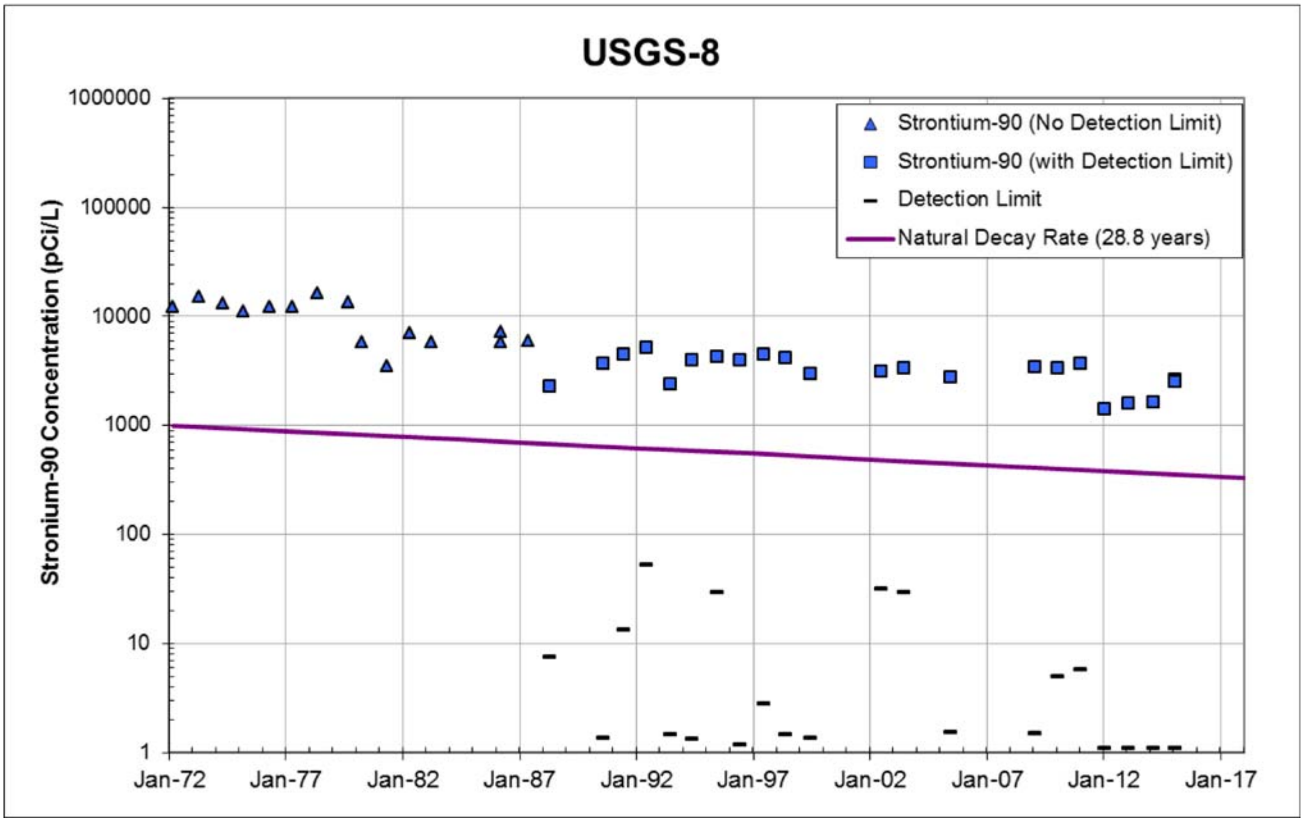

Chart 5. Strontium-90 Concentration at Well USGS-8

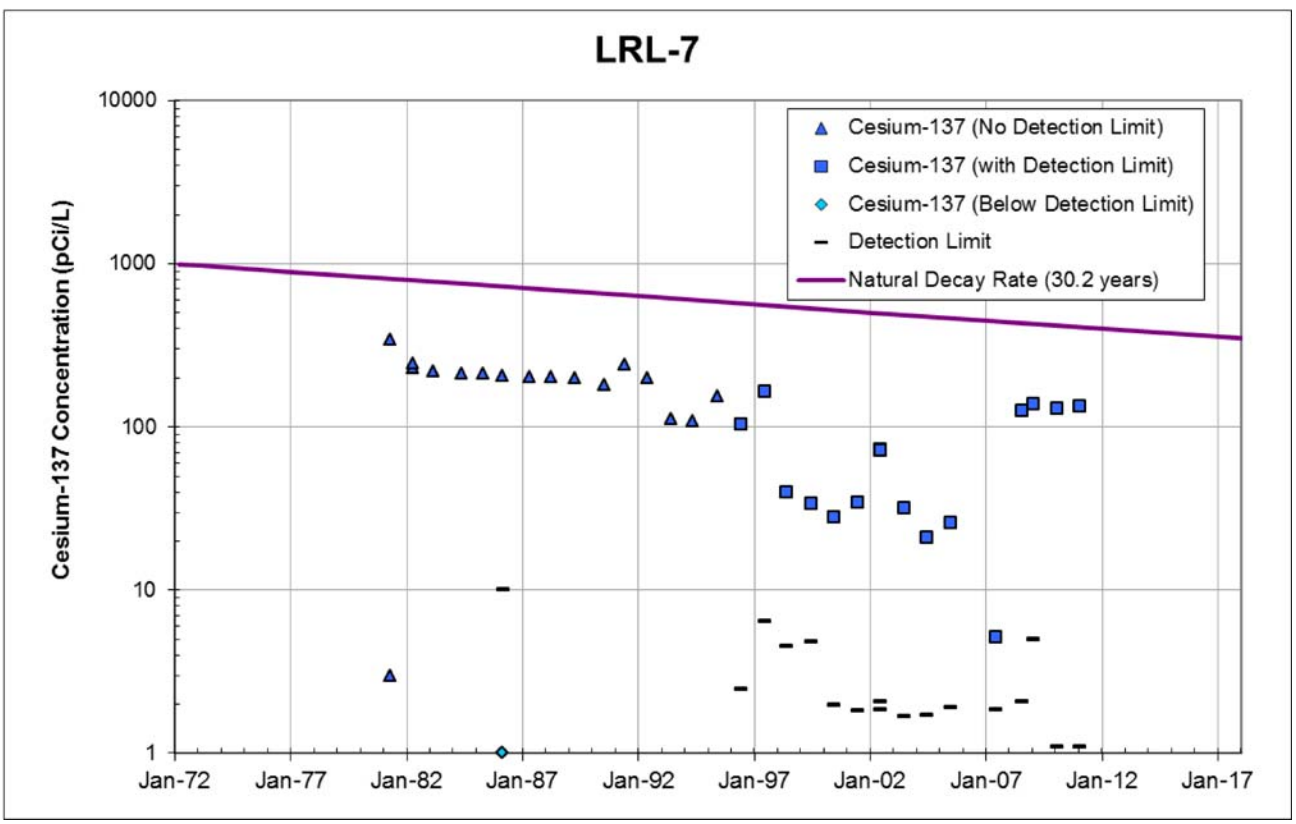

Chart 6. Cesium-137 Concentration at Well LRL-7

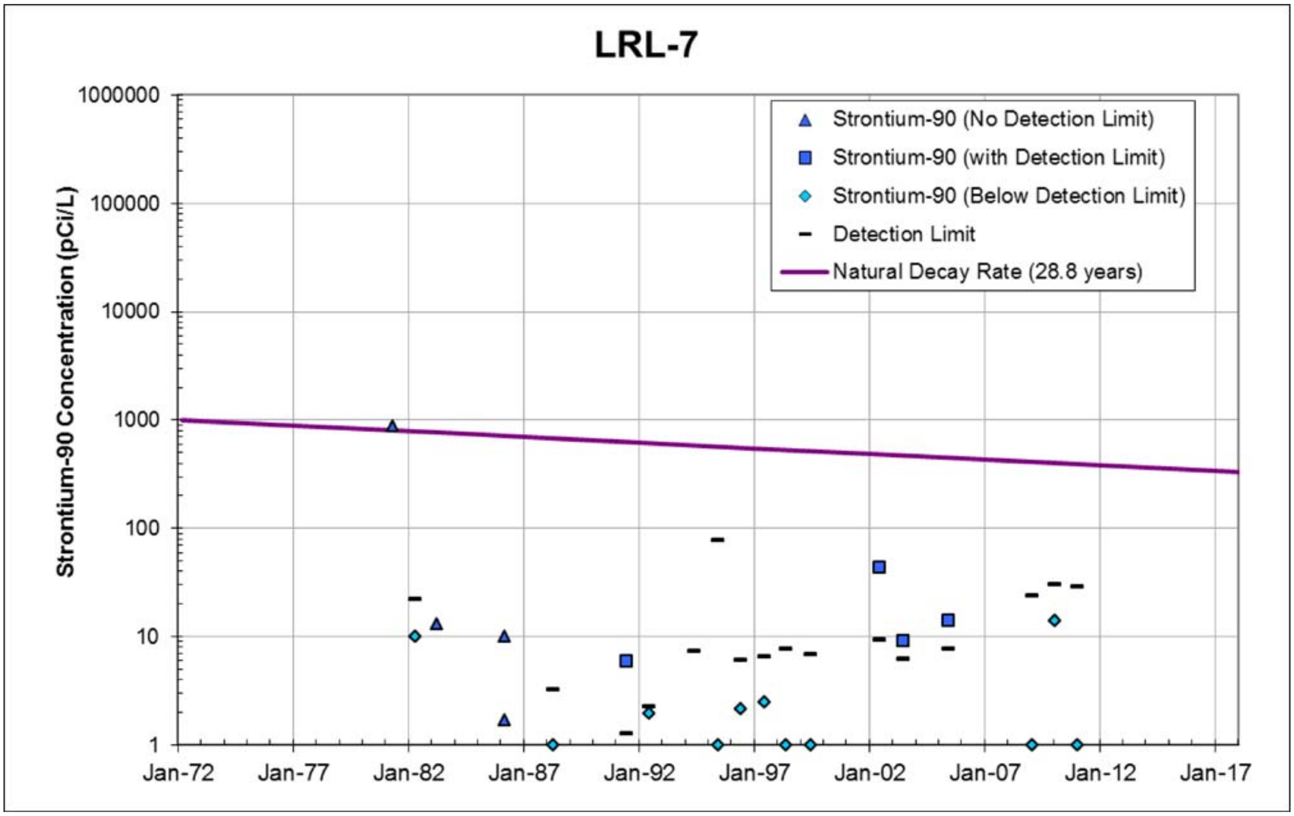

Chart 7. Strontium-90 Concentrations at Well LRL-7

Appendix B

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