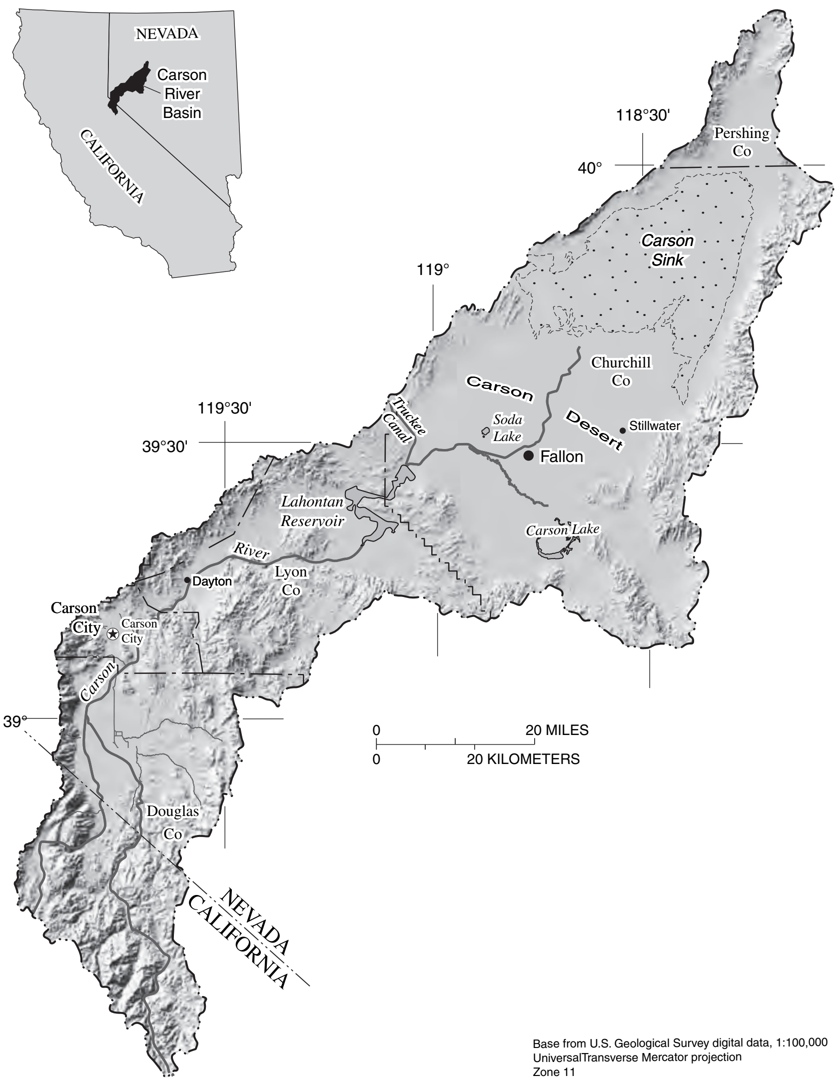
Methods and Data Used to Investigate Polonium-210 as a Source of Excess Gross-Alpha Radioactivity in Ground Water, Churchill County, Nevada



Open-File Report 2007-1231

U.S. Department of the Interior
U.S. Geological Survey

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By Ralph L. Seiler

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Conversion Factors

Multiply	By	To obtain
Length		
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Radioactivity		
picocurie per liter (pCi/L)	0.037	becquerel per liter (Bq/L)

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:
°C=(°F-32)/1.8
Vertical coordinate information is referenced to the insert datum name (and abbreviation) here for instance, "North American Vertical Datum of 1988 (NAVD 88)."
Horizontal coordinate information is referenced to the insert datum name (and abbreviation) here for instance, "North American Datum of 1983 (NAD 83)."
Altitude, as used in this report, refers to distance above the vertical datum.
Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Methods and Data Used to Investigate Polonium-210 as a Source of Excess Gross-Alpha Radioactivity in Ground Water, Churchill County, Nevada

By Ralph L. Seiler

Abstract

Ground water is the major source of drinking water in the Carson River Basin, California and Nevada. Previous studies have shown that uranium and gross-alpha radioactivities in ground water can be greater than U.S. Environmental Protection Agency Maximum Contaminant Levels, particularly in the Carson Desert, Churchill County, Nevada. Studies also have shown that the primary source of the gross-alpha radioactivity and alpha-emitting radionuclides in ground water is the dissolution of uranium-rich granitic rocks and basin-fill sediments that have their origins in the Sierra Nevada. However, ground water sampled from some wells in the Carson Desert had gross-alpha radioactivities greater than could be accounted for by the decay of dissolved uranium. The occurrence of polonium-210 (Po-210) was hypothesized to explain the higher than expected gross-alpha radioactivities.

This report documents and describes the study design, field and analytical methods, and data used to determine whether Po-210 is the source of excess gross-alpha radioactivity in ground water underlying the Carson Desert in and around Fallon, Nevada. Specifically, this report presents: 1) gross alpha and uranium radioactivities for 100 wells sampled from June to September 2001; and 2) pH, dissolved oxygen, specific conductance, and Po-210 radioactivity for 25 wells sampled in April and June 2007. Results of quality-control samples for the 2007 dataset are also presented.

Introduction

Ground water is the major source of drinking water in the Carson River Basin, CA and NV (fig. 1). Previous U.S. Geological Survey (USGS) studies have shown that uranium and gross-alpha radioactivities in ground water can be greater than U.S. Environmental Protection Agency Maximum Contaminant Levels (MCLs)[1], particularly in the Carson Desert at the downstream end of the flow system (Horton (1985), Lico and others, (1989), Lico and Rowe (1991), Welch (1993), Thomas and others (1993), Lico and Seiler (1994), and Seiler (2004). The primary source of the gross-alpha radioactivity and alpha-emitting radionuclides in ground water is the dissolution of uranium-rich granitic rocks and basin-fill sediments originating from the Sierra Nevada.

[1] The USEPA MCL for gross-alpha radioactivity is 15 pCi/L and excludes uranium and radon (U.S. Environmental Protection Agency, 2000).

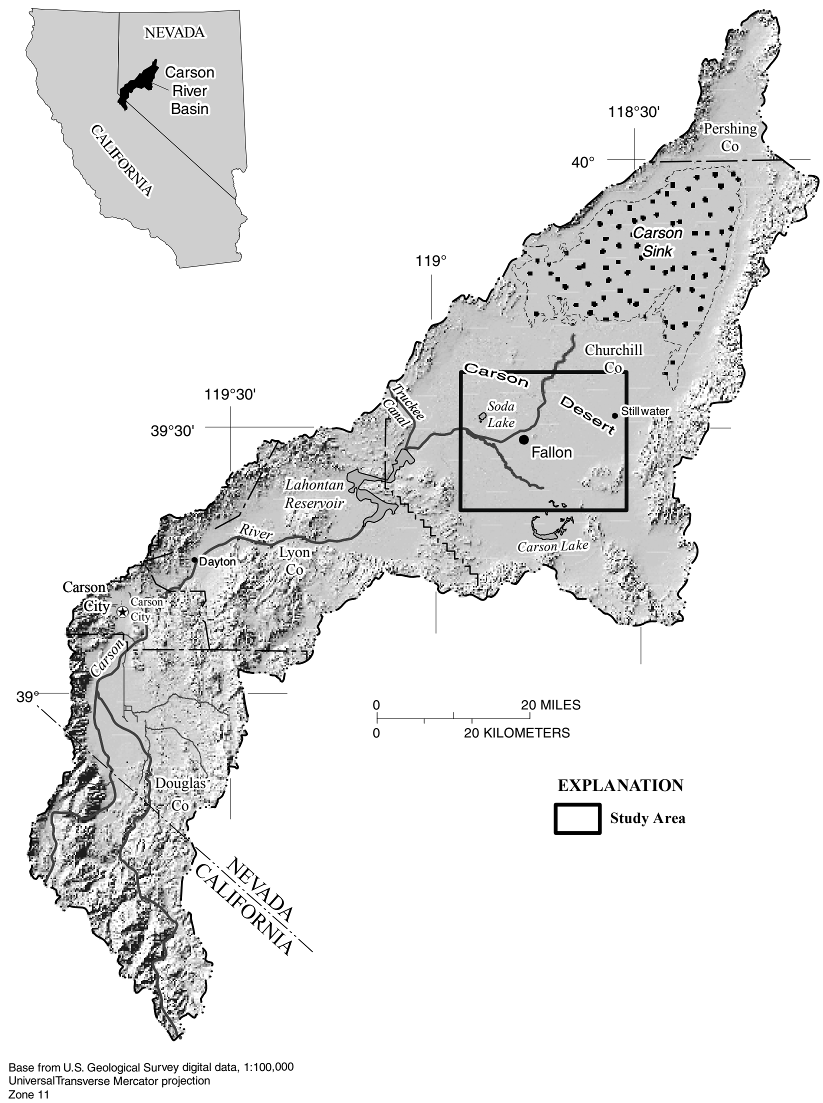

Figure 1. Map showing location of Carson River Basin and Carson Desert, California and Nevada.

Excess gross-alpha radioactivity (radioactivity that cannot be accounted for by the decay of dissolved uranium alone) was measured in 12 percent of the 204 ground-water samples collected prior to 1993 throughout the Carson River Basin (Thomas and others, 1993). All of the samples which had excess gross-alpha radioactivity were collected from wells in the Carson Desert. Samples from four wells were analyzed for a broader suite of radionuclides including uranium, radium, thorium and polonium-210 (Po-210) to test the hypothesis that the excess gross-alpha radioactivity was due to radionuclides other than uranium. One of the four samples had gross-alpha radioactivity of 11 pCi/L, 0.29 pCi/L of uranium, and about 20 pCi/L of Po-210. Thus, Thomas and others (1993) hypothesized that Po-210 may account for the excess gross-alpha radioactivity.

Purpose and Scope

One of the objectives of ongoing ground-water studies in the Carson River Basin is to determine whether Po-210 is the source of the excess alpha radioactivity in the aquifer underlying the Carson Desert in and around Fallon, NV. The purpose of this report is to document and describe the study design, field and analytical methods and data used to address this objective.

Description of Study Area

This study was done in the southern end of the Carson Desert, a closed basin at the terminus of the Carson River in Churchill County, NV (fig. 1). The floor of the Carson Desert in the Fallon area lies at an altitude of about 4,000 ft. The Carson Desert lies in the rainshadow of the Sierra Nevada and annually receives about 5 in. of precipitation (Maurer and others, 1996). Annual potential evaporation rates are more than 10 times this amount. Average temperatures range from about 18° to 90°F.

The principal land use in the Fallon area is agricultural; however, the area is rapidly urbanizing and agricultural land is being converted to residential areas. The Carson River is the source of most of the water used for agriculture. Water for irrigation is stored about 19 mi west of Fallon in Lahontan Reservoir. Fields typically are flood irrigated, water being delivered to the fields through an extensive network of mostly unlined canals. Drain water discharges to surface drains and is ultimately delivered to wildlife areas near Carson Lake and Stillwater.

Hydrogeology

The Carson Desert is in the Basin and Range physiographic province. During the Quaternary Period, the ancestral Carson, Truckee, and Walker Rivers carried sediment from the eastern slopes of the Sierra Nevada into ancient Lake Lahontan (Maurer, 1986). Glancy (1986) defined four aquifers including three basin-fill aquifers (shallow, intermediate, and deep) and a basalt aquifer in the Carson Desert (fig. 2). Unconsolidated Quaternary sediments from ancient Lake Lahontan and unconsolidated and semi-consolidated Tertiary sediments form the basin-fill aquifers. The shallow basin-fill aquifer extends from the water table (generally less than 10 ft) to a depth of 50 ft. The principal source of recharge to the shallow basin-fill aquifers is infiltration of surface water from the Carson River and numerous canals and ditches that crisscross the area. The Newlands Project constructed in the early 1900s supplied irrigation water to the Fallon area and resulted in water levels in the shallow aquifer rising to within 7–10 ft of land surface in irrigated areas (Maurer and others, 1996).

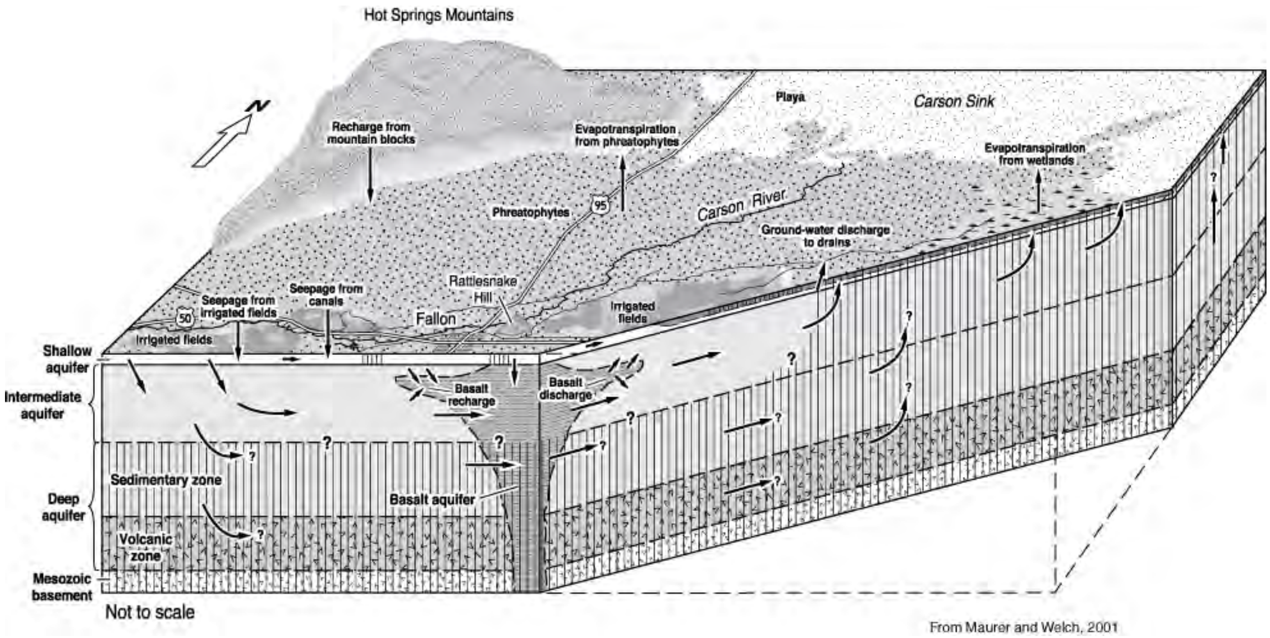

Figure 2. Conceptual model of ground-water flow in basin fill and basalt aquifers in the Carson Desert, Nevada. Boundaries between aquifers are dashed where uncertain; arrows depicting ground-water flow are queried where uncertain. Vertical lines indicate possible extent of nonpotable water.

The boundary between the shallow and intermediate basin-fill aquifers is not well defined and is poorly correlated with geologic units. The intermediate aquifer is a confined aquifer with water levels in wells rising to within 10–40 ft of land surface (Maurer and Welch, 2001). The vertical hydraulic gradient between the shallow and intermediate aquifers is downward west of Fallon and upward in the rest of the basin. Infiltration of Carson River water through the shallow aquifer provides most of the recharge to the intermediate aquifer (Maurer and others, 1996), with minor amounts of recharge from the basalt aquifer, upwelling geothermal water, and infiltration of precipitation in mountains surrounding the Carson Desert.

The boundary between the intermediate and deep aquifers is about 500–1,000 ft below land surface. There are few wells in the deep aquifer because of the ground-water salinity. This aquifer boundary may correspond to the boundary between Quaternary and Tertiary age sediments (Maurer and others, 1996).

The basalt aquifer is an asymmetrical, mushroom-shaped body, mostly buried by Lake Lahontan sediments. Municipal wells tapping the basalt aquifer supply drinking water to residents of the town of Fallon, Naval Air Station Fallon, and the Fallon Paiute-Shoshone Reservation. Eight municipal wells in the basalt aquifer supply water to about one-half of the people that reside in the Fallon area. Wells tapping the basalt aquifer are all more than 390 ft deep, except for one municipal well which is about 95 ft deep and near Rattlesnake Hill.

Almost all domestic wells in the Fallon area are less than 250 ft deep, and older domestic wells commonly are less than 50 ft deep. These very shallow wells typically are near the Carson River or major irrigation canals and depend on seepage losses as a source of water. Many wells drilled during the early- and mid-1990s were less than 100 ft deep, however, newer wells are required by law to be deeper than 100 ft because of their susceptibility to surface and near-surface contamination.

Methods

Selection of Sampling Sites

Domestic and public-supply wells were sampled in the Carson Desert in and around Fallon, Nevada during 2001 and 2007 (fig. 3). Data from 100 wells sampled during June—September 2001 (Seiler, 2004; Seiler and others, 2005) and 25 wells sampled during April and June 2007 are documented in this report.

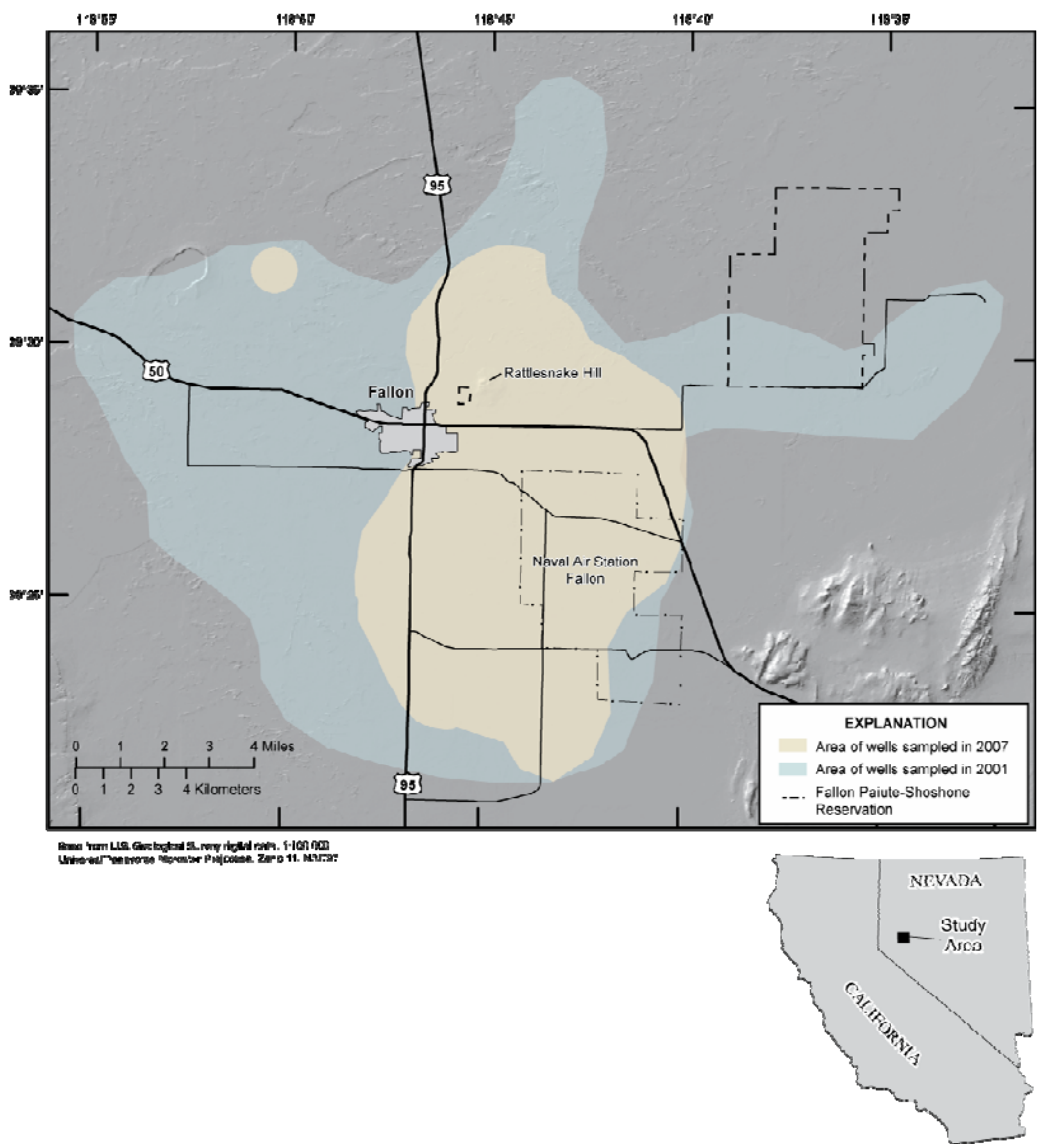

Figure 3. Areal extent of ground-water quality study areas for wells sampled in 2001 and 2007, Carson Desert, Nevada

In 2001, domestic wells were selected in the shallow and intermediate basin-fill aquifers to provide complete geographic coverage of the study area. Preference was given to wells with drillers' logs (Seiler, 2004).

In 2007, some of the 100 wells sampled in 2001 were targeted for re-sampling to test the hypothesis that measured excess gross-alpha radioactivity in ground water from the Carson Desert was due to Po-210. Nineteen of the 25 wells sampled in 2007 had been sampled in 2001 and were sampled to represent the full range of excess gross-alpha radioactivity measured. Of the 19 wells, three had excess gross-alpha radioactivity less than 1 pCi/L, three were between 1 and 10 pCi/L, and the remainder ranged from 10–108.94 pCi/L. Twenty-two of the 25 wells were sampled from the intermediate aquifer because excess gross alpha radioactivity was greatest in the intermediate aquifer. One sample was collected from the basalt aquifer; two samples were collected from the shallow aquifer. Six of the 25 wells were not sampled in 2001 and were selected to increase the spatial density of wells within the study area.

Sample Collection and Analysis

One sample per well was collected according to the protocol described by Koterba and others (1995). Water samples were collected from spigots near the wellhead before any water treatment. During sample collection, the water had contact only with materials in the well and pump system, Teflon® tubing, and stainless-steel connections. All tubing and other sampling materials were decontaminated before sampling collection following protocols described in Koterba and others (1995).

Wells were purged of at least three casing volumes and field measurements (temperature, pH, dissolved oxygen, and specific conductance) were allowed to stabilize before sample collection. Unfiltered samples for Po-210 were collected in 1 liter acid rinsed polyethylene bottles and acidified to pH <2 with 7.7 N ultrapure HNO_3. All samples for Po-210 analyses were shipped within 1–2 days of sample collection to the USGS contract laboratory by overnight delivery.

Analytical Methods

The concentration of the alpha-particle-emitting Po-210 radionuclide was determined using alpha spectrometry. The sample bottle was well rinsed in 8N HNO_3 to remove sorbed Po-210 from the container walls. The rinse solution was then added back to the sample and filtered through a 0.45 micron filter. After digestion of solids with concentrated HNO_3, the Po-210 was deposited on a silver disk. Sample counting time by alpha spectrometry was 100 minutes to ensure a contractual minimum detectable concentration of about 1 pCi/L. Special care was taken to minimize counter contamination for the volatile polonium radionuclides using the techniques outlined by Sill and Olson (1970). A Po-209 tracer was added to the sample to compute the yield. Results for Po-210 analyses were corrected to the time of sample collection.

Uranium isotopic analyses were done by alpha spectrometry following American Society for Testing and Materials (ASTM) method D3972-97 by a USGS contract laboratory in 2001. Samples collected in 2001 were analyzed for gross-alpha radioactivity at USGS National Water Quality Laboratory following EPA Method 900.0 within 72 hours of sample collection and again 30 days after sample collection using thorium-230 as the calibration standard.

Quality-Assurance and Quality-Control Samples

Contract and USGS laboratories follow quality-assurance plans which include evaluation of yields, recoveries, blanks and duplicates, as well as sample-specific parameters such as the critical level and minimum detectable concentration. Replicate samples for Po-210 analysis were collected at 4 of the 25 wells (16 percent). An equipment blank using USGS-certified inorganic blank water was collected at one well to verify adequate decontamination of sampling lines and equipment. Concentrations in replicate samples were within 3.5 percent of the environmental sample concentrations. The blank contained 0.2 pCi/L gross-alpha radioactivity.

Results

Table 1. Gross-alpha and uranium radioactivity for filtered samples and excess gross-alpha radioactivity in ground-water samples collected from 100 wells in the Carson Desert, Nevada in June–September 2001. Gross-alpha radioactivity determined using thorium-230 curve.
[Abbreviations: pCi/L, picocuries per liter; --, missing data]

		Gross-alpha radioactivity (pCi/L)		Uranium radioactivity (pCi/L)				Excess gross-alpha radioactivity[1] (pCi/L)	
Well name	**Date**	**72 hours**	**30 days**	**U-238**	**U-235**	**U-234**	**Sum[2]**	**72 hours**	**30 days**
Basalt aquifer									
CDP-01	06/19/01	3.16	1.51	0.78	0.05	0.94	1.77	1.39	-0.27
CDP-02	08/06/01	4.44	1.36	0.17	0.01	0.23	0.41	4.03	0.95
CDP-03	06/26/01	2.79	1.55	0.63	0.03	0.89	1.54	1.24	0.01
CDP-12[3]	07/11/01	2.03	-0.03	0.85	0.02	1.11	1.98	0.05	-2.01
FCL-10	06/19/01	2.61	6.24	0.66	0.05	0.89	1.60	1.01	4.65
FCL-11	06/26/01	3.83	2.56	0.61	0.02	0.80	1.43	2.40	1.14
FCL-12	06/18/01	1.46	2.19	0.68	0.02	0.92	1.62	-0.16	0.58
FCL-13	06/14/01	3.97	1.50	0.60	0.01	0.82	1.43	2.54	0.07
Shallow aquifer									
CDP-05	07/09/01	28.54	29.46	25.20	1.10	30.70	57.00	-28.46	-27.54
CDP-07	06/27/01	89.48	99.22	34.50	1.48	41.40	77.38	12.10	21.84
CDP-08	06/13/01	40.46	23.95	16.10	0.65	20.20	36.95	3.51	-13.00
CDP-14	06/25/01	26.81	15.28	15.30	0.62	19.30	35.22	-8.41	-19.94
CDP-17	06/26/01	39.64	45.20	25.40	1.14	31.10	57.64	-18.00	-12.44
CDP-19	06/25/01	13.34	12.43	7.63	0.32	9.70	17.65	-4.31	-5.22
CDP-21	06/12/01	8.76	11.17	4.13	0.16	5.26	9.55	-0.79	1.62
CDP-25	06/21/01	29.89	37.67	12.60	0.62	16.40	29.62	0.27	8.05
CDP-26	06/26/01	7.48	5.53	3.04	0.13	4.10	7.27	0.21	-1.74
CDP-34	07/18/01	64.49	54.51	29.60	1.26	38.10	68.96	-4.47	-14.45
FCL-02	06/12/01	4.20	2.82	1.17	0.05	1.41	2.63	1.57	0.19
FCL-06	06/11/01	11.24	6.09	2.70	0.12	3.37	6.19	5.06	-0.09
FCL-09	06/12/01	2.65	1.75	1.57	0.05	1.87	3.49	-0.84	-1.74
FCL-18	06/27/01	12.86	16.10	14.10	0.56	17.40	32.06	-19.20	-15.96
FCL-23	07/12/01	4.03	1.49	0.46	0.02	0.67	1.15	2.88	0.34

Well name	Date	Gross-alpha radioactivity (pCi/L) 72 hours	Gross-alpha radioactivity (pCi/L) 30 days	Uranium radioactivity (pCi/L) U-238	U-235	U-234	Sum[2]	Excess gross-alpha radioactivity[1] (pCi/L) 72 hours	30 days
Shallow aquifer—Continued									
FCL-30	07/10/01	134.15	145.43	92.80	5.00	109.00	206.80	-72.65	-61.37
FCL-36	07/18/01	30.16	21.81	25.00	1.31	31.00	57.31	-27.15	-35.50
FCL-38	07/16/01	5.64	2.52	1.68	0.09	2.29	4.06	1.57	-1.54
FCL-40	08/16/01	84.87	42.30	37.60	1.53	48.10	87.23	-2.36	-44.93
FCL-41	08/29/01	5.28	4.50	3.33	0.13	4.09	7.55	-2.27	-3.05
FCL-45	09/26/01	18.87	16.92	2.11	0.09	3.13	5.33	13.54	11.59
FCL-47	08/02/01	2.36	3.07	1.60	0.08	2.25	3.93	-1.57	-0.86
FCL-49	08/08/01	36.72	31.61	11.20	0.50	13.80	25.50	11.23	6.11
FCL-54	08/13/01	42.36	42.63	18.40	0.87	22.50	41.77	0.59	0.86
FCL-55	09/26/01	2.32	2.31	0.53	0.02	0.68	1.23	1.08	1.08
FCL-56[3]	08/07/01	42.38	43.20	20.70	0.73	25.00	46.43	-4.05	-3.23
FCL-58	08/27/01	34.23	41.80	19.80	0.77	23.90	44.47	-10.24	-2.68
FCL-64	08/16/01	38.64	25.68	20.60	0.85	25.80	47.25	-8.62	-21.57
FCL-67	09/10/01	2.82	2.47	2.16	0.10	2.71	4.97	-2.15	-2.50
Intermediate aquifer									
CDP-04	06/18/01	1.86	0.48	0.07	--	0.14	0.20	1.66	0.28
CDP-06	06/19/01	2.34	1.59	0.05	0.00	0.04	0.10	2.24	1.50
CDP-10	07/19/01	5.66	1.83	0.22	0.01	0.25	0.48	5.18	1.35
CDP-11	07/17/01	16.83	19.09	0.11	0.01	0.13	0.24	16.59	18.85
CDP-15	09/06/01	8.31	7.23	0.14	0.00	0.17	0.32	7.99	6.91
CDP-16	07/12/01	1.01	0.56	0.02	0.00	0.03	0.06	0.95	0.50
CDP-18[3]	06/13/01	45.66	41.08	0.32	0.02	0.45	0.80	44.86	40.28
CDP-20	06/25/01	1.40	3.16	0.28	0.01	0.47	0.75	0.64	2.41
CDP-22	06/13/01	1.80	0.80	0.26	0.02	0.33	0.61	1.19	0.19
CDP-23	06/20/01	8.90	3.23	0.07	0.00	0.08	0.15	8.75	3.08
CDP-27[3]	06/27/01	58.13	47.93	0.05	0.01	0.05	0.11	58.03	47.82
CDP-28[3]	06/19/01	35.76	34.62	0.13	--	0.18	0.31	35.45	34.32
CDP-29[3]	07/12/01	77.99	69.69	0.07	0.00	0.10	0.18	77.81	69.52
CDP-30[3]	07/19/01	47.18	39.70	0.59	0.02	0.90	1.50	45.68	38.19
CDP-37	07/11/01	3.00	0.75	0.45	0.02	0.59	1.06	1.94	-0.31
CDP-39[3]	06/20/01	54.02	52.60	13.10	0.56	16.90	30.56	23.46	22.04
FCL-01	06/11/01	9.67	6.22	3.41	0.12	4.36	7.89	1.78	-1.67
FCL-03	06/14/01	6.67	1.47	0.03	-0.01	0.01	0.03	6.64	1.43
FCL-04	06/11/01	4.04	1.24	0.23	0.01	0.39	0.63	3.41	0.61
FCL-05	06/12/01	1.04	0.33	0.12	0.00	0.21	0.34	0.70	-0.01
FCL-07	06/13/01	18.21	26.21	4.36	0.18	5.79	10.33	7.87	15.88
FCL-08	06/14/01	8.84	0.31	0.20	0.00	0.29	0.50	8.34	-0.19
FCL-14	08/14/01	9.43	1.44	2.18	0.08	2.78	5.04	4.39	-3.60
FCL-15[3]	06/21/01	15.33	13.61	0.10	0.00	0.13	0.24	15.09	13.37
FCL-16[3]	06/26/01	246.11	235.44	111.00	5.03	135.00	251.03	-4.92	-15.59
FCL-17	06/28/01	3.56	2.17	0.64	0.03	0.82	1.49	2.07	0.69
FCL-19[3]	06/27/01	6.46	5.70	0.22	0.01	0.22	0.45	6.02	5.25
FCL-20	07/10/01	5.84	5.55	0.03	0.01	0.06	0.10	5.73	5.45

Well name	Date	Gross-alpha radioactivity (pCi/L) 72 hours	30 days	Uranium radioactivity (pCi/L) U-238	U-235	U-234	Sum[2]	Excess gross-alpha radioactivity[1] (pCi/L) 72 hours	30 days
Intermediate aquifer—Continued									
FCL-21	06/28/01	5.19	0.43	0.18	0.01	0.23	0.42	4.77	0.01
FCL-22	06/28/01	1.10	0.75	0.38	0.02	0.47	0.87	0.24	-0.11
FCL-24	07/10/01	0.88	0.25	0.03	0.00	0.04	0.07	0.81	0.18
FCL-25	07/09/01	0.24	1.04	0.06	0.00	0.06	0.12	0.11	0.92
FCL-26	07/11/01	1.90	0.41	0.27	0.01	0.37	0.65	1.26	-0.23
FCL-27	07/11/01	2.19	1.16	0.01	0.00	0.00	0.02	2.18	1.14
FCL-28	07/17/01	13.84	12.50	0.14	0.00	0.11	0.24	13.59	12.26
FCL-29	08/15/01	3.75	2.70	0.10	0.00	0.13	0.23	3.52	2.46
FCL-31[3]	07/18/01	11.49	7.14	0.21	0.01	0.30	0.52	10.98	6.62
FCL-32	07/10/01	0.64	0.66	0.04	0.01	0.12	0.17	0.47	0.49
FCL-33[3]	07/16/01	17.14	16.17	3.17	0.12	4.16	7.45	9.69	8.72
FCL-34	07/18/01	6.95	10.30	3.89	0.17	4.88	8.94	-1.99	1.36
FCL-35	07/11/01	2.36	1.40	0.19	0.01	0.18	0.37	1.99	1.03
FCL-37	07/17/01	2.91	3.35	0.06	0.00	0.09	0.15	2.76	3.20
FCL-39	08/01/01	8.35	6.29	1.44	0.07	1.87	3.38	4.97	2.91
FCL-42[3]	07/30/01	14.65	12.60	0.03	0.00	0.06	0.10	14.55	12.50
FCL-43	07/30/01	5.59	3.21	0.12	0.01	0.12	0.25	5.35	2.96
FCL-44	07/31/01	2.86	1.34	0.25	0.02	0.46	0.73	2.13	0.62
FCL-46	07/31/01	3.99	1.87	0.50	0.03	0.52	1.05	2.94	0.82
FCL-48	08/02/01	6.48	4.39	3.20	0.17	4.18	7.55	-1.07	-3.16
FCL-50[3]	08/08/01	110.56	97.12	0.65	0.03	0.95	1.63	108.94	95.50
FCL-51[3]	08/07/01	30.22	18.72	0.30	0.01	0.35	0.66	29.57	18.06
FCL-52	08/06/01	0.94	0.31	0.05	0.00	0.13	0.19	0.76	0.12
FCL-53	08/15/01	7.28	4.47	3.16	0.16	4.10	7.42	-0.13	-2.94
FCL-57	08/29/01	2.56	0.69	0.56	0.02	0.67	1.25	1.31	-0.55
FCL-59[3]	09/25/01	47.42	40.77	0.13	0.01	0.18	0.32	47.10	40.46
FCL-60[3]	08/09/01	16.66	4.91	0.07	0.00	0.07	0.14	16.52	4.77
FCL-61[3]	08/30/01	8.69	-2.02	0.08	0.00	0.10	0.18	8.51	-2.19
FCL-62	08/14/01	2.77	-1.02	0.02	0.00	0.03	0.05	2.72	-1.07
FCL-63	09/10/01	1.01	0.59	0.32	0.01	0.38	0.72	0.29	-0.12
FCL-65	08/28/01	1.38	0.24	0.10	0.02	0.19	0.31	1.07	-0.07
FCL-68	09/25/01	2.99	2.49	0.03	0.00	0.05	0.08	2.92	2.41
FCL-69	09/24/01	1.23	0.24	0.11	0.00	0.22	0.33	0.90	-0.09
FCL-70	09/26/01	21.77	37.74	5.74	0.22	7.04	13.00	8.77	24.73
FCL-71	09/27/01	3.58	-0.72	0.15	0.01	0.13	0.28	3.29	-1.00

[1] Excess gross-alpha radioactivity is calculated as the gross-alpha radioactivity minus the sum of the activities of all uranium isotopes.

[2] Sum of U-238, U-235, and U-234.

[3] Well re-sampled in 2007 (table 2)

Table 2. Polonium-210 and other selected water-quality constituents in ground-water samples collected from 25 wells in the Carson Desert, Nevada in April and June 2007. All polonium-210 samples are unfiltered, except as noted.

[Abbreviations: µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; pCi/L, picocuries per liter; --, missing data; <, less than; CSU, Combined Standard Uncertainty; Lc, sample-specific critical level]

Well name	Well depth	Date	Time	pH	Specific Conductance (µS/cm)	Dissolved Oxygen (mg/L)	Excess gross-alpha radioactivity[a] (pCi/L)	Polonium-210 (pCi/L)		
								Radio-activity	1σ[b] CSU	Lc
Basalt aquifer										
CDP-12	95	4/11/07	0905	9.48	930	0.51	0.05	0.216	0.022	0.004
Shallow aquifer										
P68[c]	28[d]	4/10/07	1215	7.54	2100	0.12	--	0.095	0.015	0.007
FCL-56	33	4/11/07	1205	8.88	1410	<0.1	-4.05	0.118	0.015	0.008
Intermediate aquifer										
CDP-18	129	4/25/07	1050	9.24	633	--	44.86	41.8	1.5	0.020
CDP-27	120	6/13/07	1030	9.27	503	<0.1	58.03	67.5	2.2	0.008
Replicate								68.3	2.1	0.005
CDP-28	144	6/12/07	1310	9.22	544	<0.1	35.45	39.8	1.3	0.004
CDP-29	128	4/25/07	0850	9.23	518	--	77.81	76.0	2.6	0.013
Replicate								78.7	2.7	0.017
CDP-30	180	6/11/07	1100	8.43	1820	--	45.68	49.8	1.5	0.005
CDP-39	96	4/24/07	1120	8.50	3490	--	23.46	25.0	1.1	0.028
FCL-15	106	4/24/07	0845	9.03	379	--	15.09	14.25	0.52	0.007
FCL-16	78	6/13/07	1220	8.31	2790	<0.1	-4.92	0.061	0.011	0.006
FCL-19	107	4/10/07	0845	9.34	1100	0.34	6.02	3.17	0.14	0.014
FCL-31	125	6/19/07	0825	9.27	566	0.30	10.98	6.76	0.38	0.018
FCL-33	110	6/18/07	0855	9.00	945	<0.1	9.69	9.88	0.56	0.019
FCL-42	120	6/19/07	1030	9.03	479	<0.1	14.55	18.0	1.0	0.021
FCL-50	133	4/09/07	0925	8.74	2380	<0.1	108.94	64.3	2.0	0.004
Replicate								61.8	1.9	0.005
FCL-50[e]								51.8	1.6	0.006
FCL-51	156	6/13/07	0850	9.13	577	0.30	29.57	25.76	0.88	0.008
FCL-59	105	4/24/07	1320	9.19	596	--	47.1	50.8	1.8	0.008
FCL-60	130	6/11/07	1100	8.62	5120	--	16.52	0.296	0.024	0.007
FCL-61	103	6/11/07	1315	8.57	5310	--	8.51	0.756	0.042	0.007
Fpo-01[c]	123	4/25/07	1300	8.46	6810	--	--	0.259	0.049	0.037
Fpo-02[c]	137	6/12/07	0905	9.08	634	<0.1	--	44.4	1.4	0.006
Fpo-03[c]	143	6/12/07	1120	9.11	1070	<0.1	--	9.08	0.52	0.020
Fpo-05[c]	155	6/18/07	1100	8.87	983	<0.1	--	36.5	2.0	0.023
Fpo-06[c]	138	6/19/07	1205	9.15	584	<0.1	--	37.8	1.5	0.010
Replicate								37.7	1.6	0.013

[a] Excess 72 hour gross-alpha radioactivity measurement from 2001 sampling (see table 1).

[b] One standard deviation.

[c] Wells not sampled in 2001.

[d] Well depth reported by owner.

[e] Filtered through 0.45 µm capsule filter.

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