DOE/NV/25946--1977

NEVADA NATIONAL SECURITY SITE

2013 DATA REPORT: GROUNDWATER MONITORING PROGRAM AREA 5 RADIOACTIVE WASTE MANAGEMENT SITE

February 2014

Prepared for:

U.S. Department of Energy
National Nuclear Security Administration
Nevada Field Office

Prepared by:

National Security Technologies, LLC
Las Vegas, Nevada

DISCLAIMER

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the U.S. Government or any agency thereof.

Available for sale to the public from:

U.S. Department of Commerce
National Technical Information Service
5301 Shawnee Road
Alexandria, VA 22312
Telephone: (800) 553-6847
Fax: (703) 605-6900
E-mail: orders@ntis.gov
Online ordering: http://www.ntis.gov/help/ordermethods.aspx

Available electronically at http://www.osti.gov/bridge

Available for a processing fee to the U.S. Department of Energy and its contractors, in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
Telephone: (865) 576-8401
Fax: (865) 576-5728
E-mail: reports@adonis.osti.gov

DOE/NV/25946--1977

NEVADA NATIONAL SECURITY SITE

2013 DATA REPORT: GROUNDWATER MONITORING PROGRAM AREA 5 RADIOACTIVE WASTE MANAGEMENT SITE

February 2014

Prepared for:

U.S. Department of Energy
National Nuclear Security Administration
Nevada Field Office

Prepared by:

National Security Technologies, LLC
Las Vegas, Nevada

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

ac	acre
AMSL	above mean sea level
BN	Bechtel Nevada
°C	degrees Celsius
Ca	calcium
CFR	Code of Federal Regulations
Cl	chloride
cm	centimeter
cm/s	centimeter per second
DOE	U.S. Department of Energy
E	easting
°F	degrees Fahrenheit
F	fluoride
Fe	iron
ft	foot
ft/s	foot per second
gal.	gallon
GW	groundwater
ha	hectare
HCO_3	bicarbonate
HDPE	high density polyethylene
IL	investigation level
in.	inch
K	potassium
l	liter
LCA	lower carbonate aquifer
m	meter
m/m	meter change in water level elevation per meter change in gradient direction
m^3/m^3	void space volume (cubic meter) per total aquifer volume (cubic meter)
MDC	minimum detectable concentration
MDL	method detection limit
Mg	magnesium
mg/L	milligram per liter
mmhos/cm	millimhos per centimeter
Mn	manganese
N	northing
Na	sodium
NDEP	Nevada Division of Environmental Protection
NNSS	Nevada National Security Site
PCB	polychlorinated biphenyl
pCi/L	picocurie per liter
QL	quantification limit
RCRA	Resource Conservation and Recovery Act
REECo	Reynolds Electrical and Engineering Company, Inc.
RWMS	Radioactive Waste Management Site

LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS (Continued)

SC	specific conductance
SiO_2	silicate
SO_4	sulfate
TOC	total organic carbon
TOX	total organic halides
µg/L	microgram per liter

EXECUTIVE SUMMARY

This report is a compilation of the groundwater sampling results from the Area 5 Radioactive Waste Management Site (RWMS) at the Nevada National Security Site, Nye County, Nevada. Groundwater samples from the aquifer immediately below the Area 5 RWMS have been collected and analyzed and static water levels have been measured in this aquifer since 1993. This report updates these data to include the 2013 results. Beginning with this report, analysis results for leachate collected from the mixed-waste cell at the Area 5 RWMS (Cell 18) are also included.

During 2013, groundwater samples were collected and static water levels were measured at three wells surrounding the Area 5 RWMS. Groundwater samples were collected at wells UE5PW-1, UE5PW-2, and UE5PW-3 on March 5 and August 13, 2013, and static water levels were measured at each of these wells on March 4, June 6, August 12, and October 15, 2013. Groundwater samples were analyzed for the following indicators of contamination: pH, specific conductance, total organic carbon, total organic halides, and tritium. General water chemistry (cations and anions) was also measured. Results from samples collected in 2013 are within the limits established by agreement with the Nevada Division of Environmental Protection for each analyte. The data from the shallow aquifer indicate that there has been no measurable impact to the uppermost aquifer from the Area 5 RWMS and there were no significant changes in measured groundwater parameters compared to previous years.

Leachate from above the primary liner of Cell 18 drains into a sump and is collected in a tank at the ground surface. Since Cell 18 began receiving waste in January 2011, 87,477 liters (l) (23,109 gallons [gal.]) of leachate has been collected in the tank. During 2013, 45,898 l (12,125 gal.) of leachate were collected. Samples were collected from the tank when the leachate volume approached the 3,000-gallon tank capacity. Leachate samples have been collected eleven times since January 2011. During 2013, samples were collected on March 27, July 31, October 3, November 6, and December 18. Each leachate sample was analyzed for toxicity characteristic contaminants and polychlorinated biphenyls (PCB). Beginning with the sample from July 31, 2013, pH and specific conductance were also measured. Leachate analysis results show no evidence of contamination. Results for toxicity characteristic contaminants are all below regulatory levels and most are below detection limits. No PCBs were detected in any sample. Results for pH and specific conductance are also within expected ranges. After analysis, leachate was pumped from the collection tank and used in Cell 18 for dust control.

The report contains an updated cumulative chronology for the Area 5 RWMS Groundwater Monitoring Program and a brief description of the site hydrogeology.

THIS PAGE INTENTIONALLY LEFT BLANK

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This report is a compilation of sampling results for groundwater and leachate collected from the Area 5 Radioactive Waste Management Site (RWMS) at the Nevada National Security Site (NNSS), Nye County, Nevada. Groundwater samples were collected from three monitoring wells surrounding the Area 5 RWMS (Pilot Wells), and leachate samples were collected from the lined mixed-waste disposal cell inside the Area 5 RWMS (Cell 18). Data from calendar year 2013 are included.

The NNSS is an approximately 3,561 square kilometer (1,375 square mile) restricted-access federal facility located approximately 105 kilometers (65 miles) northwest of Las Vegas, Nevada (Figure 1-1). The three Pilot Wells, UE5PW-1, UE5PW-2, and UE5PW-3, are located just outside the Area 5 RWMS. These wells are used to monitor groundwater in the top aquifer below the Area 5 RWMS. The mixed-waste disposal cell and leachate collection tank are located in the northeast corner of the Area 5 RWMS (Figure 1-2). In addition to groundwater and leachate monitoring results, this report includes information regarding site hydrogeology, well construction, sample collection, and meteorological data measured at the Area 5 RWMS.

The disposal of low-level radioactive waste and mixed low-level radioactive waste at the Area 5 RWMS is regulated by U.S. Department of Energy (DOE) Order DOE O 435.1, “Radioactive Waste Management” (DOE 2001). The disposal of mixed low-level radioactive waste is also regulated by the State of Nevada under the Resource Conservation and Recovery Act (RCRA) regulation Title 40 Code of Federal Regulations (CFR) Part 265, “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities” (CFR 1999). The format of this report was requested by the Nevada Division of Environmental Protection (NDEP) in a letter dated August 12, 1997. The appearance and arrangement of this document have been modified slightly since that date to provide additional information, to facilitate the readability of the document, and to include the leachate monitoring results. The objective of this report is to satisfy any Area 5 RWMS groundwater monitoring reporting agreements between DOE and NDEP.

1.2 SITE HYDROGEOLOGY

The Area 5 RWMS is located in northern Frenchman Flat in the southeast portion of the NNSS. Frenchman Flat is a topographically closed basin. Erosion of surrounding mountains has resulted in accumulation of thick, unsaturated, alluvial deposits above volcanic rocks within the basin (Bright et al. 2001). Alluvial and volcanic aquifers are present beneath the Area 5 RWMS and are believed to extend throughout much of the Frenchman Flat basin (Bechtel Nevada [BN] 2005). In this south-central portion of the NNSS, a moderately thick volcanic confining unit, consisting of altered volcanic rocks, separates the shallow alluvial and volcanic aquifers from the underlying regional lower carbonate aquifer (LCA) (BN 2005; Laczniak et al. 1996).

The groundwater type from the three monitoring wells (UE5PW-1, UE5PW-2, and UE5PW-3) is sodium-bicarbonate. This type of groundwater is common in the upper aquifers in Frenchman Flat. UE5PW-1 and UE5PW-2 are completed in the alluvial aquifer, and UE5PW-3 is completed in the volcanic aquifer. Similar groundwater chemistry and water table elevations in UE5PW-1, UE5PW-2, and UE5PW-3 indicate that the alluvial and volcanic aquifers are locally connected near the Area 5 RWMS.

Some vertical groundwater flow occurs between the uppermost aquifers in Frenchman Flat and the underlying regional LCA (Navarro Nevada Environmental Services 2010). Based on measured groundwater elevations above mean sea level (AMSL) (Figure 1-3), the lateral hydraulic gradient in the upper Frenchman Flat aquifer is very small. Lateral groundwater movement beneath Frenchman Flat primarily occurs within the deep carbonate aquifer and is generally from the northeast to southwest. It eventually discharges in Amargosa Valley and Ash Meadows in southwest Nevada and Death Valley in California (Figure 1-4) (Laczniak et al. 1996).

For more detailed descriptions of Area 5 RWMS site characteristics, refer to the report *Revised Area 5 Radioactive Waste Management Site, Outline of a Comprehensive Groundwater Monitoring Program* (BN 1998).

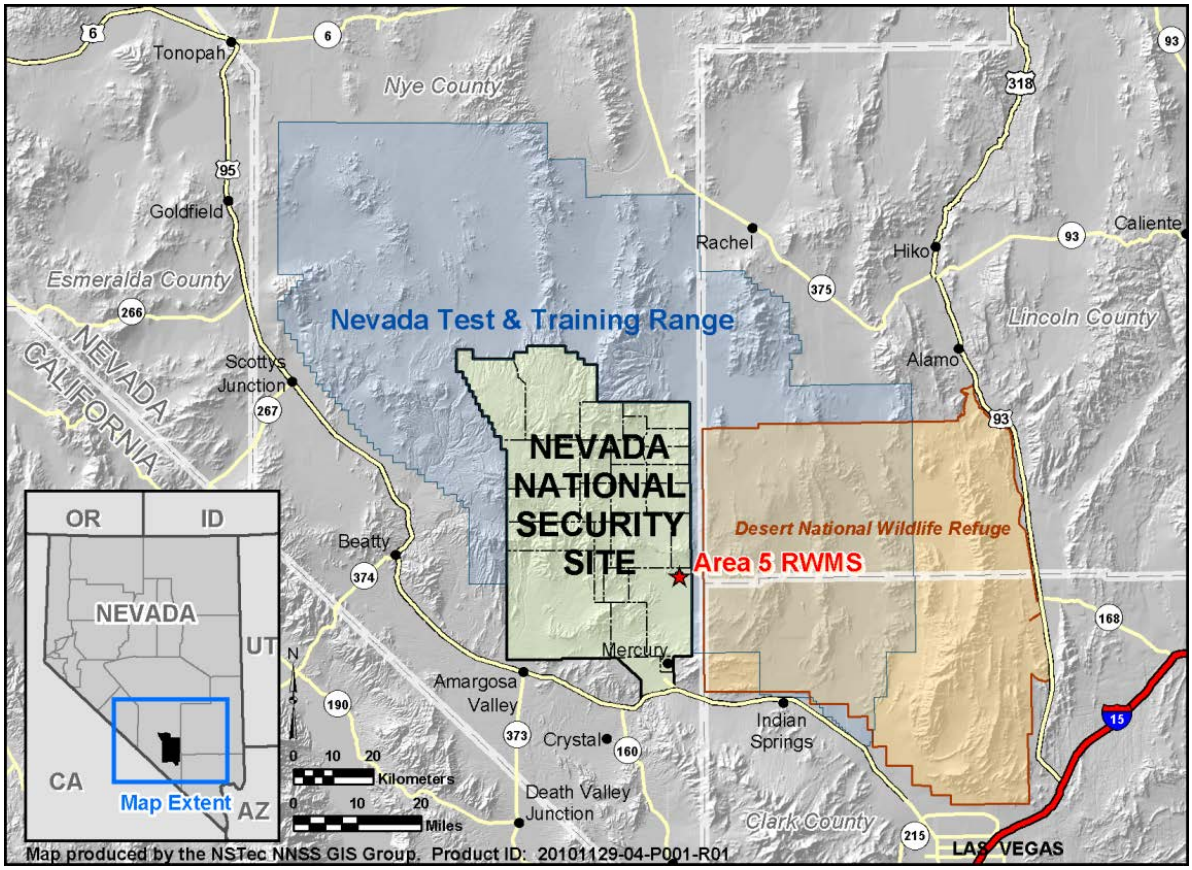

Figure 1-1. Location of Area 5 RWMS and Nevada National Security Site within Nevada

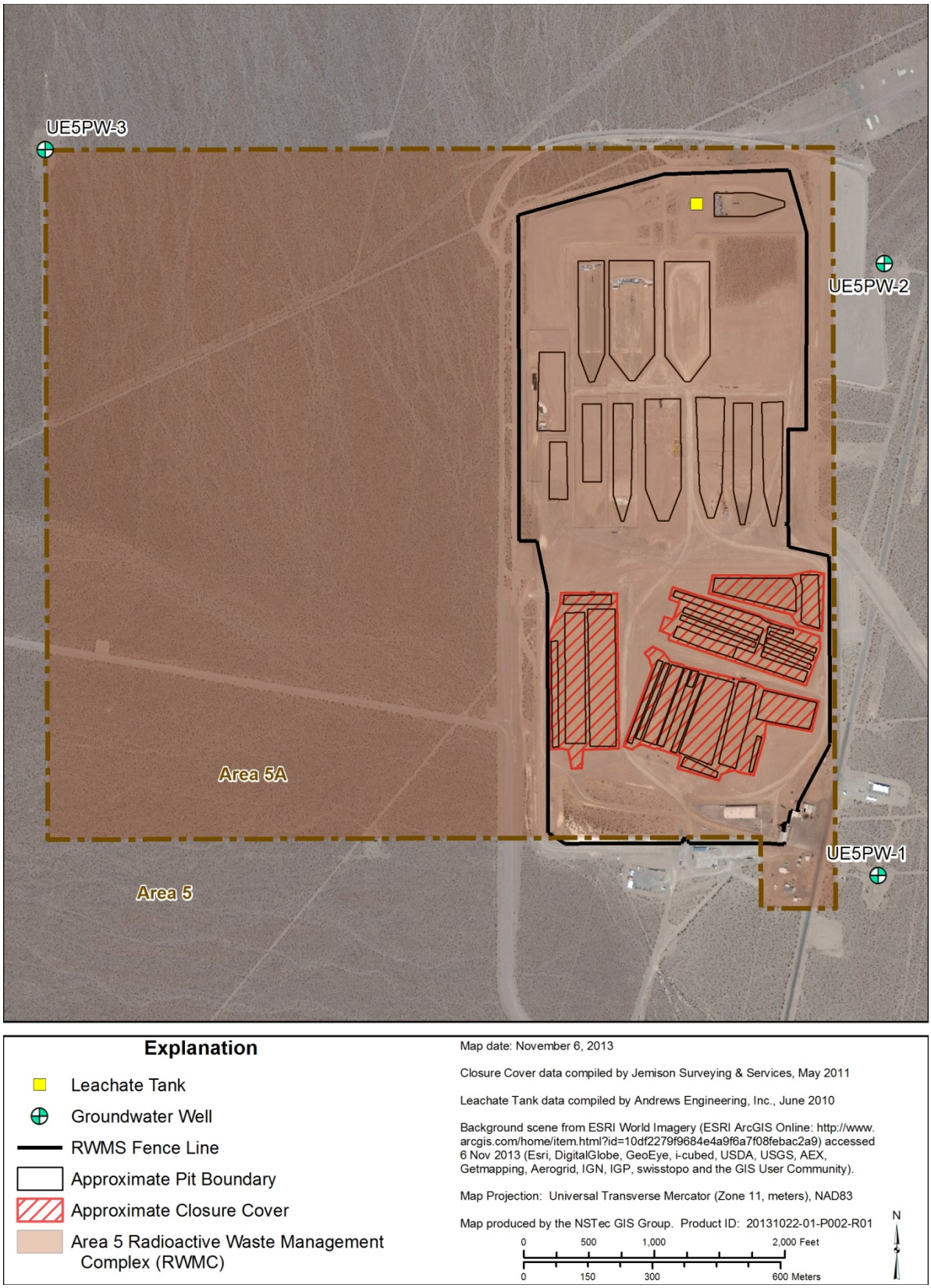

Figure 1-2. Location of Pilot Wells and Leachate Collection Tank at Area 5 RWMS

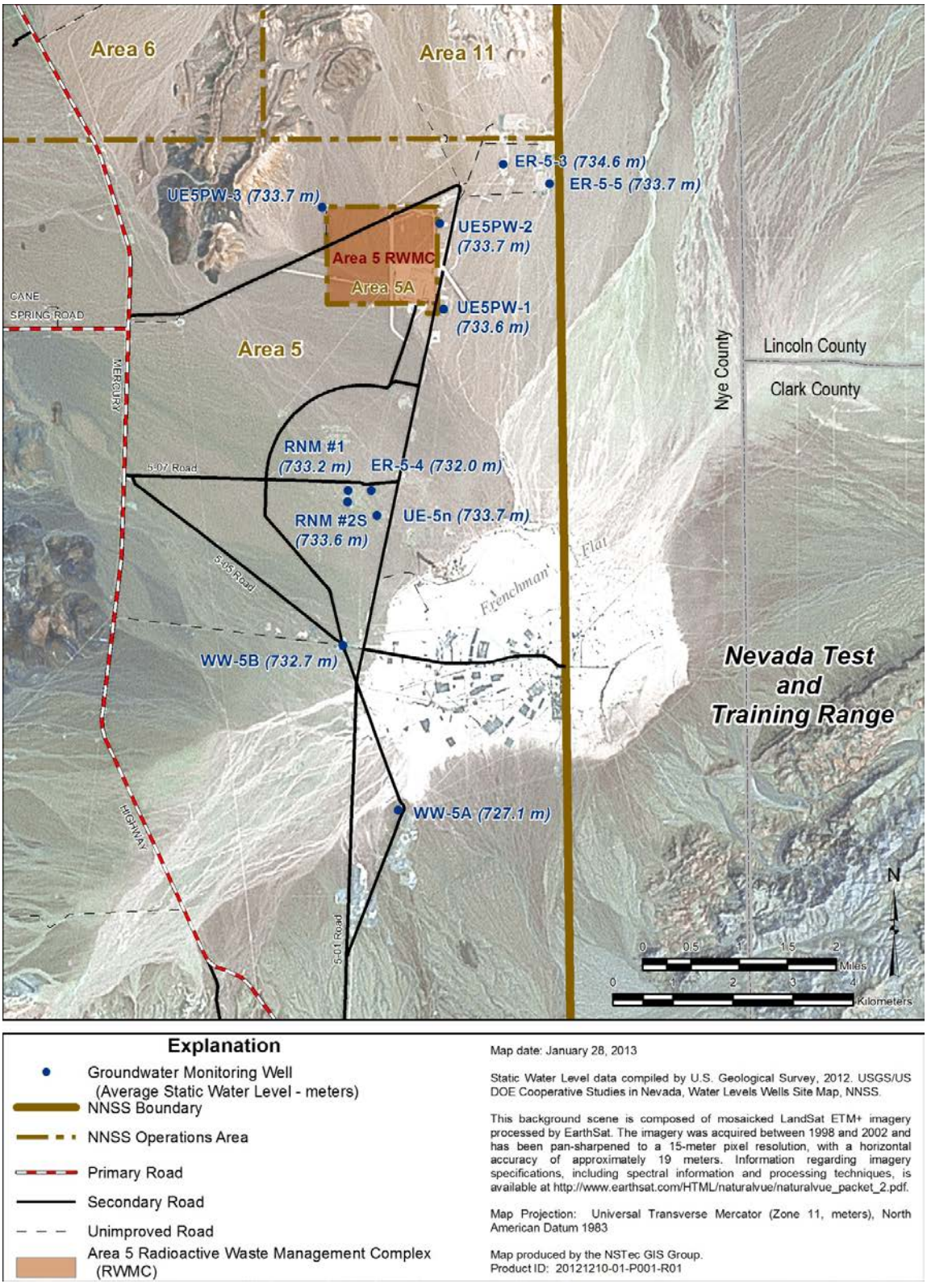

Figure 1-3. Average Water Level Elevation at Groundwater Monitoring Wells in the Vicinity of the Area 5 RWMS (U.S. Geological Survey 2013)

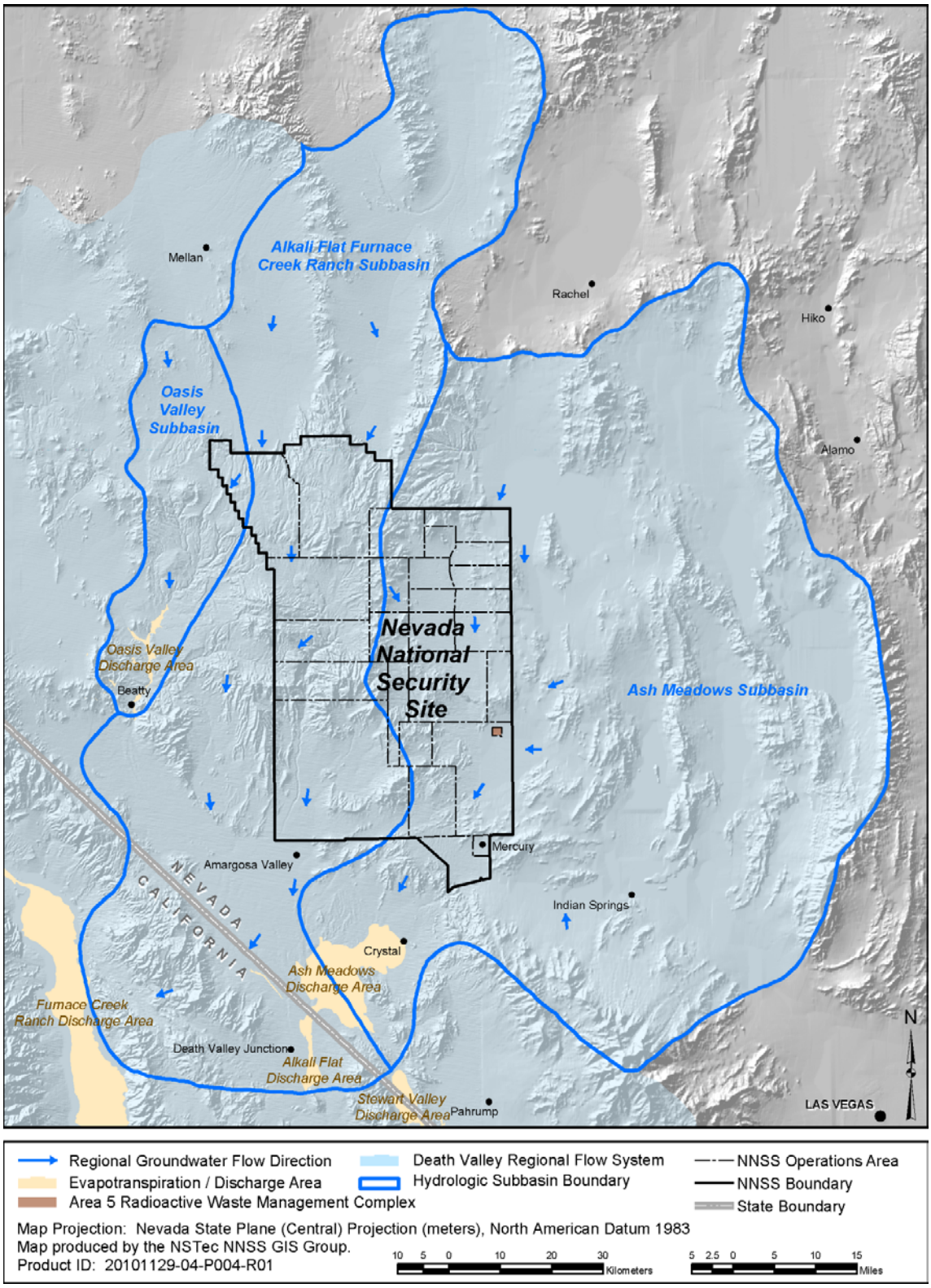

Figure 1-4. Groundwater Sub-basins and Flow in the Vicinity of the Area 5 RWMS

1.3 MONITORING WELL DESCRIPTIONS

Pilot Wells UE5PW-1, UE5PW-2, and UE5PW-3 were drilled between March and November 1992, and the groundwater has been monitored since 1993. Each well is completed with a centralized 6.35-centimeter (cm) (2.50-inch [in.]) diameter stainless steel casing with an 18.3-meter (m) (60-foot [ft]) dual-screen filter pack attached to the bottom of the casing. The borehole annulus below and around the screen is filled with 6/12 coarse mesh sand (Reynolds Electrical and Engineering Company, Inc. [REECo] 1994). Well locations around the Area 5 RWMS are shown in Figure 1-2 and summarized in Table 1-1.

Table 1-1. Pilot Well Locations

	UE5PW-1 (m [ft])	UE5PW-2 (m [ft])	UE5PW-3 (m [ft])
Northing[1]	233,386.48 (765,702.19)	234,817.13 (770,395.90)	235,089.93 (771,290.92)
Easting[1]	216,357.08 (709,831.57)	216,376.00 (709,893.63)	214,415.04 (703,460.07)
Top of Casing Elevation[2]	969.37 (3,180.35)	990.12 (3,248.42)	1,005.22 (3,297.97)
Well Deviation at Water Table	0.08 (0.27)	0.21 (0.68)	0.02 (0.06)

[1]Nevada State Plan Central Zone 1927 North American Datum
[2]1929 National Geodetic Vertical Datum
Source: REECo (1994)

UE5PW-1 is 255.7 m (839 ft) deep from the top of the casing and is screened from 232.3 m (762 ft) to 250.5 m (822 ft). UE5PW-1 is completed in alluvium. During 2013, the average water table depth below the top of the well casing was 235.86 m (773.82 ft), and the average water table elevation was 733.51 m (2,406.52 ft) AMSL.

UE5PW-2 is 280.3 m (920 ft) deep from the top of the casing and is screened from 253.0 m (830 ft) to 271.3 m (890 ft). UE5PW-2 is completed in alluvium. During 2013, the average water table depth below the top of the well casing was 256.46 m (841.40 ft), and the average water table elevation was 733.66 m (2,407.01 ft) AMSL.

UE5PW-3 is 291.1 m (955 ft) deep from the top of the casing and is screened from 267.6 m (878 ft) to 282.9 m (928 ft). UE5PW-3 is completed in volcanic rock. The alluvium/volcanic rock contact is 188 m (617 ft) deep at UE5PW-3 (REECo 1994). During 2013, the average water table depth below the top of the well casing was 271.56 m (890.94 ft), and the average water table elevation was 733.66 m (2,407.01 ft) AMSL.

Groundwater samples are collected from each well twice per year. A dedicated, removable pump is used for each well. The pumps are stainless steel, air-powered, submersible piston pumps. Flexible polypropylene tubing for air supply, air exhaust, and water discharge are bundled together and mounted on electric-powered reels. Pumping rates from the wells range from 0.15 to 0.50 gallon per minute. Static water levels at each well are measured using an electronic polyethylene tape four times per year. Water levels are measured with the sample pumps removed from the wells.

1.4 LEACHATE COLLECTION DESCRIPTION

Cell 18 is a lined, mixed waste disposal cell located in the northeastern corner of the Area 5 RWMS (Figure 1-2). Cell 18 was constructed during 2010 and began receiving waste in January 2011. The Cell 18 liner is a RCRA-compliant double liner with a leachate collection and leak detection system placed over a geosynthetic clay liner. The double liner is covered by approximately 61 cm (24 in.) of compacted soil on the cell side slopes and by approximately 76 cm (30 in.) of compacted soil on the cell floor. The primary liner is 80 mil. textured high density polyethylene (HDPE) and the secondary liner is 60 mil. textured HDPE. The primary liner is directly below a 160-mil. double-sided geocomposite drainage layer, and a second 160-mil. double- sided geocomposite drainage layer separates the primary liner from the secondary liner.

Any precipitation or other water applied to the 1.35 hectare (ha) area (3.33 acres [ac]) covered by the liner that is not removed by evapotranspiration eventually infiltrates into the soil above the liner, percolates through the soil to the primary liner, and eventually drains into the primary sump in the floor of Cell 18. Any water leaking through the primary liner would percolate to the secondary liner and eventually drains into the secondary sump in the floor of Cell 18. Water collected in the primary sump is pumped from the sump to a 3,000-gallon tank on the surface above the cell. When the tank approaches its capacity, leachate samples are collected from the tank and analyzed for toxicity characteristic contaminants, PCBs, specific conductance, and pH. Through 2013, none of the regulatory limits for toxicity characteristic contaminants have been exceeded, and no PCBs have been detected in the leachate samples. After leachate analysis results are evaluated, the leachate is pumped from the collection tank and used for dust control in Cell 18.

1.5 SITE METEOROLOGY

Meteorological data are also measured at the Area 5 RWMS. These data include temperature, relative humidity, barometric pressure, wind speed and direction, solar radiation, and precipitation. During 2013 the average daily temperature at 3 m height was 16.3 degrees Celsius (°C) (61.3 degrees Fahrenheit [°F]). The maximum observed temperature at 3 m height was 44.7°C (112.5°F) on June 30, 2013, and the minimum observed temperature at 3 m was −13.0°C (8.6°F) on January 13, 2013. The maximum observed wind gust at 3 m was 19.3 meters/second (43.2 miles per hour) on July 20, 2013. The average annual precipitation measured at the Area 5 RWMS from 1994 through 2013 is 12.2 cm per year (4.80 in. per year). The Area 5 RWMS had 11.8 cm (4.65 in.) of precipitation during 2013. During the 20-year measurement period, 2012 is the tenth wettest year. There were 32 days of measurable precipitation in 2013 at the Area 5 RWMS. The wettest month in 2012 was July, which had approximately 28 percent of the 2013 precipitation. Monthly precipitation at the Area 5 RWMS from January 1994 through December 2013 is provided in Figure 1-5.

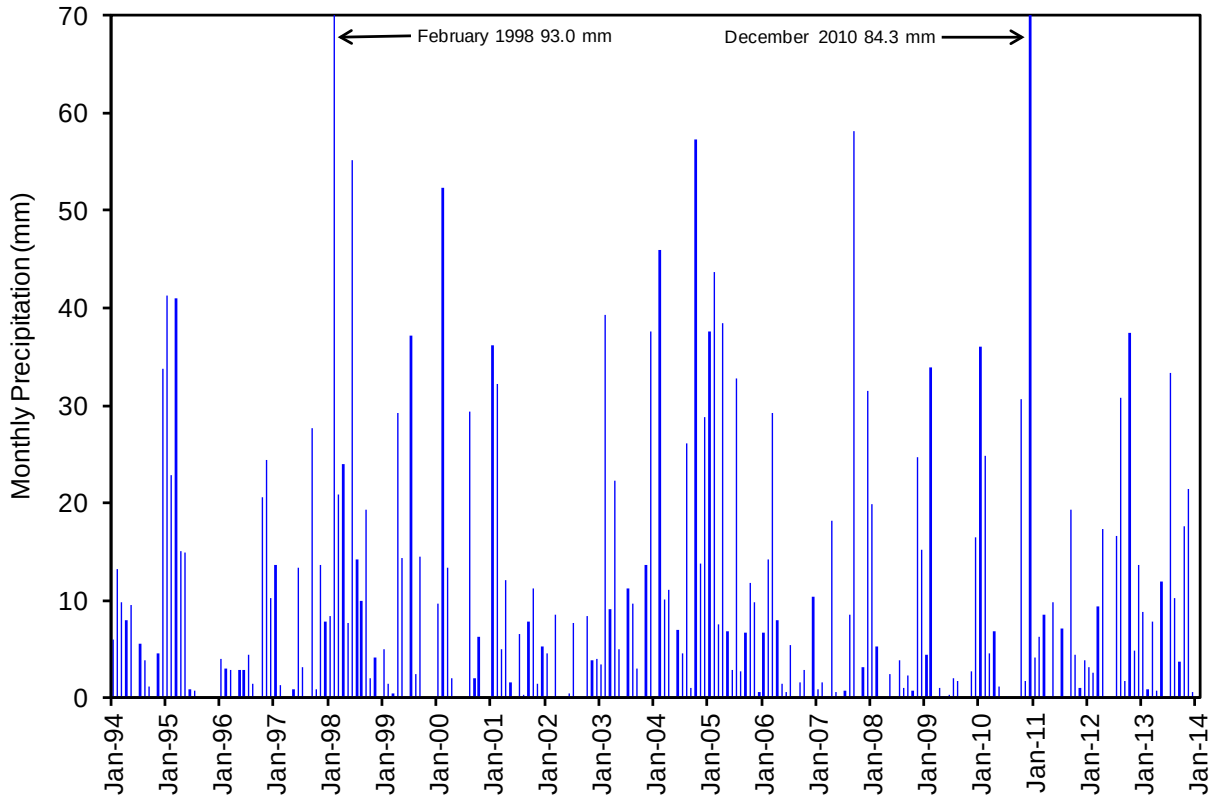

Figure 1-5. Area 5 RWMS Monthly Precipitation from 1994 through 2013

2.0 GROUNDWATER MONITORING METHODS AND RESULTS

The groundwater at the Area 5 RWMS pilot wells has been monitored since 1993 (see Appendix A). The Groundwater Monitoring Program has transitioned from monitoring all parameters required by 40 CFR 265 to a program that monitors parameters applicable to the Area 5 RWMS. The current monitoring program is modeled after the 40 CFR 265 Detection Monitoring Program.

2.1 METHODS

Samples are tested semiannually for the analytes listed below, which are divided into groups representing indicators of contamination and general water chemistry parameters.

Indicators of contamination:

- pH
- Specific conductance (SC)
- Total organic carbon (TOC)
- Total organic halides (TOX)
- Tritium

General water chemistry parameters:

- Cations: calcium (Ca), iron (Fe), magnesium (Mg), manganese (Mn), potassium (K), sodium (Na)
- Anions: bicarbonate (HCO_3), sulfate (SO_4), chloride (Cl), fluoride (F)
- Silicate (SiO_2)

Investigation levels (ILs) for each analyte identified as an indicator of contamination were established by DOE and NDEP in 1998 (Table 2-1). Further groundwater analyses are required if the IL is exceeded (BN 1998; Liebendorfer 2000). The ILs for pH and SC are based on the distributions of data collected from 1993 through 1996. Historic analyses for TOC, TOX, and tritium typically have concentration levels less than the method detection limit (MDL) or the minimum detectable concentration (MDC); however, the ILs for TOC and TOX are set slightly above their MDLs or MDCs, and the tritium IL is set at 2,000 picocuries per liter (pCi/L), which is 10 percent of the National Primary Drinking Water Standard of 20,000 pCi/L.

Table 2-1. Investigation Levels of Indicator Parameters

Parameter	Investigation Level (IL)
pH	<7.6 or >9.2
SC	0.440 mmhos/cm[a]
TOC	1 mg/L[b]
TOX	50 µg/L[c]
Tritium	2,000 pCi/L

[a] mmhos/cm = millimhos per centimeter
[b] mg/L = milligrams per liter
[c] µg/L = micrograms per liter

During 2013, groundwater samples were collected at UE5PW-1, UE5PW-2, and UE5PW-3 on March 5 and August 13, 2013. The current groundwater sampling procedure (National Security Technologies, LLC, 2010a) was followed. Tritium samples were enriched prior to shipment to a contract laboratory for analysis. Tritium analyses were conducted by ALS Laboratories and GEL Laboratories. All other analyses were conducted by GEL Laboratories.

For TOC and TOX analysis, three replicate water samples are collected consecutively from each well for each analyte. Replicate samples provide additional data in case any sample result is above the analyte's IL. Well re-sampling is required if all three replicate water samples are above the analyte's IL. False detections of these analytes above their ILs and subsequent re-sampling of the wells have occurred in the past. No resampling was done in 2013.

2.2 RESULTS

This section lists the results for each of the five indicators of contamination, the general water chemistry parameters, and the groundwater elevation.

2.2.1 pH

The measured pH at each well remained within the ILs of 7.6 and 9.2 during 2013 (Table 2-2). The 2013 pH values ranged from 7.80 to 8.30 and represent the stable pH reading obtained from each well just prior to sampling for other analytes. Measured pH has remained relatively stable throughout the entire monitoring period (Figure 2-1). No groundwater contamination is indicated by the pH monitoring results.

Table 2-2. Pilot Wells pH Values

UE5PW-1		UE5PW-2		UE5PW-3	
Date	**pH**	**Date**	**pH**	**Date**	**pH**
03/31/1993	8.17	03/24/1993	7.99	04/14/1993	8.24
07/06/1993	8.30	06/22/1993	8.24	06/02/1993	8.68
09/01/1993	8.25	11/15/1993	8.40	10/12/1993	8.69
12/07/1993	7.91	01/19/1994	8.79	12/20/1993	8.60
06/15/1994	8.45	No sample		05/24/1994	8.87
08/01/1994	8.28	06/07/1994	8.81	08/08/1994	8.77
No sample		11/29/1994	8.79	01/18/1995	8.58
04/04/1995	8.25	04/04/1995	8.58	04/05/1995	8.28
11/09/1995	8.35	11/09/1995	8.08	11/09/1995	8.43
01/18/1996	8.41	01/25/1996	8.63	01/18/1996	8.55
04/16/1996	8.22	04/23/1996	8.21	04/23/1996	8.23
No sample		04/30/1996	8.15	04/30/1996	8.15
10/02/1996	8.18	10/02/1996	8.28	10/02/1996	8.18
11/20/1996	8.25	11/20/1996	8.16	11/20/1996	8.13

Table 2-2. Pilot Wells pH Values (continued)

UE5PW-1		UE5PW-2		UE5PW-3	
Date	**pH**	**Date**	**pH**	**Date**	**pH**
04/16/1997	8.33	04/16/1997	8.40	04/16/1997	8.25
11/05/1997	8.30	11/05/1997	8.17	11/05/1997	8.22
05/13/1998	8.31	05/13/1998	8.37	05/13/1998	8.34
07/29/1998	8.63	No sample		No sample	
10/28/1998	8.34	10/28/1998	8.32	10/28/1998	8.14
05/19/1999	8.50	05/19/1999	8.49	05/19/1999	8.47
10/27/1999	8.49	10/27/1999	8.52	10/27/1999	8.34
04/26/2000	8.50	04/26/2000	8.39	04/26/2000	8.24
08/09/2000	8.26	08/09/2000	8.14	08/09/2000	8.23
05/29/2001	8.46	05/29/2001	8.25	05/29/2001	8.27
10/03/2001	8.39	10/03/2001	8.22	10/03/2001	8.13
05/15/2002	8.46	05/15/2002	8.30	05/15/2002	8.32
10/22/2002	8.43	10/22/2002	8.23	10/22/2002	8.24
04/15/2003	8.54	04/15/2003	8.38	04/15/2003	8.42
10/22/2003	8.37	10/22/2003	8.24	10/21/2003	8.16
05/04/2004	8.50	05/04/2004	8.25	05/04/2004	8.26
10/19/2004	8.30	10/19/2004	8.32	10/20/2004	8.24
04/19/2005	8.48	04/19/2005	8.30	04/19/2005	8.33
10/11/2005	8.47	10/11/2005	8.27	10/11/2005	8.31
04/26/2006	8.34	04/26/2006	8.12	04/26/2006	8.17
10/10/2006	8.11	10/10/2006	8.03	10/10/2006	8.07
03/19/2007	8.37	03/19/2007	8.13	03/19/2007	8.44
08/29/2007	8.29	08/29/2007	8.09	09/05/2007	8.10
03/11/2008	8.08	03/11/2008	8.00	03/11/2008	8.03
09/10/2008	8.17	09/10/2008	8.08	09/10/2008	8.14
03/10/2009	8.40	03/10/2009	8.17	03/10/2009	8.22
08/18/2009	8.45	08/18/2009	8.25	08/18/2009	8.22
03/10/2010	8.37	03/10/2010	8.17	03/31/2010	8.13
08/10/2010	8.39	08/10/2010	8.27	08/10/2010	8.22
03/08/2011	8.35	03/08/2011	8.27	03/08/2011	8.22
08/02/2011	8.39	08/02/2011	8.32	08/02/2011	8.30
03/21/2012	8.39	03/21/2012	8.24	03/21/2012	8.27
08/07/2012	8.35	08/07/2012	8.29	08/07/2012	8.29
03/05/2013	7.98	03/05/2013	8.30	03/05/2013	7.80
08/13/2013	8.08	08/13/2013	7.90	08/13/2013	8.13

NOTE: Values before 05/19/1999 are means of multiple measurements, and values from 05/19/1999 to present are the stable pH value measured just prior to sampling.

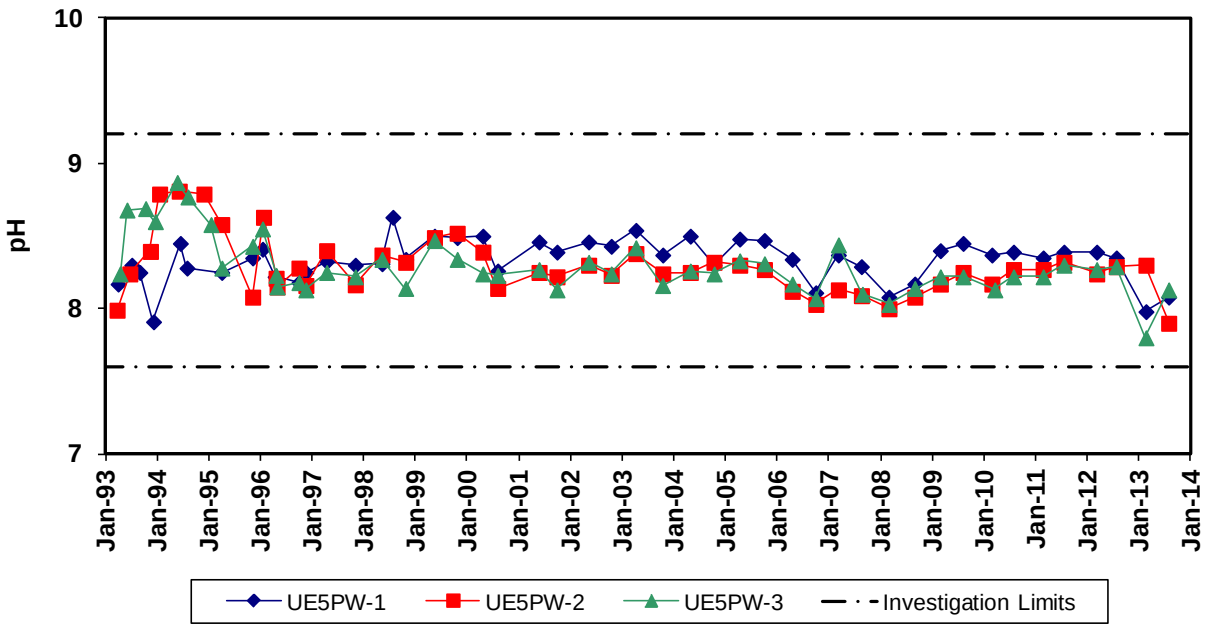

Figure 2-1. Time Series Plot of Pilot Well pH

2.2.2 Specific Conductance

The 2013 measured SC of water samples from each well remained below the IL of 0.440 mmhos/cm and ranged from 0.352 to 0.374 mmhos/cm (Table 2-3). SC values from each well have remained relatively stable throughout the entire monitoring period (Figure 2-2). No groundwater contamination is indicated by the SC monitoring results.

Table 2-3. Pilot Wells SC Values in mmhos/cm

UE5PW-1		UE5PW-2		UE5PW-3	
Date	**SC**	**Date**	**SC**	**Date**	**SC**
03/31/1993	0.401	03/24/1993	0.371	04/14/1993	0.383
06/06/1993	0.391	06/22/1993	0.411	06/02/1993	0.382
09/01/1993	0.391	11/15/1993	0.384	10/12/1993	0.376
12/07/1993	0.383	01/19/1994	0.371	12/20/1993	0.359
06/15/1994	0.383	06/07/1994	0.363	05/24/1994	0.363
08/01/1994	0.380	No Sample		08/08/1994	0.367
No Sample		11/29/1994	0.325	01/18/1995	0.338
04/04/1995	0.320	04/04/1995	0.336	04/05/1995	0.347
11/09/1995	0.366	11/09/1995	0.348	11/09/1995	0.352
01/18/1996	0.360	01/25/1996	0.343	01/18/1996	0.355
04/16/1996	0.363	04/23/1996	0.355	04/23/1996	0.363
No Sample		04/30/1996	0.356	04/30/1996	0.379
10/02/1996	0.383	10/02/1996	0.363	10/02/1996	0.376

Table 2-3. Area 5 RWMS SC Values in mmhos/cm (continued)

UE5PW-1		UE5PW-2		UE5PW-3	
Date	**SC**	**Date**	**SC**	**Date**	**SC**
11/20/1996	0.374	11/20/1996	0.365	11/20/1996	0.378
04/16/1997	0.385	04/16/1997	0.364	04/16/1997	0.376
11/05/1997	0.377	11/05/1997	0.358	11/05/1997	0.361
05/13/1998	0.377	05/13/1998	0.356	05/13/1998	0.370
07/29/1998	0.373	No Sample		No Sample	
10/28/1998	0.380	10/28/1998	0.358	10/28/1998	0.370
05/19/1999	0.379	05/19/1999	0.351	05/19/1999	0.369
10/27/1999	0.370	10/27/1999	0.355	10/27/1999	0.370
04/26/2000	0.378	04/26/2000	0.355	04/26/2000	0.369
08/09/2000	0.378	08/09/2000	0.357	08/09/2000	0.370
05/29/2001	0.377	05/29/2001	0.358	05/29/2001	0.371
10/03/2001	0.376	10/03/2001	0.358	10/03/2001	0.371
05/15/2002	0.386	05/15/2002	0.374	05/15/2002	0.384
10/22/2002	0.374	10/22/2002	0.368	10/22/2002	0.368
04/15/2003	0.372	04/15/2003	0.355	04/15/2003	0.369
10/22/2003	0.376	10/22/2003	0.357	10/21/2003	0.373
05/04/2004	0.378	05/04/2004	0.361	05/04/2004	0.353
10/19/2004	0.372	10/19/2004	0.352	10/20/2004	0.365
04/19/2005	0.377	04/19/2005	0.359	04/19/2005	0.369
10/11/2005	0.368	10/11/2005	0.352	10/11/2005	0.364
04/26/2006	0.361	04/26/2006	0.341	04/26/2006	0.357
10/10/2006	0.384	10/10/2006	0.363	10/10/2006	0.376
03/19/2007	0.390	03/19/2007	0.330	03/19/2007	0.332
08/29/2007	0.385	08/29/2007	0.359	09/05/2007	0.378
03/11/2008	0.386	03/11/2008	0.371	03/11/2008	0.386
09/10/2008	0.378	09/10/2008	0.360	09/10/2008	0.375
03/10/2009	0.376	03/10/2009	0.363	03/10/2009	0.386
08/18/2009	0.377	08/18/2009	0.363	08/18/2009	0.376
03/10/2010	0.379	03/10/2009	0.358	No Sample	
08/10/2010	0.363	08/10/2010	0.345	08/10/2010	0.359
03/08/2011	0.381	03/08/2011	0.360	03/08/2011	0.374
08/02/2011	0.376	08/02/2011	0.358	08/02/2011	0.374
03/21/2012	0.374	03/21/2012	0.362	03/21/2012	0.374
08/07/2012	0.383	08/07/2012	0.370	08/07/2012	0.381
03/05/2013	0.374	03/05/2013	0.366	03/05/2013	0.370
08/13/2013	0.372	08/13/2013	0.352	08/13/2013	0.364

NOTE: Values before 05/19/1999 are means of multiple measurements, and values from 05/19/1999 to present are the stable SC value measured just prior to sampling.

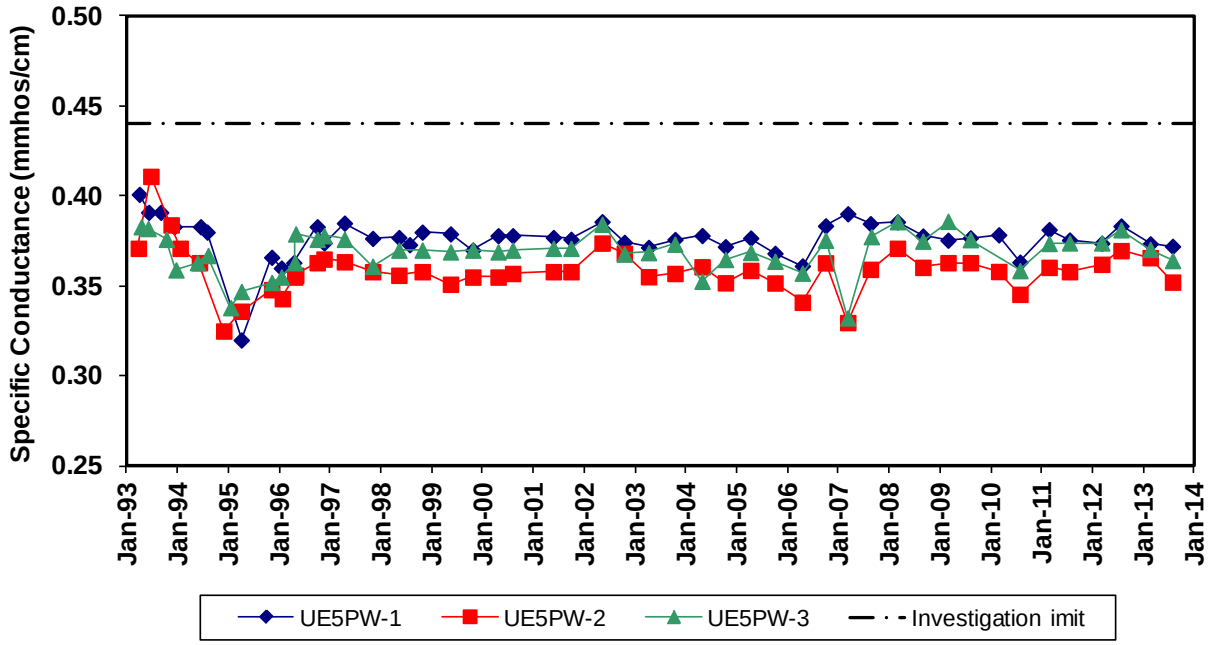

Figure 2-2. Time Series Plot of Pilot Wells SC

2.2.3 Total Organic Carbon

Three samples were collected consecutively from each well on each sampling date for TOC analysis. The averages of the three sample measurements are reported in Table 2-4. When sample TOC values fell below the sample's MDL, the MDL value was used to calculate the reported average. Values preceded by a less than symbol (<) in Table 2-4 indicate that all three sample results were less than the MDL. During 2013, the contract analysis lab increased the MDL for TOC from 0.2 mg/L to 0.33 mg/L. This resulted in slightly higher reported TOC results for 2013. TOC values ranged from 0.63 to 0.41 mg/L.

TOC values have remained relatively low and stable throughout the monitoring period (Figure 2-3). Most variation in TOC values is the result of variation in the MDL. No groundwater contamination is indicated by the TOC monitoring results.

Table 2-4. Pilot Wells TOC Values in mg/L

UE5PW-1		UE5PW-2		UE5PW-3	
Date	**TOC**	**Date**	**TOC**	**Date**	**TOC**
03/31/1993	<1.0	03/24/1993	<1.0	04/14/1993	<1.0
07/06/1993	<1.0	06/22/1993	<1.0	06/02/1993	<1.0
09/01/1993	<1.0	11/15/1993	<1.0	10/12/1993	<1.0
12/07/1993	<1.0	01/19/1994	<1.0	12/20/1993	<1.0
No Sample		06/07/1994	<1.0	No Sample	
08/01/1994	1.7[a]	11/29/1994	<1.0	08/08/1994	<1.0
04/04/1995	<1.0	04/04/1995	<1.0	04/05/1995	<1.0
10/02/1996	<0.3	10/02/1996	<0.3	10/02/1996	<0.3
11/20/1996	<0.3	11/20/1996	<0.3	11/20/1996	<0.3
11/05/1997	<0.3	11/05/1997	<0.3	11/05/1997	<0.3
05/13/1998	<1.0	05/13/1998	<1.0	05/13/1998	<1.0
10/28/1998	<1.0	10/28/1998	<1.0	10/28/1998	<1.0
05/19/1999	<1.0	05/19/1999	<1.0	05/19/1999	<1.0
10/27/1999	<1.0	10/27/1999	1.3	10/27/1999	<1.0
No Sample		12/13/1999	<0.5	No Sample	
04/26/2000	0.98[a]	04/26/2000	0.60[a]	04/26/2000	1.3[a]
08/09/2000	<0.5[b]	08/09/2000	<0.5[b]	04/26/2000	<0.5[b]
05/29/2001	0.51[b]	05/29/2001	<0.5[b]	05/29/2001	0.53[b]
10/03/2001	<0.5	10/03/2001	<0.5	10/03/2001	<0.5
05/15/2002	<0.5	05/15/2002	<0.5	05/15/2002	<0.5
10/22/2002	<0.5	10/22/2002	0.55	10/22/2002	0.58
04/15/2003	0.51	04/15/2003	0.58	04/15/2003	0.52
10/22/2003	0.64	10/22/2003	0.68	10/21/2003	0.62
05/04/2004	0.55	05/04/2004	<0.5	05/04/2004	0.58
10/19/2004	0.58	10/19/2004	0.90	10/20/2004	0.83
04/19/2005	0.65	04/19/2005	0.62	04/19/2005	0.50
10/11/2005	0.60	10/11/2005	0.53	10/11/2005	<0.5
04/26/2006	<0.5	04/26/2006	0.97	04/26/2006	0.51
10/10/2006	0.80	10/10/2006	1.12	10/10/2006	0.52
03/19/2007	0.62	03/19/2007	0.54	03/19/2007	<0.5
08/29/2007	<0.5	08/29/2007	<0.5	09/05/2007	<0.5
03/11/2008	<0.5	03/11/2008	<0.5	03/11/2008	<0.5
09/10/2008	0.54	09/10/2008	0.56	09/10/2008	<0.5
03/10/2009	0.52	03/10/2009	0.55	03/10/2009	<0.5
08/18/2009	0.55	08/18/2009	0.56	08/18/2009	0.52

Table 2-4. Pilot Wells TOC Values in mg/L (continued)

UE5PW-1		UE5PW-2		UE5PW-3	
Date	**TOC**	**Date**	**TOC**	**Date**	**TOC**
03/10/2009	0.52	03/10/2009	0.55	03/10/2009	<0.5
08/18/2009	0.55	08/18/2009	0.56	08/18/2009	0.52
03/10/2010	0.54	03/10/2010	0.76	03/31/2010	0.60
08/10/2010	0.56	08/25/2010	<0.5	08/25/2010	0.56
03/08/2011	<0.5	03/08/2011	0.59	03/08/2011	0.52
10/19/2011	0.52	10/19/2011	0.53	10/19/2011	0.53
03/21/2012	0.35	03/21/2012	0.20	03/21/2012	<0.20
08/21/2012	0.21	08/21/2012	<0.20	08/21/2012	0.28
03/05/2013	0.44	03/05/2013	0.45	03/05/2013	0.41
08/13/2013	0.49	08/13/2013	0.47	08/13/2013	0.57

[a] Determined to be a false positive through resampling
[b] Multiple laboratories used; this value is the average of Lionville Laboratory only

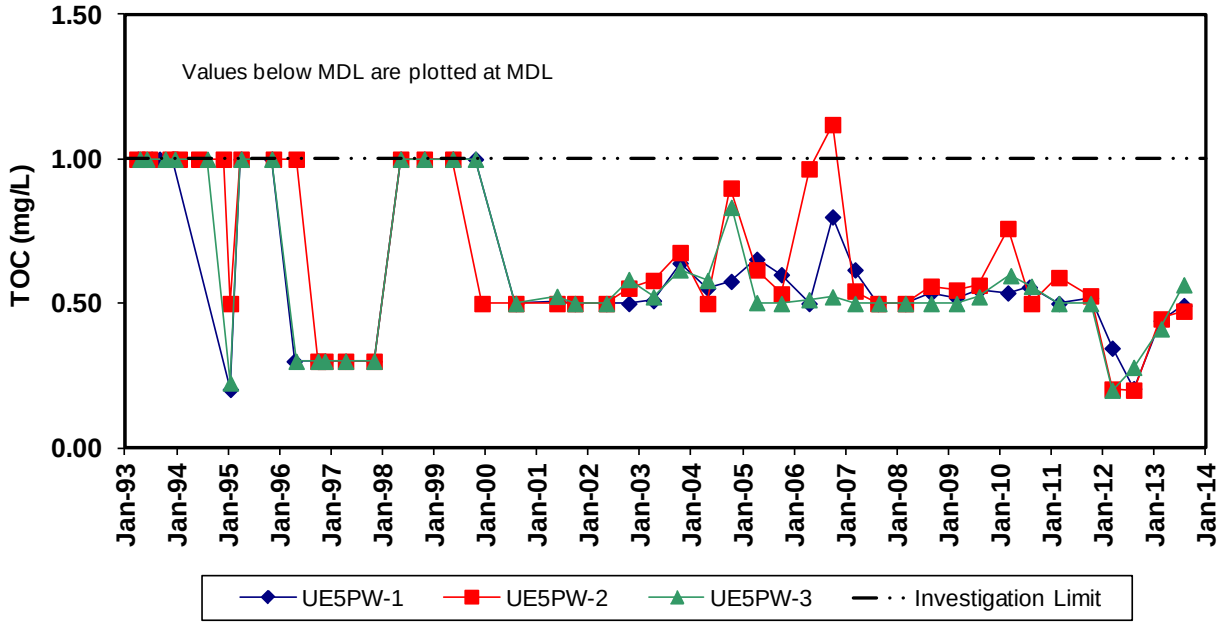

Figure 2-3. Time Series Plot of Pilot Wells TOC

2.2.4 Total Organic Halides

Three groundwater samples were collected consecutively from each well on each sampling date for TOX analysis. The averages of the three sample results are reported in Table 2-5. When sample TOX values fell below the sample's MDL, the MDL is used to calculate the reported average. Values in Table 2-5 preceded by a less than symbol (<) indicate that all three samples are less than the MDL.

TOX values have remained relatively stable and below the IL throughout the monitoring period (Figure 2-4). Most variation in TOX values is the result of variation in the MDL. No groundwater contamination is indicated by the TOX results.

Table 2-5. Pilot Wells TOX Values in µg/L

UE5PW-1		UE5PW-2		UE5PW-3	
Date	**TOX**	**Date**	**TOX**	**Date**	**TOX**
03/31/1993	17	03/24/1993	23	04/14/1993	<10
07/06/1993	<10	06/22/1993	<10	06/02/1993	13
09/01/1993	13	11/15/1993	<10	10/12/1993	<10
12/07/1993	<10	01/19/1994	<10	12/20/1993	<10
06/15/1994	<10	06/07/1994	<10	No Sample	
08/01/1994	11	11/29/1994	13	08/08/1994	<10
01/18/1995	<10	01/18/1995	<10	01/18/1995	<10
04/04/1995	<10	04/04/1995	<10	04/05/1995	<10
11/09/1995	<40	11/09/1995	<40	11/09/1995	<40
04/16/1996	<40	04/30/1996	<40	04/30/1996	<40
No Sample		10/02/1996	<20	10/02/1996	<20
11/20/1996	<20	11/20/1996	<20	11/20/1996	<20
04/16/1997	<20	04/16/1997	<20	04/16/1997	<20
11/05/1997	<20	11/05/1997	<20	11/05/1997	<20
05/13/1998	391[a]	05/13/1998	843[a]	05/13/1998	1000[a]
07/29/1998	<5	No Sample		No Sample	
10/28/1998	<5	10/29/1998	<5	10/29/1998	<5
05/19/1999	<5	05/19/1999	<5	05/19/1999	<5
10/27/1999	<5	10/27/1999	<5	10/27/1999	7
04/26/2000	72[a]	04/26/2000	59[a]	04/26/2000	57[a]
08/09/2000	92[a,b]	08/09/2000	73[a,b]	08/09/2000	83[a,b]
05/29/2001	<12.7[b]	05/29/2001	<12[b]	05/29/2001	<12[b]
10/03/2001	<6.1	10/03/2001	<5.8	10/03/2001	<5.2
05/15/2002	<5.2	05/15/2002	5.4	05/15/2002	<5.2
10/22/2002	<5.2	10/22/2002	<5.2	10/22/2002	<5.2
04/15/2003	<5.2	04/15/2003	<5.2	04/15/2003	<5.2
10/22/2003	<5.2	10/22/2003	5.5	10/21/2003	<5.2
05/04/2004	<5.2	05/04/2004	<5.2	05/04/2004	<5.2
10/19/2004	<5.2	10/19/2004	<5.2	10/20/2004	<5.2
04/19/2005	<5	04/19/2005	<5	04/19/2005	<5
10/11/2005	5.2	10/11/2005	6.5	10/11/2005	<5

Table 2-5. Pilot Wells TOX Values in µg/ (continued)

UE5PW-1		UE5PW-2		UE5PW-3	
Date	**TOX**	**Date**	**TOX**	**Date**	**TOX**
04/26/2006	7.3	04/26/2006	5.8	04/26/2006	7.4
10/10/2006	<5.1	10/10/2006	<5	10/10/2006	<5
03/19/2007	<5.2	03/19/2007	<5.2	03/19/2007	<5.2
08/29/2007	<5.2	08/29/2007	<5.2	09/05/2007	<5.2
03/11/2008	<5.2	03/11/2008	<5.2	03/11/2008	<5.2
09/10/2008	<5.2	09/10/2008	5.9	09/10/2008	8.9
03/10/2009	<5	03/10/2009	<5	03/10/2009	<5
08/18/2009	<7.7	08/18/2009	<7.7	08/18/2009	<7.7
03/10/2010	<5	03/10/2010	<5	03/31/2010	<5
08/10/2010	5.5	08/25/2010	5.9	08/25/2010	<5
03/08/2011	13.3	03/08/2011	9.1	03/08/2011	6.7
08/24/2011	<5	8/23/2011	5.2	08/23/2011	<5
03/21/2012	9.2	03/21/2012	8.2	03/21/2012	11.0
09/11/2012	<20	09/11/2012	<20	09/11/2012	<20
03/05/2013	<3.3	03/05/2013	7.6	03/05/2013	<3.3
08/13/2013	<3.3	08/13/2013	<3.3	08/13/2013	<3.3

[a] Determined to be a false positive through resampling
[b] Multiple laboratories used; this value is the average of Lionville Laboratory only

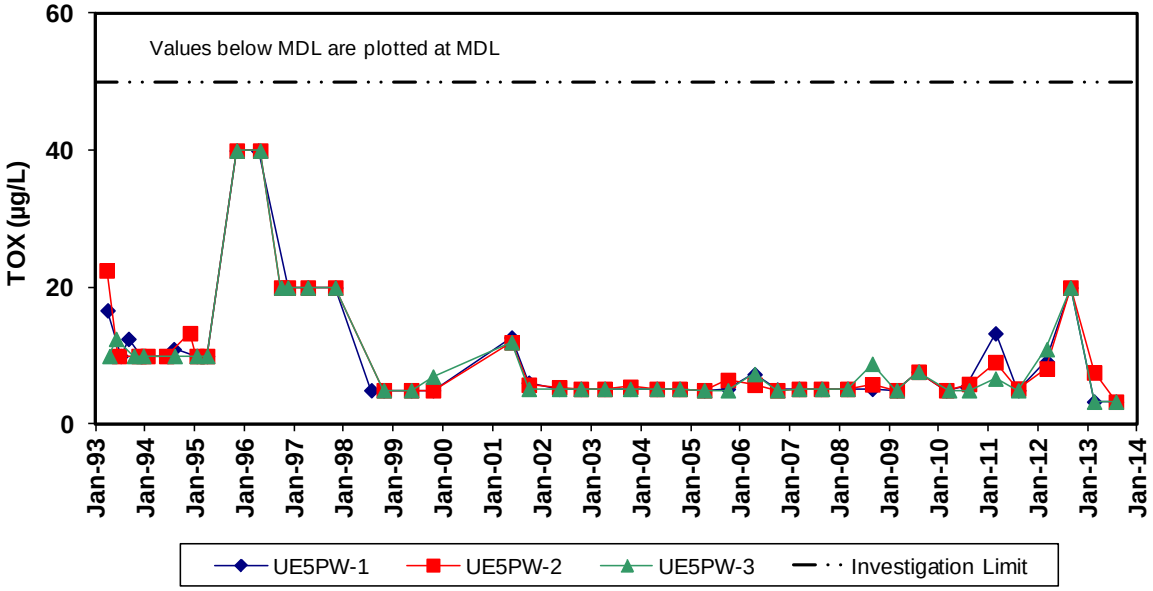

Figure 2-4. Time Series Plot of Pilot Wells TOX

2.2.5 Tritium

All tritium results from 2013 groundwater samples were below the IL of 2,000 pCi/L and below the laboratory MDC of approximately 20 pCi/L (Table 2-6, Table 2-7, and Table 2-8). In 2013, duplicate samples were collected from each well on each sampling date. Table 2-6 reports the average of these two results. Negative tritium results indicate the measured activity is less than the measured laboratory background activity. Tritium values have remained relatively stable and below the IL and MDC throughout the monitoring period (Figure 2-5). No groundwater contamination is indicated by the tritium results.

Table 2-6. Pilot Wells Tritium Values in pCi/L

UE5PW-1		UE5PW-2		UE5PW-3	
Date	**Tritium**	**Date**	**Tritium**	**Date**	**Tritium**
03/31/1993	0.442	03/24/1993	−4.28	04/14/1993	1.96
12/07/1993	−1.58	11/15/1993	32.2	06/02/1993	−2.74
No Sample		01/19/1994	3.69	12/20/1993	−0.459
06/15/1994	−2.04	06/07/1994	1.29	05/24/1994	1.13
08/01/1994	1.86	11/29/1994	0.015	08/08/1994	1.04
04/04/1995	2.80	04/04/1995	−0.920	04/05/1995	1.50
04/16/1996	−1.72	04/30/1996	−1.91	04/30/1996	−2.29
04/16/1997	3.15	04/16/1997	0.189	04/16/1997	3.69
05/13/1998	−2.35	05/13/1998	−1.95	05/13/1998	−4.71
10/28/1998	−1.09	10/28/1998	−1.85	10/28/1998	−8.25
05/19/1999	5.17	05/19/1999	4.24	05/19/1999	4.60
10/27/1999	−1.36	10/27/1999	−3.37	10/27/1999	1.08
04/26/2000	−2.56	04/26/2000	1.17	04/26/2000	−0.080
08/09/2000	−1.48	08/09/2000	6.97	08/09/2000	4.35
05/29/2001	−1.90	05/29/2001	−11.5	05/29/2001	−12.4
10/03/2001	−2.93	10/03/2001	−2.82	10/03/2001	2.46
05/15/2002	−2.82	05/15/2002	0.150	05/15/2002	−3.26
10/22/2002	−4.15	10/22/2002	0.113	10/22/2002	−1.17
04/15/2003	−1.13	04/15/2003	−5.22	04/15/2003	1.62
10/22/2003	0.952	10/22/2003	11.4	10/21/2003	0.405
05/04/2004	−2.69	05/04/2004	−6.17	05/04/2004	−6.04
10/19/2004	−1.50	10/19/2004	−10.0	10/20/2004	−6.39
04/19/2005	3.67	04/19/2005	3.76	04/19/2005	3.56
10/11/2005	8.83	10/11/2005	5.24	10/11/2005	−4.78
04/26/2006	0.480	04/26/2006	−2.70	04/26/2006	−6.71
10/10/2006	7.42	10/10/2006	9.35	10/10/2006	13.8
03/19/2007	−10.3	03/19/2007	−7.96	03/19/2007	−4.15
08/29/2007	−7.25	08/29/2007	−5.61	09/05/2007	−5.60
03/11/2008	5.33	03/11/2008	7.63	03/11/2008	−1.41

Table 2-6. Pilot Wells Tritium Values in pCi/L (continued)

UE5PW-1		UE5PW-2		UE5PW-3	
Date	**Tritium**	**Date**	**Tritium**	**Date**	**Tritium**
09/10/2008	4.53	09/10/2008	−2.03	09/10/2008	−4.98
03/10/2009	5.36	03/10/2009	11.80	03/10/2009	−3.77
08/18/2009	3.38	08/18/2009	1.62	08/18/2009	11.9
03/10/2010	−6.55	03/10/2010	−25.15	03/31/2010	−22.6
08/10/2010	−4.25	08/10/2010	0.08	08/10/2010	2.08
03/08/2011	2.97	03/08/2011	1.30	03/08/2011	2.76
08/02/2011	−1.32	08/02/2011	1.66	08/02/2011	−3.17
03/21/2012	1.57	03/21/2012	6.01	03/21/2012	2.31
08/07/2012	4.37	08/07/2012	6.84	08/07/2012	4.69
03/05/2013	-22.95	03/05/2013	-21.45	03/05/2013	-13.75
08/13/2013	-7.54	08/13/2013	-12.40	08/13/2013	-11.03

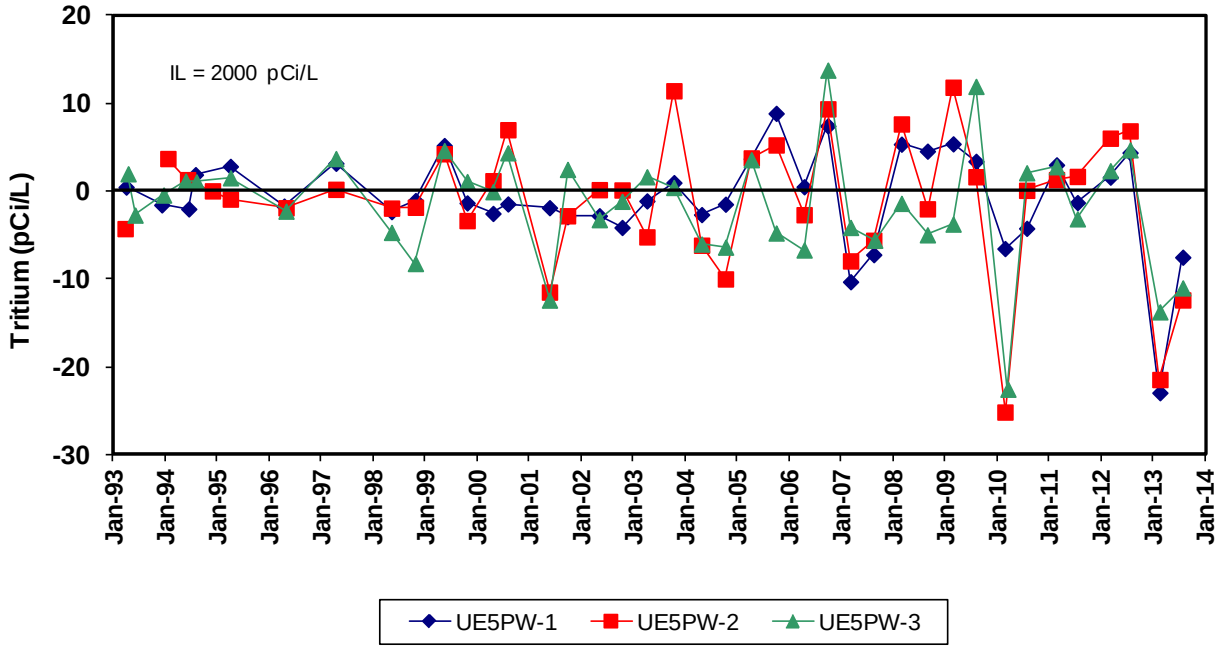

Figure 2-5. Time Series Plot of Pilot Wells Tritium

2.2.6 General Water Chemistry Parameters

General water chemistry analyses during 2013 for cations (Ca, Mg, Na, K, Fe), anions (Cl, F, SO_4, HCO_3), and SiO_2 indicate similar groundwater in all three wells and no changes in groundwater chemistry (Table 2-7, Table 2-8, and Table 2-9). Stiff plots for 2013 also indicate

similar groundwater chemistry for all three wells (Figure 2-6). A piper diagram for the same water chemistry data from 2010 through 2013 indicates that the groundwater is a sodium-bicarbonate type (Figure 2-7).

Groundwater temperatures measured in March 2013 ranged from 19.5°C to 20.9°C (67.1°F to 69.6°F) and in August 2013 ranged from 21.9°C to 24.2°C (71.4°F to 75.6°F). Temperature measurements are collected at the ground surface and are influenced by the ambient air temperature.

Table 2-7. UE5PW-1 General Water Chemistry values in mg/L

Date	Ca	Mg	K	Na	Mn	Fe	SiO_2	SO_4	HCO_3	Cl	Fl
03/31/93	NA	NA	NA	48	<0.006	0.013	NA	32	167	9.2	1.2
06/06/93	NA	NA	NA	58	<0.001	0.059	NA	37	161	9.7	1.4
09/01/93	NA	NA	NA	56	0.0066	0.027	NA	NA	158	8.4	5.7
12/07/93	NA	NA	NA	57	<0.0012	0.012	NA	36	150	9.9	1.5
06/15/94	NA	NA	NA	61	<0.004	0.01	NA	NA	NA	NA	NA
08/01/94	NA	NA	NA	53	<0.0012	0.021	NA	36	NA	10.0	NA
04/04/95	NA	NA	NA	58	<0.01	<0.05	NA	34	NA	9.9	NA
04/16/96	NA	NA	NA	61	<0.001	0.02	NA	34	NA	9.9	NA
04/16/97	15.1	5.3	5.9	54.5	<0.001	0.012	NA	32.2	156	9.3	1.3
11/05/97	15.5	5.6	6.4	57.8	NA	0.012	NA	35.2	151	10.2	1.2
05/13/98	14.0	5.4	5.2	55.8	0.0015	0.034	54.2	34.6	151	9.6	1.1
10/28/98	14.9	5.6	6.9	57.6	0.0015	0.024	60.5	34	160	9.7	1.1
05/19/99	12.5	5.3	6.9	61.0	<0.0025	<0.05	68.5	34	146	10.0	1.0
10/27/99	14.5	6.0	6.6	63.5	<0.005	<0.1	62.0	35	159	8.8	1.1
04/26/00	12.8	4.8	6.7	53.7	0.001	0.033	58.4	35.7	165	10.0	1.0
08/09/00	15.0	4.9	6.6	52.0	0.00045	<0.0164	59.9	37.1	146	10.4	1.1
05/29/01	14.4	4.9	6.0	59.0	<0.025	0.0122	61.7	0.0	143	NA	NA
10/03/01	13.7	4.8	6.7	51.0	0.0002	<0.0156	58.3	36.0	151	10.2	1.0
05/15/02	14.3	5.1	7.0	54.5	0.00053	0.0285	60.9	35.9	155	10.7	1.0
10/22/02	14.6	5.2	6.4	50.0	0.0002	0.0181	60.7	35.6	143	10.1	1.0
04/15/03	13.7	5.0	6.2	58.0	<0.005	0.0110	59.2	32.9	150	12.3	1.0
10/22/03	14.0	5.0	6.0	58.1	<0.0016	0.0141	61.2	36.6	0	9.5	1.1
05/04/04	12.9	4.6	6.4	55.3	0.0027	0.0374	54.4	34.4	154	9.8	1.1
10/19/04	13.1	5.2	6.0	56.2	<0.0003	0.0279	59.9	37.3	168	10.1	1.0
04/19/05	13.8	4.8	6.6	55.1	<0.0006	0.007	58.6	39.6	149	10.5	1.0
10/11/05	13.4	5.0	6.1	50.5	<0.0002	<0.026	61.2	35.7	156	9.7	1.0
04/26/06	14.6	5.3	6.3	60.4	<0.0032	<0.0054	63.3	35.4	149	10.7	1.2
10/10/06	14.0	5.2	5.9	58.8	0.0007	<0.0048	61.4	33.8	148	9.9	0.9
03/19/07	15.7	5.4	6.0	57.4	<0.0036	0.0124	64.0	37.7	151	10.5	1.0
08/29/07	15.4	5.4	6.2	59.0	0.00046	0.0058	64.6	35.9	148	10.0	1.2
03/11/08	14.0	5.4	6.3	60.4	<0.00045	0.0066	63.1	37.4	149	11.1	1.2
09/10/08	14.3	5.5	6.4	59.1	<0.0009	<0.045	62.5	34.7	155	11.0	1.2
03/10/09	13.4	5.3	6.1	58.1	<0.005	<0.100	58.6	35.7	174	10.1	1.1
08/18/09	13.4	5.3	6.0	58.3	0.00113	0.0168	61.8	37.1	160	11.0	1.0
03/10/10	13.3	5.3	6.0	59.6	<0.005	<0.100	65.2	38.5	151	10.7	1.0
08/10/10	12.8	5.2	5.9	57.6	0.00054	<0.050	44.1	35.7	162	11.0	1.0
03/09/11	13.6	5.6	6.1	59.6	<0.002	<0.050	60.1	42.4	173	10.5	1.0
08/02/11	14.2	5.6	6.1	59.2	<0.002	<0.050	64.4	36.2	162	9.1	1.2
03/21/12	13.2	5.2	5.9	56.8	<0.002	<0.050	62.5	38.0	155	9.7	1.4
08/08/12	14.5	5.6	6.0	58.3	<0.002	0.0112	64.4	36.2	162	10.0	1.3
03/05/13	14.2	5.9	6.4	63.0	<0.002	<0.03	65.7	35.4	151	9.0	1.1
08/13/13	14.6	5.8	6.3	58.3	<0.002	<0.03	63.8	36.8	159	9.5	1.2

Data source: Data before 10/27/1999 from BN, 2001.

NA is no analysis.

Table 2-8. UE5PW-2 General Water Chemistry Values in mg/L

Date	Ca	Mg	K	Na	Mn	Fe	SiO_2	SO_4	HCO_3	Cl	Fl
03/24/93	NA	NA	NA	46	0.11	0.062	NA	28	159	8.4	1.0
06/22/93	NA	NA	NA	54	0.032	0.25	NA	30	183	9.7	1.1
11/15/93	NA	NA	NA	51	<0.004	0.180	NA	31	171	9.4	1.3
01/19/94	NA	NA	NA	45	<0.0012	0.074	NA	29	159	NA	1.2
06/07/94	NA	NA	NA	55	<0.004	0.14	NA	NA	NA	NA	NA
11/29/94	NA	NA	NA	NA	NA	NA	NA	28	NA	8.0	NA
04/04/95	NA	NA	NA	50	<0.01	<0.05	NA	28	NA	8.5	NA
04/30/96	NA	NA	NA	51	<0.001	0.013	NA	29	NA	8.3	NA
04/16/97	15.9	6.0	5.0	47.6	<0.001	0.012	NA	26.4	149	7.9	1.2
11/05/97	17.4	6.8	4.9	50.6	NA	0.018	NA	28.9	140	8.6	0.9
05/13/98	14.8	5.7	3.8	45.2	<0.0011	0.066	50.8	28.2	151	8.2	1.0
10/28/98	15.8	6.2	5.6	47.4	0.0009	0.015	55.9	28.4	157	8.3	1.0
05/19/99	15.0	6.3	6.2	52.0	<0.0025	<0.05	62.0	27.5	134	8.7	0.9
10/27/99	16.0	6.7	5.7	52.0	<0.005	<0.1	55.6	28.0	152	7.4	1.0
04/26/00	15.3	6.5	5.6	45.6	0.0007	0.029	55.8	29.1	177	8.6	0.8
08/09/00	17.0	6.6	5.3	44.5	<0.0002	<0.0164	59.2	28.8	155	9.3	0.9
05/29/01	16.6	6.6	4.8	48.8	<0.0088	<0.0107	60.4	NA	152	NA	NA
10/03/01	16.0	6.7	5.5	44.7	0.00017	0.0214	58.8	28.4	152	8.7	1.0
05/15/02	16.5	6.8	5.6	46.1	0.00059	0.0603	60.1	28.7	155	9.3	0.9
10/22/02	17.6	7.1	5.3	44.4	0.0031	<0.0181	63.0	28.7	149	8.7	0.8
04/15/03	16.3	6.6	5.3	50.8	<0.0005	<0.0101	60.3	26.7	157	9.8	0.8
10/22/03	16.1	6.6	5.2	49.6	<0.0016	0.0618	60.5	29.5	141	8.8	0.9
05/04/04	16.0	6.3	5.4	47.2	<0.0007	0.0397	58.2	28.1	159	8.2	0.9
10/19/04	15.7	6.7	5.1	48.6	<0.0003	<0.0279	59.7	29.6	169	8.9	0.9
04/19/05	16.3	6.3	5.2	44.9	<0.0006	0.0115	58.6	31.3	133	8.4	0.9
10/11/05	16.0	6.8	5.0	44.0	<0.0002	0.0270	62.2	29.0	167	8.1	0.9
04/26/06	16.6	6.7	5.4	51.2	<0.0032	0.0612	62.5	28.1	152	8.8	1.1
10/10/06	16.5	6.5	5.2	48.0	<0.0007	0.0170	61.2	27.2	156	8.6	1.1
03/19/07	16.8	6.6	5.4	49.8	<0.0036	0.0387	62.9	42.2	149	11.3	0.9
08/29/07	16.9	6.7	5.2	50.5	<0.00045	0.0098	63.7	27.9	151	9.0	1.1
03/11/08	16.7	6.7	5.2	50.5	<0.00045	0.0159	60.3	30.7	149	10.0	1.0
09/10/08	16.8	7.0	5.7	52.7	0.0020	<0.045	60.3	28.7	152	9.2	1.0
03/10/09	15.9	6.7	5.0	50.0	<0.005	<0.100	61.6	28.9	165	8.4	1.0
08/18/09	15.5	6.8	5.1	50.9	0.00066	0.0123	61.2	29.1	155	8.8	0.9
03/10/10	15.6	6.6	5.0	51.2	0.00052	0.0199	62.2	30.9	156	8.9	0.9
08/10/10	15.2	6.5	4.9	49.9	0.00074	0.0158	47.5	29.8	167	8.8	0.9
03/08/11	15.6	6.7	4.9	49.2	<0.002	<0.050	55.6	32.4	172	8.8	0.8
08/02/11	16.6	7.1	5.2	51.0	<0.002	0.0118	62.9	29.0	162	8.8	1.1
03/22/12	15.1	6.2	5.0	49.4	<0.002	<0.050	60.7	30.6	166	9.1	1.3
08/08/12	15.8	6.7	4.9	49.3	<0.002	<0.050	60.1	29.1	169	8.8	1.2
03/06/13	17.1	7.5	5.6	55.3	<0.002	<0.03	66.4	33.7	150	7.9	1.0
08/13/13	16.5	7.2	5.4	51.1	<0.002	<0.03	61.8	31.9	163	8.4	1.1

Data source: Data before 10/27/1999 from BN, 2001.

NA is no analysis.

Table 2-9. UE5PW-3 General Water Chemistry Values in mg/L

Date	Ca	Mg	K	Na	Mn	Fe	SiO_2	SO_4	HCO_3	Cl	Fl
04/14/93	NA	NA	NA	46	0.042	0.024	NA	31	157	8.5	1.3
06/02/93	NA	NA	NA	53	0.009	0.014	NA	31	162	9.1	1.2
10/12/93	NA	NA	NA	57	<0.006	0.11	NA	30	156	7.9	1.2
12/20/93	NA	NA	NA	48	<0.0012	0.1	NA	33	156	8.7	1.3
05/24/94	NA	NA	NA	56	<0.0012	0.02	NA	NA	NA	NA	NA
08/08/94	NA	NA	NA	51	<0.0012	<0.009	NA	33	NA	8.9	NA
04/05/95	NA	NA	NA	55	<0.01	<0.05	NA	31	NA	8.8	NA
04/30/96	NA	NA	NA	57	<0.001	0.0088	NA	32	NA	8.7	NA
04/16/97	15.8	5.7	4.0	54.2	<0.001	<0.006	NA	29	155	8.4	1.3
11/05/97	16.8	6.1	4.3	55.5	NA	0.0133	NA	32.1	140	9.2	1.1
05/13/98	15.8	5.8	3.3	53.8	<0.0011	0.035	56.6	30.9	151	8.6	1.0
10/28/98	15.6	5.7	4.2	53.7	0.0009	0.009	57.1	31.4	156	8.7	1.0
05/19/99	15.0	5.8	4.8	56.0	<0.0025	<0.05	66.3	30.5	146	9.2	0.9
10/27/99	16.0	6.4	3.8	58.5	<0.005	<0.1	59.9	31.0	159	7.7	0.9
04/26/00	15.3	5.9	4.5	49.8	0.0003	0.0178	58.5	32.0	169	9.1	0.9
08/09/00	16.0	5.8	4.3	48.3	<0.0002	<0.0164	57.8	32.6	162	9.9	1.0
05/29/01	16.4	5.9	4.0	54.8	0.0018	<0.0107	60.5	NA	151	NA	NA
10/03/01	15.6	6.0	4.5	48.4	0.00022	0.0237	57.9	31.5	154	8.9	1.0
05/15/02	15.7	6.0	4.5	49.3	0.00027	0.0249	57.9	33.0	151	9.8	0.9
10/22/02	17.2	6.2	4.3	47.6	<0.0002	<0.0181	60.5	32.2	143	9.3	0.9
04/15/03	16.0	5.9	4.5	54.7	0.00083	0.0195	58.4	29.3	144	11.8	0.8
10/21/03	16.3	5.8	4.1	54.4	<0.0016	0.0212	59.5	32.5	160	9.2	1.0
05/04/04	16.1	5.6	4.7	52.2	0.0019	0.0453	58.2	31.1	155	8.7	1.0
10/20/04	15.6	5.9	4.0	52.3	<0.0003	<0.0279	58.4	32.0	166	9.4	0.8
04/19/05	16.2	5.6	4.5	50.9	<0.0006	0.0319	57.8	34.4	148	8.8	0.9
10/11/05	16.1	6.1	4.3	48.5	<0.0002	<0.026	61.4	32.5	156	8.5	0.9
04/26/06	16.6	6.1	4.2	58.1	<0.0032	0.0057	61.6	31.6	159	9.4	1.2
10/10/06	15.9	5.5	4.0	49.7	0.0007	0.0114	57.3	30.1	152	9.0	1.0
03/19/07	16.8	6.1	4.0	55.5	<0.0036	0.0921	61.2	19.9	149	9.3	0.8
09/05/07	16.5	5.9	4.3	54.7	0.0012	0.0041	60.1	32.5	149	9.8	1.1
03/11/08	16.7	6.1	4.2	57.2	<0.00045	0.0045	58.8	32.1	144	9.9	1.0
09/10/08	16.4	6.1	4.5	56.4	<0.0009	<0.045	58.8	35.9	165	9.5	1.0
03/10/09	15.9	6.0	4.2	55.6	<0.005	0.100	59.0	31.7	155	9.0	0.9
08/18/09	15.4	5.9	4.0	54.7	0.00062	0.0112	58.4	32.5	152	9.4	0.9
03/31/10	15.5	6.1	4.1	55.9	0.00111	0.0276	56.9	38.3	144	11.0	1.3
08/10/10	14.9	5.6	4.0	54.6	<0.002	0.0154	49.4	31.5	162	9.5	0.9
03/08/11	15.5	6.0	4.0	54.2	0.001	<0.05	55.6	37.3	172	9.4	0.9
08/02/11	15.8	6.2	4.2	55.7	<0.002	0.023	61.0	32.5	156	9.5	1.1
03/21/12	15.0	5.7	4.1	54.6	<0.002	<0.05	59.0	33.2	157	9.7	1.3
08/08/12	15.7	6.0	4.1	54.5	<0.002	<0.05	59.0	32.1	167	9.2	1.2
03/06/13	16.3	6.6	4.4	59.5	<0.002	0.0674	62.8	35.2	150	8.1	1.0
08/13/13	16.9	6.5	4.6	58.2	<0.002	<0.05	62.2	33.0	161	9.3	1.1

Data source: Data before 10/27/1999 from BN, 2001.

NA is no analysis.

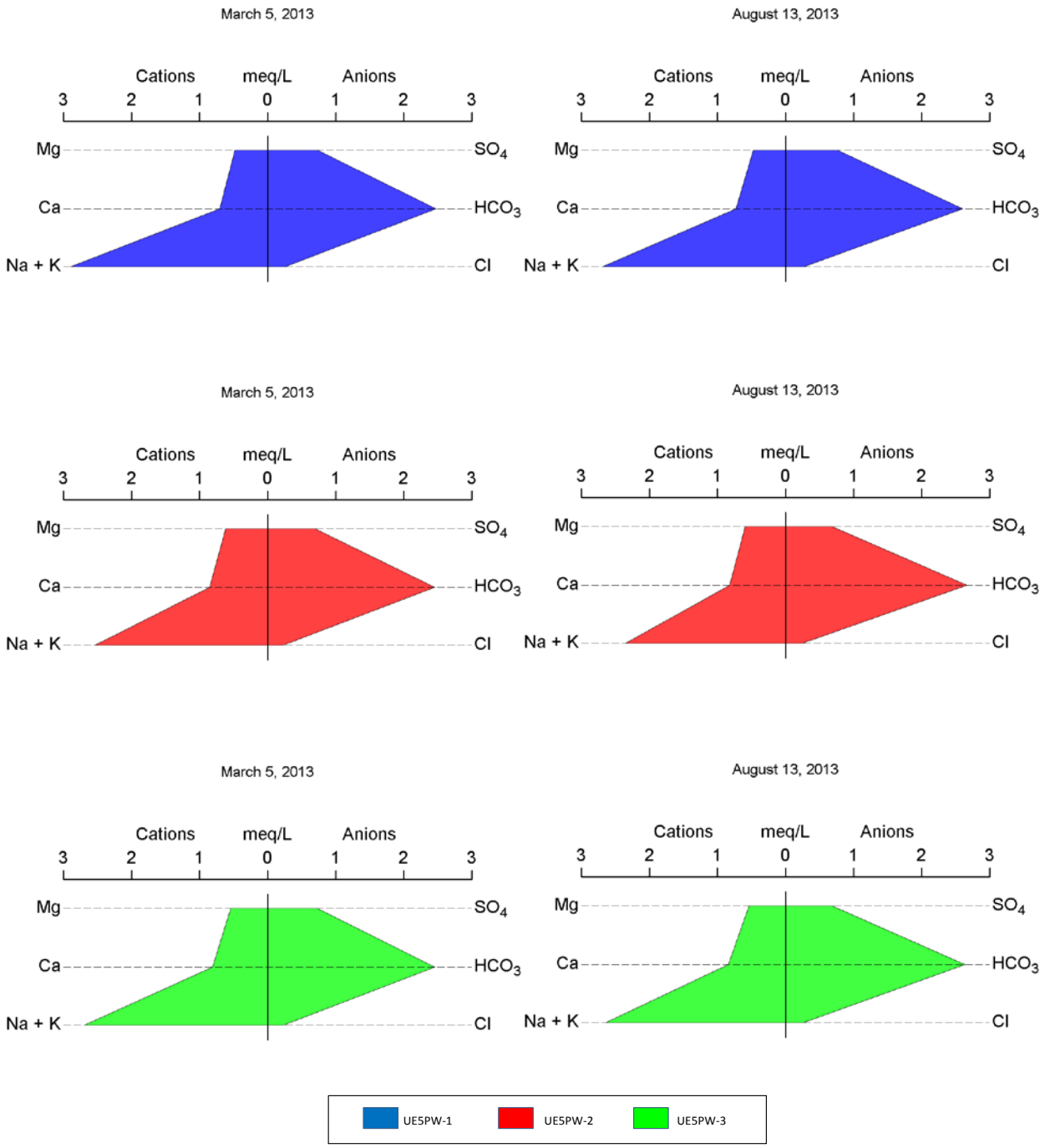

Figure 2-6. Stiff Diagrams for Pilot Well Samples Collected in 2013

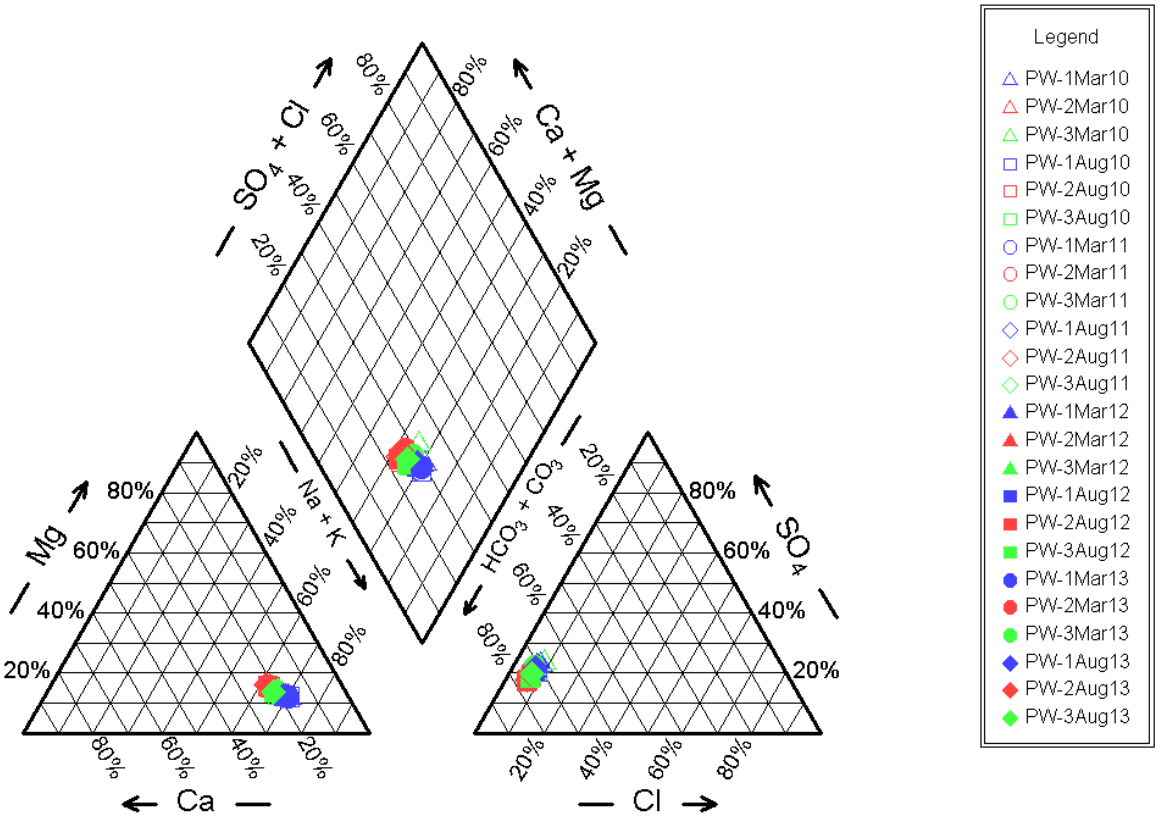

Figure 2-7. Piper Diagram for Pilot Wells from 2004 through 2013

2.2.7 Groundwater Elevation

Groundwater elevations in UE5PW-1, UE5PW-2, and UE5PW-3 are measured quarterly using an electronic water-level tape (Table 2-10). The 2013 average depths to water from the top of casing are 235.86 m (773.82 ft), 256.46 m (841.40 ft), and 271.56 m (890.94 ft) for UE5PW-1, UE5PW-2, and UE5PW-3, respectively. These measurements are corrected for borehole deviation (REECo 1994).

The 2013 average groundwater elevations are 733.51 m (2,406.52 ft) AMSL, 733.66 m (2,407.01 ft) AMSL, and 733.66 m (2,407.01 ft) AMSL for UE5PW-1, UE5PW-2, and UE5PW-3, respectively. These measurements are corrected for borehole deviation (REECo 1994).

Based on the similar groundwater elevations, the groundwater table is essentially flat with little or no flow. Groundwater gradient, velocity, and flow direction are calculated from the groundwater elevations, borehole locations, and aquifer hydraulic properties (Table 2-11; Appendix B). The average calculated flow velocity during 2013 was 0.10 meters/year and the flow direction was south. The very low calculated flow velocities and the fluctuating flow directions indicate little or no groundwater movement.

Table 2-10. Pilot Wells Groundwater Elevation Data

Well Characteristics[a]	UE5PW-1		UE5PW-2		UE5PW-3	
Northing[b] (m)	233,386.48		234,817.13		235,089.93	
Easting[b] (m)	216,357.08		216,376.00		214,415.04	
Well Casing Elevation[c] (m)	969.37		990.12		1,005.22	
Casing Stickup Height[d] (m)	0.72		0.68		0.76	
Land Surface Elevation (m)	968.73		989.54		1,004.50	
Borehole Deviation Correction (m)	0.08		0.21		0.02	
Date	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)
03/22/1993	235.55	733.82	256.38	733.74	271.69	733.53
03/23/1993	235.53	733.84	256.48	733.64	271.68	733.54
03/24/1993	235.53	733.84	256.36	733.76	271.69	733.53
03/25/1993	235.53	733.84	256.35	733.77	271.69	733.53
03/29/1993	235.59	733.78	256.38	733.74	271.73	733.49
03/30/1993	235.62	733.75	256.43	733.69	271.75	733.47
03/31/1993	235.62	733.75	256.44	733.68	271.74	733.48
04/01/1993	235.54	733.83	256.37	733.75	271.69	733.53
04/05/1993	235.51	733.86	256.35	733.77	271.67	733.55
04/06/1993	235.59	733.78	256.40	733.72	271.75	733.47
05/10/1993	235.64	733.73	256.46	733.66	271.76	733.46
05/11/1993	235.56	733.81	256.42	733.70	271.70	733.52
05/12/1993	235.54	733.83	256.40	733.72	271.72	733.50
05/13/1993	235.61	733.76	256.45	733.67	271.75	733.47
05/17/1993	235.61	733.76	256.45	733.67	271.74	733.48
05/18/1993	235.59	733.78	256.45	733.67	271.74	733.48
05/19/1993	235.59	733.78	256.44	733.68	271.73	733.49
05/20/1993	235.54	733.83	256.39	733.73	271.70	733.52
05/24/1993	235.60	733.77	256.43	733.69	271.74	733.48
05/25/1993	235.61	733.76	256.45	733.67	271.74	733.48
06/01/1993	235.58	733.79	256.43	733.69	271.73	733.49
06/07/1993	235.64	733.73	256.46	733.66	271.76	733.46
06/14/1993	235.61	733.76	256.46	733.66	271.74	733.48

Table 2-10. Pilot Wells Groundwater Elevation Data (continued)

	UE5PW-1		UE5PW-2		UE5PW-3	
Date	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)
06/21/1993	235.58	733.79	256.43	733.69	271.73	733.49
07/26/1993	235.59	733.78	256.45	733.67	271.74	733.48
08/03/1993	235.54	733.83	256.42	733.70	271.70	733.52
08/09/1993	235.62	733.75	256.46	733.66	271.75	733.47
08/16/1993	235.59	733.78	256.42	733.70	271.73	733.49
08/30/1993	235.58	733.79	256.43	733.69	271.72	733.50
12/28/1993	235.59	733.78	256.47	733.65	271.74	733.48
01/03/1994	235.57	733.80	256.44	733.68	271.70	733.52
02/02/1994	235.53	733.84	256.44	733.68	271.66	733.56
02/22/1994	235.60	733.77	256.43	733.69	271.71	733.51
02/28/1994	235.60	733.77	256.45	733.67	271.70	733.52
03/07/1994	235.54	733.83	256.38	733.74	271.66	733.56
03/14/1994	235.55	733.82	256.45	733.67	271.67	733.55
03/21/1994	235.56	733.81	256.38	733.74	271.68	733.54
03/28/1994	235.63	733.74	256.47	733.65	271.70	733.52
04/04/1994	235.53	733.84	256.40	733.72	271.66	733.56
04/13/1994	235.55	733.82	256.43	733.69	271.65	733.57
04/20/1994	235.51	733.86	256.38	733.74	271.64	733.58
04/26/1994	235.55	733.82	256.35	733.77	271.65	733.57
01/18/1995	235.63	733.74	256.45	733.67	271.62	733.60
04/03/1995	235.57	733.80	256.39	733.73	271.61	733.61
01/16/1996	235.36	734.01	256.13	733.99	271.35	733.87
04/15/1996	235.56	733.81	256.30	733.82	271.43	733.79
10/01/1996	235.54	733.83	256.32	733.80	271.51	733.71
11/19/1996	235.59	733.78	256.33	733.79	271.52	733.70
03/03/1997	235.54	733.83	256.30	733.82	271.41	733.81
04/15/1997	235.63	733.74	256.40	733.72	271.54	733.68
06/18/1997	235.61	733.76	256.40	733.72	271.52	733.70
07/28/1997	235.60	733.77	256.37	733.75	271.51	733.71
08/20/1997	235.52	733.85	256.29	733.83	271.44	733.78
09/25/1997	235.59	733.78	256.35	733.77	271.49	733.73
10/27/1997	235.57	733.80	256.34	733.78	271.48	733.74

Table 2-10. Pilot Wells Groundwater Elevation Data (continued)

	UE5PW-1		UE5PW-2		UE5PW-3	
Date	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)
11/03/1997	235.65	733.72	256.40	733.72	271.55	733.67
11/06/1997	235.57	733.80	256.36	733.76	271.48	733.74
11/12/1997	235.66	733.71	256.45	733.67	271.54	733.68
11/13/1997	235.60	733.77	256.29	733.83	271.49	733.73
11/19/1997	235.63	733.74	256.42	733.70	271.55	733.67
11/20/1997	235.65	733.72	256.43	733.69	271.57	733.65
11/25/1997	235.64	733.73	256.39	733.73	271.54	733.68
11/26/1997	235.50	733.87	256.27	733.85	271.45	733.77
12/03/1997	235.71	733.66	256.43	733.69	271.60	733.62
01/26/1998	235.72	733.65	256.47	733.65	271.60	733.62
05/12/1998	235.60	733.77	256.32	733.80	271.52	733.70
10/27/1998	235.52	733.85	256.21	733.91	271.36	733.86
12/22/1998	235.54	733.83	256.20	733.92	271.35	733.87
02/02/1999	235.61	733.76	256.34	733.78	271.42	733.80
05/18/1999	235.56	733.81	256.26	733.86	271.35	733.87
08/25/1999	235.56	733.81	256.26	733.86	271.38	733.84
10/26/1999	235.57	733.80	256.26	733.86	271.34	733.88
04/24/2000	235.64	733.73	256.34	733.78	271.52	733.70
08/07/2000	235.59	733.78	256.30	733.82	271.47	733.75
11/13/2000	235.66	733.71	256.34	733.78	271.45	733.77
02/22/2001	235.57	733.80	256.26	733.86	271.38	733.84
05/21/2001	235.67	733.70	256.35	733.77	271.49	733.73
08/01/2001	235.66	733.71	256.36	733.76	271.48	733.74
10/01/2001	235.66	733.71	256.35	733.77	271.45	733.77
02/26/2002	235.76	733.61	256.43	733.69	271.52	733.70
05/13/2002	235.65	733.72	256.39	733.73	271.44	733.78
08/19/2002	235.61	733.76	256.28	733.84	271.42	733.80
10/21/2002	235.61	733.76	256.31	733.81	271.44	733.78
02/26/2003	235.65	733.72	256.28	733.84	271.43	733.79
04/10/2003	235.61	733.76	256.30	733.82	271.41	733.81
09/10/2003	235.74	733.63	256.35	733.77	271.50	733.72
10/20/2003	235.73	733.64	256.42	733.70	271.53	733.69

Table 2-10. Pilot Wells Groundwater Elevation Data (continued)

	UE5PW-1		UE5PW-2		UE5PW-3	
Date	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)
02/25/2004	235.78	733.59	256.36	733.76	271.52	733.70
04/27/2004	235.72	733.65	256.43	733.69	271.52	733.70
08/18/2004	235.72	733.65	256.38	733.74	271.48	733.74
10/18/2004	235.71	733.66	256.29	733.83	271.47	733.75
01/26/2005	235.67	733.70	256.45	733.67	271.46	733.76
04/18/2005	235.66	733.71	256.33	733.79	271.44	733.78
07/27/2005	235.75	733.62	256.42	733.70	271.51	733.71
10/10/2005	235.77	733.60	256.44	733.68	271.54	733.68
03/08/2006	235.74	733.63	256.39	733.73	271.50	733.72
05/03/2006	235.69	733.68	256.41	733.71	271.62	733.60
08/23/2006	235.76	733.61	256.43	733.69	271.50	733.72
10/09/2006	235.69	733.68	256.38	733.74	271.44	733.78
02/28/2007	235.74	733.63	256.29	733.83	271.49	733.73
07/11/2007	235.77	733.60	256.41	733.71	271.50	733.72
08/28/2007	235.78	733.59	256.42	733.70	271.47	733.75
10/15/2007	235.76	733.61	256.40	733.72	271.49	733.73
01/22/2008	235.79	733.58	256.39	733.73	271.53	733.69
03/03/2008	235.80	733.57	256.38	733.74	271.53	733.69
06/16/2008	235.74	733.63	256.32	733.80	271.48	733.74
09/09/2008	235.73	733.64	256.39	733.73	271.47	733.75
02/17/2009	235.78	733.59	256.40	733.72	271.52	733.70
05/06/2009	235.80	733.57	256.41	733.71	271.52	733.70
08/17/2009	235.76	733.61	256.39	733.73	271.51	733.71
11/10/2009	235.81	733.56	256.46	733.66	271.55	733.67
03/01/2010	235.85	733.52	256.47	733.65	271.57	733.65
04/26/2010	235.78	733.59	256.44	733.68	271.52	733.70
08/09/2010	235.82	733.55	256.41	733.71	271.51	733.71
11/09/2010	235.82	733.55	256.40	733.72	271.54	733.68
03/01/2011	235.88	733.49	256.50	733.62	271.56	733.66
06/07/2011	235.82	733.55	256.45	733.67	271.52	733.70
08/01/2011	235.85	733.52	256.49	733.63	271.56	733.66
10/17/2011	235.86	733.51	256.49	733.63	271.59	733.63

Table 2-10. Pilot Wells Groundwater Elevation Data (continued)

	UE5PW-1		UE5PW-2		UE5PW-3	
Date	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)
03/19/2012	235.85	733.52	256.39	733.73	271.57	733.65
06/06/2012	235.88	733.49	256.47	733.65	271.57	733.65
08/02/2012	235.81	733.56	256.46	733.66	271.52	733.70
10/15/2012	235.86	733.51	256.50	733.62	271.56	733.66
03/04/2013	235.80	733.57	256.43	733.69	271.55	733.67
06/06/2013	235.86	733.51	256.46	733.66	271.56	733.66
08/12/2013	235.87	733.50	256.45	733.67	271.56	733.66
10/15/2013	235.91	733.46	256.51	733.61	271.58	733.64

[a] Source for northings, eastings, well casing elevations, and deviation corrections: REECo (1994)
[b] Coordinate System: Nevada (Central) State Plane NAD27
[c] Measured from top of well casing
[d] Measured from top of well casing to land surface
NOTE: All elevations are m AMSL

Table 2-11. 2013 Area 5 RWMS Groundwater Flow Calculations

Hydraulic Conductivity = 1.12E-03 cm/s (3.67E-05 ft/s)[a]			
Effective Porosity = 0.38[a]			
Date	**Hydraulic Gradient (m/m)**	**Velocity (m/yr)**	**Flow Direction (degrees East of North)**
03/04/2013	8.64E-05	0.08	195
06/06/2013	1.06E-04	0.10	188
08/12/2013	1.21E-04	0.11	190
10/15/2013	1.05E-04	0.10	180

[a] Source: REECo (1994)

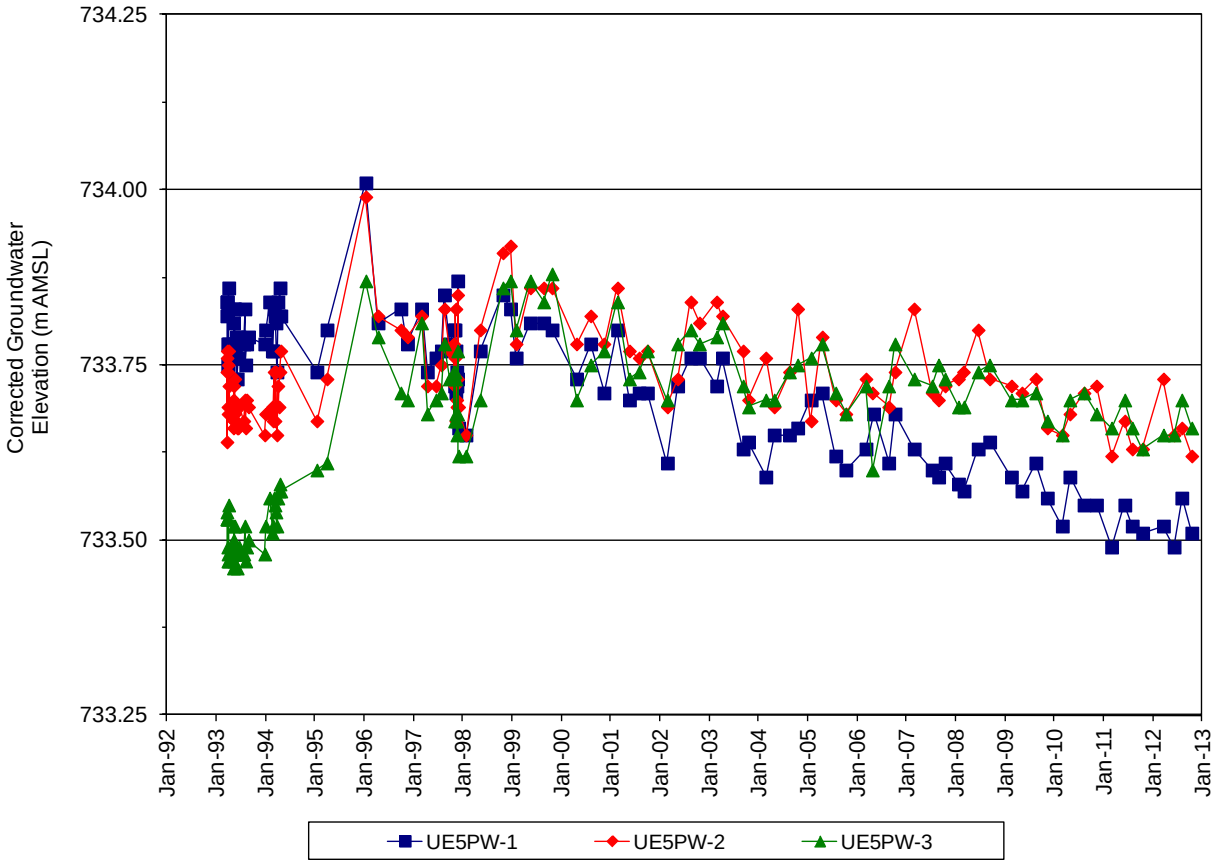

Figure 2-8. Time Series Plot of Pilot Wells Groundwater Elevations

3.0 LEACHATE MONITORING METHODS AND RESULTS

The leachate from Cell 18 has been monitored since the cell opened and began receiving waste in January 2011.

3.1 METHODS

Leachate samples were collected and analyzed when the leachate collection tank approached its 3,000-gallon capacity. The current leachate tank sampling procedure (National Security Technologies, LLC, 2010b) was followed. The RCRA permit for Cell 18 (NDEP 2011) requires groundwater monitoring at the Pilot Wells. These results are reported in Section 2.0 of this report. In addition to groundwater monitoring, the leachate samples are analyzed for the toxicity characteristic contaminants listed in Table 1 of 40 CFR 261.24 (2003), polychlorinated biphenyls (PCB), pH, and SC. These results for the leachate are reported in this section of the report.

Indicators of Contamination monitored for Leachate:

- Toxicity characteristic contaminants
    - metals – arsenic, barium, cadmium, chromium, lead, selenium, silver
    - mercury
    - semi-volatiles – o-cresol, m-cresol, p-cresol, 1,4-dichlorobenzene, 2,4-dinitrotoluene, hexachlorobenze, hexachlorobutadiene, hexachloroethane, nitrobenzene, pentrachlorophenol, pyridine, 2,4,5-trichlorophenol, 2,4,6-trichlorophenol
    - volatiles – benzene, carbon tetrachloride, chlorobenzene, chloroform, 1,2-Dichloroethane, 1,1-Dichloroethylene, methyl ethyl ketone, tetrachloroethylene, trichloroethylene, vinyl chloride
    - organochlorine pesticides – chlordane, endrin, heptachlor (and its epoxide), lindane, methoxychlor, toxaphene
    - chlorinated herbicides – 2,4-D, 2,4,5-TP (Silvex)
- Polychlorinated biphenyls
- pH
- Specific conductance

Leachate volume is measured with a totalizing flow meter when the contents of the primary sump at Cell P18 are pumped into the leachate collection tank. The flow meter measurement is recorded at an interval of approximately one week. Leachate drains into the primary sump from above the primary liner. No leachate has ever been pumped from the secondary sump which collects leachate from between the primary and secondary liner.

The total volume pumped from the primary sump into the leachate collection tank from January 2011 through December 2013 is 87,477 l (23,109 gal.). From January 2011 through December 2013 there has been 31.99 cm (12.59 in.) of precipitation at the Area 5 RMMS. The equivalent depth of the collected leachate distributed over the 1.35 ha (3.33 ac) covered by the Cell 18 liner is 0.66 cm (0.26 in.). Neglecting additional water applied to Cell 18 for dust control, leachate is approximately 2 percent of the precipitation.

3.2 RESULTS

This section provides analysis results for leachate samples.

3.2.1 Toxicity Characteristic Contaminants

All leachate analysis results toxicity characteristic contaminants and the regulatory limits for each contaminant are provided in Table 3-1. Results in Table 3-1 preceded by a less than symbol (<) are below the MDL or MDC. None of the contaminants were above the regulatory limit and most are below the MDL or MDC. There is no evidence for leachate contamination indicated by analysis for the toxicity characteristic contaminants.

Table 3-1. Results for Toxicity Characteristic Contaminants from Cell 18 Leachate

Contaminent	Regulatory Level (mg/L)	3/9/11	9/28/11	8/23/12	9/19/12	11/27/12	3/27/13	7/31/13	10/3/13	11/6/13	12/18/13
Arsenic	5.0	<0.075	0.0184	0.0205	0.0304	0.0199	<0.03	<0.04	<0.04	<0.04	<0.04
Barium	100.0	0.0794	0.09	0.0565	0.0388	0.0277	0.15	0.036	0.048	0.057	0.046
Benzene	0.5	<0.02	<0.02	<0.005	<0.02	<0.02	<0.001	<0.01	<0.001	<0.001	<0.001
Cadmium	1.0	<0.015	<0.015	<0.015	<0.015	<0.015	<0.0014	<0.005	<0.005	<0.005	<0.005
Carbon tetrachloride	0.5	<0.02	<0.02	<0.005	<0.02	<0.02	<0.001	<0.01	<0.001	<0.001	<0.001
Chlordane	0.03	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01	<0.01	<0.01	<0.01	<0.01
Chlorobenzene	100.0	<0.02	<0.02	<0.005	<0.02	<0.02	<0.001	<0.01	<0.001	<0.001	<0.001
Chloroform	6.0	<0.02	<0.02	<0.005	<0.02	<0.02	0.00094	<0.01	0.00067	0.001	0.0012
Chromium	5.0	<0.025	0.00502	<0.025	<0.025	<0.025	<0.006	<0.006	<0.006	<0.006	<0.006
o-Cresol	200.0	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1
m- and p-Cresol	200.0	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1
2,4-D	10.0	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1,4-Dichlorobenzene	7.5	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1
1,2-Dichloroethane	0.5	<0.02	<0.02	<0.005	<0.02	<0.02	<0.001	<0.01	<0.001	<0.001	<0.001
1,1-Dichloroethylene	0.7	<0.02	<0.02	<0.005	<0.02	<0.02	<0.001	<0.01	<0.001	<0.001	<0.001
2,4-Dinitrotoluene	0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin	0.02	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Heptachlor (and epoxide)	0.008	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Hexachlorobenze	0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1
Hexachlorobutadiene	0.5	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1
Hexachloroethane	3.0	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1
Lead	5.0	0.0116	0.0214	<0.05	<0.05	<0.05	<0.009	<0.02	<0.02	<0.02	0.022
Lindane	0.4	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Mercury	0.2	<0.0002	<0.0002	<0.0002	<0.0002	0.000066	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006
Methoxychlor	10.0	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
Methyl ethyl ketone	200.0	<0.05	<0.05	<0.01	<0.05	<0.05	<0.01	<0.1	<0.01	<0.01	<0.01
Nitrobenzene	2.0	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1
Pentrachlorophenol	100.0	<0.125	<0.125	<0.125	<0.125	<0.125	<0.2	<0.2	<0.2	<0.2	<0.2
Pyridine	5.0	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1
Selenium	1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.015	<0.03	0.077	<0.03	<0.03
Silver	5.0	<0.03	<0.03	<0.03	<0.03	<0.03	<0.022	<0.022	<0.022	<0.022	<0.022
Tetrachloroethylene	0.7	<0.02	<0.02	<0.005	<0.02	<0.02	<0.001	<0.01	<0.001	<0.001	0.36
Toxaphene	0.5	<0.005	<0.005	<0.005	<0.005	<0.005	<0.025	<0.025	<0.025	<0.025	<0.025
Trichloroethylene	0.5	<0.02	<0.02	<0.005	<0.02	<0.02	0.00074	<0.01	0.00086	0.0014	0.002
2,4,5-Trichlorophenol	400.0	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1
2,4,6-Trichlorophenol	2.0	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1
2,4,5-TP (Silvex)	1.0	<0.005	<0.005	<0.005	<0.005	<0.005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Vinyl chloride	0.2	<0.05	<0.05	<10	<0.05	<0.05	<0.001	<0.01	<0.001	<0.001	<0.001

Toxicity contaminant results are in mg/L

3.2.2 Polychlorinated Biphenyls

All leachate analysis results for PCBs are provided in Table 3-2. None of the PCB analysis results are above the analysis method detection limit. There is no evidence for leachate contamination indicated by analysis for PCBs.

Table 3-2. PCB Results for Cell 18 Leachate

Date	AROCLOR 1016	AROCLOR 1221	AROCLOR 1232	AROCLOR 1242	AROCLOR 1248	AROCLOR 1254	AROCLOR 1260	AROCLOR 1262	AROCLOR 1268
3/9/2011	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40
9/28/2011	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	no analysis	no analysis
8/23/2012	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	no analysis	no analysis
9/19/2012	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40
11/27/2012	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40
3/27/2013	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	no analysis	no analysis
7/31/2013	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	no analysis	no analysis
10/3/2013	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	no analysis	no analysis
11/6/2013	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	no analysis	no analysis
12/18/2013	<0.49	<0.49	<0.49	<0.49	<0.49	<0.49	<0.49	no analysis	no analysis

PCB results are in mg/L

3.2.3 Specific Conductance and pH

Field measurements of SC and pH were taken for leachate samples collected on October 3, 2013, November 6, 2013, and December 18, 2013. The results are provided in Table 3-3. The measurements are within expected ranges. SC values are above the ILs for groundwater but this is expected due to evaporation. pH results are within the IL for groundwater of between 7.6 and 9.2. No leachate contamination is indicated by the SC and pH monitoring results.

Table 3-3. SC and pH Results for Cell 18 Leachate

Date	SC mmhos/cm	pH
10/3/2013	2.480	7.95
11/6/2013	2.702	7.59
12/18/2013	2.811	7.72

4.0 SUMMARY

The hydrologic conditions in the uppermost aquifer beneath the Area 5 RWMS remain stable. Groundwater flow in this uppermost aquifer is negligible. No significant changes were detected in the water chemistry, and all indicator parameters remain within the established ILs.

Analysis of the Cell 18 leachate indicates there is no leachate contamination from waste.

THIS PAGE INTENTIONALLY LEFT BLANK

5.0 CONCLUSION

There is no measurable impact to the uppermost aquifer from the Area 5 RWMS. Leachate from Cell 18 is not contaminated and is suitable to use for dust control on Cell 18.

THIS PAGE INTENTIONALLY LEFT BLANK

6.0 REFERENCES

Bechtel Nevada, 1998. *Revised Area 5 Radioactive Waste Management Site, Outline of a Comprehensive Groundwater Monitoring Program*. Report to U.S. Department of Energy, Nevada Operations Office. February 1998. Las Vegas, Nevada.

Bechtel Nevada, 2001. *Nevada Test Site 2000 Data Report: Groundwater Monitoring Program, Area 5 Radioactive Waste Management Site*. Report to U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. February 2001. DOE/NV/11718--514. Las Vegas, Nevada.

Bechtel Nevada, 2005. *A Hydrostratigraphic Framework Model and Alternatives for the Groundwater Flow and Contaminant Transport Model of Corrective Action Unit 98: Frenchman Flat, Clark, Lincoln, and Nye Counties, Nevada.* Report to U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. September 2005. DOE/NV/11718--1064. Las Vegas, Nevada.

BN, see Bechtel Nevada.

Bright, D. J., S. A. Watkins, and B. A. Lisle, 2001. *Analysis of Water Levels in the Frenchman Flat Area, Nevada Test Site*. U.S. Geological Survey Water-Resources Investigations Report 00-4272.

CFR, see Code of Federal Regulations.

Code of Federal Regulations, 1999. Title 40, Part 265, “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities.”

Code of Federal Regulations, 2003. Title 40, Part 261, “Identification and Listing of Hazardous Waste.”

DOE, see U.S. Department of Energy.

Laczniak, R. J., J. C. Cole, D. A. Sawyer, and D. A. Trudeau, 1996. *Summary of the Hydrogeologic Control at the Nevada Test Site, Nye County, Nevada.* U.S. Geological Survey Water-Resources Investigations Report 96-4109.

Liebendorfer, P. J., 2000. Nevada Division of Environmental Protection, Carson City, Nevada, Letter to R. C. Wycoff, U.S. Department of Energy, Nevada Operations Office, Las Vegas, Nevada. *1999 Annual Groundwater Monitoring Report, Area 5 Radioactive Waste Management Site (RWMS).* April 17, 2000.

National Security Technologies, LLC, 2010a. *Instructions for Area 5 RWMS Groundwater Well Preparation and Groundwater Sampling.* Standard Operating Procedure SOP-2151.104. Las Vegas, Nevada.

National Security Technologies, LLC, 2010b. *RCRA Cell Leachate System Management,* Standard Operating Procedure SOP-2151.456. Las Vegas, Nevada.

Navarro Nevada Environmental Services, 2010. *Phase II Documentation Overview of Corrective Action Unit 98: Frenchman Flat, Nevada Test Site, Nye County, Nevada.* Report to U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. February 2010. N-I/28091--007.

Nevada Department of Environmental Protection, 2011. *RCRA Permit for a Hazardous Waste Management Facility, Permit No. NEV HW001, Rev 2, April 2011.*

NDEP, see Nevada Department of Environmental Protection.

REECo, see Reynolds Electrical and Engineering Company, Inc.

Reynolds Electrical and Engineering Company, Inc., 1994. *Site Characterization and Monitoring Data from Area 5 Pilot Wells, Nevada Test Site, Nye County, Nevada*. U.S. Department of Energy Report DOE/NV/11432--74. Las Vegas, Nevada.

U.S. Department of Energy Order DOE O 435.1, "Radioactive Waste Management," June 2001.

U.S. Geological Survey, 2013*. USGS/US DOE Cooperative Studies in Nevada, Water-Level Wells Site Map, Nevada National Security Site*. [Internet] Available at: http://nevada.usgs.gov/doe_nv/ntsmap.htm [Accessed October 21, 2013].

Appendix A – Cumulative Chronology for the Area 5 Radioactive Waste Management Site Groundwater Monitoring Program

THIS PAGE INTENTIONALLY LEFT BLANK

Cumulative Chronology for the Area 5 Radioactive Waste Management Site (RWMS) Groundwater (GW) Monitoring Program					
Date	**UE5PW-1**	**Date**	**UE5PW-2**	**Date**	**UE5PW-3**
03/20/1990	U.S. Department of Energy (DOE) letter requesting installation of monitoring wells near the Area 5 RWMS.				
03/13/1992	Drilling begins				
06/16/1992	Drilling ends	06/18/1992	Drilling begins		
09/11/1992	Well developed	09/04/1992	Drilling ends		
				09/16/1992	Drilling begins
				11/09/1992	Drilling ends
		03/24/1993	GW Sampling		
03/31/1993	GW Sampling	03/30/1993	Well developed	04/04/1993	Well developed
				04/14/1993	GW Sampling
06/06/1993	GW Sampling	06/22/1993	GW Sampling	06/02/1993	GW Sampling
09/01/1993	GW Sampling			10/12/1993	GW Sampling
12/07/1993	GW Sampling	11/15/1993	GW Sampling	12/20/1993	GW Sampling
12/17/1993	DOE letter to Nevada Division of Environmental Protection (NDEP) requesting to establish pilot wells located near the Area 5 RWMS as Resource Conservation and Recovery Act (RCRA) GW monitoring wells.				
02/24/1994	NDEP letter stating that the pilot wells appear to meet the applicable design, construction, and development criteria for RCRA GW monitoring wells.				
06/15/1994	GW Sampling	06/07/1994	GW Sampling	05/24/1994	GW Sampling
08/01/1994	GW Sampling			08/08/1994	GW Sampling
		11/29/1994	GW Sampling		
09/30/1994	DOE submits 1993 GW monitoring results from quarterly sampling effort.				
01/18/1995	UE5PW-3 GW resampling for 08/01/1994 total organic carbon (TOC) hit.				
02/23/1995	DOE transmits to NDEP GW Monitoring Program Outline.				
03/01/1995	1994 GW Monitoring Report submitted to NDEP.				
04/04/1995	GW Sampling				
11/09/1995	GW Sampling				
11/09/1995	UE5PW-1 pump snagged in hole, resulting in a bent shaft on the reel.				
01/18/1996	GW Sampling	01/25/1996	GW Sampling	01/18/1996	GW Sampling
01/22/1996	Bennett pump seals replaced at all three wells.				
03/01/1996	DOE submits to NDEP the 1995 GW Monitoring Report.				
04/16/1996	GW Sampling	04/23/1996	GW Sampling		

Cumulative Chronology for the Area 5 Radioactive Waste Management Site (RWMS) Groundwater (GW) Monitoring Program					
Date	**UE5PW-1**	**Date**	**UE5PW-2**	**Date**	**UE5PW-3**
		04/30/1996	GW Sampling		
10/02/1996	GW Sampling				
10/25/1996	NDEP requests clarifications/changes in the GW Monitoring Report.				
11/20/1996	GW Sampling				
03/01/1997	DOE submits 1996 GW Monitoring Report and revised GW Monitoring Program Outline.				
04/16/1997	GW Sampling				
08/12/1997	NDEP comments on 1996 GW Monitoring Report/Proposed Outline.				
10/22/1997	Pump and water-level meter lodge in UE5PW-1 during simultaneous operation; retrieved 10/23/1997.				
10/22/1997	Larger diameter air lines installed at all three wells.				
11/05/1997	GW Sampling				
03/01/1998	DOE submits to NDEP the 1997 GW Monitoring Report and new outline.				
03/31/1998	NDEP letter stating that they concur on the indicator parameters and investigation levels submitted in the GW Monitoring Outline.				
05/13/1998	GW Sampling				
06/22/1998	Total organic halides (TOX) detected in the 05/13/1998 samples and blanks from all three wells.				
07/10/1998	DOE and NDEP agree to resample UE5PW-1 to confirm no TOX.				
07/29/1998	GW resampling at UE5PW-1 for 05/13/1998 TOX hits.				
09/10/1998	Results from 07/29/1998 resampling are non-detect for TOX. TOX results from the 05/13/1998 sampling event are determined to be false positives.				
09/10/1998	Bennett pumps from three wells and spare pumps are sent to manufacturer for refurbishing.				
09/12/1998	Reels from three wells are returned to manufacturer for new tubing bundles.				
10/28/1998	GW Sampling				
09/12/1998	UE5PW-1 reel returned to manufacturer for repair of exhaust tube. Spare pump returned to manufacturer for the repair of a leaky seal.				
03/01/1999	DOE submits to NDEP 1998 GW Monitoring Report.				
03/31/1999	NDEP requests statistical analysis of data and states that values determined to be false positives through resampling do not need to be presented graphically.				
05/19/1999	GW Sampling				
10/27/1999	GW Sampling				
12/13/1999	Resample UE5PW-2 after TOC hit from 10/27/1999.				

Cumulative Chronology for the Area 5 Radioactive Waste Management Site (RWMS) Groundwater (GW) Monitoring Program					
Date	**UE5PW-1**	**Date**	**UE5PW-2**	**Date**	**UE5PW-3**
12/27/1999	Results from the resampling of UE5PW-2 are non-detect for TOC. TOC result from 10/27/1999 is determined to be a false positive.				
02/25/2000	DOE submits to NDEP 1999 GW Monitoring Report.				
04/17/2000	NDEP states that future reports do not need to include statistical analyses.				
04/26/2000	GW Sampling				
06/28/2000	DOE contacts State to report TOX/TOC hits from 04/26/2000. DOE and NDEP agree that the wells will be resampled in August, which would also constitute the Fall sampling event.				
08/09/2000	GW Sampling				
09/20/2000	DOE contacts NDEP to report TOX hits from 08/09/2000 sampling.				
11/07/2000	Letter from NDEP stating that DOE does not have a valid data set for TOX and possibly TOC and requests a plan to address contamination concerns prior to next sampling event.				
11/20/2000	Video log well			11/27/2000	Video log well
12/20/2000	DOE transmits to NDEP a proposed plan to address contamination issues.				
01/31/2001	Letter from NDEP generally concurring that the plan submitted to determine the cause of TOX and TOC hits is sound.				
02/21/2001	DOE submits to NDEP 2000 GW Monitoring Report.				
03/14/2001	Letter from NDEP stating that the 2000 GW Monitoring Report was received in a timely manner and contains all the data required by Title 40 Code of Federal Regulations Part 265.94. Letter also requests information regarding data in Appendix A of the 2000 GW Monitoring Report (Bechtel Nevada 2001).				
04/19/2001	Letter from DOE responding to NDEP's 3/14/2001 request for information regarding presentation of TOX/TOC data in the 2000 report.				
04/30/2001	Letter from NDEP concurring with the approach to data presentation as outlined by DOE in the 4/19/2001 correspondence.				
05/29/2001	GW Sampling				
10/03/2001	GW Sampling				
03/01/2002	DOE submits to NDEP 2001 GW Monitoring Report.				
05/15/2002	GW Sampling				
10/22/2002	GW Sampling				
03/01/2003	DOE submits to NDEP 2002 GW Monitoring Report.				
04/15/2003	GW Sampling				
10/22/2003	GW Sampling			10/21/2003	GW Sampling
02/27/2004	DOE submits to NDEP 2003 GW Monitoring Report.				
05/04/2004	GW Sampling				

Cumulative Chronology for the Area 5 Radioactive Waste Management Site (RWMS) Groundwater (GW) Monitoring Program					
Date	**UE5PW-1**	**Date**	**UE5PW-2**	**Date**	**UE5PW-3**
10/19/2004	GW Sampling			10/20/2003	GW Sampling
02/25/2005	DOE submits to NDEP 2004 GW Monitoring Report.				
04/19/2005	GW Sampling				
10/11/2005	GW Sampling				
02/28/2006	DOE submits to NDEP 2005 GW Monitoring Report.				
04/26/2006	GW Sampling				
10/10/2006	GW Sampling				
03/01/2007	DOE submits to NDEP 2006 GW Monitoring Report.				
03/19/2007	GW Sampling				
08/29/2007	GW Sampling			09/05/2007	GW Sampling
03/01/2008	DOE submits to NDEP 2007 GW Monitoring Report.				
03/11/2008	GW Sampling				
09/10/2008	GW Sampling				
04/22/2009	DOE submits to NDEP 2008 GW Monitoring Report.				
03/10/2009	GW Sampling				
08/18/2009	GW Sampling				
03/01/2010	DOE submits to NDEP 2009 GW Monitoring Report.				
03/10/2010	GW Sampling			03/31/2010	GW Sampling
08/10/2010	GW Sampling				
03/01/2011	DOE submits to NDEP 2010 GW Monitoring Report.				
03/08/2011	GW Sampling				
03/19/2011	Leachate Tank Sampling				
08/02/2011	GW Sampling				
08/24/2011	GW Sampling				
09/28/2011	Leachate Tank Sampling				
10/18/2011	Sample Pumps and Tubing Disinfected				
10/19/2011	GW Sampling				
03/01/2012	DOE submits to NDEP 2011 GW Monitoring Report				
03/21/2012	GW Sampling				
08/08/2012	GW Sampling				

Cumulative Chronology for the Area 5 Radioactive Waste Management Site (RWMS) Groundwater (GW) Monitoring Program					
Date	**UE5PW-1**	**Date**	**UE5PW-2**	**Date**	**UE5PW-3**
08/21/2012	GW Sampling				
08/23/2012	Leachate Tank Sampling				
09/11/2012	GW Sampling				
09/19/2012	Leachate Tank Sampling				
11/27/2012	Leachate Tank Sampling				
03/01/2013	DOE submits to NDEP 2011 GW Monitoring Report				
03/05/2013	GW Sampling				
03/27/2013	Leachate Tank Sampling				
07/31/2013	Leachate Tank Sampling				
08/13/2013	GW sampling				
10/03/2013	Leachate Tank Sampling				
11/06/2013	Leachate Tank Sampling				
12/18/2013	Leachate Tank Sampling				

THIS PAGE INTENTIONALLY LEFT BLANK

Appendix B – Gradient/Velocity Calculations

THIS PAGE INTENTIONALLY LEFT BLANK

Calculation of Magnitude and Direction of Area 5 Alluvial Aquifer Gradient

Water level elevations measured at three wells near the Area 5 Radioactive Waste Management Site (UE5PW-1, UE5PW-2, and UE5PW-3) are used to calculate the magnitude and direction of the aquifer hydraulic gradient.

The locations of the three wells are given in Nevada State Central Zone coordinates in meters as northing (N) and easting (E) values. The coordinates of each of the three water elevation points define a plane that contains the water level points. The coordinates of the water elevation points are (E_i, N_i, e_i), where:

E_i is the East Coordinate of the i^{th} well (m)
N_i is the North Coordinate of the i^{th} well (m)
e_i is the water level elevation of the i^{th} well (m)

Assuming i=1 for UE5PW-1, i=2 for UE5PW-2, and i=3 for UE5PW-3, the vector **a** connecting the water level at UE5PW-1 to the water level at UE5PW-2 and the vector **b** connecting the water level at UE5PW-1 to the water level at UE5PW-3 are defined by:

$$\mathbf{a} = (E_2 - E_1)\mathbf{i} + (N_2 - N_1)\mathbf{j} + (e_2 - e_1)\mathbf{k}$$
$$\mathbf{b} = (E_3 - E_1)\mathbf{i} + (N_3 - N_1)\mathbf{j} + (e_3 - e_1)\mathbf{k}$$

The aquifer hydraulic gradient is the cross product **a** x **b.**

$$\mathbf{a} \times \mathbf{b} = \mathbf{DET}\begin{bmatrix} i & j & k \\ E_2 - E_1 & N_2 - N_1 & e_2 - e_1 \\ E_3 - E_1 & N_3 - N_1 & e_3 - e_1 \end{bmatrix}$$

$$= [(N_2 - N_1)(e_3 - e_1) - (e_2 - e_1)(N_3 - N_1)]\mathbf{i} +$$
$$[(e_2 - e_1)(E_3 - E_1) - (E_2 - E_1)(e_3 - e_1)]\mathbf{j} +$$
$$[(E_2 - E_1)(N_3 - N_1) - (N_2 - N_1)(E_3 - E_1)]\mathbf{k}$$
$$= A\mathbf{i} + B\mathbf{j} + C\mathbf{k}$$

Where: $A = (N_2 - N_1)(e_3 - e_1) - (e_2 - e_1)(N_3 - N_1)$
$B = (e_2 - e_1)(E_3 - E_1) - (E_2 - E_1)(e_3 - e_1)$
$C = (E_2 - E_1)(N_3 - N_1) - (N_2 - N_1)(E_3 - E_1)$

Dividing hydraulic gradient by C gives the magnitude of the gradient in Easting (**i**) and Northing (**j**) for a unit change in elevation (**k**)

$$(\mathbf{a} \times \mathbf{b})/C = A/C\,\mathbf{i} + B/C\,\mathbf{j} + \mathbf{k}$$

The magnitude of the gradient is:

$$\sqrt{A/C^{2} + B/C^{2}}$$

The direction of the gradient from north (θ) is calculated using the magnitudes of easting (E) and northing (N).

If B > 0, then θ = arctan (a/b)
If B < 0, then θ = 180° + arctan (a/b)
If B = 0 and A > 0, then θ = 90°
If B = 0 and A < 0, then θ = 270°
If B = 0 and A = 0, then the flow is straight down.

Calculation of Mean Groundwater Velocity

Groundwater flux is calculated from Darcy's Law:

$$J = -K\left(\frac{\Delta e}{C}\right)$$

Where: J is groundwater flux (m/s)
K is saturated hydraulic conductivity (m/s)
$\Delta e/C$ is the hydraulic gradient (m/m)

The mean groundwater velocity is calculated from the flux:

$$V = J/\phi$$

Where: V is mean groundwater velocity (m/s)
J is the groundwater flux (m/s)
Φ is porosity (m^3/m^3)

DISTRIBUTION LIST

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office

Jhon T. Carilli — 4
Low-Level Waste Activity Lead, Environmental Management Operations
U.S. Department of Energy
National Nuclear Security Administration
Nevada Field Office
P.O. Box 98518 M/S 505
Las Vegas, NV 89193-8518

Kenneth M. Small — 1
RCRA Program Manager, Waste Management Project
U.S. Department of Energy
National Nuclear Security Administration
Nevada Field Office
P.O. Box 98518 M/S 505
Las Vegas, NV 89193-8518

U.S. Department of Energy — 2 (CD)
National Nuclear Security Administration
Nevada Field Office
Public Reading Facility
P.O. Box 98521, M/S 400
Las Vegas, NV 89193-8521

U.S Department of Energy — 1 digital file
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062

National Security Technologies, LLC

David M. Black — 1
National Security Technologies, LLC
P.O. Box 98521, M/S NNSS403
Las Vegas, NV 89193-8521

David B. Hudson — 1
National Security Technologies, LLC
P.O. Box 98521, M/S NLV083
Las Vegas, NV 89193-8521

Theodore J. Redding — 1
National Security Technologies, LLC
P.O. Box 98521, M/S NNSS273
Las Vegas, NV 89193-8521

Gregory J. Shott — 1
National Security Technologies, LLC
P.O. Box 98521, M/S NLV083
Las Vegas, NV 89193-8521

Jon D. Yonko — 1
National Security Technologies, LLC
P.O. Box 98521, M/S NNSS304
Las Vegas, NV 89193-8521

Vefa Yucel — 1
National Security Technologies, LLC
P.O. Box 98521, M/S NLV083
Las Vegas, NV 89193-8521