NEVADA NATIONAL SECURITY SITE

2012 DATA REPORT:

GROUNDWATER MONITORING PROGRAM

AREA 5 RADIOACTIVE WASTE MANAGEMENT SITE

February 2013

Prepared for:

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

Prepared by:

National Security Technologies, LLC
Las Vegas, Nevada

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LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

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
GW	groundwater
HCO ₃	bicarbonate
IL	investigation level
in.	inch
K	potassium
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
pCi/L	picocurie per liter
QL	quantification limit
RCRA	Resource Conservation and Recovery Act
REEC _o	Reynolds Electrical and Engineering Company, Inc.
RWMS	Radioactive Waste Management Site
SC	specific conductance
SiO ₂	silicate
SO ₄	sulfate
TOC	total organic carbon
TOX	total organic halides
µg/L	microgram per liter

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EXECUTIVE SUMMARY

This report is a compilation of the groundwater sampling results from the Area 5 Radioactive Waste Management Site (RWMS). The data have been collected since 1993 and include calendar year 2012 results. During 2012, groundwater samples were collected and static water levels were measured at the three pilot wells surrounding the Area 5 RWMS. Groundwater samples were collected at UE5PW-1, UE5PW-2, and UE5PW-3 on March 21, August 7, August 21, and September 11, 2012, and static water levels were measured at each of the three pilot wells on March 19, June 6, August 2, and October 15, 2012. Groundwater samples were analyzed for the following indicators of contamination: pH, specific conductance, total organic carbon, total organic halides, and tritium. Indicators of general water chemistry (cations and anions) were also measured. Final results from samples collected in 2012 were within the limits established by agreement with the Nevada Division of Environmental Protection for each analyte.

These data indicate that there has been no measurable impact to the uppermost aquifer from the Area 5 RWMS.

There were no significant changes in measured groundwater parameters compared to previous years.

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

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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This report is a compilation of the groundwater sampling results from three monitoring wells located near the Area 5 Radioactive Waste Management Site (RWMS) at the Nevada National Security Site (NNSS), Nye County, Nevada, and includes the results for calendar year 2012. 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). Pilot Wells UE5PW-1, UE5PW-2, and UE5PW-3 are used to monitor the groundwater at the Area 5 RWMS (Figure 1-2). In addition to groundwater 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 and to facilitate the readability of the document. The objective of this report is to satisfy any Area 5 RWMS 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; Lacznia 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.

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

Figure 1-2. Location of Pilot Wells at 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).

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).

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 2012, the average water table depth below the top of the well casing was 235.85 m (773.78 ft), and the average water table elevation was 733.52 m (2,406.55 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 2012, 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 733.67 m (2,407.05 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 2012, 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 733.67 m (2,407.05 ft) AMSL.

Groundwater Monitoring Program
Area 5 Radioactive Waste Management Site

Figure 1-3. Average Water Level Elevation at Groundwater Monitoring Wells in the Vicinity of the Area 5 RWMS (U.S. Geological Survey 2012)

Figure 1-4. Groundwater Subbasins and Flow Directions in the Area 5 RWMS Vicinity

1.4 SITE METEOROLOGY

Meteorological data are measured at the Area 5 RWMS. These data include temperature, relative humidity, barometric pressure, wind speed and direction, solar radiation, and precipitation. During 2012 the average daily temperature at 3 m height was 16.9 degrees Celsius (°C) (62.4 degrees Fahrenheit [°F]). The maximum observed temperature at 3 m height was 43.9°C (111.0°F) on July 11, 2012, and the minimum observed temperature at 3 m was -10.4°C (13.3°F) on January 13, 2012. The maximum observed wind gust at 3 m was 24.9 meters/second (55.7 miles per hour) on March 6, 2012. The average annual precipitation measured at the Area 5 RWMS from 1994 through 2012 is 12.2 cm per year (4.80 in. per year). The Area 5 RWMS had 13.8 cm (5.43 in.) of precipitation during 2012. During the 18-year measurement period, 2012 is the sixth wettest year. There were 32 days of measurable precipitation in 2012 at the Area 5 RWMS. The wettest month in 2012 was October, which had approximately 27 percent of the 2012 precipitation. Monthly precipitation at the Area 5 RWMS from January 1994 through December 2012 is provided in Figure 1-5.

Figure 1-5. Monthly Precipitation at the Area 5 RWMS

2.0 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 2012, groundwater samples were initially collected at UE5PW-1, UE5PW-2, and UE5PW-3 on March 21 and August 7, 2012. The current groundwater sampling procedure (National Security Technologies, LLC 2010) was followed. Tritium samples were enriched prior to shipment to a contract laboratory for analysis. Tritium analyses were conducted by ALS Laboratories. All other analyses were conducted by Lionville Laboratory Incorporated.

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.

The samples for TOC analysis collected on August 7, 2012, were destroyed during shipment to the contract lab, so all three pilot wells were re-sampled for TOC analysis on August 21, 2012.

Some TOX results for samples collected on August 7, 2012, were above the detection limit but below the TOX IL. Previous TOX results were typically below detection limits, so all three pilot wells were re-sampled for TOX analysis on September 11, 2012.

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 2012 (Table 2-2). The 2012 pH values ranged from 8.24 to 8.39 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. Area 5 RWMS 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

Table 2-2. Area 5 RWMS pH Values (continued)

UE5PW-1		UE5PW-2		UE5PW-3	
Date	pH	Date	pH	Date	pH
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
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

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. Area 5 RWMS Time Series Plot of pH

2.2.2 Specific Conductance

The 2012 measured SC of water samples from each well remained below the IL of 0.440 mmhos/cm and ranged from 0.362 to 0.383 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. Area 5 RWMS 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
11/20/1996	0.374	11/20/1996	0.365	11/20/1996	0.378

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

UE5PW-1		UE5PW-2		UE5PW-3	
Date	SC	Date	SC	Date	SC
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

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. Area 5 RWMS Time Series Plot of SC

2.2.3 Total Organic Carbon

Three samples were collected consecutively from each well on each sample 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 2012, the contract analysis lab decreased the MDL for TOC from 0.5 mg/L to 0.2 mg/L. This resulted in lower reported TOC results for 2012.

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. Area 5 RWMS 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
01/18/1995	0.20	01/18/1995	0.50	01/18/1995	0.23
04/04/1995	<1.0	04/04/1995	<1.0	04/05/1995	<1.0
11/09/1995	<1.0	11/20/1995	<1.0	11/09/1995	<1.0

Table 2-4. Area 5 RWMS TOC Values in mg/L (continued)

UE5PW-1		UE5PW-2		UE5PW-3	
Date	TOC	Date	TOC	Date	TOC
04/16/1996	<0.3	04/30/1996	<0.3	04/30/1996	<0.3
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
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

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

Figure 2-3. Area 5 RWMS Time Series Plot of TOC

2.2.4 Total Organic Halides

Three groundwater samples were collected consecutively from each well on each sample date for TOX analysis. Samples were initially collected on March 21, 2012, and August 7, 2012. Wells were re-sampled on September 11, 2012, for TOX analyses. 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. Values in parentheses following a reported average below are the individual measurements used to calculate the average.

All but one TOX result from 2012 were below the IL. One sample from UE5PW-3 collected on August 7, 2012, had a TOX result above the IL. Due to this result above the IL and somewhat higher TOX results for other samples from this date, all three pilot wells were re-sampled for TOX analyses on September 11, 2012. TOX results for these samples were all below the IL and also below the MDL.

Between May 2002 and August 2011, the laboratory reported MDL for TOX analyses are between 7.2 µg/L and 5.0 µg/L. The laboratory began reporting quantification limits (QL) in 2011, which were initially equal to the reported 5.0 µg/L MDL. Beginning with the March 2012 results, the reported QL increased to 20 µg/L. The TOX results for samples collected on March 21, 2012, are 9.2 µg/L (11.7 µg/L, 9.25 µg/L, 6.63 µg/L) for UE5PW-1, 8.2 µg/L (<5.0 µg/L, 9.41 µg/L, 10.1 µg/L) for UE5PW-2, and 11.0 µg/L (6.21 µg/L, 14.3 µg/L, 12.5 µg/L) for UE5PW-3. Only one TOX result for these samples is below the 5.0 µg/L MDL. The remaining results are between the 5.0 µg/L MDL and the 20 µg/L quantification limit. Standard laboratory reporting conventions qualify results greater than the MDL but less than the QL as estimated and provide no bounds for these estimates. All results for the March 21, 2012, samples are below the 50 µg/L IL. The TOX results for samples collected on August 7, 2012, are 20.4 µg/L

(46.2 µg/L, 7.00 µg/L, 8.14 µg/L) for UE5PW-1, 25.7 µg/L (31.8 µg/L, 33.8 µg/L, 11.6 µg/L) for UE5PW-2, and 35.6 µg/L (50.7 µg/L, 37.6 µg/L, 18.6 µg/L) for UE5PW-3. All three pilot wells were re-sampled for TOX analysis on September 11, 2012. The laboratory reported a 20 µg/L MDL and a 100 µg/L QL for these samples. All results for these samples are less than the 20 µg/L MDL. The TOC results for samples collected on March 21, 2012, and September 11, 2012, are provided in Table 2-5 and Figure 2-4.

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. Area 5 RWMS 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

Table 2-5. Area 5 RWMS TOX Values in µg/ (continued)

UE5PW-1		UE5PW-2		UE5PW-3	
Date	TOX	Date	TOX	Date	TOX
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
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

^a Determined to be a false positive through resampling

^b Multiple laboratories used; this value is average of Lionville Laboratory only

Figure 2-4. Area 5 RWMS Time Series Plot of TOX

2.2.5 Tritium

All tritium results from 2012 groundwater samples were below the IL of 2,000 pCi/L and below the laboratory MDC of approximately 20 pCi/L (Table 2-6). In 2012, duplicate samples were collected from each well on each sample date. Table 2-6 reports the average of these two results. 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. Area 5 RWMS 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
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

Table 2-6. Area 5 RWMS Tritium Values in pCi/L (continued)

UE5PW-1		UE5PW-2		UE5PW-3	
Date	Tritium	Date	Tritium	Date	Tritium
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

Figure 2-5. Area 5 RWMS Time Series Plot of Tritium

2.2.6 General Water Chemistry Parameters

General water chemistry analyses during 2012 for cations (Ca, Mg, Na, K, Fe), anions (Cl, F, SO₄, HCO₃), and SiO₂ 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 2011 and 2012 indicate similar groundwater chemistry for all three wells and no changes in the groundwater chemistry (Figure 2-6). A piper diagram for the same water chemistry data from 2009 through 2012 indicates that the groundwater is a sodium-bicarbonate type (Figure 2-7).

Groundwater temperatures measured in March 2012 ranged from 18.5°C to 10.5°C (65.3°F to 68.9°F) and in August 2012 ranged from 21.7°C to 26.0°C (71.1°F to 78.8°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	FI
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	N/A	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

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

N/A is no analysis.

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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	FI
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	N/A
04/04/95	NA	NA	NA	50	<0.01	<0.05	NA	28	NA	8.5	N/A
04/30/96	NA	NA	NA	51	<0.001	0.013	NA	29	NA	8.3	N/A
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	N/A	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	<0.0002	<0.050	55.6	32.4	172	8.8	0.8
08/02/11	16.6	7.1	5.2	51.0	<0.0002	0.0118	62.9	29.0	162	8.8	1.1
03/22/12	15.1	6.2	5.0	49.4	<0.0002	<0.050	60.7	30.6	166	9.1	1.3
08/08/12	15.8	6.7	4.9	49.3	<0.0002	<0.050	60.1	29.1	169	8.8	1.2

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

N/A 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	N/A	N/A	N/A	46	0.042	0.024	N/A	31	157	8.5	1.3
06/02/93	N/A	N/A	N/A	53	0.009	0.014	N/A	31	162	9.1	1.2
10/12/93	N/A	N/A	N/A	57	<0.006	0.11	N/A	30	156	7.9	1.2
12/20/93	N/A	N/A	N/A	48	<0.0012	0.1	N/A	33	156	8.7	1.3
05/24/94	N/A	N/A	N/A	56	<0.0012	0.02	N/A	N/A	N/A	N/A	N/A
08/08/94	N/A	N/A	N/A	51	<0.0012	<0.009	N/A	33	N/A	8.9	N/A
04/05/95	N/A	N/A	N/A	55	<0.01	<0.05	N/A	31	N/A	8.8	N/A
04/30/96	N/A	N/A	N/A	57	<0.001	0.0088	N/A	32	N/A	8.7	N/A
04/16/97	15.8	5.7	4.0	54.2	<0.001	<0.006	N/A	29	155	8.4	1.3
11/05/97	16.8	6.1	4.3	55.5	N/A	0.0133	N/A	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	N/A	151	N/A	N/A
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

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

N/A is no analysis.

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Figure 2-6. Area 5 RWMS Stiff Diagrams for 2011 and 2012

Figure 2-7. Area 5 RWMS 4-Year Piper Diagram

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 2012 average depths to water from the top of casing are 235.85 m (773.78 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 2012 average groundwater elevations are 733.52 m (2,406.55 ft) AMSL, 733.67 m (2,407.05 ft) AMSL, and 733.67 m (2,407.05 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 2012 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 flow.

Table 2-10. Area 5 RWMS 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
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

Table 2-10. Area 5 RWMS 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)
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
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

Table 2-10. Area 5 RWMS 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)
11/19/1997	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
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

Table 2-10. Area 5 RWMS 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)
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
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

^a Source for northings, eastings, well casing elevations, and deviation corrections: REEC Co (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 above mean sea level

Table 2-11. 2012 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)
03/19/2012	1.58E-04	0.15	203
06/06/2012	1.13E-04	0.11	188
08/02/2012	7.08E-05	0.07	171
10/15/2012	7.76E-05	0.07	173

^a Source: REECO (1994)

Figure 2-8. Area 5 RWMS Time Series Plot of Groundwater Elevations

3.0 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.

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4.0 CONCLUSION

There is no measurable impact to the uppermost aquifer from the Area 5 RWMS.

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

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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		

Groundwater Monitoring Program
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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				

Groundwater Monitoring Program
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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				
08/02/2011	GW Sampling				
08/24/2011	GW 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				
08/21/2012	GW Sampling				
09/11/2012	GW Sampling				

Appendix B – Gradient/Velocity Calculations

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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:

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

The aquifer hydraulic gradient is the cross product $\mathbf{a} \times \mathbf{b}$.

$$\begin{aligned}\mathbf{a} \times \mathbf{b} &= \text{DET} \begin{bmatrix} i & j & k \\ E_2 - E_1 & N_2 - N_1 & e_2 - e_1 \\ E_3 - E_1 & N_3 - N_1 & e_3 - e_1 \end{bmatrix} \\ &= [(N_2 - N_1)(e_3 - e_1) - (e_2 - e_1)(N_3 - N_1)]\mathbf{i} + \\ &\quad [(e_2 - e_1)(E_3 - E_1) - (E_2 - E_1)(e_3 - e_1)]\mathbf{j} + \\ &\quad [(E_2 - E_1)(N_3 - N_1) - (N_2 - N_1)(E_3 - E_1)]\mathbf{k} \\ &= A\mathbf{i} + B\mathbf{j} + C\mathbf{k}\end{aligned}$$

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)

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

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 $\theta = \arctan (a/b)$
- If $B < 0$, then $\theta = 180^\circ + \arctan (a/b)$
- If $B = 0$ and $A > 0$, then $\theta = 90^\circ$
- If $B = 0$ and $A < 0$, then $\theta = 270^\circ$
- If $B = 0$ and $A = 0$, then the flow is straight down.

Calculation of Mean Groundwater Velocity

Groundwater flux is from 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)

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

Jhon T. Carilli LLW Federal Sub-Project Director, Waste Management Project U.S. Department of Energy National Nuclear Security Administration Nevada Site Office P.O. Box 98518 M/S 505 Las Vegas, NV 89193-8518	4
Kenneth M. Small RCRA Program Manager, Waste Management Project U.S. Department of Energy National Nuclear Security Administration Nevada Site Office P.O. Box 98518 M/S 505 Las Vegas, NV 89193-8518	1
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Groundwater Monitoring Program
Area 5 Radioactive Waste Management Site

National Security Technologies, LLC

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

Stevon A. Rainey 1
National Security Technologies, LLC
P.O. Box 98521, M/S NNSS273
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

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