Section 1

Hydrologic Monitoring and Data Assessment

Table of Contents

Hydrologic Monitoring and Data Assessment

M.B. Hillesheim and R.L. Beauheim

Executive Summary

Groundwater monitoring activities at the Waste Isolation Pilot Plant (WIPP) are an integral part of the U.S. Department of Energy's (DOE) broader requirement to ensure protection of the environment, the health and safety of workers and the public, proper characterization of the disposal system, and compliance of the WIPP with applicable regulations. This commitment is not only for the current operational phase of the WIPP but extends through the post-closure phase to meet regulatory requirements. The Management and Operating Contractor (MOC) for the WIPP, Washington TRU Solutions, is responsible for collecting groundwater data (e.g., manual water-level measurements) to meet regulatory requirements. The DOE Scientific Advisor (SA) for the WIPP, Sandia National Laboratories (SNL), is responsible for evaluating the regulatory compliance data and addressing any concerns raised by DOE or WIPP stakeholders. SNL also performs additional hydrologic monitoring activities focused on developing a clearer picture of water-level fluctuations that occur on less than monthly time-scales. In 2004 and 2005, SNL deployed 30 TROLLs (programmable pressure-temperature gauges) in Culebra and Magenta wells to collect hourly data (SNL also takes manual water-level measurements).

Results from the high-frequency monitoring have shown a number of water-level/pressure-head fluctuations in WIPP wells. Many wells showed clear, and expected, drawdown and recovery responses to the numerous pumping tests performed by SNL. Short-term spikes in water levels followed by gradual returns to previous levels (e.g., H-6b, H-10a, and H-10c) can usually be correlated with the drilling of nearby oil wells, and are believed to reflect loss of drilling fluid into the Culebra and/or Magenta before casing is installed in the wells. Plugging and abandonment (P&A) of deteriorating and/or unneeded wells and well-reconfiguration activities (e.g., plugbacks) typically cause temporary head fluctuations in other wells on the same drilling pad, although on the H-5 drilling pad, these activities seem to have caused a "permanent" 6-ft rise in Culebra water levels in H-5b. New wells (primarily SNL-series) typically show water-level rises attributable to recovery from well-development activities. WIPP-26 and IMC-461 show repeated drawdown and recovery responses to some stress that has not yet been identified. Nash Draw wells WIPP-26 and, to a lesser extent, WIPP-25 appear to respond to major rainfall events (>2.5 inches) in Nash Draw, with the resulting pressure wave then propagating under Livingston Ridge to wells nearer the WIPP site. SNL-12 showed an apparent drawdown response (~1 ft) to an unknown event in July 2004.

Planned activities include the deployment of additional TROLLs, installation of rain gauges at additional locations, and development of a database for storing and accessing all monitoring data collected by SNL and the MOC.

1. Introduction

Groundwater monitoring activities at the WIPP are conducted to meet DOE requirements to ensure protection of the environment, the health and safety of workers and the public, proper characterization of the disposal system, and compliance of the WIPP with applicable regulations outlined in EPA (1998) and NMED (1999. This commitment is for the current operational phase and extends through the post-closure phase. WTS collects the compliance groundwater data (e.g., manual water-level measurements and water-quality data) and SNL evaluates the data. SNL also performs additional hydrologic monitoring and testing activities to address any concerns raised by DOE or WIPP stakeholders.

Between January 2004 and December 2005, SNL deployed approximately 30 TROLLs (programmable pressure-temperature gauges) in Culebra and Magenta wells to collect hourly data (SNL also takes manual water-level measurements). This report discusses the activities conducted by SNL regarding groundwater monitoring at WIPP between January 2004 and December 2005. The activities combine the assessment of compliance groundwater data collected by the MOC and additional data collected by SNL.

2. WIPP Groundwater Compliance Data

2.1 Background

The focus of the WIPP Groundwater Monitoring Program is the Culebra Member of the Rustler Formation because it is the most transmissive of the saturated units at the WIPP site. Other formations, including the Magenta Member of the Rustler Formation and the Dewey Lake and Bell Canyon Formations, are monitored where access is available.

At present, the WIPP groundwater-monitoring network consists of approximately 70 wells completed to various water-bearing horizons located within and outside the WIPP Land Withdrawal Act boundary (LWB; Figure 1). Information collected by the MOC from these wells for compliance purposes consists of water quality, water levels, and fluid density. Water quality is measured in seven wells (known as WQSP wells) twice per year (spring and fall). Water levels are measured monthly in all primary wells and quarterly in redundant wells (i.e., wells located on the same hydropad and completed to the same hydrologic unit as the primary well). The MOC also conducts an annual pressure-density (PD) survey in most of the wells to determine the fluid density of the water column.

In addition to collecting these compliance data, the MOC regularly performs well maintenance including well logging and integrity testing, plugging and abandonment (P&A) of wells that are unreliable for monitoring because of some well-related problem (e.g., corroded casing or poor cement) found during integrity testing, and plug back of dual/multi-completion wells, that are deemed to be sound, to single-completion for data integrity reasons. The MOC also provides oversight for the drilling of new and replacement wells, as required.

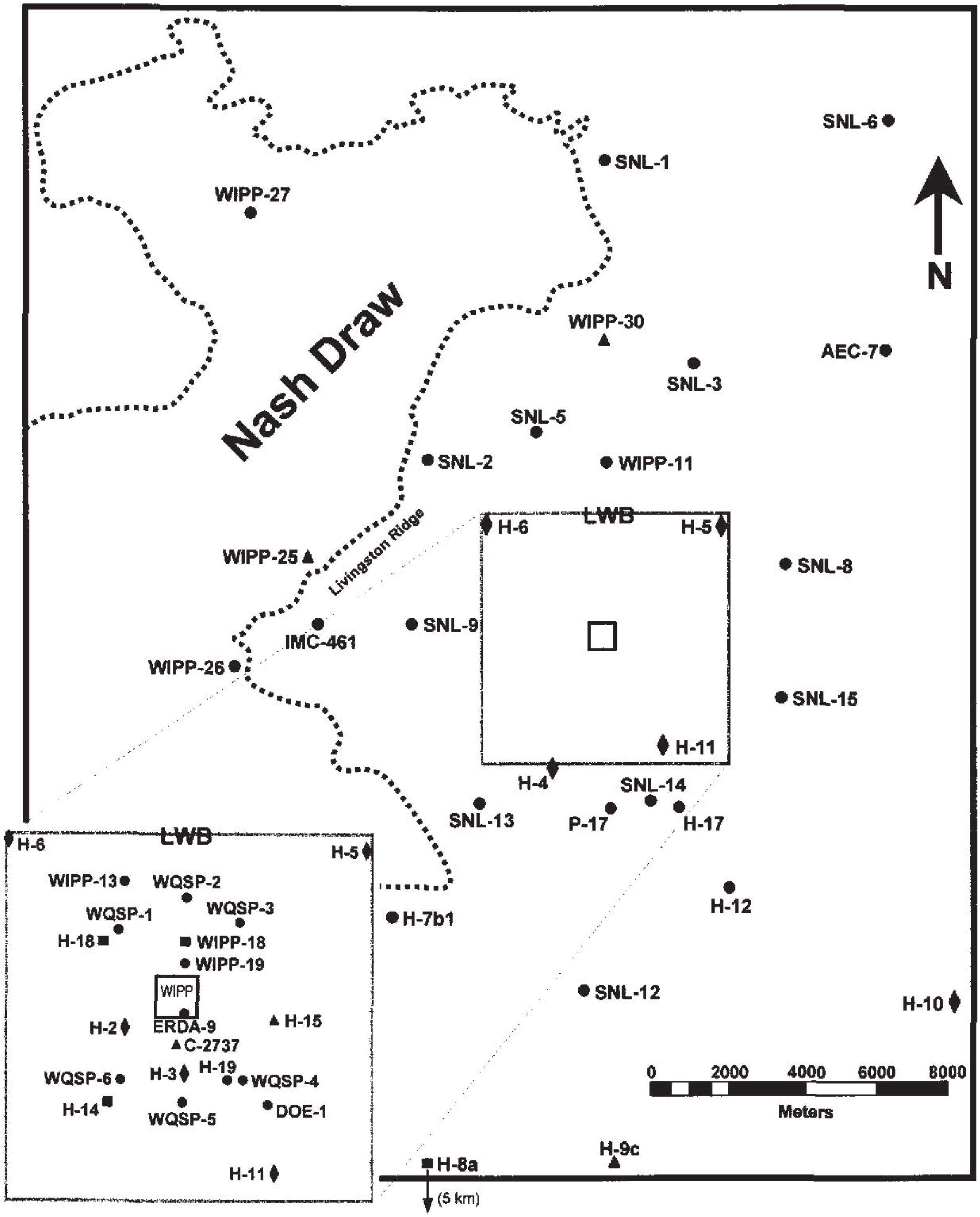

Figure 1. Map showing the locations of the WIPP groundwater monitoring network wells in 2004 and 2005. Well-completion horizons are as follows: Culebra – circle (●); Magenta – square (■); dual-completion Culebra/Magenta – triangle (▲); hydropad cluster Culebra/Magenta – diamond (♦). The dashed line demarks the edge of Nash Draw.

2.2 Data Assessment

Groundwater compliance monitoring data collected by the MOC are reviewed by SNL as it is received (i.e., monthly water-level memoranda), in order to identify any problems/anomalous behavior as soon as possible. SNL also provides an annual evaluation of these data against regulatory compliance requirements (SNL responsibilities and technical scope are provided in DOE [1999] and SNL [2000]) in the form of a compliance assessment report (i.e., COMPs Report). The assessment includes preparation and review of updated hydrographs, analysis of new well configurations, review of data trends, and identification of deviations from normal or expected groundwater behavior. Compliance assessments conducted by SNL for 2004 and 2005 are detailed in SNL (2005) and SNL (2006) and will not be discussed further in this report.

In addition to the assessment of compliance data, SNL has provided scientific feedback to the MOC with regards to water-quality and fluid-density results, and the optimal placement of new and replacement wells. SNL also reviews technical documents for the MOC (e.g., basic data reports, program plans, annual site environmental report, etc.) and assists in well-maintenance activities (i.e., bailing, scraping, etc.).

3. SNL Groundwater Monitoring Activities and Data

3.1 Background

As directed by DOE, SNL has developed and implemented various investigations over the past few years in order to address a variety of issues. These include: observed water-level rise in the Culebra, re-assessment of the assumptions and models used in the Compliance Recertification Application (CRA; DOE, 2004) flow and transport calculations, recalculation of the WIPP transmissivity (T) fields, and revision of the Culebra hydrologic conceptual model for use in future recertification application and performance assessment (PA) calculations.

The frequency of water-level measurements (i.e., monthly) made by the MOC is adequate for assessing the long-term regional changes in water level, but not of the resolution needed to conduct the detailed studies requested by the EPA (Figure 2). Therefore, SNL collects additional data (e.g., high-frequency pressure-temperature (P-T), depth-to-water (DTW), etc.) to aid in these studies. These additional data serve another purpose by providing further supporting evidence for recommendations made by SNL to improve, if necessary, the quality of the groundwater data collected by the MOC and the effectiveness and efficiency of the groundwater-monitoring network.

3.2 SNL Monitoring Activities

Between January 2004 and December 2005, SNL monitoring activities primarily consisted of the collection of high-frequency P-T data and DTW measurements. SNL collected the high-frequency P-T data using programmable transducers called TROLLs, manufactured by In-Situ, Inc. TROLLs are installed in a well or wells that SNL determines to be in need of high-frequency monitoring for various reasons, including: the need to monitor the response of wells to SNL and MOC activities (i.e., pumping tests, WQSP sampling, P&A etc.); oil, gas, and potash industry activities; and anomalous behavior observed in the data collected by the MOC.

The current practice by SNL is to place a TROLL in a well at a fixed depth below the water surface (ideally the midpoint of the monitored formation) programmed to take readings at a user-specified interval (minutes to hours). In the case of SNL monitoring activities, a TROLL is programmed to take pressure and temperature readings every hour unless pressure changes by 0.1 psi or greater over any given 5-min. interval within the defined hour. Data collected by

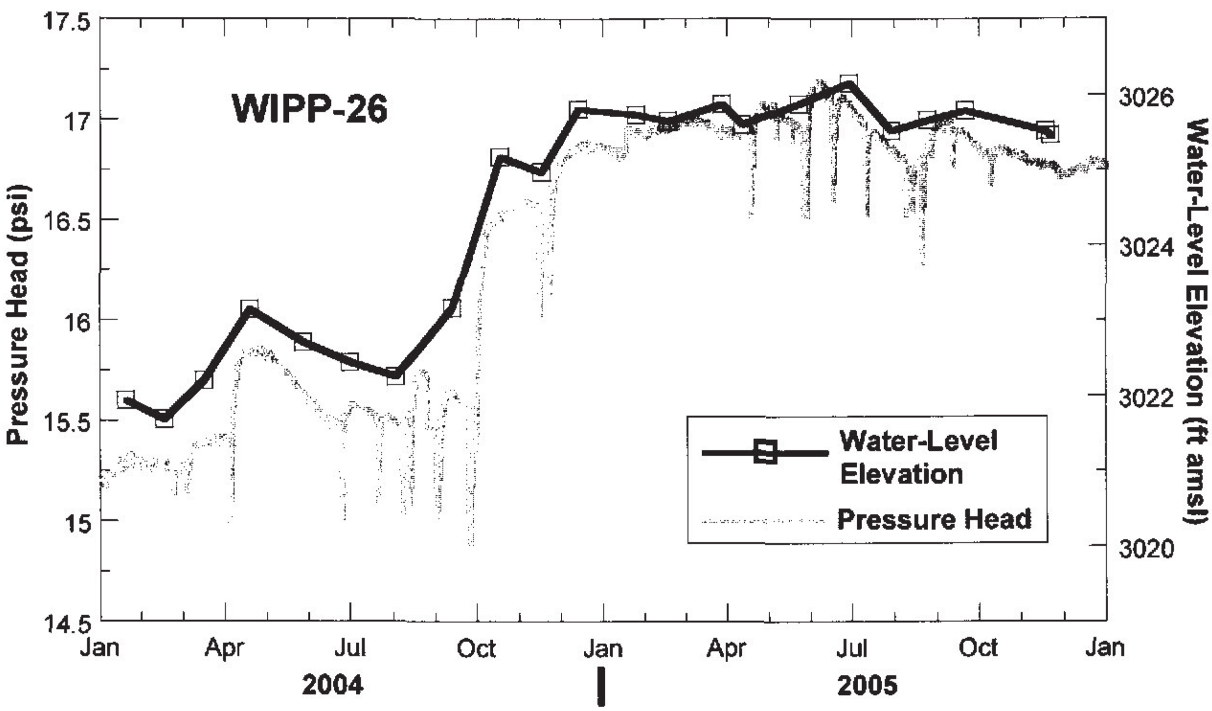

Figure 2. Comparison of monthly water-level data collected at WIPP-26 with hourly pressure-temperature gauge measurements of pressure-head.

TROLLs are downloaded monthly, concomitant with a DTW measurement. The pressure-head record is then corrected for barometric pressure and earth tide effects using BETCO (Toll and Rasmussen, 2006).

3.3 Discussion

Between January 2004 and December 2005, SNL groundwater monitoring activities were primarily focused on the Culebra Member of the Rustler Formation. This marks a shift in focus from prior SNL monitoring activities that were split almost evenly between the Culebra and the Magenta, as can be observed in the shift in the number of TROLL installations for each unit. Between January 2004 and December 2005, the overall number of TROLL installations remained steady at 30, but the number of TROLL installations monitoring the Magenta changed from 12 to 2 and from 18 to 28 in the Culebra. The increased interest in the Culebra is driven, in

Table 1. Summary of 2004-2005 water-level elevations measured by SNL for the Culebra and Magenta Members of the Rustler Formation.

Well I.D.	01/04 W.L. (ft AMSL)	12/04 W.L. (ft AMSL)	2004 Change (ft)	11/05 W.L. (ft AMSL)	2005 Change (ft)	Hydrologic Unit
C-2737	3142.22	3010.37	-131.85	3008.00	-2.37	Culebra
CB-1	3072.47	Well reconfigured to monitor Bell Canyon - 02/04				Culebra
DOE-1	NA	NA	-	2992.67[b]	-	Culebra
ERDA-9	3009.67	3009.68	0.01	3008.57	-1.11	Culebra
H-2b2	3038.76	3037.73	-1.03	3037.96[d]	0.23	Culebra
H-3b2	2999.87	2999.58	-0.29	3001.09[b]	1.51	Culebra
H-4b	NA	3002.48	-	3004.02[b]	1.54	Culebra
H-5b	3029.73	3029.21	-0.52	3036.04	6.83	Culebra
H-6b	3052.23	3054.07	1.84	3057.99	3.92	Culebra
H-7b1	2997.76	3000.54	2.78	3001.00	0.46	Culebra
H-9c	2987.62	2996.29[f]	8.67	2996.71	0.42	Culebra
H-11b4	NA	2987.23[b]	-	NA	-	Culebra
H-12	NA	2959.19[d]	-	2968.52[h]	9.33	Culebra
H-15	2990.16	2989.74[f]	-0.42	2984.74	-5.00	Culebra
H-17	NA	2963.71[i]	-	2966.01[b]	2.30	Culebra
H-19b0	NA	2992.05[b]	-	2986.29	-5.76	Culebra
IMC-461	3025.20[j]	3050.18	25.02	3051.70	1.52	Culebra
P-17	2983.86	2985.82	1.96	2988.62	2.80	Culebra
SNL-1	3071.72[c]	3073.74	2.02	3077.91	4.17	Culebra
SNL-2	3063.86	3069.89[k]	6.03	3073.26	3.37	Culebra
SNL-3	3058.57[j]	3066.64	8.07	3070.60	3.96	Culebra
SNL-5	3068.28[l]	3070.55	2.27	3074.26	3.71	Culebra
SNL-6	Well completed 09/05, no DTW due to post-development recovery					Culebra
SNL-8	N/A	3024.39[b]	-	3028.80[m]	4.41	Culebra
SNL-9	3045.45	3047.60	2.15	3050.75	3.15	Culebra
SNL-12	2996.62[j]	3001.14	4.52	3002.67[b]	1.53	Culebra
SNL-13	NA	3007.34[a]	-	3007.55[b]	0.21	Culebra
SNL-14	NA	2996.68[a]	-	2990.41	-6.25	Culebra
SNL-15	NA	2655.33[a]	-	2759.78	104.45	Culebra
WIPP-11	3045.01[n]	3061.15	16.14	3066.05	4.90	Culebra
WIPP-12	NA	3033.03[f]	-	3033.15[a]	0.12	Culebra
WIPP-13	3056.52	3056.74	0.22	3060.54	3.80	Culebra
WIPP-25	3063.58	3068.40	4.82	3075.34	6.94	Culebra
WIPP-26	3021.60	3025.80	4.20	3025.51	-0.29	Culebra
WIPP-30	3070.21	3070.99	0.78	3077.82[m]	6.83	Culebra
C-2737	3141.47	3142.92	1.45	3143.69[a]	0.77	Magenta
H-2b1	3145.29	3144.76[c]	-0.53	NA	-	Magenta
H-3b1	3132.28	3141.20[l]	8.92	NA	-	Magenta
H-6c	3066.30	3066.52	0.22	3067.25[d]	0.73	Magenta
H-9c	3134.68	3135.10	0.42	3135.92	0.82	Magenta
H-11b2	3132.72	3132.92	0.20	3133.09[g]	0.17	Magenta
H-14	3109.29	3110.46	1.17	3111.51[d]	1.05	Magenta
H-18	3074.82	3074.34[i]	-0.48	NA	-	Magenta
WIPP-18	3142.68	3144.44	1.76	3144.69[e]	0.25	Magenta
WIPP-25	NA	3061.52	-	3063.66[o]	2.14	Magenta
WIPP-30	NA	NA	-	3077.20[m]	-	Magenta

[a] DTW taken 06/05
[b] DTW taken 07/05
[c] DTW taken 05/04
[d] DTW taken 04/05
[e] DTW taken 05/05
[f] DTW taken 01/05
[g] DTW taken 02/05
[h] DTW taken 12/05
[i] DTW taken 08/04
[j] DTW taken 02/04
[k] DTW taken 11/04
[l] DTW taken 06/04
[m] DTW taken 09/05
[n] DTW taken 09/04
[o] DTW taken 10/05
NA = not available

large part, by requests made by the EPA. The planned responses to these requests are summarized in two documents which call for the investigation into possible causes of the observed rise in water levels in the Culebra (Beauheim, 2003) and the need for the replacement of older, deteriorating Culebra wells, with subsequent testing of the new wells (SNL, 2003).

DTW measurements, converted to water-level elevations in feet above mean sea level (ft amsl), taken in association with the monthly TROLL data downloads between January 2004 and November 2005 (SNL did not conduct a monitoring run in December 2005) are summarized in Table 1. Water levels in both hydrologic units fluctuated during this time due to a myriad of stresses ranging from long-term (decadal) to short-term (monthly to sub-monthly). At the WIPP site, the long-term trend in both the Culebra and Magenta is one of rising water levels with intermediate-term (i.e., annual) trends dominated by increasing water levels, though there are periods of steady or even decreasing water level. As mentioned previously, compliance-monitoring data collected by the MOC are of adequate resolution to distinguish these trends, but are not of high enough frequency to resolve short-term changes in water level. This is due to the nature of short-term variations, which tend to be abrupt and/or short-lived. This causes some anomalous behavior to not be observed or, as is sometimes the case, be generally observed without being able to determine specific start and end dates.

3.3.1 Long- and intermediate-term water-level changes

The origins of long- and intermediate-term water-level rises observed in both the Culebra and Magenta are not entirely understood. Beauheim (2003) proposed three scenarios to account for the observed long-term water-level rise, including: 1) leakage from potash mining tailings piles/ponds causing locally elevated Culebra (and Magenta) heads, which then propagate through the system; 2) leakage through boreholes that are poorly cased or incompletely plugged and abandoned, including leakage from both units above and below the Culebra; and 3) leakage from wells injecting into the Bell Canyon or deeper formations (either directly from the injection well into the Culebra or through a nearby well). Results of SNL modeling studies show that scenarios 1 and 2 could plausibly account for, or at least contribute to, the observed rise in water levels around WIPP (Lowry and Beauheim, 2004; 2005); scenario 3 is still under investigation. Another possible explanation for Culebra water-level rise is recharge from precipitation. Lowry and Beauheim (2005) suggested that an area south of WIPP, possibly Nash Draw (where it is believed that the Culebra is unconfined), may be a source of recharge to the Culebra. Recharge in northern and central Nash Draw may also contribute, especially to wells on or near to Livingston Ridge. SNL is currently investigating this hypothesis.

3.3.2 Short-term water-level changes

The causes of short-term variations in Culebra and Magenta water levels fall under two categories: known and unknown. Known causes include SNL and MOC well activities (e.g., well testing and maintenance, water sampling, etc.) and oil and gas industry activities (e.g., well drilling, brine disposal or injection for secondary hydrocarbon recovery, etc.), which are monitored by the MOC. Unknown, or at least hard to determine, causes include both natural (e.g., precipitation) and anthropogenic (e.g., ranching and potash industry activities, and some oil and gas industry activities). Determining the cause(s) of observed water-level fluctuations can be difficult with much data needing to be collected. SNL has been focusing on this issue for a number of years and has written numerous test and analysis plans (e.g., Beauheim, 2003) to govern and carry out testing of various hypotheses proposed about the causal mechanisms for short-term water-level fluctuations observed in the Culebra and the Magenta.

3.3.2.1 Culebra short-term water-level fluctuations

Between January 2004 and December 2005, SNL monitored 35 different Culebra wells. Water levels measured generally increased across the site, continuing the long-term and recent intermediate-term trends, but many short-term variations were observed in the DTW and TROLL data.

One of the known causes of short-term variation in Culebra wells is due to the drilling of new and replacement (SNL-series) wells to modernize and optimize the WIPP groundwater monitoring network, which began in 2003. TROLLs were installed and DTW measurements were begun as soon as post-drilling well development was complete. Much, if not all, of the water-level rise observed early in the history of the new SNL-series wells, as well as IMC-461 (completed in January 2004) and WIPP-11 (recompleted to be a Culebra monitoring well in September 2004), can be attributed to recovery after development activities were completed (Figure 3).

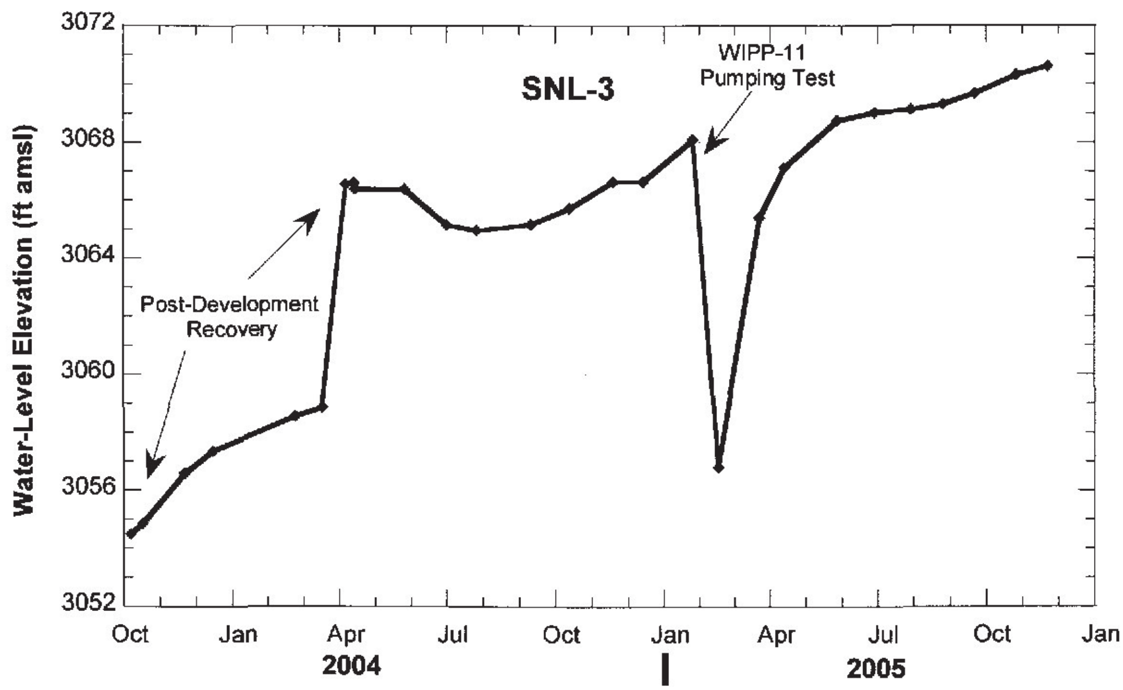

Figure 3. SNL-3 hydrograph.

As part of the WIPP Integrated Groundwater Hydrology Program Plan (SNL, 2003), SNL is characterizing the hydraulic properties of all new and recompleted wells. Hydrologic characterization typically involves either pumping or slug tests. During 2004 and 2005, thirteen pumping tests and one water-quality sampling exercise were conducted by SNL, and five slug tests were conducted (all at IMC-461). The pumping tests ranged in duration from one to 32 days, with most being four days in length. Three long-term pumping tests spanned 19 days (WIPP-11), 22 days (SNL-14), and 32 days (SNL-9). Long-term pumping tests affect water levels over an extensive area. For instance, the WIPP-11 pumping test affected water levels in 11 wells. Short-duration tests (i.e., 4-day) tend to affect the water level only near the well, though in some cases where other wells are situated nearby, these too can show a response (e.g., H-6b response to SNL-2 pumping, Figure 4). Slug tests only affect water level in the well being tested. Data acquisition during tests is accomplished using TROLLs or other pressure transducers, rather than by measuring water levels.

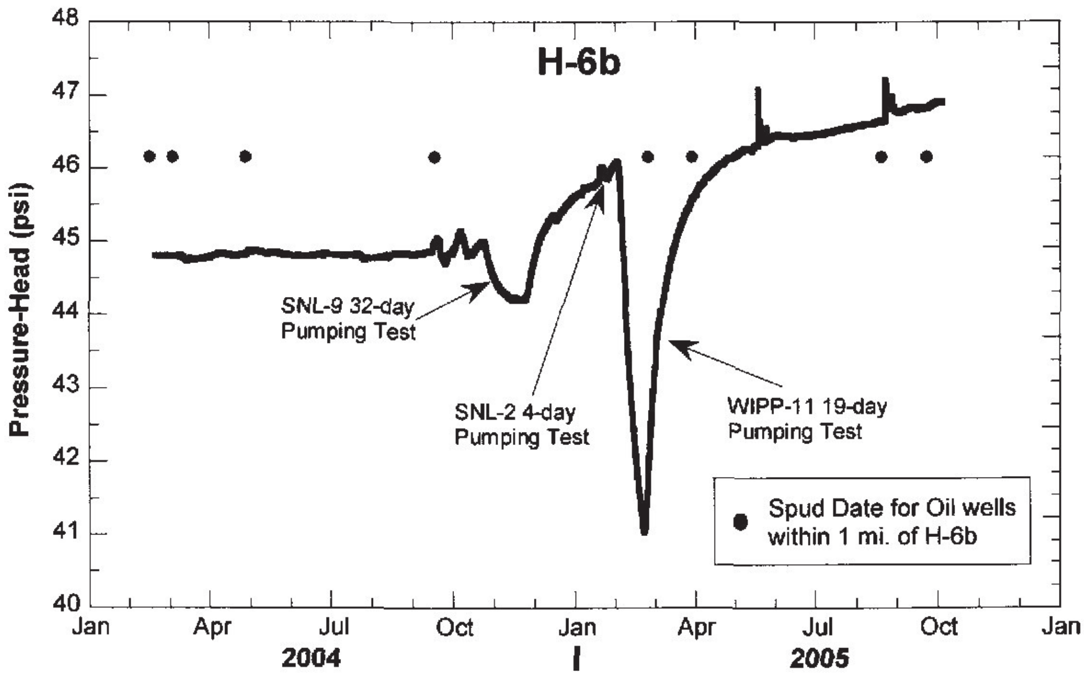

Figure 4. Pressure-head data for H-6b showing drawdown responses to the SNL-2 (4-day), SNL-9, and WIPP-11 pumping tests. Also note the relation between spud dates for oil wells within 1 mile of H-6b and the pressure-head data.

The first long-term pumping test was conducted between October 22 and November 23, 2004 at SNL-9. Wells H-6b (Figure 4), IMC-461, WIPP-25, and H-2b2 showed drawdown responses to the test. The second long-term pumping test was conducted at WIPP-11 between February 1 and 20, 2005. Wells that showed drawdown responses to the pumping included: H-6b (Figure 4), SNL-1, SNL-3, SNL-5, WIPP-12, WIPP-13, WIPP-19, WIPP-30, WQSP-1, WQSP-2, and WQSP-3. The third long-term pumping test was the SNL-14 pumping test, conducted between August 4 and 26, 2005. Wells showing drawdown responses included: C-2737, DOE-1, ERDA-9, H-3b2, H-4b, H-9c, H-11b4, H-12, H-15, H-17, H-19b0, P-17, SNL-13, SNL-12, WQSP-4, WQSP-5, and WQSP-6.

After the conclusion of each pumping test, wells affected by the test recovered to previous water levels at various rates. For example, after the SNL-14 pumping test, wells closest to and wells to the south of SNL-14 had recovered or were near full recovery by the end of 2005, but wells farther away and to the north of SNL-14, such as H-19b0, were still early in the recovery mode.

P&A and reconfiguration activities conducted by the MOC during summer 2005 are another cause of short-term variation in Culebra water levels. Though it was not the focus of the P&A activities, well H-5b experienced a 6.83-ft increase in water level after H-5a was plugged and abandoned and H-5c was plugged back to be a single-completion Magenta well (Figure 5). After P&A activities, water levels in H-5b have remained high relative to historical levels. SNL speculates that prior to these activities, water may have been leaking between units in the now reconfigured or plugged and abandoned wells, causing the local Culebra water level to be depressed. This issue is still under investigation by SNL.

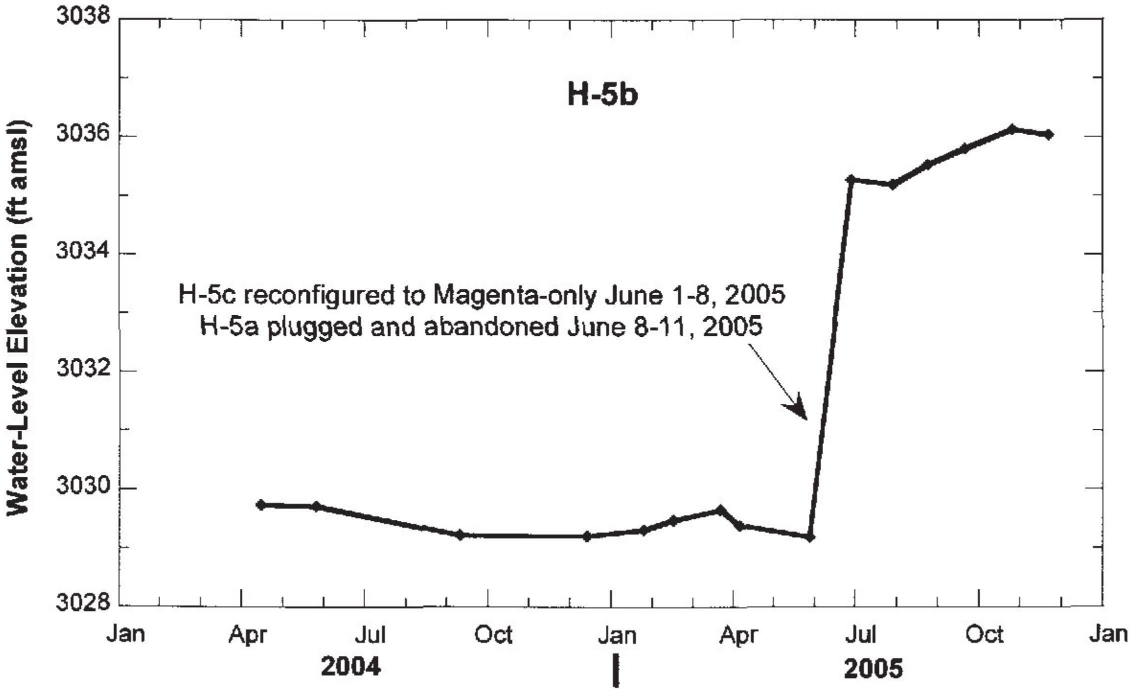

Figure 5. H-5b hydrograph.

Unknown causes of water-level variation in WIPP wells, as mentioned previously, are thought to be linked to various oil, gas, and potash industry and ranching activities as well as natural phenomena (i.e., precipitation).

At H-6b, short-term water-level fluctuations observed in the pressure-head data that could not be linked to known SNL or MOC activities in the area were thought to be linked to the drilling of oil/gas wells nearby. This is because the standard practice for oil/gas well drilling in the Delaware Basin is to drill with fluid at all times and to drill to the top of the Salado (typically taking ~4 days) before setting casing. The H-6b hypothesis, however, was not able to be fully confirmed by correlating the spud dates of oil wells located near H-6b with anomalous changes in pressure-head (Figure 4). In contrast to the poor correlation between oil well spud dates at H-6b, a strong correlation exists between oil well spud dates and spikes in both the Culebra and Magenta water levels recorded by the MOC at the H-10 hydropad (Figure 6).

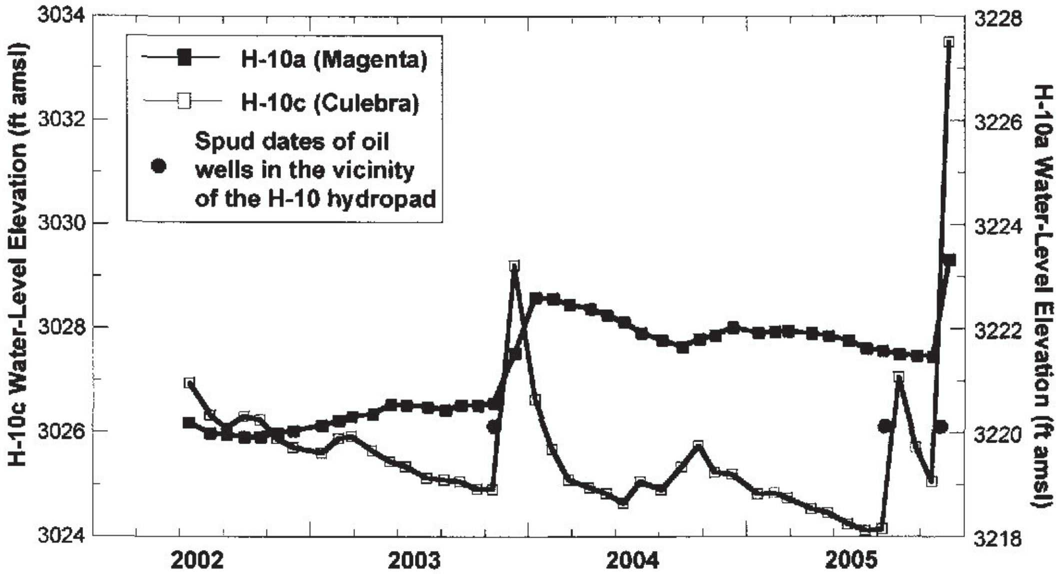

Figure 6. H-10c and H-10a hydrographs.

At IMC-461 and WIPP-26, pressure-head data show a series of drawdown events that occurred throughout 2004 and 2005 (Figure 7). The events typically begin between 20:00 and 03:00 and last approximately one day; drawdown is usually less than 1.5 ft. The origin of the observed drawdown events is as yet unknown, but only IMC-461 and WIPP-26 show strong responses. We speculate that these drawdown events may be caused by an undocumented ranch or mine well located in the area. Further investigations, including field reconnaissance, are planned by SNL.

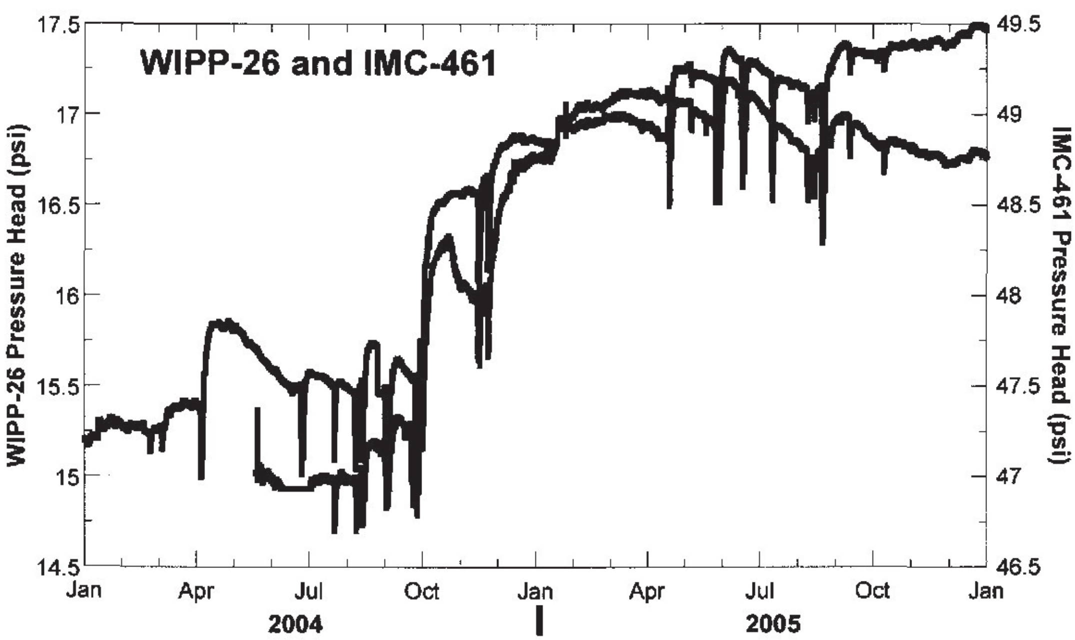

Figure 7. IMC-461 and WIPP-26 pressure heads.

Some wells show anomalous behavior that cannot currently be explained by SNL. For example, SNL-12 experienced a decrease in pressure head (equivalent to ~1 ft of drawdown) in July 2004 after a pump was installed and prior to the well being tested (Figure 8). The cause of this drawdown is unknown and SNL is collecting more data in order to resolve this issue.

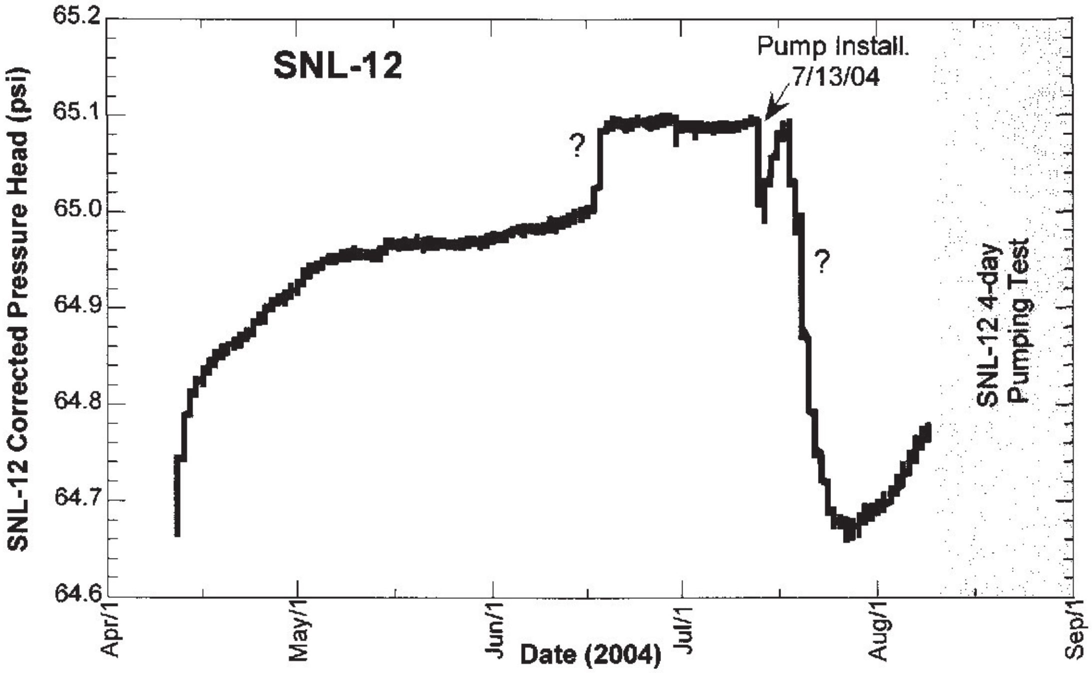

Figure 8. SNL-12 pressure-head record showing unexplained fluctuations.

Wells H-7b1, WIPP-25, and WIPP-26, located in Nash Draw, experienced water-level increases of 2.78, 4.82, and 4.20 ft, respectively, from late 2004 into early 2005. In all three wells, water levels were relatively steady until September 2004, at which time water levels began to rise rapidly (see Figure 9). The observed water-level rise is coincident with a large rainfall event (designated E4) that occurred over a four-day period in late September 2004, in which 6.41 inches of rain fell at the WIPP facility. The large rainfall event caused widespread flooding in Nash Draw that appears to have led to the abrupt increase in water level in Nash Draw wells. SNL-2, located on Livingston Ridge overlooking Nash Draw, also showed an increase in water level that is likely linked to the rainfall event. These increases continued until they peaked in early 2005. Other wells located to the north (e.g., SNL-5) and south (e.g., P-17) of the WIPP surface facility also showed much more gradual increases in water level over the following months (see Figure 9). The increase was likely in response to the diffusion of the pressure wave generated by the infiltration of water into the Culebra in Nash Draw.

Prior to the E4 rainfall event, a smaller rainfall event (E3) occurred in early April 2004. During this 2-day event, 2.59 inches of rain fell and only WIPP-26 appears to have responded, registering an ~1 ft increase in water level (Figure 9). SNL speculates that certain areas within Nash Draw may be acting as local recharge zones to the Culebra. Further investigations are being undertaken by SNL to confirm this speculation.

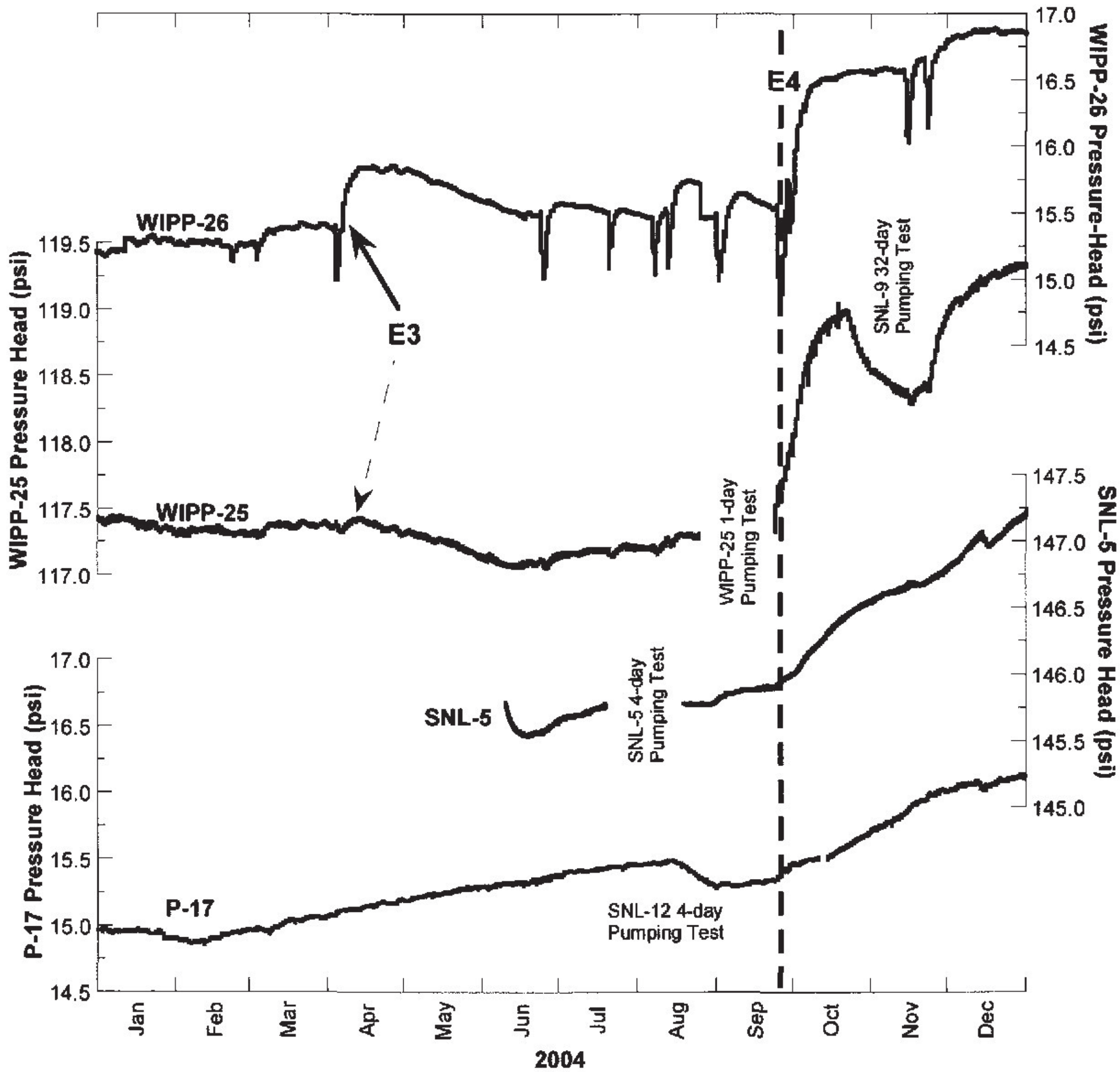

Figure 9. Comparison of pressure-head records from SNL-5 (completed May 2004; ~2 mi northeast of H-6b), P-17, WIPP-26, and WIPP-25. WIPP-26 and WIPP-25 are located in Nash Draw, P-17 is south and SNL-5 is north of the WIPP surface facility. Note: E3 and E4 designate the early April and late September 2004 rainfall events, respectively.

3.3.2.2 Culebra Summary

Based on the assessment of Culebra water-level and TROLL data collected between January 2004 and December 2005, SNL believes that observed short-term variability observed in Culebra water levels can largely be explained on the basis of anthropogenic activities (i.e., well testing and maintenance, oil and gas industry activities, etc.). Long-term Culebra water-level rise scenarios need to be further investigated and, to this end, eleven new Culebra wells (i.e., SNL-series) have been completed since 2003 with five additional wells to be completed in 2006. SNL is conducting hydraulic testing and water-quality sampling of the new wells as they are completed as well as closely monitoring water levels. The data collected by these activities provides input for ongoing (Beauheim, 2003; Lowry and Beauheim, 2004; 2005) and new studies (e.g., precipitation and recharge), with the results being incorporated into a new conceptual model of the Culebra as well as into the second-generation T-fields that will be used as part of PA for the next CRA.

3.3.2.3 Magenta short-term water-level fluctuations

Pressure-head and water-level measurements for the Magenta Member of the Rustler Formation are important for refining the conceptual model of site hydrology by providing information about confinement of and connectivity to the underlying Culebra Member. In general, water levels have risen in the Magenta between January 2004 and December 2005, continuing the long- and intermediate-term trends.

In 2004, Magenta water-level changes ranged from -0.53 to 8.92 ft in nine wells monitored by SNL. The only well to experience a significant (i.e., $\geq \pm 2$ ft) change in water level was H-3b1. H-3b1 was cleaned in February 2002 by the MOC, but did not appear to begin to recover until late 2003 and was continuing to recover up to P&A/reconfiguration activities on the H-3 hydropad in June 2005.

In 2005, Magenta water-level changes ranged from 0.17 to 2.14 ft in seven wells monitored by SNL. Most of the wells, with the exception of WIPP-25 and H-9c, were not monitored after July 2005 because TROLLs installed in the Magenta wells were needed for Culebra wells involved in the SNL-14 pumping test. WIPP-25 was the only well to experience a significant change in water level, an increase of 2.14 ft. SNL speculates that the increase was caused by the late-September 2004 rainfall event (see previous Section) based on the timing of the water-level rise.

Many of the older WIPP wells were originally completed to more than one water-bearing zone. Some short-term variations observed in the Magenta in 2004 and before were thought to be caused by failures of bridge plugs and packers used to isolate the Magenta from other hydrologic units. DOE, SNL, and the MOC decided to reconfigure the wells to single-completion Magenta wells instead of replacing the failing bridge plugs and packers (Salness, 2006). During the summer of 2005, packers and bridge plugs were removed from nine Magenta wells (H-2b1, H-3b1, H-4c, H-5c, H-6c, H-11b2, H-14, H-18, and WIPP-18). The wells were then cemented from the bottom to a level ~20-30 ft below the Magenta perforations. None of these wells were monitored by SNL after reconfiguration activities (because of the need for TROLLs for the SNL-14 pumping test), but some of the activities did affect Culebra water levels (e.g., H-5b).

3.3.2.4 Magenta Summary

Magenta water levels are rising slowly and show much less variation than Culebra water levels. The low variability is due, in large part, to the minimal testing that has been done on the Magenta over the past two years relative to the amount of testing in the Culebra, which has been significant. Though SNL is not currently focusing much effort on the Magenta, SNL is planning on installing TROLLs in more Magenta wells (see Section 3.4) in 2006.

3.4 SNL Monitoring Activities Planned for CY2006

Future monitoring efforts planned by SNL include:

- The continued use of TROLLs to monitor WIPP wells. SNL is also planning on purchasing more TROLLs in 2006 to increase the total number of wells with installations, including Magenta wells.

- The writing of new activity-specific procedures to formalize the TROLL monitoring process. A test plan will also be written to synthesize the procedures into a cohesive monitoring strategy for improved and efficient data collection.

- The development of a database for storing all monitoring data collected by SNL and the MOC, where applicable. The database will store TROLL data and DTW measurements, among other data, and increase the efficiency of the monitoring efforts.

- The installation of rain gauges at various locations around WIPP to provide better spatial coverage. Additional gauges are needed because rainfall can be extremely localized in southeast New Mexico and more data are needed for the Culebra-Nash Draw recharge study.

4. References

Beauheim, R.L. 2003. *Analysis Plan for Evaluation of Culebra Water-Level-Rise Scenarios, AP-110, Revision 0*. Carlsbad, NM: Sandia National Laboratories WIPP Records Center, ERMS# 532799.

DOE (U.S. Department of Energy). 1999. *40 CFR Parts 191 and 194 Compliance Monitoring Implementation Plan*. DOE/WIPP 99-3119. Carlsbad, NM: U.S. Department of Energy Carlsbad Field Office.

DOE (U.S. Department of Energy). 2004. *Title 40 CFR Part 191 Subparts B and C Compliance Recertification Application for the Waste Isolation Pilot Plant.* DOE/WIPP 04-3231, U.S. DOE, Carlsbad Area Office, Carlsbad, NM.

EPA (U.S. Environmental Protection Agency). 1998. *40 CFR Part 194: Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with the Disposal Regulations: Certification Decision; Final Rule*. Federal Register: 63(95):27353-27406. U.S. EPA, Office of Radiation and Indoor Air, Washington, D.C.

Lowry, T.S., and R.L. Beauheim. 2004. *Analysis Report, Task 2 of AP-110, Evaluation of Water-Level Rise in the Culebra Due to Recharge from Refining Process Water Discharged onto Potash Tailings Piles*. Carlsbad, NM: Sandia National Laboratories WIPP Records Center, ERMS# 536239, 57 p.

Lowry T.S., and R.L. Beauheim. 2005. *Analysis Report, Task 3 of AP-110, Evaluation of Water-Level Rise in the Culebra Due to Leakage Through Poorly Plugged and Abandoned Potash Boreholes.* Carlsbad, NM: Sandia National Laboratories WIPP Records Center, ERMS# 540187, 91 p.

NMED (New Mexico Environment Department). 1999. *Hazardous waste facility permit issued to Waste Isolation Pilot Plant.* EPA No. NM4890139088. NMED, Santa Fe, NM.

Salness, R.A. 2006. *Basic Data Report for Well Plugging and Abandonment and Reconfiguration Activities for Fiscal Year 2005.* DOE/WIPP 05-3326. Carlsbad, NM: US DOE.

SNL (Sandia National Laboratories). 2000. *Analysis Plan AP-069: An Analysis Plan for Annually Deriving Compliance Monitoring Parameters and their Assessment Against Performance Expectations to Meet the Requirements of 40 CFR 194.42e.* Carlsbad, NM: Sandia National Laboratories.

SNL (Sandia National Laboratories). 2003. *Program Plan, WIPP Integrated Groundwater Hydrology Program, FY03-09, Revision 0.* Carlsbad, NM: Sandia National Laboratories WIPP Records Center, ERMS# 526671.

SNL (Sandia National Laboratories). 2005. *Sandia National Laboratories Annual Compliance Monitoring Parameter Assessment (for Year 2004).* Carlsbad, NM: Sandia National Laboratories.

SNL (Sandia National Laboratories). 2006. *Sandia National Laboratories Compliance Monitoring Parameter Assessment for 2006.* Carlsbad, NM: Sandia National Laboratories.

Toll, N.J., and T.C. Rasmussen. 2006. *Removal of Barometric Pressure Effects and Earth Tides from Observed Water Levels.* Proceedings of the 11th International High-Level Radioactive Waste Management Conference (IHLRWM), April 30-May 4, 2006, Las Vegas, NV. p. 21-24. La Grange Park, IL: American Nuclear Society.