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Sandia National Laboratories Compliance Monitoring Parameter Assessment For 2006

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Executive Summary

This document reports the eighth annual (2006) derivation and assessment of the Waste Isolation Pilot Plant (WIPP) Compliance Monitoring Parameters (COMPs). The COMPs program is a requirement of the U.S. Environmental Protection Agency's (EPA) long-term disposal regulations (EPA 1993 and 1996). The concept of deriving and assessing COMPs is explained in Sandia National Laboratories (SNL) Nuclear Waste Management Program Analysis Plan, AP-069 titled: *An Analysis Plan for Annually Deriving Compliance Monitoring Parameters and their Assessment Against Performance Expectations to Meet the Requirements of 40 CFR 194.42* (SNL 2000a).

The WIPP has many monitoring programs, each designed to meet various regulatory and operational safety requirements. The comprehensive WIPP monitoring effort is not under the auspice of one program, but is comprised of many discrete elements, one of which was designed to fulfill the EPA's long-term disposal requirements found at 40 CFR Part 191 Subparts B and C, and the Certification Criteria at 40 CFR 194. Monitoring parameters that are related to the long-term performance of the repository were identified in a monitoring analysis.[1] Since these parameters fulfill a regulatory function, they were termed Compliance Monitoring Parameters so that they would not be confused with similar performance assessment (PA) input parameters.

The Department of Energy (DOE) uses PA to predict the containment performance of the WIPP. COMPs are then used to indicate conditions that are not within the PA data ranges, conceptual model assumptions or expectations of the modelers and to alert the project of conditions not accounted for or expected. COMPs values and ranges were developed such that exceedance of these values indicate a condition that is potentially outside PA expectations. These values were appropriately termed "trigger values." Deriving COMPs trigger values (TV) was the first step in assessing the monitoring data. TVs were derived in 1999 and are documented in the *Trigger Value Derivation Report* (SNL 2002a). In some instances, a COMP will not have a TV because sensitivity analysis has demonstrated that PA is insensitive to that parameter or because the parameter is subjective in nature and is not directly related to PA inputs.

This COMPs Report is the first derived after WIPP's recertification (the Compliance Recertification Application (CRA-2004; DOE 2004) was submitted and subsequent WIPP recertification notification in EPA 2006). The EPA requested a new PA in support of the recertification called the performance assessment baseline calculation (PABC). As such, a revised baseline for which to assess COMPs has been established. Work has been initiated to reassess the compliance monitoring program (per 40 CFR § 194 .42 – see SNL AP-126, Wagner 2005). Recommendation from this activity may change the COMPs program to realign it with the new baseline. Changes to the compliance monitoring program will require EPA approval through a planned change request scheduled in 2007. Therefore, this year's COMPs assessment compares the parameters against the original certification baseline. It is expected that the next COMPs assessment in 2007 will be assessed against the recertification baseline under a revised COMPs program.

In the Final Certification Ruling (EPA 1998a), EPA approved ten COMPs: two relating to human activities, five relating to geotechnical performance, two relating to regional

[1] Attachment MONPAR to Appendix MON in the CCA (DOE 1996) documents the analysis of monitoring parameters. The analysis was performed to fulfill 40 CFR § 194.42 requirements.

hydrogeology and one relating to the radioactive components of the waste. The EPA also requires the DOE to report any condition that would indicate the repository would not function as predicted or a condition that is substantially different from the information contained in the most recent compliance application. Periodic assessments of COMPs will allow the DOE to monitor the predicted performance of the repository and report any condition adverse to the containment performance. This compliance monitoring program is described in greater detail in DOE's *40 CFR Parts 191 and 194 Compliance Monitoring Implementation Plan* (MIP; DOE 2005a).

This document reports these results and the recommendations based on the 2006 COMPs Assessment. This assessment concludes that the COMP values assessed in this report do not indicate a condition for which the repository will perform in a manner other than that represented in the WIPP certification PAs.

1 Introduction

The WIPP is governed by the EPA's long-term radioactive waste disposal regulations at 40 CFR Part 191 Subparts B and C (EPA 1993) and the WIPP-specific certification criteria at 40 CFR Part 194 (EPA 1996). Monitoring WIPP performance is an "assurance requirement" of these regulations and is intended to provide assurances that the WIPP will protect the public and environment (see 40 CFR § 191.14). In the WIPP Compliance Certification Application (CCA; DOE 1996), the DOE made commitments to conduct a number of monitoring activities to comply with the criteria at 40 CFR § 194.42 and to ensure that deviations from the expected long-term performance of the repository are identified at the earliest possible time. These DOE commitments are represented by ten COMPs, which are listed in Section 2.

The COMPs are an integral part of the overall WIPP monitoring strategy. The DOE's MIP (DOE 2005a) describes the overall monitoring program and responsibilities for COMPs derivation and assessment. This report documents the results of the reporting year 2006 COMPs assessment (July 1st 2005 to June 30th 2006). The reporting period has changed to match the reporting period of the 194.4(b)(4) report (EPA 2003). This reporting cycle overlaps the WIPP recertification[2]. Now that the recertification baseline is complete, a new analysis similar to that performed to comply with 40 CFR § 194.42 will be used to determine if new parameters should be monitored or if other changes should be made to the COMP program (Wagner 2005). The next COMPs report is expected to be derived under the new program pending the reevaluation of the revised baseline and completion of a new 40 CFR §194.42 monitoring assessment. Because these activities have not been completed, this COMPs assessment follows the program developed under the original certification baseline. This is considered appropriate because the new recertification baseline is not significantly difference than the original certification baseline.

1.1 Monitoring and Evaluation Strategy

The Compliance Monitoring Program is an integrated effort between the Management and Operating Contractor (M&OC), the Scientific Advisor (SA) and the DOE Carlsbad Field Office (CBFO). The CBFO oversees and directs the monitoring program to ensure compliance with the EPA monitoring and reporting requirements. The SA is responsible for the development and maintenance of the TVs. An observation beyond the acceptable range of TVs represents a condition that requires further actions, but does not indicate an out-of-compliance condition. This approach assures that conditions that are not consistent with expected repository performance are recognized as early as possible. These conditions may include data inconsistent with the conceptual models implemented in PA, or invalidation of assumptions and arguments used in the screening of Features, Events and Processes (FEPs) screened into PA.

1.2 Reporting Cycle

Under 40 CFR §194.4, the DOE is required to report significant, and non-significant, changes to the EPA. The CCA and the CRA-2004 state in Section 7.2.1 that the results of the monitoring program would be submitted annually (DOE 1996, DOE 2004). Additionally, the recertification requirements at 40 CFR §194.15(a)(2) also require inclusion of all additional monitoring data,

[2] The DOE must demonstrate continued compliance with EPA's disposal standard every five years past first waste receipt. This activity is called recertification.

analysis and results in DOE's documentation of continued compliance as submitted in periodic Compliance Recertification Applications.

Changes to monitoring data, associated parameter values and monitoring information must be reported even if the assessment concludes there is no impact on the repository regardless of whether or not the monitoring data agree with expectations. The monitoring data will be compiled and reported to the DOE to assist in DOE's reporting to the EPA. The SA's role is to use the monitoring data to derive the COMPs, and to use the new and updated information to make any recommendations for modification to the Compliance Baseline.

2 Assessment of COMPs

The compliance monitoring program tracks the following ten COMPs:

1. Drilling Rate
2. Probability of Encountering a Castile Brine Reservoir
3. Waste Activity
4. Subsidence
5. Changes in Culebra Groundwater Flow
6. Change in Culebra Groundwater Composition
7. Creep Closure
8. Extent of Deformation
9. Initiation of Brittle Deformation
10. Displacement of Deformation Features

A periodic review of these COMPs is necessary to meet the intent of 40 CFR §191.14 assurance requirements, which states:

> "(b) Disposal systems shall be monitored after disposal to detect substantial and detrimental deviations from expected performance. This monitoring shall be done with techniques that do not jeopardize the isolation of the wastes and shall be conducted until there are no significant concerns to be addressed by further monitoring."

This section summarizes the results of the 2006 calendar year assessment. In the following sections, each COMP is evaluated and compared to the applicable TV. This assessment is performed under Analysis Plan AP-069 (SNL 2000a).

2.1 Human Activities COMPs

The CCA identifies ten COMPs that the DOE is required to monitor and assess during the WIPP operational period. Two of these parameters monitor "Human Activities" in the WIPP vicinity which include:

- Probability of Encountering a Castile Brine Reservoir
- Drilling Rate

2.1.1 Probability of Encountering a Castile Brine Reservoir

Monitoring activities for Castile brine encounters have identified no new brine encounter during this reporting period. The total of encounters identified since the CCA is seven. Data used for the CCA were compiled from drilling record searches for the region surrounding the WIPP. The results of this initial search recorded 27 drilling encounters with pressurized brine (water) in the Castile Formation. Of these encounters, 25 were hydrocarbon wells scattered over a wide area in the vicinity of the WIPP site; two wells, ERDA 6 and WIPP 12, were drilled in support of the WIPP site characterization effort (see DOE 2006a, Table 7 for a complete listing of brine encounters). The Delaware Basin Drilling Surveillance Program reviews the well files of all new wells drilled in the New Mexico portion of the Delaware Basin each year looking for instances of Castile brine encounters. The program also sends out an annual survey to operators of new wells to determine if pressurized brine was encountered. Since the CCA, data have been compiled through August 2006. No pressurized Castile brine encounters have been reported in the official drilling records for wells drilled in the New Mexico portion of the Delaware Basin (DOE 2006a).

Of the seven Castile Brine encounters recorded since the 1996 CCA, six were identified when WIPP Site personnel performing field work talked to area drillers. The other encounter was reported by an operator in the Annual Survey of area drillers. All the new encounters are located in areas where Castile Brine is expected to be encountered during the drilling process. Table 2.1 shows all known Castile Brine encounters in the vicinity of the WIPP Site since the CCA.

The impacts of brine encounters are modeled in the PA. The CCA used a 0.08 probability of encountering a Castile brine reservoirs. In the Performance Assessment Verification Test (PAVT), the EPA mandated a range of 0.01 to 0.6. The new range did not influence the predicted performance of the repository. This range was also used in the recertification PAs. The EPA also determined in their sensitivity analysis that this parameter (PBRINE) does not have a significant impact on PA results (EPA 1998b).

Table 2.1. Well Locations Encountering Brine Since the CCA.

Number	Location	Well Name and Location	Spud Date	Well Information
1	21S-31E-35	Lost Tank "35" State #4	09/11/2000	Oil Well: Estimated several hundred barrels per hour. Continued drilling.
2	21S-31E-35	Lost Tank "35" State #16	02/06/2002	Oil Well: At 2,705 ft, encountered 1,000 Barrels per hour. Shut-in to get room in reserve pit with pressure of 180 psi.
3	22S-31E-02	Graham "AKB"State #8	04/12/2002	Oil Well: Estimated 105 barrels per hour. Continued drilling.
4	23S-30E-01	James Ranch Unit #63	12/23/1999	Oil Well: Sulfur water encountered at 2,900 ft 35 ppm H_2S was reported but quickly dissipated to 3 ppm in a matter of minutes. Continued drilling.
5	23S-30E-01	Hudson "1" Federal #7	01/06/2001	Oil Well: Estimated initial flow at 400 to 500 barrels per hour with a total volume of 600 to 800 barrels. Continued drilling.
6	22S-30E-13	Apache "13" Federal #3	11/26/2003	Oil Well: Encountered strong water flow with blowing air at 2,850-3,315 ft 362 ppm H_2S was reported. Continued drilling.
7	21S-31E-34	Jaque "AQJ" State #7	03/04/2005	Oil Well: Estimated 100 barrels per hour. 1,300 ppm H_2S was reported. Continued drilling.

Probability of Encountering a Brine Reservoir - 2006:

Trigger Value Derivation				
COMP Title:	Probability of Encountering a Castile Brine Reservoir			
COMP Units:	Unitless			
Related Monitoring Data				
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value	
DBMP(1)	NA	Driller's survey – Field observations	0.01 to .60	
COMP Derivation Procedure				
Analysis of encounters of pressurized brine recorded and reported by industry in the 9-township area centered on WIPP.				
Year 2006 COMP Assessment Value - Reporting Period September 2005 to August 2006				
No new data reported in State record during the reporting period; No new report from Field Observations. 34 Total Brine Encounters 27 CCA total occurrences before 1996 0 State Record occurrences since 1996 7 Site Personnel/ Drillers Survey occurrences since 1996				
Related Performance and Compliance Elements				
Element Title	Parameter Type & ID or Model Description	Derivation Procedure	Compliance Baseline	Impact of Change
Probability of Encountering Brine	Parameter PRBRINE	CCA MASS Attachment 18-6 geostatistical study based on area occurrences. EPA Technical Support Document justified the upper value in their range by rounding up the upper value interpreted from the Time Domain Electromagnetic survey, which suggested a 10 to 55% areal extent.	0.08 0.01 to 0.60	Not a sensitive parameter.
Monitoring Data Trigger Values				
Monitoring Parameter ID	Trigger Value	Basis		
Probability of Encountering a Castile Brine Reservoir	None	After the DOE proposed the brine reservoir probability as potentially significant in the CCA Appendix MONPAR, the EPA conducted analyses that indicate a lack of significant effects on performance from changes in this parameter. For this reason and since the parameter is evaluated for significant changes at least once annually, no TV is needed.		

(1) Delaware Basin Monitoring Program

2.1.2 Drilling Rate

The drilling rate COMP tracks deep drilling (> 2150 ft in depth) activities relating to resource exploration and extraction. Boreholes relating to resources include potash and sulfur core holes, hydrocarbon exploration wells, saltwater disposal wells and water wells drilled in the Delaware Basin. The first drilling rate, reported in the CCA, was determined using an equation provided in 40 CFR Part 194. The formula is as follows: number of deep holes times 10,000 years divided by 23,102.1 square kilometers (area of the Delaware Basin) divided by 100 years equals the number of boreholes per square kilometer per 10,000 years. The number of deep boreholes over the last 100 years is used in the equation (1896 – June 1995 for the CCA value). The rate reported in the CCA using this equation was 46.8 boreholes per square kilometer over 10,000 years. Including the time period after the CCA (June 1995 to June 2006) increases the rate to 57.0 boreholes per square kilometer per 10,000 years (DOE 2006a).

Table 2.2. Drilling Rates for Each Year since the CCA.

Year	Number of Boreholes Deeper than 2,150 ft	Drilling Rate (bore holes per square kilometer per 10,000 years)
1996 (CCA Value)	10,804	46.8
1997	11,444	49.5
1998	11,616	50.3
1999	11,684	50.6
2000	11,828	51.2
2001	12,056	52.2
2002	12,219	52.9
2002 (revised)	12,139	52.5
2003	12,316	53.3
2004	12,531	54.2
2005	12,732	55.1
2006	13,171	57.0

As shown in Table 2.2, the drilling rate has risen from 46.8 holes per square kilometer to 57.0 holes per square kilometer since 1996. The rate will continue to climb because of the method used to calculate the rate. Since the first well drilled in the area occurred in 1911, it will be 2011 before one well is dropped from the count and 2014 before the next well is dropped from the count. In the meantime, numerous wells will have been added, increasing the drilling rate.

Although the drilling rate TV was exceeded in 2004, the exceedance was expected. As discussed in the Delaware Basin Monitoring Annual Report, the drilling rate will continue to rise with each new well drilled until the 100 year window moves to a time when there are more older wells removed from consideration than new wells are added. Studies have demonstrated that much higher drilling rates are needed to impact compliance (EEG 1998). For example, in response to a request from EPA (EPA 2004), the SA analyzed the impact of drilling rate on repository performance. This analysis shows that even if the drilling rate were doubled relative to that used for the CRA-2004 PA, the disposal system performance would be well within the release limits set forward in EPA regulations (Kanney and Kirchner 2004). Additionally, the recertification

PA used a drilling rate of 52.5, (data cut-off for CRA-2004 is 2002) demonstrating compliance with a higher drilling rate than the CCA.

Drilling Rate - 2006:

<table>
<tr><td colspan="5">Trigger Value Derivation</td></tr>
<tr><td>COMP Title:</td><td colspan="4">Drilling Rate</td></tr>
<tr><td>COMP Units:</td><td colspan="4">Deep boreholes (i.e., > 2,150 ft deep)/square kilometer/10,000 years</td></tr>
<tr><td colspan="5">Related Monitoring Data</td></tr>
<tr><td>Monitoring Program</td><td>Monitoring Parameter ID</td><td>Characteristics (e.g., number, observation)</td><td colspan="2">Compliance Baseline Value (CRA-2004)</td></tr>
<tr><td>DBMP</td><td>Deep hydrocarbon boreholes drilled</td><td>Integer per year</td><td colspan="2">12,139 per 100 years</td></tr>
<tr><td colspan="5">COMP Derivation Procedure</td></tr>
<tr><td colspan="5">(Total number of deep boreholes drilled/number of years of observations (100)) x (10,000/23,102.1) [i.e., over 10,000 years divided by the area of the Delaware Basin in square kilometers]</td></tr>
<tr><td colspan="5">Year 2006 COMP Assessment Value - Reporting Period September 1, 2005 to August 31, 2006</td></tr>
<tr><td colspan="5">(13,171 boreholes on record for the Delaware Basin) Drilling Rate = 57.0 boreholes per square kilometer per 10,000 yrs.</td></tr>
<tr><td colspan="5">Related Performance and Compliance Elements</td></tr>
<tr><td>Element Title</td><td>Parameter Type & ID or Model Description</td><td>Derivation Procedure</td><td>Compliance Baseline</td><td>Impact of Change</td></tr>
<tr><td>Drilling rate</td><td>Parameter LAMBDAD</td><td>COMP/10,000 years</td><td>5.25 E-03 per square kilometer per year</td><td>Cuttings/cavings releases increase proportionally with the drilling rate. Doubling CRA drilling rate does not exceed compliance limit.</td></tr>
<tr><td colspan="5">Monitoring Data Trigger Values</td></tr>
<tr><td>Monitoring Parameter ID</td><td>Trigger Value</td><td colspan="3">Basis</td></tr>
<tr><td>Deep boreholes drilled (derived from the sum of the five monitoring parameters given above)</td><td>53.5 boreholes per square kilometer per 10,000 yrs.</td><td colspan="3">CCA direct releases are influenced by drilling rate changes, however only a dramatic and improbable change in drilling rate could affect compliance with the containment requirements. There is little information upon which to justify the choice of a TV based on FEP screening decisions. Therefore, a change in the drilling rate greater than approximately 15% (i.e., greater than 53.5 boreholes per square kilometer per 10,000 years) is considered prudent as a TV to revisit the low-consequence assumptions associated with the effects of abandoned boreholes on fluid flow and climatic changes used to construct the PA calculations.</td></tr>
</table>

2.2 Geotechnical COMPs

The CCA lists ten monitoring parameters that the DOE is required to monitor and assess during the WIPP operational period. Five of these parameters are considered "geotechnical" in nature and include:

- Creep Closure
- Extent of Deformation
- Initiation of Brittle Deformation
- Displacement of Deformation Features
- Subsidence

Data needed to derive and evaluate the geotechnical COMPs are available from the most recent annual Geotechnical Analysis Report (GAR; DOE 2006b) and the annual Subsidence Monument Leveling Survey (DOE 2005b). Three of the geotechnical parameters lend themselves to quantification: creep closure, displacement of deformation features and subsidence. In contrast, the extent of deformation and initiation of brittle deformation are qualitative or observational parameters.

The WIPP GARs have been available since 1983 and are currently prepared by the M&OC on an annual basis. The purpose of the GAR is to present and interpret geotechnical data from the underground excavations. These data are obtained as part of a regular monitoring program and are used to characterize current conditions, to compare actual performance to the design assumptions, and to evaluate and forecast the performance of the underground excavations during operations. Additionally, the GAR fulfills various regulatory requirements and through the monitoring program, provides early detection of conditions that could affect operational safety, data to evaluate disposal room closure, and guidance for design changes. Data are presented for specific areas of the facilities including: (1) Shafts and Keys, (2) Shaft Stations, (3) Northern Experimental Area, (4) Access Drifts, and (5) Waste Disposal Areas. Data are acquired using a variety of instruments including convergence points and meters, multipoint borehole extensometers, rockbolt load cells, pressure cells, strain gauges, piezometers and joint meters. All of the geotechnical COMPs involve analyses of deformations/displacements, so the most pertinent data derived from the GAR are convergence and extensometer data. The most recent GAR (DOE 2006b) summarizes data collected from July 2004 through June 2005.

Subsidence monitoring survey reports are also prepared by the M&OC on an annual basis and present the results of leveling surveys performed for nine vertical control loops comprising approximately 18 linear miles traversed over the ground surface of the WIPP site. Elevations are determined for 48 current monuments and 14 National Geodetic Survey vertical control points using digital leveling techniques to achieve Second-Order Class II loop closures or better. The data are used to estimate total subsidence and subsidence rates in fulfillment of regulatory requirements. The most recent survey (DOE 2005b) summarizes data collected between September and November of 2005.

Comparisons between available geotechnical COMP related data and the TVs allow evaluation of the most recent geotechnical observations for the COMPs program. The cited reports and programs provide a good evaluation of all observations where deviations from historical normal occurrences are recorded. This process, as engaged for COMPs assessments, not only focuses attention on monitored parameters, it allows for reassessment of the proposed TVs. Notable deviations are addressed in the GAR and other references, and are reexamined here in the context of COMPs and TVs.

Geotechnical COMPs can be derived from or related to the repository's operational safety monitoring program, which has been implemented to ensure worker and mine safety. By nature, changes in geotechnical conditions evolve slowly; however, they are monitored continuously and reported annually. Since pertinent data from the underground reflect slowly evolving conditions, relationships that correlate to geotechnical COMPs also evolve slowly. Therefore, geotechnical conditions warranting action for operational safety will become evident before such conditions would impact long-term waste isolation. Monitoring underground response allows continuing assessment of conceptual geotechnical models supporting certification. In effect, these annual comparisons of actual geotechnical response with expected response serve to validate or improve models.

2.2.1 Creep Closure

The GAR compiles all geotechnical operational safety data gathered from the underground. The most readily quantifiable geomechanical response in the WIPP underground is creep closure. The GAR routinely measures and reports creep deformation, either from rib-to-rib, roof-to-floor, or extensometer borehole measurements. With the exception of newly mined openings, rates of closure are relatively constant within each zone of interest and usually range from about 1-5 cm/yr. A closure rate in terms of cm/yr can be expressed as a global or nominal creep rate by dividing the displacement by the room dimension and converting time into seconds. Nominally these rates are of the order of 1×10^{-10} /s and are quite steady over significant periods. From experience, increases and decreases of rates such as these might vary by 20 percent without undue concern. Therefore, the "trigger value" for creep deformation was set as one order of magnitude increase in creep rate. Such a rate increase would alert the M&OC geotechnical staff to scrutinize the area exhibiting accelerating creep rates.

Extensive GAR data suggest that possible TV could be derived from creep rate changes. The WIPP underground is very stable, relative to most operating production mines, and deformation is steady for long periods. However, under certain conditions creep rates accelerate, indicating a change in the deformational processes. Arching of microfractures to an overlying clay seam might create the onset of the roof beam de-coupling and increase the measured closure rate. Phenomena of fracture coalescence and DRZ growth comprise important elements of PA assumption confirmation. Therefore, a measured creep rate change over a yearly period constitutes the COMP TV for creep closure. Rate changes are necessarily evaluated on a case-by-case basis since closure is related to many factors such as age of the opening, location in the room or drift, convergence history, recent excavations, and geometry of the excavations.

The creep deformation COMP is addressed by examining the deformations measured in specific regions of the underground including: (1) Shafts and Shaft Stations and (2) Access Drifts and Waste Disposal Areas. Figure 2.1 shows the current configuration of the WIPP underground with specific elements and regions annotated for reference. Information used for all geotechnical COMPs is derived from the GAR which has a reporting period ending June 2005. For this reporting period, Panels 1, 2 and 3 had been fully excavated. Panel 4 mining was not complete at that time. Figure 2.1 shows all areas mined as of June 30, 2005 (the reporting period for geotechnical information is through June 2005 such that the reported mining and emplacement activities depicted in Figure 2.1 from the GAR are not as current as the waste activity COMP information, through June 2006 at which time Panel 2 had been filled and waste had been emplaced in rooms 3 through 7 of Panel 3). Panels 1 and 2 have been filled with waste and the entry drifts have been sealed to prevent access. For this evaluation, waste disposal is occurring in only room 7 of Panel 3.

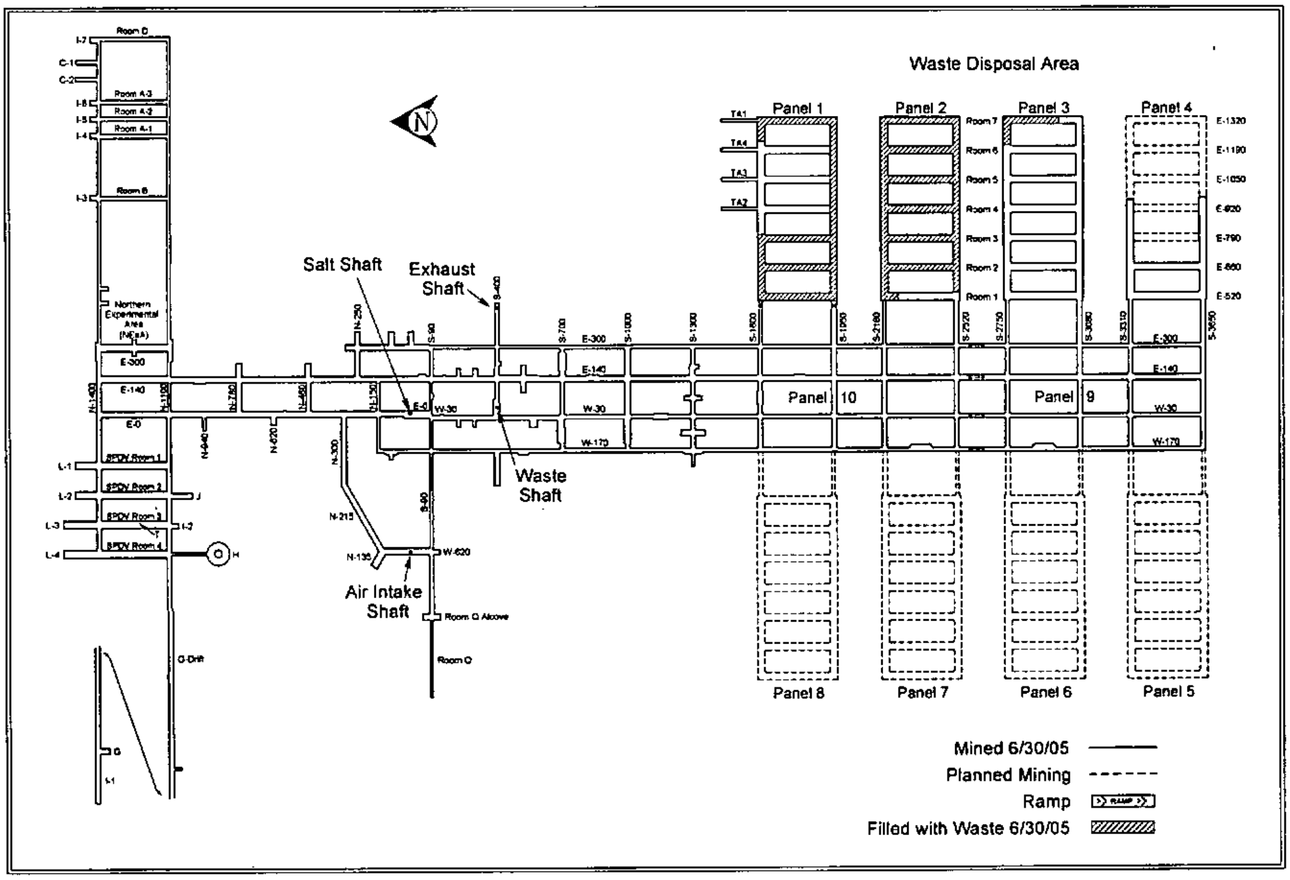

Figure 2.1. Configuration of the WIPP Underground for Geotechncial COMPs (after DOE 2006b; Reporting Period July 2004 through June 2005).

Shafts and Shaft Stations

The WIPP underground is serviced by four vertical shafts including the following: (1) Salt Handling Shaft, (2) Waste Shaft, (3) Exhaust Shaft, and (4) Air Intake Shaft. At the repository level (approximately 650 m below ground surface), enlarged rooms have been excavated around the Salt Handling and Waste shafts to allow for movement of equipment, personnel, mined salt and waste into or out of the facility. The enlarged rooms are called shaft stations and assigned designations consistent with the shaft they service (e.g., Salt Handling Shaft Station).

<u>Shafts.</u> With the exception of the Salt Handling Shaft, the shafts are configured nearly identically. From the ground surface to the top of the Salado Formation, the shafts are lined with un-reinforced concrete. Reinforced concrete keys are cast at the Salado/Rustler interface with the shafts extending through the keys to the Salado. Below the keys, the shafts are essentially "open holes" through the Salado Formation and terminate either at the repository horizon or at sumps that extend approximately 40 m below the repository horizon. In the Salt Handling Shaft, a steel liner is grouted in place from the ground surface to the top of the Salado. Similar to the

three other shafts, the Salt Handling Shaft is configured with a reinforced concrete key and is "open-hole" to its terminus. For safety purposes, the portions of the open shafts that extend through the Salado are typically supported using wire mesh anchored with rock bolts to contain rock fragments that may become detached from the shaft walls. Within the Salado Formation, the shaft diameters range from 3.65 m to 7.0 m.

Data available for assessing creep deformations in the salt surrounding the shafts are derived exclusively from routine inspections and extensometers extending radially from the shaft walls. These data are reported in the GAR. The Salt Handling Shaft, Waste Shaft, and Air Intake Shaft are inspected weekly by underground operations personnel. Although the primary purpose of these inspections is to assess the conditions of the hoisting and mechanical equipment, observations are also made to determine the condition of the shaft walls, particularly with respect to water seepage, loose rock, and sloughing. In contrast to the other three shafts, the Exhaust Shaft is inspected quarterly using remote-controlled video equipment. Based on these visual observations, all four shafts are in satisfactory condition and have required no significant ground-control support during the reporting period.

Shortly after its construction, each shaft was instrumented with extensometers to measure the inward movement of the salt at three levels within the Salado Formation. In addition to COMPs assessment, measurements of shaft closure are used periodically as a calibration of calculational models and have been used in shaft seal system design. The approximate depths corresponding to the three instrumented levels are 330 m, 480 m and 630 m. Three extensometers are emplaced at each level to form an array. The extensometers comprising each array extend radially outward from the shaft walls and are equally spaced around the perimeter of the shaft wall. Over the years, most of these extensometers have malfunctioned. As a result, reliable data are not available at some locations. The DOE currently has no plans to replace failed instrumentation installed in any of the shafts because monitoring data acquired to date have shown no unusual shaft movements or displacements.

Table 2.3 provides a summary of the current displacement rates of the shaft walls based on data reported in the GAR (DOE 2006b). No data was reported for the Exhaust Shaft in this year's GAR; no data for the Waste Handling Shaft was reported in last year's GAR such that no rate calculations can be made for either shaft this reporting period.

Shaft Station. Shaft station openings are typically rectangular in cross-section with heights ranging from approximately 4 to 6 m and widths ranging from 6 to 10 m. Over the life-time of the individual shaft stations, modifications have been made that have altered the dimensions of the openings. In the past, portions of the Salt Handling Shaft Station have been enlarged by removing the roof beam that extended up to anhydrite "b". In the Waste Handling Shaft Station, the walls have been trimmed to enlarge the openings for operational purposes. No major modifications were performed at the shaft stations during this reporting period. Ground control was performed as routine maintenance.

The effects of creep on the shaft stations are assessed through visual observations and displacement measurements made using extensometers and convergence points. Because of the modifications made over the years, some of the original instrumentation has been removed or relocated. In addition, some instruments have malfunctioned or been damaged and no longer provide reliable data. Displacement rates available from the GAR for the current reporting period (2004-2005) and the previous reporting period (2003-2004) are summarized in Table 2.3.

Creep data are available only for the Exhaust Shaft and Waste Shaft Stations (data for the Air Intake Shaft Station are reported below under the Access Drift section of this report, there were no data for the Exhaust Shaft during this reporting period). Most of the measurements are for vertical closure. Based on convergence data, current vertical displacement rates range from 0.46 to 1.45 in/yr (1.17 to 3.68 cm/yr), while current horizontal displacement rates range from 0.81 to 0.89 in/yr (2.06 to 2.26 cm/yr). Dividing convergence rates by the average room dimension (approximately six meters) and expressing the results in units of 1/sec yields vertical and horizontal creep rates between approximately 6.2×10^{-11}/s to 1.9×10^{-10}/s. These rates are still low and represent typical creep rates for stable openings in salt. An examination of the percentage changes in displacement rates shown in Table 2.3 suggests the current shaft station displacement rates (where available) are essentially identical to those measured during the previous reporting period. Based on the extensometer and convergence data, as well as the limited maintenance required in the shaft stations during the last year, creep deformations associated with the WIPP shaft stations are considered acceptable and meet the TV requiring creep deformation rates to change by less than one-order of magnitude in a one-year period.

Table 2.3. Summary of Closure Rates for WIPP Shafts and Shaft Stations.

Location	Inst. Type[a]	Displacement Rate (in/yr)		Change In Rate (%)
		2003–2004	2004–2005	
Salt Handling Shaft	No extensometers remain functional			
Waste Handling Shaft				
1071 ft (326 m) level, S15W	Ext	nr	0.006	-
1566 ft (477 m) level, N45W	Ext	nr	0.052	-
1566 ft (477 m) level, N75E	Ext	nr	0.030	-
1566 ft (477 m) level, S15W	Ext	nr	0.122	-
2059 ft (628 m) level, N45W	Ext	nr	0.444	-
2059 ft (628 m) level, N75E	Ext	nr	0.011	-
2059 ft (628 m) level, S15W	Ext	nr	0.175	-
Exhaust Shaft				
1573 ft (479 m) level, N75E	Ext	0.015	nr	-
1573 ft (479 m) level, N45W	Ext	0.016	nr	-
1573 ft (479 m) level, S15W	Ext	0.016	nr	-
2066 ft (630 m) level, N75E	Ext	0.077	nr	-
2066 ft (630 m) level, S15W	Ext	nr	nr	-
Salt Handling Shaft Station				
E0 Drift – S30 (Vert)	Ext	nr[d]	0.56	-
E0 Drift – S60 (Vert)	Ext	nr[d]	0.46	-
E0 Drift – W12 (Vert CL)	CP	0.73	0.70	-4
E0 Drift – S18 (Vert. CL)	CP	1.39	1.38	-1
E0 Drift – S30 (Vert. CL)	CP	1.47	1.45	-1
E0 Drift – S65 (Vert. CL)	CP	1.08	1.07	-1
Waste Shaft Station				
S400 Drift – W30 (Vert. CL)	Ext	0.65	0.25	-62
Waste Shaft Brow (North)	Ext	0.05	0.06	20
Waste Shaft Brow (South)	Ext	0.13	0.13	0
S400 Drift – E87	Ext	0.53	0.52	-2
S400 Drift – E30 (Horiz. CL)	CP	0.84	0.81	-4
S400 Drift – E90 (Horiz. CL)	CP	0.97	0.89	-8
Air Intake Shaft Station	Information provided below under access drift discussion			

(a) Instrument Type: Ext = extensometer; CP = convergence point.
(b) CL = Centerline
(c) nr = no reading available
(d) New, installed 2005

Access Drifts and Waste Disposal Area

Access Drifts. The access drifts comprise the four major North-South drifts extending southward from near the Salt Handling Shaft to the entries into the waste disposal panels and several short cross-drifts intersecting these major drifts. The access drifts are typically rectangular in cross-section with heights ranging from 2.4 m to 6.4 m and widths ranging from 4.3 m to 9.2 m. During the current reporting period (July 2004 to June 2005), excavations of Panel 4 was initiated. Panels 3 and 4 were excavated at a slightly higher stratigraphic position (2.4 m) than either Panels 1 or 2. The roof of these panels coincides with Clay G. As such Panels 1, 2, 7 and 8 will be at the original horizon and Panels 3, 4, 5 and 6 approximately 2.4 m higher in elevation (roof at Clay G).

Assessment of creep deformations in the access drifts is made through the examination of extensometer and convergence point data reported annually in the GAR. Tables 2.4 and 2.5 summarize, respectively, the vertical and horizontal displacement data reported in the most recent GAR (DOE 2006b). Each table examines percentage changes between displacement rates measured during the current and previous annual reporting periods and breaks these percentage changes into ranges (e.g., 0 to 25%). Only data from instruments located along the drift centerlines are reported here. In addition, extensometer data are based only on the displacements of the collar relative to the deepest anchor. The numbers shown in the tables represent the number of instrumented locations that fall within the range of the indicated percentage change. For example, data from thirty-nine vertically-oriented extensometers installed in the access drifts were assessed with fifteen of these instruments showing percentage changes < 0% (i.e., the rate decreased or slowed). In general, the majority of the rate changes comparing last year's data to the data reported in the GAR are negative or near zero which demonstrates that displacements are slowing. The maximum displacement rates corresponding to these data are given below:

Maximum Vertical Displacement Rates Along Access Drift Centerlines:

5.97 cm/yr – based on extensometer data
13.84 cm/yr – based on convergence point data

Maximum Horizontal Displacement Rate Along Access Drift Centerlines:

9.17 cm/yr – based on convergence point data

Using a typical average drift dimension of 5 m and the maximum displacement rates shown above, the inferred maximum creep rate is approximately 8.77×10^{-10}/s. This rate is based on the maximum displacement which is not representative of the behavior of the system.

Approximately 94% of all of the changes in vertical and horizontal displacement rates in Tables 2.4 and 2.5 are negative or near zero (i.e., in the range categories: < 0% and 0-25%) indicating that current creep deformations in the access drifts are approximately the same or less than they were for the previous reporting period.

Creep deformations associated with the Access Drifts are acceptable and meet the TV requiring creep deformation rates to change by less than one-order of magnitude in a one-year period. High displacement rates observed at a few locations have little effect on safety as geotechnical engineering provides continuous ground-control monitoring and remediation on an as-needed basis.

Waste Disposal Area: The Waste Disposal Area is located at the extreme southern end of the WIPP facility and is serviced by the access drifts described above. Eventually, the Waste Disposal Area will include eight disposal panels, each comprising seven rooms (the major north-south access drifts servicing the eight panels will also be used for waste disposal and will make up the ninth and tenth panels). Currently however, only three panels have been completely excavated including Panel 1 constructed in the late 1980s, Panel 2 constructed during the 1999-2000 time period, Panel 3 constructed during the 2002-2004 time period and the initiation of Panel 4 during 2005. Waste emplacement operations are complete in Panel 1 are almost complete in Panel 2 and have started in room 7 of Panel 3 (for the GAR reporting period). The waste emplacement rooms are rectangular in cross-section with a height of 4 m and a width of 10 m. Entry drifts that provide access into the disposal rooms are also rectangular with heights of 3.65 m and widths of 4.3 m.

Table 2.4. Summary of Changes in Vertical Displacement Rates Measured Along the Centerlines of the WIPP Access Drifts and Waste Disposal Area Openings.

Location	Number of Instrument Locations Where the Indicated Percentage Change has Occurred					
	Percentage Increase in Displacement Rate for Measurements Made During the 2001-2002 and 2002-2003 Reporting Periods					
	< 0%	0 – 25%	25 – 50%	50 – 75%	75 – 100%	100 – 200%
Access Drifts						
Extensometers[a]	15	13	5	4	0	2
Convergence Points	139	56	3	3	1	0
Waste Disposal Area						
Panel 2:						
Extensometers[a]	1	5	1	0	0	0
Convergence Points	5	8	0	0	0	0
Panel 3:						
Extensometers[a]	4	1	1	0	0	0
Convergence Points	42	2	0	0	0	0

(a) Based on displacement of collar relative to deepest anchor.

Table 2.5. Summary of Changes in Horizontal Displacement Rates Measured Along the Centerlines of WIPP Access Drifts and Waste Disposal Area Openings.

Location	Number of Instrument Locations Where the Indicated Percentage Change has Occurred				
	Percentage Increase in Displacement Rate for Measurements Made During the 2001-2002 and 2002-2003 Reporting Periods				
	< 0%	0 – 25%	25 – 50%	50 – 75%	75 – 100%
Access Drifts					
Extensometers[a]	0	0	0	0	0
Convergence Points	72	40	1	0	0
Waste Disposal Area					
Panel 2:					
Extensometers[a]	0	0	0	0	0
Convergence Points	6	4	0	0	0
Panel 3:					
Extensometers[a]	0	0	0	0	0
Convergence Points	24	0	0	0	0

(a) Based on displacement of collar relative to deepest anchor.

Assessment of creep deformation in the waste disposal area is made through the examination of extensometer and convergence point data reported annually in the GAR. Tables 2.4 and 2.5 (presented previously) summarize, respectively, the vertical and horizontal displacement data reported in the most recent GAR (DOE 2006b) for Panel access drifts and Panels 2 and 3 only. Panel 1 is no longer monitorable. Each table examines percentage changes between displacement rates measured during the current and previous reporting periods and breaks these percentage changes into ranges. Only data from instruments located along the drift centerlines are reported here. In addition, extensometer data are based only on displacements of the collar relative to the deepest anchor. The maximum displacement rates corresponding to these data are given below.

Maximum Vertical Displacement Rates along Waste Disposal Area Centerlines:

7.83 cm/yr – based on convergence point data

5.37 cm/yr – based on extensometer data

Maximum Horizontal Displacement Rates along Waste Disposal Area Centerlines:

3.33 cm/yr – based on convergence point data

Using a nominal disposal-area-opening dimension of 8 m and the maximum displacement rates shown above the inferred maximum creep rate is approximately 3.1×10^{-10}/sec. Maximum creep rates for the waste disposal area are greater than the maximum creep rates observed for the access drifts and are considered acceptable. However, most of the changes in creep rate are negative even though Panel 3 was recently excavated.

Creep deformations associated with the Waste Disposal Area are acceptable and meet the TV requiring creep deformation rates to change by less than one-order of magnitude in a one-year period.

Creep Closure - 2006:

Trigger Value Derivation	
COMP Title:	Creep Closure
COMP Units:	Closure Rate (sec^{-1})

Related Monitoring Data			
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value
Geotechnical	Closure	Instrumentation throughout the underground.	Munson-Dawson (MD) Constitutive Model

COMP Derivation Procedure - Reporting Period July 2004 through June 2005
Evaluate GAR for centerline closure rates, compare to previous year's rate. If closure rate increases by greater than one order of magnitude, initiate technical review.

Related Performance and Compliance Elements				
Element Title	Parameter Type & ID or Model Description	Derivation Procedure	Compliance Baseline	Impact of Change
Repository Fluid Flow	Creep Closure	Porosity Surface, waste compaction, characteristics, waste properties, evolution of underground setting	SANTOS, porosity surface calculations	Provides validation of the creep closure model.

Monitoring Data Trigger Values		
Monitoring Parameter ID	Trigger Value	Basis
Creep Closure	Greater than one order of magnitude increase in closure rate.	The closure rate increase signals potential de-coupling of rock.

2.2.2 Extent of Deformation

The extent of brittle deformation can have important implications to PA. As modeled in PA, the DRZ releases brine to the disposal room while properties of the DRZ control hydrologic communication between disposal panels. Therefore, extent of deformation relates directly to a conceptual model used in performance determination. If characteristics could be tracked from inception, the spatial and temporal evolution of the DRZ would provide a validation benchmark for damage calculations.

Measurements in the GAR include borehole inspections, fracture mapping and borehole logging. These observations are linked closely to other monitoring requirements concerned with initiation of brittle deformation and displacement of deformation features. These monitoring requirements define the characteristics of the DRZ, which help validate the baseline conceptual model, and its flow characteristics. The extent of deformation quantifies the DRZ, a significant element of PA analyses.

The Geotechnical Engineering Department at WIPP has compiled back-fracturing data into a database. The supporting data for the GAR (Volume 2, DOE 2006b) consists of plan and isometric plots of fractures. Fracture development is most continuous parallel to the rooms and near the upper corners. These fractures are designated "low angle fractures" relative to the horizontal axis. The original excavation horizon results in a 2.4-m thick beam of halite between the roof and Clay Seam G. Low-angle fractures arch over rooms and asymptotically connect with Clay Seam G. Although the preponderance of monitoring information derives from the roof (back), buckling extends into the floor to the base of Marker Bed 139, which is located about 2 m below the disposal room floors. Fracture mapping thus far is consistent with expectations and tracks stress trajectories derived from computational work. At this time, a comprehensive model and supporting data for model parameters for damage evolution has not been developed for PA.

Excavation of Panel 3 raises the waste disposal panels by 2.4 m such that the roof of the disposal rooms will be coincident with Clay Seam G and the floor will be an additional 2.4 m above Marker Bed 139. This change will likely alter the typical fracture patterns observed to date and may cause subtle changes in how the DRZ develops. Effects of excavation to Clay G have been evaluated by finite element analyses to assess possible impact to PA (Park and Holland 2003). Their modeling shows that the DRZ does not extend below MB139 at the new horizon, as it does at the original horizon. The rise in repository elevation otherwise causes no discernable change to the porosity surface used in PA.

Data provided in the GAR suggest that brittle deformation extends at least 2.4 m (to Clay Seam G) and perhaps as much as 4.5 m (to Clay Seam H) above the roof of the WIPP openings. In addition, brittle deformation extends below the floor of the openings to at least the base of Marker Bed 139 (approximately 2 to 3 m).

Data provided in the 2005 GAR was compared to fracture maps in the previous year's report to determine if fractures exceed the 1m/yr TV. This comparison did not identify data exceeding the TV.

Extent of Deformation - 2006:

Trigger Value Derivation				
COMP Title:	Extent of Deformation			
COMP Units:	Areal extent (length, direction)			
Related Monitoring Data				
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value	
Geotechnical	Displacement	Meters	Not Established	
COMP Derivation Procedure - Reporting Period July 2004 through June 2005				
Extent of deformation deduced from borehole extensometers, feeler gauges, and visual inspections are examined yearly for active cross sections. Anomalous growth is determined by comparison.				
Related Performance and Compliance Elements				
Element Title	Parameter Type & ID or Model Description	Derivation Procedure	Compliance Baseline	Impact of Change
DRZ Conceptual Model	Micro- and macro-fracturing in the Salado Formation	Constitutive model from laboratory and field databases.	Permeability of DRZ was originally assigned a constant value of $10^{-15} m^2$ for the CCA; per EPA direction, a uniform distribution from 3.16×10^{-13} to 3.98×10^{-20} m^2 is used for all subsequent PAs (PABC is the current baseline)	DRZ spatial and temporal properties have important PA implications for permeability to gas, brine, and two-phase flow.
Monitoring Data Trigger Values				
Monitoring Parameter ID	Trigger Value	Basis		
Fractures at depth	Growth of 1 m/y	Coalescence of fractures at depth in rock surrounding drifts will control panel closure functionality and design, as well as discretization of PA models.		

2.2.3 Initiation of Brittle Deformation

Initiation of brittle deformation around WIPP openings is not directly measured and is therefore a qualitative observational parameter. By definition, qualitative COMPs can be subjective and are not prone to the development of well-defined TVs. This COMP is not directly related to a PA parameter. Brittle deformation eventually leads to features that are measured as part of geotechnical monitoring requirements, such as the extent and displacement of deformation features. Initiation of brittle deformation is expected to begin immediately upon creation of an opening. The ongoing geophysical program will help quantify damage evolution around WIPP openings. Initiation and growth of damaged rock zones are important considerations to operational period panel closures as well as compliance PA calculations. As stated previously, this COMP is qualitative and is not directly related to PA parameters.

Initiation of Brittle Deformation - 2006:

Trigger Value Derivation				
COMP Title:	Initiation of Brittle Deformation			
COMP Units:	Qualitative			
Related Monitoring Data				
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value	
Geotechnical	Closure	Observational	Not Established	
COMP Derivation Procedure - Reporting Period July 2004 through June 2005				
Qualitative and pertinent to operational considerations. Captured qualitatively in association with other COMPs				
Performance and Compliance Elements				
Element Title	Parameter Type & ID or Model Description	Derivation Procedure	Compliance Baseline	Impact of Change
Not directly related to PA as currently measured	NA	NA	NA	NA
Monitoring Data Trigger Values				
Monitoring Parameter ID	Trigger Value	Basis		
Initiation of Brittle Deformation	None	Qualitative COMPs can be subjective and are not prone to the development of meaningful TVs.		

2.2.4 Displacement of Deformation Features

The displacement of deformation features primarily focuses on those features located in the immediate vicinity of the underground openings, e.g., mining-induced fractures and lithological units within several meters of the roof and floor. As discussed previously, fracture development is most continuous parallel to the openings and near the upper corners. These fractures tend to propagate or migrate by arching over and under the openings and, thus are designated "low-angle fractures" relative to the horizontal axis. Typically, the fractures intersect or asymptotically approach lithologic units such as clay seams and anhydrite stringers. As a result, salt beams are formed. In the roof, the beams are de-coupled from the surrounding formation requiring use of ground support. In the floor, the beams sometimes buckle into the openings requiring floor milling and trimming. Lithologic units of primary interest are Clay G and H. These features are located approximately 2.4 m and 4.5 m respectively, above the roof of Panels 1, 2, 7 and 8.

Marker Bed 139 (anhydrite) is located approximately 2 m below the floor of these panels. For Panels 3 through 7, the panels are mined up to Clay G. Clay H is therefore located 2.1 m above the roof of these panels and Marker Bed 139 is located approximately 4.4 m below the panel floors.

Monitoring of these deformation features is accomplished through visual inspection of observation boreholes (OBH) drilled from the openings through the feature of interest. In general, these boreholes are aligned vertically (normal to the roof and floor surfaces) because of the location and orientation of the fractures and lithological units of interest. All of the OBHs are 7.6 cm (3 in) in diameter, and many intersect more than one deformation feature. The ages of the OBHs vary from more than 20 years to recent. There are data on 157 OBHs (of which 66 were drilled during the reporting period) listed in the GAR (DOE 2006b). Of these, most are associated with Panel 3 and access drifts (most associated with E 140). Data for OBHs in closed panels or that are no longer accessible due to waste emplacement are not listed.

The deformation features in OBHs are classified as: 1) offsets, 2) separations, 3) rough spots and 4) hang-ups. All of the OBHs exhibited some separation within the roof beam. The greatest separations are generally associated with anhydrite stringers in the lower portion of the roof beam. Forty-four of the 48 observation holes in Panel 3 show some offset. Most holes show offsetting along anhydrite stringers and clay layers. Only four boreholes did not indicate offsetting. One borehole at the intersection of S-3080 and Room 1 exhibited a 3-inch lateral displacement. Only one other OBH not directly associated with Panel 3 was fully occluded. This OBH is at S 2986 E 140, a main drift located between the entries to Panel 3.

Of the four features, offsets are the principle metric for this COMP and are quantified by visually estimating the degree of borehole occlusion created by the offset. The direction of offset along displacement features is defined as the movement of the stratum nearer the observer relative to the stratum farther from the observer. Typically, the nearer stratum moves toward the center of the excavation. Based on previous observations in the underground, the magnitude of offset is usually greater in boreholes located near the ribs as compared to boreholes located along the centerline of openings.

The TV for displacement of deformation features is the observation of a fully occluded borehole. However, many of the boreholes monitored during the previous years COMPs reports are no longer monitored, many of which were occluded. Most of these OBHs were old, dating back to the time Panel 1 was completed in 1990. Most of the currently monitored boreholes are less than four years old. The TV does not consider the age of the OBH. Based on the current data available from the GAR, two (1.2 % of the total) OBHs were fully occluded. Exceedance of the TV is not a cause for concern given that no significant impact on safety or performance has occurred in those locations where the TV has been exceeded. However, to limit the formation of low angle fractures and de-coupled beams over the roof, the elevation of Panel 3 and future disposal panels (i.e., Panels 4, 5, 6, and 7) have been raised approximately 2.4 m so the roof will then coincide with Clay G. This horizon change was implemented to improve ground control. As such, the horizon change will change the expected deformation and displacement behavior.

Displacement of deformation features has been useful for implementation of ground control alternatives (i.e., horizon change to Clay G). Displacement features complement observation of brittle deformation initiation and corroborate estimates of the extent of deformation.

Displacement of Deformation Features - 2006:

<table>
<tr><td colspan="5">Trigger Value Derivation</td></tr>
<tr><td>COMP Title:</td><td colspan="4">Displacement of Deformation Features</td></tr>
<tr><td>COMP Units:</td><td colspan="4">Length</td></tr>
<tr><td colspan="5">Related Monitoring Data</td></tr>
<tr><td>Monitoring Program</td><td>Monitoring Parameter ID</td><td>Characteristics (e.g., number, observation)</td><td colspan="2">Compliance Baseline Value</td></tr>
<tr><td>Geotechnical</td><td>Delta D/D_0</td><td>Observational</td><td colspan="2">Not established</td></tr>
<tr><td colspan="5">COMP Derivation Procedure - Reporting Period July 2004 through June 2005</td></tr>
<tr><td colspan="5">Observational – Lateral deformation across boreholes.</td></tr>
<tr><td colspan="5">Related Performance and Compliance Elements</td></tr>
<tr><td>Element Title</td><td>Parameter Type & ID or Model Description</td><td>Derivation Procedure</td><td>Compliance Baseline</td><td>Impact of Change</td></tr>
<tr><td>Not directly related to PA</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td colspan="5">Monitoring Data Trigger Values</td></tr>
<tr><td>Monitoring Parameter ID</td><td>Trigger Value</td><td colspan="3">Basis</td></tr>
<tr><td>Borehole diameter closure</td><td>Obscured observational borehole.</td><td colspan="3">If lateral displacement is sufficient to close diameter of observational borehole, technical evaluation of consequences will be initiated.</td></tr>
</table>

2.2.5 Subsidence0

Subsidence is currently monitored via elevation determination of 48 existing monuments and 14 of the National Geodetic Survey's vertical control points. To address EPA monitoring requirements, the most recent survey results (DOE 2005b) are reviewed and compared to derived TVs. Because of the low extraction ratio and the relatively deep emplacement horizon (650 m), subsidence over the WIPP is expected to be much lower and slower than over potash mines. Maximum observed subsidence over potash mines near the WIPP is 1.5 m, occurring over a time period of months to a few years. In contrast, calculations show that the maximum subsidence predicted directly above the WIPP waste emplacement panels is 0.62 m assuming emplacement of CH-TRU waste and no backfill (Backfill Engineering Analysis Report [BEAR; WID 1994]). Further considerations, such as calculations of room closure, suggest that essentially all surface subsidence would occur during the first few centuries following construction of the WIPP, so the maximal vertical displacement rates would be approximately 0.002 m/yr (0.006 ft/yr). Obviously, these predicted rates could be higher or lower depending on mining activities as well as other factors such as time. Because the vertical elevation changes are very small, survey accuracy, expressed as the vertical closure of an individual loop times the square root of the loop length, is of primary importance. For the current subsidence surveys, a Second-Order Class II loop closure accuracy of 8 mm × √km (or 0.033 ft × √mile) or better was achieved in all cases.

Three monuments have also been included in various annual surveys, but were not included in the current surveys because the monuments no longer exist (S-17 & S-18 are under a salt pile) or have been physically disturbed (PT-31). Historically, the surveys were conducted by private companies under subcontract to DOE; however, since 1993, the WIPP M&OC has conducted the surveys using a set of standardized methods. Starting with the 2002 survey, the M&OC has been following WIPP procedure, WP 09-ES4001 (WTS 2002).

The current surveys comprise nine leveling loops containing as few as five to as many as ten monuments/control points per loop as shown in Figure 2.2 (Surveys of Loop 1 benchmarks have been discontinued because only two benchmarks comprise this loop and these benchmarks are redundant to other survey loops). Elevations are referenced to Monument S-37 located approximately 7,700 ft north of the most northerly boundary of the WIPP underground excavation. This location is considered to be far enough from the WIPP facility to be unaffected by excavation-induced subsidence expected directly above and near the WIPP underground. The elevation of S-37 has been fixed for all of the subsidence leveling surveys conducted since 1993. Survey accuracy for all loops was 0.007 feet per mile or better. Adjusted elevations are determined for every monument/control point by proportioning the vertical closure error for each survey loop to the monuments/control points comprising the loop. The proportions are based on the number of instrument setups and distance between adjacent points within a survey loop.

The adjusted elevations for each monument/control point are plotted as functions of time to assess subsidence trends. Figures 2.3 through 2.7 provide, respectively, elevations for selected monuments including those located (1) directly above the first waste emplacement panel, (2) directly above the second waste emplacement panel, (3) directly above the north experimental area, (4) near the salt handling shaft, and (5) outside the repository footprint of the WIPP underground excavation. As expected, subsidence is occurring directly above the underground openings (Figures 2.3 through 2.6); however the magnitude of the subsidence above the openings is small ranging from about -0.10 ft to -0.20 ft. Most of the observed subsidence has occurred in the time period from 1987 to 1993, but as discussed above, consistent surveying practices were not implemented until 1993 so some of the observed elevation changes may be related to differences in methodology rather than subsidence.

Elevations of survey points located directly above Waste Emplacement Panel 1 were stable during the 1994 to 1998 surveys, as shown in Figure 2.3. However, when the excavation of Panel 2 was initiated in 1999, the elevations of the survey points above Panel 1 began to decrease with time in a nearly linear manner. These higher rates of subsidence were anticipated because the excavation of Panel 2 caused a redistribution of stress in the salt around Panel 1, leading to higher creep rates in the salt and higher convergence rates of panel rooms. Based on three-dimensional modeling conducted by Patchet et al. (2001), the convergence rates within Panel 1 were predicted to increase by as much as 60 to 96 percent as a result of the mining of Panel 2. A manifestation of these higher convergence rates is higher subsidence rates at the surface, particularly above Panel 1. Higher subsidence rates were also expected directly above Panel 2 because of the excavation. Figure 2.4 shows that the elevations of the survey points located above Panel 2 also began to decrease immediately following the initiation of Panel 2 excavation in 1999. With the completion of the Panel 2 excavation in October 2000, subsidence rates of survey points located above both Panel 1 and Panel 2 slowed as indicated by the 2002 survey results shown in Figures 2.3 and 2.4, but then accelerated again in 2003 (particularly above Panel 2) most likely as a result of the initiation of excavation of Panel 3 and its access drifts.

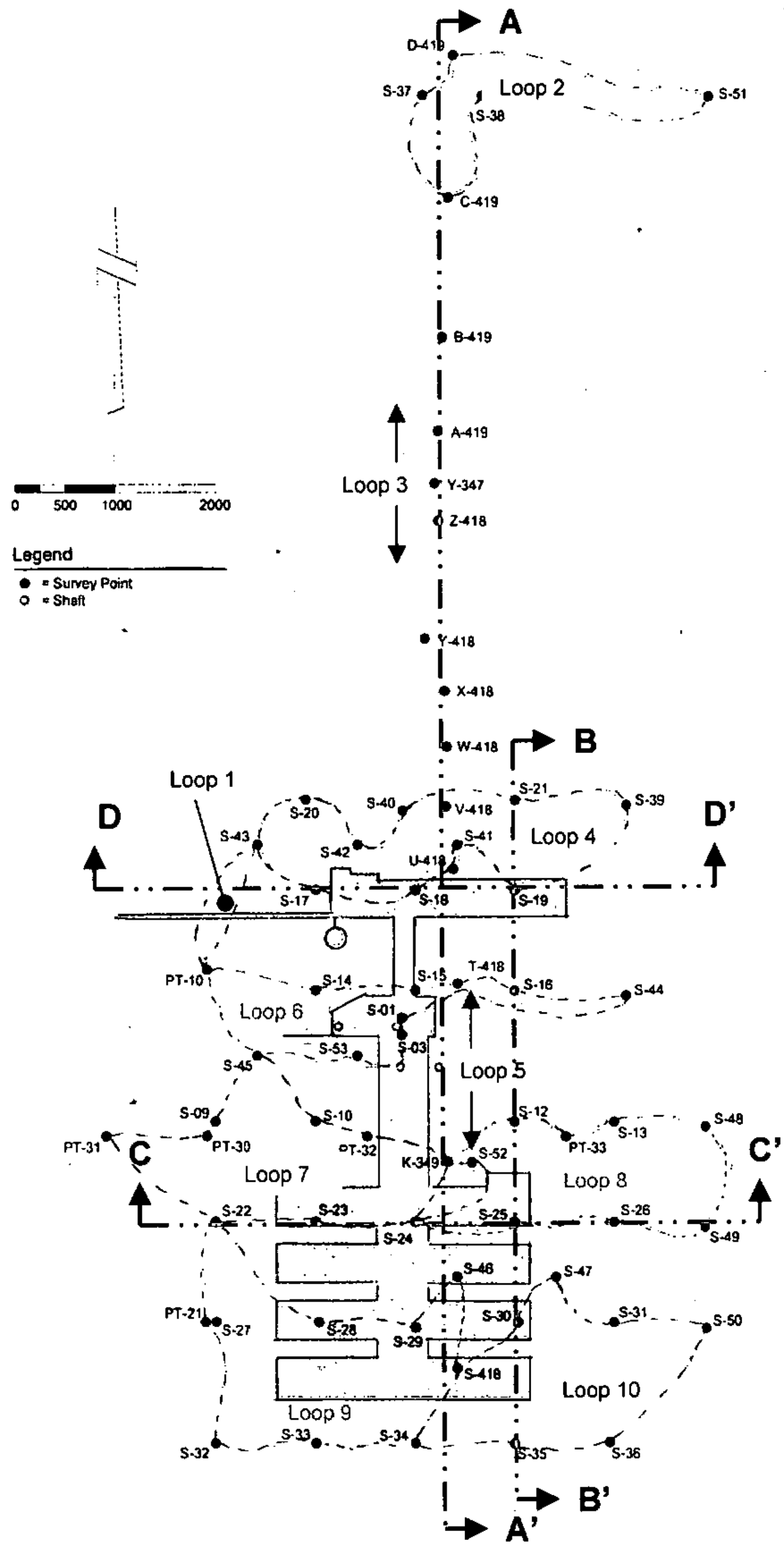

Figure 2.2. Monuments and vertical control points comprising WIPP subsidence survey loops.

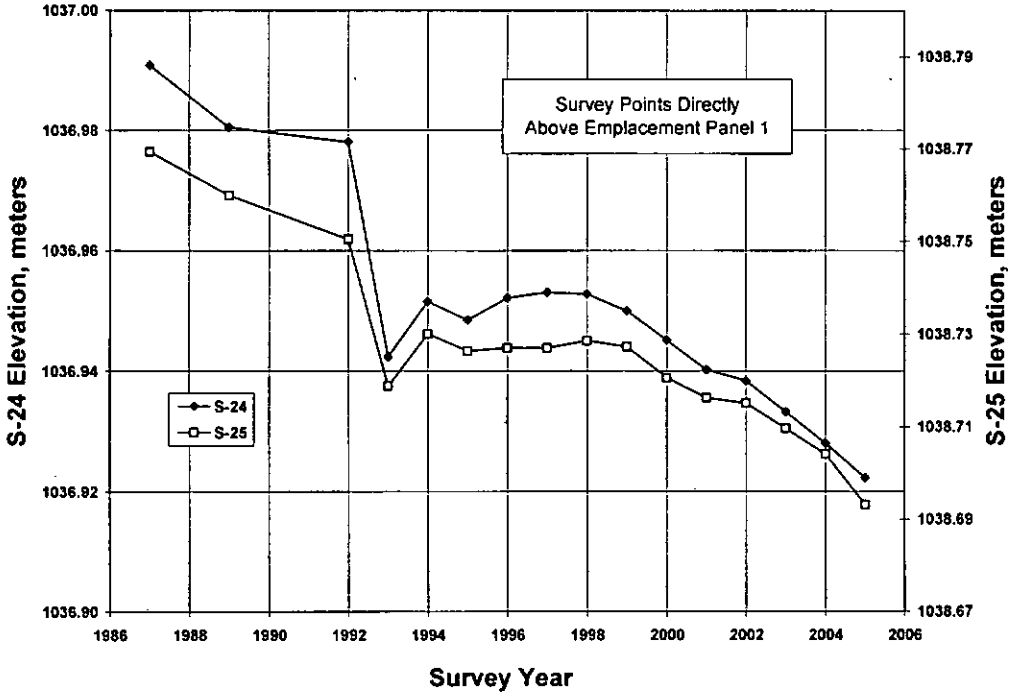

Figure 2.3. Elevations of WIPP monuments S-24 and S-25 located directly above emplacement Panel 1.

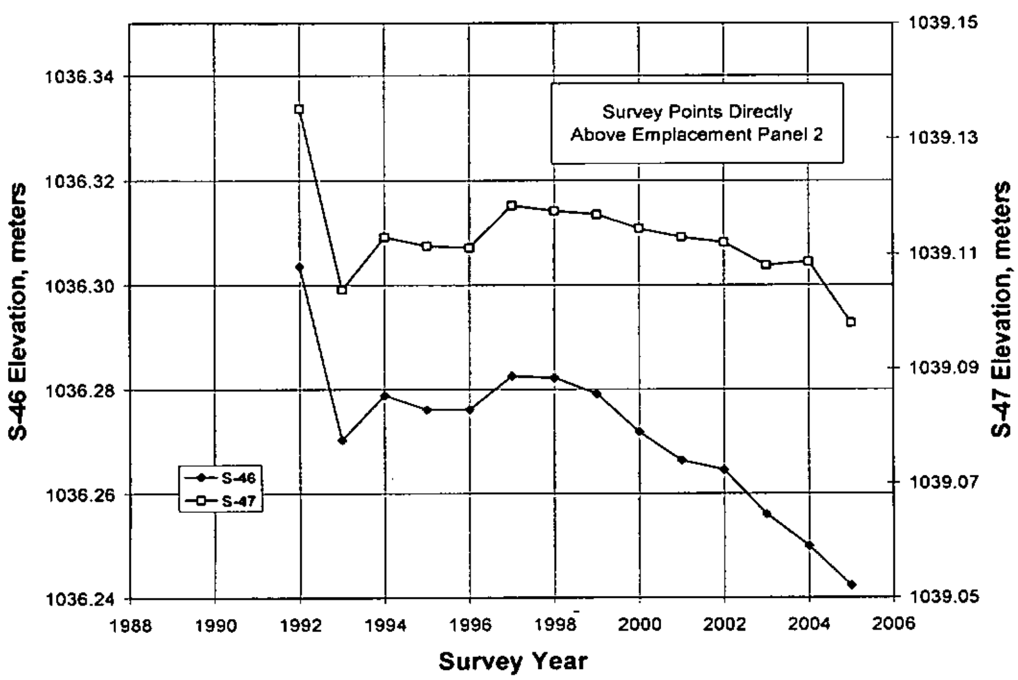

Figure 2.4. Elevations of WIPP monuments S-46 and S-47 located directly above emplacement Panel 2.

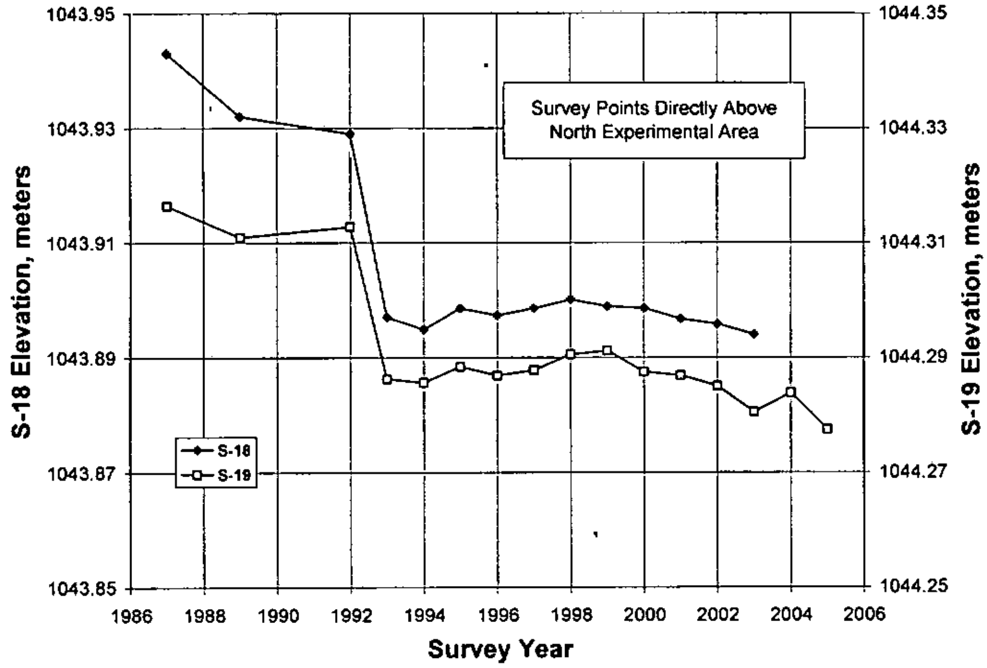

Figure 2.5. Elevations of WIPP monuments S-18 and S-19 located directly above the north experimental area.

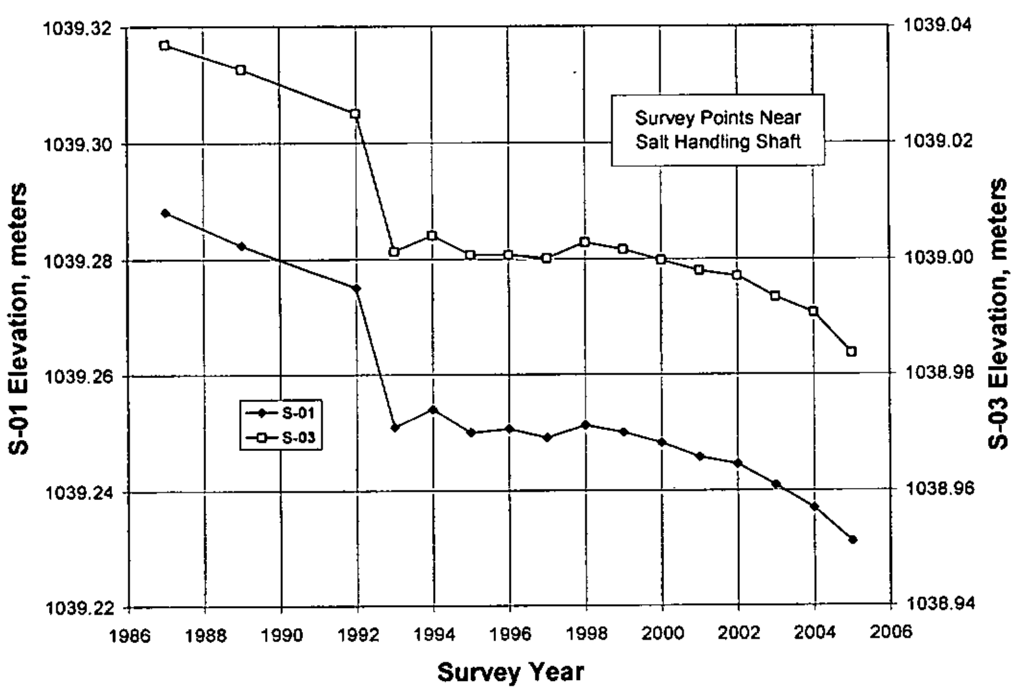

Figure 2.6. Elevations of WIPP monuments S-01 and S-03 located near the Salt Handling Shaft.

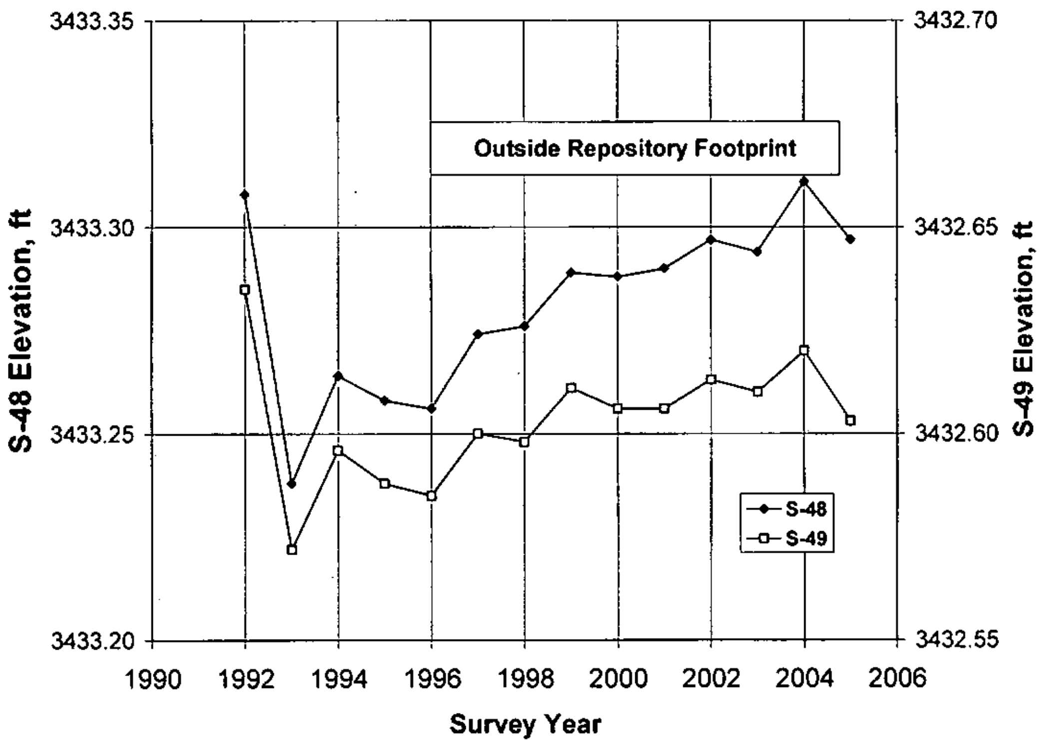

Figure 2.7. Elevations of WIPP monuments S-48 and S-49 located outside the repository footprint.

As time passes, subsidence is expected to be most pronounced directly above the WIPP underground excavations and will be minimal away from the repository footprint. Early results suggest this pattern is already occurring, as shown in Figures 2.8 through 2.11 for the following subsidence profiles (shown in plan view in Figure 2.2):

- Section A-A′, North-South section extending through the WIPP site
- Section B-B′, North-South section extending from the north experimental area through the south emplacement panels
- Section C-C′, East-West section extending through Panel 1
- Section D-D′, East-West section extending through the north experimental area.

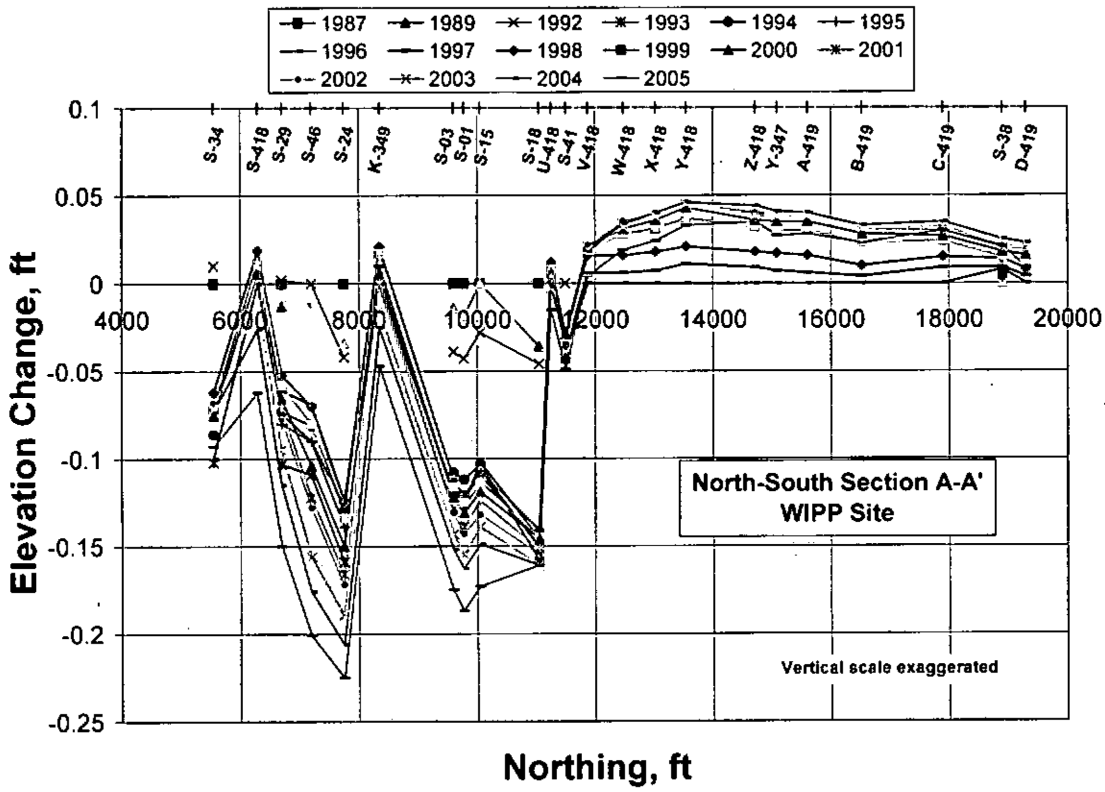

Figure 2.8. North-South subsidence profile A-A'.

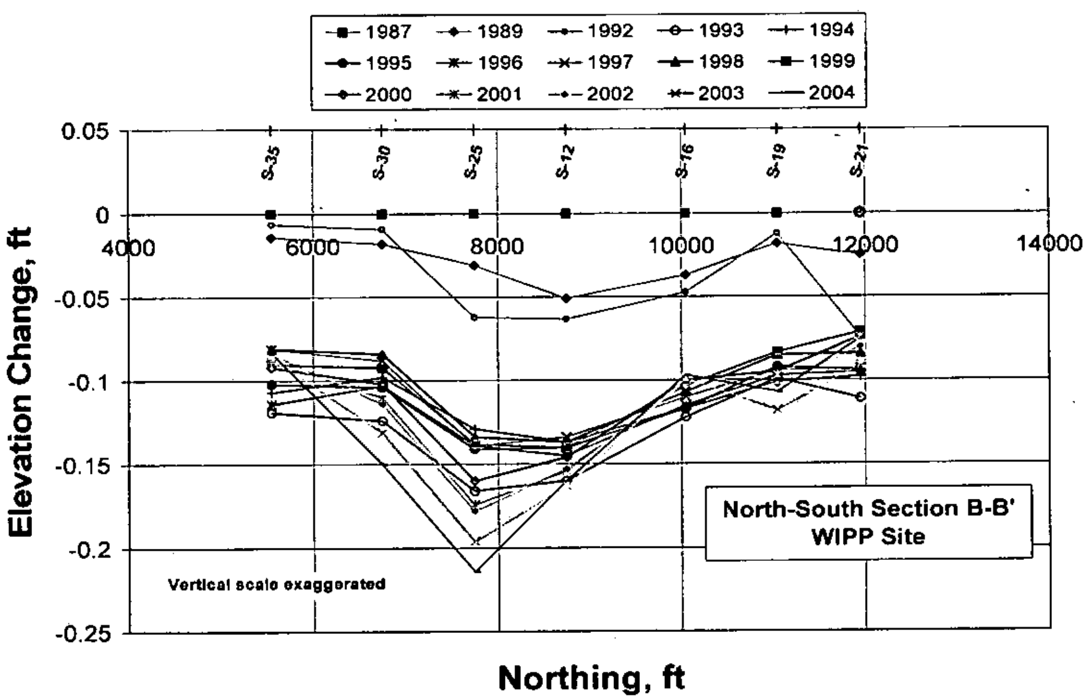

Figure 2.9. North-South subsidence profile B-B'.

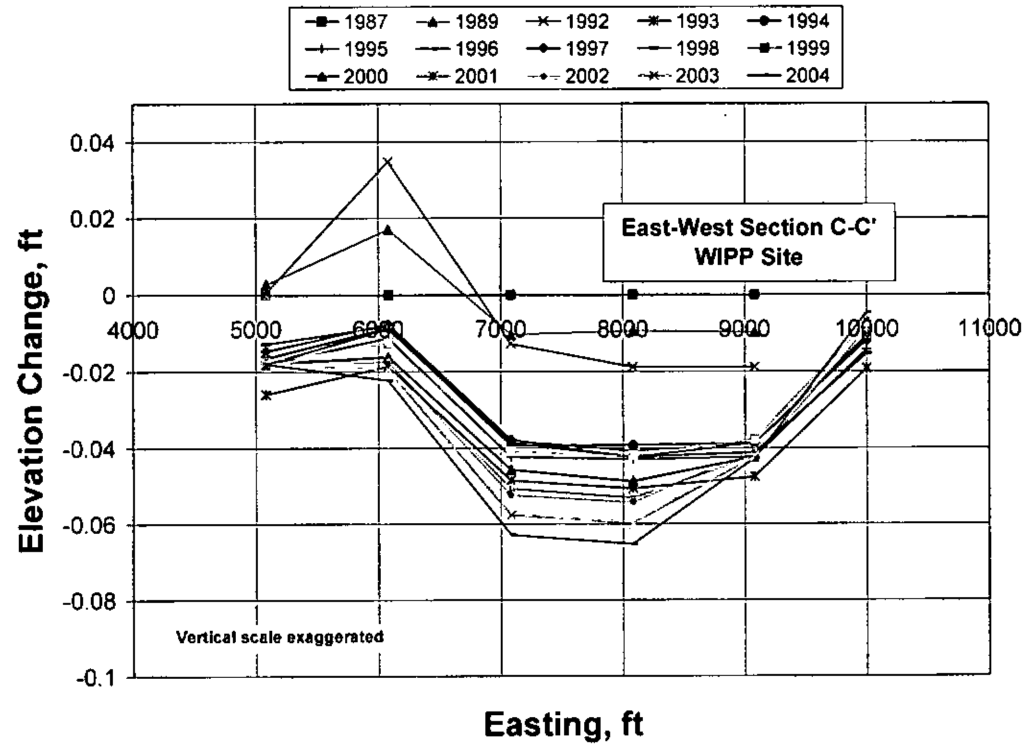

Figure 2.10. East-West subsidence profile C-C′.

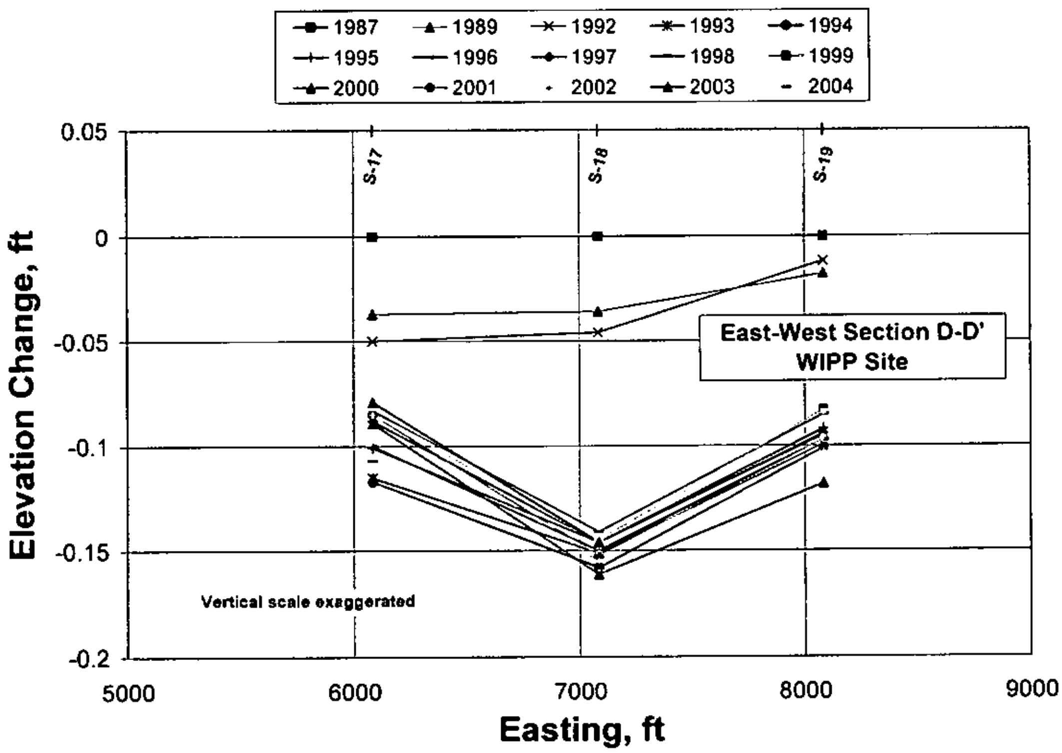

Figure 2.11. East-West subsidence profile D-D′.

The elevation changes of individual monuments shown in these figures are referenced to the elevations determined from the annual surveys that first incorporated the monument so, in some cases, direct temporal comparisons between pairs of monuments cannot be made. For example, only 29 monuments were included in the 1987 survey, while 50 and 65 monuments were included in the 1992 and 1996 surveys, respectively. Although direct comparisons cannot always be made, several observations are possible including:

1. The most significant subsidence (greater than - 0.20 ft) occurs directly above Panels 1, 2 and 3 (Monuments PT-21, S-24 and S-25), with slightly less subsidence (- 0.18 ft) near the Salt Handling Shaft (Monuments S-01, S-03, S-14 and S-15) and above the North Experimental Area (S-18).
2. The highest subsidence rates measured for the 2004-2005 surveys correspond to benchmarks located above Panels 1 through 4. These rates ranged from 1.1×10^{-2} m/yr at S-13, S-25, S-29, and S-47 (above Panels 1 through 3) to 9.1×10^{-3} m/yr at S-30 (above Panel 3).
3. The effects of subsidence extend away from the repository footprint approximately 1,000 to 1,500 ft (e.g., S-26, see Figures 2.2 and 2.10).

Furthermore, total subsidence and subsidence rates are small, and are approximately at the resolution level of the survey accuracy. The benchmarks with the highest rates are seen above the mined panels and have increased since the mining of Panels 3 and 4. Based on the survey data available, subsidence rates of the ground surface at the WIPP have slightly exceeded the 1×10^{-2} m/yr TV. Since the TV is based on a maximum rate over a 35 year period, a rate that exceeds the TV for many years would merit additional investigations. It is recommended that these rates be monitored to determine their rate of change over the next five years to determine the trend of the response. No additional activities are recommended at this time.

Subsidence - 2006:

Trigger Value Derivation			
COMP Title:	Subsidence		
COMP Units:	Change in surface elevation in meters per year		
Related Monitoring Data			
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value
Subsidence Monitoring Leveling Survey (SMP)	Elevation of 62 monitoring monuments	Decimal (meters)	Not Established
SMP	Change in elevation over year	Decimal (meters)	Not Established
COMP Derivation Procedure - 2006			
Survey data from annual WIPP Subsidence Monument Leveling are evaluated. Elevations of 48 monitoring monuments are compared to determine change.			

Related Performance and Compliance Elements				
Element Title	Parameter Type & ID or Model Description	Derivation Procedure	Compliance Baseline	Impact of Change
Subsidence	FEP [W-23]	Predictions are of low consequence to the calculated performance of the disposal system – based on WID (1994) analysis and EPA treatment of mining.	Maximum total subsidence of 0.62 m above the WIPP.	Predicted subsidence will not exceed existing surface relief of 3 m – i.e., it will not affect drainage. Predicted subsidence may cause an order of magnitude rise in Culebra hydraulic conductivity (CRA Appendix PA Attachment SCR , Section SCR-6.3.1.4) – this is within range modeled in the PA. Predicted WIPP subsidence is below that predicted for the effects of potash mining (0.62 m vs.1.5 m; EPA 1996).

Monitoring Data Trigger Values		
Monitoring Parameter ID	Trigger Value	Basis
Change in elevation per year	1.0×10^{-2} m (3.25×10^{-3} ft) per year subsidence	Based on the most conservative prediction by analyses referenced in the CCA.

2.3 Hydrological COMPs

As stated in the previous sections, the Compliance Recertification Application (CRA; DOE 2004) lists ten monitoring parameters that the DOE is required to monitor and assess during the WIPP operational period. Two of these parameters are considered hydrological in nature and include:

- Changes in Culebra Water Composition
- Changes in Culebra Groundwater Flow

The SA has reviewed the data collected by the M&OC during 2005 under the Groundwater Surveillance Program (GSP; DOE 2003). The GSP has two components:

- The Water Quality Sampling Program (WQSP)
- The Water-Level Monitoring Program (WLMP)

WQSP and WLMP data are reported in the Waste Isolation Pilot Plant Annual Site Environmental Report for 2005 (DOE 2006c) and WLMP data are also reported in monthly memoranda from the M&OC to the SA.

2.3.1 Changes in Culebra Water Composition

2.3.1.1 Water Quality Sampling Program (WQSP)

Under the current WQSP, seven wells are sampled by the M&OC. Six of the wells (WQSP-1 through 6) are completed to the Culebra Dolomite Member of the Rustler Formation and the seventh (WQSP-6a) is completed to the Dewey Lake Formation (Figure 2.12). All the WQSP wells are located within the WIPP Land Withdrawal Act boundary (LWB). WQSP-1, 2, and 3 are situated hydraulically up-gradient (north) of the WIPP surface facilities and WQSP-4, 5, and 6 are situated down-gradient (south) of the WIPP surface facilities. The Dewey Lake, to which WQSP-6a is completed, bears water only in the southern portion of the WIPP site and farther to the south.

Flow and transport in the Dewey Lake are not modeled explicitly in Performance Assessment (PA) because PA modeling shows no radionuclides reach the Dewey Lake and the sorptive quality of the Dewey Lake would be expected to retard migration of any radionuclides that did reach the unit. Nevertheless, the Dewey Lake water quality is monitored because it might help to increase the understanding of Dewey Lake hydrology.

The Culebra is modeled for PA because it is the most transmissive, saturated water-bearing zone in the WIPP vicinity. It is not, however, a source of drinking water, so Culebra water quality is not of concern in an immediate health sense. Instead, Culebra water quality is important because of what it implies about the nature of the flow system.

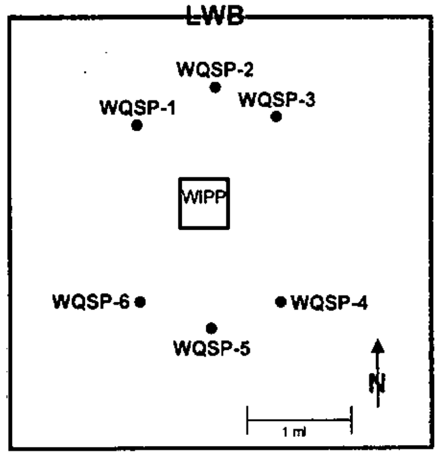

Figure 2.12. Map showing locations of WQSP wells in relation to the WIPP surface facilities and the LWB. Note: WQSP-6a is on the same well pad as WQSP-6.

Solute concentrations for the Culebra differ widely among wells across the WIPP site, reflecting local equilibrium, diffusion, and, perhaps most importantly, transport rate. The conceptual model for the Culebra presented in the CRA (DOE 2004) and implemented in PA numerical models is that of a confined aquifer with solute travel times across the WIPP site on the order of tens of thousands of years. In such a system, no changes in water quality at an individual well outside the range of normal analytical uncertainty and noise should be observed during the WIPP operational phase of a few decades duration. If sustained and statistically significant changes in the concentrations of major ionic species (Na^+, Ca^{2+}, Mg^{2+}, K^+, Cl^-, SO_4^{2-}, HCO_3^-) were observed, this would imply that water was moving faster through the Culebra than was consistent with PA models. Stability of major ion concentrations, on the other hand, is consistent with and supports the SA's models. Thus, this evaluation of the water-quality data focuses on the stability of major ion concentrations.

2.3.1.1.1 Water Quality Sampling

One primary and one duplicate water sample are collected from each WQSP well twice per year, in the spring and again in the fall. Water sampling procedures are outlined in the WIPP Strategic Plan for Groundwater Monitoring (DOE 2003) and are summarized here.

Samples are collected using a submersible pump (each well has its own dedicated pump) that is set at the mid-formation level. Water samples are collected in serial and final. Serial samples are taken at regular intervals while the well is being pumped and analyzed in a mobile field laboratory to determine when water chemistry has stabilized using the parameters of temperature, Eh, pH, alkalinity, chloride, divalent cations, and total iron. The final sample is collected when water quality has stabilized to within ±5% of the field parameter average. Final samples are collected in appropriate containers (i.e., preserved versus unpreserved), placed in coolers, and delivered to the analytical laboratory on the day of collection.

2.3.1.1.2 Laboratory Analysis

The M&OC collects samples to be analyzed for volatiles, total organic halogens, total organic carbon, semi-volatiles, metals, and general chemistry. For this report, only the results from the metals and general chemistry samples are discussed. In the field, the general chemistry samples are not preserved, while the metals samples are preserved with nitric acid; neither sample is filtered.

TraceAnalysis, Inc. of Lubbock, TX is responsible for analysis of the water samples submitted by the M&OC (and has been since round 7). Samples are analyzed using a variety of published and accepted EPA or American Public Health Association methods. In the lab, metals samples are analyzed for total cations (e.g., Na^{+}, Ca^{2+}, Mg^{2+}, K^{+}) and general chemistry samples are split, filtered (if necessary), and analyzed for chloride (Cl^{-}), sulfate (SO_4^{2-}), alkalinity (i.e., bicarbonate; HCO_3^{-}), and other constituents that are not reported here.

2.3.1.1.3 Data Analysis

Based on the considerations listed in Section 2.3.1.1, a TV for Culebra groundwater composition has been defined as the condition where both primary and duplicate analyses for any major ion fall outside the 95% confidence interval (C.I.) for three consecutive sampling periods. When and if this criterion is met, the project will evaluate the sampling and analytical procedures to see if the apparent change in groundwater composition can be explained by procedural changes or irregularities. If the change appears to reflect conditions in the Culebra accurately, the SA will investigate what effects the changes might have on the conceptualization and modeling of the Culebra and, if appropriate, the model will be revised to be consistent with the new information.

In this COMP evaluation, stability is defined as a condition where the concentration of an ion remains within the 95% C.I. (mean ± two standard deviations) established from the baseline measurements at a well, assuming a normal distribution of concentrations. The original baseline was defined by the first five rounds of sampling in the WQSP wells conducted between July 1995 and September 1997 (Crawley and Nagy 1998). The baseline was revised in 2000, expanding from the first five rounds to the first ten rounds of sampling, which were performed between July 1995 and May 2000, before the first receipt of RCRA-regulated waste at WIPP. The baseline data are presented in the WIPP Resource Conservation and Recovery Act Background Quality Baseline Report (Crawley and Nagy 1998) and in Addendum 1 to that report (IT Corporation 2000). For the purposes of this evaluation, a small number of measurements have been eliminated from the baselines for WQSP-3, 5, 6, and 6a. The reasons for eliminating these values are discussed in detail in the COMPs assessment report for data collected in the year 2000 (SNL 2000b). The elimination of these values is always conservative in that it reduces the "stable" range of concentrations for the affected parameters. The 95% confidence intervals derived from the baseline data (SNL 2000b) are presented in Table 2.6.

A charge-balance error, defined as the difference between the positive and negative charges from the ions in solution divided by the sum of the positive and negative charges, was also calculated for each analysis using the average of the primary and duplicate sample. Charge-balance errors are useful in evaluating the reliability of an analysis because water must be electrically neutral. Charge-balance errors are rarely zero because of inherent inaccuracy in analytical procedures, but a reliable analysis should not have a charge-balance error exceeding five percent (Freeze and Cherry 1979). Charge-balance errors in excess of five percent imply either that the analysis of one or more ions is inaccurate (most common) or that a significant ion has been overlooked (rare). The variation between the values obtained for the "sample" and "duplicate" analyses of individual ions is also considered. Generally speaking, this variation should be less than ten percent. Greater variation indicates a potential problem with one or both analyses. Analytical results and charge-balance errors for rounds 20 and 21 of sampling are presented in Table 2.6.

2.3.1.2 Results

WQSP results for 2005 come from sampling rounds 20 and 21 and are reported in Table 2.6. Sampling round 20 was conducted between March and May and round 21 between late August and November.

Table 2.6. Rounds 20 and 21 major ion concentrations and charge-balance errors, with baseline 95% confidence intervals for each major ion.

Well I.D.	Sample	Cl^- Conc. (mg/L)	SO_4^{2-} Conc. (mg/L)	HCO_3^- Conc. (mg/L)	Na^+ Conc. (mg/L)	Ca^{2+} Conc. (mg/L)	Mg^{2+} Conc. (mg/L)	K^+ Conc. (mg/L)	Charge-Balance Error (%)
WQSP-1	Round 20	38800/38400	4840/4790	52/52	19100/18500	1700/1610	1150/1090	**934/907**	**-7.9**
	Round 21	*34800/39100*	4440/4600	50/48	**23400/22500**	1910/1840	*1400/1120*	**998/1010**	3.6
	95% C.I.	31100-39600	4060-5600	45-54	15900-21100	1380-2030	939-1210	322-730	
WQSP-2	Round 20	***39800/47400***	*5920/6610*	*56/44*	19200/19900	1580/1730	*1110/1250*	**944/1010**	**-12.6**
	Round 21	37900/**39600**	5630/5830	52/50	***22700/25500***	1720/1670	**1230**/1120	**1080/1170**	1.8
	95% C.I.	31800-39000	4550-6380	43-53	14100-22300	1230-1770	852-1120	318-649	
WQSP-3	Round 20	*144000/126000*	**8060**/7560	34/32	77500/75900	**1980/2000**	**2710/2530**	2490/2670	-3.3
	Round 21	140000/144000	7860/**8160**	32/34	82700/78300	**1810/1810**	2490/2420	2480/2550	-3.6
	95% C.I.	114000-145000	6420-7870	23-51	62600-82700[c]	1090-1620	1730-2500	2060-3150[a]	
WQSP-4	Round 20	**67200/65200**	6980/7010	42/42	32400/30300	1510/1580	*1180/1340*	*1320/1130*	**-12.2**
	Round 21	**63400/63300**	***8610/7660***	38/40	35100/35600	1760/1650	**1540**/1410	1550/1470	-4.6
	95% C.I.	53400-63000	5620-7720	31-46	28100-37800	1420-1790	973-1410	832-1550[b]	
WQSP-5	Round 20	**18100/17700**	5520/5500	46/44	8420/8550	1020/1060	474/497	**539/553**	**-13.3**
	Round 21	14800/15400	**6440/6870**	46/44	8820/8920	1130/1150	**553/568**	**598/608**	**-5.7**
	95% C.I.	13400-17600	4060-5940	42-54	7980-10400[c]	902-1180	389-535	171-523	
WQSP-6	Round 20	6140/6220	**5260/5280**	44/46	3980/3840	736/756	232/**246**	**275/270**	**-9.8**
	Round 21	6120/5540	*5030/4320*	44/46	4380/4250	739/776	**238/248**	**258/260**	-2.0
	95% C.I.	5470-6380[c]	4240-5120[c]	41-54	3610-5380[c]	586-777	189-233[c]	113-245	
WQSP-6a	Round 20	**432/401**	1920/1890	104/102	**205/211**	628/626	173/173	6.21/6.38	1.5
	Round 21	**360/357**	1940/1940	106/108	**226/216**	580/561	156/151	*8.99/6.29*	-1.3
	95% C.I.	444-770[c]	1610-2440	97-111	253-354	554-718	146-185	1.8-9.2	

Bold signifies outside 95% confidence interval or charge-balance error >5%
Italics signifies sample and duplicate analyses differ by more than 10%
[a] baseline defined from rounds 8-10
[b] baseline defined from rounds 7-10
[c] baseline definition excludes anomalous values

2.3.1.2.1 WQSP-1

For round 20, concentrations of all major ions at WQSP-1 were within the 95% confidence intervals, except for both potassium analyses. None of the duplicate samples differed by ≥10%.

For round 21, concentrations of most major ions were within the 95% confidence intervals, with the exception of both sodium and potassium samples and the primary magnesium sample, which were all above the upper 95% C.I. Analyses of the duplicate magnesium and chloride samples differed by 20% and 12%, respectively, relative to their respective primary sample.

Charge-balance errors were –7.9% and +3.6% for rounds 20 and 21, respectively, indicating a surplus of anions or a deficit of cations for round 20 and the opposite for round 21. Figure 2.13 shows that the WQSP-1 hydrochemical facies in 2005 are consistent with previous results.

2.3.1.2.2 WQSP-2

For round 20, concentrations of half (i.e., 7 of 14) of the major ions were within the 95% confidence intervals. Analyses for chloride, sulfate, alkalinity, magnesium, and potassium showed at least one of the values to be above the upper 95% C.I. Analyses of the duplicate samples showed that chloride, sulfate, alkalinity, and magnesium differed by ≥10% from the primary samples. For round 21, concentrations of most major ions were within the 95% confidence intervals. Analyses for chloride, sodium, magnesium, and potassium showed at least one of the values to be above the upper 95% C.I. Analyses of the duplicate samples showed that only sodium differed by ≥10% from the primary samples, though magnesium results differ by almost 9%.

Charge-balance errors were –12.6% and +1.8% for rounds 20 and 21, respectively, indicating a surplus of anions and/or a deficit of cations for round 20 and the opposite for round 21. Figure 2.13 shows that the WQSP-2 hydrochemical facies in 2005 are consistent with previous results.

2.3.1.2.3 WQSP-3

For round 20, concentrations of most major ions at WQSP-3 were within the 95% confidence intervals. Analyses of the primary and duplicate samples showed that sulfate, magnesium, and calcium, in at least one of the samples, were above the upper 95% C.I. Only chloride had results of ≥10% difference between the primary and duplicate sample. For round 21, concentrations of most major ions were within the 95% confidence intervals. Analyses of the primary and duplicate samples showed that sulfate and calcium, in at least one of the samples, were above the upper 95% C.I. None of the duplicate samples differed by ≥10% from the primary.

Charge-balance errors were -3.3% and -3.6% for rounds 20 and 21, respectively, indicating a surplus of anions and/or a deficit of cations for both rounds. Figure 2.13 shows that the WQSP-3 hydrochemical facies in 2005 are consistent with previous results.

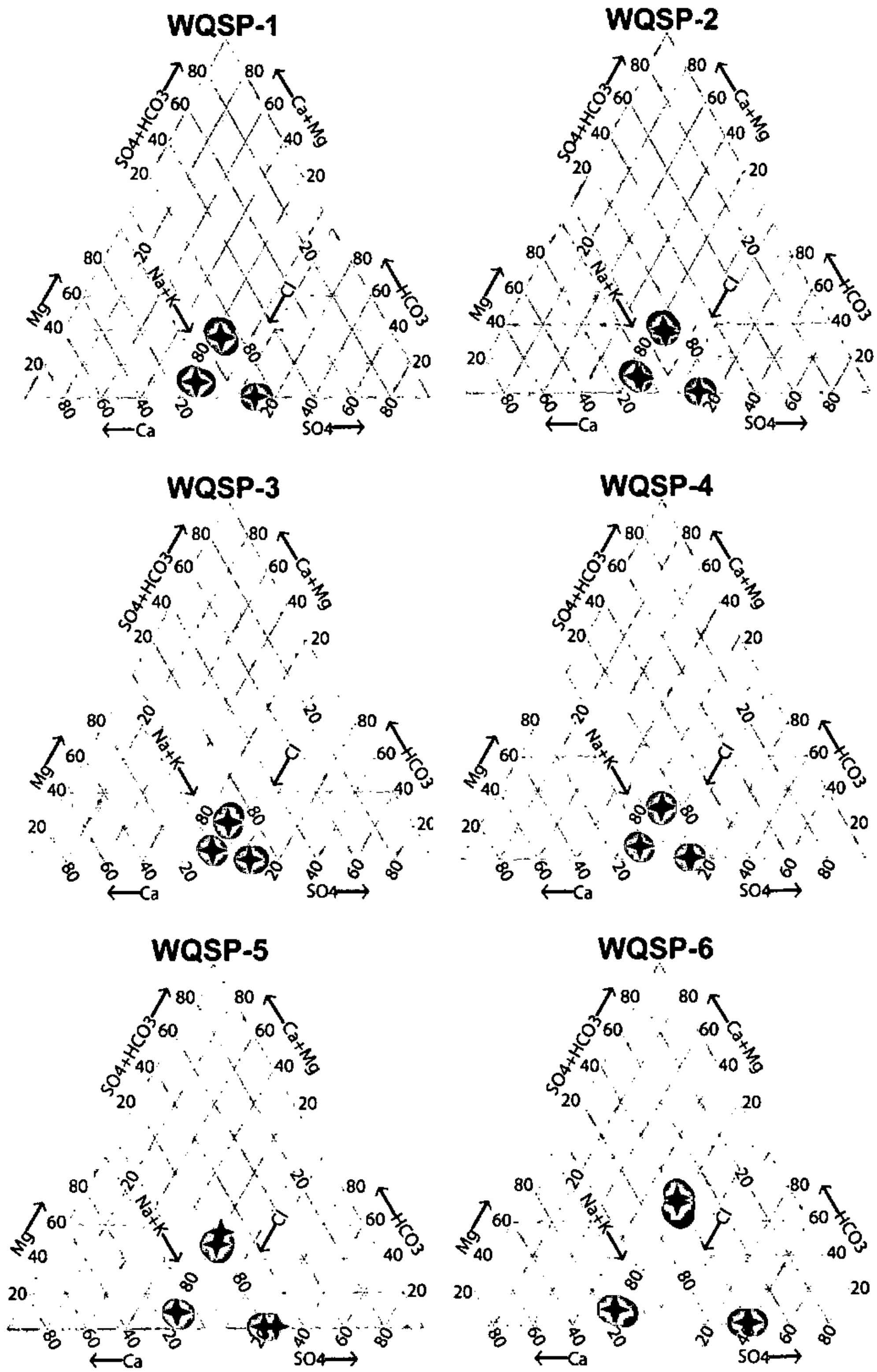

Figure 2.13. Hydrochemical facies plots generated with data collected from WQSP-1 through WQSP-6 during rounds 20 and 21 (2005). The plots show both historical data (gray areas) and results from rounds 20 and 21 (black stars).

2.3.1.2.4 WQSP-4

For round 20, almost all of the major ion concentrations at WQSP-4 were within the 95% confidence intervals. The exception was both of the chloride samples, which were above the upper 95% C.I. Analyses of the duplicates showed that magnesium and potassium differed by ≥10% from their respective primary samples. For round 21, concentrations of most of the major ions were within the 95% confidence interval. Analyses of the primary and duplicate samples showed that chloride, sulfate, and magnesium, in at least one of the samples, were above the upper 95% C.I. Only the duplicate of sulfate had results ≥10% different from the primary.

Charge-balance errors for rounds 20 and 21 were –12.2% and –4.6%, respectively, indicating a surplus of anions and/or a deficit of cations for both rounds. Figure 2.13 shows that the WQSP-4 hydrochemical facies in 2005 are consistent with previous results.

2.3.1.2.5 WQSP-5

For round 20, most of the major ion concentrations at WQSP-5 were within the 95% confidence intervals. Analyses for chloride and potassium showed that both the primary and duplicate samples had concentrations above their respective upper 95% C.I. None of the duplicate samples differed by ≥10% from the primary. For round 21, concentrations for most of the major ions were within the 95% confidence intervals. Analyses of sulfate, magnesium, and potassium showed that both the primary and duplicate samples had concentrations above their respective 95% C.I. None of the duplicate samples differed by ≥10% from the primary.

Charge-balance errors for rounds 20 and 21 were -13.3% and -5.7%, respectively, indicating a surplus of anions and/or a deficit of cations for both rounds. Figure 2.13 shows that the WQSP-5 hydrochemical facies in 2005 are consistent with previous results.

2.3.1.2.6 WQSP-6

For round 20, most major ion concentrations at WQSP-6 were within the 95% confidence intervals. Analyses of the primary and duplicate samples showed that sulfate, magnesium, and potassium, in at least one of the samples, were above the upper 95% C.I. None of the duplicate samples differed by ≥10% from the primary. For round 21, most major ion concentrations were within the 95% confidence intervals, with the exception of the primary and duplicate samples of magnesium and potassium, which were above the upper 95% C.I. Sulfate had the only duplicate sample that differed by ≥10% from the primary.

Charge-balance errors for rounds 20 and 21 were -9.8% and -2.0%, respectively. Figure 2.13 shows that the WQSP-6 hydrochemical facies in 2005 were consistent with previous results.

2.3.1.2.7 WQSP-6a

For round 20, all major ion concentrations were within the 95% confidence intervals except for chloride and sodium results from both the primary and duplicate samples, which were below the lower 95% C.I. (Table 2.6). None of the duplicate samples differed by ≥10% from the primary. For round 21, primary and duplicate sample results for chloride and sodium remained below the lower 95% C.I. The duplicate for potassium was the only duplicate analysis to return a ≥10% difference from the primary.

Charge-balance errors were +1.5% and -1.3% for rounds 20 and 21, respectively. Figure 2.14 shows that the WQSP-6a hydrochemical facies in 2005 were consistent with previous results.

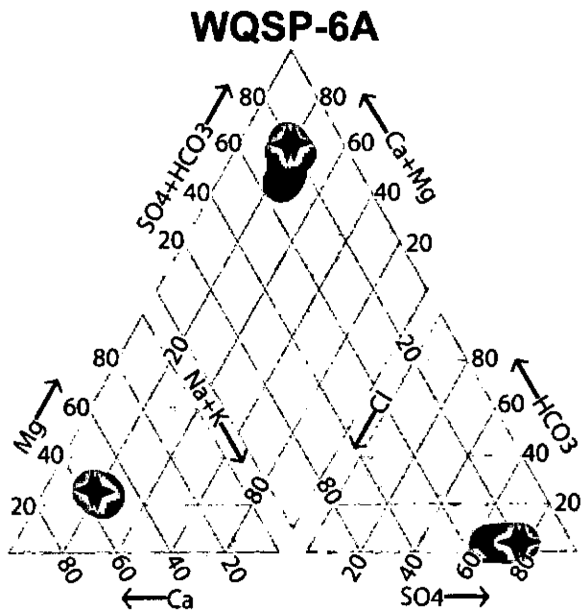

Figure 2.14. Hydrochemical facies plot generated with data collected from WQSP-6a during rounds 20 and 21 (2005). The plot shows both historical data (gray areas) and results from rounds 20 and 21 (black stars).

2.3.1.3 Assessment of Water Quality Data

As of round 21, three of the six Culebra wells sampled under the WQSP have exceeded groundwater composition TVs for a major ion; two other wells can be considered borderline. WQSP-1, WQSP-2, and WQSP-6 have returned both primary and duplicate samples with ion concentrations outside a given confidence interval for at least the past three rounds. WQSP-3 and WQSP-4 have had either the primary, duplicate, or both samples with ion concentrations outside confidence intervals for the past three rounds. In addition, WQSP-6a has been exceeding the lower TV for sodium for the past five rounds.

2.3.1.3.1 Culebra Wells

In WQSP-1, 2, and 6, potassium concentrations for both primary and duplicate samples have exceeded the upper 95% C.I. beginning with round 19 (Figure 2.15). In WQSP-1 and WQSP-2, the increase in potassium concentrations has been steady, beginning after round 16 (i.e., spring 2003). On the other hand, the increase in potassium concentrations at WQSP-6 was abrupt starting with round 19. This suggests that the cause(s) for the observed increase in potassium concentrations between the two up-gradient wells and the one down-gradient well may be different. Since the inception of the WQSP, however, potassium concentrations have been problematic. During the first six rounds, wells showed little variation in potassium concentration, but beginning with round 7 (when TraceAnalysis, Inc. began doing the laboratory work), results for potassium concentrations have been generally higher and more variable. For example, WQSP-3 and WQSP-4 potassium concentrations from rounds 1 through 7 and 1 through 6, respectively, appear to constitute a separate population from the concentrations from rounds 8 through 10 and 7 through 10, respectively, with no overlap of the 95% confidence intervals.

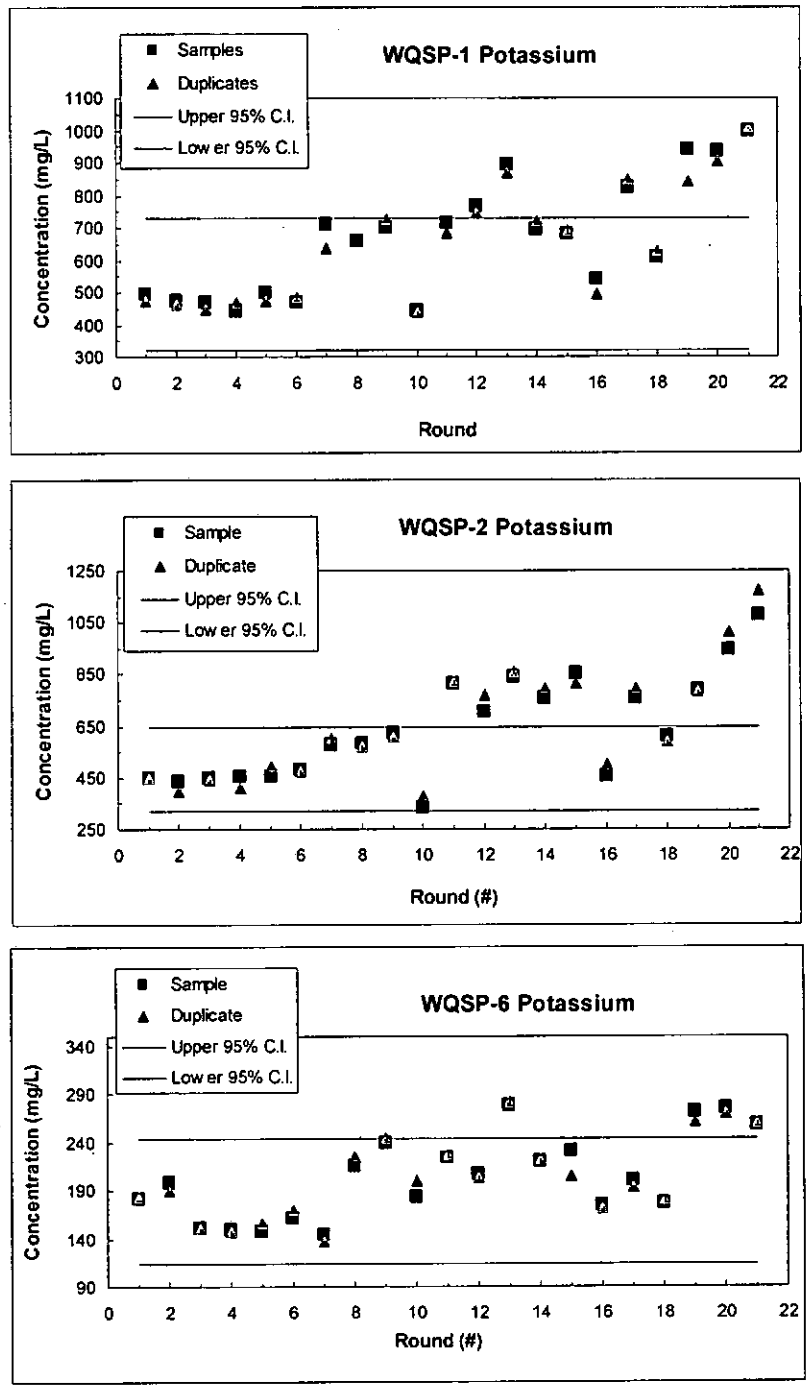

Figure 2.15. WQSP-1, WQSP-2, and WQSP-6 historic and current potassium concentrations.

Charge-balance errors for round 20 ranged from -3.3% to -13.3%, with only WQSP-3 (-3.3%) having a charge-balance error of less than ±5%. In one or two wells, this can partially be explained by comparing the charge-balance error with the number of analyses that returned concentrations that had ≥10% differences between the primary and duplicate samples. For example, WQSP-2 had a charge-balance error of -12.6% and three analyses had results where the difference between the primary and duplicate sample was ≥10% (chloride 19%, sulfate 12%, and magnesium 13%). This may also hold for WQSP-4 (-12.2%), which had two analyses (magnesium 12% and potassium (14%) with a ≥10% difference, but not for WQSP-1 (-7.9%), WQSP-5 (-13.3%), and WQSP-6 (-9.8%), which had none. Relative to round 20, charge-balance errors for round 21 were better (ranging from 3.6% to -5.7%). WQSP-5 (-5.7%) was the only well with a charge-balance error greater than ±5%. Once again, a number of analyses returned concentrations, for a particular ion, with ≥10% differences between the primary and duplicate samples. There appears, however, to be no correlation between the charge-balance error and the percent difference between primary and duplicate, similar to that observed with WQSP-2 in round 20. It is also worth noting that for round 21, both WQSP-1 and WQSP-2 have positive charge-balance errors compared to negative errors during round 20. Both wells experienced a ≥10% change in charge-balance error, which is largely driven by the large increase in sodium concentration observed in these two wells from round 20 to 21. Because sodium is the dominant cation in all the WQSP wells and chloride is the dominant anion, large changes in these two ions will cause similarly large changes in charge-balance errors.

The use of hydrochemical facies plots can provide further insight into the stability of the hydrologic system. Figure 2.13 presents facies plot for all six WQSP Culebra wells. Evaluation of these plots suggests that Culebra water quality has been and is stable. Hydrochemical facies for rounds 20 and 21 plot within the long-term envelopes created by previous sampling rounds. Only WQSP-5 has a significant difference between rounds 20 and 21 and this is due, in large part, to the abrupt decrease in chloride concentrations between the two rounds, which could be attributed to analytical error.

Based on this assessment of the water-quality data collected in 2005 from the WQSP Culebra wells, the SA believes that the reason for the observed variability has more to do with the high total dissolved solids (TDS) in many of the WQSP Culebra wells, which creates problems for the analytical laboratory, and less to do with changes in the Culebra flow regime. This is because analysis of solutes in the concentrated brines of the Culebra (TDS ranges from 15,000 to 200,000 mg/L) is not a routine procedure, and analytical errors are to be expected. In order to better understand this problem, the SA has begun investigating this issue with the help of the M&OC. Beginning with sampling round 23 (fall 2006), splits of samples for major ion analysis from WQSP wells will be sent to another analytical laboratory for comparison with TraceAnalysis, Inc. results. Concomitantly, the SA will evaluate the M&OC's sample collection techniques to determine if any problems exist.

2.3.1.3.2 Dewey Lake

All major ions at WQSP-6a are within the 95% C.I. envelope with the exception of sodium, which has remained below the lower limit for the past 5 rounds (i.e., since round 17; Figure 2.16) and chloride (which was also below the lower limit for rounds 13-17). Charge-balance errors for rounds 20 and 21 were both less than ±5% and only potassium had a difference ≥10% between primary and duplicate samples in round 21. Historically, WQSP-6a shows little variability in any major ion from one round to the next, with the exception of the shift in sodium concentrations between rounds 16 and 17 (Figure 2.16). Based on interpretation of the long-term data and the hydrochemical facies plot (Figure 2.14), water chemistry in WQSP-6a is stable. As mentioned in the previous section, the SA is in the process of evaluating both the sampling techniques and laboratory methods to determine if problems exist.

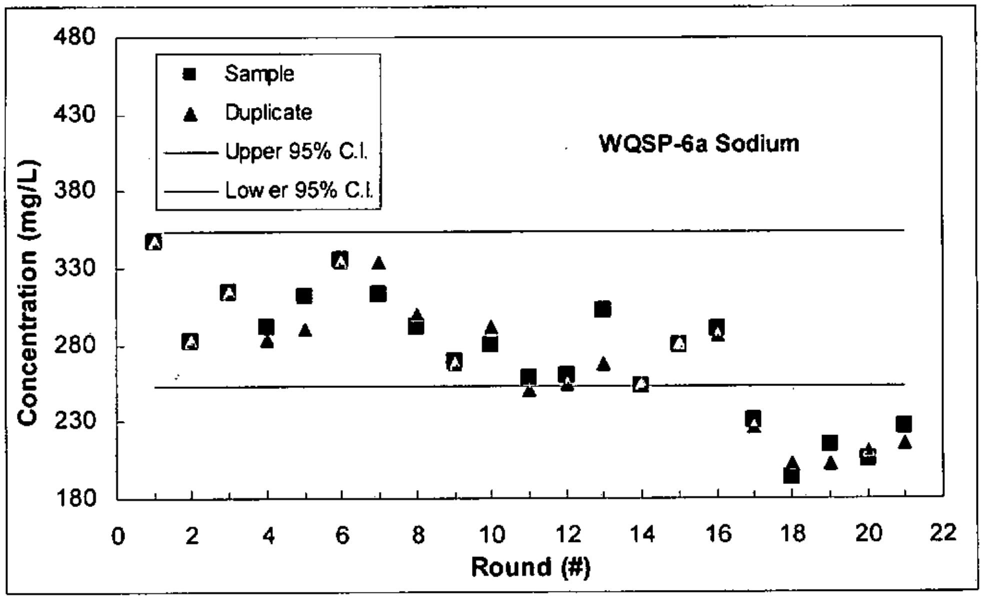

Figure 2.16. WQSP-6a sodium concentrations.

Change in Groundwater Composition - 2006:

Trigger Value Derivation				
COMP Title:	Groundwater Composition			
COMP Units:	mg/L			
Related Monitoring Data				
Monitoring Program	**Monitoring Parameter ID**	**Characteristics (e.g., number, observation)**	**Compliance Baseline Value**	
Groundwater Monitoring	Composition	Semi-annual chemical analysis	RCRA Background Water Quality Baseline	
COMP Derivation Procedure				
Annually evaluate ASER data and compare to previous years and baseline information				
Related Performance and Compliance Elements				
Element Title	**Type & ID**	**Derivation Procedure**	**Compliance Baseline**	**Impact of Change**
Groundwater conceptual model, brine chemistry, actinide solubility	Indirect	Conceptual models	Indirect – The average Culebra brine composition is not used.	Provides validation of the various PA models, potentially significant with respect to flow, transport, and solubility and redox assumptions.
Monitoring Data Trigger Values				
Monitoring Parameter ID	**Trigger Value**	**Basis**		
Change in Culebra groundwater composition	Both duplicate analyses for any major ion falling outside the 95% confidence interval (see Table 2.6) for three consecutive sampling periods	The 95% confidence interval for a particular analyte defines the range of concentrations that 19 out of 20 analyses, on average, should fall within. Therefore, TVs should not be set so that a single analysis falling outside the 95% confidence interval is significant. In addition, analysis of solutes in the concentrated brines of the Culebra is not a routine procedure, and occasional analytical errors are to be expected, particularly when a new laboratory is contracted to perform the analyses (SNL 2002b).		

2.3.2 Changes in Groundwater Flow (Water Level)

Assessment of the COMP "Changes in Groundwater Flow" involves TVs derived from the steady-state freshwater heads estimated for Culebra flow modeling in the CRA (DOE 2004). The Culebra transmissivity (T) fields that were used to simulate the transport of radionuclides through the Culebra were considered calibrated when, among other things, the modeled heads at 37 wells fell within the ranges of uncertainty estimated for steady-state freshwater heads at those wells. If monitoring shows that heads at these wells are outside the ranges used for T-field calibration (hereafter called the "CRA range"), the cause(s) and ramifications of the deviations must be investigated.

2.3.2.1 Water Level Monitoring Program (WLMP)

The Water Level Monitoring Program (WLMP) collects two types of data:

1) the water level, to determine the height of the water column in the well above the midpoint of the unit; and
2) fluid density of the water column.

Using the known ground-surface elevation at a given well, these data are used to calculate freshwater head (FWH), which is the elevation of the column of freshwater (density = 1.0 g/cm^3) that would exert the same pressure at the midpoint of the Culebra as that exerted by the column of fluid actually in the well.

2.3.2.1.1 Fluid Density Survey

In 2000, the M&OC began an annual program of pressure-density (PD) surveys in monitoring wells. In addition to the data collected via the PD survey, specific gravity (SG) is measured on samples collected from the seven WQSP wells (SG is the ratio of the density of the water being measured to that of freshwater and is unitless). In 2005, a total of 50 PD and SG measurements were taken in WIPP wells (DOE 2006c). Eleven were first-time measurements on new or existing wells, while the others updated previous measurements. Measurements were collected from 39 Culebra wells, ten Magenta wells, and one Dewey Lake well.

2.3.2.1.2 Water-Level Monitoring

In 2005, the M&OC made monthly or quarterly water-level measurements in 67 wells. Of these, 46 are completed to the Culebra, 16 to the Magenta, and one to the lower Los Medaños (i.e., Rustler-Salado contact) Members of the Rustler Formation, three to the Bell Canyon Formation, and one to the Dewey Lake Formation. Measurements were taken monthly in 40 Culebra wells and quarterly in six "redundant" Culebra wells located on the H-19 hydropad. During 2005, five Culebra wells were plugged and abandoned (H-7b2, WIPP-12, WIPP-21, WIPP-22, and WIPP-29), five new Culebra wells were drilled (SNL-6, 8, 13, 14, and 15), two Culebra wells that were obstructed through most of 2004 were cleared (H-12 and H-15), and monthly monitoring on the H-7 hydropad switched from H-7b2 to H-7b1 when H-7b2 was plugged and abandoned.

The Dewey Lake, Magenta, Los Medaños, and Bell Canyon are not currently monitored as COMPs and do not have TVs. The water-level measurements in these units do, however, provide information used in the development of the conceptual model of site hydrology.

2.3.2.2 Assessment of Culebra Data

Culebra water levels have been gradually increasing, with a few exceptions, since measurements began in 1977. In general, water levels continued to rise with approximately two-thirds of the wells registering a >0.50-ft increase in water level during 2005. From December 2004 to December 2005, the largest increases in water level were observed in two wells located on the eastern margin of the WIPP region. Smaller but significant increases in water level occurred in the northern portion of the WIPP region (including northern Nash Draw), while most of the decreases in water level occurred in the southern portion of the WIPP region (including southern Nash Draw). At present, most of these changes can be explained as being caused either by anthropogenic activities (i.e., well testing and maintenance activities, oil and gas industry activities, etc.), natural phenomenon (i.e., precipitation), or both.

Over the past few years, the WIPP region has experienced an increase in oil and gas exploration and reopening of some potash mines. The U.S. DOE has also renewed hydrologic testing efforts with respect to the various water-bearing units represented in the WIPP vicinity. In 2005, five new hydrologic wells were drilled to provide geologic and hydrologic data at key locations. These wells were tested to provide new information about hydrologic parameters of the Culebra. Tests included a 22-day pumping test conducted at SNL-14 and six slug tests (two each at SNL-8, 13, and 15). SNL-6 has not been tested as it is still recovering from post-drilling well development. In addition, a 19-day pumping test was conducted at WIPP-11, which was recompleted as a Culebra well in late 2004. Also during 2005, a number of wells were plugged and abandoned or recompleted (Salness 2006), and a number of dual-completion Culebra-Magenta wells were reconfigured to single-completion Magenta wells (see Section 2.3.2.3).

2.3.2.2.1 Assessment of Fluid Density Data

Results from the 2005 PD and SG measurements are compared with previous results (DOE 2005c) in Table 2.7. Of the 28 resurveyed Culebra wells, 12 experienced a significant change in fluid density of $\geq \pm 0.01$ g/cm^3 from previous measurements. In four of these wells (DOE-1, H-6b, H-9c, and H-17) the change was relatively minor (i.e., $< \pm 0.015$ g/cm^3) and in the other eight wells, changes ranged from -0.015 to +0.120 g/cm^3.

Based on the fact that 12 of 28 Culebra wells measured experienced apparent significant changes in fluid density from 2004 to 2005, it might be surmised that the Culebra flow system is changing. The SA, however, does not feel that this is the case. During 2005, the M&OC had difficulty obtaining reproducible PD results due to inconsistencies and inaccuracies in the depth counter mounted on the PD survey reel, thereby making it difficult to calculate an accurate fluid density. Many, if not all, of the observed changes could be a result of this problem. In 2006, the SA is planning on conducting a comparative study by measuring SG in all the wells analyzed as part of the 2006 PD survey in order to resolve this issue.

Table 2.7. Summary of fluid densities in monitored wells.

Well	Date	Unit	Most Recent Density (g/cm^3)	Previous Density (g/cm^3)	Method
AEC-7	12/14/05	Culebra	**1.209**	1.089	PD
C-2737	11/11/05	Culebra	**1.037**	1.001	PD
DOE-1	11/01/05	Culebra	**1.113**	1.099	PD
H-2b2	10/27/05	Culebra	1.010	1.013	PD
H-3b2	11/15/05	Culebra	**1.056**	1.001	PD
H-4b	11/15/05	Culebra	**1.037**	1.011	PD
H-5b	10/24/05	Culebra	1.106	1.099	PD
H-6b	10/04/05	Culebra	**1.054**	1.041	PD
H-7b1	11/01/05	Culebra	**1.009**	1.024	PD
H-9c	12/01/05	Culebra	**1.016**	1.003	PD
H-10c	11/29/05	Culebra	1.016	1.009	PD
H-11b4	11/15/05	Culebra	**1.075**	1.043	PD
H-12	11/28/05	Culebra	1.076	1.083	PD
H-17	11/28/05	Culebra	**1.149**	1.136	PD
H-19b0	11/15/05	Culebra	**1.079**	1.062	PD
IMC-461[a]	10/04/05	Culebra	1.036	-	PD
P-17	11/30/05	Culebra	1.070	1.069	PD
SNL-1[a]	09/29/05	Culebra	1.051	-	PD
SNL-2	10/24/05	Culebra	1.019	1.013	PD
SNL-3	10/24/05	Culebra	1.034	1.027	PD
SNL-5[a]	09/28/05	Culebra	1.019	-	PD
SNL-8[a]	11/29/05	Culebra	1.056	-	PD
SNL-9	09/29/05	Culebra	**1.038**	1.012	PD
SNL-12	12/01/05	Culebra	1.015	1.015	PD
SNL-13[a]	11/17/05	Culebra	1.062	-	PD
SNL-14[a]	11/17/05	Culebra	1.057	-	PD
SNL-15[a]	12/14/05	Culebra	1.230	-	PD
WIPP-11[a]	11/02/05	Culebra	1.043	-	PD
WIPP-13	10/25/05	Culebra	1.048	1.050	PD
WIPP-19	10/25/05	Culebra	1.060	1.060	PD
WIPP-25[a]	11/30/05	Culebra	1.013	-	PD
WIPP-26[a]	11/30/05	Culebra	1.011	-	PD
WIPP-30[a]	11/14/05	Culebra	1.019	-	PD
WQSP-1	04/27/05 & 08/31/05	Culebra	1.048	1.045	SG
WQSP-2	05/11/05 & 09/21/05	Culebra	1.048	1.045	SG
WQSP-3	05/25/05 & 10/06/05	Culebra	1.148	1.143	SG
WQSP-4	03/08/05 & 11/16/05	Culebra	1.070	1.070	SG
WQSP-5	04/06/05 & 11/09/05	Culebra	1.025	1.020	SG
WQSP-6	04/13/06 & 10/26/05	Culebra	1.010	1.010	SG
H-2b1[a]	10/27/05	Magenta	1.021	1.012	PD
H-3b1	10/28/05	Magenta	1.016	1.012	PD
H-4c	10/28/05	Magenta	1.018	1.023	PD
H-6c	10/04/05	Magenta	**1.021**	1.005	PD
H-8a	12/01/05	Magenta	1.045	1.043	PD
H-10a	11/29/05	Magenta	1.009	1.006	PD
H-11b2	11/01/05	Magenta	**1.044**	1.054	PD
H-14	10/27/05	Magenta	1.023	1.028	PD
H-18	11/02/05	Magenta	1.016	1.008	PD
WIPP-18	10/25/05	Magenta	1.013	1.017	PD
WQSP-6a	04/20/05 & 10/19/05	Dewey Lake	1.005	1.003	SG

[a] First time PD or SG measurements on new or existing wells as of 2005.
PD = Pressure Density and SG = Specific Gravity
Bold = Changes in fluid density ≥ ±0.01 g/cm^3 from previous measurements.

The lone exception is the large increase in fluid density (+0.120 g/cm^3) observed in AEC-7. AEC-7 is the oldest groundwater monitoring well; drilled in 1974, deepened in 1979, and reconfigured to a single-completion Culebra well in early 2004 (by cementing the borehole to ~100 ft below the lower perforations in the Culebra). Since that time, the water level has been rising at a rate of 7-8 ft per month (Figure 2.17). In late 2005, based on downhole video logging and the results of the PD survey, which showed a fluid-density increase from 1.089 to 1.201 g/cm^3, it was determined that brine (1.2 g/cm^3 is near the density of halite-saturated brine) from deeper hydrologic units (Salado and/or Castile) was infiltrating the wellbore due to poor cementing during the plug-back activities. AEC-7 is slated for repair or plugging and abandonment in 2007.

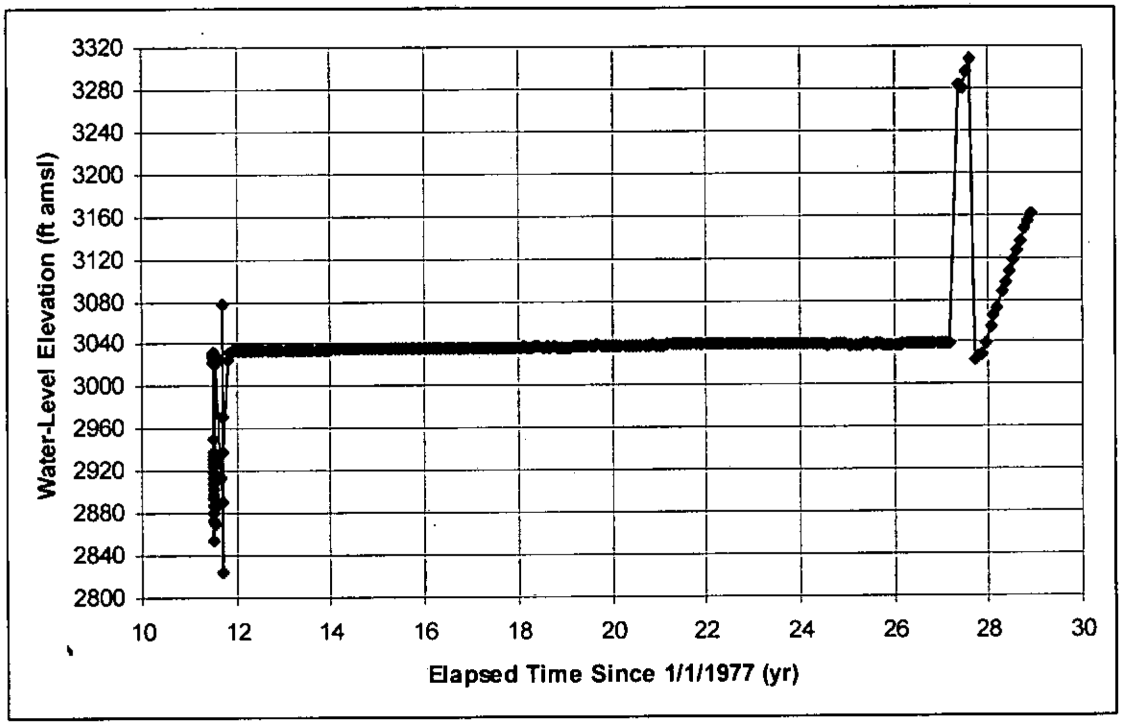

Figure 2.17. AEC-7 hydrograph.

2.3.2.2.2 Assessment of Culebra Water-Level Data

A comparison of Culebra water levels, in feet above mean sea level (ft amsl), from December 2004 to December 2005 is presented in Table 2.8. Water-level changes in the 46 Culebra wells ranged from -3.55 ft to +122.42 ft, with half of the wells experiencing water-level changes of ≥ ±2 ft. Water level rose in 30 of the 46 wells, fell in nine, and remained approximately the same (i.e., ±0.50 ft or less) in seven.

Table 2.8. Summary of 2005 Culebra water-level changes and freshwater heads.

Well I.D.	12/04 W.L. (ft AMSL)	12/05 W.L. (ft AMSL)	2005 Change (ft)	12/05 FWH (ft AMSL)	CRA FWH Range (ft AMSL)	Outside CRA Range?
AEC-7	3039.54	3161.97	**122.42**	3195.68	3057.1-3066.2	Y
C-2737	3009.95	3008.23	-1.72	3010.73	N/A	N/A
DOE-1	2986.45	2989.01	**2.56**	3025.10	3001.8-3012.3	Y
ERDA-9	3009.87	3008.84	-1.03	3029.98	3018.6-3028.6	Y
H-2b2	3038.35	3042.23	**3.88**	3046.11	3036.8-3043.4	Y
H-3b2	3000.07	2996.87	**-3.20**	3007.55	3004.2-3013.9	N
H-4b	3002.79	3002.80	0.01	3004.70	3000.2-3007.3	N
H-5b	3029.66	3036.26	**6.60**	3079.76	3065.5-3077.9	Y
H-6b	3053.98	3058.28	**4.30**	3071.65	3059.9-3070.0	Y
H-7b1	3000.45	3001.00	0.55	3001.19	2996.4-3001.0	Y
H-9c	2996.00	2996.80	0.80	2998.06	2987.7-2993.8*	Y
H-10c	3025.20	3033.51	**8.31**	3040.00	N/A	N/A
H-11b4	2986.13	2984.45	-1.68	3004.23	2998.6-3008.5	N
H-12	2967.64[b]	2968.54	0.90	3000.00	2993.3-3008.4	N
H-15	2990.13[c]	2986.58	**-3.55**	3023.15	3012.5-3023.4	N
H-17	2964.88	2963.21	-1.67	3003.71	2999.8-3006.6	N
H-19b0	2991.17	2988.04	**-3.13**	3009.69	3005.5-3012.4	N
IMC-461	3050.18	3051.83	1.65	3052.38	N/A	N/A
P-17	2985.99	2988.21	**2.22**	3003.59	2998.6-3006.7	N
SNL-1	3074.19	3078.02	**3.83**	3083.01	N/A	N/A
SNL-2	3069.89	3073.61	**3.72**	3075.82	N/A	N/A
SNL-3	3067.11	3070.74	**3.63**	3082.90	N/A	N/A
SNL-5	3070.82	3074.40	**3.58**	3076.46	N/A	N/A
SNL-6	No DTW taken due to water level >1000 ft BTOC, well completed 09/05					
SNL-8	N/A	3029.20[d]	N/A	3053.98	N/A	N/A
SNL-9	3049.39	3051.02	1.63	3056.62	N/A	N/A
SNL-12	3001.53	3001.52	-0.01	3002.44	N/A	N/A
SNL-13	3007.25[e]	3007.16	-0.09	3013.40	N/A	N/A
SNL-14	2989.88[f]	2990.84	0.96	3008.74	N/A	N/A
SNL-15	No DTW measurements taken in 2005 due to SNL testing, well completed 07/05					
WIPP-11	3064.36[g]	3066.25	1.89	3085.08	N/A	N/A
WIPP-12	3032.29	3033.66[h]	1.37	3074.84	3059.1-3070.4	Y
WIPP-13	3056.84	3060.66	**3.82**	3079.05	3062.7-3073.6	Y
WIPP-19	3040.58	3042.56	1.98	3065.18	3054.3-3065.5	N
WIPP-21	3017.15	3016.71[i]	-0.44	3040.90	3036.1-3046.6	N
WIPP-22	3031.14	3030.37[j]	-0.77	3061.46	3048.9-3059.8	Y
WIPP-25	3063.58	3068.40	**4.82**	3075.34	3055.2-3064.9	Y
WIPP-26	3025.89[k]	3025.45	-0.44	3026.80	3020.0-3024.3	Y
WIPP-27	3085.44	3087.92[l]	**2.48**	3096.55	3083.4-3091.2	Y
WIPP-29	2967.97	2967.81[m]	-0.16	2971.11	2967.8-2972.5	N
WIPP-30	3071.46	3079.02	**7.56**	3086.37	3069.1-3078.4	Y
WQSP-1	3054.88	3058.76	**3.88**	3072.87	3067.0-3072.4	Y
WQSP-2	3060.07	3063.93	**3.86**	3080.91	3077.2-3083.0	N
WQSP-3	3012.05	3014.56	**2.51**	3069.73	3067.4-3073.6	N
WQSP-4	2988.47	2985.47	**-3.00**	3005.31	3007.8-3012.4	Y
WQSP-5	3003.95	3000.70	**-3.25**	3006.30	3006.3-3012.2	N
WQSP-6	3017.65	3017.91	0.26	3020.42	3016.2-3020.7	N

All measurements made in December, except as noted
[a] Last measurement taken 04/05, well plugged and abandoned 05/05; H-7b1 new primary well
[b] Water-level elevation on 05/05 after obstruction was removed
[c] Water-level elevation on 02/05 after well reconfigured to dual (Culebra-Magenta) completion
[d] First measurements taken 12/05, well completed 08/05
[e] First measurements taken06/05, well completed 04/05
[f] First measurements taken 06/05, well completed 05/05
[g] Well perforated 09/04, no M&OC measurements until 06/05 due to SNL testing
[h] Last measurement taken 06/05, well plugged and abandoned 07/05
[i] Last measurement taken 05/05, well plugged and abandoned 05/05

[j] Last measurement taken 05/05, well plugged and abandoned 05/05
[k] Measurement taken 03/05, not monitored from 10/04 to 02/05 due to poor road condition
[l] Measurements taken 11/05, well no longer monitored due to poor road condition
[m] Last measurement taken 04/05, well plugged and abandoned 05/05
N/A = not applicable; data from well not used in CRA T-field calibration or data unavailable
* Range established for H-9b

The WIPP-11 pumping test was conducted from February 1-20, 2005. Wells that showed drawdown responses to the pumping included: H-6b, SNL-1, SNL-3, SNL-5, WIPP-12, WIPP-13, WIPP-19, WIPP-30, WQSP-1, WQSP-2, and WQSP-3. All of these wells, with the exception of WIPP-30, experienced net water-level increases ranging from 1.89 to 4.30 ft during 2005, most of which occurred after the end of the WIPP-11 pumping test. WIPP-30 experienced a water-level increase of 7.56 ft between December 2004 and December 2005. Water levels were not collected in the first half of 2005 (i.e., January to June) due to well testing conducted by the SA. Most of the year's increase (4.16 ft) occurred between the December 2004 and July 2005 measurements, but the July measurement was the first one conducted after the PIP separating the Culebra and Magenta in the well was reset. Setting water-inflatable PIPs invariably causes fluid-density changes in a well, so much of the difference between the December 2004 and July 2005 measurements may be attributable to a change in fluid density. Between July and December, the water level rose 3.40 ft, which is comparable to the increases observed in other wells affected by the WIPP-11 pumping test.

The SNL-14 pumping test was conducted from August 4-26, 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-12, SNL-13, WQSP-4, WQSP-5, WQSP-6, and possibly H-7b1. Between December 2004 and December 2005, many of these wells recorded little overall change in water level. By December 2005, most of the wells closest to SNL-14 and wells to the south of SNL-14 had recovered or were near full recovery from the SNL-14 test. Wells farther away and to the north of SNL-14, such as H-19b0 and the WQSP wells, were clearly still recovering. In addition, drawdown occurred in the WQSP wells, and those nearby, due to water quality sampling that was done in late 2005 (see Section 2.3.1.1).

Prior to the SNL-14 pumping test, water levels in all of the wells that responded to that test had increased on the order of 1.0 to 1.5 ft between December 2004 and July 2005. Two exceptions to this are DOE-1 and P-17, both of which experienced water-level increases of ~5 ft. DOE-1 was continuing an anomalous rising trend of approximately 7.5 ft/yr that started in 2003 (Figure 2.18). The SA believes that the Culebra perforations in DOE-1 are partially plugged, and that high Salado-Castile pressures are leaking around the bridge plug set in the casing below the perforations, causing the water level to rise. Given its proximity to WQSP-4, DOE-1 is not considered to be an essential well in the Culebra monitoring network, and is scheduled for plugging and abandonment in the summer of 2006. The rise in water level at P-17 was caused by the addition of freshwater to the well (decreasing the fluid density of the water column) while scraping the well casing and attempting to bail sediment and debris partially covering the Culebra perforations. The well casing was found to be in such poor condition that P-17 is now scheduled for plugging and abandonment in the summer of 2006.

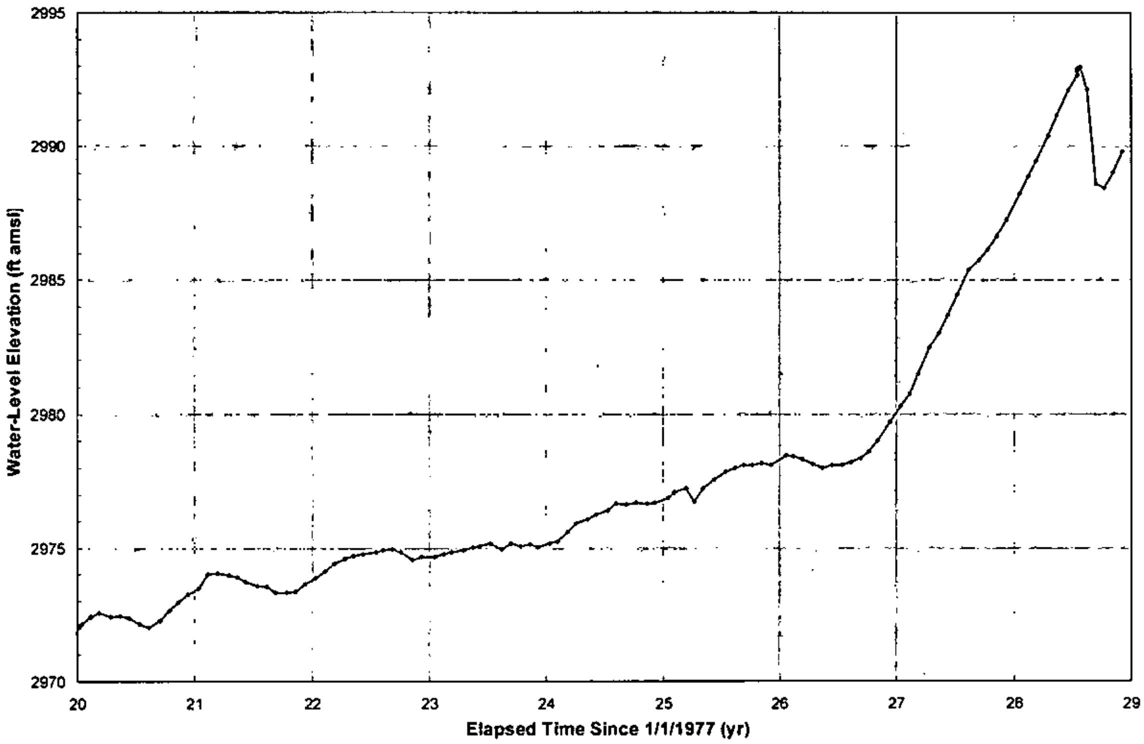

Figure 2.18. DOE-1 hydrograph.

After plugging and abandonment and reconfiguration activities conducted by the M&OC during summer 2005, two wells experienced shifts in baseline water level, though neither well was the focus of these activities. H-2b2 and H-5b experienced 4.10 ft and 6.67 ft increases, respectively, after wells on the same hydropad were plugged and abandoned or plugged back to be single-completion Magenta wells. The causes of these shifts are, as yet, unknown, but water levels are not returning to previous levels. This suggests 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 the SA.

In 2002, H-10c was recompleted as a single-completion Culebra well. Since that time, the general trend has been one of decreasing water level (Figure 2.19). In late 2003, this trend was interrupted by a sudden increase in water level of ~4 ft followed by a gradual return to baseline conditions. In late 2004, a much smaller spike (~1 ft) was observed, again followed by a decrease to baseline conditions. Again in late 2005, a spike (3 ft increase) was observed followed by an even larger spike (8.5 ft) in December 2005. When the December 2005 water-level measurement was taken, an oil and gas drill rig was set up ~500 ft away from the H-10 hydropad. The standard practice for oil drilling in the Delaware Basin is to drill with fluid at all times and to drill the well to the top of the Salado (typically taking ~4 days) before setting casing. The December 2005 spike was most likely caused by loss of drilling fluid into the Culebra while the well was being drilled. The three other water-level spikes described above all correlate with other nearby oil wells being drilled.

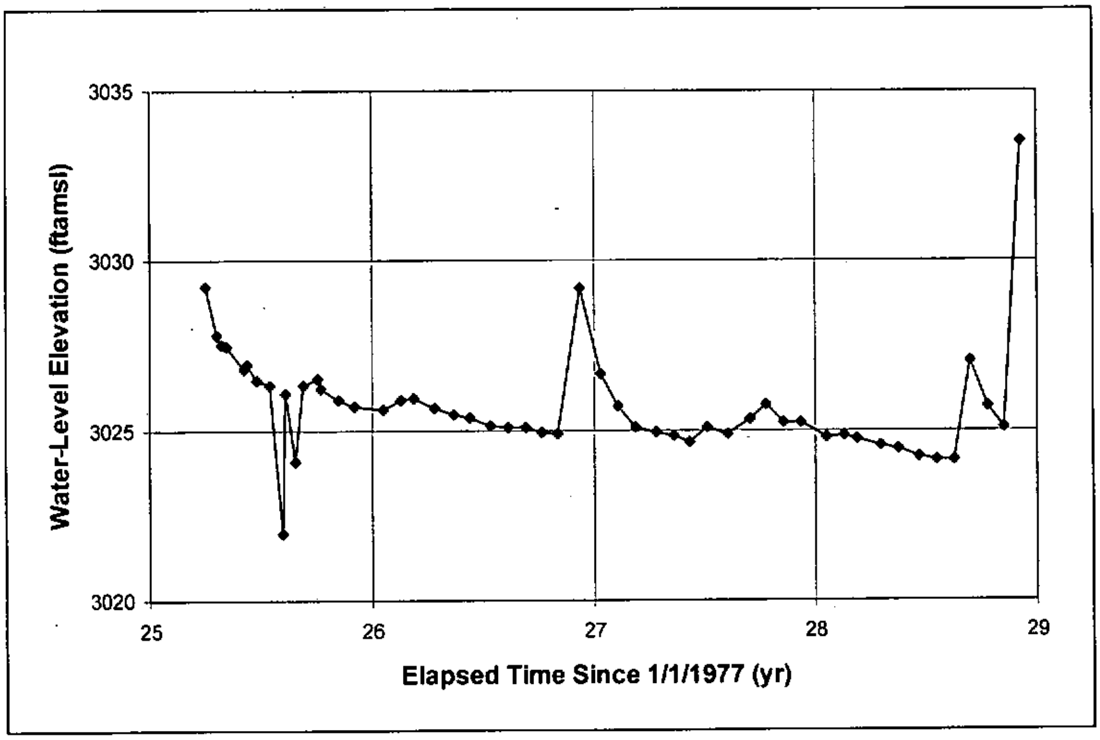

Figure 2.19. H-10c hydrograph.

The 2004 COMPs assessment (SNL 2005) reported that four of the Nash Draw wells (WIPP-25, WIPP-26, WIPP-27, and H-7b2) experienced water-level increases ranging from 2.57 to 5.06 ft, most of which occurred between October and December 2004. These increases continued until they peaked in early 2005. This was followed by steadily decreasing water levels in all four wells until summer 2005, when the water levels in the northern Nash Draw wells (WIPP-25 and WIPP-27) began rising again. The water level in WIPP-25 rose 2.86 ft between July and December 2005, and that in WIPP-27 rose 1.94 ft during the same interval. After the early 2005 peak, water levels in southern Nash Draw wells H-7b1, which replaced H-7b2, and WIPP-26 decreased 0.27 and 0.45 ft, respectively, by December. Recent work by the SA suggests that the cause of this rise in Culebra water levels can be linked to a large rainfall event (~6 inches of rainfall over a four-day period) in September 2004, which caused large-scale flooding in and around Nash Draw (Hillesheim et al. 2006; Powers et al. 2006). The SA now speculates that certain areas within Nash Draw may be acting as local recharge zones to the Culebra. Further investigations are being undertaken by the SA to confirm this speculation.

2.3.2.2.3 Assessment of FWH Data

A comparison of December 2005 FWH to the CRA ranges for the 32 remaining wells used in the generation of the CRA T fields is presented in Table 2.8. FWH for each well was calculated using fluid densities reported in DOE (2005b). FWH in 16 of the 32 wells are now outside the upper limit of the CRA ranges. As discussed above, the FWH in AEC-7 and DOE-1 are not considered representative of the actual Culebra heads at those locations. The high FWH in the other 14 wells reflect the general water-level rise discussed earlier. The FWH in WQSP-4 was lower than the CRA range at the end of 2005 because it was still recovering from the SNL-14 pumping test. We reiterate that Culebra heads in excess of the respective CRA ranges are not likely to affect WIPP's compliance with EPA regulations. Nevertheless, the cause(s) of the change needs to be understood to provide confidence in our conceptual understanding of the Culebra. In 2000, the SA began an investigation of possible causes of the high heads (Powers 2001). This was followed up in 2002 with the SA formalizing an integrated hydrology program plan that outlines the path forward with respect to this investigation (SNL 2003). In addition, the Strategic Plan for Groundwater Monitoring at the Waste Isolation Pilot Plant (DOE 2003) provides the authorization for the groundwater activities that need to be conducted as part of the integrated hydrology program plan. The integrated hydrology program plan further details the completion of a number of strategically placed new Culebra wells as well as several wells replacing Culebra wells that have been lost to deterioration. The new wells have been sited in order to investigate possible sources of the rising Culebra heads as well as to fill gaps in existing Culebra information.

2.3.2.2.4 Summary of Culebra Data

Based on the assessment of Culebra water-level and density data collected during 2005, the SA concludes 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 (SNL-series) have been completed since 2003 with five additional wells to be completed in 2006. The SA 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 (Hillesheim et al. 2006; Powers et al. 2006), with the results being incorporated into a new conceptual model of the Culebra that will form the basis for a new generation of T-fields that will be used as part of PA for the next CRA.

2.3.2.3 Assessment of Data from Other Units

Results from the 2005 PD and SG measurements are compared with previous results (DOE 2005c) in Table 2.9. Of the 10 Magenta wells with repeated PD surveys, only two experienced changes of $\geq \pm 0.01$ g/cm^3 in fluid density from previous measurements. In the case of H-11b2, this change was minor (-0.010 g/cm^3), and is probably related to the bailing on August 16, 2005, of the water left in the hole after cementing the Culebra interval. The fluid density in H-6c changed by +0.016 g/cm^3, and this change was also probably related to plug-back operations.

Assessment of water-level changes from other hydrologic units present in the WIPP vicinity (Table 2.9) is important for refining the conceptual model of site hydrology. Water-level measurements for the Magenta Member of the Rustler Formation provide information about confinement of and connectivity to the underlying Culebra Member. In general, water levels rose in the Magenta during 2005, continuing the long-term trend. Superimposed upon this long-term trend are variations that suggested possible problems with some of the wells. Many of the older WIPP wells were originally completed to more than one water-bearing zone. Packers and bridge plugs were placed to isolate the various zones, and water levels were taken in tubing attached to the packers. Due to the age (in most cases 20+ years) of the packers and bridge plugs, failures were becoming more and more common. Instead of replacing the packers and bridge plugs on a continuing basis, the wells were reconfigured to single-completion Magenta wells. During the summer of 2005, this goal was accomplished by removing the packers and bridge plugs from nine wells (H-2b1, H-3b1, H-4c, H-5c, H-6c, H-11b2, H-14, H-18, and WIPP-18; Salness 2006) and cementing the wells from the bottom to a level ~20-30 ft below the Magenta perforations. After cementing, the wells were left with artificially high water levels, which decreased over several months as the water seeped into the Magenta, until the wells were bailed down to draw water out of the Magenta. After being bailed, water levels in three of the nine wells (H-3b1, H-6c, and H-18) returned to approximately pre-reconfiguration levels, water levels in three other wells (H-4c, H-11b2, and WIPP-18) recovered to levels ~4 ft higher than historic measurements, H-2b1 and H-14 are still recovering, and H-5c did not recover at all, remaining ~348 ft below pre-reconfiguration levels. In the case of H-4c, the Magenta water level rose steadily from 1986 until late 2002, when it abruptly started an anomalous decline. Since plugback operations, the water level seems to be moving back in line with the 1986-2002 rise, suggesting that the bridge plug that had been in the well was leaking. The changes in water levels in H-11b2 and WIPP-18 appear to be related to changes (decreases) in fluid density in the wells since the wells were bailed in late 2005. The reason H-5c did not recover was found to be that too much cement had been placed in the well when cementing the lower Culebra interval, inadvertently plugging the Magenta interval as well.

WIPP-25 and WIPP-30 are both dual-completion (Culebra-Magenta) wells. Both experienced water-level increases ≥2 ft in the Magenta during 2005 (Table 2.9). The rise at WIPP-25 is probably related to what caused the similar increase observed in the Culebra (see Section 2.3.2.2). The cause of the water-level increase at WIPP-30 is under investigation.

Water levels were stable within 0.50 ft in both the Dewey Lake well (WQSP-6a) and in the lower Los Medaños well (H-8c) (Table 2.9). In September 2005, H-3d was converted to a piezometer to measure water levels at the Santa Rosa-Dewey Lake contact.

Table 2.9. Summary of 2005 water-level changes in units other than the Culebra.

Well I.D.	12/04 W.L. (ft AMSL)	12/05 W.L. (ft AMSL)	2005 Change (ft)
Magenta Wells			
C-2737	3143.15	3143.72	0.57
H-2b1	3143.76	3074.81	**-68.95**
H-3b1	3145.19	3146.27	1.08
H-4c	3141.34	3146.25	**4.91**
H-5c	3156.68	2808.06	**-348.62**
H-6c	3067.09	3067.39	0.30
H-8a	3027.31	3027.06	-0.25
H-9c	3135.51	3135.93	0.42
H-10a	3222.02	3223.33	1.31
H-11b2	3133.24	3138.07	**4.83**
H-14	3110.60	3089.67	**-20.93**
H-15	3123.99[a]	3124.21[b]	0.22
H-18	3075.31	3074.90[c]	-0.41
WIPP-18	3144.56	3148.56	**4.00**
WIPP-25	3061.53	3063.97	**2.44**
WIPP-30	3075.75[d]	3078.34	**3.59**
Dewey Lake Wells			
H-3d	Well obstructed since 02/02, converted to Santa Rosa/Dewey Lake piezometer 09/05		
WQSP-6a	3197.09	3196.73	-0.36
Los Medaños Well			
H-8c	2981.18	2981.61[e]	0.43
Bell Canyon Wells			
AEC-8	3067.82	3070.90[f]	**3.08**
CB-1	2725.86	2727.05	1.19
DOE-2	2675.45	2683.62	**8.17**

All measurements made in December, except as noted
[a] June 2005, after well recompleted as dual (Culebra-Magenta) completion
[b] November 2005, no measurements after this date due to SA testing activities
[c] April 2005, prior to plugback as single-completion Magenta well, no further 2005 measurements due to broken cattle guard making the pad inaccessible.
[d] July 2005, after recompleted as dual (Culebra-Magenta) completion
[e] Last measurement taken 09/05, well transferred to Bureau of Land Management 09/05
[f] Last measurement taken 02/05, well plugged and abandoned 04/05
N/A = not available

Reversing its 2004 trend (a decrease of -2.45 ft), the Bell Canyon water level in CB-1 rose ~1 ft in 2005. The water level in DOE-2 continued to increase, rising 8.17 ft in addition to the 10.31-ft increase observed during 2004. DOE-2 appears to still be recovering from reconfiguration activities conducted in June 2004. The Bell Canyon water level in DOE-2 in December 2005 was ~350 ft lower than the last measurement made in March 1986, before the well was recompleted to the Culebra. No PD survey has yet been performed, however, to allow us to compare the density of the fluid currently in the well to the density measured in 1985 (SG = 1.1; Beauheim 1986).

Changes in Groundwater Flow - 2006:

Trigger Value Derivation

COMP Title:	Changes in Groundwater Flow
COMP Units:	Inferred from water-level data

Related Monitoring Data

Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value
Groundwater Monitoring	Head and Topography	Monthly water-level measurements; annual pressure-density surveys.	Indirect

COMP Derivation Procedure

Annual assessment from ASER data.

Related PA Elements

Element Title	Type & ID	Derivation Procedure	Compliance Baseline	Impact of Change
Groundwater conceptual model, Transmissivity fields	NA	NA	NA	Provides validation of the various CCA/CRA models - T-field assumptions and groundwater basin model.

Monitoring Data Trigger Values

Monitoring Parameter ID	Trigger Value	Basis
Change in Culebra Groundwater Flow	CRA range; see Table 2.8	Annual comparisons with ranges of undisturbed steady-state freshwater heads used to calibrate Culebra T fields for CRA.

2.4 Waste Activity

For this reporting period, waste emplacement was completed in Panel 2 and continues in Panel 3. Panel 1 was closed prior to this reporting period.

Radionuclide inventory information is contained in Table 2.10. A comparison of the tracked actinides and the total repository inventory used in the PABC is detailed in Table 2.11. No other activity-related assessment has been made at this time.

As discussed in the Trigger Value Derivation Report, Waste Activity COMPs assessments are not performed until half the panel is filled since small quantities do not yield statistically valid assessments. There are no TVs for CH activity, only RH. There are no recognized reportable issues associated with this COMP. No changes to the monitoring program are recommended at this time. A detailed waste inventory assessment has been provided in the CRA-2004.

Table 2.10. Radionuclide inventory information.

Radionuclide	Panel 1	Panel 2	Panel 3	Cumulative Activity (Ci)
^{241}Am	1.20×10^{5}	3.18×10^{4}	1.86×10^{4}	1.71×10^{5}
^{137}Cs	5.09×10^{-4}	1.27	1.31×10^{-1}	1.40
^{238}Pu	6.19×10^{3}	1.46×10^{4}	3.22×10^{4}	5.29×10^{4}
^{239}Pu	1.52×10^{5}	8.21×10^{4}	1.77×10^{4}	2.52×10^{5}
^{240}Pu	3.43×10^{4}	2.12×10^{4}	5.01×10^{3}	6.05×10^{4}
^{242}Pu	3.32	4.19	1.12	8.63
^{90}Sr	3.81×10^{-5}	1.44	1.2×10^{-1}	1.56
^{233}U	4.14×10^{-1}	2.27×10^{-1}	1.21	1.85
^{234}U	1.57	4.59	3.53	9.69
^{238}U	7.54	2.31	3.000^{-1}	10.20
Total	3.12×10^{5}	1.50×10^{5}	7.36×10^{4}	5.36×10^{5}

Table 2.11. Comparison of tracked radionuclide inventory to the PABC Inventory (from Leigh et al. 2005a and DOE 2006d).

Radionuclide CCA Table 4-10)	Non-Decayed Inventory as of June 30, 06	PABC Total Inventory at Closure	Percentage of PABC Inventory
^{241}Am	1.71×10^{5}	5.17×10^{5}	33%
^{238}Pu	5.29×10^{4}	1.13×10^{6}	5%
^{239}Pu	2.52×10^{5}	5.82×10^{5}	43%
^{240}Pu	6.05×10^{4}	9.54×10^{4}	63%
^{242}Pu	8.63	1.27×10^{1}	68%
^{233}U	1.85	1.23×10^{3}	<1%
^{234}U	9.69	3.44×10^{2}	3%
^{238}U	10.20	2.17×10^{2}	5%
^{90}Sr	1.56	1.76×10^{5}	< 1%
^{137}Cs	1.40	2.07×10^{5}	< 1%

Waste Activity - 2006:

Trigger Value Derivation			
COMP Title:	Waste Activity		
COMP Units:	Curies		
Related Monitoring Data			
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value
WWIS, BIR	Radionuclide activity per container and volume	Curies per container. Container volume.	TRU Waste Inventory for the 2004 Compliance Recertification Application Performance Assessment Baseline Calculation (Leigh et al. 2005a)
COMP Derivation Procedure - Reporting Period 9/1/2005 to 8/31/2006			
Tabulation of waste activity in each panel. Total curie content of emplaced CH-TRU and RH-TRU waste. *[Total radionuclide inventories reported by WWIS]*			
Year 2006 COMP Assessment Value			
A comparison of emplaced and PA waste parameters is found in Table 2.11. No RH has been emplaced.			

Element Title	**Type and ID**	**Derivation Procedure**	**Compliance Baseline**	**Impact of Change**
Radionuclide inventories	Parameter	Product of waste stream content and volume scaled up to the Land Withdrawal Act limits. (U.S. Congress 1992)	Table 14 in Leigh et al.	May affect direct brine releases for those radionuclides that become inventory-limited during a PA simulation.
Activity of waste intersected for cuttings and cavings releases.	Parameter	Function of waste stream volumes and activities	Figure 6-30 of the CRA-2004	Cuttings are a significant contributor to releases. An increase in activity of intersected waste is potentially significant.
WIPP-scale average activity for spallings releases	Parameter	Average of all CH-TRU waste only.	NA	Spallings are a significant contributor to releases. An increase in average activity of intersected waste is potentially significant.

Monitoring Data Trigger Values		
Monitoring Parameter ID	**Trigger Value**	**Basis**
Waste emplacement records	Panel half-full	Check that PA assumptions about waste activity will remain valid as remainder of panel is filled and verify random emplacement assumptions.
Total emplaced RH-TRU waste activity	5.1 million curies	LWA emplacement limit reached. Administrative controls address these limits.

3 COMPs Assessment Conclusion

The operational period monitoring program designed to meet the Assurance Requirements of 40 CFR 191.14 and the terms of WIPP certification was initiated in 1999. This monitoring program is useful to further validate the assumptions and conceptual models that were used to predict WIPP performance and identify conditions that could potentially cause radioactive release above the limits established in 40 CFR § 191.13. Since releases above these limits cannot occur during the operational period of WIPP, the monitoring program looks at other potential performance indicators of the disposal system and compares these data to PA performance expectations. Specifically, ten monitoring parameters are assessed and compared to PA expectations and assumptions. The CRA-2004 (DOE 2004) and later the PABC (Leigh et al. 2005b) contain the results of updated PAs presented to EPA. The PABC was used in EPA's certification decision and became the new compliance baseline PA. The results of this year's COMP assessment using the new baseline are documented in this report and conclude that there are no COMPs data or results that indicate a reportable event or condition adverse to predicted performance. In instances where TVs have been exceeded, further investigations or activities will be pursued as described in previous sections. The operational period monitoring program will continue to seek to identify conditions that could indicate deviations from the expected disposal system performance.

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⊞ PA_Send_Mgr_Reviewer (06711)

⊞ PA_Sending_Mgmt (06711)

⊟ Paper_Signature_Authority (06711)

delegated to	start date
KESSEL,DAVID S. (06710)	09/28/2006
RIGALI,MARK J. (06712)	09/28/2006

⊞ PCI_Approver (06711)

⊞ PHN_Manager (06711)

⊞ RA_Center_Approver (06711)

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