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Sandia National Laboratories Compliance Monitoring Parameter Assessment For 2007

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Compliance Monitoring
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Executive Summary

This document reports the eighth annual (2007) derivation and assessment of the Waste Isolation Pilot Plant (WIPP) Compliance Monitoring Parameters (COMPs). The COMPs program is designed to meet certain requirements 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 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 exceedances of identified values indicate a condition that is potentially outside PA expectations. These values were appropriately termed "trigger values." Deriving COMPs trigger values (TVs) 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 second 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). The PABC therefore, represents the current compliance baseline. This year's COMPs assessment compares the parameters against the original certification baseline and the revised PABC baseline where appropriate. Reference to the appropriate baseline will be highlighted in this report.

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 that was originally scheduled in 2007.

[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.

However, the change request containing the revised COMPs was rescheduled until after the second recertification.
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 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 2005).

This document reports these results and the recommendations based on the 2007 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 2005) describes the overall monitoring program and responsibilities for COMPs derivation and assessment. This report documents the results of the reporting year 2007 COMPs assessment (July 1st 2006 to June 30th 2007). The reporting period has changed to match the reporting period of the 194.4(b)(4) report (EPA 2003). Now that the recertification baseline is complete, a new analysis similar to that performed to comply with 40 CFR § 194.42 is ongoing and will be used to determine if new parameters should be monitored or if other changes should be made to the COMP program (Wagner 2005). Should changes be identified, EPA approval will be necessary to modify the monitoring program prior to modifying the COMPs program. As such, this COMPs assessment follows the program developed under 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 necessarily 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, analysis and results in the DOE's documentation of continued compliance as submitted in periodic CRAs.

Monitoring data, the associated parameter values and monitoring information must be reported even if the assessment concludes there is no impact on the repository. The monitoring data will be compiled and provided to the DOE to fulfill DOE's monitoring reporting requirements to the EPA. The SA's role in the reporting task is to use the monitoring data to derive the COMPs, compare the results to repository performance expectations in PA 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 2007 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 2007a, 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 2007. 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 2007a).

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 probability range of 0.01 to 0.60. The new range did not significantly 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 - 2007:

<table>
<tr><td colspan="5">Trigger Value Derivation</td></tr>
<tr><td>COMP Title:</td><td colspan="4">Probability of Encountering a Castile Brine Reservoir</td></tr>
<tr><td>COMP Units:</td><td colspan="4">Unitless</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>DBMP[(1)]</td><td>NA</td><td>Driller's survey – Field observations</td><td colspan="2">0.01 to .60</td></tr>
<tr><td colspan="5">COMP Derivation Procedure</td></tr>
<tr><td colspan="5">Analysis of encounters of pressurized brine recorded and reported by industry in the 9-township area centered on WIPP.</td></tr>
<tr><td colspan="5">Year 2007 COMP Assessment Value - Reporting Period September 2006 to August 2007</td></tr>
<tr><td colspan="5">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</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>Probability of Encountering Brine</td><td>Parameter PRBRINE</td><td>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.</td><td>0.08

0.01 to 0.60</td><td>Not a sensitive parameter.</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>Probability of Encountering a Castile Brine Reservoir</td><td>None</td><td colspan="3">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.</td></tr>
</table>

(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 1996 to June 2007) increases the rate to 58.5 boreholes per square kilometer per 10,000 years (DOE 2007a).

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
2007	13,448	58.5

As shown in Table 2.2, the drilling rate has risen from 46.8 holes per square kilometer to 58.5 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.

When the TV report was written, it was thought that the drilling rate used in PA would not be changed for each recertification. However, each recertification updates the drilling rate parameter and effectively accounts for the change in rate. Because the change in the drilling rate is accounted for every five years, the concept of applying a TV is unnecessary. 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 point in 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). 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 - 2007:

<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 2007 COMP Assessment Value - Reporting Period September 1, 2006 to August 31, 2007</td></tr>
<tr><td colspan="5">(13,448 boreholes on record for the Delaware Basin) Drilling Rate = 58.5 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</td><td>NA.</td><td colspan="3">Calculations have shown that doubling the drilling rate does not impact compliance with the EPA release limits (Kanney and Kirchner 2004).</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 2007b) and the annual Subsidence Monument Leveling Survey (DOE 2006a). 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 2007b) summarizes data collected from July 2005 through June 2006.

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 2006a) summarizes data collected between September and December of 2006.

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 2006. For this reporting period, Panels 1 through 4 had been fully excavated. Figure 2.1 shows all areas mined as of June 30, 2006. At that time, Panels 1 and 2 waste disposal operations had ceased and the entry drifts had been sealed to prevent access (please note that the reporting period for geotechnical information is through June 2006 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, which is through June 2007; at that time, Panel 2 had been filled and waste had been emplaced in most of Panel 3 and in Rooms 6 and 7 of Panel 4).

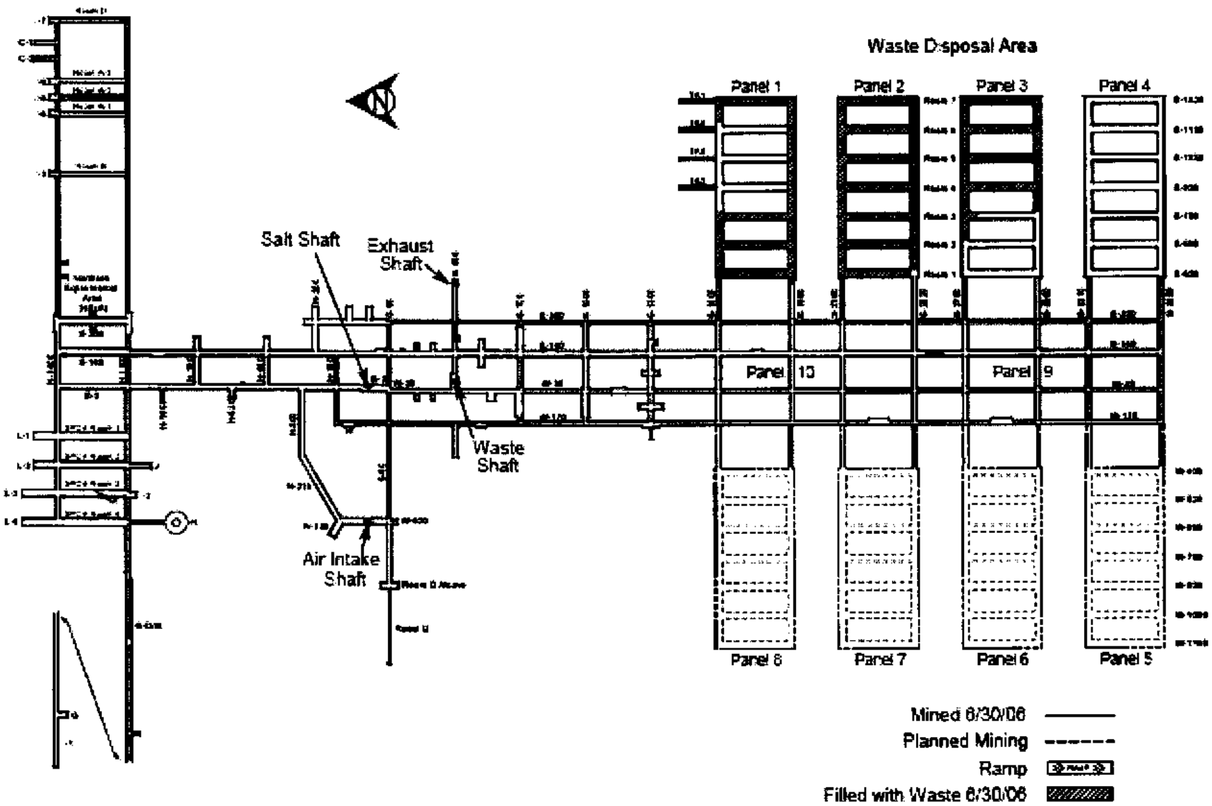


Figure 2.1. Configuration of the WIPP Underground for Geotechnical COMPs (after DOE 2007b; Reporting Period July 2005 through June 2006).

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).

Shafts. 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 annually 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. These inspections have focused on salt build-up in the Exhaust shaft and the impacts this build-up has on power cabling in the shaft. Based on these visual observations, all four shafts are in satisfactory condition and have required only routine ground-control activities during this 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 2007b). It should be noted that no Exhaust shaft data was reported in this year's report due to cable failure. The data logger use to monitor data in the Waste shaft malfunctioned such that remote data acquisition for the extensometers is not possible. The 22 year old extensometers and logger are no longer manufactured. The data for these instruments is limited and questionable for this reporting period. As such the rate information from the Waste shaft is reported but was not used in this assessment.

<u>Shaft Station.</u> 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 (2005-2006) and the previous reporting period (2004-2005) are summarized in Table 2.3. Most of the measurements are for vertical closure. Based on convergence data (excluding the waste shaft), current vertical displacement rates range from 0.03 to 1.46 in/yr (0.08 to 3.71 cm/yr); Current horizontal displacement rates range from 0.82 to 0.95 in/yr (2.08 to 2.41 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 $1.59 x 10^{-12}$/s to $7.74 x 10^{-11}$/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)[c]		Change In Rate (%)
		2004–2005	2005–2006	
Salt Handling Shaft	No extensometers remain functional			
Waste Handling Shaft				
1071 ft (326 m) level, S15W	Ext	0.061	-0.003	-105
1566 ft (477 m) level, N45W	Ext	0.052	-0.010	-267
1566 ft (477 m) level, N75E	Ext	0.030	nr	-
1566 ft (477 m) level, S15W	Ext	0.122	0.010	-92
2059 ft (628 m) level, N45W	Ext	0.444	-0.025	-106
2059 ft (628 m) level, N75E	Ext	0.011	0.410	273
2059 ft (628 m) level, S15W	Ext	0.175	-0.807	-561
Exhaust Shaft	No extensometer data available for 2004-2006			
Salt Handling Shaft Station				
E0 Drift – S30 (Vert)	Ext	0.56	nr	-
E0 Drift – S60 (Vert)	Ext	0.46	0.03	-94[d]
E0 Drift – W12 (Vert CL)	CP	0.70	0.50	-29
E0 Drift – S18 (Vert. CL)	CP	1.38	1.36	-1
E0 Drift – S30 (Vert. CL)	CP	1.45	1.46	1
E0 Drift – S65 (Vert. CL)	CP	1.07	1.02	-5
Waste Shaft Station				
S400 Drift – W30 (Vert. CL)	Ext	0.25	0.28	15
Waste Shaft Brow (North)	Ext	0.06	0.08	17
Waste Shaft Brow (South)	Ext	0.13	0.20	50
S400 Drift – E87	Ext	0.52	nr	-2
S400 Drift – E30 (Horiz. CL)	CP	0.81	0.82	1
S400 Drift – E90 (Horiz. CL)	CP	0.89	0.95	7
Air Intake Shaft Station				
S65 Drift – W620 (Vert CL)	Ext	0.25	0.28	12
N95 Drift – W620 (Vert CL)	Ext	0.35	0.38	9

(a) Instrument Type: Ext = extensometer; CP = convergence point.
(b) CL = Centerline
(c) nr = no reading available
(d) 2005-2006 rate interval was taken over the winter months

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 2005 to June 2006), excavations of Panel 4 was completed. 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). Trimming, scaling, floor milling and rock bolting operations were performed as necessary during the reporting period.

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 2007b). 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%). Extensometer data are based 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. In general, closure rates have increased in various locations by more than ten percent since the last reporting period. Operationally, these locations are assessed in greater detail in the GAR to determine the cause of the closure rate increase. Most of these locations are in the E-140 drift. Increased closure rates were observed in E-140 from S-700 to S-1000 and from S-1300 to S-2750. The increased rates from S-700 to S-1000 can be partially attributed to the effects of a floor trim performed in 2005 and continued aging and deterioration of the roof beam. Other areas, such as the access drifts in the southern portion of the repository, had closure rate increases that can be directly attributed to the mining of the new disposal panels and associated drifts. The majority of the rate changes comparing the 2006 year's COMP data were negative or near zero which demonstrates that displacements were slowing. For this 2007 COMP report, the majority of the data are in the 0 to 25% range. The maximum displacement rates corresponding to these data are given below:

Maximum Vertical Displacement Rates Along Access Drift Centerlines:

4.80 cm/yr – based on extensometer data
16.61 cm/yr – based on convergence point data

Maximum Horizontal Displacement Rate Along Access Drift Centerlines:

10.08 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 1.06×10^{-9}/s. This rate is based on the maximum displacement which is not representative of the behavior of the system.

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). Panel 1 was 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 completion of Panel 4 during 2006. As of June 30, 2006 (for the GAR reporting period), waste emplacement operations are complete in Panels 1 and 2. Panel 3 is currently being used for waste emplacement while Panel 4 has been readied for waste disposal. Figure 2.1 shows the state of waste emplacement and mining 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 a height of 3.65 m and a width 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 2004-2005 and 2005-2006 Reporting Periods					
	< 0%	0 – 25%	25 – 50%	50 – 75%	75 – 100%	100 – 200%
Access Drifts						
Extensometers[(a)]	8	13	10	3	3	1
Convergence Points	80	142	14	0	0	0
Waste Disposal Area						
Panel 2:						
Extensometers[(a)]	2	4	2	1	0	0
Convergence Points	2	0	0	0	0	0
Panel 3:						
Extensometers[(a)]	8	3	0	0	0	0
Convergence Points	27	3	4	1	0	2
Panel 4[(b)]:						
Extensometers[(a)]	1	0	0	0	0	0
Convergence Points	5	0	0	0	0	0

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

(b) Since this is a newer excavation, many instruments were installed in 2005-2006 and only a few were installed in 2003-2004 such that only one measurement has been recorded for most of the existing instruments. The displacement rate for the recently installed instruments will be available in the next COMPs report.

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 2004-2005 and 2005-2006 Reporting Periods				
	< 0%	**0 – 25%**	**25 – 50%**	**50 – 75%**	**75 – 100%**
Access Drifts					
Extensometers[(a)]	0	0	0	0	0
Convergence Points	70	73	4	0	0
Waste Disposal Area					
Panel 2:					
Extensometers[(a)]	0	0	0	0	0
Convergence Points	1	1	0	0	0
Panel 3:					
Extensometers[(a)]	0	0	0	0	0
Convergence Points	7	17	1	0	0
Panel 4[(b)]:					
Extensometers[(a)]	0	0	0	0	0
Convergence Points	3	0	0	0	0

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

(b) Since this is a newer excavation, many instruments were installed in 2005-2006 and only a few were installed in 2003-2004 such that only one measurement has been recorded for most of the existing instruments. The displacement rate for the recently installed instruments will be available in the next COMPs report.

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 2007b) for Panel access drifts and Panels 3 and 4 only. Panel 1 and 2 are closed and are no longer accessible. 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:

28.85 cm/yr – based on convergence point data

16.97 cm/yr – based on extensometer data

Maximum Horizontal Displacement Rates along Waste Disposal Area Centerlines:

12.29 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 1.15×10^{-9}/sec. Maximum creep rates for the waste disposal areas are all associated with Panel 4, the newest of the panels monitored. Creep deformations associated with the Waste Disposal Areas 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 - 2007:

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 located throughout the underground.	Munson-Dawson (MD) Constitutive Model	
COMP Derivation Procedure - Reporting Period July 2005 through June 2006				
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 determinations. 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 2007b) 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 where present) 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 2007 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 - 2007:

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 2005 through June 2006				
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 $3.98 \times 10^{-20} m^2$ was used for all subsequent PAs	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 - 2007:

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 2005 through June 2006				
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 6, 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 210 OBHs (of which 36 were drilled during the reporting period) listed in the GAR (DOE 2007b). Data for OBHs in closed panels or that are no longer accessible due to waste emplacement are not available.

The deformation features in OBHs are classified as: 1) offsets, 2) separations, 3) rough spots and 4) hang-ups. 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.

All of the 30 observation holes associated with Panel 3 show some offset. Most holes show offsetting along anhydrite stringers and clay layers. Offsets in Panel 4 are confined exclusively to Anhydrite "a" at the top of the beam. Offsets of less than 3/4-in. are found in Rooms 1 through 7, while offsets of up to 1-3/4 in. are found in the access drifts to Panel 4. Six OBHs were recorded as 100% occluded in the most recent GAR. One OBH in room 1 of Panel 3 was reported to be fully occluded. This OBH is at S 2910 E 525. One OBH located in the Panel 1 entryway has fully occluded. Four other boreholes associated with the E140 drift have fully occluded. These boreholes are located along the drift passing Panels 1 through 3. No other boreholes were reported to be fully occluded in the latest GAR.

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, some of which were occluded. Most of these OBHs are in the closed Panels 1 and 2 or are no longer accessible due to waste emplacement in Panel 3. 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, six (3 % 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 3, 4, 5, and 6) 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 - 2007:

Trigger Value Derivation				
COMP Title:	Displacement of Deformation Features			
COMP Units:	Length			
Related Monitoring Data				
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value	
Geotechnical	Delta D/D_o	Observational	Not established	
COMP Derivation Procedure - Reporting Period July 2005 through June 2006				
Observational – Lateral deformation across boreholes.				
Related Performance and Compliance Elements				
Element Title	Parameter Type & ID or Model Description	Derivation Procedure	Compliance Baseline	Impact of Change
Not directly related to PA	N/A	N/A	N/A	N/A
Monitoring Data Trigger Values				
Monitoring Parameter ID	Trigger Value	Basis		
Borehole diameter closure	Obscured observational borehole.	If lateral displacement is sufficient to close diameter of observational borehole, technical evaluation of consequences will be initiated.		

2.2.5 Subsidence

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 2006a) 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 within the allowable limits. 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 new panels 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 of the next consecutive panel. 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) as a result of the excavation of Panel 3 and its access drifts. This general trend has continued as more panels are mined. For this reporting period, the Waste Disposal Area as of June 30, 2006, consists of Panels 1, 2, 3, and 4. Panels 1 and 2 have been filled and closed. Panel 3 is currently being used for waste disposal and Panel 4 has been readied for waste disposal.

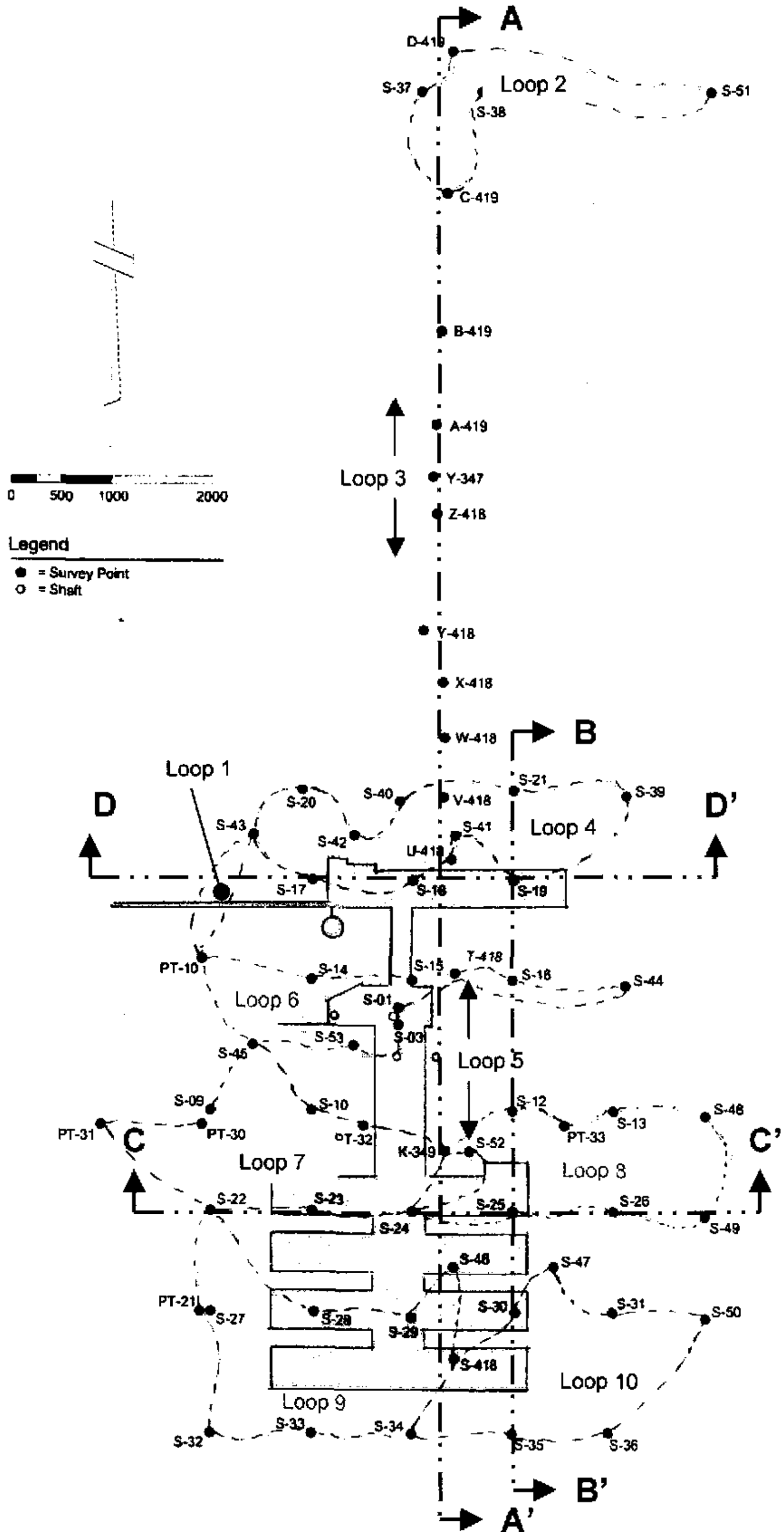


Figure 2.2. Monuments and vertical control points comprising WIPP subsidence survey

loops.

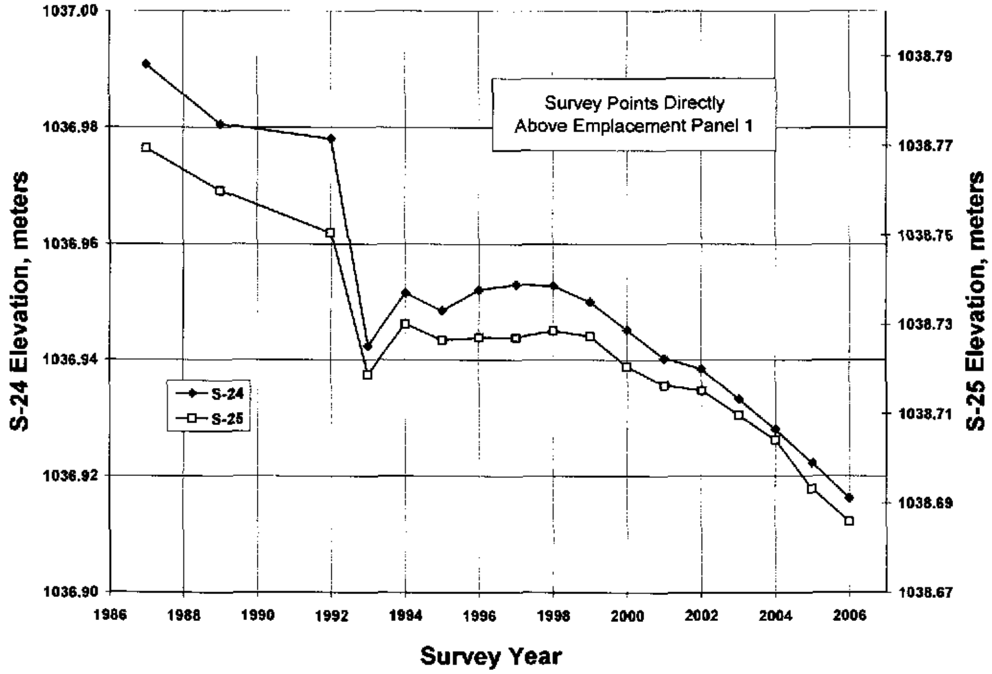


Figure 2.3. Elevations of WIPP monuments S-24 and S-25 located directly above emplacement Panel 1.

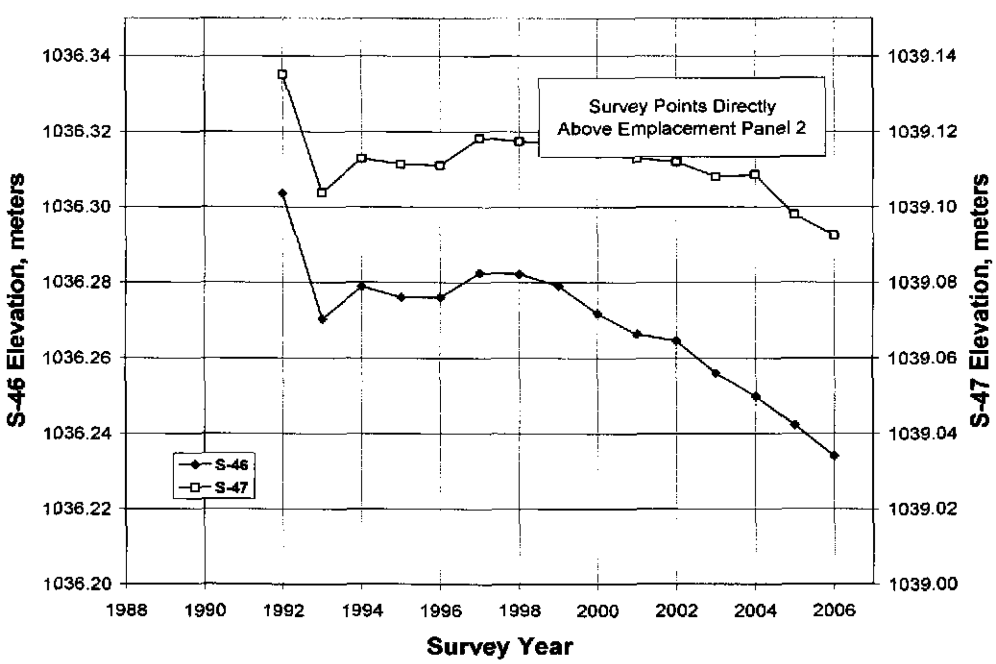


Figure 2.4. Elevations of WIPP monuments S-46 and S-47 located directly above emplacement Panel 2.

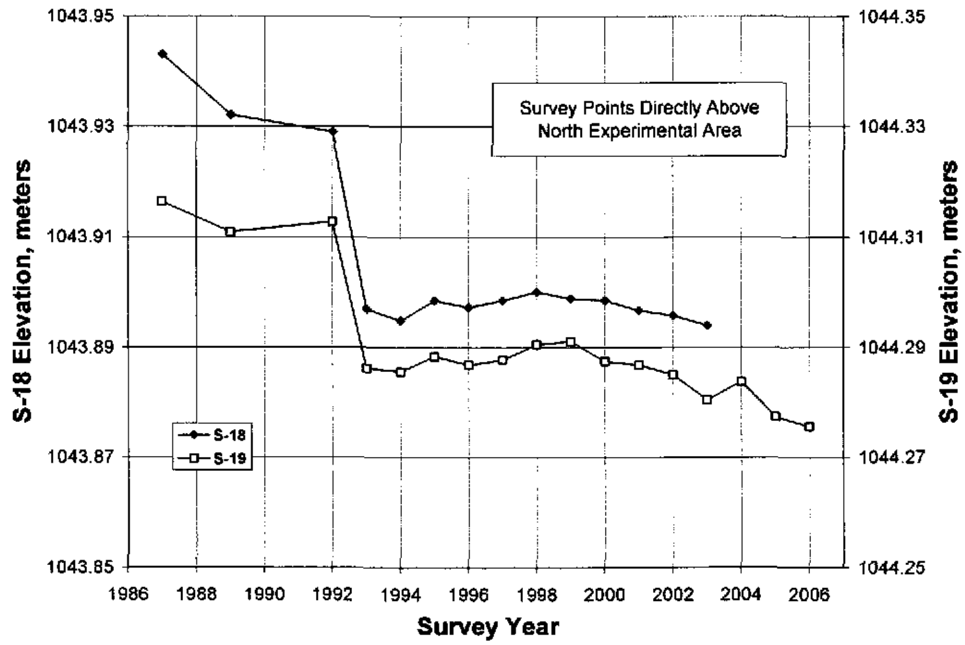


Figure 2.5. Elevations of WIPP monuments S-18 and S-19 located directly above the north experimental area.

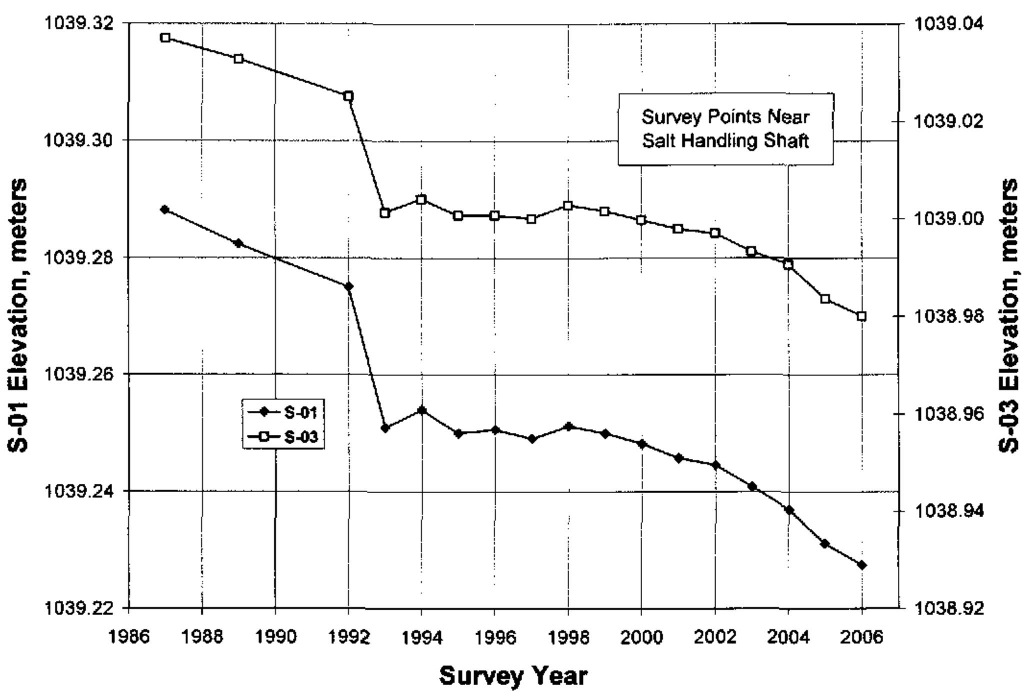


Figure 2.6. Elevations of WIPP monuments S-01 and S-03 located near the Salt Handling Shaft.

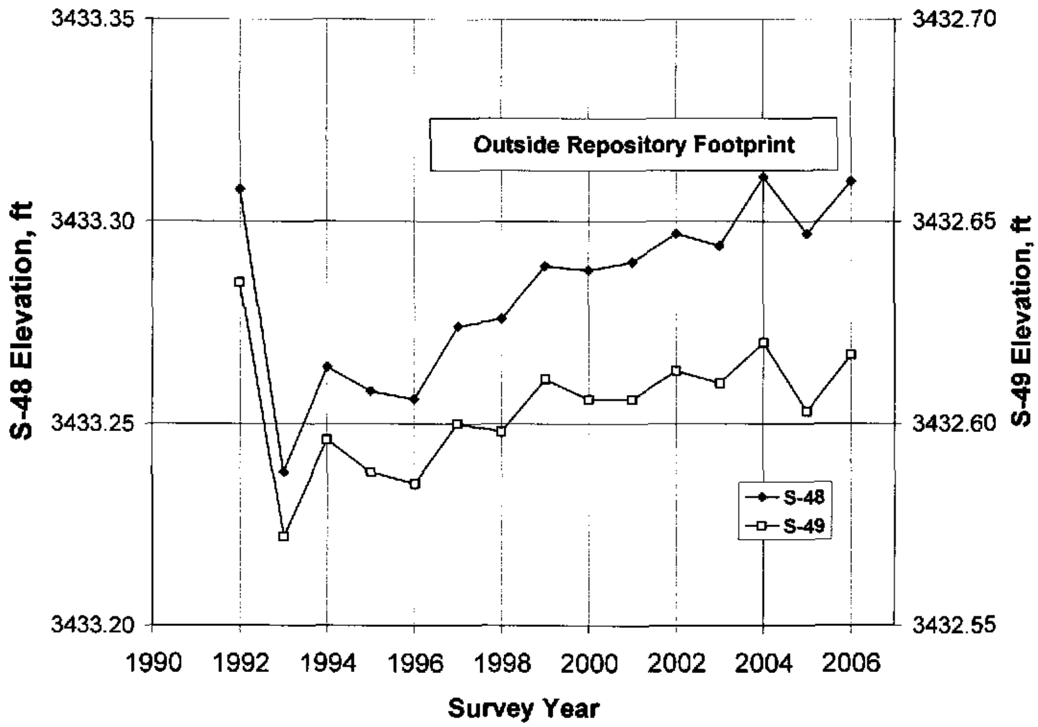


Figure 2.7. Elevations of WIPP monuments S-48 and S-49 located outside the repository footprint.

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.

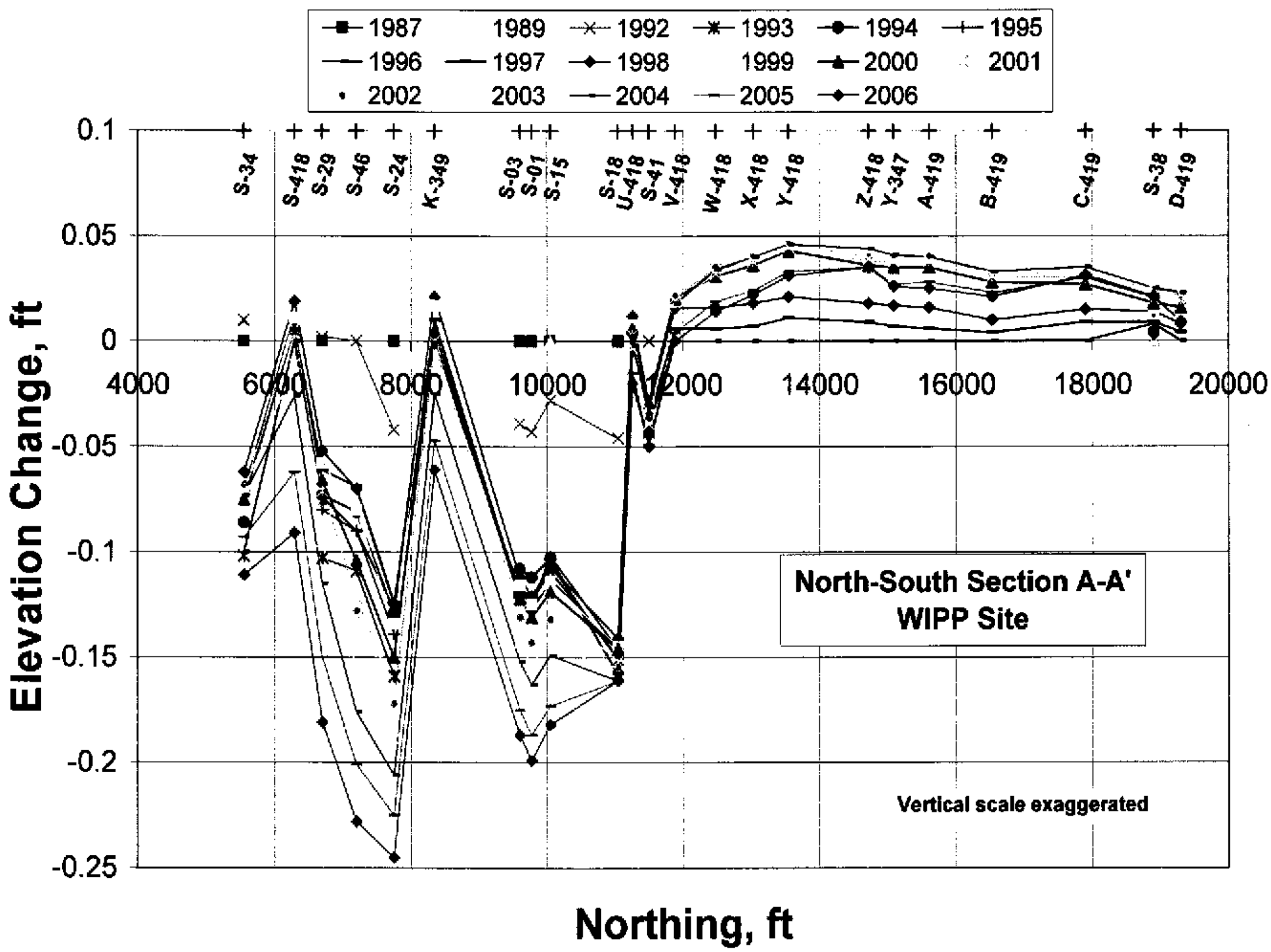


Figure 2.8. North-South subsidence profile A-A'.

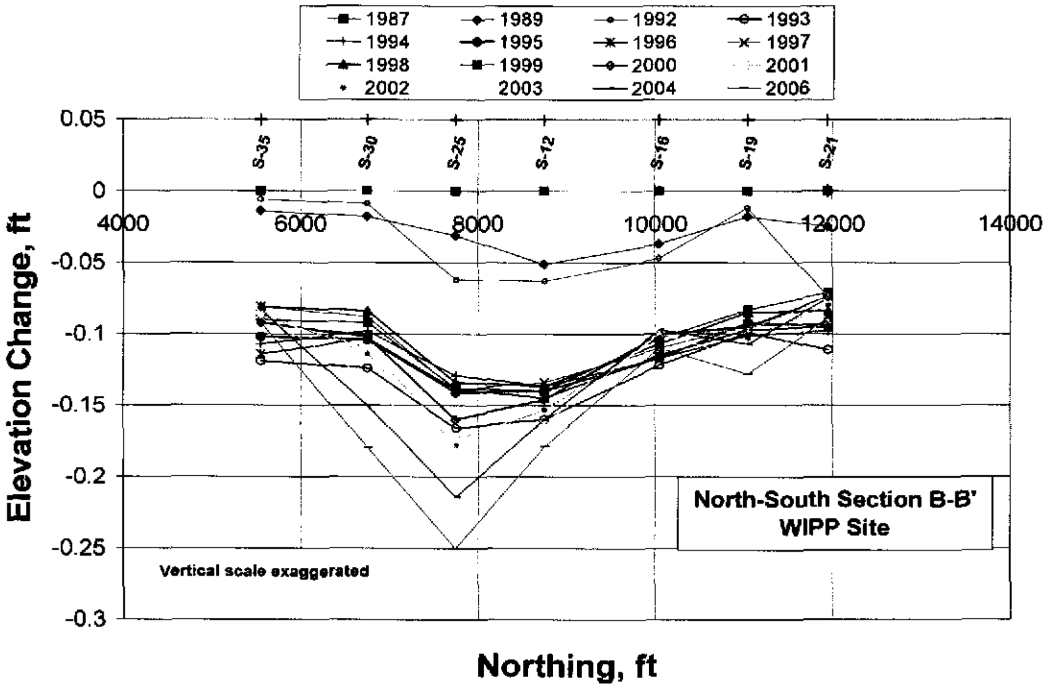


Figure 2.9. North-South subsidence profile B-B'.

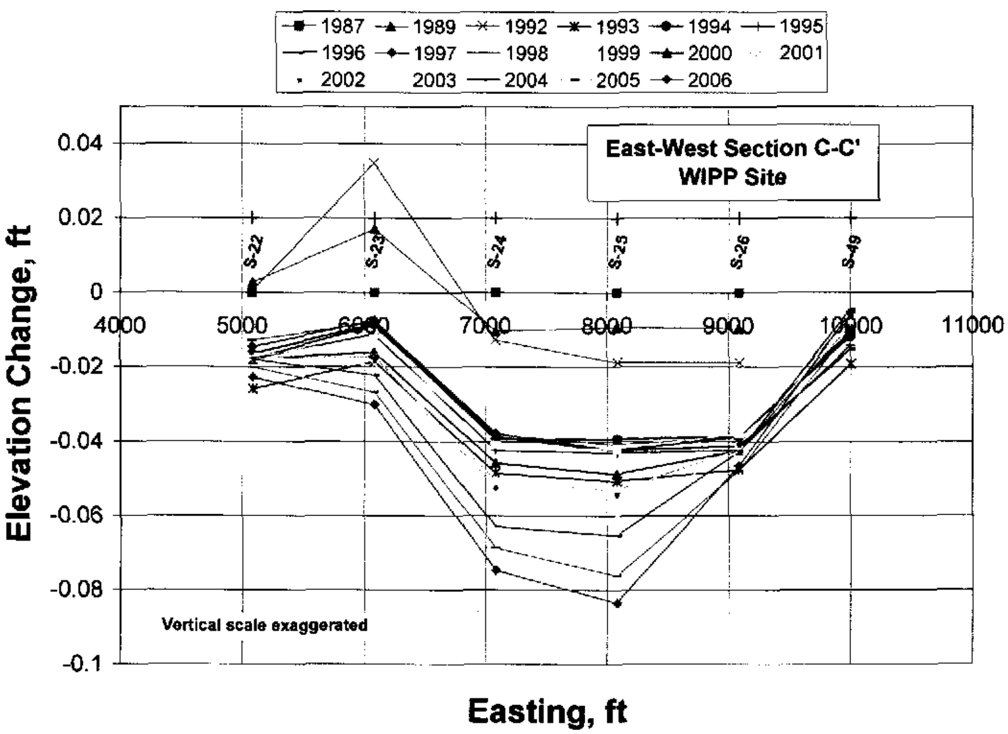


Figure 2.10. East-West subsidence profile C-C′.

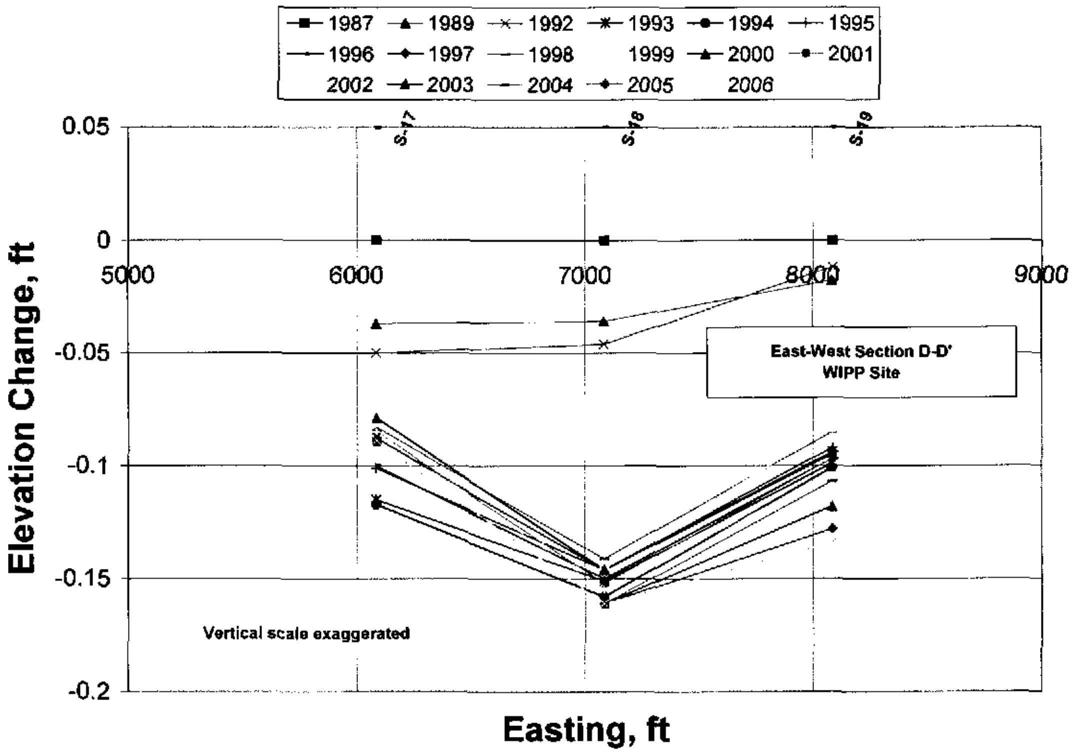


Figure 2.11. East-West subsidence profile D-D′.

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 the waste panels (Monuments PT-32, S-23, S-24, S-25, S-30 and S-46), with slightly less subsidence (- 0.18 ft) near the Salt Handling Shaft (Monuments S-01, S-03, S-14 and S-15) above the waste panels (S-29) and adjacent to Panel 1 (S-12).
2. The highest subsidence rates measured for the 2005-2006 surveys correspond to benchmarks located above Panels 1 through 4. Markers S-46 and S-418 above Panels 2 and 4 had a rate of approximately 8×10^{-3} m/yr and a rate of 9×10^{-3} m/yr at S-29 and 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 latest survey data, subsidence rates of the ground surface at the WIPP have not exceeded the $1x10^{-2}$ m/yr TV. No additional activities are recommended at this time.

Subsidence - 2007:

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 original monitoring monuments		Decimal (meters)	Not Established
SMP	Change in elevation over year		Decimal (meters)	Not Established
COMP Derivation Procedure – 2007; Data acquired between September and November of 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; DOE 2004).
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 CRA lists ten monitoring parameters that the DOE is required to monitor and assess during the WIPP operational period (DOE 2004). 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 2006 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 (ASER) for 2006 (DOE 2007c) 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.

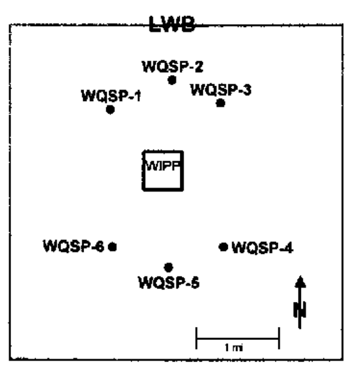


Figure 2.12 Map showing locations of WQSP wells in relation to the WIPP surface facilities and the LWB. Note: WQSP-6a is on the same well pad as WQSP-6.

Flow and transport in the Dewey Lake are not modeled explicitly in 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.

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

Two water samples (a primary and a duplicate) 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 by the WIPP M&OC 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 the appropriate containers (i.e., preserved versus unpreserved) for each particular analysis, 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, metals samples are preserved with nitric acid, and 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 U.S. Environmental Protection Agency methods. In the lab, metals samples are analyzed for total cations (e.g., Na^+, Ca^{2+}, Mg^{2+}, K^+) and general chemistry samples are 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

The results of the WQSP analyses are compared to baseline results in order to determine stability, which is defined as a condition where the concentration of a given ion remains within its derived 95% confidence interval (CI; 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% CIs derived from the baseline data (SNL 2000b) are presented in Table 2.6.

Based on the baseline analysis described above a Trigger Value (TV) for Culebra groundwater composition has been defined. A TV is defined as the condition where both primary and duplicate analyses for any major ion fall outside the 95% CI 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 addition to the above analyses, a charge-balance error (CBE), 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. A CBE is useful in evaluating the reliability of an analysis because water must be electrically neutral. CBE is rarely zero because of inherent inaccuracy in analytical procedures, but a reliable analysis should not have a CBE exceeding five percent (Freeze and Cherry 1979). A CBE in excess of five percent implies 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 CBE for rounds 22 and 23 of sampling are presented in Table 2.6.

2.3.1.2 Results

WQSP results for 2006 come from sampling rounds 22 and 23 and are reported in Table 2.6. Sampling round 22 was conducted between March and May and round 23 between September and November.

Table 2.6. Rounds 22 and 23 major ion concentrations and charge-balance errors, with baseline 95% confidence intervals (CIs)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 22	38500/35000	4780/4560	*50/44*	17500/17600	1780/1800	**1230/1240**	**1050/950**	**-7.3**
	Round 23	*39200/* ***44200***	5580/5490	50/48	***25700/28400***	*1890/* ***2110***	***1220/1350***	598/612	3.9
	95% C.I.	31100-39600	4060-5600	45-54	15900-21100	1380-2030	939-1210	322-730	
WQSP-2	Round 22	37500/38000	6300/5880	52/50	17000/17000	1520/1480	1060/1060	**992/995**	**-12.5**
	Round 23	**40600/41100**	6220/6220	***40*** */50*	**25100/25200**	1540/1580	1040/1050	594/561	-0.4
	95% C.I.	31800-39000	4550-6380	43-53	14100-22300	1230-1770	852-1120	318-649	
WQSP-3	Round 22	140000/144000	**8780/9050**	*34/40*	**62400**/65000	*1340/* ***1690***	*2280/* ***2590***	2870/2910	**-14.6**
	Round 23	***156000/181000***	**9520/9610**	*35/41*	**96400/96100**	1390/1370	2200/2160	**1640/1580**	**-5.0**
	95% C.I.	114000-145000	6420-7870	23-51	62600-82700[c]	1090-1620	1730-2500	2060-3150[a]	
WQSP-4	Round 22	**66500/66700**	**7920/8370**	42/42	*29500/28800*	***1870/1900***	*1400/* ***1460***	**1570**/1500	**-14.8**
	Round 23	***75700/64200***	7390/7420	42/42	**38400/37900**	1770/1720	1310/1280	896/897	**-6.3**
	95% C.I.	53400-63000	5620-7720	31-46	28100-37800	1420-1790	973-1410	832-1550[b]	
WQSP-5	Round 22	15900/16600	5280/5630	48/52	8180/8130	1050/1120	489/533	***568/635***	**-10.2**
	Round 23	17400/17600	**6430/6320**	46/46	**10800**/10400	1030/1000	460/426	337/317	**-5.9**
	95% C.I.	13400-17600	4060-5940	42-54	7980-10400[c]	902-1180	389-535	171-523	
WQSP-6	Round 22	6250/5990	**5800/5500**	52/54	**3470**/3650	766/**785**	**237/244**	**288/292**	**-13.7**
	Round 23	**6410**/6250	4930/4650	48/48	4400/4660	675/721	201/215	153/163	-4.9
	95% C.I.	5470-6380[c]	4240-5120[c]	41-54	3610-5380[c]	586-777	189-233[c]	113-245	
WQSP-6a	Round 22	450/446	2210/2220	106/100	**212/202**	**510/507**	*151/131*	6.35/6.32	**-13.4**
	Round 23	**360/381**	2120/2080	108/110	266/**246**	635/628	171/170	4.98-4.90	0.8
	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 22, concentrations of all major ions at WQSP-1 were within their respective 95% CIs, except for both magnesium and potassium analyses. The duplicate alkalinity sample was below its 95% CI, but had a ≥10% difference relative to the primary sample, no other sample pairs had this problem. For round 23, concentrations of most major ions had at least one sample within their respective 95% CIs. For chloride and calcium one of the two samples was outside their respective 95% CIs and both sodium and magnesium analyses were outside their respective 95% CIs. All analyses that had at least one sample outside a 95% CI had a difference between the primary and duplicate of ≥10%.

CBEs were –7.3% and +3.9% for rounds 22 and 23, respectively, indicating a surplus of anions or a deficit of cations for round 22 and the opposite for round 23. Figure 2.13 shows that the WQSP-1 hydrochemical facies in 2006 are consistent with previous results.

2.3.1.2.2 WQSP-2

For round 22, concentrations of all major ions at WQSP-2 were within the 95% CI, except for both potassium analyses. No samples had a difference between primary and duplicate ≥10%. For round 23, concentrations of most major ions were within their respective 95% CIs. Analyses of both the primary and duplicate analyses of chloride and sodium were above their upper 95% CIs and the alkalinity analysis on the primary sample was below the 95% CI, though it was ≥10% than the duplicate. None of the other analyses showed differences between the primary and duplicate to be ≥10%.

CBEs were –12.5% and -0.4% for rounds 22 and 23, respectively, indicating a surplus of anions and/or a deficit of cations for both rounds. Figure 2.13 shows that the WQSP-2 hydrochemical facies in 2006 are consistent with previous results.

2.3.1.2.3 WQSP-3

For round 22, concentrations of chloride, alkalinity, and potassium in both samples at WQSP-3 were within their respective 95% CIs. Analyses of the primary and duplicate samples showed that sodium, magnesium, and calcium, in at least one of the samples, were outside their respective 95% CI. The calcium and magnesium samples returned differences of ≥10% between primary and duplicate, as well as alkalinity. Also during round 22, both sulfate analyses returned results of above 95% CI. For round 23, concentrations of both primary and duplicate samples analyzed for chloride, sulfate, sodium and potassium concentrations were above their respective 95% CI, with only chloride having a difference of ≥10% between primary and duplicate, in addition to alkalinity.

CBEs were -14.6% and -5.0% for rounds 22 and 23, 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 2006 are consistent with previous results.

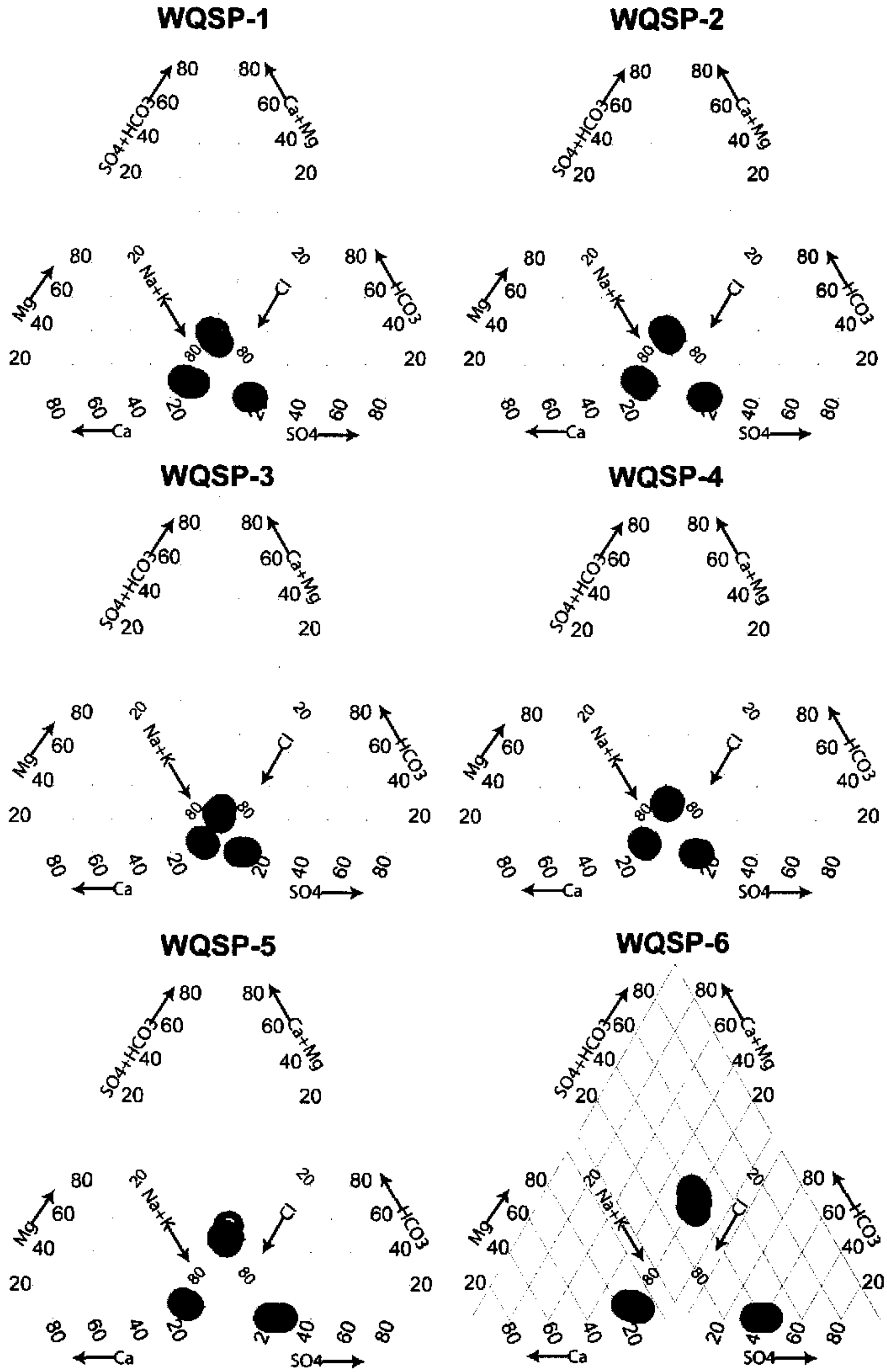


Figure 2.13. Hydrochemical facies plots generated with data collected from WQSP-1 through WQSP-6 during rounds 22 and 23 (2006). The plots show both historical data (gray areas) and results from rounds 22 (blue star) and 23 (red star).

2.3.1.2.4 WQSP-4

For round 22, most major ion concentrations at WQSP-4 were outside their respective 95% CIs. For chloride, sulfate, and calcium, both the primary and duplicate samples returned values above the upper limits of their 95% CIs and for magnesium and potassium at least on sample was above their upper 95% CIs. No samples had a difference between primary and duplicate ≥10%. For round 23, concentrations of most of the major ions were within their respective 95% CIs. Chloride and sodium were above their upper 95% CI in both the primary and duplicate samples. Only the duplicate of chloride was ≥10% different from the primary.

Charge-balance errors for rounds 22 and 23 were –14.8% and –6.3%, 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 2006 are consistent with previous results.

2.3.1.2.5 WQSP-5

For round 22, all major ion concentrations at WQSP-5 were within their respective 95% CIs with the exception of both potassium analyses, which were also different by ≥10%. For round 23, concentrations for most of the major ions were again within their respective 95% CIs, with the exception of both sulfate analyses and the primary sodium analysis. None of the duplicate samples differed by ≥10% from the primary.

Charge-balance errors for rounds 22 and 23 were -10.2% and -5.9%, 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 2006 are consistent with previous results.

2.3.1.2.6 WQSP-6

For round 22, most major ion concentrations at WQSP-6 were outside their respective 95% CIs. Both the primary and duplicate samples for sulfate, magnesium, and potassium returned results above their upper 95% CIs and sodium and calcium had either a primary or duplicate sample above their 95% CIs. None of the duplicate samples differed by ≥10% from the primary. For round 23, only the analysis for chloride concentration in the primary sample registered a value above its upper 95% CI and none of the samples had a difference of ≥10% between the primary and duplicate samples.

Charge-balance errors for rounds 22 and 23 were -13.7% and -4.9%, respectively, indicating a surplus of anions and/or a deficit of cations for both rounds. Figure 2.13 shows that the WQSP-6 hydrochemical facies in 2006 were consistent with previous results.

2.3.1.2.7 WQSP-6a

For round 22, most major ion concentrations were within their respective 95% CI, with the exception of both the primary and duplicate sample analyses of sodium and calcium and the duplicate analysis of magnesium, which were all below the lower limit of their 95% CIs. Only magnesium had a ≥10% difference between primary and duplicate. For round 23, again most major ion concentrations were within their respective 95% CI, with the exception of both the primary and duplicate analyses of chloride and the duplicate analysis of sodium, which were below the lower limit of their 95% CIs. None of the duplicate samples differed by ≥10% from the primary.

Charge-balance errors were -13.4% and +0.8% for rounds 22 and 23, respectively. Figure 2.14 shows that the WQSP-6a hydrochemical facies in 2006 were consistent with previous results.

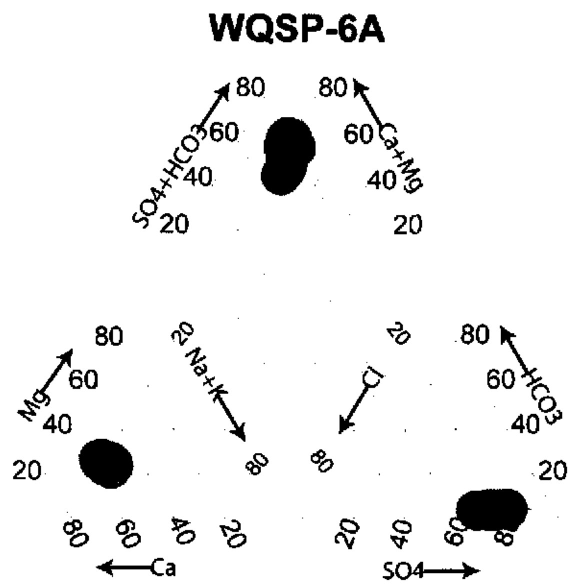


Figure 2.14 Hydrochemical facies plot generated with data collected from WQSP-6a during rounds 22 and 23 (2006). The plot shows both historical data (gray areas) and results from rounds 22 (blue star) and 23 (red star).

2.3.1.3 Assessment of Water Quality Data

2.3.1.3.1 Investigative Results based on the 2007 COMPs Report

In the 2005 COMPs report (SNL, 2006), it was noted that potassium concentrations in wells WQSP-1, WQSP-2, and WQSP-6 reached the TV. High potassium concentrations in both primary and duplicate samples from all three wells began in round 19 and continued into round 22. In all cases, however, potassium was below the respective upper 95% CIs in round 23; thereby, causing the TV to no longer be applicable.

As a result of the TV occurrence the SA began an investigation to determine the cause(s) of the observed change in water chemistry. The investigation included: observation of WIPP M&OC sampling procedures, review of historical (i.e., rounds 1-19) data, and discussions with the analytical lab (TraceAnalysis, Inc.) about their methods and results.

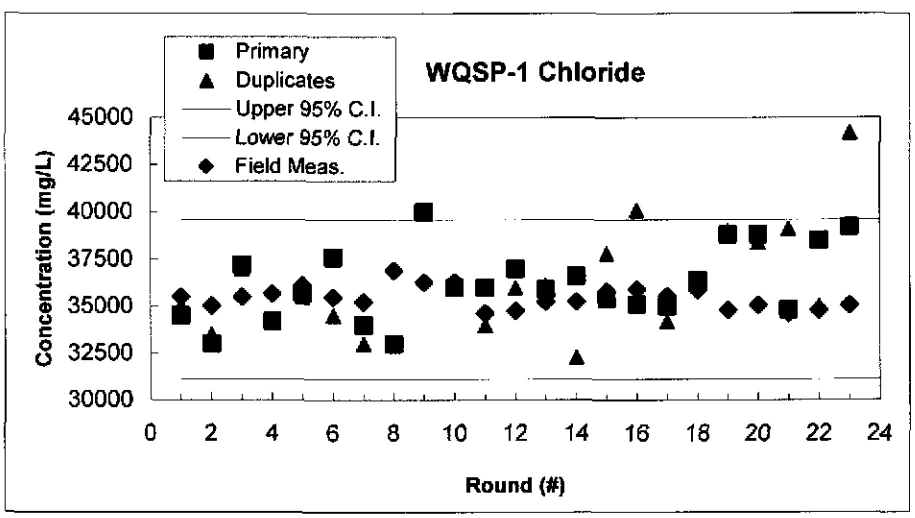
During round 23, the SA observed sampling techniques by the M&OC and determined that their methodology followed procedure and was sufficient. The SA did note that samples collected for metals analyses were not filtered in the field, and although it is not required, groundwater sampling usually involves filtering of this particular sample. The lack of filtering could lead to analytical error if the lab were to overlook this element of the sampling technique. Review of data reports supplied by the analytical lab for rounds 20-22 show higher than normal levels of total suspended solids (TSS) in WQSP samples (DOE 2007a); the SA believes that the lab has, at times, not filtered the sample in the lab prior to analysis.

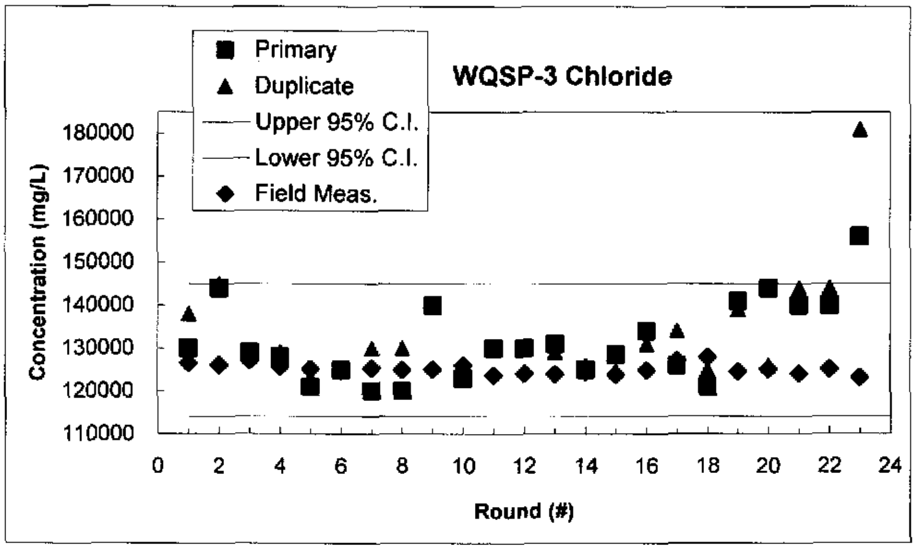
Review of historic data revealed that since round 7 when TraceAnalysis began analyzing the WQSP water chemistry, sample variability from one round to the next, as well as within a given round, increased significantly. This is likely due to the difficulty of analyzing water samples with high total dissolved solids (TDS) such as the concentrated brine of the Culebra (TDS ranges from 15,000 to 200,000 mg/L). For example, for both rounds of 2006 the samples with the most results outside of the 95% CI and with ≥10% differences between primary and duplicate samples came from WQSP-3, which has the highest TDS of ~200,000 mg/L. Analyzing samples with high TDS is not routine and precision and accuracy are typically lower then desired due to the need to dilute samples to get them to levels that can be run in the analytical equipment.

The review showed that a comparison of analytes (e.g., chloride concentrations) measured in the field to those measured in the lab do not match well, particularly after round 18 (Figure 2.15). It has not been until recently (i.e., round 20) that lab reports have been thoroughly reviewed by the SA (in the past this review was performed by the M&OC).

The final part of the investigation was the collection of split samples by the SA from each well (except WQSP-6a) during round 23. The samples (one per well) were sent to a different analytical lab for analyses. Comparison of the results is presented in Table 2.7. Of the 42 analyses conducted on the samples only three returned concentrations outside the 95% CIs, and in all cases they were below the lower limit.

Improvements in data quality were observed between rounds 22 and 23 (with indicators of analytical problems being the most notable). CBEs changed from double to single digit errors and there were fewer instances of ≥10% differences between primary and duplicate samples, with the exception of WQSP-1. Also, as mentioned above, values for potassium concentrations in wells WQSP-1, 2, and 6 were again within the 95% CI.





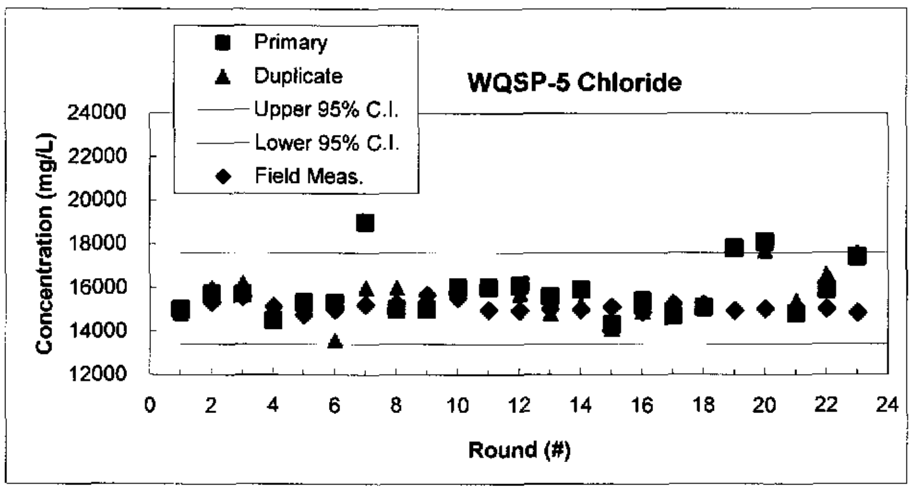


Figure 2.15 Comparison of chloride concentrations measured in the field and in the lab for WQSP-1, WQSP-3, and WQSP-5.

Table 2.7. Comparison of Round 23 major ion concentrations and charge-balance errors for samples analyzed by TraceAnalysis and split samples sent to another lab. Also included are the baseline 95% confidence intervals (CIs) 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	Prim./Dup.	39200/**44200**	5580/5490	50/48	**25700/28400**	1890/**2110**	**1400**/1120	598/612	3.9
	Split	32000	4500	50	19000	1600	1100	470	0.6
	95% C.I.	31100-39600	4060-5600	45-54	15900-21100	1380-2030	939-1210	322-730	
WQSP-2	Prim./Dup.	**40600/41100**	6220/6220	48/50	**25100/25200**	1540/1580	1040/1050	594/561	-0.4
	Split	**30000**	5000	47	21000	1600	1100	520	**7.1**
	95% C.I.	31800-39000	4550-6380	43-53	14100-22300	1230-1770	852-1120	318-649	
WQSP-3	Prim./Dup.	**156000/181000**	**9520/9610**	35/41	82700/78300	1390/1370	2200/2160	**1640/1580**	**-5.0**

	Split	120000	7100	33	78000	1500	2400	**1600**	2.4
	95% C.I.	114000-145000	6420-7870	23-51	62600-82700[c]	1090-1620	1730-2500	2060-3150[a]	
WQSP-4	Prim./Dup.	**75700/64200**	7390/7420	42/42	**38400/37900**	1770/1720	1310/1280	896/897	**-6.3**
	Split	55000	6100	40	35000	1600	1200	**730**	1.2
	95% C.I.	53400-63000	5620-7720	31-46	28100-37800	1420-1790	973-1410	832-1550[b]	
WQSP-5	Prim./Dup.	17400/17600	**6430/6320**	46/46	**10800**/10400	1030/1000	460/426	337/317	**-5.9**
	Split	14000	4900	46	8500	990	420	280	-3.5
	95% C.I.	13400-17600	4060-5940	42-54	7980-10400[c]	902-1180	389-535	171-523	
WQSP-6	Prim./Dup.	**6410**/6250	4930/4650	48/48	4400/4660	675/721	201/215	153/163	-4.9
	Split	**5400**	4600	46	4300	710	220	160	-0.8
	95% C.I.	5470-6380[c]	4240-5120[c]	41-54	3610-5380[c]	586-777	189-233[c]	113-245	

Bold signifies outside 95% confidence interval or charge-balance error ≥5%
[a] baseline defined from rounds 8-10
[b] baseline defined from rounds 7-10
[c] baseline definition excludes anomalous values

2.3.1.3.2 Culebra Wells

As of round 23, only one Culebra well sampled under the WQSP qualifies as a TV for a major ion and two other wells can be considered borderline. Chloride concentrations measured in both the primary and duplicate samples from WQSP-4 have been above the upper 95% CI since round 20 (Fall 2005), which qualifies as a TV. At least one of the samples (either the primary or duplicate) or both have been above the upper 95% CI for sulfate concentrations in WQSP-3 since round 20 and for magnesium concentrations in WQSP-1 since round 21, which makes these wells borderline.

In WQSP-4, chloride concentrations for both primary and duplicate samples have exceeded the upper limit of its 95% CI since round 20 (Figure 2.16). Of eight analyses over the past four rounds only the primary sample from round 23 was significantly different from its duplicate (75700 versus 64200 mg/L). Chloride has been problematic for the analytical lab as it is the ion with the highest concentrations in the WQSP wells. The higher the concentration the more difficult it has been for the analytical lab to achieve accurate and reproducible results (see also Section 2.3.1.3.1). Worth mentioning is, the chloride concentration measured in the split sample from round 23 was within the 95% CI and considerably lower than that measured by TraceAnalysis. Due to the uncertainty in validity of the sampling results, the TV is not considered significant and the SA will continue to investigate the chloride TV.

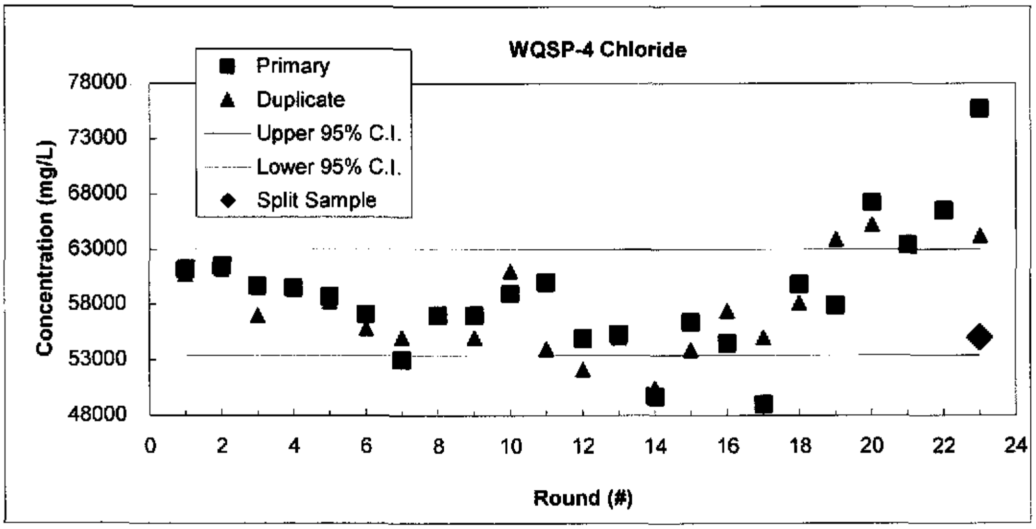


Figure 2.16 Chloride concentrations measured in WQSP-4

As of round 23, at least one if not both analyses of sulfate have returned results that are above its 95% CI since round 21 (Figure 2.17). Also, the results of the round 23 primary and duplicate samples measured by TraceAnalysis, do not compare well with the split sample measured by another analytical lab. As discussed above, WQSP-3 results for many of the analyses were poor and CBEs were high, probably due to the high TDS concentration (~200,000 mg/L). This can cause difficulties during analysis resulting in errors. Magnesium concentrations in WQSP-1 are only slightly over the upper 95% CI limit (Figure 2.18) and can be considered insignificant at this time.

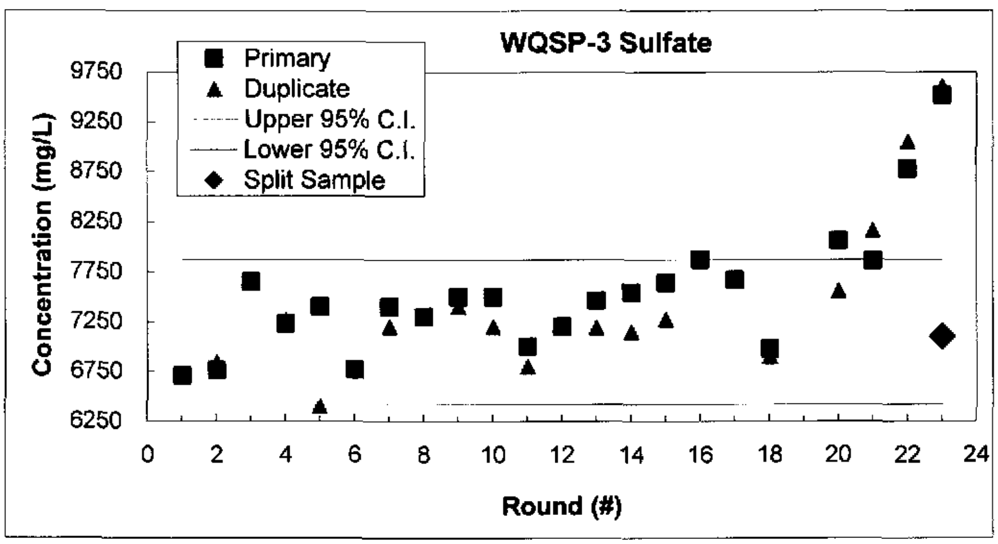


Figure 2.17. Sulfate concentrations measured in WQSP-3

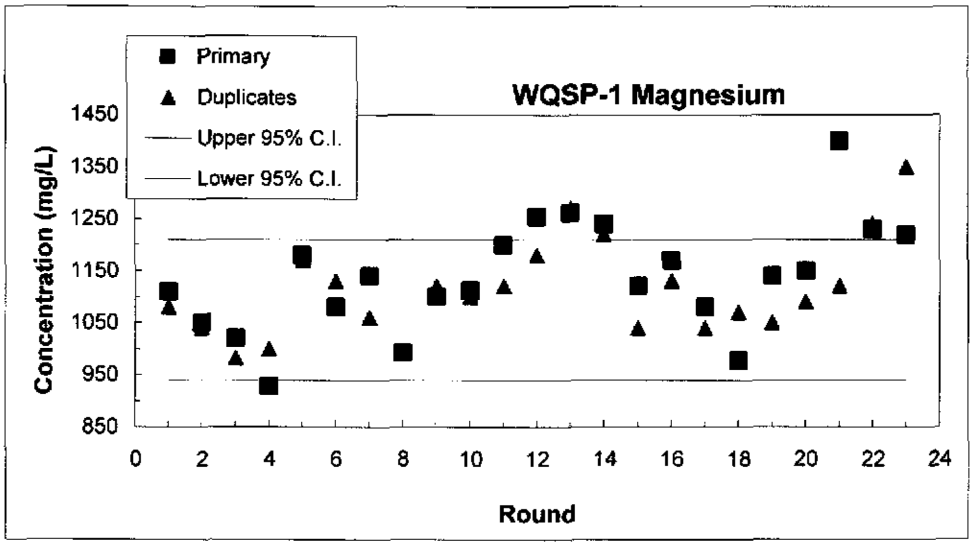


Figure 2.18. Magnesium concentrations measured in WQSP-1

Though there is apparent variability from one round to the next between individual analytes a better indicator of water chemistry stability is the relation between the percentage of ions or ion pairs relative to each other and hydrochemical facies plots allow for such a comparison. Hydrochemical facies plots of Culebra water chemistry (Figure 2.13) over the course of the WQSP (20+ years) show that the groundwater is relatively stable.

2.3.1.3.3 Dewey Lake

In WQSP-6a only sodium has reached its TV, though this was reversed in round 23 when the primary sample returned a value within the 95% CI. CBE for round 22 was -13.4% suggesting an analytical problem, while CBE for round 23 was much better at 0.8%. Based on interpretation of the long-term data and the hydrochemical facies plot (Figure 2.14), water chemistry in WQSP-6a is considered stable.

Change in Groundwater Composition - 2007:

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 – Data acquired between March and May 2006				
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 CCA 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 COMPs "Changes in Groundwater Flow" involves TVs derived from the steady-state freshwater heads estimated for Culebra flow modeling in the CCA. 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 32 wells (of which only 18 remain) 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 "CCA 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 2006, a total of 48 PD and SG measurements were made in WIPP wells (DOE, 2007c). Two were first-time measurements on new wells, while the others updated previous measurements. Measurements were collected from 37 Culebra wells, ten Magenta wells, and one Dewey Lake well.

2.3.2.1.2 Water-Level Monitoring

In 2006, the M&OC made monthly or quarterly water-level measurements in 65 wells (includes 5 dual-completion Culebra-Magenta wells). Of these, 52 are completed to the Culebra Member of the Rustler Formation, 15 to the Magenta Member of the Rustler Formation, two to the Bell Canyon Formation, and one to the Dewey Lake Formation. Measurements were taken monthly in 46 Culebra wells and quarterly in the six redundant Culebra wells on the H-19 hydropad. Water levels were not measured in two wells, WIPP-27 and SNL-6, due to unsafe road conditions leading up to the WIPP-27 well pad and water level being >1000 ft in SNL-6. During 2006, four Culebra monitoring wells (DOE-1, P-17, WIPP-26, and WIPP-27) were plugged and abandoned and five new Culebra wells were drilled (SNL-10, 16, 17, 18, and 19). Water-level measurements were limited to the last few months of 2006 in the five new wells and four other Culebra wells (H-15, SNL-14, SNL-15, and WIPP-25) had limited water-level measurements (i.e., <9 measurements) due to SA testing activities. In addition the production-injection packer (PIP) used in WIPP-30 to separate the Magenta and Culebra failed and was replaced in late April 2006.

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

2.3.2.2 Assessment of Culebra Data

Assessment of Culebra data involves the interpretation of both fluid density and water-level data. Both are indicators of the flow regime, in that if density or water level change significantly it may reflect a change in flow direction and/or velocity. Though it is unlikely for this to occur, any significant change in these two parameters must be noted and investigated.

2.3.2.2.1 Assessment of Culebra Fluid Density Data

Results from the 2006 PD and SG measurements are compared with previous results (DOE 2006b) in Table 2.8. Of the 37 resurveyed Culebra wells, 13 experienced a significant change in fluid density of $\geq \pm 0.01$ g/cm^3 from previous measurements. In ten of these wells the change was relatively minor (i.e., $\leq \pm 0.020$ g/cm^3) and in the other three wells (H-3b2, SNL-1, and SNL-13), changes ranged from -0.024 to -0.054 g/cm^3.

Because it appears that approximately one-third of the Culebra wells measured in 2006 experienced apparent significant changes in fluid density from 2005 to 2006, it could be surmised that the Culebra flow system is changing. The SA, however, does not feel that this is the case. There have been problems obtaining accurate and reproducible PD data since 2005, likely because of equipment issues experienced by the M&OC (SNL 2006). For the 2006 PD survey, the M&OC used the same PD equipment from the 2005 PD survey, though the depth-counter was fixed. The SA believes that variation within the 0.020 g/cm^3 envelope is within error of the measurements and should not be construed as changes in flow regime of the Culebra. The SA and M&OC are currently working towards a solution for better determining fluid density in all wells, which may include using calculated densities in lieu of survey measurements, and should be implemented before the 2007 COMPs report.

The larger more significant changes in fluid density at H-3b2 (-0.047 g/cm^3) and SNL-13 (-0.054 g/cm^3) can be linked to water-quality sample collection activities conducted by the SA in late June and early July of 2006. The -0.024 g/cm^3 change at SNL-1 cannot be explained at this time though it can be probably linked to the almost 5 ft increase in water-level either through the addition of recharge water (unlikely) or due to the inflow of more representative formation water (more likely) caused by the water-level rise.

Table 2.8. Summary of fluid densities collected in monitoring wells during the 2006 PD survey.

Well	Date	Unit	2006 Density (g/cm^3)	2005 Density (g/cm^3)	Method
AEC-7	11/29/06	Culebra	1.211*	1.209*	PD
C-2737	08/08/06	Culebra	**1.027**	1.037	PD
H-2b2	08/08/06	Culebra	**1.000**	1.010	PD
H-3b2	08/14/06	Culebra	**1.009**	1.056	PD
H-4b	08/16/06	Culebra	**1.021**	1.037	PD
H-5b	08/17/06	Culebra	1.099	1.106	PD
H-6b	08/03/06	Culebra	**1.043**	1.054	PD
H-7b1	08/16/06	Culebra	1.006	1.009	PD
H-9c	08/29/06	Culebra	1.007	1.016	PD
H-10c	08/21/06	Culebra	**1.005**	1.016	PD
H-11b4	08/14/06	Culebra	1.071	1.075	PD
H-12	08/21/06	Culebra	1.108	1.076	PD
H-17	08/16/06	Culebra	**1.134**	1.149	PD
H-19b0	08/14/06	Culebra	1.071	1.079	PD
IMC-461	08/29/06	Culebra	**1.017**	1.036	PD
SNL-1	08/01/06	Culebra	**1.027**	1.051	PD
SNL-2	08/28/06	Culebra	1.017	1.019	PD
SNL-3	08/01/06	Culebra	1.028	1.034	PD
SNL-5	07/26/06	Culebra	1.010	1.019	PD
SNL-8	08/22/06	Culebra	1.051	1.056	PD
SNL-9	08/03/06	Culebra	**1.024**	1.038	PD
SNL-10[a]	08/28/06	Culebra	1.004	N/A	PD
SNL-12	08/22/06	Culebra	1.006	1.015	PD
SNL-13	07/26/06	Culebra	**1.008**	1.062	PD
SNL-14	07/25/06	Culebra	**1.038**	1.057	PD
SNL-15	08/22/06	Culebra	1.221	1.230	PD
SNL-16[a]	07/26/06	Culebra	1.000	N/A	PD
WIPP-11	08/01/06	Culebra	1.039	1.043	PD
WIPP-13	08/17/06	Culebra	1.041	1.048	PD
WIPP-19	08/17/06	Culebra	1.055	1.060	PD
WIPP-30	08/29/06	Culebra	**1.007**	1.019	PD
WQSP-1	11/15/06	Culebra	1.048	1.048	SG
WQSP-2	11/01/06	Culebra	1.047	1.048	SG
WQSP-3	10/25/06	Culebra	1.145	1.148	SG
WQSP-4	10/18/06	Culebra	1.074	1.070	SG
WQSP-5	10/04/06	Culebra	1.025	1.025	SG
WQSP-6	09/13/06	Culebra	1.014	1.010	SG
H-2b1	08/08/06	Magenta	**1.009**	1.021	PD
H-3b1	08/08/06	Magenta	1.007	1.016	PD
H-4c	08/16/06	Magenta	1.009	1.018	PD
H-6c	08/03/06	Magenta	**1.007**	1.021	PD
H-8a	08/22/06	Magenta	**1.032**	1.045	PD
H-10a	08/21/06	Magenta	1.004	1.009	PD
H-11b2	08/14/06	Magenta	1.040	1.044	PD
H-14	08/16/06	Magenta	**1.006**	1.023	PD
H-18	08/03/06	Magenta	**1.006**	1.016	PD
WIPP-18	08/17/06	Magenta	1.004	1.013	PD
WQSP-6a	09/20/06	Dewey Lake	1.005	1.005	SG

* The fluid density in AEC-7 is not reflective of the Culebra (see SNL 2006)
[a] First time PD or SG measurements on new or existing wells as of 2006.
PD = Pressure Density and SG = Specific Gravity
Bold = Changes in fluid density $\geq \pm 0.010 g/cm^3$ from previous measurements.

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 2005 to December 2006 is presented in Table 2.9. Water-level changes in 39 of the 46 Culebra wells (new wells drilled in 2006 and wells with no water levels measured during late 2006 were excluded from this analysis) ranged from -8.27 ft to +72.68 ft, with 26 of the wells experiencing water-level changes of ≥ ±2.0 ft. Water level rose in 33 of the 39 wells, fell in five, and remained approximately the same (i.e., ±0.50 ft or less) in one (SNL-8).

In general, water levels continue to rise with approximately two-thirds of the wells registering a significant (i.e., ≥ 2.0 ft) increase in water levels during 2006. From December 2005 to December 2006, the largest increases in water level, 36.23 and 72.68 ft, were observed in SNL-15 and AEC-7, respectively, located in the eastern portion of the WIPP vicinity. The large increase in water-level at AEC-7 is due to the continuation of the water-level rise noted in the 2005 COMPs report (SNL 2006b) and the leakage of foreign fluid/pressure from lower units around the cement plug placed in the well in 2004; this problem is scheduled to be fixed in late 2007. SNL-15 continues to recover from post-drilling development and is projected to be recovering for some time.

Culebra water levels, in general, rose across the entire WIPP vicinity. During the first eight months of 2006, water levels across the site were relatively stable, with the exception of wells being tested (i.e., the newly drilled wells) or those influenced by the well testing or WQSP sampling events. Beginning as early as late August and continuing until the end of the year water levels began to increase in most wells. This increase has been qualitatively linked to two large rainfall events that occurred in the WIPP vicinity in mid-August and again in early September (Hillesheim et al. 2007). After each event, water levels rose abruptly in wells located in and near Nash Draw followed by progressively more gradual and delayed response away from Nash Draw.

An exception to the general water-level rise of the Culebra was an observed water-level decrease in wells located south of the WIPP site. The cause of this decrease, with the exception of H-10c, is due to a large drawdown event of unknown origin. The SA speculates that the drawdown event is the result of a long duration (i.e., 2-3 months) pumping event at Engle well, which is located approximately 2 km southeast of H-9c. Engle well is completed to the Culebra and is pumped to fill stock tanks for watering of livestock. With regards to the large water-level decrease (-8.27 ft) observed at H-10c, it is largely due to the well returning to normal levels after an oil and gas industry induced drilling disturbance discussed in the 2005 COMPs report (SNL 2006).

2.3.2.2.3 Assessment of Fresh Water Head Data

A comparison of December 2006 FWH to the CCA ranges for the 18 remaining wells used in the generation of the CCA T fields is also presented in Table 2.9. FWHs for each well were calculated using fluid densities reported in the 2006 ASER (DOE 2007c). FWHs in all the remaining Culebra wells used in the CCA are now outside the upper limit of the CCA ranges. The FWHs are outside the CCA range determinations independent of any density uncertainties, as no physically reasonable density (i.e., 1.0 to 1.25 g/cm^3) would result in calculated FWHs within the CCA ranges. It must be stated, however, that Culebra FWHs in excess of the respective CCA ranges are not likely to affect WIPP's compliance with EPA regulations.

Table 2.9. Summary of 2006 Culebra water-level changes and freshwater heads.

Well I.D.	12/05 W.L. (ft amsl)	12/06 W.L. (ft amsl)	2006 Change (ft)	12/06 FWH (ft amsl)	CCA FWH Range (ft amsl)	Outside CCA Range?
AEC-7	3161.97	3234.65	**72.68**	3274.83	3055.1-3060.4	Y
C-2737	3008.23	3012.30	**4.07**	3015.32	N/A	N/A
DOE-1	2989.01	2995.97[a]	**6.96**	3031.85	2992.5-3013.8	Y
ERDA-9	3008.84	3012.44	**3.60**	3033.82	N/A	N/A
H-2b2	3042.23	3044.97	**2.74**	3048.89	3033.8-3040.0	Y
H-3b2	2996.87	3001.12	**4.25**	3011.95	2995.1-3007.5	Y
H-4b	3002.80	3003.39	0.59	3005.29	2988.2-2992.1	Y
H-5b	3036.26	3037.67	1.41	3081.31	3060.4-3069.6	Y
H-6b	3058.28	3060.40	**2.12**	3073.86	3054.5-3061.0	Y
H-7b1	3001.00	3000.37	-0.63	3000.55	N/A	N/A
H-9c	2996.80	2991.13	**-5.67**	2992.36	2973.4-2977.7	Y
H-10c	3033.51	3025.24	**-8.27**	3031.65	3015.4-3029.9	Y
H-11b4	2984.45	2986.66	**2.21**	3006.58	2990.2-3003.3	Y
H-12	2968.54	2969.75	1.21	3001.31	2993.1-3001.0	Y
H-15	2986.58	2989.38[b]	-	3026.22	3005.2-3019.4	Y
H-17	2963.21	2965.85	**2.64**	3006.71	2985.9-2991.8	Y
H-19b0	2988.04	2992.20	**4.16**	3014.13	N/A	N/A
IMC-461	3051.83	3053.60	1.77	3054.16	N/A	N/A
P-17	2988.21	2990.67[c]	**2.46**	3006.22	2981.0-2985.6	Y
SNL-1	3078.02	3082.95	**4.93**	3088.11	N/A	N/A
SNL-2	3073.61	3074.83	1.22	3077.05	N/A	N/A
SNL-3	3070.74	3074.35	**3.61**	3086.64	N/A	N/A
SNL-5	3074.40	3077.71	**3.31**	3081.52	N/A	N/A
SNL-6	No water-level measurements due to >1000ft between top of casing and water column					
SNL-8	3029.20	3029.58	0.38	3054.38	N/A	N/A
SNL-9	3051.02	3052.59	1.57	3058.22	N/A	N/A
SNL-10	-	3054.84[d]	-	3055.13	N/A	N/A
SNL-12	3001.52	3000.94	-0.58	3001.86	N/A	N/A
SNL-13	3007.16	3008.55	1.39	3014.86	N/A	N/A
SNL-14	2990.84	2992.18[e]	1.34	3010.16	N/A	N/A
SNL-15	2788.58	2824.81	**36.23**	2885.21	N/A	N/A
SNL-16	-	3011.55	-	3012.76	N/A	N/A
SNL-17	-	3006.94	-	3007.05	N/A	N/A
SNL-18	-	3075.14	-	3078.89	N/A	N/A
SNL-19	-	3075.73	-	3077.18	N/A	N/A
WIPP-11	3066.25	3069.56	**3.31**	3088.52	N/A	N/A
WIPP-13	3060.66	3063.60	**2.94**	3082.14	3059.1-3068.2	Y
WIPP-19	3042.56	3045.96	**3.40**	3068.63	N/A	N/A
WIPP-25	3068.40	3068.84[f]	-	3075.79	3043.6-3050.2	Y
WIPP-26	3025.45	3024.14[g]	-1.31	3025.47	3013.1-3014.8	Y
WIPP-27	Plugged and Abandoned 08/06, not water-level measurements due to inaccessibility					
WIPP-30	3079.02	3080.90	1.88	3088.29	3060.4-3067.6	Y
WQSP-1	3058.76	3062.10	**3.34**	3076.34	N/A	N/A
WQSP-2	3063.93	3067.34	**3.41**	3084.46	N/A	N/A
WQSP-3	3014.56	3017.53	**2.97**	3073.11	N/A	N/A
WQSP-4	2985.47	2988.54	**3.07**	3008.56	N/A	N/A
WQSP-5	3000.70	3005.17	**4.47**	3010.86	N/A	N/A
WQSP-6	3017.91	3020.64	**2.71**	3023.17	N/A	N/A

All measurements made in December, except as noted

[a] Last water-level measurement taken 08/16/06, well plugged and abandoned 09/06

[b] Water-level elevation on 03/07/06, prior to reconfiguration for Magenta testing by SA

[c] Last water-level measurement taken 07/10/06, well plugged and abandoned 08/06

[d] Water-level elevation taken 10/10/06, first measurement taken 9/14/06, well completed 08/06

[e] Water-level measurement taken 09/11/06, prior to installation of a pump for age-dating sampling.

[f] Water-level measurement taken 01/16/06, prior to reconfiguration for Magenta testing by SA

[g] Last water-level measurement taken 08/15/06, well plugged and abandoned 10/06

N/A = not applicable; data from well not used in CCA T-field calibration or data unavailable

2.3.2.2.4 Summary of Culebra Data

Based on the assessment of Culebra water-level and density data collected during 2006, it would appear that there is no apparent change in groundwater flow. Though Culebra water level continues to rise, it is widespread and does not appear to affect flow direction or velocity (DOE, 2007c). Culebra water levels have been rising gradually, with minor short-term variability, since measurements began in 1977. Various scenarios have been proposed to explain this observed rise in Culebra water-level including: leaky boreholes (Beauheim 2003) and precipitation recharge to the Culebra through Nash Draw (Hillesheim et al. 2006; 2007). The results of the Beauheim (2003) study have been inconclusive, but have indicated that Nash Draw, a large karst valley approximately 5 km west of WIPP, may act as a local recharge zone to the Culebra (Lowry and Beauheim 2004; 2005). As mentioned above, two large rainfall events that occurred in August and September 2006 have been linked to increases in Culebra water level (Hillesheim et al. 2006) and as reported in the 2005 COMPs report (SNL 2006), a similar increase in Culebra water level was observed after a large rainfall event in September 2004 (Hillesheim et al. 2006), both of which propagated away from Nash Draw.

The investigation into the cause(s) of the observed Culebra water level rise still needs further refinement, and as part of the ongoing investigations the SA is collecting more detailed data. This new data is being used to refine the SA's conceptual model of Culebra hydrology. In addition, well testing and water-quality sampling activities being conducted by the SA are providing needed information to increase our understanding of hydrology in the WIPP vicinity.

2.3.2.3 Assessment of Data from Other Units

Results from the 2006 PD and SG measurements are compared with previous results (DOE, 2006b) in Table 2.8. Of the 10 Magenta wells with repeated PD surveys, exactly half experienced changes of $\geq \pm 0.01$ g/cm^3 in fluid density from previous measurements. All changes were relatively minor ranging between -0.010 and -0.017 g/cm^3 and are probably related to problems with the equipment discussed in Section 2.3.2.2.1. Changes in fluid density in 2005, however, may be linked to well reconfiguration activities completed on H-2b1, H-14, and H-18 in 2005 (DOE 2006c).

Assessment of water-level changes from other hydrologic units present in the WIPP vicinity (Table 2.10) is important for refining the conceptual model of overall 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. Water levels in all 15 Magenta wells rose during 2006, continuing the long-term trend. Water-level rises ranged from 0.15 to 66.71 ft, with only four wells experiencing water-level increases of $\geq$2.0 ft. As mentioned above, wells H-2b1, H-14, and H-18 were reconfigured in 2005 (Salness 2006) and were still recovering from those activities throughout 2006. At WIPP-30 the PIP was reset in April 2006 after it was determined that it had failed, which resulted in a new, representative Magenta water level.

Table 2.10. Summary of 2006 water-level changes in units other than the Culebra.

Well I.D.	12/05 W.L. (ft AMSL)	12/06 W.L. (ft AMSL)	2006 Change (ft)
Magenta Wells			
C-2737	3143.72	3144.18	1.46
H-2b1	3074.81	3140.84	**66.03**
H-3b1	3146.27	3146.65	0.38
H-4c	3146.25	3146.44	0.19
H-6c	3067.39	3068.47	1.08
H-8a	3027.06	3027.21	0.15
H-9c	3135.93	3136.23	0.30
H-10a	3223.33	3223.63	0.30
H-11b2	3138.07	3138.45	0.38
H-14	3089.67	3133.80	**44.13**
H-15	3124.21[a]	3124.13[b]	N/A
H-18	3074.90[c]	3141.61	**66.71**
WIPP-18	3148.56	3149.36	0.80
WIPP-25	3063.97	3064.28[d]	N/A
WIPP-30	3078.34	3122.96e	**44.62**
Dewey Lake Wells			
WQSP-6a	3196.73	3196.91	0.18
Bell Canyon Wells			
CB-1	2727.05	2729.96	**2.91**
DOE-2	2683.62	2689.23	**5.61**

All measurements made in December, except as noted

[a] November 2005, no measurements after this date due to SA testing activities

[b] March 2006, only measurement in 2006 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] January 2006, only measurement in 2006 due to SA testing activities.

N/A = not available

Bold = changes in water level ≥ ±2.0 ft

The water level was stable within 0.50 ft in WQSP-6a, the Dewey Lake well (Table 2.10). The two wells completed to the Bell Canyon showed water-level rises of ≥2.0 ft during 2006 (Table 2.10). In both wells the water-level rises are a continuation of the previous year's trend. The water level in DOE-2 appears to still be recovering from reconfiguration activities conducted in June 2004 as the water level in DOE-2 in December 2006 was ~345 ft lower than the last measurement made in March 1986, before the well was recompleted to the Culebra.

Changes in Groundwater Flow - 2007:

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 - Data acquired between January and December of 2006

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 models - T-field assumptions and groundwater basin model.

Monitoring Data Trigger Values

Monitoring Parameter ID	Trigger Value	Basis
Change in Culebra Groundwater Flow	CCA range; see Table 2.9	Annual comparisons with ranges of undisturbed steady-state freshwater heads used to calibrate Culebra T fields for CCA.

2.4 Waste Activity

The reporting period for the waste activity COMP started at first waste receipt and ended on June 30, 2007. At this time, CH emplacement had progressed to room 6 of Panel 4 and RH had progressed to room 5 of the same panel. 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.

There are no TVs for CH activity, only RH. The TV for RH is the regulatory limit of 5.1 million Curies. This is the first reporting period for RH waste. The total curies of RH waste for the period ending June 30, 2007 is 1.86×10^2 Curies, well below the TV. 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 (DOE 2004).

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

Radionuclide CCA Table 4-10)	Non-Decayed CH Inventory as of June 30, 2007	Non-Decayed RH Inventory as of June 30, 2007	Non-Decayed Total Activity as of June 30, 2007	PABC Total Inventory at Closure (2033)
^{241}Am	1.827×10^5	4.251	1.827×10^5	5.17×10^5
^{137}Cs	1.253	95.360	96.622	2.07×10^5
^{238}Pu	9.97×10^4	2.419	9.978×10^4	1.13×10^6
^{239}Pu	2.652×10^5	8.760	2.652×10^5	5.82×10^5
^{240}Pu	6.415×10^4	4.611	6.416×10^4	9.54×10^4
^{242}Pu	9.659	1.454×10^{-3}	9.660	12.70
^{90}Sr	3.054	72.1	73.650	1.76×10^5
^{233}U	2.640	70.600	2.656	1.23×10^3
^{234}U	16.820	2.841×10^{-2}	16.850	3.44×10^2
^{238}U	10.530	1.684×10^{-4}	10.530	2.17×10^2
Total	6.119×10^5	1.860×10^2	6.121×10^5	2.71×10^6

Waste Activity - 2007:

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 7/1/2006 to 6/30/2007			
Total curie content of emplaced CH-TRU and RH-TRU waste. *[Total radionuclide inventories reported by WWIS]*			
Year 2007 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. 2005a.	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 (DOE 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.

4 References

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

Crawley, M.E., and M. Nagy. 1998. *Waste Isolation Pilot Plant RCRA Background Groundwater Quality Baseline Report.* DOE/WIPP 98-2285. Albuquerque, NM: IT Corporation for Westinghouse Electric Corporation.

DOE (U. S. Department of Energy). 2007a. *Delaware Basin Monitoring Annual Report,* DOE/WIPP-07-2308, September 2007.

DOE (U. S. Department of Energy). 2007b. *Geotechnical Analysis Report for July 2005–June 2006* DOE/WIPP07-3177, Volume 1 & 2, March 2007.

DOE (U.S. Department of Energy). 2007c. *Waste Isolation Pilot Plant Site Environmental Report for 2006.* DOE/WIPP 07-2225. Carlsbad, NM: US DOE.

DOE (U. S. Department of Energy). 2006a. *WIPP Subsidence Monument Leveling Survey 2006*, DOE/WIPP 07-2293, December 2006.

DOE (U. S. Department of Energy). 2006b. *Waste Isolation Pilot Plant 2005 Site Environmental Report,* DOE/WIPP-06-2225, September 2006.

DOE (U. S. Department of Energy). 2006c. *Basic Data Report for Well Plugging and Abandonment and Reconfiguration Activities for Fiscal Year 2005.* DOE/WIPP 05-3326

DOE (U.S. Department of Energy). 2005. *40 CFR Parts 191 and 194 Compliance Monitoring Implementation Plan,* DOE/WIPP 99-3119, Revision 4, April 2005.

DOE (U. S. Department of Energy). 2004. *Title 40 CFR Part191 Compliance Recertification Application for the Waste Isolation Pilot Plant*, DOE/WIPP 2004-3231, March 2004.

DOE (U. S. Department of Energy). 2003. *Strategic Plan for Groundwater Monitoring at the Waste Isolation Pilot Plant*, DOE/WIPP 03-3230, February 2003.

DOE (U.S. Department of Energy). 1996. *Title 40 CFR Part191 Compliance Certification Application for the Waste Isolation Pilot Plant*, DOE/CAO 1996-2184, October 1996.

EEG (Environmental Evaluation Group). May 1998. *Sensitivity Analysis of Performance Parameters used in Modeling the WIPP.* EEG-69/DOE AL58309-69, Carlsbad, NM.

EPA (U.S. Environmental Protection Agency). 2006. 40 CFR Part 194: Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's Compliance With the Disposal Regulations: Recertification Decision; Final Rule." Federal Register, Vol. 71, pp. 18010, April 10, 2006, Office of Radiation and Indoor Air, Washington, D.C.

EPA (U.S. Environmental Protection Agency). 2004. E-mail from Betsy Forinash, to Lloyd Piper, Assistant Manager Carlsbad Fields Office, requesting analyses of increased drilling rates. December 3, 2004. ERMS# 538307.

EPA (U.S. Environmental Protection Agency). 2003. Letter from Frank Marcinowski, Director of Radiation Protection Division to Ines Triay, Manager of Carlsbad Field Office, August 8, 2003.

EPA (U.S. Environmental Protection Agency). 1998a. 40 CFR Part 194: Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's Compliance With the Disposal Regulations: Certification Decision; Final Rule." Federal Register, Vol. 63, No. 95, pp. 27396, May 18, 1998. Office of Radiation and Indoor Air, Washington, D.C.

EPA (U.S. Environmental Protection Agency). 1998b. Technical Support Document for Section 194.23: Sensitivity Analysis Report, May 1998. Office of Radiation and Indoor Air, Washington, D.C.

EPA (U.S. Environmental Protection Agency). 1996. 40 CFR Part 194: Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR part 191 Disposal Regulations; Final Rule. *Federal Register*, Vol. 61, No. 28 pp. 5224-5245, February 9, 1996. Office of Radiation and Indoor Air, Washington, D.C.

EPA (U.S. Environmental Protection Agency). 1993. 40 CFR Part 191: Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuels, High Level and Transuranic Radioactive Wastes: Final Rule. *Federal Register*, Vol. 58, No.242, pp. 66398-66416, December 20, 1993. Office of Radiation and Indoor Air, Washington, D.C.

Freeze, R.A., and J.A. Cherry. 1979. *Groundwater*. Englewood Cliffs, NJ: Prentice-Hall, Inc. 604 p.

Hillesheim, M.B., N.J. Toll, and L.A. Hillesheim. 2007. *Mapping of Pressure-Head Responses of a Fractured Rock Aquifer to Rainfall Events*. U.S. Environmental Protection Agency/National Groundwater Association Fractured Rock Conference, 24-26 September 2007, Portland, ME.

Hillesheim, M.B., R.L. Beauheim, and R.G. Richardson. 2006. *Overview of the WIPP Groundwater Monitoring Programs with Inferences about Karst in the WIPP Vicinity.* New Mexico Geological Society, 57th Annual Fall Field Conference Guidebook, Caves and Karst of Southeastern New Mexico. 277-286 pp.

IT Corporation. 2000. *Addendum 1, Waste Isolation Pilot Plant RCRA Background Groundwater Quality Baseline Update Report.* Prepared for Westinghouse Electric Corporation, Carlsbad, NM.

Kanney, J. F., and T. B. Kirchner. 2004. Impact of Potential Drilling Rate Increases on WIPP Repository Performance. Technical Memorandum, Sandia National Laboratories, Carlsbad, NM. ERMS # 538262.

Leigh, C.D., J. Trone and B. Fox. 2005a. *TRU Waste Inventory for the 2004 Compliance Recertification Application Performance Assessment Baseline Calculation.*, Sandia National Laboratories, Carlsbad, NM. ERMS # 541118.

Leigh, C.D., J.F., Kanney, L. Brush, J. Garner, G.R. Kirkes, T. Lowry, M. Nemer, J.S. Stein, E. Vugrin and S.W. Wagner. 2005b. *2004 Compliance Recertification Application Performance Assessment Baseline Calculation,* , Sandia National Laboratories, Carlsbad, NM. ERMS# 541521.

Lowry, T.S., and R.L. Beauheim. 2005. *Analysis report, Task 3 of AP-110, evaluation of water-level rise in the Culebra due to leakage through poorly plugged and abandoned potash boreholes.* ERMS# 540187, Sandia National Laboratories Carlsbad, NM. 91 p.

Lowry, T.S., and R.L. Beauheim. 2004. *Analysis report, Task 2 of AP-110, evaluation of water-level rise in the Culebra due to recharge from refining process water discharged onto potash tailings pile*, Sandia National Laboratories, Carlsbad, NM. 57 p. ERMS# 536239

Park, B-Y and J. F. Holland. 2003. Structural Evaluation of WIPP Disposal Room Raised to Clay Seam G. SAND2003-3409. Sandia National Laboratories, Albuquerque NM.

Patchet, S. J., R. C. Carrasco, C. T. Franke, R. Salari, and S. Saeb. 2001. *Interaction Between Two Adjacent Panels at WIPP,* Proc. 38th U. S. Rock Mechanics Symposium, Washington, D. C., pp. 517 – 523, Eds. D. Elsworth, J. P. Tinucci, and K. A. Heasley, A. A. Balkema Publishers, July 2001.

SNL (Sandia National Laboratories). 2006. *Sandia National Laboratories Annual Compliance Monitoring Parameter Assessment (for Year 2005).* Carlsbad, NM: Sandia National Laboratories.

SNL (Sandia National Laboratories). 2002a. *Trigger Value Derivation Report,* Sandia National Laboratories, Carlsbad, NM, May 2002, ERMS #. 510062.

SNL (Sandia National Laboratories). 2002b. *Sandia National Laboratories Annual Compliance Monitoring Parameter Assessment Report for 2002*, Sandia National Laboratories, Carlsbad, NM, November 2002, ERMS# 524449.

SNL (Sandia National Laboratories). 2000a. *An Analysis Plan for Annually Deriving Compliance Monitoring Parameters and their Assessment Against Performance Expectations to Meet the Requirements of 40 CFR 194.42,* AP-069 Revision 0, Sandia National Laboratories, Carlsbad, NM., March 2000.

SNL (Sandia National Laboratories). 2000b. *Sandia National Laboratories Annual Compliance Monitoring Parameter Assessment (for Year 2000).* WBS 1.2.10.09.01.02, Sandia National Laboratories, Carlsbad, NM, October 2000, ERMS # 510062.

U.S. Congress. 1992. Waste Isolation Pilot Plant Land Withdrawal Act. Public Law 102-579, October 1992. 102nd Congress, Washington, D.C.

Wagner, S.W. 2005. *Analysis Plan for Monitoring Parameter Assessment per 40 CFR 194.42 Using the 2005 Recertification Baseline Performance Assessment Results,* , Sandia National Laboratories, Carlsbad, NM. ERMS# 540672.

WID (Waste Isolation Division), Westinghouse. 1994. Backfill Engineering Analysis Report, IT Corporation for WID.

WTS (Westinghouse TRU Solutions). 2002. Subsidence Survey Data Acquisition Report, WP 09-ES4001, June 2002.