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Sandia National Laboratories Compliance Monitoring Parameter Assessment For 2005

WBS 1.3.1

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Pkg. No.

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Executive Summary

This document reports the seventh annual (2005) derivation and assessment of the Waste Isolation Pilot Plant (WIPP) Compliance Monitoring Parameters (COMPs). The COMPs program is a requirement of the U.S. Environmental Protection Agency's (EPA) long-term disposal regulations (EPA 1993 and 1996). The concept of deriving and assessing COMPs is explained in Sandia National Laboratories (SNL) Nuclear Waste Management Program Analysis Plan, AP-069 titled: *An Analysis Plan for Annually Deriving Compliance Monitoring Parameters and their Assessment Against Performance Expectations to Meet the Requirements of 40 CFR 194.42* (SNL 2000a).

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

The Department of Energy (DOE) uses performance assessment (PA) to predict the containment performance of the WIPP. COMPs are then used to indicate conditions that are not within the PA data ranges, conceptual model assumptions or expectations of the modelers and to alert the project of conditions not accounted for or expected. COMPs values and ranges were developed such that exceedance of these values indicate a condition that is potentially outside PA expectations. These values were appropriately termed "trigger values." Deriving COMPs trigger values (TV) was the first step in assessing the monitoring data. TVs were derived in 1999 and are documented in the *Trigger Value Derivation Report* (SNL 2002a). In some instances a COMP will not have a TV because sensitivity analysis has demonstrated that PA is insensitive to that parameter (EPA 1998b).

This COMPs Report falls between the time the Compliance Recertification Application (CRA-2004) was submitted and an EPA certification notification. The EPA has also requested a new PA in support of the recertification called the performance assessment baseline calculation (PABC) which is in progress (EPA 2005). As such, a revised baseline for which to assess COMPs has not been established. Therefore, this year's COMPs assessment compares the parameters against the original certification baseline. Work has been initiated to reassess the compliance monitoring program (per 40 CFR § 194 .42) against the recertification baseline to update the current program if warranted. However, this work cannot be completed until a recertification baseline is established through EPA's recertification determination expected in early 2006. It is expected that the next COMPs assessment will be assessed against the recertification baseline.

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

[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.

repository and report any condition adverse to the containment performance. This compliance monitoring program is described in greater detail in DOE's *40 CFR Parts 191 and 194 Compliance Monitoring Implementation Plan* (MIP; DOE 2005a).

This document reports these results and the recommendations based on the 2005 COMPs Assessment. This assessment concludes that the COMP values assessed in this report do not indicate a condition for which the repository will perform in a manner other than that represented in the WIPP certification PAs.

1 Introduction

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

The COMPs are an integral part of the overall WIPP monitoring strategy. The DOE's MIP (DOE 2005a) describes the overall monitoring program and responsibilities for COMPs derivation and assessment. This report documents the results of the reporting year 2005 COMPs assessment (July 1st 2004 to June 30th 2005). The reporting period has changed to match the reporting period of the 194.4(b)(4) report (EPA 2003). This reporting cycle overlaps the WIPP recertification[2]. After the recertification baseline is complete, a new analysis similar to that performed to comply with 40 CFR § 194.42 will be used to determine if new parameters should be monitored or if other changes should be made to the COMP program. The next COMPs report is expected to be derived under the new program pending recertification, establishment of a revised baseline and completion of a monitoring assessment. Because recertification activities have not been completed, 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. Observations beyond the acceptable range of TVs represents a condition that requires further actions, but does not indicate an out-of-compliance condition. This approach assures that conditions that are not consistent with expected repository performance are recognized as early as possible. These conditions may include data inconsistent with the conceptual models implemented in PA, or invalidation of assumptions and arguments used in the screening of Features, Events and Processes (FEPs) screened into PA.

1.2 Reporting Cycle

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

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

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

2 Assessment of COMPs

The compliance monitoring program tracks the following ten COMPs:

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

An 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 2005 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 one new brine encounter during this reporting period bringing the total of encounters identified since the CCA to six.

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 2004b, Table 11 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 2004. 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 2004b).

As reported in WID 2001, there were two Castile Brine encounters reported by area drillers to WIPP Site personnel that do not appear in records on file at New Mexico Oil Conservation District (NMOCD) offices. The following year, WID (2002) reported that three additional brine encounters were reported to site personnel that do not appear in the well records at the NMOCD offices. Two of the encounters were located northeast of the WIPP Site near ERDA 6. These wells were reported to have an initial brine flow of several hundred barrels per hour. All brine was contained within the drilling pits and therefore did not require reporting to the NMOCD. The third encounter was to the southwest of the WIPP Site reporting an initial rate of 400 to 500 barrels per hour that dissipated in a matter of minutes.

During last year's reporting period, WIPP Site personnel were informed of a possible Castile Brine encounter during the drilling of the Apache "13" Federal #3 located in T22S-R30E-13. Strong water flow with blowing air was encountered at 2,850-3,315 ft. Hydrogen sulfide was recorded at 362 ppm. At the first encounter of hydrogen sulfide, the well was shut in for several hours while additional monitoring equipment was installed. The water flow had no impact on drilling operations (DOE 2004b).

During this year's reporting period, WIPP Site personnel were informed in March of a Castile Brine encounter during the drilling of Jaque "AQJ" State # 7. Brine was encountered at a depth of approximately 2,850 ft with a flow of approximately 100 barrels per hour. Hydrogen sulfide was recorded at 1,300 ppm. Drilling continued during the brine encounter (DOE 2005b).

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 brine reservoirs. In the Performance Assessment Verification Test (PAVT), the EPA mandated a range of 0.01 to 0.6. These higher values did not influence the predicted performance of the repository. Thus, the EPA determined that this parameter (PBRINE) does not have a significant impact on PA results (EPA 1998b). Additionally, the PAVT parameter values have been incorporated into the compliance baseline and have been used in recertification calculations.

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	03/4/05	Oil Well: Estimated 100 barrels per hour. 1,300 ppm H_2S was reported. Continued drilling.

Probability of Encountering a Brine Reservoir - 2005:

<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">0.08 constant – CCA
0.01 to .60 - PAVT</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 2005 COMP Assessment Value - Reporting Period 9/1/2004 to 8/31/2005</td></tr>
<tr><td colspan="5">No new data reported in State record during the reporting period; One new report from Field Observations. 33 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 drilling rate that was 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 – 1996 for the CCA value). The rate reported in the CCA using this equation was 46.8 boreholes per square kilometer over 10,000 years. Including the time period after the CCA (June 1995 to June 2005) increases the rate to 55.1 boreholes per square kilometer per 10,000 years (DOE 2004b). This increase from 46.8 to 55.1 boreholes per square kilometer over 10,000 years indicates the increased drilling rates over the past 5 years versus the average for the previous 100 years.

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

As shown in Table 2.2, the drilling rate has risen from 46.8 holes per square kilometer to 55.1 holes per square kilometer since 1996. The rate will continue to climb because of the method used to calculate the rate. Since the first well drilled in the area occurred in 1911, it will be 2011 before one well is dropped from the count and 2014 before the next well is dropped from the count. In the meantime, numerous wells will have been added, increasing the drilling rate.

Although the drilling rate TV was exceeded in 2004, the exceedance was expected. As discussed in the Delaware Basin Monitoring Annual Report, the drilling rate will continue to rise with each new well drilled until the 100 year window moves to a time when there are more older wells removed from consideration than new wells are added. Studies have demonstrated that much higher drilling rates are needed to impact compliance (EEG 1998). For example, in response to a recent request from EPA (EPA 2004), the SA has analyzed the impact of increases in modeled drilling rates on repository performance. This analysis shows that even if the drilling rate were doubled relative to that used for the CRA-2004 PA, the disposal system performance would be well within the release limits set forward in EPA regulations (Kanney and Kirchner 2004). Additionally, the recertification PA has used a new 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 - 2005:

<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 2005 COMP Assessment Value - Reporting Period 9/1/2004 to 8/31/2005</td></tr>
<tr><td colspan="5">(12,732 boreholes on record for the Delaware Basin) Drilling Rate = 55.1 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>4.68E-03 per square kilometer per year (CCA)[3]</td><td>Cuttings/cavings releases increase proportionally with the drilling rate. It would require a 23-fold increase in the drilling rate to exceed the EPA release limit at a probability of 0.1 (EEG 1998).</td></tr>
<tr><td colspan="5">Monitoring Data Trigger Values</td></tr>
<tr><td>Monitoring Parameter ID</td><td>Trigger Value</td><td colspan="3">Basis</td></tr>
<tr><td>Deep boreholes drilled (derived from the sum of the five monitoring parameters given above)</td><td>53.5 boreholes per square kilometer per 10,000 yrs.</td><td colspan="3">CCA direct releases are influenced by drilling rate changes, however only a dramatic and improbable change in drilling rate could affect compliance with the containment requirements. There is little information upon which to justify the choice of a TV based on FEP screening decisions. Therefore, a change in the drilling rate greater than approximately 15% (i.e., greater than 53.5 boreholes per square kilometer per 10,000 years) is considered prudent as a TV to revisit the low-consequence assumptions associated with the effects of abandoned boreholes on fluid flow and climatic changes used to construct the PA calculations.</td></tr>
</table>

[3] CRA-2004 value is 5.25E-03 per square kilometer per year

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 2005c) and the annual Subsidence Monument Leveling Survey (DOE 2004c). 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 2005c) summarizes data collected from July 2003 through June 2004.

Subsidence monitoring leveling 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 2004c) summarizes data collected between August and December of 2004.

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. 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 (or 900%) 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, (2) the Northern Experimental Area, and (3) 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. Panels 1, 2 and 3 have been fully excavated. Panel 1 has been filled with waste and the entry drifts have been sealed to prevent access. Presently, waste disposal is occurring in Panel 2. Panel 3 is located 2.4-m higher in the stratigraphic sequence as indicated in Figure 2.1 by the ramps shown in the long North-South haulage drifts.

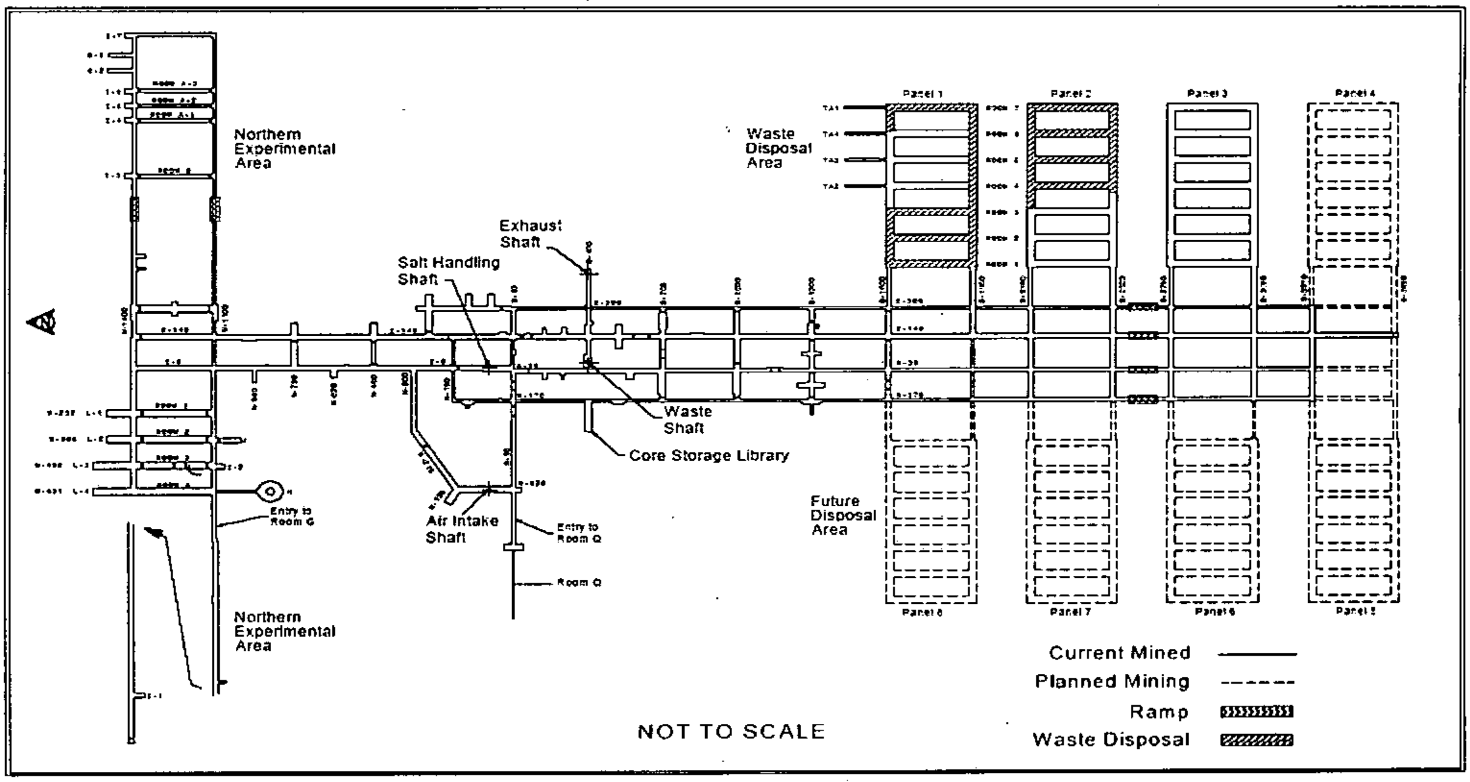

Figure 2.1 Configuration of the WIPP Underground for Geotechncial COMPs (after DOE 2005c Reporting Period July 2003 through June 2004)

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 unreinforced concrete. Reinforced concrete keys are cast at the Salado/Rustler interface with the shafts extending through the keys to the Salado. Below the keys, the shafts are essentially "open holes" through the Salado Formation and terminate either at the repository horizon or at sumps that extend approximately 40 m below the repository horizon. In the Salt Handling Shaft, a steel liner is grouted in place from the ground surface to the top of the Salado. Similar to the three other shafts, the Salt Handling Shaft is configured with a reinforced concrete key and is "open-hole" to its terminus. For safety purposes, the portions of the open shafts that extend through the Salado are typically supported using wire mesh anchored with rock bolts to contain rock fragments that may become detached from the shaft walls. Within the Salado Formation, the shaft diameters range from 3.65 m to 7.0 m.

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

Shortly after its construction, each shaft was instrumented with extensometers to measure the inward movement of the salt at three levels within the Salado Formation. In addition to COMPs assessment, measurements of shaft closure are used periodically as a calibration of calculational models and have been used in shaft seal system design. The approximate depths corresponding to the three instrumented levels are 330 m, 480 m and 630 m. Three extensometers are emplaced at each level to form an array. The extensometers comprising each array extend radially outward from the shaft walls and are equally spaced around the perimeter of the shaft wall. Over the years, some 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 (July 2003 – June 2004) displacement rates of the shaft walls based on extensometer data reported in the GAR (DOE 2005c). There were no data reported in the GAR for the Waste Handling Shaft for this reporting period. The rates for the Exhaust Shaft make use of collar displacement measured relative to the deepest anchor for individual extensometers. Rates range from 0.015 in/yr to 0.077 in/yr (0.038 cm/yr to 0.196 cm/yr) and increase with depth, as expected, because of the higher stress levels associated with the overburden at greater depth. Dividing the displacement rates by the typical shaft radius (approximately three meters) and expressing the results in units of 1/sec yields creep rates that range from 4.01×10^{-12}/s to 2.07×10^{-11}/s. These creep rates are very low and are typical of rates for stable openings mined from salt. Table 2.3 also gives displacement rates for the previous reporting period (2002 to 2003) and the percentage change in these rates compared to the current rates. In general, the rate changes are small and all are negative indicating creep rates are slowing. Based on visual observations and quantitative displacement measurements, creep deformations associated with the WIPP shafts are acceptable and meet the TV requiring creep deformation rates to change by less than one-order of magnitude in a one-year period.

Shaft Station. Shaft station openings are typically rectangular in cross-section with heights ranging from approximately 4 to 6 m and widths ranging from 6 to 10 m. Over the life-time of the individual shaft stations, modifications have been made that have altered the dimensions of the openings. For example, 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.

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 (2003-2004) and the previous reporting period (2002-2003) are summarized in Table 2.3. Creep data are available only for the Exhaust Shaft and Waste Shaft Stations (data for the Air Intake Shaft Station are reported below under the Access Drift section of this report, there were no data for the Waste Handling Shaft during this reporting period). Most of the measurements are for vertical closure. Based on convergence data, current vertical displacement rates range from 0.546 to 1.666 in/yr (1.39 to 4.23 cm/yr), while current horizontal displacement rates range from 0.871 to 1.609 in/yr (2.21 to 4.10 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 7.3×10^{-11}/s to 2.2×10^{-10}/s. These rates are somewhat higher than those measured in the shafts but 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 are essentially identical to those measured during the previous reporting period. Based on the extensometer and convergence data, as well as the limited maintenance required in the shaft stations during the last year, creep deformations associated with the WIPP shaft stations are considered acceptable and meet the TV requiring creep deformation rates to change by less than one-order of magnitude in a one-year period.

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

Location	Inst. Type[a]	Displacement Rate (in/yr)		Change In Rate (%)
		2002–2003	2003–2004	
Salt Handling Shaft	No extensometers remain functional			
Waste Handling Shaft				
1071 ft (326 m) level, S15W	Ext	0.006	nr	-
1566 ft (477 m) level, N45W	Ext	0.026	nr	-
1566 ft (477 m) level, N75E	Ext	0.023	nr	-
1566 ft (477 m) level, S15W	Ext	0.027	nr	-
2059 ft (628 m) level, N45W	Ext	nr[c]	nr	-
2059 ft (628 m) level, N75E	Ext	0.074	nr	-
2059 ft (628 m) level, S15W	Ext	0.088	nr	-
Exhaust Shaft				
1573 ft (479 m) level, N75E	Ext	0.019	0.015	-22
1573 ft (479 m) level, N45W	Ext	0.020	0.016	-21
1573 ft (479 m) level, S15W	Ext	0.022	0.016	-21
2066 ft (630 m) level, N75E	Ext	0.086	0.077	-10
2066 ft (630 m) level, S15W	Ext	nr	Nr	–
Salt Handling Shaft Station				
E0 Drift – N39 (Vert. CL[b])	CP	nr	nr	–
E0 Drift – N39 (Horiz. CL)	CP	nr	nr	–
E0 Drift – W12 (Vert CL)	CP	0.927	0.847	-9
E0 Drift – S18 (Vert. CL)	CP	1.738	1.609	-7
E0 Drift – S30 (Vert. CL)	CP	1.820	1.666	-8
E0 Drift – S65 (Vert. CL)	CP	1.341	1.216	-9
Waste Shaft Station				
S400 Drift – W30 (Vert. CL)	Ext	0.334	0.546	63
S400 Drift – E140 (Vert. CL)	Ext	0.692	1.260	82
S400 Drift – E30 (Horiz. CL)	CP	0.900	0.871	-3
S400 Drift – E90 (Horiz. CL)	CP	0.980	0.981	~ 0
Air Intake Shaft Station	Information provided below under access drift discussion			

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

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 2003 to June 2004), final excavations of Panel 3 were completed; no other new excavations were made. Panel 3 was excavated at a slightly higher stratigraphic position (2.4 m) than either Panels 1 or 2. The Panel 3 roof is coincident with Clay G. As such Panels 1, 2, 7 and 8 will be at the original horizon and Panels 3, 4, 5 and 6 approximately 2.4 m higher in elevation (roof at Clay G).

Assessment of creep deformations in the access drifts is made through the examination of extensometer and convergence point data reported annually in the GAR. Tables 2.4 and 2.5

summarize, respectively, the vertical and horizontal displacement data reported in the most recent GAR (DOE 2005c). Each table examines percentage changes between displacement rates measured during the current and previous annual reporting periods and breaks these percentage changes into ranges (e.g, 0 to 25%). Only data from instruments located along the drift centerlines are reported here. In addition, extensometer data are based only on the displacements of the collar relative to the deepest anchor. The numbers shown in the tables represent the number of instrumented locations that fall within the range of the indicated percentage change. For example, data from twenty-eight vertically-oriented extensometers installed in the access drifts were assessed with fifteen of these instruments showing percentage changes < 0% (i.e., the rate decreased or slowed), eleven showing changes between 0 and 25%, none showing changes between 25 and 50%, one showing changes between 50 and 75%, none showing changes between 75 and 100%, and one showing changes between 100 and 200%. The maximum displacement rates corresponding to these data are given below:

Maximum Vertical Displacement Rates Along Access Drift Centerlines:

2.84 cm/yr – based on extensometer data
22.86 cm/yr – based on convergence point data

Maximum Horizontal Displacement Rate Along Access Drift Centerlines:

6.20 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 15×10^{-10}/s. This rate is relatively high so further analyses were performed as described below.

Most (approximately 97% of all data) of the changes in vertical and horizontal displacement rates fall within three categories or subdivisions shown in Tables 2.4 and 2.5, i.e., < 0%, 0 to 25%, and 25 to 50% indicating that current creep deformations in the access drifts are approximately the same as they were for the previous reporting period. The few remaining data show relatively large changes in rate and indicate accelerations of displacement in some locations. As a general rule, accelerations in displacement would be cause for concern; however, a careful examination of these relatively large accelerations in displacement reveals that the extensometers/convergence points associated with these accelerations are associated with recent mining of Panel 3 and excavation of the access drifts. According to the GAR (DOE 2005c), the rates in East 140, from South 1882 to South 2998, where the roof has been mined to Clay G show an increase in the closure rates. These rates are expected to decrease over time as the roof beam removal effect subsides.

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

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

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

Location	Number of Instrument Locations Where the Indicated Percentage Change has Occurred					
	Percentage Increase in Displacement Rate for Measurements Made During the 2001-2002 and 2002-2003 Reporting Periods					
	< 0%	0 – 25%	25 – 50%	50 – 75%	75 – 100%	100 – 200%
Access Drifts						
Extensometers[a]	15	11	0	1	0	1
Convergence Points	76	56	2	1	1	2
Waste Disposal Area Panel 2:						
Extensometers[a]	0	5	2	1	0	2
Convergence Points	9	21	4	0	0	0

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

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

Location	Number of Instrument Locations Where the Indicated Percentage Change has Occurred				
	Percentage Increase in Displacement Rate for Measurements Made During the 2001-2002 and 2002-2003 Reporting Periods				
	< 0%	0 – 25%	25 – 50%	50 – 75%	75 – 100%
Access Drifts					
Extensometers[a]	0	0	0	0	0
Convergence Points	43	34	0	0	0
Waste Disposal Area Panel 2:					
Extensometers[a]	0	0	0	0	0
Convergence Points	0	21	1	1	0

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

Assessment of creep deformation in the waste disposal area is made through the examination of extensometer and convergence point data reported annually in the GAR. Tables 2.4and 2.5 (presented previously) summarize, respectively, the vertical and horizontal displacement data reported in the most recent GAR (DOE 2005c) for Panel access drifts and Panel 2 only. Panel 1 is no longer monitorable while Panel 3 monitoring has only recently started (two years worth of data are necessary). 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:

11.30 cm/yr – based on convergence point data

6.94 cm/yr – based on extensometer data

Maximum Horizontal Displacement Rates along Waste Disposal Area Centerlines:

7.78 cm/yr – based on convergence point data

Using a nominal disposal-area-opening dimension of 8 m and the maximum displacement rates shown above yields an inferred maximum creep rate of approximately $4.8x10^{-10}$/sec. Maximum creep rates for the waste disposal area are less than the maximum creep rates observed for the access drifts and are considered acceptable. Furthermore, most of the changes in creep rate are negative even though Panel 3 was recently excavated.

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

Creep Closure - 2005:

<table>
<tr><td colspan="5">Trigger Value Derivation</td></tr>
<tr><td>COMP Title:</td><td colspan="4">Creep Closure</td></tr>
<tr><td>COMP Units:</td><td colspan="4">Closure Rate (sec^{-1})</td></tr>
<tr><td colspan="5">Related Monitoring Data</td></tr>
<tr><td>Monitoring Program</td><td>Monitoring Parameter ID</td><td>Characteristics
(e.g., number, observation)</td><td colspan="2">Compliance Baseline Value</td></tr>
<tr><td>Geotechnical</td><td>Closure</td><td>Instrumentation throughout the underground.</td><td colspan="2">Munson-Dawson (MD) Constitutive Model</td></tr>
<tr><td colspan="5">COMP Derivation Procedure - Reporting Period July 2003 through June 2004</td></tr>
<tr><td colspan="5">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.</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>Repository Fluid Flow</td><td>Creep Closure</td><td>Porosity Surface, waste compaction, characteristics, waste properties, evolution of underground setting</td><td>SANTOS, porosity surface calculations</td><td>Provides validation of the CCA creep closure model.</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>Creep Closure</td><td>Greater than one order of magnitude increase in closure rate.</td><td colspan="3">The closure rate increase signals potential de-coupling of rock.</td></tr>
</table>

2.2.2 Extent of Deformation

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

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

The Geotechnical Engineering Department at WIPP has compiled back-fracturing data into a database. The supporting data for the GAR (Volume 2, DOE 2005c) 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.

The SA has conducted independent field investigations to understand the spatial and temporal development of the DRZ. In 1988, when the Air Intake Shaft (AIS) was constructed, three acoustic transducer arrays were installed in the shaft at depths of 343 m, 480 m, and 626 m below ground surface (Hardy and Holcomb 2000). Each array consists of transducers permanently installed in three holes drilled parallel to each other. Two holes are aligned in the vertical plane and two in the horizontal plane, forming an "L" shape and angled upward at 45°. Multiple transmitter-receiver transducer pairs were installed in each hole which allowed the measurement of transmitted signal velocities and amplitudes along 216 paths parallel, perpendicular, and tangential to the shaft walls. Velocity measurements have been made continuously since the arrays were installed and data were acquired using a stand-alone data logger. Velocity is considered a good metric for estimating the extent of the DRZ because as microfractures initiate and grow in geologic media such as salt, velocity is known to decrease. In 2000, Hardy and Holcomb presented the results of nine years of velocity measurements taken at the deepest array (626 m) and determined that a DRZ had formed around the AIS, but it only extended into the salt about 0.5 to 1 m. During the last year, the M&OC has indicated that it no longer has the resources to maintain data logging capability for the three acoustic transducer arrays. As a result, the SA has decommissioned the experiment and is analyzing the nearly 15 years of data. Preliminary analysis suggests that the DRZ at the 626-m level of the AIS has grown, although not significantly, perhaps from 1 to 2 m.

In 2000 – 2001, the SA also conducted similar ultrasonic velocity measurements in parallel boreholes drilled normal to the ribs of the Q Room Alcove and in angled boreholes drilled in an inside corner of the Q Room Alcove (Holcomb and Hardy 2001). In contrast to the AIS investigation, the Q Room Alcove tests made use of acoustic tools that were not permanently installed in the holes but could be moved and positioned at any location along the lengths of the holes. Velocity measurements made with these tools indicated the development of a DRZ that extended approximately 1 to 2 m into the room ribs. Results of these investigations should be documented in a report expected to be completed in late 2005.

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 planned 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 (DOE 2005c) suggest that brittle deformation extends at least 2.4 m (to Clay Seam G) and perhaps as much as 4.5 m (to Clay Seam H) above the roof of the WIPP openings. In addition, brittle deformation extends below the floor of the openings to at least the base of Marker Bed 139 (approximately 2 to 3 m). Previous and ongoing studies performed by the SA to characterize the DRZ have shown that the extent of brittle deformation is about 1 to 2 m; however, these results are for a single snapshot in time providing little information on how brittle deformation evolves with time.

Data provided in the 2004 GAR (DOE 2005c) was compared to fracture maps in the 2003 GAR (DOE 2004d) to determine if fractures exceed the 1m/yr TV. This comparison did not identify data exceeding the TV.

Extent of Deformation - 2005:

<table>
<tr><th colspan="5">Trigger Value Derivation</th></tr>
<tr><td>COMP Title:</td><td colspan="4">Extent of Deformation</td></tr>
<tr><td>COMP Units:</td><td colspan="4">Areal extent (length, direction)</td></tr>
<tr><td colspan="5">Related Monitoring Data</td></tr>
<tr><td>Monitoring Program</td><td>Monitoring Parameter ID</td><td>Characteristics (e.g., number, observation)</td><td colspan="2">Compliance Baseline Value</td></tr>
<tr><td>Geotechnical</td><td>Displacement</td><td>Meters</td><td colspan="2">Not Established</td></tr>
<tr><td colspan="5">COMP Derivation Procedure - Reporting Period July 2003 through June 2004</td></tr>
<tr><td colspan="5">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.</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>DRZ Conceptual Model</td><td>Micro- and macro-fracturing in the Salado Formation</td><td>Constitutive model from laboratory and field databases.</td><td>Permeability around panel closures was assigned a constant value of $10^{-15} m^2$ for the CCA and a uniform distribution from 3.16 x $^{-13}$ to 3.98 x 10^{-20} m^2 for the PAVT (current baseline)</td><td>DRZ spatial and temporal properties have important PA implications for permeability to gas, brine, and two-phase flow.</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>Fractures at depth</td><td>Growth of 1 m/y[a]</td><td colspan="3">Coalescence of fractures at depth in rock surrounding drifts will control panel closure functionality and design, as well as discretization of PA models.</td></tr>
</table>

(a) TV to be re-evaluated.

2.2.3 Initiation of Brittle Deformation

Initiation of brittle deformation around WIPP openings is not being 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. Initiation and growth of the DRZ are fundamental observational goals of the DRZ investigations currently being conducted under the geotechnical experimental programs, as discussed above. 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 - 2005:

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 2003 through June 2004				
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[(a)]	Qualitative COMPs can be subjective and are not prone to the development of meaningful TVs.		

(a) Recommendation could be considered to add acoustic emissions for brittle monitoring or to replace this parameter with another more directly tied to PA.

2.2.4 Displacement of Deformation Features

The displacement of deformation features primarily focuses on those features located in the immediate vicinity of the underground openings, e.g., mining-induced fractures and lithological units within several meters of the roof and floor. As discussed previously, fracture development is most continuous parallel to the openings and near the upper corners. These fractures tend to propagate or migrate by arching over and under the openings and, thus are designated "low angle fractures" relative to the horizontal axis. Typically, the fractures intersect or asymptotically approach lithologic units such as clay seams and anhydrite stringers. As a result, salt beams are formed. In the roof, the beams are de-coupled from the surrounding formation requiring use of ground support. In the floor, the beams sometimes buckle into the openings requiring floor milling and trimming. Lithologic units of primary interest are Clay G and H. These features are located approximately 2.4 m and 4.5 m respectively, above the roof of Panels 1, 2, 7 and 8. Marker Bed 139 (anhydrite) is located approximately 2 m below the floor of these panels. For Panels 3 through 7, the panels are mined up to Clay G. Clay H is therefore located 2.1 m above the roof of these panels and Marker Bed 139 is located approximately 4.4 m below the panel floors.

Monitoring of these deformation features is accomplished through visual inspection of nearly 400 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 OBH are 7.6-cm (3-in) in diameter, and many intersect more than one deformation feature. The ages of the OBH vary from more than 20 years to about two years. Many of these OBH are no longer accessible for monitoring purposes. For example, boreholes drilled in the floor have become filled with crushed-salt over time and thus, visual observations cannot be made without continual maintenance of the boreholes. In addition, observation boreholes drilled in the roof of closed panels cannot be inspected because seals placed in the access drifts prevents monitoring personnel from entering these panels.

During the current reporting period, 118 OBH were inspected including 45 located in Panel 3, 19 in Panel 2, 4 in Panel 1 and 50 located in the access drifts servicing the disposal panels. The deformation features in these OBH are classified as: 1) offsets, 2) separations, 3) rough spots and 4) hang-ups. Forty-eight of the 118 OBHs are offset and ten did not indicate separations.

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

The TV for displacement of deformation features is the observation of a fully occluded borehole. However, many of the boreholes monitored during the previous years COMPs reports are no longer monitored, many of which were occluded. Most of these OBH were older, dating back to the time Panel 1 was completed in 1990. Most of the currently monitored boreholes are less than four years old. The TV does not consider the age of the OBH. Based on the current data available from the GAR, nine (8% of the total) OBH are greater than 30% occluded, two (approximately 2%) meet or exceed the TV. The 2003 COMPs report (SNL 2005) stated 14% of the monitored OBH exceeded the TV. Exceedence of the TV, in and of itself, is not necessarily a cause for concern, particularly given that no significant impact on safety or performance has occurred in those locations where the TV has been exceeded. However, to limit the formation of low angle fractures and de-coupled beams over the roof, the elevation of Panel 3 and future disposal panels (i.e., Panels 4, 5, 6, and 7) will be 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 - 2005:

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_0	Observational	Not established	
COMP Derivation Procedure - Reporting Period July 2003 through June 2004				
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 (three less than the last survey) and 14 of the National Geodetic Survey's vertical control points. To address EPA monitoring requirements, the most recent survey results (DOE 2004c) 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 $\times \sqrt{\text{km}}$ (or 0.033 ft $\times \sqrt{\text{mile}}$) or better was achieved in all cases.

Over the years, different data sets have been included in the surveys. In general, the data sets have included:

- 27 monuments surveyed from 1987 to 2004
- 2 monuments surveyed from 1989 to 2003
- 18 monuments surveyed from 1992 to 2004
- 1 monument surveyed from 1993 to 2001
- 14 National Geodetic Survey vertical control points surveyed from 1996 to 2004.

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) or have been physically disturbed (PT-31). Historically, the surveys were conducted by private companies under subcontract to DOE; however, since 1993, the WIPP M&OC has conducted the surveys using a set of standardized methods. Starting with the 2002 survey, the M&OC has been following WIPP procedure, WP 09-ES4001 (WTS 2002).

The current surveys comprise nine leveling loops containing as few as five to as many as ten monuments/control points per loop as shown in Figure 2.2 (Surveys of Loop 1 benchmarks have been discontinued because only two benchmarks comprise this loop and these benchmarks are redundant to other survey loops). Elevations are referenced to Monument S-37 located approximately 7,700 ft north of the most northerly boundary of the WIPP underground excavation. This location is considered to be far enough from the WIPP facility to be unaffected by excavation-induced subsidence expected directly above and near the WIPP underground. The elevation of S-37 has been fixed for all of the subsidence leveling surveys conducted since 1993. Survey accuracy for all loops was 0.0042 ft or better, which exceeds the Second-Order Class II closure accuracy by about a factor of two. 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) well 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.

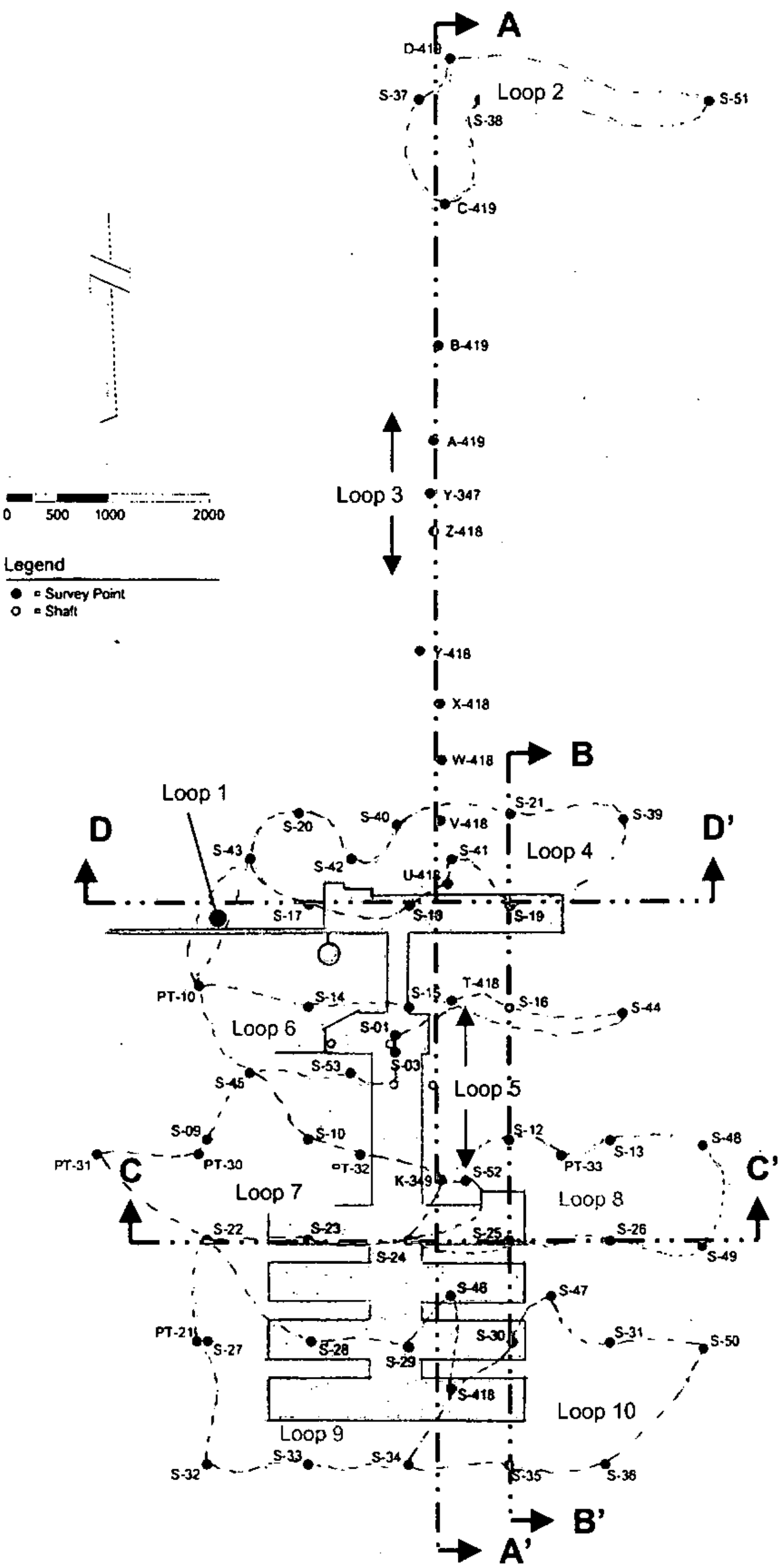

Figure 2.2. Monuments and vertical control points comprising WIPP subsidence survey loops.

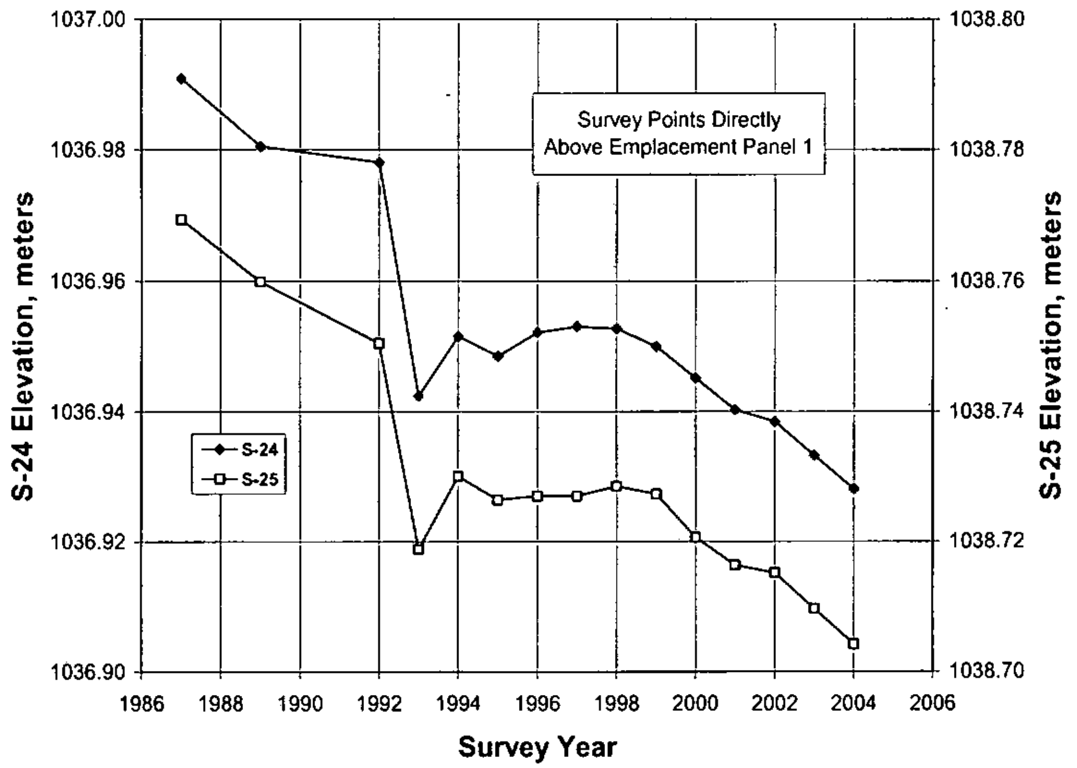

Figure 2.3. Elevations of WIPP monuments S-24 and S-25 located directly above emplacement Panel 1.

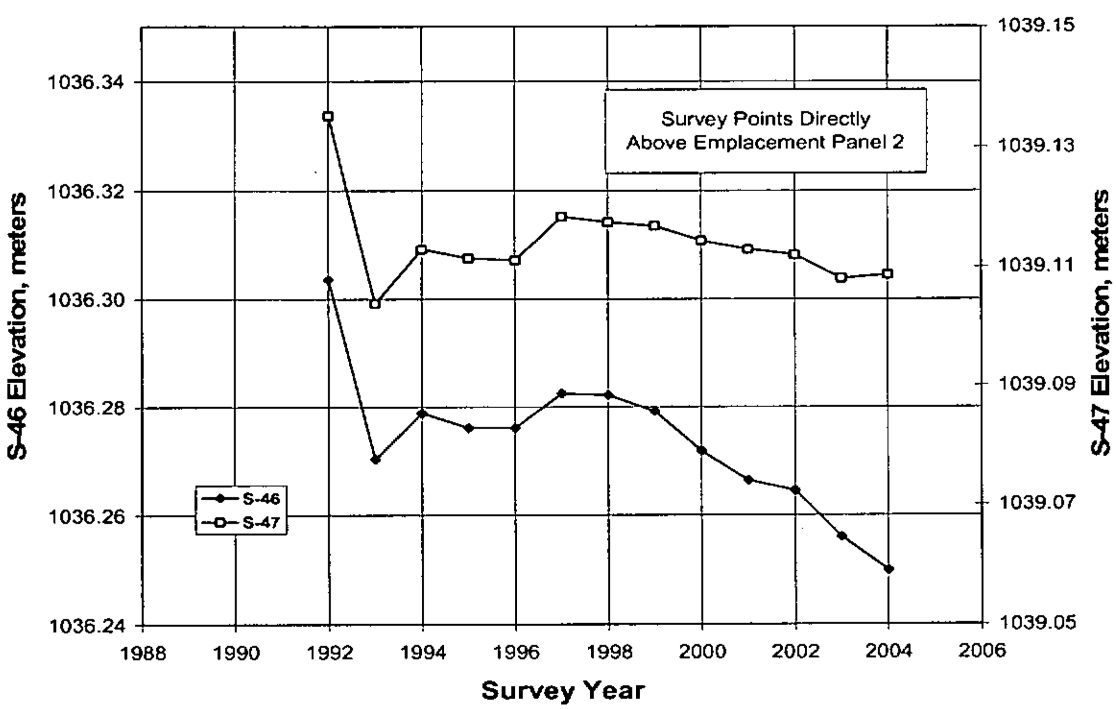

Figure 2.4. Elevations of WIPP monuments S-46 and S-47 located directly above emplacement Panel 2.

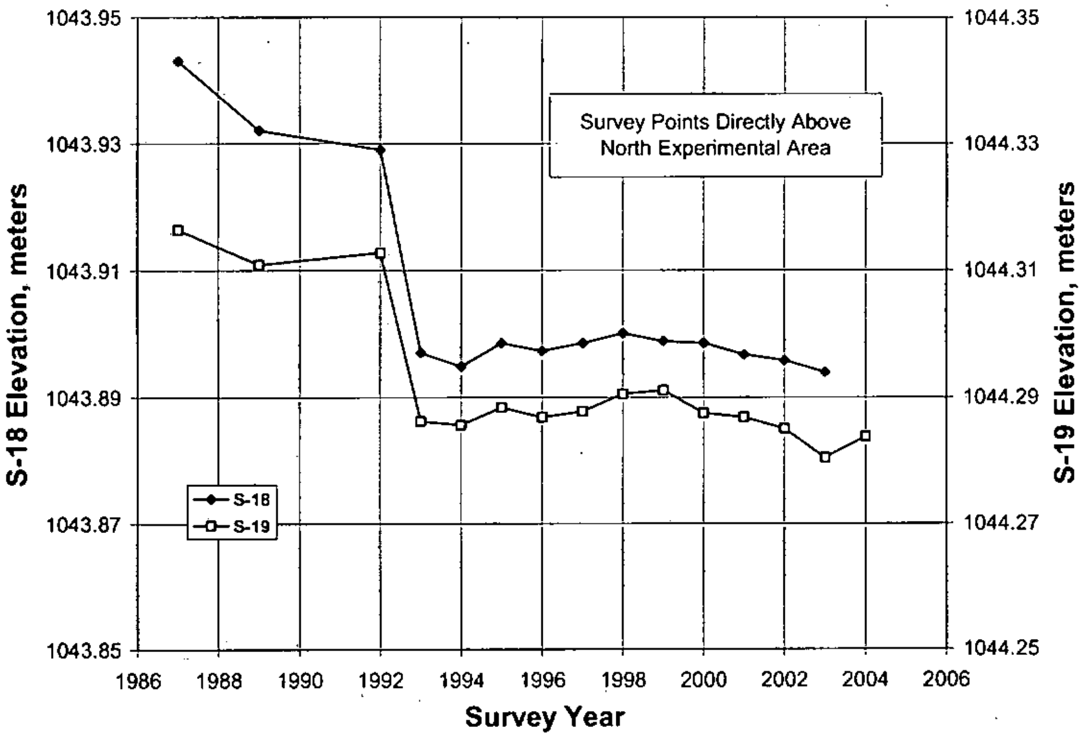

Figure 2.5. Elevations of WIPP monuments S-18 and S-19 located directly above the north experimental area.

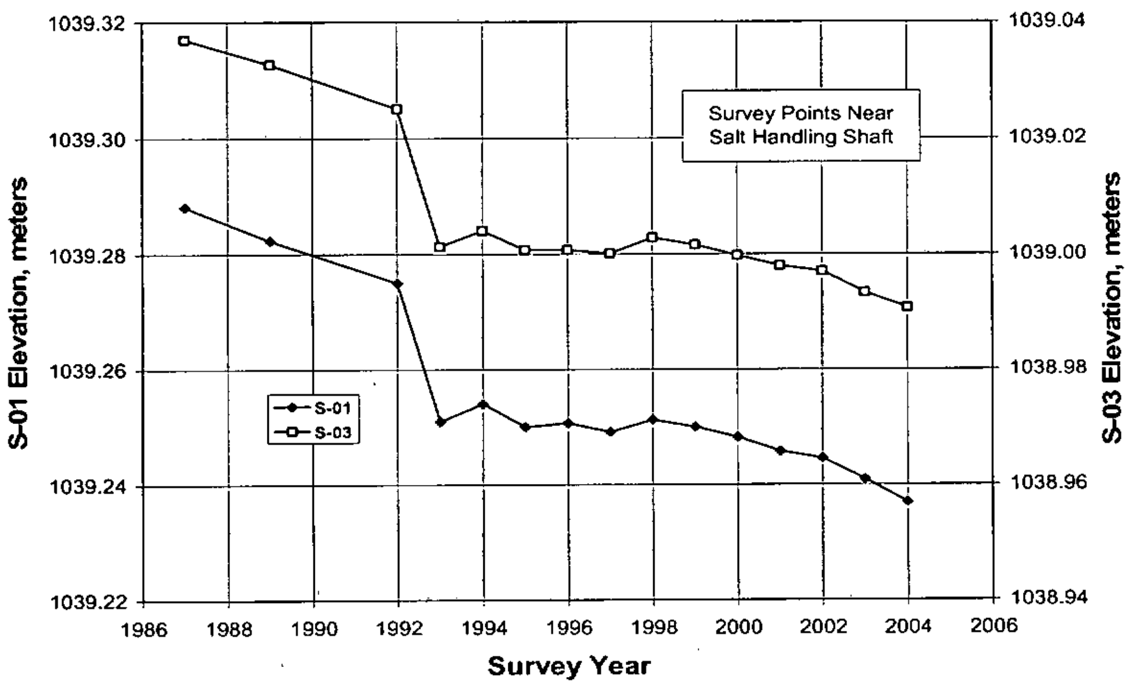

Figure 2.6. Elevations of WIPP monuments S-01 and S-03 located near the Salt Handling Shaft.

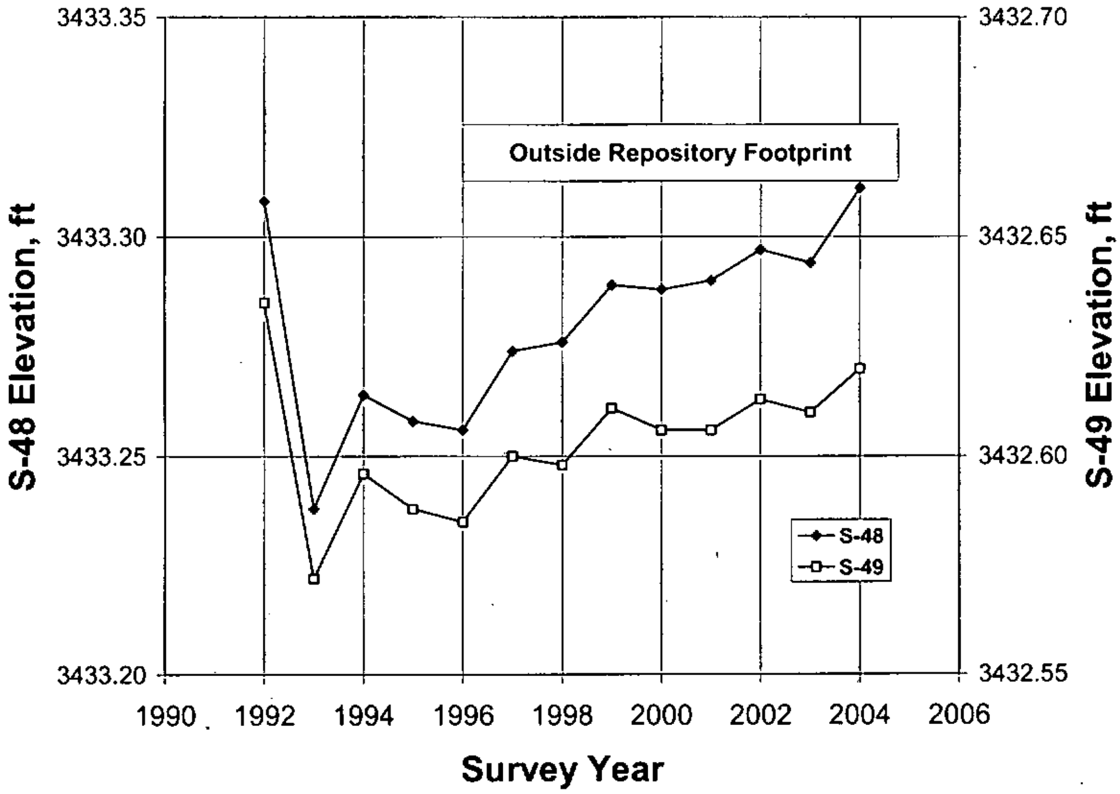

Figure 2.7. Elevations of WIPP monuments S-48 and S-49 located outside the repository footprint.

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

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.

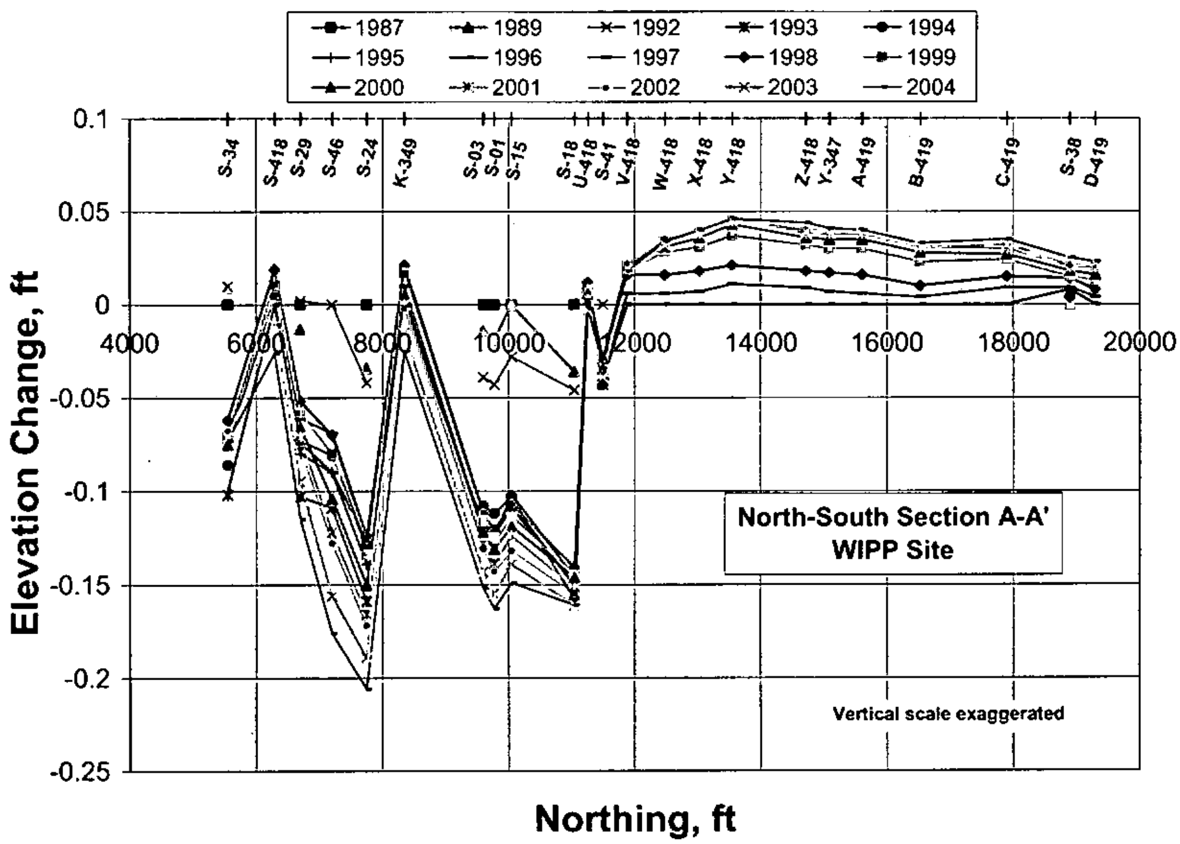

Figure 2.8. North-South subsidence profile A-A′.

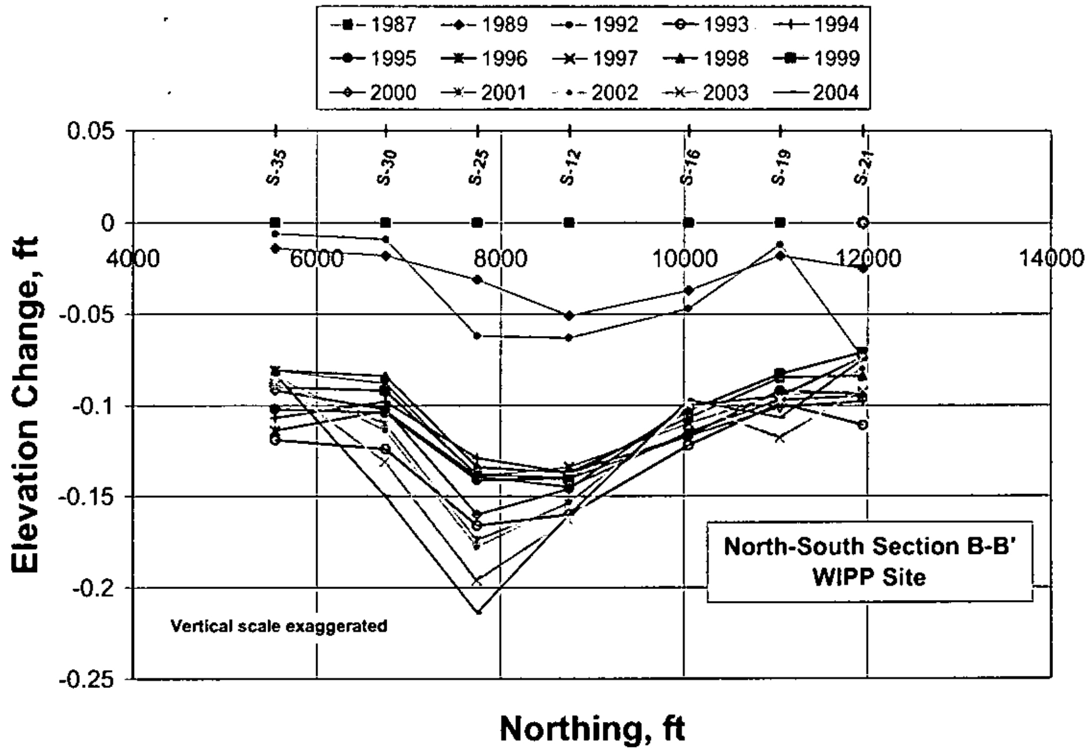

Figure 2.9. North-South subsidence profile B-B′.

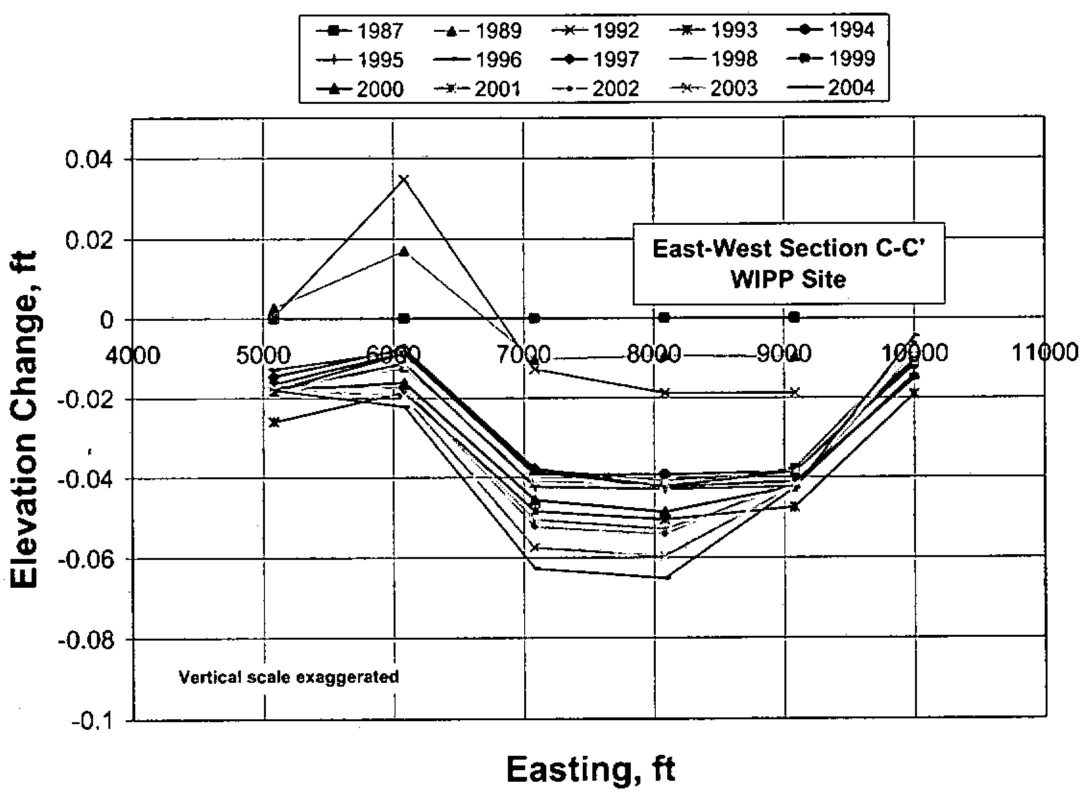

Figure 2.10. East-West subsidence profile C-C′.

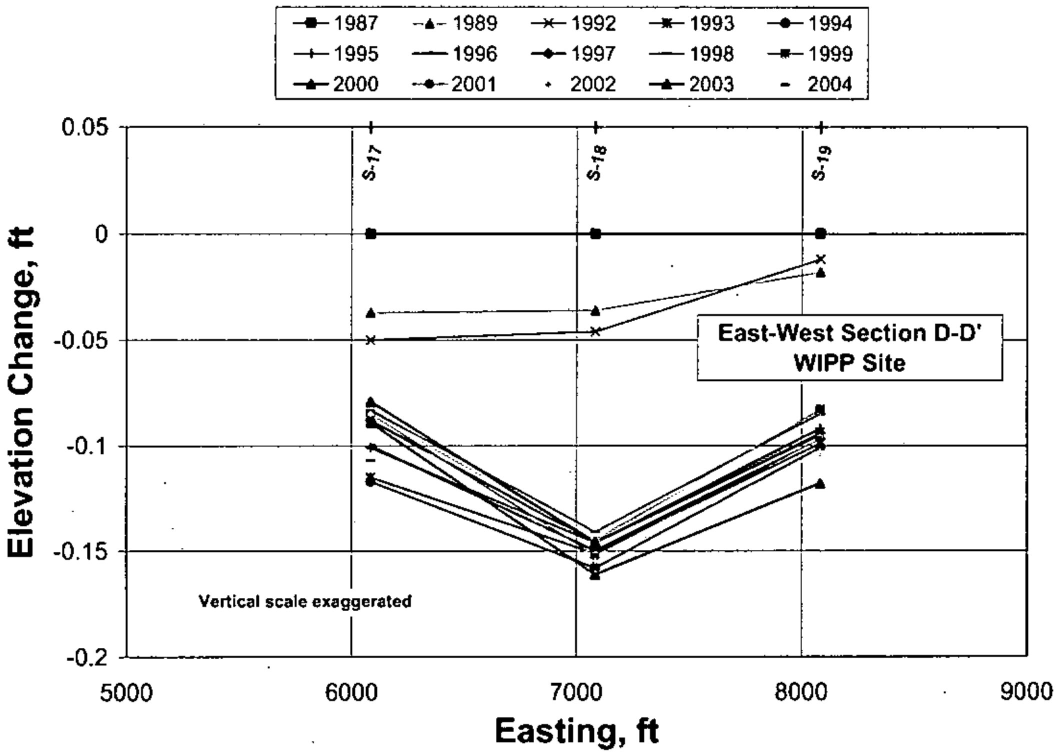

Figure 2.11. East-West subsidence profile D-D′.

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 (approximately - 0.20 ft) occurs directly above Panels 1, 2 and 3 (Monuments S-24 and S-25), with slightly less subsidence (- 0.16 ft) near the Salt Handling Shaft (Monuments S-01 and S-03) and above the North Experimental Area (S-18).
2. The highest subsidence rates measured for the 2003-2004 surveys correspond to benchmarks located above Panels 1 through 3. These rates ranged from 5.2×10^{-3} m/yr at S-24 (above Panel 1) to 6.1×10^{-3} m/yr at S-29, S-31 and S-46 (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. These minor amounts of subsidence and low subsidence rates are expected and are well within normal ranges. Based on the survey data available, subsidence rates of the ground surface at the WIPP are low and below the 1×10^{-2} m/yr TV.

Subsidence - 2005:

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 48 monitoring monuments	Decimal (meters)	Not Established
SMP	National Geodetic Survey (NGS) results	Decimal (meters)	Not Established
SMP	Change in elevation over year	Decimal (meters)	Not Established
SMP	Total change in elevation since excavation of the WIPP	Decimal (meters)	Not Established

COMP Derivation Procedure - Reporting Period August to November 2004

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 [W2.023]	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 (CCA Appendix SCR , Section 2.3.4) – this is within range modeled in the PA. Predicted WIPP subsidence is below that predicted for the effects of potash mining (0.62 m vs.1.5 m; EPA 1996).

Monitoring Data Trigger Values

Monitoring Parameter ID	Trigger Value	Basis
Change in elevation per year	1.0×10^{-2} m 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 CCA lists ten monitoring parameters that the DOE is required to monitor and assess during the WIPP operational period. Two of these parameters are considered hydrological in nature and include:

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

The SA has reviewed the data collected by the M&OC in 2004 under the Groundwater Surveillance Program (GSP). 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 Site Environmental Report Calendar Year 2004 (DOE 2005d) and WLMP data are also reported in monthly memoranda from the M&OC to the SA.

2.3.1 Change in Culebra Water Composition

Water Quality Sampling Program
Under the Water Quality Sampling Program (WQSP), the M&OC collected water samples twice (sampling rounds 18 and 19) in 2004 from seven wells, denoted WQSP-1 through WQSP-6 and WQSP-6a. WQSP-1 through WQSP-6 are completed to the Culebra Dolomite Member of the Rustler Formation and WQSP-6a is completed to the Dewey Lake Formation. Flow and transport in the Dewey Lake are not modeled explicitly in Performance Assessment (PA) because the sorptive quality of the Dewey Lake is expected to retard migration of any radionuclides that may reach the unit (considerably more so than the Culebra). Nevertheless, the Dewey Lake water quality is monitored because it might help to increase the understanding of the Dewey Lake hydrology. The water samples were analyzed in duplicate for major and minor elements and hazardous constituents per the WIPP Ground Water Monitoring Program Plan (GWMP; WID 1999).

The Culebra is not 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 differ widely among wells across the WIPP site, reflecting local equilibrium, diffusion, and perhaps most importantly, slow transport. The conceptual model for the Culebra presented in the CCA 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 Performance Assessment models. Thus, this evaluation of the water-quality data focuses on the stability of major ion concentrations. Based on these considerations, the Trigger Value (TV) for Culebra groundwater composition is defined as a condition where both duplicate analyses for any major ion fall outside the 95% confidence interval (C.I.) for three consecutive sampling periods. When and if this criterion is met, the project will evaluate the sampling and analytical procedures to see if the apparent change in groundwater composition can be explained by procedural changes or irregularities. If the change appears to reflect conditions in the Culebra accurately, the SA will investigate what effects the changes might have on the conceptualization and modeling of the Culebra and, if appropriate, the model will be revised to be consistent with the new information.

In this COMP evaluation, stability is defined as a condition where the concentration of an ion remains within the 95% C.I. (mean +/- two standard deviations) established from the baseline measurements at a well, assuming a normal distribution of concentrations. The original baseline was defined by the first five rounds of sampling in the WQSP wells conducted between July 1995 and September 1997 (Crawley and Nagy 1998). The baseline was revised in 2000, expanding from the first five rounds to the first ten rounds of sampling, which were performed between July 1995 and May 2000, before the first receipt of RCRA-regulated waste at WIPP. The baseline data are presented in the WIPP Resource Conservation and Recovery Act Background Quality Baseline Report (Crawley and Nagy 1998) and in Addendum 1 to that report (IT Corporation 2000). A charge-balance error, defined as the difference between the positive and negative charges from the ions in solution divided by the sum of the positive and negative charges, was also calculated for each analysis (Freeze and Cherry 1979). Charge-balance errors are useful in evaluating the reliability of an analysis because water must be electrically neutral. Charge-balance errors are rarely zero because of inherent inaccuracy in analytical procedures, but a reliable analysis should not have a charge-balance error exceeding five percent (Freeze and Cherry 1979). Charge-balance errors in excess of five percent imply either that the analysis of one or more ions is inaccurate (most common) or that a significant ion has been overlooked (rare). The variation between the values obtained for the "sample" and "duplicate" analyses of individual ions is also considered. Generally speaking, this variation should be less than ten percent. Greater variation indicates a potential problem with one or both analyses. Analytical results and charge-balance errors for rounds 18 and 19 of sampling are presented in Table 2.6 with the 95% confidence intervals derived from the baseline data. The charge-balance errors are calculated using the averages of the sample and duplicate analyses.

The only ion that has shown significant variation over the duration of the WQSP is potassium. Potassium concentrations in all wells showed little variation for the first six rounds of sampling. TRACE Analysis of Lubbock, Texas, has been the WQSP analytical laboratory since round 7, and potassium analyses have been problematic ever since. Beginning with the round 7 results for WQSP-1, 2, 4, 5, and 6a, and the round 8 results for WQSP-3 and 6, potassium concentrations became generally higher than they were in previous rounds and also highly variable (Figures 2.12-2.18). In the case of WQSP-3, potassium concentrations from rounds 1 through 7 appear to constitute a separate population from the concentrations from rounds 8 through 10, with no overlap of the 95% confidence intervals (1200 to 1730 versus 2060 to 3150 mg/L). A similar situation is seen at WQSP-4 with respect to potassium, except the two populations comprise rounds 1 through 6 and 7 through 10 with no overlap of the 95% confidence intervals (627 to 805 versus 832 to 1550 mg/L). The SA now evaluates potassium concentrations at WQSP-3 and WQSP-4 against the 95% confidence intervals established from rounds 8-10 and 7-10, respectively, but note that three or four rounds of sampling do not provide an adequate statistical sampling of the possible variation we might expect.

Potassium is also the ion that showed the greatest variation between rounds 18 and 19, especially in WQSP-1, WQSP-2, and WQSP-6. Round 18 potassium concentrations were lower in all the WQSP wells compared to round 19 except for WQSP-4, where it was slightly higher. All the potassium concentrations were within the 95% confidence intervals during round 18, but were exceeded during round 19 in WQSP-1, WQSP-2, and WQSP-6. This pattern is very similar to that observed in the rounds 16 and 17 sampling period during calendar year (CY) 2003, though only WQSP-1 and WQSP-2 exceeded the upper 95% C.I. limit during round 17. The reasons for these variations are uncertain at this time and will be investigated by the SA.

Table 2.6. Rounds 18 and 19 ion concentrations and baseline 95% confidence intervals.

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 18	36400/36400	4460/4490	54/54	16700/16900	1600/1680	978/1070	606/630	**-10.2**
	Round 19	38800/39000	5400/5120	50/50	20000/18400	1700/1580	1140/1050	**931/842**	**-7.9**
	95% C.I.	31100-39600	4060-5600	45-54	15900-21100	1380-2030	939-1210	322-730	
WQSP-2	Round 18	34400/34500	5370/5460	48/48	17100/16900	1500/1520	1010/999	610/588	**-8.6**
	Round 19	*35800/**40600***	*5470/6300*	44/46	19200/19300	1530/1550	1080/1090	**791/781**	**-8.0**
	95% C.I.	31800-39000	4550-6380	43-53	14100-22300	1230-1770	852-1120	318-649	
WQSP-3	Round 18	121000/125000	6980/6900	38/36	**57400/58600**	1480/1520	2230/2260	2230/2230	**-12.0**
	Round 19	141000/139000	**15500/15100**	32/32	**57300/57200**	1210/1290	1910/2070	2520/2740	**-21.0**
	95% C.I.	114000-145000	6420-7870	23-51	62600-82700[c]	1090-1620	1730-2500	2060-3150[a]	
WQSP-4	Round 18	59800/58100	6770/6670	38/38	29000/28900	1450/**1400**	1090/1070	1190/1220	**-10.8**
	Round 19	*57900/**63900***	**8590/9080**	38/38	**24600/26200**	**1190/1180**	**920/913**	975/1040	**-20.1**
	95% C.I.	53400-63000	5620-7720	31-46	28100-37800	1420-1790	973-1410	832-1550[b]	
WQSP-5	Round 18	15100/15100	4540/4650	44/46	**7600/7420**	924/915	408/407	412/411	**-11.2**
	Round 19	**17800/17800**	5710/5780	48/48	8730/9160	**1190**/1100	**540**/491	478/468	**-10.8**
	95% C.I.	13400-17600	4060-5940	42-54	7980-10400[c]	902-1180	389-535	171-523	
WQSP-6	Round 18	*4950/5700*	4450/4530	48/48	**3550/3400**	606/604	**187/188**	177/180	**-9.7**
	Round 19	6360/6230	**5180**/5080	52/50	4230/4130	720/677	*218/190*	**272/262**	**-8.5**
	95% C.I.	5470-6380[c]	4240-5120[c]	41-54	3610-5380[c]	586-777	189-233[c]	113-245	
WQSP-6a	Round 18	**416/393**	1970/2000	104/104	**193/203**	590/593	156/163	5.43/5.53	-2.9
	Round 19	491/487	1960/1950	106/106	**215/203**	575/603	166/170	*7.85/6.77*	-3.4
	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

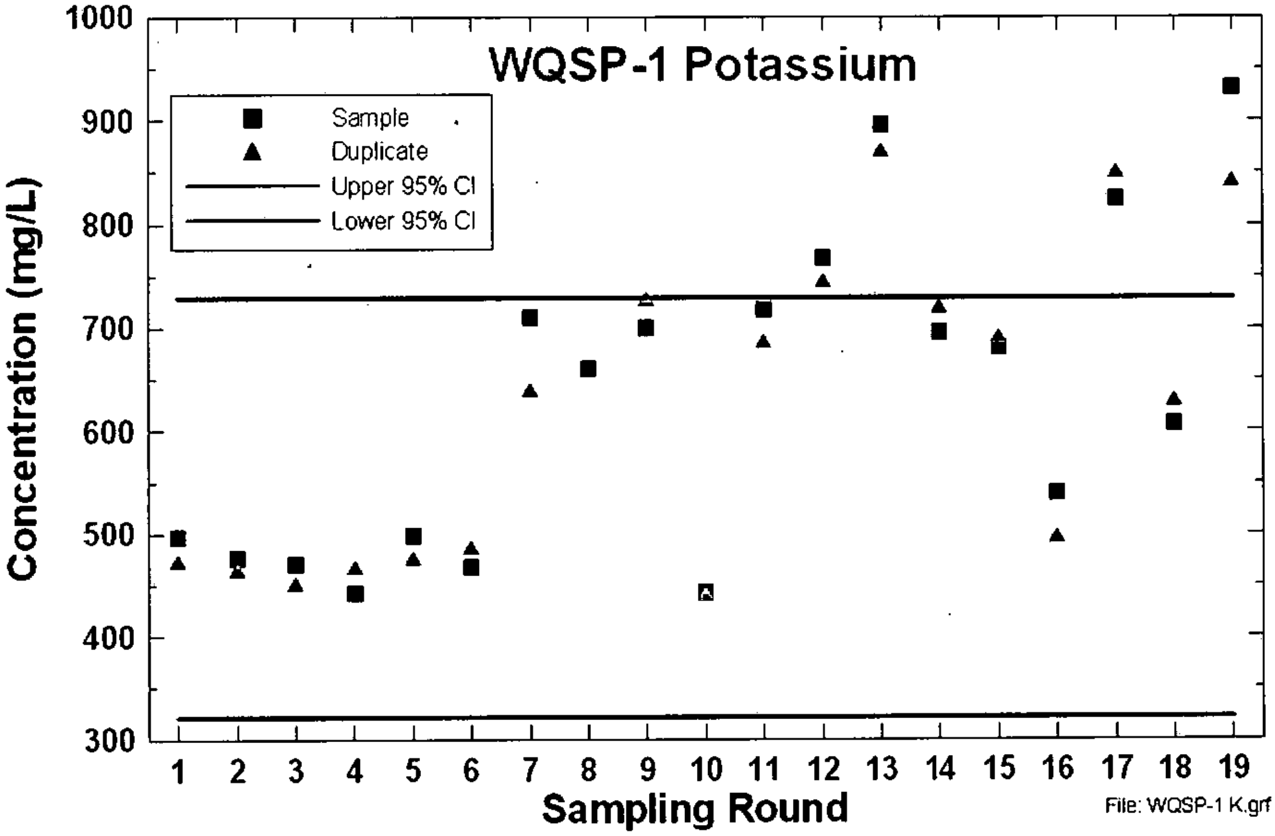

Figure 2.12. WQSP-1 potassium concentrations.

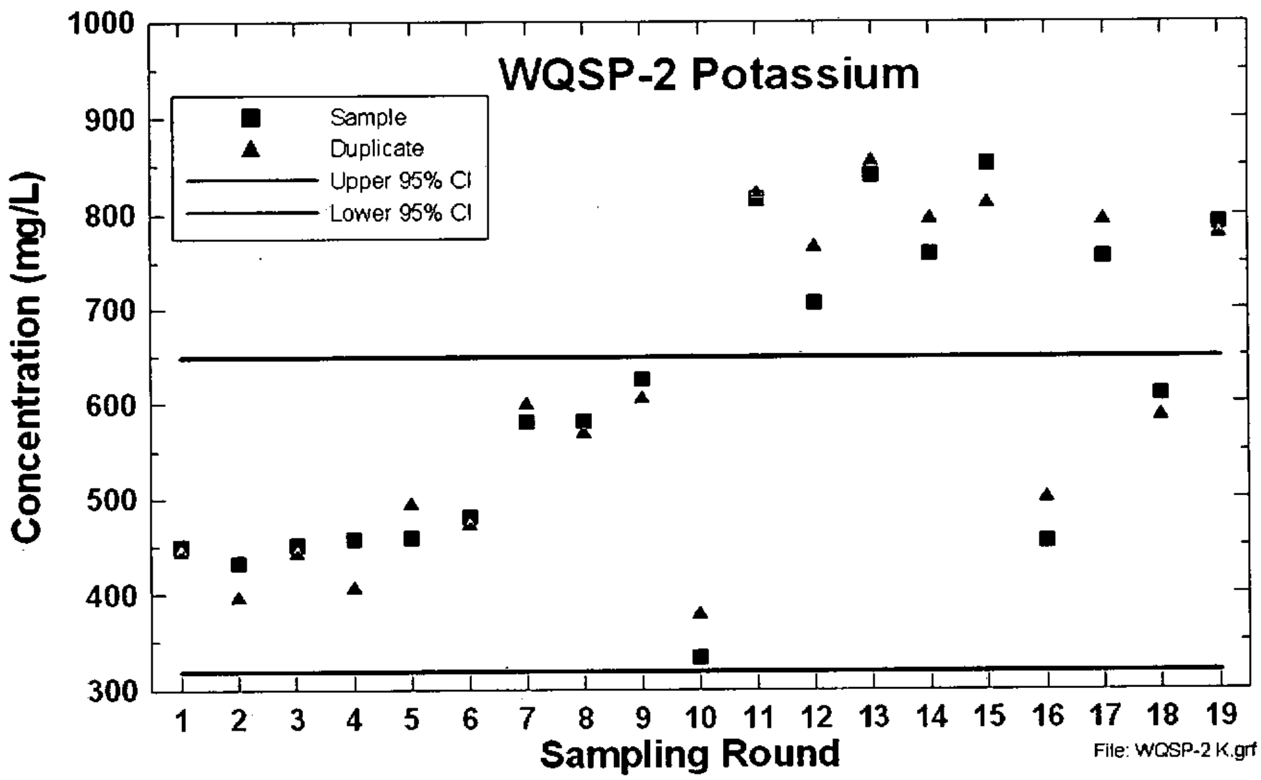

Figure 2.13. WQSP-2 potassium concentrations.

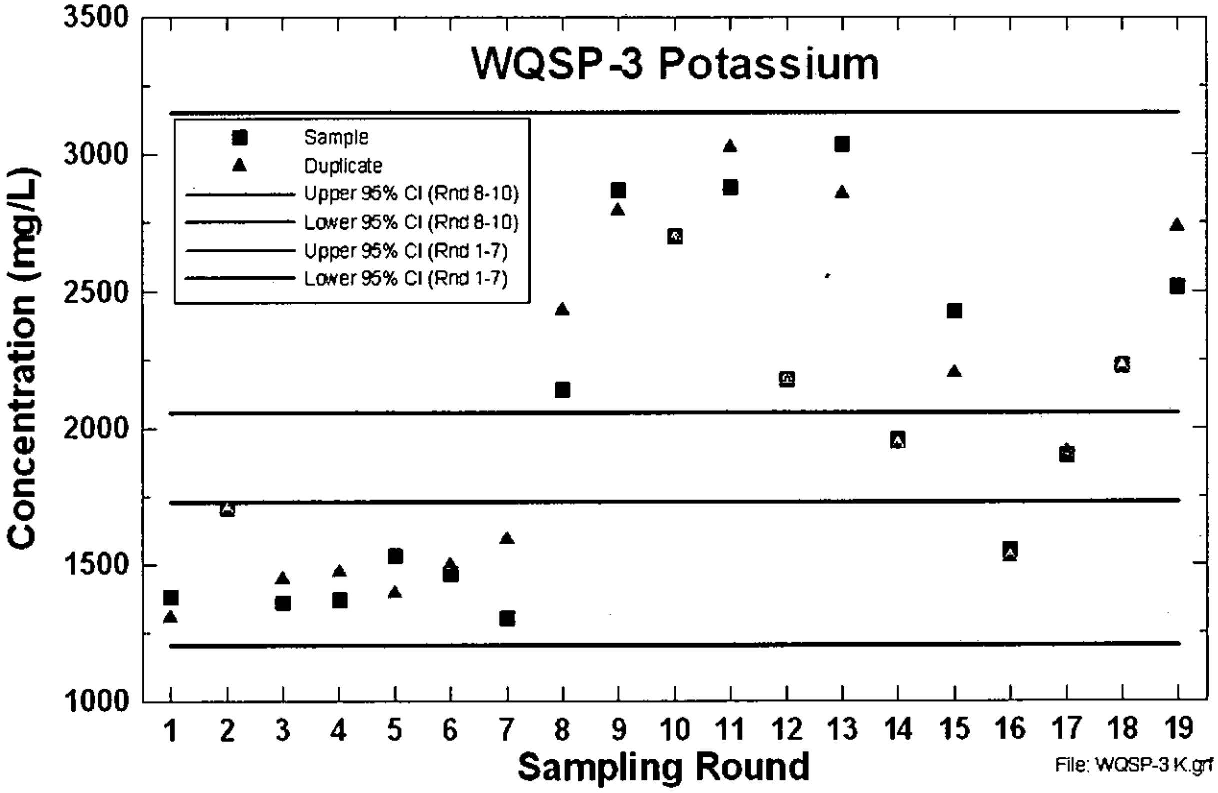

Figure 2.14. WQSP-3 potassium concentrations.

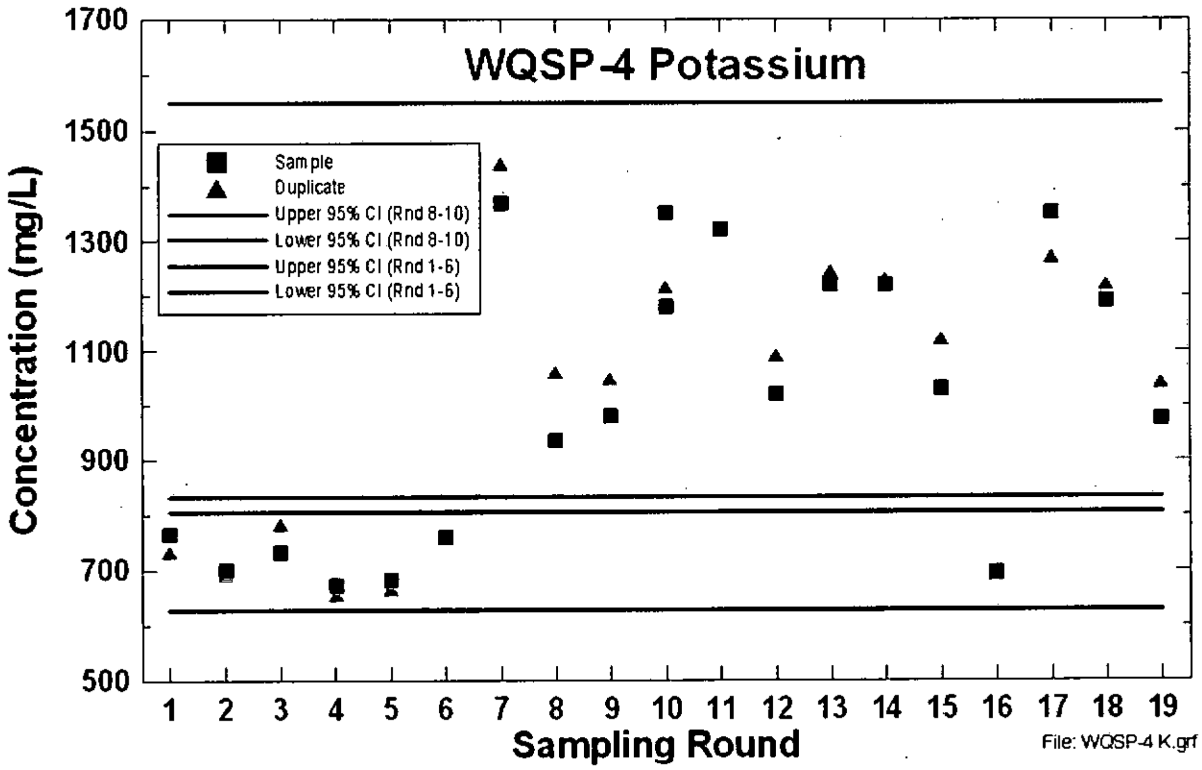

Figure 2.15. WQSP-4 potassium concentrations.

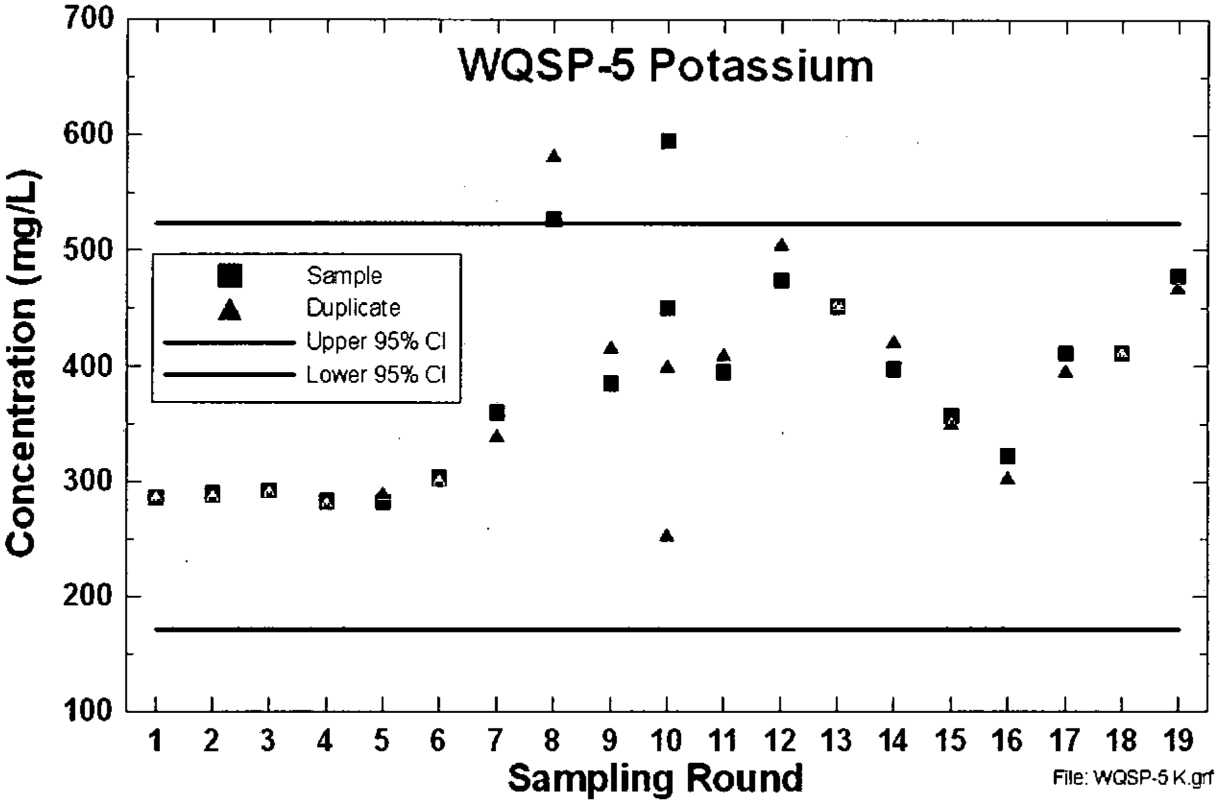

Figure 2.16. WQSP-5 potassium concentrations.

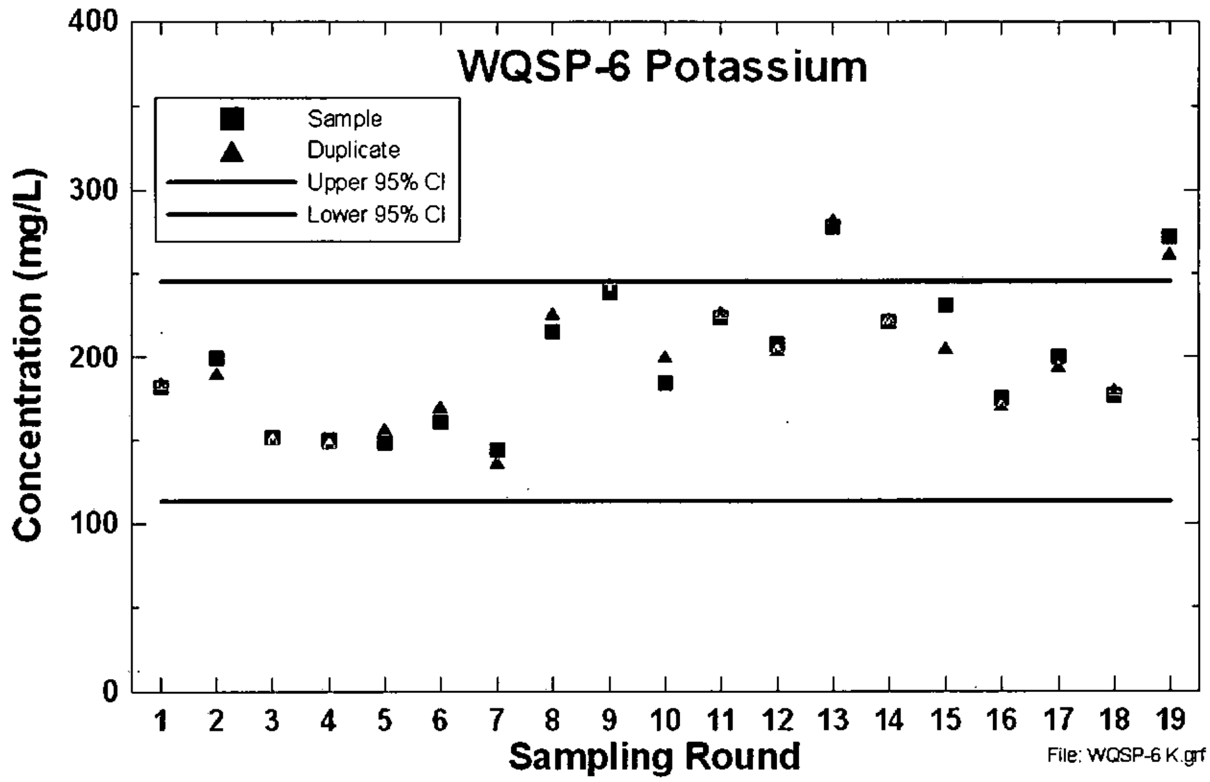

Figure 2.17. WQSP-6 potassium concentrations.

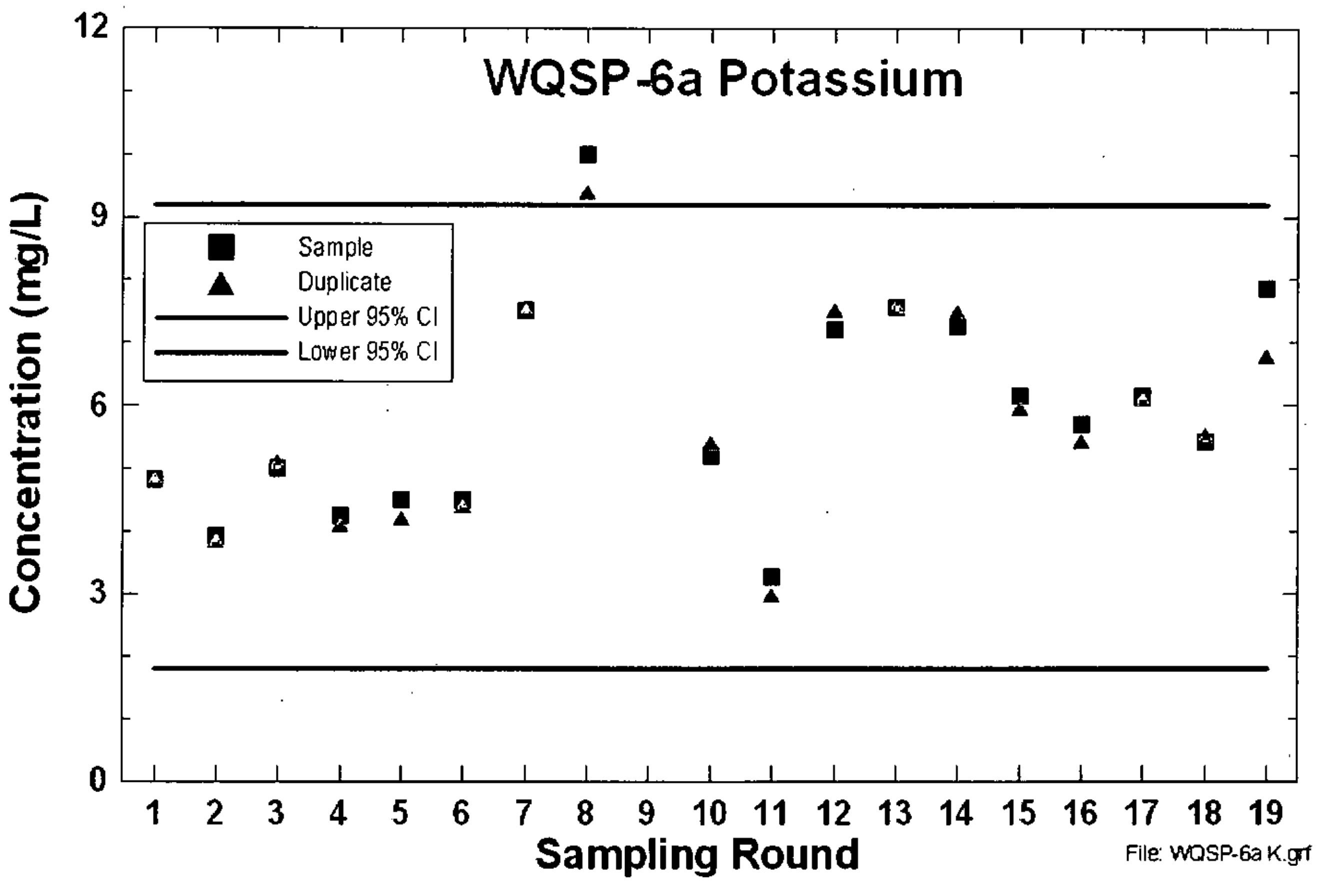

Figure 2.18. WQSP-6a potassium concentrations.

WQSP-1

Concentrations of all major ions were within the 95% confidence intervals for round 18 sampling at WQSP-1 and no duplicate samples differed by greater than 10% (Table 2.6). For round 19, concentrations of all major ions were within the 95% confidence intervals except for both potassium analyses, which were high. Charge-balance errors were –10.2% and –7.9% for rounds 18 and 19, respectively, indicating a surplus of anions and/or deficit of cations. Figure 2.19 shows that the WQSP-1 hydrochemical facies in 2004 were consistent with previous results. Overall, the water quality at WQSP-1 appears to be stable.

WQSP-2

Concentrations of all major ions were within the 95% confidence intervals for round 18 sampling at WQSP-2 and no duplicate samples differed by greater than 10% (Table 2.6). For round 19, only the potassium concentrations and one chloride concentration exceeded the 95% confidence intervals. The results for the chloride sample and its duplicates, however, differed by greater than 11%, indicating potential laboratory error. The sulfate sample and its duplicate also differed by greater then 11%. Charge-balance errors were –8.6% and –8.0% for rounds 18 and 19, respectively, indicating a surplus of anions and/or deficit of cations. Figure 2.19 shows that the WQSP-2 hydrochemical facies in 2004 were consistent with previous results. Overall, the water quality at WQSP-2 appears to be stable.

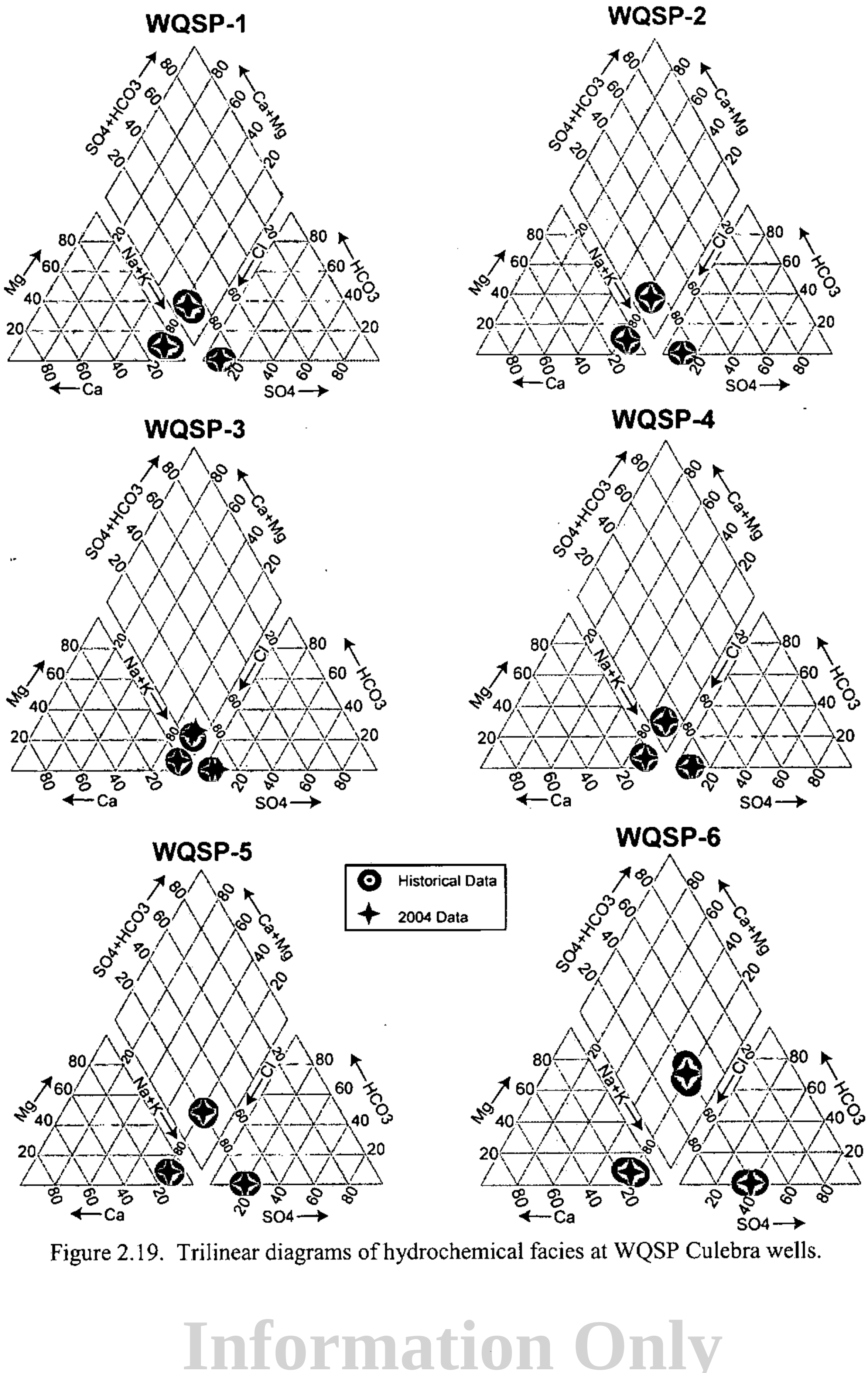

Figure 2.19. Trilinear diagrams of hydrochemical facies at WQSP Culebra wells.

WQSP-3

For round 18 sampling at WQSP-3, concentrations of all major ions were within the rounds 1-10 95% confidence intervals except for the sodium analyses (Table 2.6). As discussed above, potassium concentrations from rounds 1 through 7 appear to constitute a separate population from the concentrations from rounds 8 through 10, with no overlap of confidence intervals (1200 to 1730 mg/L versus 2060 to 3150 mg/L). Potassium concentrations in WQSP-3 fell within the rounds 8-10 95% confidence intervals for round 18 (Figure 2.14), after exceeding the upper 95% C.I. limit in the two previous rounds. For round 19, concentrations of all major ions were within the rounds 1-10 95% confidence intervals except for sulfate and sodium samples. The sulfate sample and its duplicate were both anomalously high, nearly double that of the upper limit of the 95% C.I. for sulfate. The sodium analysis results yielded values less than the lower limit of the 95% C.I., similar to round 18. Charge-balance errors were large ranging from –12.0% and –21.0% for rounds 18 and 19, respectively, indicating a significant surplus of anions and/or deficit of cations. If the round 19 sulfate concentrations represented a factor of two dilution error (i.e. actual concentrations of 7750 and 7550 mg/L) the charge balance error would be reduced slightly to -19.2%. However, Figure 2.19 shows that the WQSP-3 hydrochemical facies in 2004 were consistent with previous results. Overall, the water quality at WQSP-3 appears to be stable with the exception of sulfate.

WQSP-4

For round 18 sampling at WQSP-4, concentrations of all major ions fell within the 95% confidence intervals except for the duplicate calcium concentration (Table 2.6), which fell just slightly below the lower 95% C.I. limit. For round 19, the duplicate sample of chloride and both sulfate samples were above the upper 95% C.I. while sodium, calcium and magnesium were all below the lower 95% C.I. limit. The high chloride duplicate value may be related to laboratory error as it was >11% different from the original chloride sample. The reason(s) for the distinct change in the other concentrations from previous rounds is unclear and will need to be investigated. The charge-balance error for both rounds 18 and 19 were greater than desired at –10.8% and–20.1%, respectively. Figure 2.19 shows that the WQSP-4 hydrochemical facies in 2004 were consistent with previous results. Overall, the water quality at WQSP-4 appears to be stable.

WQSP-5

For round 18 at WQSP-5, all ion concentrations were within the 95% confidence intervals except for the sodium samples, which were below the lower 95% C.I. limit (Table 2.6). For round 19, all ion concentrations were within the 95% confidence intervals except for the chloride and one calcium samples, which were just slightly above the upper 95% C.I. limit. The charge-balance errors for rounds 18 and 19 were -11.2% and -10.8%, respectively, greater than what is desired. Figure 2.19 shows that the WQSP-5 hydrochemical facies in 2004 were consistent with previous results. Overall, the water quality at WQSP-5 appears to be stable.

WQSP-6

For round 18 at WQSP-6, most ion concentrations were within the 95% confidence intervals except for one chloride, and both sodium and magnesium analyses, which were all low (Table 2.6). The low chloride sample value maybe related to laboratory error as it was >11% different from the duplicate chloride sample. This marked the seventh consecutive sampling round in which the chloride concentration in WQSP-6 was below the 95% confidence interval (Figure 2.20). For round 19, all ion concentrations were within the 95% confidence intervals except for one sulfate and both potassium analyses (Table 2.6). The sulfate concentration is slightly higher then the upper 95% C.I. limit, while the potassium concentrations are above the upper C.I. limit by almost

10%. Also during round 19, chloride concentrations returned to the normal range (Figure 2.20). The charge-balance errors for both rounds 18 and 19 were unacceptable at -9.7% and -8.5%, respectively. Figure 2.19 shows that the WQSP-6 hydrochemical facies in 2004 were consistent with previous results. Overall, ion concentrations at WQSP-6 appear to be stable, with the exception of chloride.

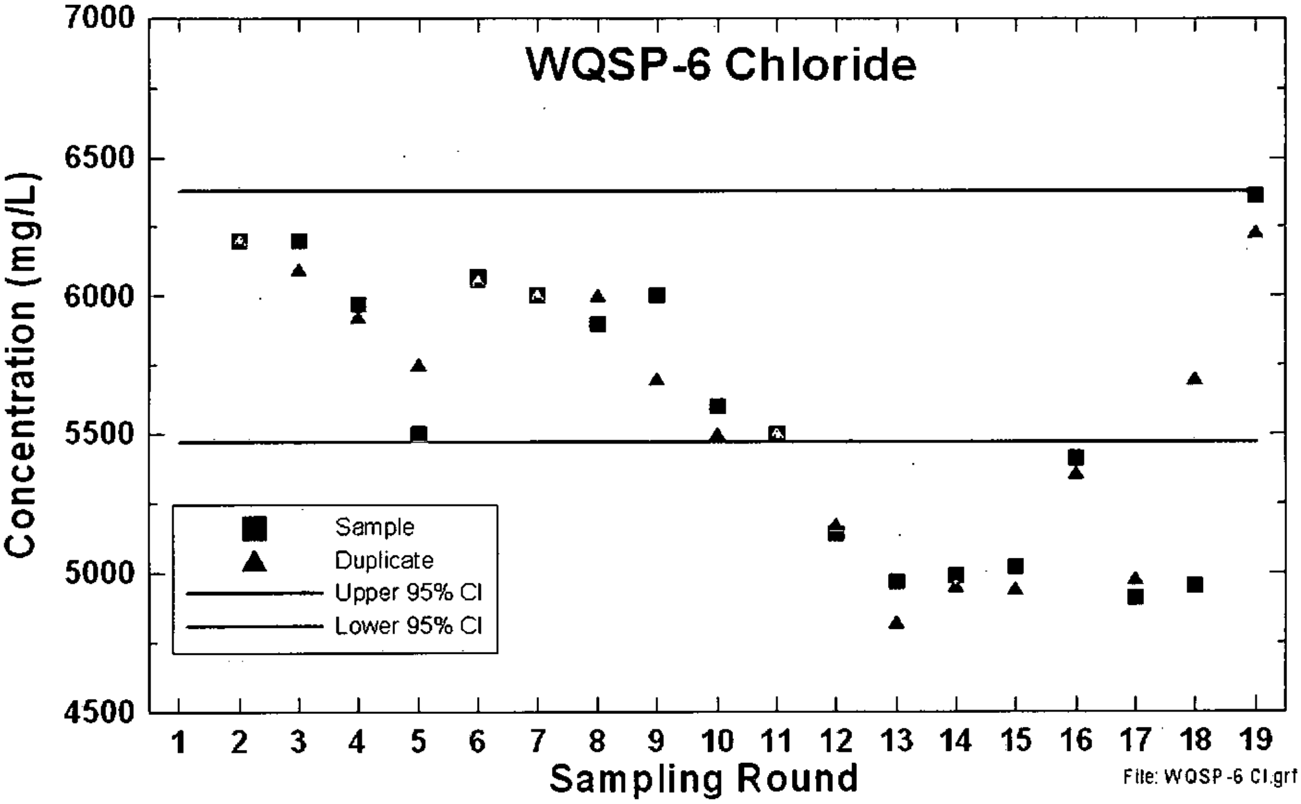

Figure 2.20. WQSP-6 chloride concentrations.

WQSP-6a

For round 18 at WQSP-6a, all ion concentrations were within the 95% confidence intervals except for chloride and sodium analyses, which were all low (Table 2.6). The chloride concentrations were also low in rounds 13-17, as was sodium during round 17 (Figures 2.22 and 2.23). These continued low values place chloride concentrations below the lower TV. For round 19, chloride returned to a normal range with the rest of the ion concentrations. The exception during round 19 was the continued low concentrations of sodium, causing it to fall below the lower TV for the third consecutive round. Figure 2.21 provides an indication of possible evolution of the hydrochemical facies at WQSP-6a towards increasing sulfate dominance of the anions coupled with decreasing chloride and sodium (Figure 2.23). No TV has been defined for Dewey Lake water quality because it plays no role in WIPP's compliance. Nevertheless, we will continue to monitor Dewey Lake water quality because of the insight it might provide with respect to the overall hydrology of the Dewey Lake. The charge-balance errors were acceptable for both rounds, being -2.9% for round 18 and -3.4% for round 19. At the present time, ion concentrations, with the possible exception of sodium, are stable at WQSP-6a.

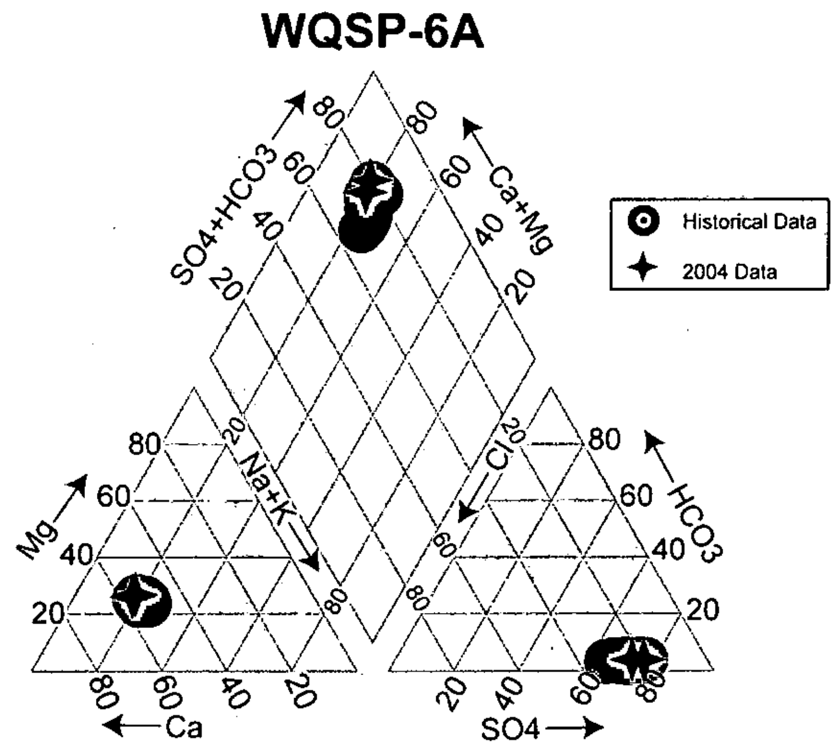

Figure 2.21. Trilinear diagram of WQSP-6a Dewey Lake hydrochemical facies.

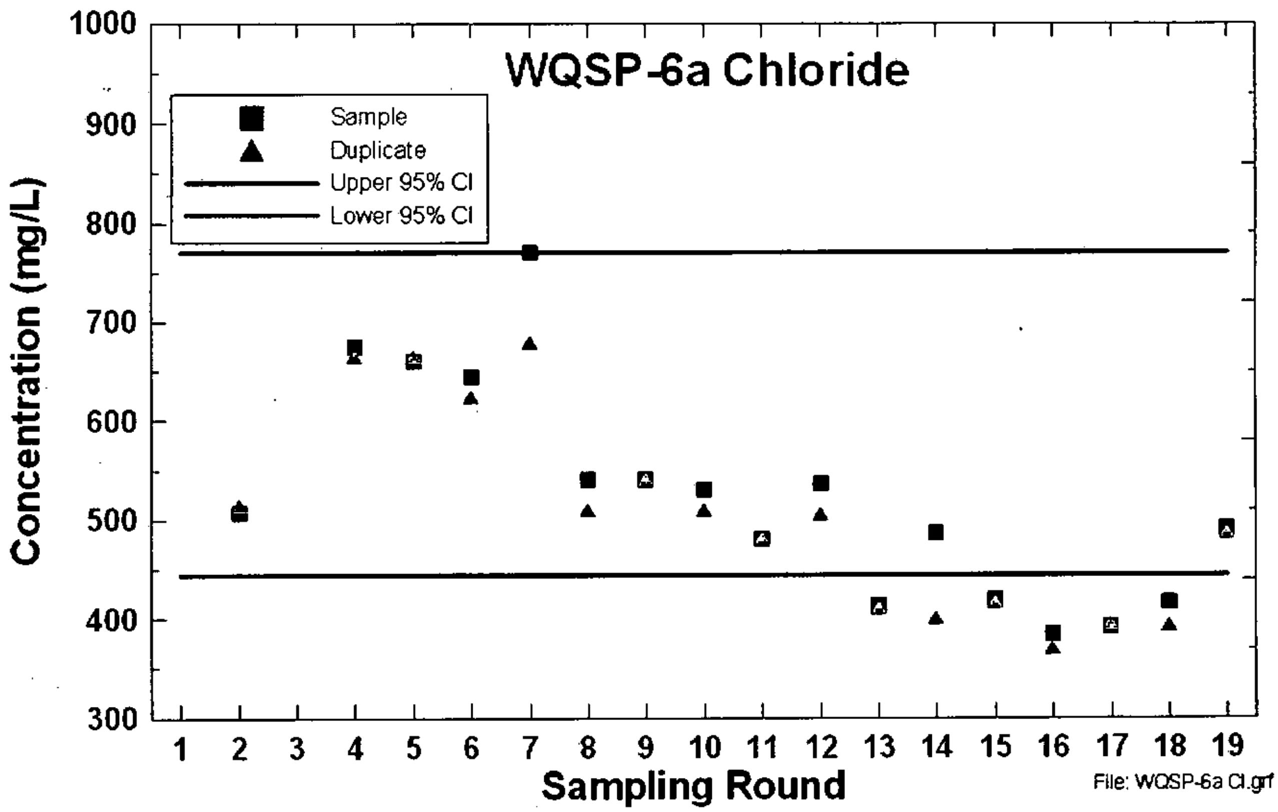

Figure 2.22. WQSP-6A chloride concentrations.

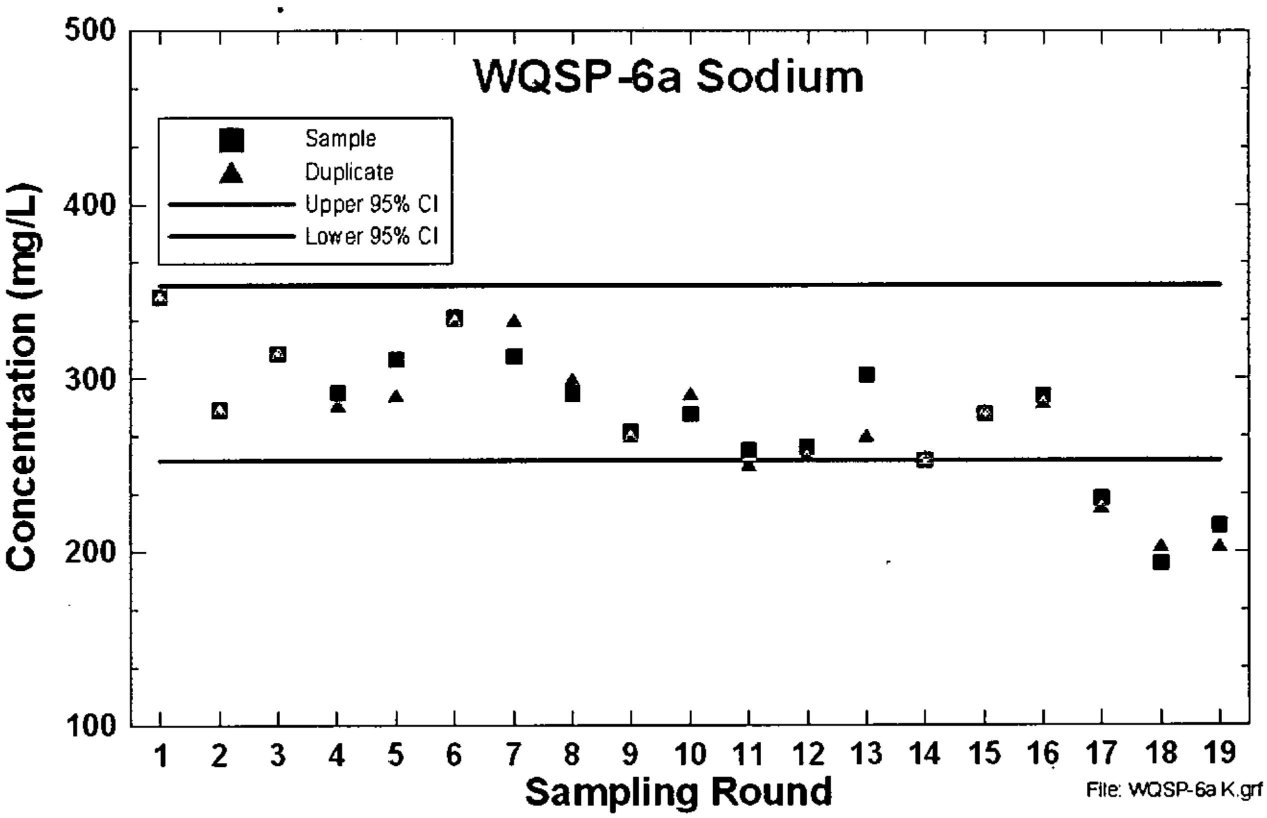

Figure 2.23. WQSP-6A sodium concentrations.

Summary

With the exception of potassium at WQSP-1, WQSP-2, and WQSP-6 and sodium at WQSP-3 and WQSP-6a, major ion concentrations are relatively stable in all wells and within the TVs. In round 19, chloride concentrations in WQSP-6 and WQSP-6A and potassium in WQSP-3 returned to their normal ranges after being out of range for several consecutive sampling rounds. Analytical error is believed to be the most probable cause for sporadic variations in water quality data. The SA is currently evaluating possible sources of the variability in Culebra groundwater quality that are being observed in several of the WQSP wells, especially those wells with variable potassium concentrations.

Change in Groundwater Composition - 2005:

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 – Reporting Period Rounds 18 & 19, 2004

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 conceptual 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 two consecutive sampling periods	The 95% confidence interval for a particular analyte defines the range of concentrations that 19 out of 20 analyses, on average, should fall within. Therefore, TVs should not be set so that a single analysis falling outside the 95% confidence interval is significant. In addition, analysis of solutes in the concentrated brines of the Culebra is not a routine procedure, and occasional analytical errors are to be expected, particularly when a new laboratory is contracted to perform the analyses (SNL 2002b).

2.3.2 Changes in Groundwater Flow (Water Level)

Assessment of the COMP "Changes in Groundwater Flow" involves TVs derived from the steady-state freshwater heads estimated for Culebra flow modeling in the 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 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.

The freshwater head 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. Thus, once the ground-surface elevation at a well site is surveyed, determination of freshwater head requires two sets of information:

1) The height of the water column in the well above the midpoint of the Culebra.
2) The density of the water in that water column.

Under the Water Level Monitoring Program (WLMP) in 2004, M&OC made monthly water-level measurements in 39 Culebra wells (up from 34 in 2003 due to the addition of five new wells and the acquisition of other wells), and quarterly in 14 "redundant" Culebra wells located on the same drilling pads as seven of the wells monitored monthly. In addition, water levels were measured in wells completed in horizons other than the Culebra. These other horizons are not currently monitored as COMPs and do not have TVs. The water-level measurements in these units do, however, provide information used in the development of the conceptual model of site hydrology. Water levels were measured in 14 wells completed in the Magenta Member of the Rustler Formation, one well completed in the Los Medaños Member of the Rustler Formation, and two wells apiece in the Dewey Lake and Bell Canyon Formations.

In 2000, M&OC began an annual program of pressure-density (P-D) surveys in monitoring wells. As part of this annual survey, pressure-density surveys were conducted in 21 Culebra wells in 2004 (DOE 2005d). Seven of the P-D measurements were first time surveys on new or existing wells, while the others updated previous P-D measurements. Thus far, P-D surveys have been completed on 28 Culebra wells since 2000. In addition to the P-D measurements, fluid-density surveys are made on samples collected bi-annually from the six WQSP wells completed in the Culebra, for a grand total of 34 Culebra water density values since 2000. Table 2.7 gives the most up-to-date results available for the wells in which water levels were measured in 2004, as well as previous results from re-analyzed wells. Also included in Table 2.7 are P-D measurements on eleven Magenta wells and one Dewey Lake well.

Results from the 2004 P-D survey indicate that five of the fourteen resurveyed Culebra wells experienced a significant change in density from previous P-D surveys. The SA considers a significant change in density to be $\geq \pm 0.01$ g/cm^3 from the previous analysis. The cause of these changes is unclear and the SA is investigating possible explanations, including analytical error.

Table 2.7. Fluid densities in monitored wells.

Well	Date	Unit	Most Recent Density (g/cm^3)	Previous Density (g/cm^3)	Method
AEC-7	2000	Culebra	1.0888	-	P-D Survey
C-2737	7/12/02	Culebra	1.0013	-	P-D Survey
DOE-1	8/2/04	Culebra	**1.099**	1.0886	P-D Survey
H-2b2	10/25/04	Culebra	1.013	1.0117	P-D Survey
H-3b2	8/20/04	Culebra	**1.001**	1.036	P-D Survey
H-4b	8/20/04	Culebra	1.011	1.003	P-D Survey
H-5b	8/18/04	Culebra	1.099	1.0892	P-D Survey
H-6b	8/6/04	Culebra	1.041	1.0343	P-D Survey
H-7b1[a]	8/16/04	Culebra	1.024	-	P-D Survey
H-9c	12/18/02	Culebra	1.0029	-	P-D Survey
H-10c	11/8/04	Culebra	1.009	1.000	P-D Survey
H-11b4	8/4/04	Culebra	**1.043**	1.064	P-D Survey
H-12	2000	Culebra	1.0833	-	P-D Survey
H-17	8/4/04	Culebra	1.136	1.1291	P-D Survey
H-19b0	6/5/01	Culebra	1.062	-	P-D Survey
H-19b2[a]	8/2/04	Culebra	1.066	-	P-D Survey
SNL-2[a]	8/16/04	Culebra	1.013	-	P-D Survey
SNL-3[a]	8/16/04	Culebra	1.027	-	P-D Survey
SNL-9[a]	8/16/04	Culebra	1.012	-	P-D Survey
SNL-12[a]	10/26/04	Culebra	1.015	-	P-D Survey
P-17	11/9/04	Culebra	**1.069**	1.0912	P-D Survey
WIPP-12	12/1/04	Culebra	1.107	1.0987	P-D Survey
WIPP-13[a]	11/8/04	Culebra	1.050	-	P-D Survey
WIPP-19	12/1/04	Culebra	1.060	1.0506	P-D Survey
WIPP-21	12/15/04	Culebra	1.081	1.0759	P-D Survey
WIPP-22	10/15/02	Culebra	1.0614	-	P-D Survey
WIPP-26	12/2/03	Culebra	1.019	-	P-D Survey
WIPP-29	10/26/04	Culebra	**1.206**	1.221	P-D Survey
WQSP-1	3/3/04 & 9/1/04	Culebra	1.045	1.039	Sampling
WQSP-2	3/17/04 & 9/22/04	Culebra	1.045	1.039	Sampling
WQSP-3	3/24/04 & 10/20/04	Culebra	1.143	1.140	Sampling
WQSP-4	4/21/04 & 10/6/04	Culebra	1.070	1.070	Sampling
WQSP-5	5/5/04 & 10/27/04	Culebra	1.020	1.020	Sampling
WQSP-6	5/19/04 &11/3/04	Culebra	1.010	1.009	Sampling
H-2b1	10/25/04	Magenta	1.012	-	P-D Survey
H-3b1	8/20/04	Magenta	1.012	-	P-D Survey
H-4c	8/20/04	Magenta	1.023	-	P-D Survey
H-5c	8/18/04	Magenta	1.009	1.0045	P-D Survey
H-6c	8/6/04	Magenta	1.005	1.003	P-D Survey
H-8a	10/26/04	Magenta	1.043	-	P-D Survey
H-10a	11/9/04	Magenta	1.006	-	P-D Survey
H-11b2	8/4/04	Magenta	**1.054**	1.070	P-D Survey
H-14	8/18/04	Magenta	1.028	1.0294	P-D Survey
H-18	8/6/04	Magenta	1.008	1.0054	P-D Survey
WIPP-18	12/1/04	Magenta	**1.017**	1.0423	P-D Survey
WQSP-6a	5/26/04 & 11/17/04	Dewey Lake	1.003	0.999	Sampling

[a]First time P-D measurements on new or existing wells as of 2004.

Bold = Changes in water density ≥ ±0.01 g/cm^3 from previous P-D survey.

Culebra Data

As part of the COMPs report, a comparison of Culebra water levels in feet above mean sea level (ft amsl) from December 2003 to December 2004 is made for the 39 monitored wells (Table 2.8; DOE 2005d). In a reversal from the previous year, where monitored water levels generally declined, 29 of the 39 wells showed an increase in water level. Of the 29 monitored wells that show increases in water level, 17 rose by more than 2 ft. In general, the largest increases (from 2.02 to 9.86 ft) were observed in the six new SNL wells. Much of the observed increase in these wells can be attributed to well filling and development after the wells were completed in late-2003 and early-2004.

The other monitored wells with water level increases of greater than 2 ft can be placed into two groups. The first falls within the boundaries of Nash Draw and includes wells: WIPP-25, WIPP-26, and WIPP-27. These three wells experienced water level increases of 3.82, 2.79, and 5.06 ft, respectively. In all three wells, water levels were steady or gradually declining until August 2004, at which time water levels began to rise relatively rapidly. It has been speculated that Nash Draw is a likely source of recharge to the Culebra and that wells located in Nash Draw are both sensitive to variations in the discharge of potash refining effluent and rainfall amount. In late-2003 and into early-2004 potash mining in the northern Nash Draw area resumed, after operations were suspended at the Mississippi (now Intrepid) West facility (near WIPP-27) from June to September 2003, and at the East facility (upgradient of WIPP-25) from June to October 2003. The lag between rising water levels and potash mining resumptions is reasonable considering that the Culebra is overlain by several other geologic units in Nash Draw. Also worth noting is that the water level rise occurred shortly after one of the wettest April-August periods on recent record in southeast New Mexico. These two factors may have led to the relatively large increase in water level compared to previous water level rises.

The second group of wells that experienced significant water level increases encompasses the area south and southeast of the WIPP site. Wells DOE-1, H-4b, H-7b2, H-9c, H-11b4, H-17 and P-17 recorded water level increases between 2.32 and 7.56 ft. The SA speculates that because of the resumption of potash mining and increased rainfall during the summer of 2004, water infiltrating the Culebra in Nash Draw may have led to higher heads propagating to the north-northwest through the high transmissivity zone located to the south of the WIPP site, thereby causing water levels to rise in wells located in that area. This hypothesis, however, needs to be tested further and compared to more recent water level data to determine if the leading edge of increasing water levels is migrating northward. The SA will continue to investigate this line of thought.

A new well added to the monitoring network is IMC-461. This well recorded a water level increase of almost 20 ft. from February 2004 to May of 2004. This large increase was related to the well filling (recovery) after completion to the Culebra in January of 2004. This well recovery has continued and has stabilized at approximately 25 ft. from the original level.

Water levels in nine of the wells decreased in 2004. In all but one of those wells, water levels decreased by more that 2 ft. The water level in H-10c, located approximately due southwest of the WIPP site decreased by ~4 ft. This decrease, however, represents a return to baseline conditions that were observed prior to elevated water levels thought to have been caused by oil well drilling in the area in late 2003.

Table 2.8. Summary of 2004 Culebra water-level changes and freshwater heads.

Well I.D.	12/03 W.L. (ft AMSL)	12/04 W.L. (ft AMSL)	2004 Change (ft)	12/04 FWH (ft AMSL)	CCA FWH Range (ft AMSL)	Outside CCA Range?
AEC-7	3039.47	3039.54	0.07	3062.65	3055.1-3060.4	Y
C-2737	3009.11[a]	3009.95	0.84	3015.95	N/A	N/A
CB-1	Recompleted as Bell Canyon well (March 2004)				2986.9-2991.5	N/A
DOE-1	2978.89	2986.45	7.56	3021.39	2992.5-3013.8	Y
DOE-2	Recompleted as Bell Canyon well (February 2004)				3061.7-3071.5	N/A
ERDA-9	3009.99	3009.87	-0.12	3025.38	N/A	N/A
H-1	Plugged and abandoned (February 2001)				3017.1-3030.2	N/A
H-2b2	3039.20	3038.35	-0.85	3040.71	3033.8-3040.0	Y
H-3b2	2999.91	3000.07	0.16	3011.46	2995.1-3007.5	Y
H-4b	3000.47	3002.79	2.32	3006.41	2988.2-2992.1	Y
H-5b	3029.66	3029.66	0.00	3074.67	3060.4-3069.6	Y
H-6b	3052.31	3053.98	1.67	3066.21	3054.5-3061.0	Y
H-7b2	2997.63	3000.20	2.57	3000.11	2994.1-2996.1	Y
H-9c	2991.76	2996.00	4.24	2996.25	2973.4-2977.7	Y
H-10c	3029.21	3025.20	-4.01	3025.30	3015.4-3029.9	N
H-11b4	2983.57	2986.13	2.56	3006.33	2990.2-3003.3	Y
H-12	No Water Level Data between 11/2003 and 12/2004				2993.1-3001.0	N/A
H-14	Recompleted as Magenta well (April 2001)				3007.9-3021.0	N/A
H-15	Insufficient water level data for CY2004				3005.2-3019.4	N/A
H-17	2962.54	2964.88	2.34	3014.59	2985.9-2991.8	Y
H-18	Recompleted as Magenta well (April 2001)				3055.4-3067.3	N/A
H-19b0	2990.52	2991.17	0.65	3013.03	N/A	N/A
IMC-461	3025.20[b]	3050.18	24.98	N/A	N/A	N/A
P-15	Plugged and abandoned (February 2002)				3008.5-3013.8	N/A
P-17	2983.66	2985.99	2.33	3000.34	2981.0-2985.6	Y
SNL-1	3072.17[c]	3074.19	2.02	3078.55	N/A	N/A
SNL-2	3064.71	3069.90	5.19	3073.16	N/A	N/A
SNL-3	3057.25	3067.11	9.86	3076.74	N/A	N/A
SNL-5	3068.45[c]	3070.82	2.37	3072.86	N/A	N/A
SNL-9	3044.36	3049.39[d]	5.03	N/A	N/A	N/A
SNL-12	2996.30	3001.53	5.23	3002.45	N/A	N/A
WIPP-12	3032.67	3032.39	-0.28	3069.11	3062.7-3070.2	N
WIPP-13	3056.73	3056.84	0.11	3067.4	3059.1-3068.2	N
WIPP-18	Recompleted as Magenta well (April 2001)				3048.9-3062.7	N/A
WIPP-19	3040.99	3040.58	-0.41	3078.45	N/A	N/A
WIPP-21	3017.31	3017.15	-0.16	3041.37	N/A	N/A
WIPP-22	3031.46	3031.14	-0.32	3062.30	N/A	N/A
WIPP-25	3059.76	3063.58	3.82	3060.47	3043.6-3050.2	Y
WIPP-26	3022.24	3025.03[e]	2.79	N/A	3013.1-3014.8	N/A
WIPP-27	3080.38	3085.44	5.06	3091.63	3075.5-3080.1	Y
WIPP-29	2966.86	2967.97	1.11	2971.30	N/A	N/A
WIPP-30	3070.53	3071.46	0.93	3078.61	3060.4-3067.6	Y
WQSP-1	3054.15	3054.88	0.73	3071.62	N/A	N/A
WQSP-2	3059.57	3060.07	0.50	3079.84	N/A	N/A
WQSP-3	3012.87	3012.05	-0.82	3069.22	N/A	N/A
WQSP-4	2987.85	2988.47	0.62	3013.5	N/A	N/A
WQSP-5	3003.73	3003.95	0.22	311.03	N/A	N/A
WQSP-6	3017.73	3017.65	-0.08	3021.41	N/A	N/A

[a]April 2004, after well reconfigured as dual completion (Culebra and Magenta)
[b]February 2004, after recompletion as Culebra well
[c]April 2004, after completion of Culebra well
[d]November 2004
[e]October 2004
N/A = not applicable; data from well not used in CCA T-field calibration or data unavailable

Table 2.8 also compares the December 2004 freshwater heads to the CCA ranges for 18 of the remaining wells used in the generation of the CCA T-fields that were monitored in 2004. Freshwater heads in 15 of the 18 wells appear to be outside the CCA ranges at the end of 2004, all higher than expected. The heads in H-10c, WIPP-12, and WIPP-13 (the only wells within their CCA range) are close to the upper limit of the uncertainty estimated for steady-state freshwater heads at those wells.

Water levels were not measured in H-12 due to the formation of an obstruction in December 2003. Insufficient monthly water level measurements were made in H-15 during CY2004 (due to well reconfiguration) to make any inferences as to changes in freshwater head. The obstruction in H-12 was cleared in early 2005 and monthly monitoring has resumed at both H-12 and H-15 for CY2005.

Although Culebra heads in excess of the respective CCA ranges are not likely to affect compliance calculations, the cause(s) of the change needs to be understood to provide confidence in our conceptual understanding of the Culebra. The SA began an investigation of possible causes of the high heads in 2000 (SNL 2001). In 2002, the SA began formalizing an integrated hydrology program plan, in conjunction with both M&OC and the DOE CBFO that outlines the path forward with respect to this investigation. The Strategic Plan for Groundwater Monitoring at the Waste Isolation Pilot Plant (DOE 2003) was published in early 2003 and is the authorization document for groundwater activities. The integrated hydrology program plan further details the completion of a number of strategically placed new Culebra wells as well as several wells replacing Culebra wells that have been lost to deterioration. The new wells will be sited in order to investigate possible sources of the rising Culebra heads as well as to fill gaps in existing Culebra information. The WIPP Integrated Groundwater Hydrology Program Plan (SNL 2003b) was completed in March 2003 and the SA, in conjunction with M&OC and DOE CBFO, have initiated this plan by drilling and completing six new wells (SNL-1, SNL-2, SNL-3, SNL-5, SNL-9, and SNL-12) in the Culebra in late 2003 and early 2004. Hydraulic testing and water quality sampling of these new Culebra wells has recently been completed by the SA. Five additional Culebra wells are scheduled to be drilled and tested in FY05. Data collected from these new Culebra wells will provide information with respect to the currently unexplained Culebra water-level rises and the variable water quality.

Preliminary findings indicate that Culebra water levels are generally rising across the entire monitoring region, not just in Nash Draw and to the south and southeast as observed in CY2004. Water-level data compiled from various sources and dating back to 1977 indicate that regional water levels were rising when Culebra monitoring began and that this trend continues today. This new information and the water level data generated since the CCA were incorporated into the T-fields used for CRA-2004.

Data from Other Units

As stated earlier, a comparison of water levels from units other than the Culebra is important to the defining of the conceptual model of site hydrology (Table 2.9). Water levels in the Magenta Member of the Rustler Formation were measured monthly in 14 wells by M&OC. All but three Magenta wells experienced an increase in water level during CY2004. Water levels decreased by less than 2 ft in the three wells showing decreases. Of the ten Magenta wells that recorded increased water levels, six changed by less than 2 ft. The four Magenta wells that had water level increases greater than 2 ft are C-2737, H-3b1, WIPP-18, and WIPP-25. Wells C-2737 and WIPP-

25 experienced water level changes due to well maintenance and reconfiguration activities and showed signs of stabilization in late 2004. It is unknown what is causing the water levels in H-3b1 and WIPP-18 to rise, but it may be related to leaky bridge plugs that are currently in the wells. To alleviate this problem, wells H-3b1 and WIPP-18 will be plugged back to just below the Magenta perforations.

Water levels were stable within one foot in the Dewey Lake well WQSP-6a and in the Los Medaños/Rustler-Salado well H-8c. The Dewey Lake water level in H-3d continued a slow rise that began in approximately 2000. Since January 2000, the water level has risen 6.28 ft, 1.5 ft and 1.58 ft of which occurred in 2003 and 2004, respectively. Access to the Forty-niner in H-3d was lost in February 2002 due to an unknown obstruction in the well.

The Bell Canyon water level behavior in AEC-8 was unusual in 2003 and 2004. A monotonic rise of unknown origin began in approximately 1993, with water levels rising from 2954.9 ft amsl in January 1993 to 3068.7 ft amsl in May 2003. We suspect that this rise in water levels was caused by a casing failure allowing water from a horizon above the Salado, possibly the Culebra, to enter the well. From May to December 2003, however, water levels dropped to 3060.1 ft amsl. This trend reversed around April 2004 when water levels began to rise again reaching 3067.82 in December 2004. The cause of this change in behavior is unknown.

The Bell Canyon water level in well Cabin Baby-1 (CB-1) decreased by 2.45 ft in 2004 (Table 2.9). This was likely due to the water level being disturbed during re-completion of CB-1 to a single completion well from a dual completion (Bell Canyon and Culebra) well in early February 2004.

The Bell Canyon water level in DOE-2 increased 10.31 ft between July and December 2004. This was likely due to the water level in DOE-2 being disturbed when the well was re-completed as a single completion well after many years as a dual completion (Bell Canyon and Magenta) well in June 2004.

Table 2.9. Summary of 2004 water-level changes in units other than the Culebra.

Well I.D.	12/03 W.L. (ft AMSL)	12/04 W.L. (ft AMSL)	2004 Change (ft)
Magenta Wells			
C-2737	3140.23[a]	3143.15	3.08
DOE-2	Recompleted as Bell Canyon well (02/2004)		N/A
H-2b1	3145.50	3143.76	-1.74
H-3b1	3132.14	3145.19	13.05
H-4c	3142.02	3141.34	-0.68
H-5c	3156.74	3156.68	-0.06
H-6c	3066.33	3067.09	0.76
H-8a	3027.06	3027.31	0.25
H-9c	3134.64	3135.65	1.01
H-10a	3221.54	3222.02	0.48
H-11b2	3132.62	3133.24	0.62
H-14	3109.02	3110.60	1.58
H-15	Recompleted as Culebra well (02/2004)		N/A
H-18	3075.27	3075.31	0.04
WIPP-18	3142.57	3144.56	1.99
WIPP-25	3051.28[b]	3061.64	10.36
Dewey Lake Wells			
H-3d	3076.42	3078.00	1.58
WQSP-6a	3197.09	3197.14	0.05
Los Medaños Well			
H-8c	2980.55	2981.18	0.63
Forty-niner Well			
H-3d	Well obstructed as of February 2002		N/A
Bell Canyon Wells			
AEC-8	3059.93	3067.82	7.89
CB-1	2728.00[c]	2725.55	-2.45
DOE-2	2665.14[d]	2675.45	10.31

[a]November 2003
[b]August 2003
[c]March 2004, after recompleted as Bell Canyon well (single completion)
[d]July 2004, after recompleted as Bell Canyon well (single completion)
N/A = not available

Changes in Groundwater Flow - 2005:

<table>
<tr><td colspan="5">Trigger Value Derivation</td></tr>
<tr><td>COMP Title:</td><td colspan="4">Changes in Groundwater Flow</td></tr>
<tr><td>COMP Units:</td><td colspan="4">Inferred from water-level data</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>Groundwater Monitoring</td><td>Head and Topography</td><td>Monthly water-level measurements; pressure-density surveys.</td><td colspan="2">Indirect</td></tr>
<tr><td colspan="5">COMP Derivation Procedure – Reporting Period December 2003 to December 2004</td></tr>
<tr><td colspan="5">Assessment from SER data (DOE 2005d).</td></tr>
<tr><td colspan="5">Related PA Elements</td></tr>
<tr><td>Element Title</td><td>Type & ID</td><td>Derivation Procedure</td><td>Compliance Baseline</td><td>Impact of Change</td></tr>
<tr><td>Groundwater conceptual model, Transmissivity fields</td><td>NA</td><td>NA</td><td>NA</td><td>Provides validation of the various CCA models - T-field assumptions and groundwater basin model.</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>Change in Culebra Groundwater Flow</td><td>CCA range; see Table 2.8</td><td colspan="3">Comparisons with ranges of undisturbed steady-state freshwater heads used to calibrate Culebra T fields for CCA.</td></tr>
</table>

2.4 Waste Activity

For this reporting period, Panel 1 has been filled with waste and closed, Panel 2 waste emplacement has progressed to six of its seven rooms and waste is being emplaced in room 1 of Panel 3. Panel 1 final utilization is shown in Figure 2.24. Panels 2 and 3 are shown in Figures 2.25 and 2.26 respectively. Panels 2 and 3 are expected to be fully utilized.

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

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

Waste Location By Month
Panel 1

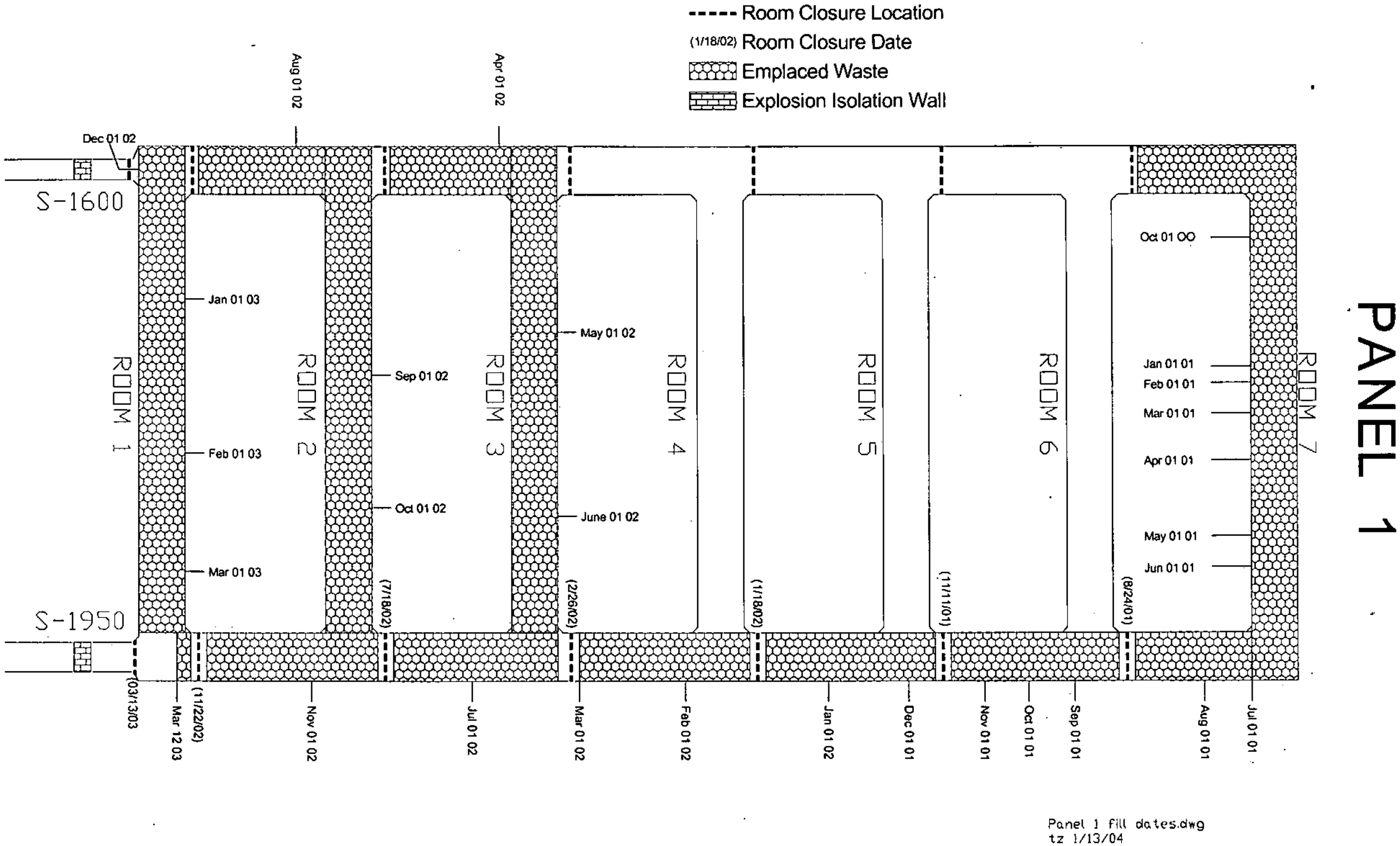

Figure 2.24 Panel 1 utilization

Waste Location By Month
Panel 2

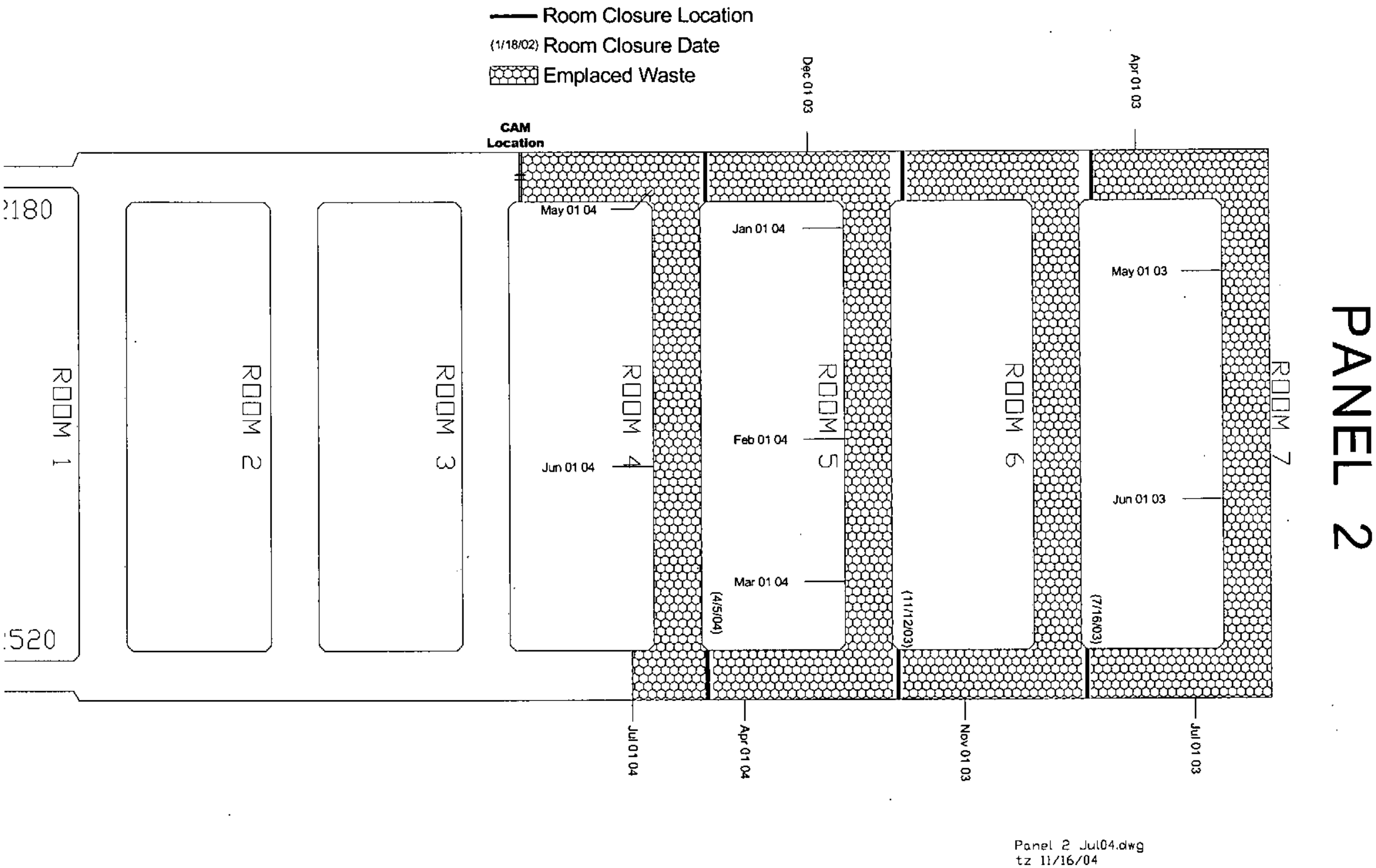

Figure 2.25 Panel 2 Utilization

Waste Location By Month
Panel 3

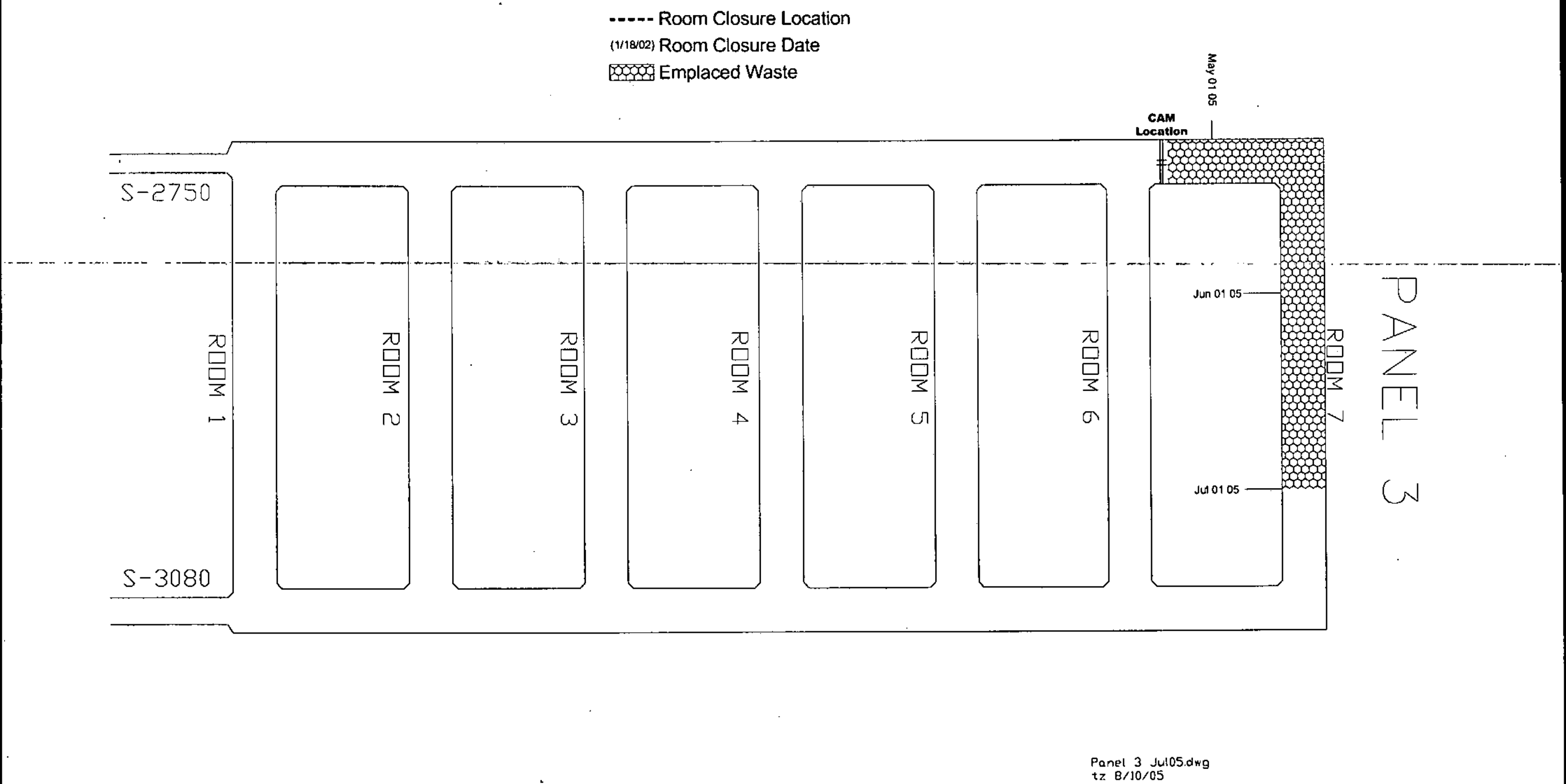

Figure 2.26 Panel 3 utilization

Table 2.10 Radionuclide inventory information

Radionuclide	Panel 1	Panel 2	Panel 3	Cumulative Activity (Ci)
^{241}Am	1.20×10^{5}	3.17×10^{4}	2.19×10^{3}	1.54×10^{5}
^{137}Cs	5.09×10^{-4}	1.27	1.42×10^{-2}	1.28
^{238}Pu	6.19×10^{3}	1.45×10^{4}	8.03×10^{3}	2.87×10^{4}
^{239}Pu	1.52×10^{5}	8.17×10^{4}	1.13×10^{3}	2.35×10^{5}
^{240}Pu	3.43×10^{4}	2.11×10^{4}	3.47×10^{2}	5.57×10^{4}
^{242}Pu	3.32	4.19	5.86×10^{-2}	7.56
^{90}Sr	3.81×10^{-5}	1.44	1.41×10^{-2}	1.46
^{233}U	4.14×10^{-1}	2.27×10^{-1}	1.64×10^{-1}	8.05×10^{-1}
^{234}U	1.57	4.58	1.40	7.56
^{238}U	7.54	2.31	3.95×10^{-2}	9.88
Total	3.12×10^{5}	1.49×10^{5}	1.28×10^{4}	4.73×10^{5}

Information from M & OC, WWIS. Reporting period includes emplacement that occurred between 7-1-2004 and 6-30-2005

Table 2.11 Comparison of tracked radionuclide inventory to CCA and CRA-2004 inventory (from DOE 2004e, DOE 2004a and SNL 2004)

Radionuclide CCA Table 4-10)	Non-Decayed Inventory as of June 30, 05	CCA Total Inventory at Closure	CRA-2004Total Inventory at Closure	Percentage of CRA-2004 Inventory
^{241}Am	1.54×10^{5}	4.48×10^{5}	4.58×10^{5}	33.6%
^{238}Pu	2.87×10^{4}	2.61×10^{5}	1.25×10^{6}	2.3%
^{239}Pu	2.35×10^{5}	7.95×10^{5}	6.65×10^{5}	35.3%
^{240}Pu	5.57×10^{4}	2.15×10^{5}	1.08×10^{5}	51.6%
^{242}Pu	7.56	1.17×10^{3}	2.71×10^{1}	27.9%
^{233}U	8.05×10^{-1}	1.95×10^{3}	1.27×10^{3}	< 1%
^{234}U	7.56	5.08×10^{2}	3.19×10^{2}	2.4%
^{238}U	9.88	50.1	1.54×10^{2}	6.4%
^{90}Sr	1.46	2.16×10^{5}	1.42×10^{5}	< 1%
^{137}Cs	1.28	2.24×10^{5}	1.79×10^{5}	< 1%

Waste Activity - 2005:

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	Radionuclide activity per container and volume	Curies per container. Container volume.	Appendix P of CCA Appendix BIR (DOE 1996) by waste stream. Appendix DATA Attachment F of the CRA-2004 (DOE 2004a)
Waste emplacement records	Location of waste in panels	Coordinates and number of containers (or volume in cubic meters).	None.
COMP Derivation Procedure - Reporting Period 9/1/2004 to 8/31/2005			
Tabulation of waste activity in each panel. Total curie content of emplaced CH-TRU and RH-TRU waste. *[Total radionuclide inventories reported by WWIS]*			
Year 2005 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 LWA limits.	CCA: Table PAR-41 and CCA Table 4-8. CRA-2004: Table PAR-37 in CRA-2004 Appendix PA, Attachment PAR	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 6-31 of the CCA and Figure 6-30 of the CRA-2004	Cuttings are a significant contributor to releases. An increase in activity of intersected waste is potentially significant.
WIPP-scale average activity for spallings releases	Parameter	Average of all CH-TRU waste only.	NA	Spallings are a significant contributor to releases. An increase in average activity of intersected waste is potentially significant.

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

3 COMPs Assessment Conclusion

The operational period monitoring program designed to meet the Assurance Requirements of 40 CFR 191.14 and the terms of WIPP certification was initiated in 1999. This monitoring program is useful to further validate the assumptions and conceptual models that were used to predict WIPP performance and identify conditions that could potentially cause radioactive release above the limits established in 40 CFR § 191.13. Since releases above these limits cannot occur during the operational period of WIPP, the monitoring program looks at other potential performance indicators of the disposal system and compares these data to PA performance expectations. Specifically, ten monitoring parameters are assessed and compared to PA expectations and assumptions. The CRA-2004 (DOE 2004a) contains the results of an updated PA that, upon acceptance from EPA, will become the new compliance baseline. As such, the compliance monitoring program will be reassessed and updated to reflect the conclusions of the new PA baseline. The results of this year's assessment 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.

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