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Sandia National Laboratories Compliance Monitoring Parameter Assessment For 2010

WBS 1.3.1

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Compliance Monitoring
Parameter Assessment for 2009

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Executive Summary

This document reports the tenth annual (2010) derivation and assessment of the Waste Isolation Pilot Plant (WIPP) Compliance Monitoring Parameters (COMPs). The COMPs program is designed to meet certain requirements of the U.S. Environmental Protection Agency's (EPA) long-term disposal regulations (EPA 1993 and 1996). The concept of deriving and assessing COMPs is explained in Sandia National Laboratories (SNL) Activity/Project Specific Procedure, SP 9-8, titled: *Monitoring Parameter Assessment Per 40 CFR 194.42* (SNL 2008).

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 Part 194. Monitoring parameters that are related to the long-term performance of the repository were identified in a monitoring analysis.[1] Since these parameters fulfill a regulatory function, they were termed Compliance Monitoring Parameters so that they would not be confused with similar performance assessment (PA) input parameters.

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

This year's COMPs Report is the first derived after the WIPP's second recertification (EPA 2010a). The EPA requested a new PA in support of the second recertification called the Performance Assessment Baseline Calculation (PABC-2009). The PABC-2009 represents the latest compliance baseline.

In the initial Certification Ruling (EPA 1998a), EPA approved 10 COMPs, 2 relating to human activities, 5 relating to geotechnical performance, 2 relating to regional hydrogeology and 1 relating to the radioactive components of the waste. The requirements of 40 CFR 194.4(b)(3) require 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. The DOE complies with these EPA requirements by conducting periodic assessments of COMPs that monitor the predicted performance of the repository and report any condition adverse to the containment performance. This compliance monitoring

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[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.

program is described in greater detail in DOE's *40 CFR Parts 191 and 194 Compliance Monitoring Implementation Plan* (MIP; DOE 2005).

This 2010 COMPs assessment presents the results and the recommendations based on the COMPs monitoring data gathered during the annual reporting cycle. This assessment concludes that the current COMP values do not indicate a condition for which the repository will perform in a manner other than that represented in the WIPP recertification 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 10 COMPs, which are listed in Section 2.

The COMPs are an integral part of the overall WIPP monitoring strategy. The DOE's *40 CFR Part 191 and 194 Compliance Monitoring Implementation Plan* (MIP; DOE 2005) describes the overall monitoring program and responsibilities for COMPs derivation and assessment. This report documents the results of the reporting year 2010 COMPs assessment (July 1st 2009 to June 30th 2010). This period matches the reporting period of the annual report that addresses 40 CFR § 194.4(b)(4) requirements (EPA 2003). This COMPs assessment follows the program developed under the original certification baseline using data and PA results from the current certified baseline, the 2009 recertification's Performance Assessment Baseline Calculation (PABC-2009).

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 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 Scientific Advisor is responsible for the development and maintenance of the TVs. An observation beyond the acceptable range of TVs represents a condition that requires further actions, but does not necessarily indicate an out-of-compliance condition. This approach assures that conditions that are not consistent with expected repository performance are recognized as early as possible. These conditions may include data inconsistent with the conceptual models implemented in PA, or invalidation of assumptions and arguments used in the screening of Features, Events and Processes (FEPs) screened into PA.

1.2 Reporting Cycle

The types of changes that must be reported to EPA are defined in 40 CFR §194.4. Under 40 CFR §194.4, changes that differ from the activities or conditions outlined in the latest compliance application are defined as either significant or non-significant based on their potential impact on the compliance baseline and potential impact on containment performance. This part of the rule also identified the timeframe to which the DOE is required to report significant and non-significant changes to the EPA. As such, the CCA state in Section 7.2.1 and the recertification applications thereafter state that the results of the monitoring program will be submitted annually (DOE 1996, DOE 2004, DOE 2009a). Additionally, the recertification requirements at 40 CFR §194.15(a)(2) also require inclusion of all additional monitoring data, analysis and results in the

DOE's documentation of continued compliance as submitted in periodic CRAs. Monitoring data, the associated parameter values and monitoring information must be reported even if the assessment concludes there is no impact on the repository. The annual monitoring data will be compiled and provided to the DOE to fulfill DOE's monitoring reporting requirements to the EPA. The Scientific Advisor's role in the annual reporting task is to use the monitoring data to derive the COMPs (as necessary), compare the results to repository performance expectations in PA (annually), and to use the new and updated information to make any recommendations for modification to the Compliance Baseline, if merited.

2 Assessment of COMPs

The compliance monitoring program tracks the following 10 COMPs:

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

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

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

This section summarizes the results of the 2010 calendar year assessment. In the following sections, each COMP is evaluated and compared to the applicable TV. This assessment is performed under Specific Procedure SP 9-8 (SNL 2008). A table for each of the ten COMPs is used to summarize the evaluation and shows the COMP derivation, related PA parameters and FEPs, the current value for the COMPs as applicable and the TV.

2.1 Human Activities COMPs

The CCA identifies 10 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

Table 2.1 summarizes data and TV information related to the COMP Probability of Encountering a Castile Brine Reservoir, as well as its implementation in PA. Monitoring activities for Castile brine encounters have identified no new brine encounter during this reporting period. The total of encounters identified since the CCA is 7. These encounters are detailed in Table 2.2. 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; 2 wells, ERDA 6 and WIPP 12, were drilled in support of the WIPP site characterization effort (see DOE 2010a, Table 7 for a complete listing of brine encounters). The Delaware Basin Drilling Surveillance Program reviews the well files of all new wells drilled in the New Mexico portion of the Delaware Basin each year looking for instances of Castile brine encounters. The program also sends out an annual survey to operators of new wells to determine if pressurized brine was encountered. Since the CCA, data have been compiled through August 2010. During this reporting period, 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 2010a).

Of the 7 Castile brine encounters recorded since the 1996 CCA, 6 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 2.2 shows all known Castile brine encounters in the vicinity of the WIPP Site since the CCA.

The impacts of brine encounters are modeled in the PA. The CCA used a 0.08 probability of encountering a Castile brine reservoir. In the Performance Assessment Verification Test (PAVT), the EPA mandated a probability range of 0.01 to 0.60. The new range did not significantly influence the predicted performance of the repository. This range has been used in all PAs since the original WIPP certification. The mean of this parameter is approximately 0.30 which is significantly more than the 0.08 used in the CCA which was based off of actual encounters. It is not expected, and more than 10 years of monitoring drilling encounters have shown that it is unlikely that further monitoring will show a probability near 0.30. The EPA also determined in their first certification sensitivity analysis that this parameter (PBRINE) does not have a significant impact on PA results (EPA 1998b).

Table 2.1 Probability of Encountering a Brine Reservoir - 2010:

<table>
<tr><th colspan="5">Trigger Value Derivation</th></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><th colspan="5">Related Monitoring Data</th></tr>
<tr><td>Monitoring Program</td><td>Monitoring Parameter ID</td><td>Characteristics (e.g., number, observation)</td><td colspan="2">Compliance Baseline Value</td></tr>
<tr><td>DBMP(1)</td><td>NA</td><td>Driller's survey – Field observations</td><td colspan="2">0.01 to .60</td></tr>
<tr><th colspan="5">COMP Assessment Process</th></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><th colspan="5">Year 2010 COMP Assessment Value - Reporting Period September 2009 to August 2010</th></tr>
<tr><td colspan="5">No new data reported in State record during the reporting period; No new report from Field Observations. 34 Total Brine Encounters
27 CCA total occurrences before 1996
0 State Record occurrences since 1996
7 Site Personnel/ Drillers Survey occurrences since 1996</td></tr>
<tr><th colspan="5">Related Performance and Compliance Elements</th></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><th colspan="5"><i>Monitoring Data Trigger Values</i></th></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

Table 2.2. Well Locations Encountering Brine since the CCA[2].

Number	Location	Well Name and Location	Spud Date	Well Information
1	T21S-R31E-Sec 35	Lost Tank "35" State #4	09/11/2000	Oil Well: Estimated several hundred barrels per hour. Continued drilling.
2	T21S-R31E-Sec 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. and water flow of 450 barrels per hour. Two days later, no water flow/full returns.
3	T22S-R31E-Sec 2	Graham "AKB"State #8	04/12/2002	Oil Well: Estimated 105 barrels per hour. Continued drilling.
4	T23S-R30E-Sec 1	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	T23S-R30E-Sec 1	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	T22S-R30E-Sec 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	T21S-R31E-Sec 34	Jaque "AQJ" State #7	03/04/2005	Oil Well: Encountered 104 barrels per hour at 2,900 ft. No impact on drilling process.

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[2] From DOE 2010a, Table 7

2.1.2 Drilling Rate

Table 2.3 summarizes data and TV information related to the COMP Drilling Rate parameter and its implementation in PA. The drilling rate COMP tracks deep drilling (> 2,150 ft in depth) activities relating to resource exploration and extraction. Boreholes relating to resources include potash and sulfur core-holes, hydrocarbon exploration wells, saltwater disposal wells and water wells drilled in the Delaware Basin. The first drilling rate, reported in the CCA, was determined using an equation provided in 40 CFR Part 194. The drilling rate formula is as follows:

$$D_r = (D_{100} \times 1{,}000 \text{ yrs}) \div A_{DB} \tag{1}$$

D_r = Drilling Rate (boreholes per km^2 per 10,000 yrs)
D_{100} = Deep boreholes greater than 2,150 ft depth drilled over the last 100 yrs
A_{DB} = Area of the Delaware Basin (23,102 km^2)

The rate reported in the CCA using this equation was 46.8 boreholes per square kilometer over 10,000 years. Including the time period after the CCA (June 1996 to June 2010) increases the rate to 61.3 boreholes per square kilometer per 10,000 years (DOE 2010a).

As shown in Table 2.4, the drilling rate has risen from 46.8 holes per square kilometer to 61.3 holes per square kilometer since 1996. The rate will continue to climb because of the method used to calculate the rate. Since the first well drilled in the area occurred in 1911, it will be 2011 before one well is dropped from the count and 2014 before the next well is dropped from the count. In the meantime, numerous wells will have been added, increasing the drilling rate. When the TV report was written, it was thought that the drilling rate used in PA would not be changed for each recertification. However, each recertification updates the drilling rate parameter and effectively accounts for the change in rate. Because the change in the drilling rate is accounted for every 5 years, the concept of applying a TV is unnecessary. Although the drilling rate TV was exceeded in 2004, the exceedance was expected. As discussed in the Delaware Basin Monitoring Annual Report, the drilling rate will continue to rise with each new well drilled until the 100-year window moves to a point in time when there are more older wells removed from consideration than new wells are added. Studies have demonstrated that much higher drilling rates are needed to impact compliance (EEG 1998). For example, in response to a request from EPA (EPA 2004), the Scientific Advisor analyzed the impact of drilling rate on repository performance. This analysis shows that even if the drilling rate were doubled relative to that used for the CRA-2004 PA, the disposal system performance would be well within the release limits set by EPA regulations (Kanney and Kirchner 2004). The most current compliance PA uses a drilling rate of 59.8 such that the original TV is of no consequence. This year's COMPs report recommends the drilling rate TV be reassessed in the next revision of the TV report.

Table 2.3 Drilling Rate - 2010:

<table>
<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 colspan="3">Characteristics (e.g., number, observation)</td></tr>
<tr><td>DBMP</td><td>Deep hydrocarbon boreholes drilled</td><td colspan="3">Integer per year</td></tr>
<tr><td colspan="5">COMP Assessment Process</td></tr>
<tr><td colspan="5">(Total number of deep boreholes drilled/number of years of observations (100)) x (10,000/23,102) [i.e., over 10,000 years divided by the area of the Delaware Basin in square kilometers]</td></tr>
<tr><td colspan="5">Year 2010 COMP Assessment Value - Reporting Period September 1, 2009 to August 31, 2010</td></tr>
<tr><td colspan="5">(14,403 boreholes on record for the Delaware Basin) Drilling Rate = 62.3 boreholes per square kilometer per 10,000 yrs.</td></tr>
<tr><td colspan="5">Related Performance and Compliance Elements</td></tr>
<tr><td>Element Title</td><td>Parameter Type & ID or Model Description</td><td>Derivation Procedure</td><td>Compliance Baseline</td><td>Impact of Change</td></tr>
<tr><td>Drilling rate</td><td>Parameter LAMBDAD</td><td>COMP/10,000 years</td><td>5.98 E-03 per square kilometer per year (CRA-2009 PABC value)</td><td>Cuttings/cavings releases increase proportionally with the drilling rate. Doubling CRA drilling rate does not exceed compliance limit.</td></tr>
<tr><td colspan="5">Monitoring Data Trigger Values</td></tr>
<tr><td>Monitoring Parameter ID</td><td>Trigger Value</td><td colspan="3">Basis</td></tr>
<tr><td>Deep boreholes</td><td>53.5 boreholes per km^2 per 10,000 yrs.</td><td colspan="3">Calculations have shown that doubling the drilling rate does not impact compliance with the EPA release limits (Kanney and Kirchner 2004).</td></tr>
</table>

Table 2.4. Drilling Rates for Each Year since the CCA.

Year	**Number of Boreholes Deeper than 2,150 ft**	**Drilling Rate (boreholes 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[3]	12,219	52.9
2002 (revised)	12,139	52.5
2003	12,316	53.3
2004	12,531	54.2
2005	12,819	55.5
2006	13,171	57.0
2007	13,520	58.5
2008	13,824	59.8
2009	14,173	61.3
2010	14,403	62.3

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[3] In Revision 3 of DOE 2010a (dated 2002), the drilling rate for 2002 was shown as 52.9, with 12,219 deep boreholes. It was later noted that 80 shallow wells in Texas were listed as being deep. Correcting the classification of the 80 boreholes resulted in a reduction of the drilling rate from 53.9 to 52.5 (DOE 2010a).

2.2 Geotechnical COMPs

The CCA lists 10 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 2010b) and the annual Subsidence Monument Leveling Survey (DOE 2009b). 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 2010b) summarizes data collected from July 2008 through June 2009.

Subsidence monitoring survey reports are also prepared by the M&OC on an annual basis and present the results of leveling surveys performed in 2008 for 9 vertical control loops comprising approximately 15 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 2009b) summarizes data collected between September and November of 2008.

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

Table 2.5 summarizes data and TV information related to the COMP parameter Creep Closure, and its implementation in PA. The GAR compiles all geotechnical operational safety data gathered from the underground. The most readily quantifiable geomechanical response in the WIPP underground is creep closure. The GAR routinely measures and reports creep deformation, either from rib-to-rib, roof-to-floor, or extensometer borehole measurements. With the exception of newly mined openings, rates of closure are relatively constant within each zone of interest and usually range from about 1-5 cm/yr. A closure rate in terms of cm/yr can be expressed as a global or nominal creep rate by dividing the displacement by the room dimension and converting time into seconds. Nominally these rates are of the order of 1×10^{-10} /s and are quite steady over significant periods. From experience, increases and decreases of rates such as these might vary by 20 percent without undue concern. Therefore, the "trigger value" for creep deformation was set as one order of magnitude increase in creep rate. Such a rate increase would alert the M&OC geotechnical staff to scrutinize the area exhibiting accelerating creep rates.

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

The creep deformation COMP is addressed by examining the deformations measured in specific regions of the underground including: (1) Shafts and Shaft Stations and (2) Access Drifts and Waste Disposal Areas. Figure 2.1 shows the current configuration of the WIPP underground

Table 2.5 Creep Closure - 2010:

<table>
<tr><td>COMP Title:</td><td colspan="4">Creep Closure</td></tr>
<tr><td>COMP Units:</td><td colspan="4">Closure Rate (s^{-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 located throughout the underground.</td><td colspan="2">Munson-Dawson (MD) Constitutive Model</td></tr>
<tr><td colspan="5">COMP Assessment Process - Reporting Period July 2008 through June 2009</td></tr>
<tr><td colspan="5">Evaluate GAR for centerline closure rates, compare to previous year's rate. Account for drift dimensions and convert to creep 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 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>

with specific elements and regions annotated for reference. Information used for all geotechnical COMPs is derived from the GAR which has a reporting period ending June 30, 2009. For this reporting period, Panels 1 through 5 had been fully excavated and panel 6 was partially mined. Figure 2.1 shows all areas mined as of June 30, 2009. At that time, waste was being emplaced in panel 5 while panels 1 through 4 waste disposal operations had ceased and the entry drifts had been sealed to prevent access (please note that the reporting period for geotechnical information is through June 2009 such that the reported mining and emplacement activities depicted in Figure 2.1 from the GAR are not as current as the waste activity COMP information, which is through June 30, 2010).

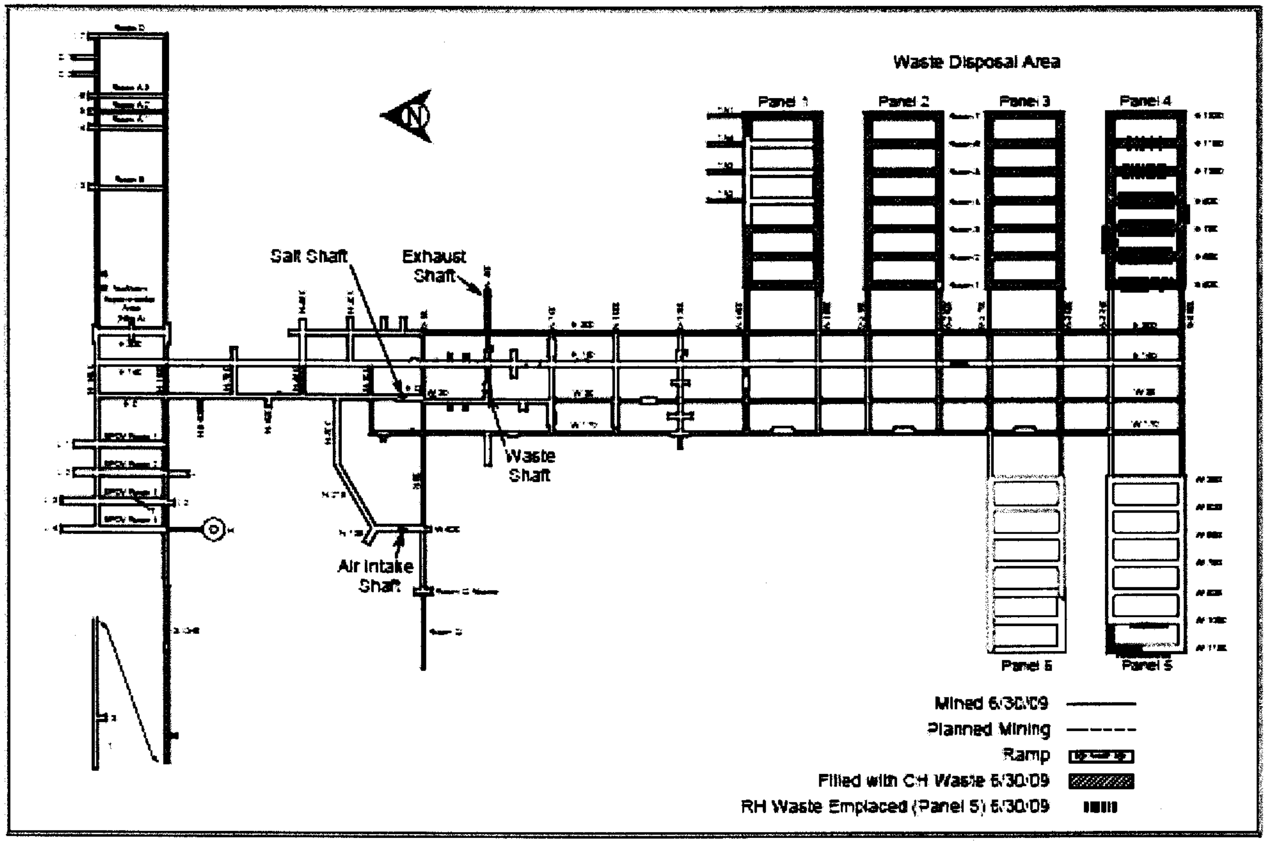


Figure 2.1. Configuration of the WIPP Underground for Geotechnical COMPs (after DOE 2010b; Reporting Period July 2008 through June 2009).

Shafts and Shaft Stations

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

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

Data available for assessing creep deformations in the salt surrounding the shafts are derived exclusively from routine inspections and extensometers extending radially from the shaft walls. These data are reported annually in the GAR. The Salt Handling Shaft, Waste Shaft, and Air Intake Shaft are inspected weekly by underground operations personnel. Although the primary purpose of these inspections is to assess the conditions of the hoisting and mechanical equipment, observations are also made to determine the condition of the shaft walls, particularly with respect to water seepage, loose rock, and sloughing. In contrast to the other three shafts, the Exhaust Shaft is inspected quarterly using remote-controlled video equipment. These inspections have focused on salt build-up in the Exhaust Shaft and the impacts this build-up has on power cabling in the shaft. Based on these visual observations, all four shafts are in satisfactory condition and have required only routine ground-control activities during this reporting period.

Shortly after its construction, each shaft was instrumented with extensometers to measure the inward movement of the salt at 3 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 3 instrumented levels are 330 m, 480 m and 630 m. Three extensometers are emplaced at each level to form an array. The extensometers comprising each array extend radially outward from the shaft walls and are equally spaced around the perimeter of the shaft wall. Over the years, most of these extensometers have malfunctioned. As a result, reliable data are not available at some locations. The DOE currently has no plans to replace failed instrumentation installed in any of the shafts because monitoring data acquired to date have shown no unusual shaft movements or displacements. It should be noted that no extensometer data was collected from the shafts during the reporting period because of a data logger failure. The type of extensometer used and its compatible data logger are no longer manufactured. DOE does not plan to replace the logger with an alternate because of compatibility and interface issues.

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

The effects of creep on the shaft stations are assessed through visual observations and displacement measurements made using extensometers and convergence points. Because of the modifications made over the years, many of the original instrumentation has been removed or relocated. In addition, some instruments have malfunctioned or have been damaged and no longer provide reliable data. Displacement rates from existing and functional instrumentation listed in the GAR for the current reporting period (2008-2009) and the previous reporting period (2007-2008) are summarized in Table 2.6. Most of the measurements are for vertical closure. Based on convergence data, current vertical displacement rates range from 0.05 to 1.58 in/yr (0.13 to 4.01 cm/yr); current horizontal displacement rates range from 0.80 to 1.79 in/yr (2.03 to 4.55 cm/yr). Dividing convergence rates by the average room dimension (approximately 6 meters) and expressing the results in units of 1/s yields vertical and horizontal creep rates between approximately 6.71 x10^{-12}/s to 2.40 x10^{-10}/s. These rates are still low and represent typical creep rates for stable openings in salt. An examination of the percentage changes in displacement rates shown in Table 2.6 suggests the current shaft station displacement rates (where available) are essentially identical to those measured during the previous reporting period. Based on the extensometer and convergence data, as well as the limited maintenance required in the shaft stations during the last year, creep deformations associated with the WIPP shaft stations are considered acceptable and meet the TV requiring creep deformation rates to change by less than one order of magnitude in a one-year period.

Table 2.6. Summary of Closure Rates for WIPP Shafts and Shaft Stations.

Location	Inst. Type[(a)]	Displacement Rate (in/yr)[(c)]		Change In Rate (%)
		2007–2008	2008–2009	
Salt Handling Shaft	No extensometers remain functional			
Waste Handling Shaft	No extensometer data available for 2006-2009			
Exhaust Shaft	No extensometer data available for 2006-2009			
Salt Handling Shaft Station				
E0 Drift – S18 (A-E)	CP	1.41	1.54	9
E0 Drift – S18 (B-D)	CP	1.57	1.79	13
E0 Drift – S18 (F-H)	CP	0.94	1.04	10
E0 Drift – S30 (A-C)	CP	1.47	1.58	8
E0 Drift – S65 (A-C)	CP	1.05	1.14	9
Waste Shaft Station				
S400 Drift – W30 (Vert. CL)	Ext	0.32	0.31	-3
Waste Shaft Brow (North)	Ext	0.08	0.05	-34
Waste Shaft Brow (South)	Ext	0.32	0.19	-39
S400 Drift – E32 (Vert CL)	Ext	NA	0.30	NA
S400 – E30 (Horizontal)	CP	0.89	0.80	-10
S400 – E32 (Horizontal)	CP	NA	1.46	NA
S400 – E85 (Horizontal)	CP	NA	1.37	NA
S400 – E90 (Horizontal)	CP	1.05	1.27	21
Air Intake Shaft Station				
S65 Drift – W620 (Vert CL)	Ext	0.30	0.32	-6
N95 Drift – W620 (Vert CL)	Ext	0.37	0.42	-12

(a) Instrument Type: Ext = extensometer; CP = convergence point.
(b) CL = Centerline
(c) NA = Not installed during the 2007 – 2008 reporting period

Access Drifts and Waste Disposal Area

Access Drifts. The access drifts comprise the 4 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 4.0 m to 6.4 m and widths ranging from 4.3 m to 9.2 m.

During the current reporting period (July 2008 to June 2009), excavation of Panel 5 was completed and Panel 6 mining was started. Panels 3 and 4 were excavated at a slightly higher stratigraphic position (2.4 m) than either Panels 1 or 2. The roof of these panels coincides with Clay G. As such, Panels 1, 2, 7 and 8 will be at the original horizon and Panels 3, 4, 5 and 6 approximately 2.4 m higher in elevation (roof at Clay G). Trimming, scaling, floor milling and rock bolting operations were performed as necessary during the reporting period

Assessment of creep deformations in the access drifts is made through the examination of extensometer and convergence point data reported annually in the GAR. Table 2.7 summarizes the vertical and horizontal displacement data reported in the most recent GAR (DOE 2010b). The 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% which includes negative values, 0 to 25%, 25 to 50%, etc.). The numbers shown in the tables represent the number of instrumented locations located on the drift vertically or horizontally that fall within the range of the indicated percentage change. In general, convergence rate accelerations continue to be minor in most locations. Other areas that have shown an increase in closure rates can be directly attributed to mining in Panel 6 and associated drifts. The majority of the rate changes for the 2009 COMPs data were negative or near zero which demonstrates that displacements were slowing. For this 2010 and the 2009 COMP reports, the majority of the data are in the less than 0 range. Both convergence point data and extensometer data were combined in this year's report. The maximum displacement rates corresponding to these data for the current reporting period are given below:

Maximum Vertical Displacement Rates along Access Drifts:

18.16 cm/yr

Maximum Horizontal Displacement Rate along Access Drifts:

8.99 cm/yr

Using a typical average drift dimension of 5 m and the maximum displacement rates shown above, the inferred maximum creep rate is approximately $1.15\text{x}10^{-9}$/s. This rate is based on the maximum displacement which is not representative of the behavior of the system. This rate is nearly identical to last year's rate of $1.03\text{x}10^{-9}$/s.

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 8 disposal panels, each comprising 7 rooms (the major north-south access drifts servicing the 8 panels will also be used for waste disposal and will make up the ninth and tenth panels). Panel 1 was constructed in the late 1980s, Panel 2 constructed during the 1999-2000 time period, Panel 3 constructed during the 2002-2004 time period and the completion of Panel 4 during 2006. As of June 30, 2009 (for the GAR reporting period), waste emplacement operations were complete in Panels 1 through 4. Panel 5 was currently being used for waste emplacement. Panel 6 mining was initiated during this GAR reporting period. Figure 2.1 shows the state of waste emplacement and mining for the GAR reporting period.

The waste emplacement rooms are rectangular in cross-section with a height of 4 m and a width of 10 m. Entry drifts that provide access into the disposal rooms are also rectangular with a height of 3.65 m and a width of 4.30 m.

Table 2.7. Summary of Changes in Vertical and Horizontal Displacement Rates 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 2007-2008 and 2008-2009 Reporting Periods					
	< 0%	0 – 25%	25 – 50%	50 – 75%	75 – 100%	100 – 200%
Access Drifts						
Vertical	108	130	9	5	2	2
Horizontal	40	88	4	1	2	1
Waste Disposal Area						
Panel 1:						
Vertical	4	8	5	0	0	0
Horizontal	3	6	0	0	0	0
Panel 2						
Vertical	1	1	0	0	0	0
Horizontal	0	2	0	0	0	0
Panel 3						
Vertical	0	4	0	0	0	0
Horizontal	0	2	0	0	0	0
Panel 4						
Vertical	7	15	2	0	2	1
Horizontal	0	0	0	0	0	0
Panel 5						
Vertical	88	10	0	0	0	0
Horizontal	0	0	0	0	0	0

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 2.6 and 2.7 (presented previously) summarize, respectively, the vertical and horizontal displacement data reported in the most recent GAR (DOE 2010b) for Panel access drifts and Panels 3, 4 and 5. Panel 1, 2 and 3 are closed and are no longer accessible. Convergence points and extensometers were installed in Panel 5 and are currently monitored. Each table examines percentage changes between displacement rates measured during the current and previous reporting periods and breaks these percentage changes into ranges. 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:

17.58 cm/yr

Maximum Horizontal Displacement Rates along Waste Disposal Area:

6.86 cm/yr

Using a nominal disposal-area-opening dimension of 8 m and the maximum displacement rates shown above, the inferred maximum creep rate is approximately $6.97\text{x}10^{-10}$/s. This is less than last year's rate of $1.24\text{x}10^{-9}$/s. Maximum creep rates for the waste disposal areas are all associated with Panels 4 and 5. Convergence rates for Panel 5 are generally decreasing due to a lesser influence from initial mining of the panel. Panel 5 was bolted and instrumented soon after mining, much sooner than Panels 3 and 4. Room beam deformation and room closure are trending lower than in Panel 4. This trend may be attributed to the early installation of the roof bolts.

2.2.2 Extent of Deformation

Table 2.8 summarizes the data and TV information relating to the COMP parameter Extent of Deformation, as well as its implementation in PA. The extent of brittle deformation can have important implications to PA. As modeled in PA, the DRZ releases brine to the disposal room while properties of the DRZ control hydrologic communication between disposal panels. Therefore, extent of deformation relates directly to a conceptual model used in performance determinations. If characteristics could be tracked from inception, the spatial and temporal evolution of the DRZ would provide a validation benchmark for damage calculations.

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

The Geotechnical Engineering Department at WIPP has compiled back-fracturing data into a database. The supporting data for the GAR (Volume 2, DOE 2010b) consists of plan and isometric plots of fractures. Fracture development is most continuous parallel to the rooms and near the upper corners. These fractures are designated "low angle fractures" relative to the horizontal axis. The original excavation horizon results in a 2.4 m-thick beam of halite between the roof and Clay Seam G. Low-angle fractures arch over rooms and asymptotically connect with Clay Seam G. Although the preponderance of monitoring information derives from the roof (back), buckling extends into the floor to the base of Marker Bed 139, which is located about 2 m below the disposal room floors. Fracture mapping thus far is consistent with expectations and tracks stress trajectories derived from computational work. At this time, a comprehensive model and supporting data for model parameters for damage evolution has not been developed for PA.

Excavation of Panel 3 raises the waste disposal panels by 2.4 m such that the roof of the disposal rooms will be coincident with Clay Seam G and the floor will be an additional 2.4 m above Marker Bed 139. This change will likely alter the typical fracture patterns observed to date and may cause subtle changes in how the DRZ develops. Effects of excavation to Clay G have been evaluated by finite element analyses to assess possible impact to PA (Park and Holland 2003). Their modeling shows that the DRZ does not extend below MB139 at the new horizon, as it does at the original horizon. The rise in repository elevation otherwise causes no discernable change to the porosity surface used in PA. Data provided in the GAR suggest that brittle deformation extends at least 2.4 m (to Clay Seam G where present) and perhaps as much as 4.5 m (to Clay Seam H) above the roof of the WIPP openings. In addition, brittle deformation extends below the floor of the openings to at least the base of Marker Bed 139 (approximately 2 to 3 m).

Data provided in the 2009 GAR were compared to fracture maps in the previous year's report to determine if fractures exceed the 1 m/yr TV. Maps for Panels 4 and 5 were reviewed this reporting cycle. Most all fracture maps looked similar or identical to last year's maps. The new fractures discussed in last-year's report that are the Panel 4, S3310 area have not progressed. Last year was the first year that Panel 5 was mapped such that no comparisons could be made at that time. There were new fractures that were mapped in this years GAR that exceed the 1 m/yr. TV in room 1. Since this panel is relatively new, initial fractures are expected however, this area will be reassessed in next year's report to determine if additional actions are recommended. No additional actions are recommended at this time.

Table 2.8 Extent of Deformation - 2010:

<table>
<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 Assessment Process - Reporting Period July 2008 through June 2009</td></tr>
<tr><td colspan="5">Extent of deformation is deduced from visual inspections and mapping which are examined yearly for active cross sections. Anomalous growth is determined by yearly 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 of DRZ was originally assigned a constant value of $10^{-15} m^2$ for the CCA; per EPA direction, a uniform distribution from 3.16×10^{-13} to $3.98 \times 10^{-20} m^2$ was used for all subsequent PAs</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</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>

2.2.3 Initiation of Brittle Deformation

Table 2.9 summarizes data and TV information relating to the COMP parameter Initiation of Brittle Deformation, as well as its implementation in PA. Initiation of brittle deformation around WIPP openings is not directly measured and is therefore a qualitative observational parameter. By definition, qualitative COMPs can be subjective and are not prone to the development of well-defined TVs. This COMP is not directly related to a PA parameter. Brittle deformation eventually leads to features that are measured as part of geotechnical monitoring requirements, such as the extent and displacement of deformation features. Initiation of brittle deformation is expected to begin immediately upon creation of an opening. The ongoing geotechnical 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.

Table 2.9 Initiation of Brittle Deformation - 2010:

<table>
<tr><td>COMP Title:</td><td colspan="4">Initiation of Brittle Deformation</td></tr>
<tr><td>COMP Units:</td><td colspan="4">Qualitative</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>Observational</td><td colspan="2">Not Established</td></tr>
<tr><td colspan="5">COMP Assessment Process - Reporting Period July 2008 through June 2009</td></tr>
<tr><td colspan="5">Qualitative and pertinent to operational considerations. Captured qualitatively in association with other COMPs</td></tr>
<tr><td colspan="5">Performance and Compliance Elements</td></tr>
<tr><td>Element Title</td><td>Parameter Type & ID or Model Description</td><td>Derivation Procedure</td><td>Compliance Baseline</td><td>Impact of Change</td></tr>
<tr><td>Not directly related to PA as currently measured</td><td>NA</td><td>NA</td><td>NA</td><td>NA</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>Initiation of Brittle Deformation</td><td>None</td><td colspan="3">Qualitative COMPs can be subjective and are not prone to the development of meaningful TVs.</td></tr>
</table>

2.2.4 Displacement of Deformation Features

Table 2.10 summarizes data and TV information relating to the COMP parameter Displacement of Deformation Features, as well as its implementation in PA. 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 Clays G and H. These features are located approximately 2.4 m and 4.5 m respectively, above the roof of Panels 1, 2, 7 and 8. Marker Bed 139 (anhydrite) is located approximately 2 m below the floor of these panels. For Panels 3 through 6, the panels are mined up to Clay G. Clay H is therefore located 2.1 m above the roof of these panels and Marker Bed 139 is located approximately 4.4 m below the panel floors.

Table 2.10 Displacement of Deformation Features - 2010:

<table>
<tr><td>COMP Title:</td><td colspan="4">Displacement of Deformation Features</td></tr>
<tr><td>COMP Units:</td><td colspan="4">Length</td></tr>
<tr><td colspan="5">Related Monitoring Data</td></tr>
<tr><td>Monitoring
Program</td><td>Monitoring Parameter ID</td><td>Characteristics
(e.g., number, observation)</td><td colspan="2">Compliance Baseline Value</td></tr>
<tr><td>Geotechnical</td><td>Delta D/D_o</td><td>Observational</td><td colspan="2">Not established</td></tr>
<tr><td colspan="5">COMP Assessment Process - Reporting Period July 2008 through June 2009</td></tr>
<tr><td colspan="5">Observational – Lateral deformation across boreholes.</td></tr>
<tr><td colspan="5">Related Performance and Compliance Elements</td></tr>
<tr><td>Element Title</td><td>Parameter Type & ID or Model Description</td><td>Derivation Procedure</td><td>Compliance Baseline</td><td>Impact of Change</td></tr>
<tr><td>Not directly related to PA</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td colspan="5">Monitoring Data Trigger Values</td></tr>
<tr><td>Monitoring Parameter ID</td><td>Trigger Value</td><td colspan="3">Basis</td></tr>
<tr><td>Borehole diameter closure</td><td>Obscured observational borehole.</td><td colspan="3">If lateral displacement is sufficient to close diameter of observational borehole, technical evaluation of consequences will be initiated.</td></tr>
</table>

Monitoring of these deformation features is accomplished through visual inspection of observation boreholes (OBH) drilled from the openings through the feature of interest. In general, these boreholes are aligned vertically (normal to the roof and floor surfaces) because of the location and orientation of the fractures and lithological units of interest. All of the OBHs are 7.6 cm (3 in) in diameter, and many intersect more than one deformation feature. The ages of the OBHs vary from more than 20 years to recent.

The deformation features in OBHs are classified as: 1) offsets, 2) separations, 3) rough spots and 4) hang-ups. Of the 4 features, offsets are the principle metric for this COMP and are quantified by visually estimating the degree of borehole occlusion created by the offset. The direction of offset along displacement features is defined as the movement of the stratum nearer the observer relative to the stratum farther from the observer. Typically, the nearer stratum moves toward the center of the excavation. Based on previous observations in the underground, the magnitude of offset is usually greater in boreholes located near the ribs as compared to boreholes located along the centerline of openings.

All of the observation holes associated with Panels 1 through 4 are no longer monitored. There are a total of 192 OBHs reported in the GAR. These OBHs are located in the panels, access drifts and the North End of the repository. There were 47 holes monitored in Panel 5. No OBHs were occluded in this panel. There are 30 OBHs in Panel 6 that are new for this reporting period. There were no occluded OBHs in Panel 6. There are 115 OBHs within the access drifts, 2 of which are fully occluded. There were 10 OBHs in the North End of the repository reported in this year's GAR, none of which were occluded. Based on the current data available from the GAR, 2 OBHs (approx. 1% of the total) were fully occluded. The TV for displacement of deformation features is the observation of a fully occluded borehole. Exceedance of the TV is not a cause for concern given that no significant impact on safety or performance has occurred in those locations where the TV has been exceeded. However, to limit the formation of low-angle fractures and de-coupled beams over the roof, the elevation of Panels 3, 4, 5, and Panel 6 have been raised approximately 2.4 m so the roof will then coincide with Clay G. This horizon change was implemented to improve ground control. As such, the horizon change will change the expected deformation and displacement behavior.

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

2.2.5 Subsidence

Table 2.11 summarizes data and TV information relating to the COMP parameter Subsidence, as well as its implementation in PA. Subsidence is currently monitored via elevation determination of 48 existing monuments and 14 of the National Geodetic Survey's vertical control points. Approximately 15 miles of leveling was performed in 2009 for 9 control loops (see Figure 2-2). To address EPA monitoring requirements, the most recent survey results (DOE 2009b) 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 the local 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 after initial mining. In contrast, calculations show that the maximum subsidence predicted directly above the WIPP waste emplacement panels is 0.62 m assuming emplacement of CH-TRU waste and no backfill (Backfill Engineering Analysis Report [BEAR; WID 1994]). Further considerations, such as calculations of room closure, suggest that essentially all surface subsidence would occur during the first few centuries following construction of the WIPP, so the maximal vertical displacement rates would be approximately 0.002 m/yr (0.006 ft/yr). Obviously, these predicted rates could be higher or lower depending on mining activities as well as other factors such as time. Because the vertical elevation changes are very small, survey accuracy, expressed as the vertical closure of an individual loop times the square root of the loop length, is of primary importance. For the current subsidence surveys, a Second-Order Class II loop closure accuracy of 8 mm × √km (or 0.033 ft × √mile) or better was achieved in all cases.

Three monuments have also been included in various annual surveys, but were not included in the current surveys because the monuments no longer exist (last surveyed in 2003, monuments S-17 & S-18 are under a salt pile) or have been physically disturbed (PT-31, last surveyed in 2003). 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).

Table 2.11 Subsidence - 2010:

COMP Title:	Subsidence
COMP Units:	Change in surface elevation in meters per year

Related Monitoring Data

Monitoring **Program**	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value
Subsidence Monitoring Leveling Survey (SMP)	Elevation of 62 original monitoring monuments	Decimal (meters)	Not Established
SMP	Change in elevation over year	Decimal (meters)	Not Established

COMP Assessment Process – 2010; Data acquired between September through December of 2009

Survey data from annual WIPP Subsidence Monument Leveling are evaluated. Elevations of 48 monitoring monuments are compared to determine change.

Related Performance and Compliance Elements

Element Title	Parameter Type & ID or Model Description	Derivation Procedure	Compliance Baseline	Impact of Change
Subsidence	FEP [W-23]	Predictions are of low consequence to the calculated performance of the disposal system – based on WID (1994) analysis and EPA treatment of mining.	Maximum total subsidence of 0.62 m above the WIPP.	Predicted subsidence will not exceed existing surface relief of 3 m – i.e., it will not affect drainage. Predicted subsidence may cause an order of magnitude rise in Culebra hydraulic conductivity (CRA Appendix PA Attachment SCR , Section SCR-6.3.1.4) – this is within range modeled in the PA. Predicted WIPP subsidence is below that predicted for the effects of potash mining (0.62 m vs.1.5 m; DOE 2004).

Monitoring Data Trigger Values

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

The current surveys comprise 9 leveling loops containing as few as 5 to as many as 10 monuments/control points per loop as shown in Figure 2.2 (Surveys of Loop 1 benchmarks have been discontinued because only 2 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 at 3,423.874 feet for all of the subsidence leveling surveys conducted since 1993. Survey accuracy for all loops was within the allowable limits (DOE 2009b). Adjusted elevations are determined for every monument/control point by proportioning the vertical closure error for each survey loop to the monuments/control points comprising the loop. The proportions are based on the number of instrument setups and distance between adjacent points within a survey loop.

The adjusted elevations for each monument/control point are plotted as functions of time to assess subsidence trends. Figures 2.3 through 2.7 provide, respectively, elevations for selected monuments including those located (1) directly above the first waste emplacement panel, (2) directly above the second waste emplacement panel, (3) directly above the north experimental area, (4) near the salt handling shaft, and (5) outside the repository footprint of the WIPP underground excavation. As expected, subsidence is occurring directly above the underground openings (Figures 2.3 through 2.6); however the magnitude of the subsidence above the openings is small ranging from about -0.10 ft to -0.30 ft.

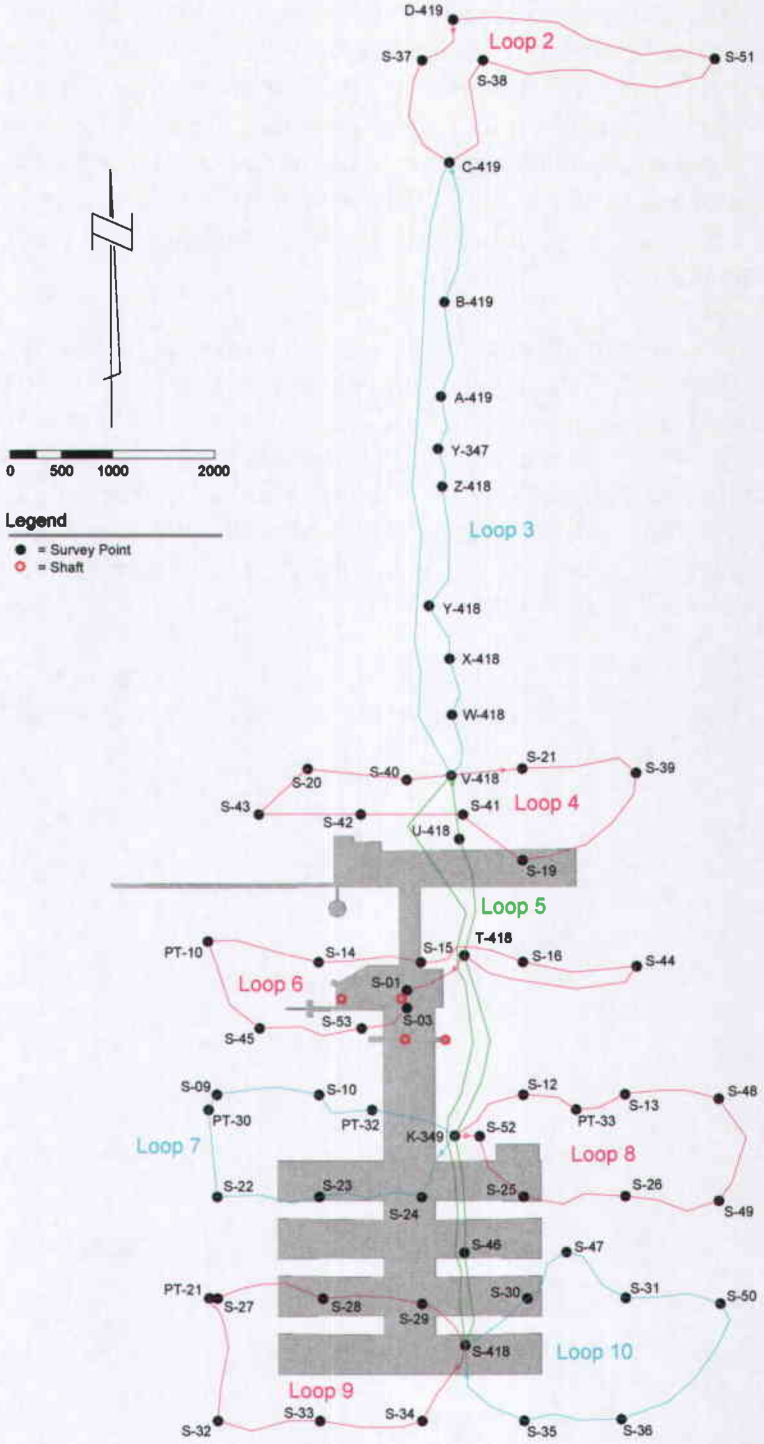


Figure 2.2. Monuments and vertical control points comprising WIPP subsidence survey loops.

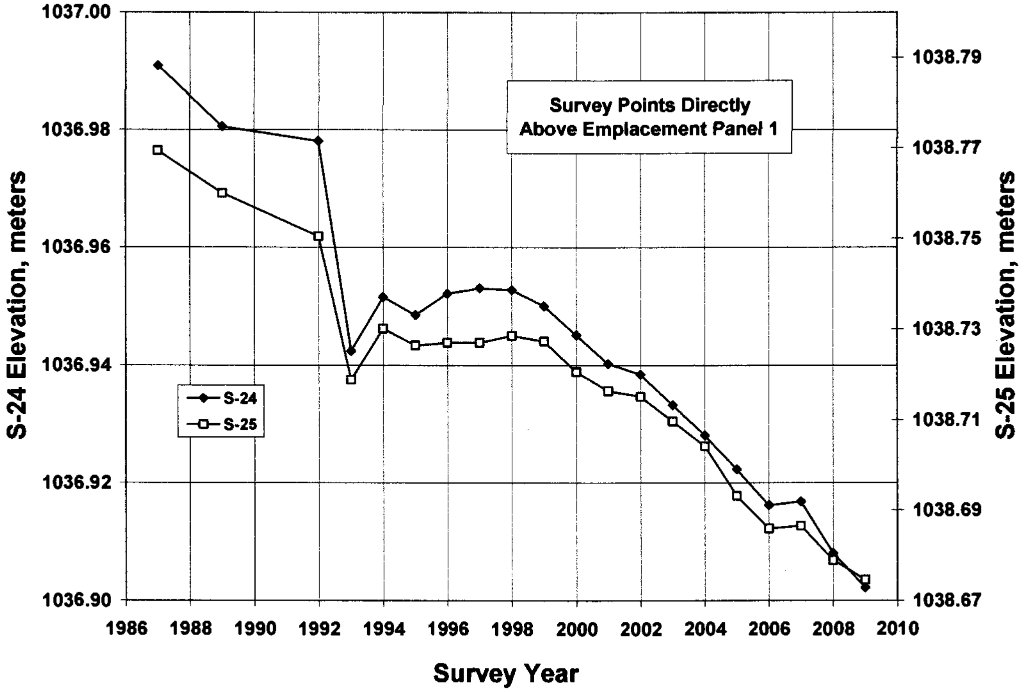


Figure 2.3. Elevations of WIPP monuments S-24 and S-25 located directly above emplacement Panel 1.

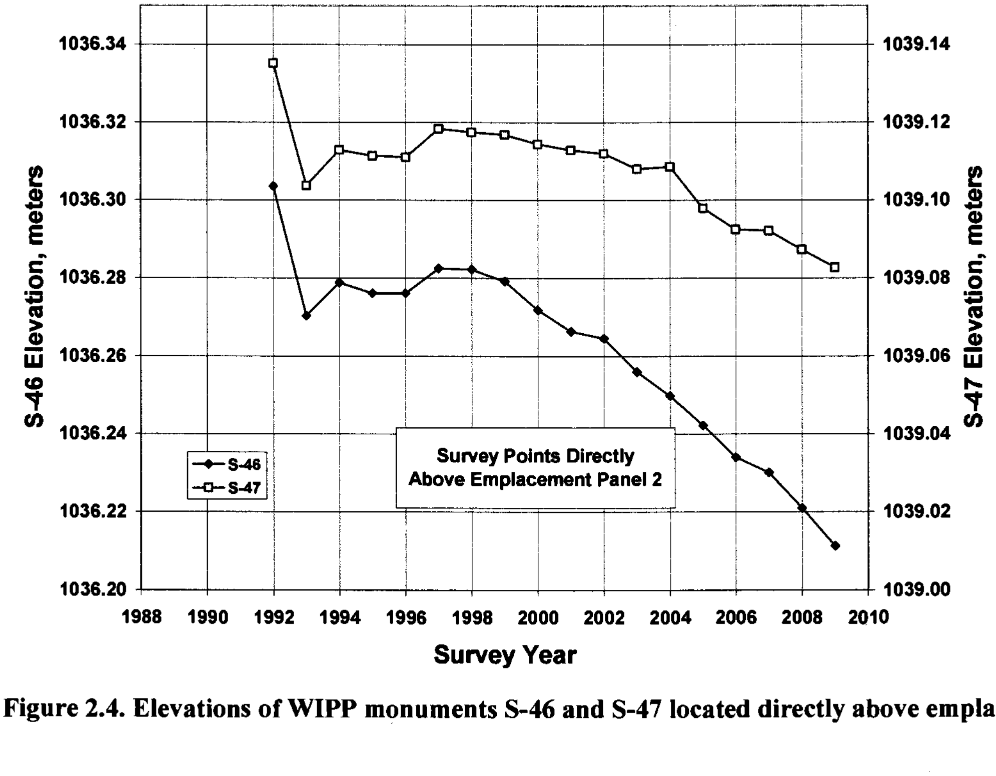


Figure 2.4. Elevations of WIPP monuments S-46 and S-47 located directly above emplacement Panel 2.

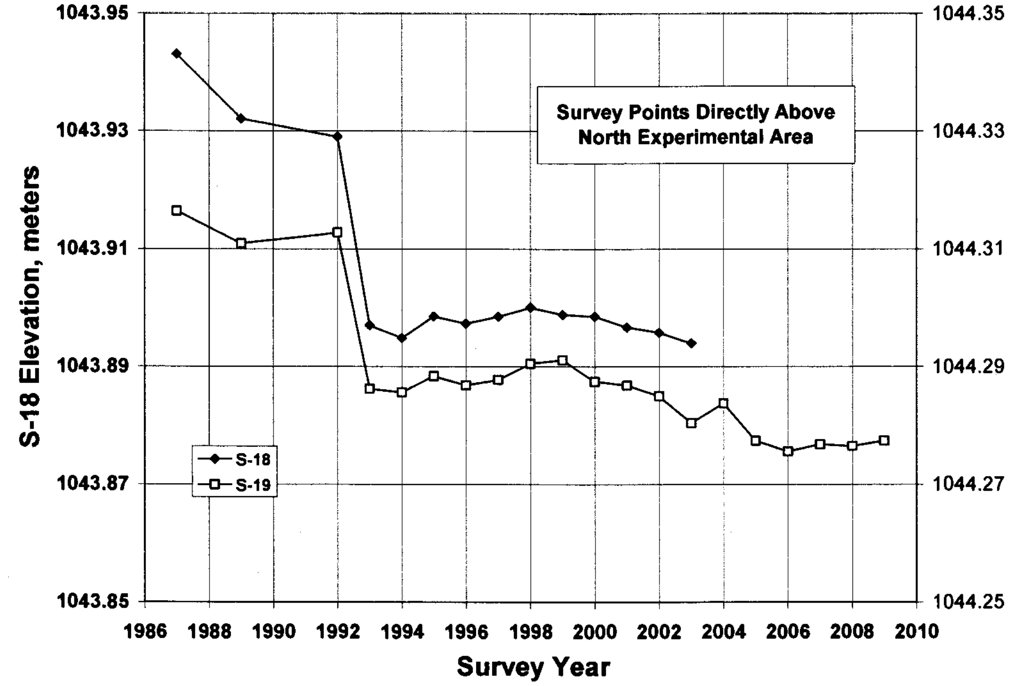


Figure 2.5. Elevations of WIPP monuments S-18 and S-19 located directly above the north experimental area.

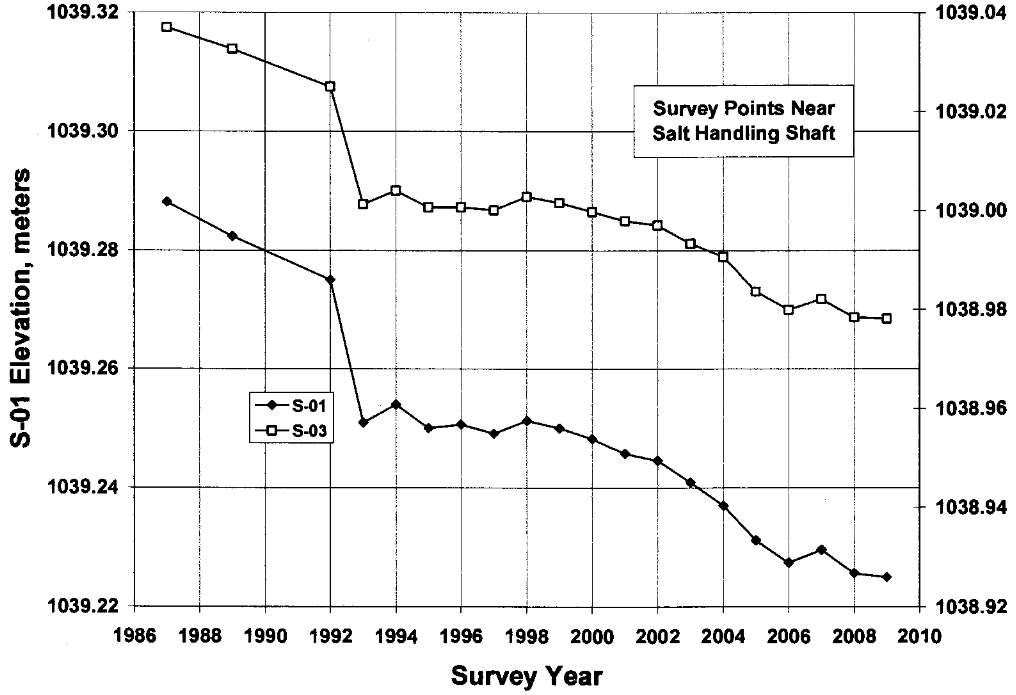


Figure 2.6. Elevations of WIPP monuments S-01 and S-03 located near the Salt Handling Shaft.

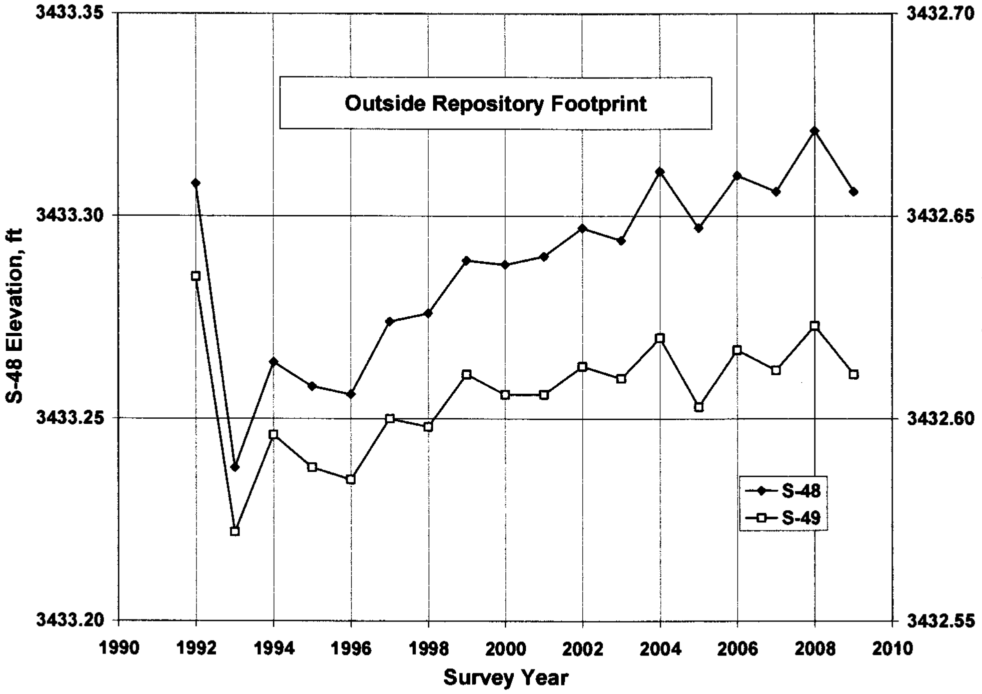


Figure 2.7. Elevations of WIPP monuments S-48 and S-49 located outside the repository footprint.

As time passes, subsidence is expected to be most pronounced directly above the WIPP underground excavations and will be minimal away from the repository footprint. Early results suggest this pattern is already occurring, as shown in Figures 2.8 through 2.10 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

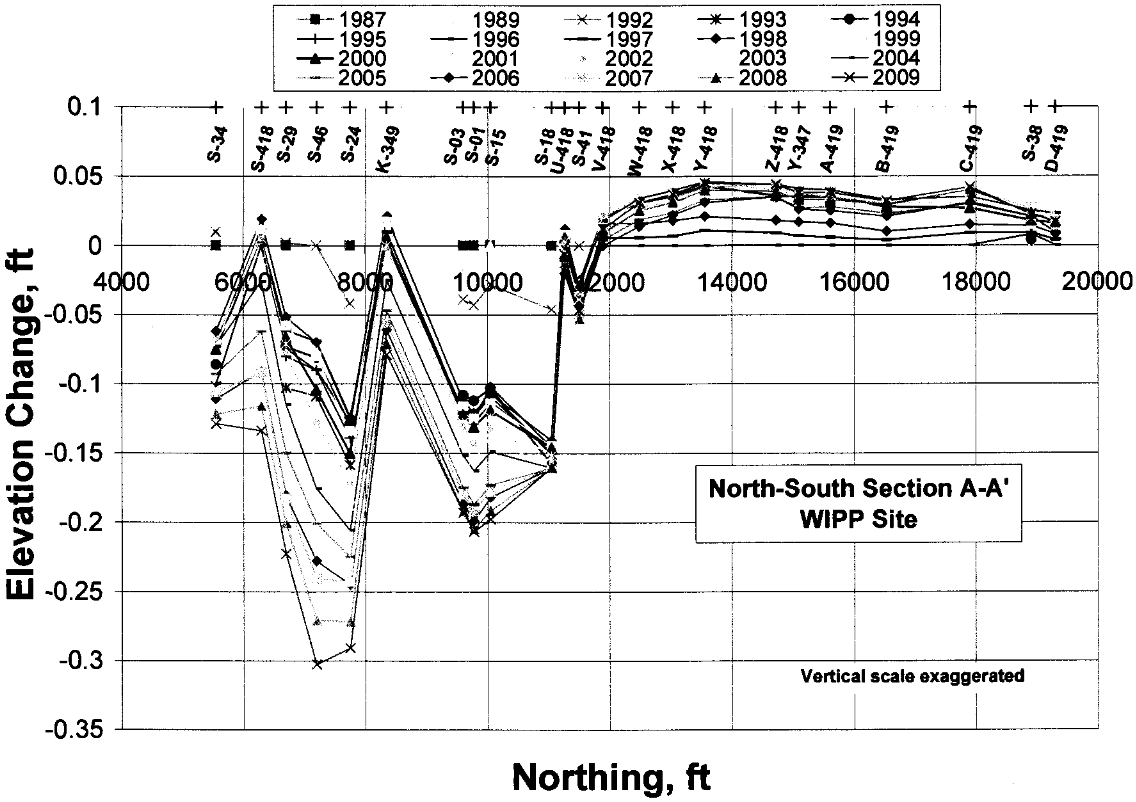


Figure 2.8. North-South subsidence profile A-A'.

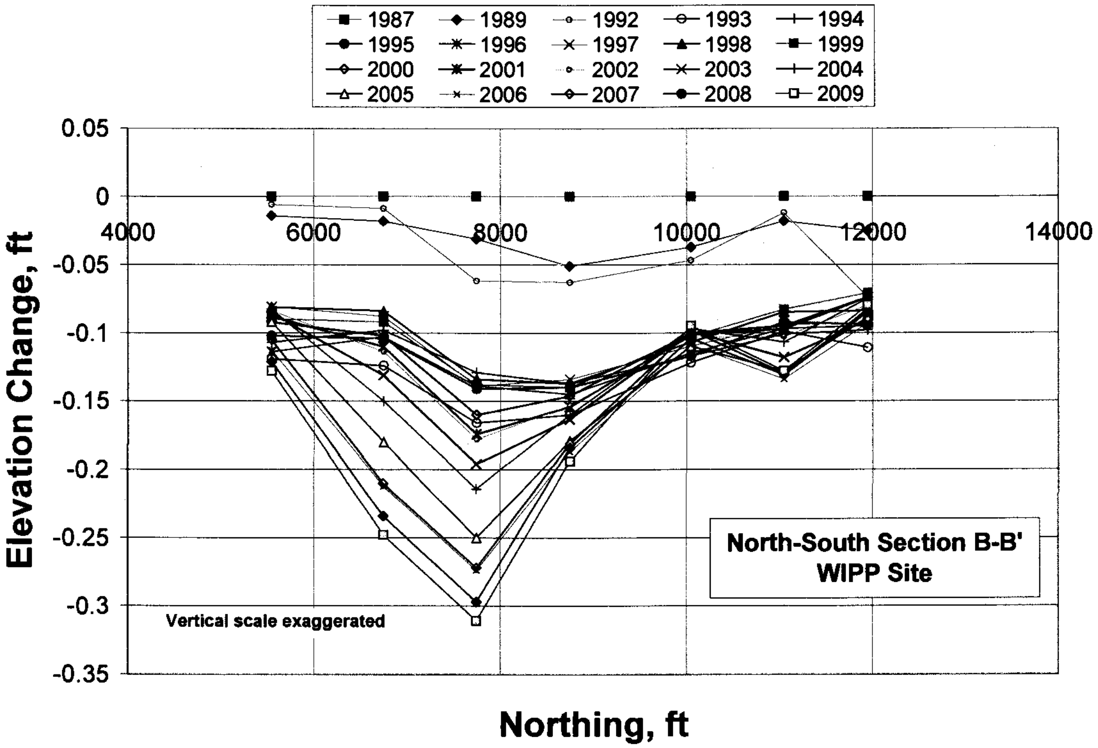


Figure 2.9. North-South subsidence profile B-B'.

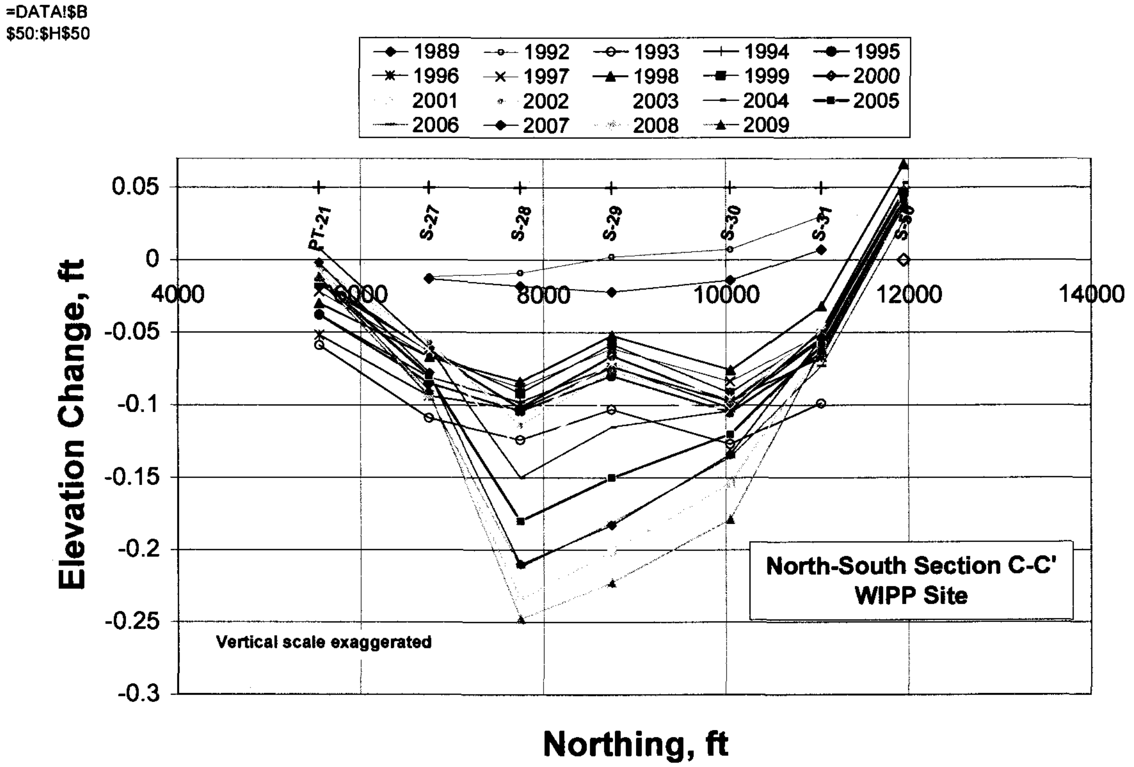


Figure 2.10. East-West subsidence profile C-C′.

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 monuments were included in the 1992 surveys and more that 60 for all surveys since 1996. Although direct comparisons cannot always be made, several observations for this reporting period are possible including:

1. The most significant subsidence (greater than - 0.20 ft) occurs above the waste panels (Monuments PT-32, S-1, S-14, S-23, S-24, S-25, S-29 and S-30). The maximum subsidence of 0.311 was over Panel 1 (S-25).
2. The highest subsidence rates measured for the 2008-2009 surveys correspond to benchmarks located over the northern Experimental Area at marker S-43 which had a rate of approximately 4x10^{-3} m/yr. As is expected, only monuments over the Experimental Area and Waste Panels showed any appreciable subsidence rate (approximately 1x10^{-3} m/yr).
3. The effects of subsidence extend away from the repository footprint approximately 1,000 to 1,500 ft (e.g., S-26, see Figures 2.2 and 2.10).

Furthermore, total subsidence and subsidence rates are small, and are approximately at the resolution level of the survey accuracy. The highest subsidence rates are seen above the mined panels and have increased since the mining of Panels 3 through 5. Based on the latest survey data, subsidence rates of the ground surface at the WIPP have not exceeded the 1x10^{-2} m/yr TV. No additional activities are recommended at this time.

2.3 Hydrological COMPs

As stated in the previous sections, the Compliance Recertification Application (CRA) lists 10 monitoring parameters that the DOE is required to monitor and assess during the WIPP operational period (DOE 2009a). Two of these parameters are considered hydrological in nature and include:

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

The Scientific Advisor has reviewed the data collected by the MOC during 2009 under the *Strategic Plan for Groundwater Monitoring at the Waste Isolation Pilot Plant* (GMP) (DOE 2003), which comprises two components:

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

WQSP and WLMP data are reported in the Waste Isolation Pilot Plant Annual Site Environmental Report (ASER) for 2009 (DOE 2010c). Additionally, WLMP data are also reported in monthly memoranda from the MOC to the Scientific Advisor.

2.3.1 Changes in Culebra Water Composition

2.3.1.1 Water Quality Sampling Program (WQSP)

Table 2.12 summarizes data and TV information relating to the COMP parameter Change in Culebra Water Composition, as well as its implementation in PA.

Under the current WQSP, 7 wells are sampled by the MOC. Six of the wells (WQSP-1 through 6) are completed to the Culebra Dolomite Member of the Rustler Formation and the seventh (WQSP-6A) is completed to the Dewey Lake Formation (Figure 2.11). All the WQSP wells are located within the WIPP Land Withdrawal Boundary (LWB). WQSP-1, 2, and 3 are situated hydraulically up-gradient (north) of the WIPP surface facilities and WQSP-4, 5, and 6 are situated down-gradient (south) of the WIPP surface facilities. The middle portion of the Dewey Lake, to which WQSP-6A is completed, is only observed to bear water in the southwestern portion of the WIPP site and farther to the south.

The Culebra is modeled for PA because it is the most transmissive, lowest head, saturated water-bearing zone in the WIPP vicinity. Because of this, it is considered the most likely groundwater release pathway for potential future inadvertent human intrusion of the repository. The Culebra is not a source of drinking water and water quality is not of concern because of potential degradation of water quality. Understanding Culebra water quality is important because it is a key component in understanding the entire flow system.

Table 2.12 Change in Groundwater Composition - 2010:

Trigger Value Derivation

COMP Title:	Groundwater Composition
COMP Units:	mg/L

Related Monitoring Data

Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value
Groundwater Monitoring	Composition	Semi-annual chemical analysis	RCRA Background Water Quality Baseline

COMP Derivation Procedure – Data acquired in two rounds, March-May (round 28) and September-November (round 29) 2009

Annually evaluate ASER data and compare to previous years and baseline information

Related Performance and Compliance Elements

Element Title	Type & ID	Derivation Procedure	Compliance Baseline	Impact of Change
Groundwater conceptual model, brine chemistry, actinide solubility	Indirect	Conceptual models	Indirect – The average Culebra brine composition is not used.	Provides validation of the various CCA models, potentially significant with respect to flow, transport, and solubility and redox assumptions.

Monitoring Data Trigger Values

Monitoring Parameter ID	Trigger Value	Basis
Change in Culebra groundwater composition	Both duplicate analyses for any major ion falling outside the 95% confidence interval (see Table 2.13) for three consecutive sampling periods	The 95% confidence interval for a particular analyte defines the range of concentrations that 19 out of 20 analyses, on average, should fall within. Therefore, TVs should not be set so that a single analysis falling outside the 95% confidence interval is significant. In addition, analysis of solutes in the concentrated brines of the Culebra is not a routine procedure, and occasional analytical errors are to be expected, particularly when a new laboratory is contracted to perform the analyses (SNL 2002b).

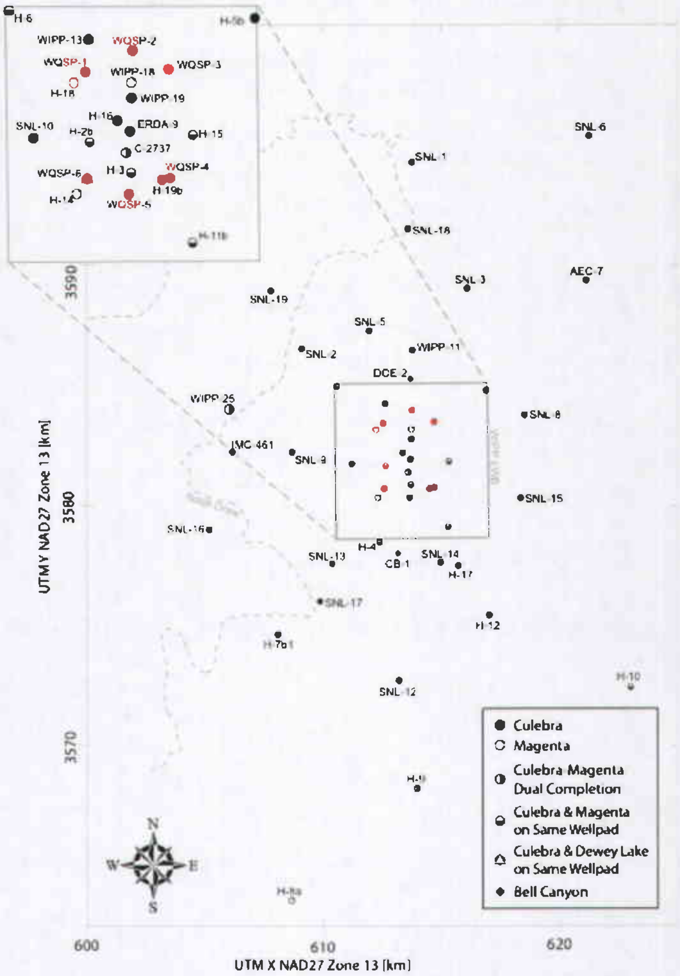


Figure 2.11. Map showing locations of WQSP wells (red) in relation to the WIPP LWB and the rest of the groundwater-monitoring network. Note: WQSP-6A is on the same well pad as WQSP-6.

Solute concentrations in Culebra waters differ widely among wells across the WIPP site, reflecting local equilibrium, diffusion, and, perhaps most importantly, slow transport rates. The conceptual model for the Culebra was presented in the CRA-2009 PABC (DOE 2009a) and implemented in PA hydrological models. The conceptual model consists of a confined groundwater flow with natural-gradient solute travel times across the WIPP site on the order of thousands to 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, representative, and statistically significant changes in the concentrations of major ionic species (Na^+, Ca^{2+}, Mg^{2+}, K^+, Cl^-, SO_4^{2-}, HCO_3^-) are observed, this condition would imply that groundwater movement through the Culebra is quicker than what is predicted by the PA models. Stability of major ion concentrations, on the other hand, is consistent with and supports the Scientific Advisor's Culebra transport conceptual model. Thus, this evaluation of the water-quality data focuses on the stability of major ion concentrations.

Flow and transport in the Dewey Lake are not modeled explicitly in PA because PA modeling assumes no radionuclides reach the Dewey Lake, and even if this did occur, it is likely that the believed discontinuous nature of the saturated portion, and the presumed sorptive properties of the Dewey Lake Formation would significantly retard offsite migration of radionuclides.

Nevertheless, the Dewey Lake water quality is monitored because it increases our understanding of WIPP area hydrology.

2.3.1.1.1 *Water Quality Sampling*

Two water samples (a primary and a duplicate) are collected from each WQSP well twice per year, in the spring and again in the fall. Water sampling procedures are outlined in the GMP (DOE 2003) and are summarized here.

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

2.3.1.1.2 *Laboratory Analysis*

The MOC collects samples to be analyzed for volatiles, total organic halogens, total organic carbon, semi-volatiles, metals, and general chemistry. For this report, only the results from the metals and general chemistry analyses are discussed, as they provide the necessary information for assessment of the COMP. In the field, the general chemistry samples are not preserved, metals samples are preserved with nitric acid, and neither sample is filtered. In the lab, samples are analyzed using a variety of published, lab-standard methods. Samples are analyzed for major cations (i.e., Na^+, Ca^{2+}, Mg^{2+}, K^+) and major anions (i.e., Cl^-, SO_4^{2-}, HCO_3^-), and other constituents that are not discussed here.

For sampling rounds 7 through 26, TraceAnalysis, Inc. of Lubbock, TX was responsible for analysis of the water samples submitted by the MOC. In 2008, the analytical contract was awarded to Hall Environmental Analysis Laboratory (HEAL) of Albuquerque, NM, who began analysis with round 27.

2.3.1.1.3 *Data Analysis*

The results of the WQSP analyses are compared to baseline results in order to determine stability, which is defined as a condition where the concentration of a given ion remains within its derived 95% confidence interval (CI; mean ± two standard deviations) established from the baseline measurements at a well, assuming a normal distribution of concentrations. The original baseline was defined by the initial 5 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 5 rounds to the first 10 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 Groundwater Quality Baseline Report (Crawley and Nagy 1998) and in Addendum 1 to that report (IT Corporation 2000). For the purposes of this evaluation, a small number of measurements have been eliminated from the baselines for WQSP-3, 5, 6, and 6A. The reasons for eliminating these values are discussed in detail in the COMPs assessment report for data collected in the year 2000 (SNL 2001). The elimination of these values is always conservative in that it reduces the "stable" range of concentrations for the affected parameters. The 95% CIs derived from the baseline data (SNL 2002a) are presented in Table 2.13.

Using the baseline analysis described above, a Trigger Value (TV) for Culebra groundwater composition has been defined. A TV is defined as the condition where both primary and duplicate analyses for any major ion fall outside the 95% CI for 3 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 Scientific Advisor 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.

Table 2.13. Rounds 28 and 29 major ion concentrations and charge-balance errors, with a baseline 95% CI defined for each major ion.

Well I.D.	Round	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	28	**42000/45000**	**5760/5740**	49.0/49.2	18700/19000	1630/1620	1070/1070	475/468	**-14.8**
	29	**40000/40300**	4830/4900	48.6/50.8	20300/19100	1750/1770	1160/1170	510/523	**-7.9**
	C.I.	31100-39600	4060-5600	45-54	15900-21100	1380-2030	939-1210	322-730	
WQSP-2	28	**40000/39500**	4940/5270	46.3/46.4	19800/18300	1490/1450	1020/1000	470/460	**-10.4**
	29	38300/38200	**6400**/6000	***54.0***/*46.5*	19000/18000	1420/1450	1020/1050	478/492	**-10.8**
	C.I.	31800-39000	4550-6380	43-53	14100-22300	1230-1770	852-1120	318-649	
WQSP-3	28	138000/145000	**7950/8570**	30.2/30.2	75100/75200	1480/1440	2390/2340	**1570/1550**	**-7.9**
	29	140000/140000	**8120/8120**	36.7/33.1	81200/79700	1480/1500	2400/2410	**1550/1610**	-3.9
	C.I.	114000-145000	6420-7870	23-51	62600-82700[c]	1090-1620	1730-2500	2060-3150[a]	
WQSP-4	28	*61700*/***68000***	6830/7090	38.2/38.1	34400/33400	1530/1530	1170/1170	**706/698**	**-8.5**
	29	**67700/67300**	6900/6930	39.2/37.6	35300/36400	1530/1470	1170/1130	**806/805**	**-7.9**
	C.I.	53400-63000	5620-7720	31-46	28100-37800	1420-1790	973-1410	832-1550[b]	
WQSP-5	28	16800/17400	5330/5570	43.5/43.2	10400/10400	1010/1010	456/436	312/309	-4.3
	29	16600/16900	5560/5420	45.0/44.9	9490/9200	988/1060	*435/480*	*274/316*	**-7.8**
	C.I.	13400-17600	4060-5940	42-54	7980-10400[c]	902-1180	389-535	171-523	
WQSP-6	28	5900/5760	5000/4910	45.7/45.6	4250/4410	680/691	213/230	*157/173*	-4.6
	29	**5100/5330**	**4120**/4310	47.0/45.5	4070/4050	629/648	201/207	142/149	-1.4
	C.I.	5470-6380[c]	4240-5120[c]	41-54	3610-5380[c]	586-777	189-233[c]	113-245	
WQSP-6A	28	**349/350**	2100/2130	103/102	**214/221**	609/623	152/154	3.86/3.85	-2.5
	29	**347/341**	2090/2060	102/103	**217/214**	574/576	153/152	4.50/4.51	-3.7
	C.I.	444-770[c]	1610-2440	97-111	253-354	554-718	146-185	1.8-9.2	

Bold denotes analyses returning values outside the 95% CI or a charge-balance error ≥5%
Italics denotes sample and duplicate analyses differ by >10%
[a] baseline defined from rounds 8-10
[b] baseline defined from rounds 7-10
[c] baseline definition excludes anomalous values

In addition to the baseline comparison, a charge-balance error (CBE), defined as the difference between the positive and negative charges from the ions in solution divided by the sum of the positive and negative charges, was also calculated for each analysis using the average of the primary and duplicate sample. A CBE is useful in evaluating the reliability of an analysis because water must be electrically neutral. CBE is rarely zero because of inherent inaccuracy in analytical procedures, but a reliable analysis should not have a CBE exceeding ±5% (Freeze and Cherry 1979). A CBE in excess of ±5% implies either that the analysis of one or more ions is inaccurate (most likely) or that a significant ion has been overlooked (in the case of the WQSP wells, which have been sampled and analyzed in depth, this is highly unlikely). The variation between the results of primary and duplicate sample analysis for each individual ion is also considered. Generally speaking, this variation should be less than 10 percent. Greater variation indicates a potential problem with one or both analyses. Analytical results and CBE for rounds 26 and 27 are presented in Table 2.13.

2.3.1.2 Results

WQSP results for sampling rounds 28 and 29 conducted in 2009 are reported in the 2009 ASER (DOE 2010c). The reported major ion concentrations are listed in Tables F.1 through F.6. Sampling round 28 was conducted between March and May and round 29 was conducted between September and November. Both rounds of samples were analyzed by HEAL.

2.3.1.2.1 WQSP-1

Concentrations of most major ions were within their respective 95% CIs for round 28. Exceptions include the chloride and sulfate ion concentrations measured in both samples. The CBE was -14.8%.

For round 29, only the chloride values (for both samples) were outside its 95% CI. The CBE was -7.9%.

2.3.1.2.2 WQSP-2

For round 28, the duplicate samples had concentrations of chloride ion above the 95% CI. All other analytes in both primary and duplicate samples were within their respective 95% CIs. The CBE was -10.4%.

For round 29, the primary samples for sulfate and bicarbonate ions were above their respective 95% CIs, while all other analytes were within their respective 95% CIs. The primary and duplicate samples for bicarbonate ion differed by 13.5%; the CBE was -10.8%.

2.3.1.2.3 WQSP-3

Sulfate ion concentrations measured in both samples were above the 95% CI for round 28. The potassium ion concentrations were both below their 95% CI. All other primary and duplicate samples of analytes were within their respective 95% CIs. The CBE was -7.9%.

For round 29, both the primary and duplicate samples of the sulfate and potassium ion were above their 95% CI. All other primary and duplicate samples of analytes were within their respective 95% CIs. The CBE was -3.9%.

2.3.1.2.4 WQSP-4

For round 28, the duplicate sample chloride ion concentration was above the 95% CI, and the difference between the primary and duplicate chloride concentrations was 10.2%. Both the primary and duplicate sample potassium ion concentrations were below the 95% CI. The remaining samples of other analytes were all within their respective 95% CIs. The CBE for round 28 was -8.5%.

For round 29, both the primary and duplicate chloride ion sample concentrations were above the 95% CI. Both the primary and duplicate sample potassium ion concentrations were below the 95% CI. The remaining samples of other analytes were all within their respective 95% CIs. The CBE was -7.9%.

The potassium ion concentration in rounds 27, 28, and 29 were all below the lower 95% CI of 832 mg/L, and therefore exceed the trigger value. Potassium is one of the minor cations, and this deviation is not a significant event warranting further investigation at this time.

2.3.1.2.5 WQSP-5

Concentrations in all of samples for the major ions were within their respective 95% CIs for round 28. The CBE was -4.3%.

For round 29, concentrations in all samples of all major ions were within their respective 95% CIs. The primary and duplicate samples for magnesium and potassium ions showed a >10% difference (10.3% and 15.3% respectively). The CBE was -7.8%.

2.3.1.2.6 WQSP-6

Concentrations in all of samples for the major ions were within their respective 95% CIs for round 28. The primary and duplicate samples for the potassium ion differed by 10.2%. The CBE was -4.6%.

For round 29, the chloride ion concentrations in the primary and duplicate samples were above the 95% CI, while the sulfate ion concentration in the primary samples was below the 95% CI. The CBE was -1.4%.

2.3.1.2.7 WQSP-6A

For rounds 28 and 29, the chloride ion concentrations in both samples were below the lower 95% CI threshold. The sodium ion concentrations in both samples were below their 95% CI. The CBE was -2.5 for round 28 and -3.7% for round 29.

2.3.1.3 Assessment of Water Quality Data

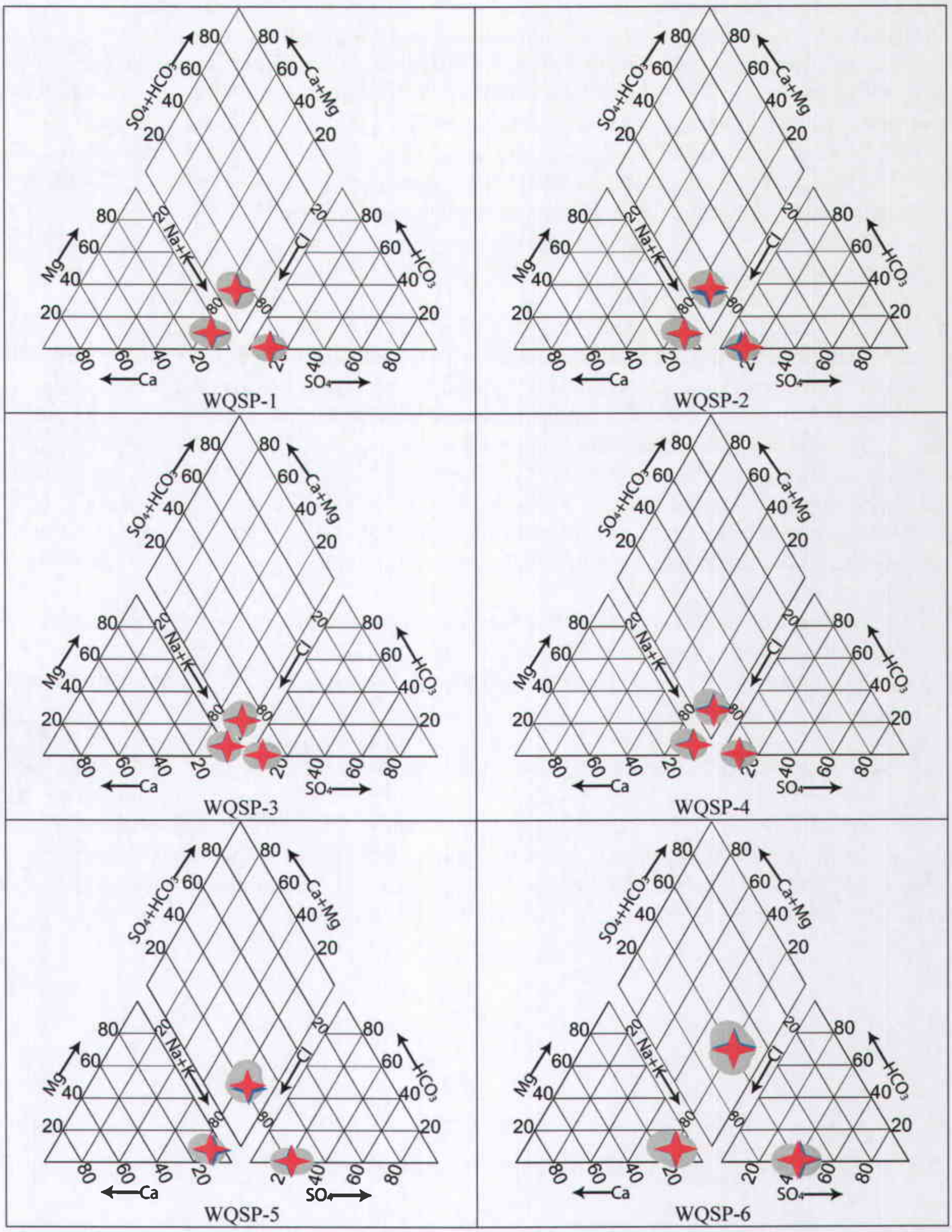
2.3.1.3.1 Culebra

Eight of the 12 calculated CBEs for the two rounds were >±5%. All the analyses with larger CBEs are negative (more anions than cations), and most are associated with analytes that have anomalously high or low concentrations. For example, several of the highest CBEs observed can be linked to anomalously high concentrations of chloride ion (WQSP-1 both rounds, WQSP-2 round 28, and WQSP-4 round 29). High CBE were observed in both rounds at WQSP-4, this corresponds to anomalously low potassium ion concentrations and anomalously high chloride ion concentrations (chloride in Round 28 had a difference >10% between sample and duplicate). In WQSP-2 round 29, CBE = -10.8%, and both the sulfate and bicarbonate ion concentrations are anomalously high (bicarbonate had a difference >10% between sample and duplicate). In WQSP-3 round 28, CBE = -7.9% and the sulfate ion has anomalously high concentration. In WQSP-5 round 29 there are differences >10% between sample and duplicate for the cations magnesium and potassium, although the values are not outside the 95% CI.

A common method of assessing water-quality stability is through the use of Piper diagrams, which illustrate relative proportions of three cation and three anion concentrations (four cations are treated by lumping sodium and potassium together). By plotting the ion ratios for every round, it can be determined if water quality of a given well is changing over time by comparing locations. Piper diagrams of Culebra water chemistry (Figure 2.12) over the course of the WQSP (now 14+ years) show that the groundwater is relatively stable, with results for each well continually plotting within relatively small envelopes.

The Piper diagrams illustrate that WQSP-4 does not show significant deviation, even though the potassium ion concentration has been below the lower 95% C.I. for three sampling rounds. This is partly due to the small contribution that the potassium ion has to overall water chemistry.

Full assessment of the Culebra water-chemistry results shows that it is stable and that the Culebra wells only have one minor analyte (K^+) in violation of a TV. Based on review of CBEs calculated for each WQSP well sampled, the analytical results appear to be generally reliable, although CBE are larger and more consistently negative than reported in previous years. Any variability observed in the data suggesting instability can be attributable to analytical problems, with the possible exception of the WQSP-5 round 29 results. As mentioned in the last year's COMPs report (SNL 2009), it is believed that the majority of analytical problems can be linked to the high salinity (i.e., TDS) observed in Culebra brines. The sensitive analytical equipment used in environmental labs requires that samples be diluted up to 10,000 times in order for samples to be run without harming the machine. Dilution of the samples introduces both human and analytical error, which can cause results to be less precise.



WQSP-1

WQSP-2

WQSP-3

WQSP-4

WQSP-5

WQSP-6

Figure 2.12. Piper diagrams of data collected from WQSP-1 through WQSP-6. The plots show both historical data (gray areas) and results from rounds 28 (blue star) and 29 (red star).

2.3.1.3.2 Dewey Lake

Interpretation of the long-term data and the Piper diagram for Dewey Lake well WQSP-6A (Figure 2.13) suggests that water chemistry has changed slightly. Both sodium and chloride concentrations show declines in concentration relative to previous rounds. The concentrations for both ions, however, appear to be stabilizing over the last few rounds at concentrations below their respective 95% CIs. This suggests that the Dewey Lake, at least at WQSP-6A, has freshened slightly, which is reinforced by evaluation of specific conductance data, which has been gradually decreasing from round to round. In the future, the 95% CI should be re-evaluated and possibly adjusted to reflect recent changes in cation and anion concentrations.

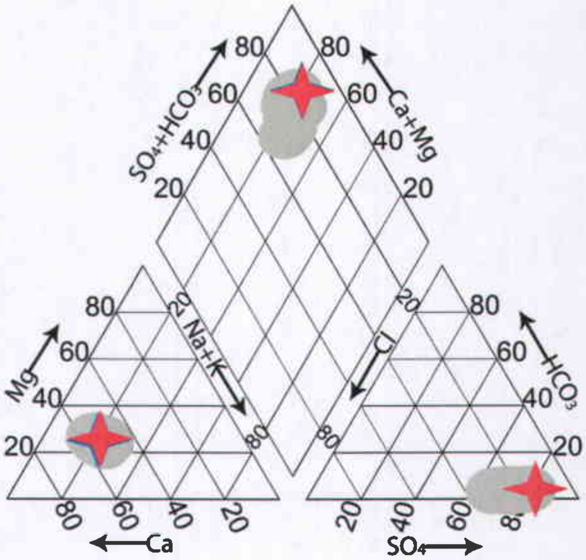


Figure 2.13. Piper diagram of data collected from WQSP-6A. The plot shows both historical data (gray areas) and results from rounds 28 (blue star) and 29 (red star).

2.3.2 Changes in Groundwater Flow (Water Level)

Table 2.14 summarizes data and TV information relating to the COMP parameter Change in Groundwater Flow, as well as its implementation in PA. Assessment of the COMP for the Culebra involves comparison of modeling results adjusted to fit freshwater heads observed in 2009 for the ASER (DOE, 2010c) with modeling results predicted from the ensemble of models used in PA for CRA-2009 PABC (e.g., Hart et al., 2009; Kuhlman, 2010a).

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

Table 2.14 Changes in Groundwater Flow - 2010:

Trigger Value Derivation

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

Related Monitoring Data

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

COMP Derivation Procedure - Data acquired between December 2007 and December of 2008

Annual assessment from ASER data.

Related PA Elements

Element Title	**Type & ID**	**Derivation Procedure**	**Compliance Baseline**	**Impact of Change**
Groundwater conceptual model, Transmissivity fields	T-Fields	Computer codes are used along with groundwater data to generate transmissivity fields for the Culebra on a regional scale. A summary of the conceptualization, implementation and calibration of the Culebra T-fields is given in Kuhlman (2010b).	Attachment T-FIELDS to Appendix PA.	Provides validation of the various CCA/CRA models - T-field assumptions and groundwater basin model.

Monitoring Data Trigger Values

Monitoring Parameter ID	**Trigger Value**	**Basis**
Change in Culebra Groundwater Flow	CRA-2004 range; see Table 2.15	Model-predicted travel time in the Culebra is compared to the distribution found in PA, for an ensemble-average model with best-fit boundary conditions to the current year's observed freshwater heads. The travel time from the center of the WIPP panels to the WIPP LWB must fall within the distribution found using 100 model runs used in the baseline PA.

2.3.2.1 Water Level Monitoring Program (WLMP)

In 2009, the MOC made monthly water-level measurements in all of the WIPP non-shallow subsurface water (SSW) monitoring network wells (see Figure 2-14 and Table 2.15), or quarterly in any redundant wells (i.e., six of the seven H-19b wells). As of June 2009, the WIPP monitoring network consisted of 65 wells (including 3 dual-completion Magenta-Culebra wells), see Table 2-15. There were 50 wells with completions to the Culebra Member of the Rustler Formation, 14 to the Magenta Member of the Rustler Formation, two to the Bell Canyon Formation, and one to the Dewey Lake Formation.

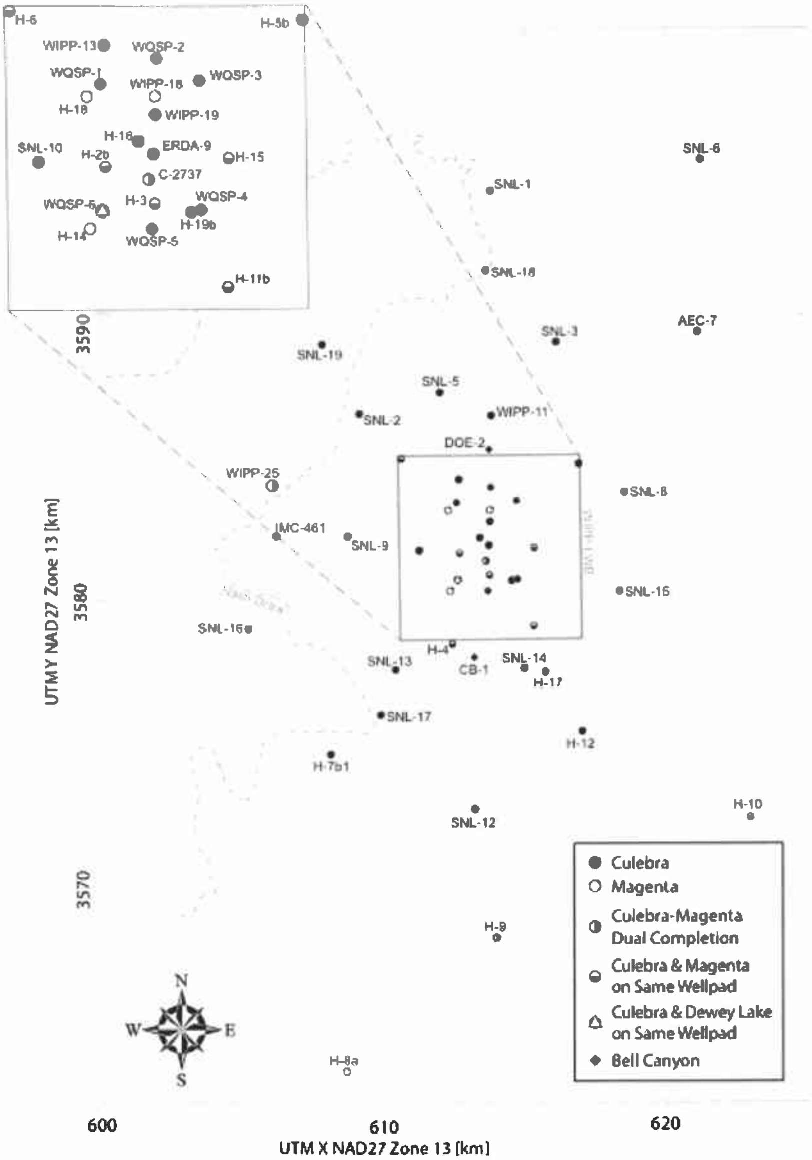


Figure 2.14. Map of the WIPP area showing well pad locations discussed in this section (See Table 2.15 for listing of wells at each well pad).

Table 2.15 June 2009 Non-SSW[1] WIPP Groundwater Monitoring Network

Well	Pad[2]	Completion[3]
AEC-7	AEC-7	CUL
C-2737	C-2737	CUL/MAG DUAL
CB-1	CB-1	BC
DOE-2	DOE-2	BC
ERDA-9	ERDA-9	CUL
H-2b1	H-2b	MAG
H-2b2		CUL
H-3b1	H-3	MAG
H-3b2		CUL
H-4b	H-4	CUL
H-4c		MAG
H-5b	H-5b	CUL
H-6bR	H-6	CUL
H-6c		MAG
H-7b1	H-7b1	CUL
H-8a	H-8a	MAG
H-9c	H-9c	CUL/MAG DUAL
H-10a	H-10	MAG
H-10c		CUL
H-11b2	H-11b	MAG
H-11b4		CUL
H-12	H-12	CUL
H-14	H-14	MAG
H-15R	H-15	CUL
H-15		MAG
H-16	H-16	CUL
H-17	H-17	CUL
H-18	H-18	MAG
H-19b0	H-19b	CUL
H-19b2		CUL REDUN
H-19b3		CUL REDUN
H-19b4		CUL REDUN
H-19b5		CUL REDUN
H-19b6		CUL REDUN
H-19b7		CUL REDUN
IMC-461	IMC-461	CUL
SNL-1	SNL-1	CUL
SNL-2	SNL-2	CUL
SNL-3	SNL-3	CUL
SNL-5	SNL-5	CUL
SNL-6	SNL-6	CUL
SNL-8	SNL-8	CUL
SNL-9	SNL-9	CUL
SNL-10	SNL-10	CUL
SNL-12	SNL-12	CUL
SNL-13	SNL-13	CUL
SNL-14	SNL-14	CUL
SNL-15	SNL-15	CUL
SNL-16	SNL-16	CUL
SNL-17	SNL-17	CUL
SNL-18	SNL-18	CUL
SNL-19	SNL-19	CUL
WIPP-11	WIPP-11	CUL
WIPP-13	WIPP-13	CUL
WIPP-18	WIPP-18	MAG
WIPP-19	WIPP-19	CUL
WIPP-25	WIPP-25	CUL/MAG DUAL
WQSP-1	WQSP-1	CUL
WQSP-2	WQSP-2	CUL
WQSP-3	WQSP-3	CUL
WQSP-4	WQSP-4	CUL
WQSP-5	WQSP-5	CUL
WQSP-6	WQSP-6	CUL
WQSP-6a		DL

[1] SSW wells and piezometers monitor the Santa Rosa / Dewey Lake Formation contact at the WIPP facilities

[2] Pad names used in Figure 2.14

[3] Well completions codes are as follows:

CUL: Culebra Member of the Rustler Formation
MAG: Magenta Member of the Rustler Formation
BC: Bell Canyon Formation
DL: Dewey Lake Formation
DUAL: dual-completion well
REDUN: redundant well (quarterly water levels)

2.3.2.2 Culebra Groundwater Flow Results and Assessment

Assessment of Culebra data involves the interpretation of freshwater head data in the context of the hydrogeologic knowledge about the WIPP area. If heads change significantly in wells, this may be due to an underlying change in flow direction and/or velocity in the Culebra. At the request of the New Mexico Environment Department (NMED), the Scientific Advisor uses the ensemble of 100 calibrated Culebra groundwater flow model runs developed for PA to create an ensemble-averaged transmissivity (T) field. This averaged T field is used to produce the freshwater head potentiometric surface map for the 2009 ASER (DOE 2010c). Each year the boundary conditions of the ensemble-averaged model are adjusted to best fit the observed freshwater head values from that year. The ensemble-averaged T field and the adjusted boundary conditions are used as inputs to the MODFLOW model (Harbaugh et al. 2000) that computes the heads, which are then contoured and presented in the ASER.

The Culebra PA model is a single-layer groundwater flow model that incorporates information about aquifer parameters (e.g., T, storativity, and anisotropy) and is based upon a peer-reviewed model of Culebra geology (Section 8.2 of EPA 2010b). The model is calibrated to both steady-state and transient head data, with the ensemble average of the 100 realizations being used to generate the Culebra potentiometric contour map. The contour map shown in Figure 2.16 shows the area immediately around the WIPP land withdrawal boundary, and indicates that flow is generally from north to south, which is consistent with previous results, and that the gradient is steepest across the WIPP site, caused by a band of low Culebra T present at the site.

The contour map is created according to SNL specific procedure SP 9-9, and the results of following the procedure along with detailed narrative descriptions are given in the analysis report *Analysis Report for Preparation of 2009 Culebra Potentiometric Surface Contour Map, Revision 1* (Kuhlman 2010c). This material is summarized in the 2009 ASER, section 6.2.5 (DOE 2010c).

2.3.2.3 Culebra Freshwater-Head Results and Assessment

Table 2.15 shows the June 2009 freshwater heads reported in the 2009 ASER and used in the development of the Culebra contour map given in the 2009 ASER (DOE 2010c). The particle shown as a blue arrow in Figure 2.15 begins where the Culebra intersects the WIPP waste-handling shaft and continues to the WIPP LWB, as required by NMED. The travel time for this particle in the boundary-calibrated ensemble-average flow field (5,900 years) is compared to the distribution of 100 travel times computed for the CRA-2009 PABC. The fastest travel time from the ensemble of 100 fields is less than 3,000 years, the ensemble-average travel time falls inside the predicted CRA-2009 PABC range. The particles illustrated in Figures 2.15 and 2.17 are released from the point in the Culebra corresponding to the center of the WIPP waste panels underground (the same location as well C-2737).

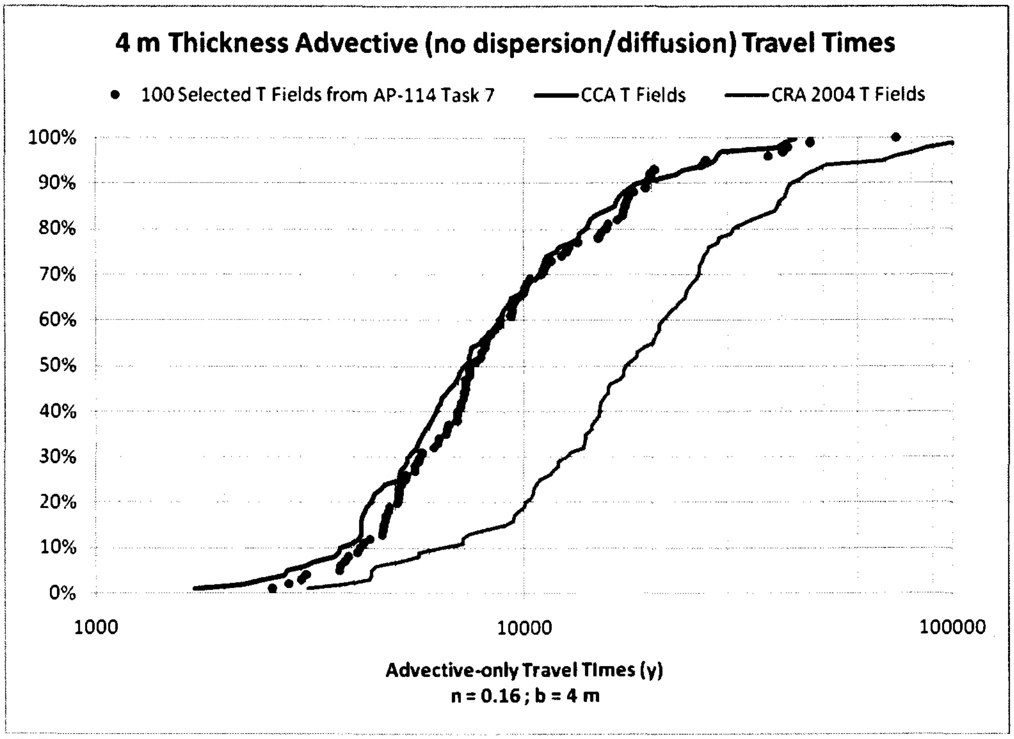


Figure 2.15. Distribution of Particle Travel Times from C-2737 (Center of Waste Panels) to WIPP LWB for CCA (black line), CRA-2004 (blue line), and CRA-2009 PABC (red dots). Figure from Hart et al. (2009).

In UTM NAD27 Zone 13 coordinates (meters), the waste-handling shaft is located at the (X, Y) location (613579, 3582079), while the center of the waste panels is (613597, 3581401). The distance between these two points is 678 meters, mostly in the north-south direction; the difference can be seen by comparing the location of the tail of the blue arrow and the location of C-2737 in Figure 2.16. The particle in the ensemble-average flowfield has a length of 4089 meters.

The ensemble average transmissivity (T) field used to compute the contour map for the ASER is by construction much smoother than any of the 100 stochastically generated fields it is averaged from. This smoothness of the input T field results in a smoother and relatively faster particle trace; compare the particle traces in Figure 2.16 (smoothed average field) and Figure 2.17 (original T fields from PA).

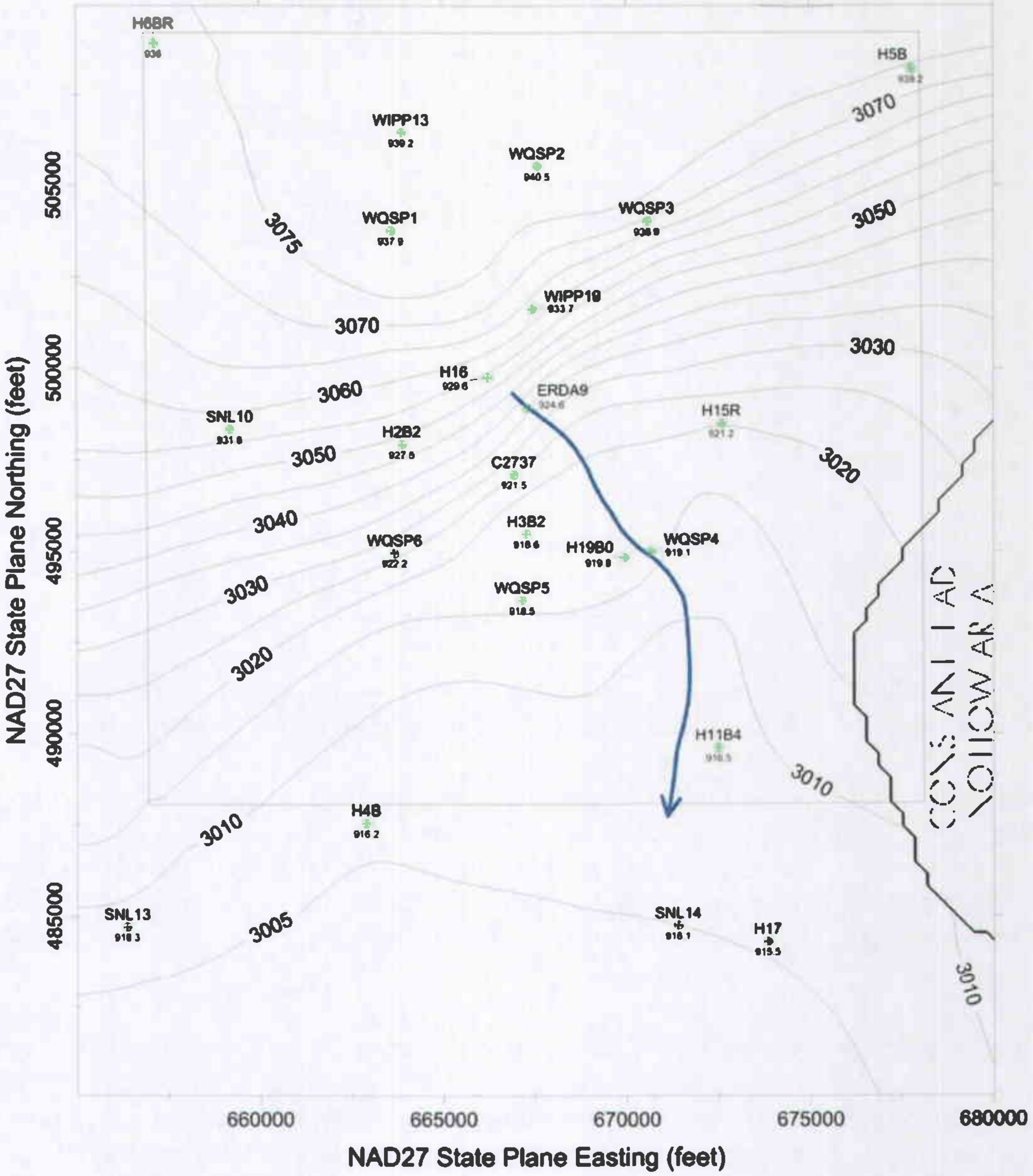


Figure 2.16. June 2009 modeled Culebra potentiometric surface of the immediate WIPP vicinity (DOE 2010) generated using ensemble average distributed aquifer parameters from the SNL Culebra flow model used in performance assessment baseline calculation for CRA-2009; see Kuhlman (2010b).

Table 2.15. Summary of 2009 Culebra freshwater heads.

Culebra Well ID	Measurement Date	Adjusted Depth to Water [m]	Specific Gravity	Adjusted Freshwater Head [m AMSL]
AEC-7	06/09/09	186.76	1.078	934.09
C-2737 (PIP)[1]	06/11/09	117.74	1.029	921.51
ERDA-9	06/11/09	121.30	1.067	924.64
H-2b2	06/10/09	102.19	1.000	927.53
H-3b2	06/11/09	118.15	1.038	918.57
H-4b	06/09/09	100.54	1.013	916.22
H-5b	06/09/09	142.23	1.093	939.21
H-6bR	06/08/09	88.17	1.033	935.98
H-7b1	06/08/09	50.40	1.000	913.90
H-9c (PIP)[1]	06/09/09	125.44	1.003	913.26
H-10c	06/09/09	202.66	1.001	921.78
H-11b4	06/09/09	129.01	1.062	916.52
H-12	06/09/09	139.18	1.096	916.64
H-15R	06/10/09	154.63	1.130	921.17
H-16	06/11/09	113.80	1.039	929.64
H-17	06/09/09	127.40	1.120	915.48
H-19b0	06/11/09	129.62	1.075	919.80
IMC-461	06/08/09	72.89	1.019	928.75
SNL-1	06/08/09	132.27	1.032	940.19
SNL-2	06/08/09	76.80	1.015	937.07
SNL-3	06/08/09	127.46	1.029	939.48
SNL-5	06/08/09	93.56	1.012	937.91
SNL-6[2]	*06/10/09*	*246.50*	*1.253*	*905.66*
SNL-8	06/09/09	165.91	1.104	931.36
SNL-9	06/08/09	94.57	1.026	931.89
SNL-10	06/08/09	99.08	1.013	931.56
SNL-12	06/09/09	102.96	1.011	915.69
SNL-13	06/08/09	86.79	1.028	918.29
SNL-14	06/09/09	114.88	1.048	916.09
SNL-15[2]	*06/09/09*	*187.11*	*1.232*	*895.42*
SNL-16	06/08/09	37.81	1.023	917.70
SNL-17	06/09/09	70.72	1.007	916.49
SNL-18	06/08/09	91.75	1.011	937.92
SNL-19	06/08/09	46.02	1.008	936.74
WIPP-11	06/10/09	110.58	1.035	939.49
WIPP-13	06/10/09	105.05	1.055	939.21
WIPP-19	06/09/09	118.68	1.046	933.68
WIPP-25 (PIP)[1]	06/11/09	45.37	1.010	935.29
WQSP-1	06/10/09	109.45	1.048	937.92
WQSP-2	06/10/09	121.54	1.048	940.48
WQSP-3	06/09/09	141.25	1.144	936.89
WQSP-4	06/10/09	134.89	1.074	919.15
WQSP-5	06/10/09	115.20	1.025	918.50
WQSP-6	06/10/09	104.52	1.015	922.21

[1] PIP indicates water levels measured in dual-completed wells

[2] SNL-6 and SNL-15 are currently not representative of undisturbed conditions in the Culebra; water levels in these well are predicted to continue to rise for the foreseeable future.

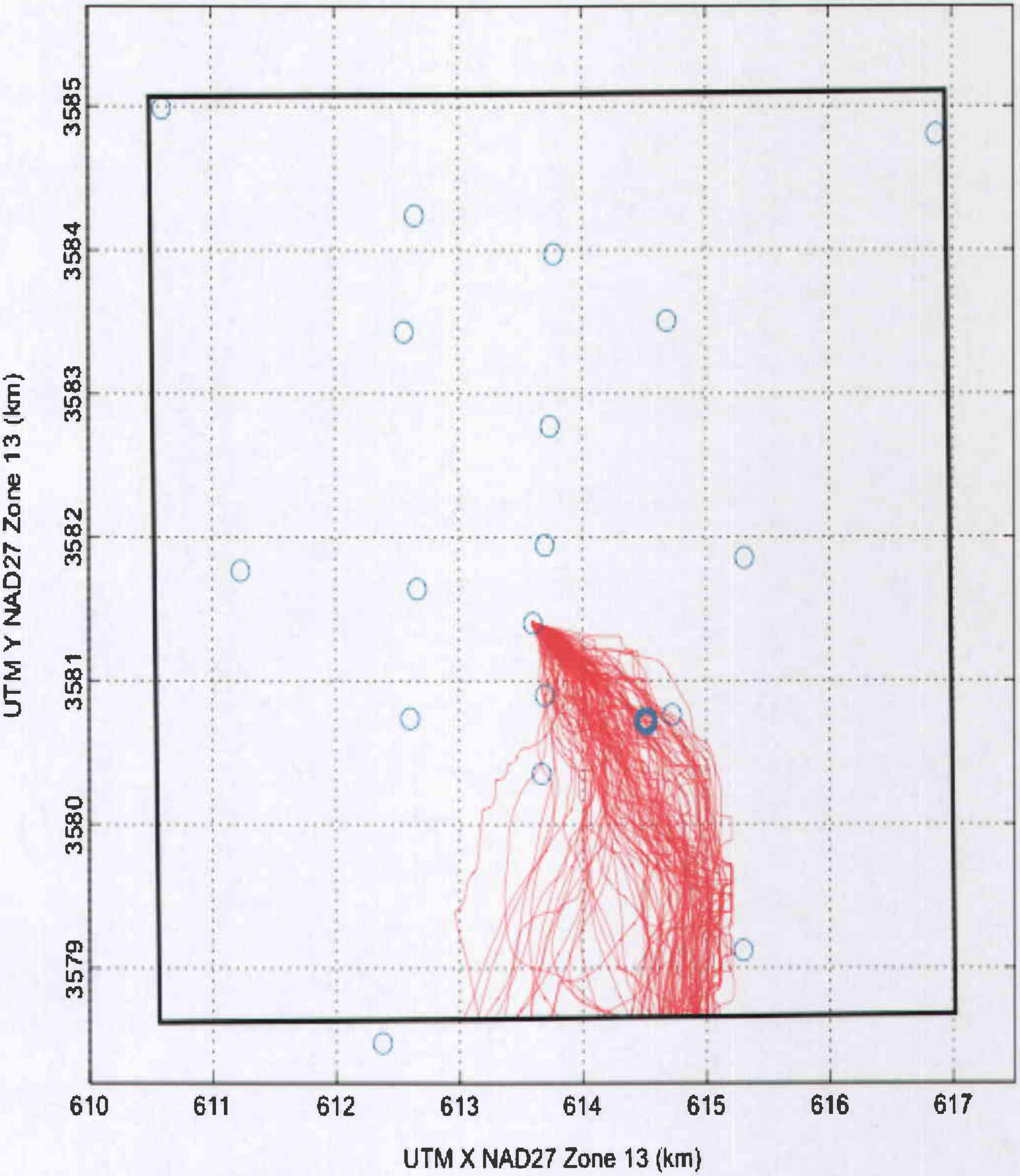


Figure 2.17. Distribution of 100 particle traces (red lines) from C-2737 (center of waste panels) to WIPP LWB (heavy black line) for CRA-2009 PABC; Figure from Kuhlman (2010b). Culebra monitoring wells are indicated with blue circles.

2.3.2.4 Interpretation/Summary of the 2009 Culebra Data

As mentioned previously, change in Culebra groundwater flow would be manifested as a change in gradient and/or flow velocity, which would be observed through changes in freshwater head measured in observation wells. In general, the potentiometric gradient of the Culebra is and has been from north to south and flow velocities are low across the WIPP modeling domain (Hart et al., 2009). The basis of this year's assessment of the groundwater flow COMP is the computed travel time and potentiometric surface map of the Culebra (Figure 2.16; DOE 2010c). The map was generated using the Culebra flow model developed by the Scientific Advisor for performance baseline calculations associated with CRA-2009 PABC and Culebra heads from June 2009.

The ensemble-model predicted travel time for a particle currently falls within the range modeled for PA, although it is near the faster end of the distribution because of the smoothness of the averaged field, compared to the stochastically generated individual fields used in PA. The travel time indicates that the current observed freshwater heads are consistent with the model used in PA, and therefore they do not violate the newly defined TV.

2.3.2.5 Results and Assessment of Data from Other Units

Assessment of water-level changes from other hydrologic units present in the WIPP vicinity (Table 2.16) is important for confirming the conceptual model of overall site hydrology. Water-level measurements for the Magenta Member of the Rustler Formation provide information about confinement of and connectivity to the underlying Culebra Member.

For consistency with the time period chosen for reporting 2008 water levels, December 2009 was chosen as the time period for reporting water level data from other (non-Culebra) units. Water-level changes in the Magenta ranged from -22.58 to 5.91 ft, with only two wells experiencing water-level changes ≥ 2.0 ft. Aside from recovery due to Scientific Advisor activities, water levels in wells are largely stable. Water levels in H-14 are 22.5 ft lower than 2008 because the well is still slowly recovering from testing activities, which spanned 9/8/08 to 2/11/09. Water levels in H-15 are almost 6 ft higher because the well was recovering in 2008, and has continued to slowly recover over 2009, due to Scientific Advisor activities, which ended on 3/31/08.

The water level was stable in WQSP-6A, the well completed to the middle of the Dewey Lake Formation (Table 2.16). Water levels in DOE-2 have continued to slowly rise (5.6 feet) after a large initial rise due to 2008 swabbing activities, which cleaned out foreign water in the well and changed wellbore water densities significantly (Table 2.16).

Table 2.16. Summary of 2008 water-level changes in units other than the Culebra.

Well I.D.	12/08 W.L. (ft AMSL)	12/09 W.L. (ft AMSL)	W.L. Change (ft)
Magenta Wells			
C-2737	3144.14	3143.23	-0.91
H-2b1	3143.37	3143.83	0.46
H-3b1	3146.66	3144.98	-1.68
H-4c	3147.43	3147.92	0.49
H-6c	3069.63	3070.20[a]	0.57
H-8a	3027.28	3027.48[b]	0.20
H-9c	3137.93	3138.72	0.79
H-10a	3222.33	3221.61	-0.72
H-11b2	3137.96	3138.76	-1.45
H-14	3128.77	3106.19	**-22.58**
H-15	3125.82	3131.73	**5.91**
H-18	3150.21	3149.88	-0.33
WIPP-18	3149.76	3149.92[c]	-0.54
WIPP-25	3066.84	3065.22[d]	-1.62
Dewey Lake Well			
WQSP-6A	3197.01	3196.97	-0.04
Bell Canyon Wells			
CB-1	3004.11	3009.69	**5.58**
DOE-2	3065.66	3066.65	0.99

All W.L. measurements made in December 2009, except as noted

[a] 10/19/09; no 12/09 H-6c W.L. due to Scientific Advisor sampling activities (pump installed 10/29/09)

[b] 10/20/09; no 12/09 H-8a W.L. due to Scientific Advisor sampling activities (pump installed 11/5/09)

[c] 06/09/09; no 12/09 WIPP-18 W.L. due to Scientific Advisor sampling activities (pump installed 6/10/09)

[d] 06/22/09; no 12/09 WIPP-25 W.L. because well was plugged & abandoned in July 2009.

Bold = changes in water level ≥ 2.0 ft

2.4 Waste Activity

Table 2.17 summarizes data and TV information relating to the COMP parameter Waste Activity, and its implementation in PA. The reporting period for the waste activity COMP started at first waste receipt and ended on June 30, 2010. A comparison of the tracked actinides and the total repository inventory used in the PABC-2009 is detailed in Table 2.18. No other activity-related assessment has been made at this time.

There are no TVs for CH activity, only RH. The TV for RH is the regulatory limit of 5.1 million Curies. This is the first reporting period for RH waste. The total curies of RH waste for the period ending June 30, 2009 is 3.50×10^3 Curies, well below the TV. There are no recognized reportable issues associated with this COMP. No changes to the monitoring program are recommended at this time. A detailed waste inventory assessment has been provided in the CRA-2009 (DOE 2009a).

Table 2.17 Waste Activity - 2010:

COMP Title:	Waste Activity
COMP Units:	Curies

Related Monitoring Data

Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value
Waste Data System (WDS; formerly the WWIS), BIR	Radionuclide activity per container and volume	Curies per container. Container volume.	TRU Waste Inventory for the 2004 Compliance Recertification Application Performance Assessment Baseline Calculation (Crawford et al. 2008)

COMP Assessment Process - Reporting Period July 1, 2009 to June 30, 2010

Total curie content of emplaced CH-TRU and RH-TRU waste.
[Total radionuclide inventories reported by the WDS]

Year 2010 COMP Assessment Value

A comparison of emplaced and PA waste parameters is found in Table 2.18.

Element Title	**Type and ID**	**Derivation Procedure**	**Compliance Baseline**	**Impact of Change**
Radionuclide inventories	Parameter	Product of waste stream content and volume scaled up to the Land Withdrawal Act limits. (U.S. Congress 1992)	Table 5-6 of Crawford et al. 2008	May affect direct brine releases for those radionuclides that become inventory-limited during a PA simulation.
Activity of waste intersected for cuttings and cavings releases.	Parameter	Function of waste stream volumes and activities	Figure 6-30 of the CRA-2004 (DOE 2004)	Cuttings are a significant contributor to releases. An increase in activity of intersected waste is potentially significant.
WIPP-scale average activity for spallings releases	Parameter	Average of all CH-TRU waste only.	NA	Spallings are a significant contributor to releases. An increase in average activity of intersected waste is potentially significant.

Monitoring Data Trigger Values

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

Table 2.18. Comparison of tracked radionuclide inventory to the PABC Inventory (from WRES 2010 and Crawford et al. 2008).

Radionuclide (CCA Table 4-10)	Non-Decayed Total Activity as of June 30, 2009[5]	Non-Decayed CH Inventory as of June 30, 2010	Non-Decayed RH Inventory as of June 30, 2010	Non-Decayed Total Activity as of June 30, 2010	PABC Total Inventory at Closure (2033)
^{241}Am	1.914E+05	2.021E+05	1.495E+02	2.023E+05	4.72E+05
^{137}Cs	9.543E+02	5.300E+00	1.753E+03	1.759E+03	8.95E+04
^{238}Pu	2.131E+05	2.725E+05	6.571E+01	2.725E+05	1.47E+06
^{239}Pu	2.802E+05	2.913E+05	9.739E+01	2.914E+05	5.13E+05
^{240}Pu	6.815E+04	7.105E+04	6.610E+01	7.112E+04	1.45E+05
^{242}Pu	1.152E+01	1.440E+01	9.375E-02	1.450E+01	7.59E+01
^{90}Sr	7.058E+02	1.086E+01	1.362E+03	1.373E+03	8.04E+04
^{233}U	3.777E+00	4.703E+00	1.354E-01	4.839E+00	2.07E+02
^{234}U	3.592E+01	4.610E+01	2.778E-01	4.638E+01	3.09E+02
^{238}U	1.099E+01	1.190E+01	6.035E-03	1.191E+01	2.73E+01
Total	**7.546E+05**	**8.371E+05**	**3.495E+03**	**8.406E+05**	**2.77E+06**

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, 10 monitoring parameters are assessed and compared to PA expectations and assumptions. The CRA-2009 (DOE, 2009a) contain the results of the most recent PAs submitted to the EPA for compliance purposes. The PABC-2009 was used in EPA's 2010 certification decision and became the new compliance baseline PA (EPA 2010a). The results of this year's COMP assessment conclude that there are no COMPs data or results that indicate a reportable event or condition adverse to predicted performance. In instances where TVs have been exceeded, further investigations or activities will be pursued and the results will be captured in a revision to the TV report. The goal of the operational period monitoring program is to identify conditions, should they occur, that may indicate deviations from the expected disposal system performance.

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[5] The values reported in the 2009 COMPs report are slightly difference than those shown below. The values shown here have been corrected and are from the Annual Change Report 2008/2009 (WRES 2010).

4 References

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SW 11-30-10

Wagner, Steve

From: Chavez, Mario Joseph
Sent: Monday, November 29, 2010 5:26 PM
To: Davis, Steve
Cc: Wagner, Steve
Subject: Signature Authority for the 2010 COMPS report

Steve,

I anm on vacation and am unable to sign off on the subject report. So if you would please sign the COMPS report on my behalf I would truly appreciate it. My DRC has been completed and all of my QA comments are resolved.

Thank you

Mario