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Trigger Value Derivation Report

Revision 2

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Trigger Value Derivation Report

WBS 1.3.1

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Revision History

Revision 1 – May 31, 2002

Modifications made in revision 1 of this document include:

The revision reassessed the Trigger Values (TVs) and made minor editorial changes. The "Change in Groundwater Composition" Compliance Monitoring Parameter (COMP) TV was modified. The TV included the provision that both duplicate analyses for major ions must fall outside of the 95% confidence range for three consecutive samples before the TV is exceeded. The revision also recognized that the "Change in Culebra Groundwater Flow" COMP results showed the TV being exceeded. Additional groundwater investigations were initiated and a future revision to the TV was expected. No changes were made to the TV. The revision also recognized that the "Drilling Rate" COMP would be exceeded in a few years and that the TV should be reassessed at that time.

Revision 2

Modifications made in revision 1 of this document include:

The TVs for the "Drilling Rate", "Extent of Deformation Features" and "Displacement of Deformation Features" were removed. The assessment period for the "Waste Activity" TV was revised to be assessed annually. The derivation method for the "Change in Culebra Groundwater Flow" TV was revised and a new TV was developed. No changes were made to the remaining TVs. Minor editorial changes were also made to the text.

Preface

This report is the second revision to the trigger value (TV) derivation report last published in 2002 (Beauheim et al., 2002). TVs are used in the compliance monitoring program as an indicator of conditions that may require further actions should a compliance monitoring program parameter's TV be exceeded. As the Waste Isolation Pilot Plant (WIPP) project knowledge advances with the maturing monitoring program, the basis for TVs may also change. Ten years of compliance monitoring results, performance assessment (PA) improvements and new PA results indicate that some of the original monitoring parameter TVs are no longer justified and in some cases are no longer useful. As PA expectations and results change, corresponding TVs must be updated to align them with expected conditions predicted or assumed in the latest baseline PA. Therefore, this TV report is being revised to account for these conditions and assign new TVs where needed.

The evaluations documented in the previous TV revision and repeated in this report were conducted to derive the TVs that are used to support the annual compliance monitoring parameter (COMP) assessment and reporting of compliance-related monitoring data to the Environmental Protection Agency (EPA). The monitoring data are first used by the Scientific Advisor (SA) to derive COMPs which are then evaluated against PA expectations. The concept of deriving and using TVs is explained in Sandia National Laboratories (SNL) Activity/Project Specific Procedure, SP 9-8 titled "Monitoring Parameter Assessment per 40 CFR §194.42 (Wagner 2008)." The perceived impact on PA conceptual models was used as the first-order basis for TV derivation. It should be noted that the term "Trigger Value" can represent events, trends, criteria, rates, probabilities, ranges, conditions, or a specific value. In some cases, no specific values are assigned because the monitoring parameters have been proven to be insensitive to the long-term performance of the repository. However, even in cases where the monitoring parameter does not directly affect performance, it may still have an impact on feature, event and process (FEP) screening, modeling assumptions, or some other important repository factor. Because the monitoring program will continue to gather information and experience relating to the WIPP disposal system, periodic assessments of TVs and COMPs have been planned to continue over the WIPP operational period. This second revision revisits TVs to assess the validity and usefulness of the values using the latest information and project knowledge. This assessment results in a more robust monitoring program and is a precursor to the periodic assessment of the entire compliance monitoring program.

The SA is committed to analyze the COMPs annually, as outlined in the DOE's 40 CFR Part 191 and 194 Compliance Monitoring Implementation Plan (DOE 2005) and SP 9-8, to determine if the monitoring program output indicates a potentially significant impact on repository performance or unexpected conditions. The annual assessment of each COMP is documented in another records package entitled "Sandia National Laboratories Compliance Monitoring Parameter Assessment (records package ERMS 510062)."

There are ten COMPs used in the compliance monitoring program. These parameters are:

1. Drilling Rate
2. Probability of Encountering a Castile Brine Reservoir

3. Waste Activity
4. Subsidence Measurement
5. Changes in Culebra Groundwater Flow
6. Culebra Groundwater Composition
7. Creep Closure
8. Extent of Deformation
9. Initiation of Brittle Deformation
10. Displacement of Deformation Features

Of these, the following summarizes the TVs that were updated within this revision of the TV report. The reminder of the COMP's TVs were not changed.

Drilling Rate

The drilling rate as represented in PA is the rate of drilling that is assumed to occur over the next 10,000 years. The derivation of this rate is based on actual drilling activities in a specified area that have occurred over the past 100 years. As such, the DOE originally believed that the drilling rate parameter, used in PA and calculated by the requirements in 40 CFR§194.33, would be determined once as a fixed parameter. However, the EPA required the DOE to recalculate the parameter using the latest drilling data during each recertification. A new value is derived every five years such that any change in the rate is accounted for in each recertification PA. During the first recertification, the EPA also required DOE to determine what the potential impacts on PA results would be if the drilling rate was doubled (EPA 2006). The DOE determined that the WIPP continued to comply with the EPA disposal standard under these conditions. Since the drilling rate is not expected to double over the operational lifetime of WIPP and the latest drilling rate is included in each recertification PA, no TV is needed for this monitoring parameter

Waste Activity

The impacts due to changes in waste activity are assessed during the recertification process. When available, new inventory information that accounts for emplaced, stored and projected waste is included in the recertification baseline. New waste activity limits are determined based on the input values used in the latest baseline PA. These input values are used as waste activity limits by the WIPP and represent a suitable TV for waste activity. The annual assessment of waste activity is a change from the original TV that evaluated impact when waste emplacement in a panel progresses to the point that it was half full. An annual evaluation was determined to be more practical since it does not require tracking of waste emplacement in disposal panels. Additionally, the WIPP Waste Data System (WDS, formerly called the WIPP Waste Information System or WWIS) also tracks radionuclide activity against the activity limits. A report meeting the 40 CFR §194.4(b)(4) reporting requirements is submitted to EPA each year and contains a list of emplaced waste activity for the 10 tracked radionuclides. Since this report effectively monitors the 10 tracked radionuclides to the emplacement limits and reports the emplacements totals to EPA annually, a TV that is set at these same limits is duplicative and is no longer needed.

Change in Culebra Groundwater Flow

The conceptual model and implementation of groundwater flow and transport was changed in the last recertification PA in a way that does not allow for the same TV approach to be used for the change in groundwater flow COMP. A new method has been developed. The new TV occurs when a comparison of the predicted marked water-particle travel time from the center of the WIPP panels to the WIPP Land Withdrawal Boundary (as predicted by the particle tracking code DTRKMF used in PA; Rudeen 2003) falls outside the cumulative distribution function (CDF) predicted using the ensemble of 100 calibrated baseline PA Culebra T-fields. The averaged Culebra model is a single forward simulation using the input parameter field geometrically averaged from the 100 calibrated Culebra T-fields with adjusted boundary conditions to best match each year's observed freshwater head values.

Extent of Deformation
The TV for extent of deformation features was removed. The original TV occurred when a comparison of room and drift fracture maps showed a yearly fracture growth of more than one meter in length. PA models do not address fractures directly such that quantified changes in fracture length do not correlate with PA expectations. Although fracture propagation into the host rock directly relates to DRZ PA assumptions, surface fractures in rooms and drifts are not indicative of fracture depth. The management and operating contractor (MOC) monitors these fractures to ensure adequate ground control and worker safety.

Displacement of Deformation Features
The TV for displacement of deformation features was removed. The original TV occurred when a borehole was fully occluded by differential movement of strata penetrated by the borehole. Due to their age, there are existing boreholes drilled in older areas of the WIPP that are fully occluded. This type of displacement is expected. The MOC continues to monitor these boreholes to ensure adequate ground control. Occluded boreholes do not indicate a condition outside the current creep conceptual model such that the use of occlusions for a TV does not indicate a condition requiring additional analysis relating to PA assumptions.

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1.0 Compliance Monitoring Parameters

The compliance monitoring program uses ten monitoring parameters and was first described in the Compliance Certification Application (CCA) (DOE 1996). This program continues to monitor the ten monitoring parameters or COMPs. The Trigger Values (TVs) for the ten COMPs were assessed in the first TV determination report and are reassessed in this second revision. The ten COMPs are:

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

The process for deriving TVs for each COMP is outlined in SP 9-8 and contains five basic steps. These steps are outlined in Appendix A of SP 9-8, which has been reduced to the following:

Step 1
Define the procedure for deriving COMPs.
Define the COMP-related monitoring data characteristics (i.e., what is actually measured/ observed and reported).

Step 2
Map COMP-related data to:
- Performance Assessment parameters
- Feature, Event and Processes screening arguments
- Conceptual models
- Model assumptions

Define data handling procedures used to process COMP data for Performance Assessment (PA) purposes. Generate COMP Table with the information listed above.

Step 3
Use relationships identified in Steps 1 and 2 to identify COMP-related data that were used to support the latest compliance application PA (termed the Compliance Baseline). Define the Compliance Baseline for these COMPs and monitoring data in the context of the PA element(s) derived from them. When reassessing the COMPs, this step should use the latest PA information.

Step 4
Use previous project experience (sensitivity analyses, the 40 CFR §194.42 monitoring analysis, etc.) to compile a list of potential impacts that changes in the PA elements identified in Step 2 above have on the predicted performance of the disposal system.

Step 5
Derive TVs for COMP-related monitoring data. TVs will represent deviations from the Compliance Baseline determined in Step 3. Exceedence of TVs could lead to either a significant impact on the performance of the disposal system, as determined in Step 4, or may simply indicate variances within modeling assumptions, or conceptual and/or numerical models (not within PA expectations).

Reassessment of Trigger Value Process

The original process to derive TVs is also used to reassess the TVs for this second revision of the report. Each step is reviewed to determine if the original conclusions are still valid. If a TV is changed, deviations and justification for the change are documented. It is expected that TVs will be reassessed periodically which necessitates a method to track the history of TV changes. Therefore, Attachment 1 (TV Revision Log) documents the TV change history.

2.0 Step 1 - Define the Procedure for Deriving COMPs

Define the procedure for deriving each COMP and define the monitoring data characteristics. The CCA (DOE 1996) was originally used to generate the information compiled in Table 1.1.

Table 1.1 Step 1 COMP Derivation and Data Characteristics Table

COMP	Procedure for Deriving COMP	Data Characteristics
Drilling Rate	Using information available from the WIPP Delaware Basin Monitoring Program determine on an annual basis, the total number of deep (> 2,150 feet) boreholes drilled in the Delaware Basin during the 100-year period immediately preceding the current derivation period and calculate a drilling rate based on the area of the Basin and the regulatory time period (i.e., 10,000 years). Specifically, the rate equals the total number of deep boreholes drilled/100 years) x (10,000 years/23,102.1 square kilometers). .	The Delaware Basin Monitoring Program is implemented by the WIPP Management and Operating Contractor (M&O) and collects data from DOE-qualified commercial sources and government agencies including the Midland Map Company, Petroleum Information Incorporated, Whitestar, Bureau of Land Management, Texas Railroad Commission, and the New Mexico Oil Conservation Division. Deep boreholes are defined as those greater than 2,100 feet deep drilled in the Delaware Basin for purposes of hydrocarbon, sulfur and potash evaluation/ exploitation, deep stratigraphic investigations and any other relevant deep boreholes. The Delaware Basin is defined as those surface and subsurface features which lie inside the boundary formed to the north, east and west of the WIPP disposal system, by the innermost edge of the Capitan Reef, and formed, to the south, by a straight line drawn from the southeastern point of the Davis Mountains to the most southwestern point of the Glass Mountains.
Probability of Encountering a Castile Brine Reservoir	Using information available from the WIPP Delaware Basin Monitoring Program determine on an annual basis, the number of intercepts of pressurized brine encountered in the Castile Formation in the 9-township area centered on WIPP and reported by industry.	Qualitative probability. As described above, the Delaware Basin Monitoring Program is implemented by the M&O and collects data on drilling activities within the Basin from several sources. The primary source of data for this COMP is from surveys submitted to commercial drillers. Since the drillers are not required to report brine encounters, their responses to the surveys requesting information on brine encounters in the Castile are voluntary.
Waste Activity	Waste activity derived from data entered into the WIPP Waste Data System (WDS) by generator sites for all waste shipped to WIPP. Data calls are periodically made which compile the information for ten radionuclides, cellulosics, plastics and rubbers and any other information provided by the generator sites.	Data are a compilation from generator sites. Radionuclide curie content is derived from process knowledge and radioassay. The M&O Data Administrator oversees the data system. Activity is tracked using the WDS.

Table 1.1 Step 1 COMP Derivation and Data Characteristics Table (Continued)

COMP	Procedure for Deriving COMP	Data Characteristics
Subsidence Measurement	Using information available from the WIPP Subsidence Monitoring Program, changes in elevation (vertical displacement) are determined from annual leveling surveys performed over a network of monuments located at the ground surface above and around the WIPP footprint. For each monument, incremental and total elevation changes are determined for the current year and for the time period since the monument was installed, respectively. Annualized subsidence rates (meters/year) are also determined by dividing the incremental elevation changes by the observation period (i.e., 1 year).	The WIPP Subsidence Monitoring Program is implemented by the M&O and collects data annually through a Second-Order Class II loop survey with a closure accuracy of 8 mm × √km or better. The annual survey includes traverses over ten leveling loops comprising approximately 60 monuments and National Geodetic Survey vertical control points. Elevations are referenced to Monument S-37 located ~ 7,700 ft north of the most northerly boundary of the WIPP underground excavations. Vertical closure errors for each loop are proportioned to the monuments within each loop based on the number of instrument setups and the horizontal distance between adjacent monument points.
Changes in Culebra Groundwater Flow	Changes in groundwater flow, both rate and direction, are observed through changes in hydraulic head. Using the information from the WIPP Groundwater Monitoring Program, the depth to water measurements taken monthly in the Culebra wells are corrected for water density and combined with ground surface elevations to derive equivalent freshwater elevations (heads) at the specified well locations. The ensemble average of 100 calibrated Culebra groundwater model realizations are matched to each year's observed heads. The predicted travel times are compared for particles in both the original 100 PA flow model runs and the head-matched ensemble average.	The WIPP Groundwater Monitoring Program is implemented by the M&O and collects water level data at least monthly at all primary wells and quarterly at redundant wells (wells located on the same hydropad as a primary well). Water level measurements are made manually using water-level sounders or with pressure transducers. As part of the Groundwater Monitoring Program, pressure-density surveys are conducted on a routine basis to establish current water densities for use in calculating freshwater heads. The 100 realizations of the Culebra flow model constructed for PA incorporate geologic data, estimated values of transmissivity, and are calibrated to observed large-scale well test results; see (Kuhlman 2010).
Culebra Groundwater Composition	Culebra groundwater composition data are derived directly from the WIPP Groundwater Monitoring Program. Major ionic species evaluated include Na^+, Ca^{2+}, Mg^{2+}, K^+, Cl^-, SO_4^{2-} and HCO_3^-. Ion concentrations for these species are reported in units of mg/L. Charge-balance error, defined as the difference between the positive and negative charges from the ions in solution divided by the sum of the positive and negative charges, is also calculated to assess the reliability of the measured ion concentrations for each sample.	As described above, the WIPP Groundwater Monitoring Program is implemented by the M&O and collects water quality data on a semi-annual basis by sampling from six Culebra wells, i.e., WQSP Wells 1 – 6 (water quality is also determined in WQSP Well 6a completed to the Dewey Lake). Duplicate analyses are performed on samples recovered from each round. Analyses determine the concentrations of all analytes called out in the WIPP Hazardous Waste Facility Permit plus approximately 20 other chemicals and metals. Analytes include major ion concentrations and hazardous chemical and radionuclide concentrations.

Table 1.1 Step 1 COMP Derivation and Data Characteristics Table (Continued)

COMP	Procedure for Deriving COMP	Data Characteristics
Creep Closure	Using information available directly from the annual WIPP Geotechnical Analysis Report (GAR), current creep closure rates recorded along monitored WIPP openings (e.g., shafts, experimental areas, waste emplacement rooms and haulage drifts) are compared to the previous year's listed rate.	The WIPP Geotechnical Monitoring Program is implemented by the M&O and collects both geomechanical and hydrological data from an extensive array of instruments. Instrumentation installed for measuring the response of shafts, drifts, and other WIPP openings includes convergence points, convergence meters, extensometers, rockbolt load cells, pressure cells, strain gauges, piezometers and joint meters. Data are acquired both manually and automatically using electronic data acquisition systems. Visual inspection and mapping of exposed surfaces around openings also supplement the quantitative data. Relates to mine operational ground control monitoring.
Extent of Deformation	Using information available from the annual WIPP GAR, extent of deformation deduced from borehole extensometers, feeler gauges, and visual inspections are examined yearly for active cross sections Anomalous growth is determined by comparison to previous observations.	As described above, the WIPP Geotechnical Monitoring Program collects both quantitative and qualitative data related to mine operational ground control monitoring issues. Of particular importance to this COMP are the mapping of fractures on exposed surfaces and the projection of these fractures through mapping in observational boreholes.
Initiation of Brittle Deformation	Methods and instrumentation needed to quantify the initiation of brittle deformation are not sufficiently advanced to be implemented in the existing WIPP monitoring programs. Therefore, derivation of this COMP is limited to an observational and qualitative assessment of related geotechnical data used to derive other COMPs such as extent of deformation and displacement of deformation features.	Quantitative data for the initiation of brittle deformation is not available from any of the current WIPP monitoring programs; however with time, brittle deformation induces features such as fractures and displacements along deformation features.
Displacement of Deformation Features	Using information available from the annual WIPP GAR, displacement of deformation features is derived from measurements of the offsets in observational boreholes drilled normal to common deformation features such as low-angle fractures, clay seams, bedding planes etc. Borehole offset is calculated as the ratio of borehole displacement to the borehole diameter expressed as a percentage.	The WIPP Geotechnical Monitoring Program implemented by the M&O includes visual estimates of borehole offsets where the borehole intersects common deformation features (e.g., low-angle fracture, clay seams, bedding planes etc). This monitoring is used to assess ground conditions for operational safety. Boreholes are monitored until there is no longer access because of waste emplacement or closure of a panel. Additional boreholes are drilled as new panels are mined. All boreholes are oriented vertically and located in the salt roof. Monitored data relate to mine operational ground control monitoring.

3.0 Step 2 – Map COMPs-Related Data

Step 2 in the process is to map COMP-related data to PA parameters, Feature, Event and Processes (FEP) screening arguments, conceptual models, and model assumptions and to define data manipulation procedures used to process COMP data for PA purposes. The results of this step are provided in COMP Table 3.1.

Table 3.1 COMP Mapping Table

M&O Program that Generates Data	Monitoring Parameter	Related PA Parameter†		FEP with related Screening Decision†		Related Modeling Assumption†		FEP with related Screening text‡	Comments
Geotechnical Monitoring Program (GTMP)	Creep Closure	Elastic properties of halite and anhydrite (e.g., Young's Modulus, shear modulus, Poisson's ratio, specific heat) Creep constitutive model Plastic constants for consolidation of the waste/backfill	N N Y	Mechanical effects of backfill Thermally-induced changes in stress	Y N	The amount of creep closure is a function of time, gas pressure, and waste matrix strength	N	Salt creep Excavation-induced changes in stress Changes in the stress field Pressurization Consolidation of waste	Provides validation of the CCA creep closure model. Thermal or backfill effects may be apparent during the operational period

† The second column under this heading indicates whether it is likely (Y) or unlikely (N) that the most recent compliance application position on the Parameter, FEP, or Assumption could change due to monitoring program results.

‡ FEPs with related screening text are those FEPs whose screening decision will not be affected by monitoring results, but whose screening discussion in the most recent compliance application may need to be updated in light of any changes related to monitoring results.

§ Parameter is not a COMP but relevant information is being/could be collected as part of the same monitoring program

M&O Program that Generates Data	Monitoring Parameter	Related PA Parameter†		FEP with related Screening Decision†		Related Modeling Assumption†		FEP with related Screening text‡	Comments
	Extent of deformation	DRZ parameters (e.g., extent, permeability) Intrinsic shaft DRZ permeability	Y N	-	-	Drift DRZ has sampled permeability (constant over each realization) The shaft is *surrounded* by a DRZ which heals with time Drift DRZ has constant (very large) size	Y Y Y	Disturbed rock zone Seismic activity (repository-induced) Roof falls Gas explosions Underground boreholes Consolidation of seals	If the PA DRZ model is modified to account for transient behavior, then this monitoring may have a significant bearing on parameter values and performance assessment
	Initiation of brittle deformation	Anhydrite fracturing model parameters (e.g., fracture initiation pressure, increment for full fracturing, fracture permeability enhancement) DRZ Properties	N Y	-	-	Initial pressure conditions PA model discretization	N N	Disruption due to gas effects	Also has bearing on the behavior of the DRZ (see above for related parameters and FEPs)

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§ Parameter is not a COMP but relevant information is being/could be collected as part of the same monitoring program

M&O Program that Generates Data	Monitoring Parameter	Related PA Parameter†		FEP with related Screening Decision†		Related Modeling Assumption†		FEP with related Screening text‡	Comments
	Displacement of deformation features §*Seismic activity*	-	-	Subsidence Large-scale rock fracturing Fault movement	N N N	-		Seismic activity (natural)	Significant subsidence would require development of a new conceptual model
	§*Brine sampling and monitoring*	DRZ permeability, effective porosity Average Salado brine composition (and source term parameters)	Y N	-	-	Initial pressure conditions Initial saturation conditions	N N	Brine inflow	Sufficient brine samples have been collected to make a change in average brine composition unlikely

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M&O Program that Generates Data	Monitoring Parameter	Related PA Parameter†		FEP with related Screening Decision†		Related Modeling Assumption†		FEP with related Screening text‡	Comments
Ground Water Monitoring Program (GWMP)	Culebra water levels/ Goundwater flow	Culebra transmissivity Fracture and matrix porosity Fracture spacing Dispersivity Climate index	N N N N N	Density effects on groundwater flow Freshwater intrusion (hydrological effect) Hydrological response to earthquakes Lake formation River flooding Thermal effects on groundwater flow	N N N N N N	No vertical flow to the Culebra (in the 2-D model) Culebra boundary conditions Culebra initial head conditions	N N N	Saturated groundwater flow Groundwater recharge Groundwater discharge Infiltration Changes in groundwater recharge and discharge Precipitation Temperature	Will build confidence in the 3-D groundwater basin modeling of the Rustler. FEPs may only be affected through sudden response to unexpected events. Any adjustments to the 3-D model may also affect PA parameters and assumptions for the other Rustler units

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‡ FEPs with related screening text are those FEPs whose screening decision will not be affected by monitoring results, but whose screening discussion in the most recent compliance application may need to be updated in light of any changes related to monitoring results.

§ Parameter is not a COMP but relevant information is being/could be collected as part of the same monitoring program

M&O Program that Generates Data	Monitoring Parameter	Related PA Parameter†		FEP with related Screening Decision†		Related Modeling Assumption†		FEP with related Screening text‡	Comments
	Culebra brine composition	Average Culebra brine composition	N	Changes in groundwater pH	N	Sorption models account for water chemistry	N	Groundwater geochemistry	Will build confidence in the 3-D groundwater basin modeling of the Rustler. The average Culebra brine composition is not used directly in the PA, but changes in estimates of recharge, redox conditions, etc. may be significant
		Matrix distribution coefficient for U(VI)	N	Changes in groundwater Eh	N	Natural actinide concentrations are zero	N	Actinide sorption	
		Matrix distribution coefficient for U(IV)	N	Freshwater intrusion (chemical effect)	N	No vertical flow to the Culebra (in the 2-D model)	N	Groundwater recharge Changes in groundwater recharge and discharge	
		Matrix distribution coefficient for Pu(III)	N	Effects of dissolution	N	Culebra boundary conditions	N	Infiltration	
		Matrix distribution coefficient for Pu(IV)	N						
		Matrix distribution coefficient for Th(IV)	N						
		Matrix distribution coefficient for Am(III)	N						
DBMP	Drilling rate	Drilling rate projected over a 10,000 year period derived from drilling occurrences over the past 100 years per unit area	Y	Drilling fluid flow	N	Drilling may occur after 100 years according to a Poisson model	N	-	Average rate will change(increase) as more data become available

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‡ FEPs with related screening text are those FEPs whose screening decision will not be affected by monitoring results, but whose screening discussion in the most recent compliance application may need to be updated in light of any changes related to monitoring results.

§ Parameter is not a COMP but relevant information is being/could be collected as part of the same monitoring program

M&O Program that Generates Data	Monitoring Parameter	Related PA Parameter[†]		FEP with related Screening Decision[†]		Related Modeling Assumption[†]		FEP with related Screening text[‡]	Comments
	Probability of encountering a Castile brine reservoir	Probability of encountering a Castile brine reservoir	Y	Brine reservoirs	N	Probability of intersecting a brine reservoir	N	Drilling fluid flow Drilling fluid loss Blowouts	FEP screening will only change if probability is reduced to zero
	[§]*Intersected reservoir characteristics*	Reservoir properties Castile brine composition (and source term parameters)	N N	-	-	-	-	Brine reservoirs Drilling Induced Geochemical Changes	Expected that brine composition will not differ significantly from those already sampled

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‡ FEPs with related screening text are those FEPs whose screening decision will not be affected by monitoring results, but whose screening discussion in the most recent compliance application may need to be updated in light of any changes related to monitoring results.

§ Parameter is not a COMP but relevant information is being/could be collected as part of the same monitoring program

M&O Program that Generates Data	Monitoring Parameter	Related PA Parameter†		FEP with related Screening Decision†		Related Modeling Assumption†		FEP with related Screening text‡	Comments
	§*Drilling practices* §*Borehole plugging activities* §*New drilling activities*	Drilling parameters (e.g., bit diameter) Borehole plug configurations and permeabilities	N N	Oil and gas extraction Groundwater extraction Liquid waste disposal Hydrocarbon storage Enhanced oil and gas recovery Investigation boreholes	N N N N N N	Diameter of the intrusion borehole is constant at 12.25 inches Future drilling practices will be the same as present Plugging practices will be the same as present Probability of plugging configurations	N N N N	All FEPs that describe current drilling activity Borehole fluid flow Waste-induced borehole flow Changes in groundwater chemistry due to mining	If plugging practices change, then plugging configuration conceptual model may need revision, and plugging practice for WIPP boreholes may need to be revisited.
Subsidence Monitoring Program (SMP)	Subsidence measurement	-	-	Subsidence Large-scale rock fracturing Oil and gas extraction	N N N	-	-	Changes in groundwater flow due to mining	Significant subsidence would require development of a new conceptual model

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M&O Program that Generates Data	Monitoring Parameter	Related PA Parameter[†]		FEP with related Screening Decision[†]		Related Modeling Assumption[†]		FEP with related Screening text[‡]	Comments
WIPP Waste Information System (WWIS)	Waste activity	Radionuclide inventories	N	-	-	Homogeneous waste distribution Specific CH-TRU waste streams based on inventory data and one RH-TRU waste stream based on combined inventory data	N N	Waste inventory Heterogeneity of wasteforms	-
	[§]*Average waste composition*	Average waste density Waste consolidation and permeability parameters	N N	-	-	-	-	Consolidation of waste	-
Environmental Monitoring Program (EMP)	None	-	-	-	-	-	-	-	-

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‡ FEPs with related screening text are those FEPs whose screening decision will not be affected by monitoring results, but whose screening discussion in the most recent compliance application may need to be updated in light of any changes related to monitoring results.

§ Parameter is not a COMP but relevant information is being/could be collected as part of the same monitoring program

4.0 Steps 3, 4, & 5 – Identify COMPs Data, Compile Potential List of Impacts and Derive TVs

A form has been created to aid in the compilation of information derived from steps 3 through 5. This form also standardized the format such that the information presented for each COMP was consistent.

Drilling Rate:

Trigger Value Derivation				
COMP Title:	Drilling Rate			
COMP Units:	Deep boreholes (i.e., > 2,150 feet deep)/square kilometer/10,000 years			
Related Monitoring Data				
Monitoring Program	**Monitoring Parameter ID**	**Characteristics (e.g., number, observation)**	**Values used in the CRA-2009 (DOE 2009)**	
Delaware Basin Monitoring Program (DBMP)	Deep hydrocarbon boreholes drilled	Integer per year	13,520 per 100 years – 58.5 boreholes per square kilometer per 10,000 years	
COMP Derivation Procedure				
(Total number of deep boreholes drilled/number of years of observations) x (10,000/23,102.1) [i.e., over 10,000 years divided by the area of the Delaware Basin in square kilometers]				
Related PA Elements				
Element Title	**Type and ID**	**Derivation Procedure**		
Drilling rate	Parameter LAMBDAD #3494	COMP/10,000 years		
Monitoring Data Trigger Values				
Monitoring Parameter ID	**Trigger Value**	**Basis**		
Deep boreholes drilled per km^2 per 10,000 yrs.z	None.	PA direct releases are sensitive to drilling rate changes. However only a dramatic and improbable change in drilling rate could affect containment of radionuclides. The sensitivity of changes to the drilling rate was evaluated during the first recertification as part of an analysis that doubled the drilling rate (Kanney and Kirchner 2004). A revised drilling rate is used in each recertification and the associated impacts are accounted for in PA. A rate that is twice what the rate used in the first recertification demonstrates containment compliance. Since changes to the drilling rate are assessed in PA every 5-years and a doubled rate is not expected and has been shown to not impact compliance, the use of a TV is unnecessary.		

Drilling Rate:

This report revised the drilling rate COMP TV.

The drilling rate used in PA is determined according to the method prescribed by the EPA in 40 CFR §194.33, by using an average value determined from the record from the past 100 years. For the CCA, a drilling rate of 46.8 boreholes per square kilometer per 10,000 years was derived. Because the drilling rate that represents the rate for the next 10,000 years is based on the recent drilling that has occurred over the past 100 years, the DOE originally believed that the drilling rate parameter used in PA would not change. The project has since decided a new rate should be used based on the latest 100 years of borehole data. As of August 2010, the drilling rate has increased to 62.3 which is a 33% increase from the CCA value. Because the drilling rate uses a 100-year rolling window, the drilling rate will continue to increase until more wells drop out of the 100-year period than are added. This cannot occur until 2011 when the first well drilled in 1911 will drop out (DOE 2008). It is expected that more wells will be added over the thirty-year WIPP operational period than will be removed such that the rate will continue to increase over the lifetime of the monitoring activity.

Although the original drilling rate TV was exceeded in 2004, the exceedance was expected. As discussed above, the drilling rate will continue to rise. 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 2006), the SA analyzed the impact of drilling rate on repository performance. This analysis shows that even if the drilling rate were doubled relative to that used for the CRA-2004 PA, the disposal system performance would be well within the release limits set by EPA regulations (Kanney and Kirchner 2004). The CRA-2009 recertification PA used a drilling rate of 58.5, (DOE 2009; data cut-off for CRA-2009 is 2007) demonstrating compliance with a higher drilling rate than the CCA.

Changes in drilling rate could affect the assumptions used in assembling the component models of the PA calculation. The original FEP screening process used in the CCA (Section 6.2 and Appendix SCR; DOE 1996) evaluated the impact of interconnections between stratigraphic units created by boreholes. These interconnections were found to be of low consequence for the drilling rates assumed. The finding of low consequence was used to support the models of the Culebra, Magenta, and Dewey Lake. Furthermore, the analysis of climate change effects is predicated on a low consequence associated with abandoned boreholes. Although these assumptions accounted for potential boreholes, the impacts of substantially more boreholes were not assessed. Should the drilling rate increase dramatically, FEPs assessments conducted as part of the periodic recertifications would address the impact.

A TV is not needed for the drilling rate during the time period for which monitoring will occur. No drilling will occur over the WIPP site during the operational and active controls period such that any impact of increased drilling on post-closure performance can be assessed in recertification application activities. WIPP PA does not implement the drilling scenario until 100 years after WIPP closure. It is expected that the drilling rate at that time would be less than today's due to the way the rate is calculated (many wells would drop out of the calculation).

Summary:

The drilling intrusion rate affects repository performance as well as the assumptions made during the development of models of hydrology and climate change. Based on DOE and independent analyses, only a dramatic and improbable change in the drilling rate could affect containment of radionuclides. The sensitivity of hydrologic and climate change assumptions used in low consequence FEP screening decisions have not been assessed for large increases in the drilling rate. However the possibility of any borehole intrusion into the site over the operational and active controls period is zero such that any calculated increase to the drilling rate that impacts the FEPs screening decisions would be assessed in the periodic recertifications of the site that occur over the operational period. Therefore, a TV is unnecessary for the drilling rate COMP and has been discontinued.

Probability of Encountering a Brine Reservoir:

<table>
<tr><td colspan="5">Trigger Value Derivation</td></tr>
<tr><td>COMP Title:</td><td colspan="4">Probability of Encountering a Castile Brine Reservoir</td></tr>
<tr><td>COMP Units:</td><td colspan="4">Unitless</td></tr>
<tr><td colspan="5">Related Monitoring Data</td></tr>
<tr><td>Monitoring Program</td><td>Monitoring Parameter ID</td><td>Characteristics (e.g., number, observation)</td><td colspan="2">Compliance Baseline Value</td></tr>
<tr><td>DBMP</td><td></td><td>Driller's Survey – observations</td><td colspan="2">0.08 constant – CCA</td></tr>
<tr><td colspan="5">COMP Derivation Procedure</td></tr>
<tr><td colspan="5">Analysis of intercepts of pressurized brine recorded and reported by industry in the 9-township area centered on WIPP.</td></tr>
<tr><td colspan="5">Related PA Elements</td></tr>
<tr><td>Element Title</td><td>Type and ID</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 (EPA 1998) justified the upper value in their range by rounding up the upper value interpreted from the TDEM survey, which suggested a 10 to 55% areal extent.</td><td>0.08 (CCA Value)

0.01 to 0.60 (Current Value)</td><td>Not a sensitive parameter.</td></tr>
<tr><td colspan="5">Monitoring Data Trigger Values</td></tr>
<tr><td>Monitoring Parameter ID</td><td>Trigger Value</td><td colspan="3">Basis</td></tr>
<tr><td>Probability of Encountering a Castile Brine Reservoir</td><td>None</td><td colspan="3">After the DOE proposed the brine reservoir probability as potentially significant in the CCA Appendix MONPAR, the EPA conducted sensitivity analyses that indicate a lack of significant effects on performance from changes in this parameter. Since no value of this parameter can significantly affect the performance of the disposal system predicted by the CCA PA and since the parameter is evaluated at least once annually, no TV is needed.</td></tr>
</table>

Probability of Encountering a Brine Reservoir:

This report does not change the TV for the probability of encountering a brine reservoir COMP.

The brine reservoir probability affects the consequences of modeled intrusion scenarios in PA. These scenarios involve the interconnection of a brine reservoir in the Castile Formation with the repository.

The development of the brine reservoir probability used in the PA is described in CCA Appendix MASS, Section 18-6 (DOE 1996). In the CCA, the brine reservoir probability was selected based on an analysis of recorded and reported brine intercepts by the drilling industry in the 9-township WIPP vicinity. This probability was anticipated to be important to the results of the CCA PA, and therefore was proposed for monitoring in CCA Appendix MONPAR.

The EPA conducted an extensive evaluation of the sensitivity of CCDFs to the occurrence of a brine reservoir intrusion, as well as the properties of the brine reservoir, in their Performance Assessment Verification Test (PAVT). The EPA's interpretation of the data on the existence of a brine reservoir led them to require the DOE to change the brine encounter probability (from a constant 0.08 to a sampled value from 0.01 to 0.6). The EPA's PAVT indicated that changes in brine reservoir assumptions can affect the position of CCDFs. However, there is no combination of reservoir intercept probabilities and reservoir properties that can affect the overall compliance of the WIPP. This suggests that no TV for the penetration of a brine reservoir is needed, because the sensitivity of performance predictions to changes in the value is low.

Summary:

Originally the DOE proposed the probability of encountering a brine reservoir as potentially significant PA parameter (CCA Appendix MONPAR; DOE 1996). The EPA has since conducted analyses that indicate that the probability does not have a significant effect on long-term repository performance. Additionally the EPA required probabilities for this parameter that are higher than the one originally derived from the drilling data. It is not expected that monitoring observations could lead to values higher than what the EPA requires. For these reasons, no TV is needed. Monitoring of the occurrence of brine reservoirs will continue. The information collected will support a current and accurate understanding of human activities in the vicinity of WIPP. These data and information may be considered in support of parameter selection for future PA calculations.

Waste Activity:

Trigger Value Derivation				
CMPMP Title:	Waste Activity			
CMPMP Units:	Curies			
Related Monitoring Data				
Monitoring Program	**Monitoring Parameter ID**	**Characteristics (e.g., number, observation)**	**Compliance Baseline Value**	
WDS	Total emplaced curies for tracked radionuclides, emplaced waste volumes	Curies per container. Container volume. Total curies of ten radionuclides	Inventory cited in the latest Compliance Recertification Application (CRA)	
COMP Derivation Procedure				
Total curie content of the ten monitored actinides emplaced in WIPP for both CH-TRU and RH-TRU waste. *[Total radionuclide inventories reported by WDS]*				
Related PA Elements				
Element Title	**Type and ID**	**Derivation Procedure**	**Compliance Baseline**	**Impact of Change**
Radionuclide inventories	Parameter	Product of waste stream content and volume scaled up to the LWA limits.	Latest CRA Inventory	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	-	Cuttings are a significant contributor to releases. Therefore, 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.	-	Spallings are a significant contributor to releases. Therefore, an increase in average activity of intersected waste is potentially significant.
Monitoring Data Trigger Values				
Monitoring Parameter ID	**Trigger Value**	**Basis**		
Total emplaced waste activity for the ten monitored actinides	Actinide values in latest CRA - Section 24	40 CFR§194.24 (c) requires a system of controls to confirm important waste limits are not exceeded. Actinide curie values use in baseline PA are used as the waste limit values.		
Total emplaced RH-TRU waste activity	5.1 million curies	LWA emplacement limit reached. Administrative controls address these limits.		

Waste Activity:

This report modifies the TV for the CH waste activity COMP. The actinide curie values (which have been decayed to the year 2023) that are used in the latest PA baseline are used as the TVs. Originally, the compliance monitoring assessment would check the actinide values of the emplaced waste against the values used in PA when a panel was half-full. The implementation of the TV has been changed such that the COMP is no longer associated with the extent that a panel is filled with waste. The assessment will now be made annually. The TV associated with the RH waste activity limit of 5.1 million curies has not changed. Monitoring of RH-TRU waste activity will be used to ensure that the WIPP complies with the LWA activity limit of 5.1 million curies and the 250,000 cubic feet RH waste volume limit.

Releases due to cuttings and cavings are calculated by sampling a probability distribution of waste activity based on individual waste stream volumes and activities (Figure 6-31 of the CCA)(DOE 1996). Spalling and direct brine releases are calculated assuming a WIPP-scale average activity and waste distribution. Changes to the activity estimates have a direct influence on PA results such that assuring the values used in PA are representative of the actual values emplaced in the repository is essential. The latest waste information is used in each baseline PA such that changes are accounted for at least every five years. Annual checks on the emplaced waste activities ensure that the waste values used in PA are not exceeded.

Subsidence Measurement:

Trigger Value Derivation

CMPMP Title:	Subsidence Measurement
CMPMP Units:	Rate of change in surface elevation in meters per year

Related Monitoring Data

Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value
SMP	Elevation of existing monitoring benchmarks	Decimal (meters)	Values not used in PA. (WIPP Subsidence Monument Leveling Survey – Annual Report)
SMP	National Geodetic Survey (NGS) results	Decimal (meters)	Powers (1993)
SMP	Change in elevation over year	Decimal (meters)	-
SMP	Total change in elevation since excavation of the WIPP	Decimal (meters)	1996 NGS elevation - 1981 NGS elevation (from Powers 1993)

COMP Derivation Procedure

Subsidence profiles taken along sections crossing relevant portions of the WIPP footprint. Contour plots of the monitoring benchmarks showing [Elevation this year – Elevation last year], and [Elevation this year – Baseline Elevation].
Maximum value of (Elevation this year – Baseline Elevation) from the available monitoring benchmarks.

Related PA Elements

Element Title	Type and ID	Derivation Procedure	Compliance Baseline	Impact of Change
Subsidence	FEP [W23]	Predictions are of low consequence to the calculated performance of the disposal system – based on Westinghouse (1994) analysis and EPA treatment of mining.	Maximum total subsidence of 0.62m above the WIPP.	Predicted subsidence will not exceed existing surface relief of 3 m – i.e., it will not affect drainage. Predicted subsidence may cause an order of magnitude rise in Culebra hydraulic conductivity (CCA Appendix SCR , Section 2.3.4) – this is within the range modeled in the PA. Predicted WIPP subsidence is below that predicted for the effects of potash mining (0.62 m vs.1.5 m; EPA 1996).

Monitoring Data Trigger Values

Monitoring Parameter ID	Trigger Value	Basis
Rate of change in elevation	1.0×10^{-2} m per year subsidence	Based on the most conservative prediction by analyses referenced in the CCA.

Subsidence Measurement:

This report does not change the TV for the subsidence COMP. Changes were made to the text to update and organize the information presented.

Subsidence is expected over the WIPP site due to the mining and eventual closure of the mined void space. Subsidence over the WIPP is expected to be much lower and slower than that observed over potash mines in the region because of the low extraction ratio (pillar to mined room volume) and relative depth. Maximum observed subsidence over these potash mines is 1.5 m, occurring over a time period of months to a few years. EPA took this amount of subsidence into account when specifying its treatment of mining (EPA 1996). Therefore, any predicted subsidence below 1.5 m would not impact the EPA's mining assumptions. Since the WIPP rate is expected to be much lower that above the potash mines, other rates were considered in the TV assessment.

Several subsidence analyses were performed by the project for various reasons to estimate possible subsidence over the WIPP. These analyses could be used to determine possible subsidence rates over the WIPP. Exceedance of the highest rate expected could be used as a TV, however the assumptions used in the analyses and the purpose of the analyses should also be considered in the TV selection.

In one analysis, the maximum subsidence figure calculated for the WIPP assuming emplacement of CH-TRU waste and no backfill is 0.62 m (Backfill Engineering Analysis Report [BEAR], Westinghouse 1994). Maximum subsidence occurs above the waste emplacement panels. Analyses also were made assuming an empty repository, this increases the maximum calculated subsidence to 0.95 m. The majority of the subsidence predictions give no time scales. However, computer modeling in the BEAR predicts subsidence to occur over a time period of 380 years. Assuming the maximum subsidence of 0.95 m for this time period, would result in a subsidence rate of less than 0.003 m per year.

Another subsidence analysis is documented in the Final Safety Analysis Report (FSAR, DOE 1990). This analysis predicts maximum surface subsidence of 12 to 15 inches (0.3 to 0.38 m) over the 35-year operating period. This translates into a subsidence rate of approximately 0.4 inches (0.01 m) per year. Since this is significantly higher that the 0.003 m rate discussed above, this higher rate is considered an acceptable TV for the subsidence COMP.

Changes in Culebra Groundwater Flow:

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**	
Ground Water Monitoring	Head and Topography	Monthly water-level measurements, annual pressure-density surveys.	Indirect	
COMP Derivation Procedure				
Annual assessment from ASER data.				
Related PA Elements				
Element Title	**Type & ID**	**Derivation Procedure**	**Compliance Baseline**	**Impact of Change**
Groundwater conceptual model Transmissivity Fields (T-Fields)	T-Field	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 (2010).	Appendix T-Fields	Provides validation of the various PA models - T-Field assumptions and groundwater basin model.
Monitoring Data Trigger Values				
Monitoring Parameter ID	**Trigger Value**	**Basis**		
Change in Culebra Groundwater Flow	See Figure 4.1	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 Land Withdrawal Boundary must fall within the distribution found using the 100 model runs used in the baseline PA.		

Changes in Culebra Groundwater Flow:

This report revises the TV for the change in groundwater flow COMP.

Groundwater flow in the Culebra is controlled primarily by the distribution of transmissivity and the freshwater head hydraulic gradient. Changes in predicted groundwater flow may result when changes in either or both of these parameters occur. To calculate groundwater travel times and radionuclide releases through the Culebra for PA, a set of transmissivity (T) fields were generated and calibrated to observed heads. These T-fields were generated using "point" values of geologic information, transmissivity and head data obtained from well tests, and water-level measurements at well locations. Boundary conditions (heads) for the model domain were estimated from both hydrologic information about the system (e.g., no-flow boundaries in Nash Draw and low-permeability constant-head boundaries along the Rustler halite margins) and water-level measurements (constant-head boundaries at the north and south ends of the Culebra PA flow model).

The original TV, derived from CCA information, used the ranges of freshwater heads that were used in the calibration of baseline T-fields. For example, Table TFIELD-3 in Appendix TFIELD (DOE 1996) of the CCA lists the undisturbed freshwater heads and uncertainties for 32 wells used in calibration of the CCA baseline Culebra T-fields. At that time, water levels in 26 of those wells were measured monthly as part of the Ground Water Monitoring Program (GWMP). Water levels were expected to remain within the ranges defined for the CCA. If water levels in one or more wells fell outside those ranges, it was thought at the time to mean one of four things. It could mean that the well casing or a packer has failed, and water is entering the Culebra interval of the well from another interval. It could mean that human activities, such as pumping or circulation losses during drilling, are affecting Culebra water levels in nearby wells. It could mean that the undisturbed heads estimated for the CCA are in error. Lastly, it could mean that our conceptual model for the Culebra, which includes an assumption that heads are in a steady-state condition on the time scale of centuries to millennia, is in error. None of these conditions necessarily imply that WIPP is out of compliance with EPA regulations. Groundwater flow directions and rates are controlled by gradients, not by head values, so uniform changes in heads do not necessarily imply (significant) changes in flow. However, prior to the first recertification (termed the CRA 2004), observed water levels fell outside the CCA ranges and triggered an investigation into the cause and possible ramifications. New water level data were used to calculate new T-fields during CRA 2004 activities which defined new freshwater head ranges. Continued monitoring has again observed freshwater heads outside of the new ranges. This condition has been assessed through further investigations. The CRA-2009 PABC revised the Culebra conceptual model and approach used to generate T-fields such that freshwater heads are parameterized as a fixed value, not a range. Therefore, a new TV was necessary.

A failure of the well casing or a packer might be indicated by sudden changes and erratic behavior of the water level. Such a failure would have no long-term impact on WIPP compliance. Changes suspected of being caused by a casing or packer failure have been investigated using methods such as video and/or geophysical logs, isolating and pressurizing different sections of the casing, and imposing a different pressure differential across a packer to verify its integrity.

Most local-scale (e.g., observed in one or two wells) human-induced changes in Culebra heads are likely to be short-term, rarely if ever lasting more than one year. Human-induced changes might take the form of sudden (e.g., between two monthly measurements) rises or drops in water levels, followed by a decay back towards the initial water level. Short-term changes such as this have no impact on WIPP compliance. Changes suspected of being human induced have been investigated by collecting information on human activities in the area such as discharges in potash evaporation ponds and ranch water uses to determine if the activities correlate with or can be modeled to produce the observed changes.

The new TV for assessing change in Culebra groundwater flow involves comparison of the model-predicted travel time for a DTRKMF (Double precision TRacKing with MODFLOW 2000)-predicted particle of water from a point in the Culebra above the center of the WIPP panels to the WIPP Land Withdrawal Boundary (Harbaugh et al. 2000 and Rudeen 2003). If the predicted travel time is outside the distribution predicted as part of the current PA, the heads used to drive the average Culebra model must be investigated to determine the cause of the discrepancy between modeled and predicted travel times and decide if the PA model needs to be revised.

Each year, a model consisting of the ensemble average of calibrated T-fields used in PA analysis is used to match to observed heads from that year. The model input parameters are taken from the calibrated PA model, while the constant-head boundary conditions are adjusted to improve the match between the averaged model and that year's observed heads. Once a best-fit average model is determined, it is used to predict travel time associated with a conservative particle (i.e., a marked water particle without dispersion or retardation) from the location of well C-2737 in the Culebra (above the center of the WIPP panels) to the WIPP Land Withdrawal Boundary. This single travel time from the average flow model with best-fit boundary conditions is compared with the distribution of 100 travel times computed for PA (see red dots in Figure 4.1) to determine whether or not the TV has been exceeded.

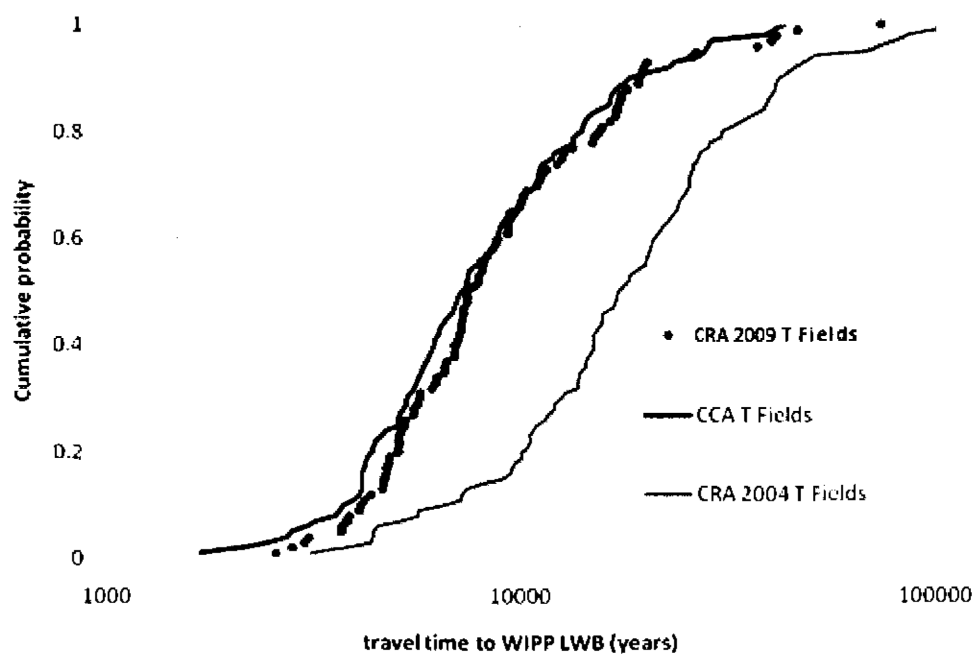

Figure 4.1 Distribution of travel times from above the center of the WIPP panels to the WIPP Land Withdrawal Boundary.

Culebra Groundwater Composition:

Trigger Value Derivation				
COMP Title:	Culebra Groundwater Composition			
COMP Units:	mg/L			
Related Monitoring Data				
Monitoring Program	**Monitoring Parameter ID**	**Characteristics (e.g., number, observation)**	**Compliance Baseline Value**	
Ground Water Monitoring	Composition	Semi-annual chemical and radionuclide analyses	Updated Resource Conservation and Recovery Act (RCRA) Background Water Quality baseline	
COMP Derivation Procedure				
Annually evaluate ASER data and compare to previous years' and baseline information				
Related PA Elements				
Element Title	**Type & ID**	**Derivation Procedure**	**Compliance Baseline**	**Impact of Change**
Groundwater conceptual model, brine chemistry, actinide solubility	Indirect	Conceptual models	Indirect – The average Culebra brine composition is not used.	Provides validation of the various PA models, potentially significant with respect to flow, transport, and solubility and redox assumptions.
Monitoring Data Trigger Values				
Monitoring Parameter ID	**Trigger Value**	**Basis**		
Change in Culebra Groundwater Composition	Both duplicate analyses for any major ion falling outside the 95% C.I.s given in Table 4.1 for three consecutive sampling periods	Annual comparisons of major ion concentrations with 95% confidence intervals derived from the ten rounds of sampling (pre-waste emplacement) composing the water quality baseline.		

Culebra Groundwater Composition:

This revision does not change the TV for the Culebra groundwater composition COMP. Changes were made to the text to update the information presented.

Groundwater composition is not in itself a parameter affecting repository performance or compliance. However, stability of groundwater composition on the time scale of the WIPP operational period is implicit in both the confined, two-dimensional model of the Culebra used for PA calculations and in the three-dimensional basin model from which the two-dimensional model is abstracted as a conservative simplification. Therefore, changes in groundwater composition would indicate the need to revise our models of flow and transport through the Culebra.

The results of the groundwater analyses are compared to baseline results in order to determine stability, which is defined as a condition where the concentration of a given ion remains within its derived 95% confidence interval (CI; mean ± two standard deviations) established from the baseline measurements at a well, assuming a normal distribution of concentrations. The original baseline was defined by the first 5 rounds of sampling in the Water Quality Sampling Program (WQSP) wells conducted between July 1995 and September 1997 (IT Corporation 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 Resource Conservation and Recovery Act (RCRA) -regulated waste at WIPP. The baseline data are presented in the WIPP Resource Conservation and Recovery Act Background Quality Baseline Report (IT Corporation 1998) and in Addendum 1 to that report (IT Corporation 2000).

The rationale for definition of TVs involves the following considerations. The 95% confidence interval for a particular analyte defines the range of concentrations that 19 out of 20 analyses, on average, should fall within. Thus, one out of every 20 samples could have a concentration outside of this range without indicating the groundwater composition had changed. Therefore, TVs should not be set so that a single analysis falling outside the 95% confidence interval is considered 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. Thus, TVs should entail some number of successive measurements showing consistent results (or a consistent trend) outside the 95% confidence interval.

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

Table 4.1 95% Confidence Intervals for Major Ions

Well	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)
WQSP-1	31100-39600	4060-5600	45-54	15850-21130	1380-2030	940-1210	322-730
WQSP-2	31800-39000	4550-6380	43-53	14060-22350	1230-1730	852-1120	318-649
WQSP-3	113900-145200	6420-7870	23-51	62600-82700*	1090-1620	1730-2500	682-2940
WQSP-4	53400-63000	5620-7720	31-46	28100-37800	1420-1790	973-1410	364-1450
WQSP-5	13400-17600	4060-5940	42-54	7980-10420*	902-1180	389-535	171-523
WQSP-6	5470-6380*	4240-5120*	41-54	3610-5380*	586-777	189-233*	113-245

*baseline definition excludes anomolus values

Geotechnical COMPs

Geotechnical COMPs are directly related to the repository's operational safety monitoring program performed to ensure mine safety. By nature, changes in geotechnical conditions evolve slowly; however, they are monitored on a continual basis. Since these geotechnical changes correlate to geotechnical COMPS, changes to these COMPS also evolve slowly. For most instances, a geotechnical condition that warrants action for operational safety will occur before data on the same condition would impact long-term repository performance predictions. For these reasons, an annual assessment of the geotechnical COMPs will adequately address conditions that would be a concern for predicting repository performance. Future assessments will evaluate possible trigger events, features phenomenon, trends, and conditions that would warrant further actions related to predicting long-term performance of the repository. Examples and the rationale for development of these TVs are described below.

Creep Closure:

This report does not change the TV for the creep closure COMP. Changes were made to the text to update the information presented.

The annual Geotechnical Analysis Report (GAR; e.g., Westinghouse 2001) compiles all geotechnical operational safety data gathered from the underground. The GAR reports routine measurements of creep deformation, either from rib-to-rib, roof-to-floor, or extensometer borehole measurements. Rates of closure are relatively constant and slow (5×10^{-10} s^{-1}), such that upward trends could be readily observed at no risk to operational personnel or to safety. Extensive GAR data suggest that possible TVs could be derived from creep rate changes. The WIPP underground is essentially stable relative to most operational mines, and deformation is steady for long periods of time. However, under certain conditions, creep rates accelerate which indicates a structural change to the deformation 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. Therefore, a measured creep rate change which occurs over a yearly period would constitute the COMP TV for creep closure on a case-by-case basis since this rate is directly related to factors such as age of the opening, location in the room or drift, convergence history, recent excavations, and geometry of the excavations.

Initiation of Brittle Deformation:

This report does not change the TV for the initiation of brittle deformation COMP. The Initiation of Brittle Deformation around WIPP openings cannot be 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. Initiation of brittle deformation manifests quantitatively in COMPs related to deformational extent and displacement of deformational features. WIPP geotechnical personnel possess historical knowledge of the WIPP underground, and continually assess deformation features, assess roof bolt behaviors, and perform caliper fracture mapping. These assessments are reported in the GAR and will be used along with information from the other geotechnical COMPs in the annual assessments to ensure that there are no conditions that could be impactive to repository performance, or predicted behavior.

Extent of Deformation:

This report discontinues the use of a TV for the extent of deformation COMP. The extent of deformation is quantifiable as it defines spatial and temporal evolution of the DRZ. Derivation of this COMP is made from yearly comparisons of room and drift surface fracture mapping provided in the annual GARs. A qualitative TV was originally applied using a change of more than 1 m/yr in fracture length. The results from this COMP cannot be directly applied to the current conceptual model's numerical implementation such that observed changes in fracture lengths do not indicate a condition outside of PA expectations. The fracture depth into the host rock is related to DRZ assumptions, however the surface fracture lengths do not correlate to depth. For this reason, applying a TV to this COMP is not an indicator of unexpected behaviors and should be discontinued.

Displacement of Deformation Features:

This report discontinues the use of the TV for the COMP, displacement of deformation features. The displacement of deformation features largely occurs vertically via crack openings and is associated laterally along clay seams. Extensive deformational features may include occlusion of observational borehole diameters. This parameter is not currently associated with a PA parameter or modeling assumption. Data related to this COMP could be used in the future if the creep closure model is further refined. Observational borehole monitoring data are currently used to assess ground control in an effort to ensure adequate operational safety. A TV related to PA parameters or assumptions is not practical and is unnecessary. Therefore, the TV has been discontinued.

Creep Closure:

<table>
<tr><th colspan="5">Trigger Value Derivation</th></tr>
<tr><td>COMP Title:</td><td colspan="4">Creep Closure</td></tr>
<tr><td>COMP Units:</td><td colspan="4">Closure Rate (sec^{-1})</td></tr>
<tr><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>Geotechnical</td><td>Closure</td><td>Instrumentation is through out the underground.</td><td colspan="2">Munson-Dawson (MD) Constitutive Model</td></tr>
<tr><th colspan="5">COMP Derivation Procedure</th></tr>
<tr><td colspan="5">Annually evaluate GAR for centerline closure rates, compare to previous year's rate. If closure rate increases by greater than one order of magnitude, initiate technical review.</td></tr>
<tr><th colspan="5">Related PA Elements</th></tr>
<tr><td>Element Title</td><td>Type & ID</td><td>Derivation Procedure</td><td>Compliance Baseline</td><td>Impact of Change</td></tr>
<tr><td>PA Grid</td><td>Creep Closure</td><td>Porosity Surface
Waste Compaction Characteristics
Waste Properties
Evolution of underground setting</td><td>MD Model</td><td>Provides validation of the CCA creep closure model.</td></tr>
<tr><th colspan="5">Monitoring Data Trigger Values</th></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">Closure rate increase signals potential de-coupling of rock.</td></tr>
</table>

Extent of Deformation:

Trigger Value Derivation				
COMP Title:	Extent of Deformation			
COMP Units:	Areal extent (length, direction)			
Related Monitoring Data				
Monitoring Program	**Monitoring Parameter ID**	**Characteristics (e.g., number, observation)**	**Compliance Baseline Value**	
Geotechnical	Displacement	Meters	Room geometry	
COMP Derivation Procedure				
Extent of deformation deduced from borehole extensometers, feeler gauges, and visual inspections are examined yearly for active cross sections. Anomalous growth is determined by comparison.				
Related PA Elements				
Element Title	**Type and ID**	**Derivation Procedure**	**Compliance Baseline**	**Impact of Change**
PA Grid	DRZ (shaft, drift and panel closure)	Constitutive model from laboratory and field databases.	See Fox 2008 for DRZ parameter values	DRZ spatial and temporal properties have important PA implications for permeability to gas, brine and two-phase flow.
Monitoring Data Trigger Values				
Monitoring Parameter ID	**Trigger Value**	**Basis**		
Fractures at depth	None	Fracture coalescence at depth in rock surrounding drifts are important to closure performance and DRZ assumptions however surface observations do not correlate well with fracture depth.		

Initiation of Brittle Deformation:

Trigger Value Derivation				
COMP Title:	Initiation of Brittle Deformation			
COMP Units:	Qualitative			
Related Monitoring Data				
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value	
Geotechnical	Closure	Observational	Operational and Remedial	
COMP Derivation Procedure				
Qualitative and pertinent to operational considerations. Captured qualitatively in association with other COMPs				
Related PA Elements				
Element Title	Type and ID	Derivation Procedure	Compliance Baseline	Impact of Change
Not directly related to PA	NA	NA	NA	NA
Monitoring Data Trigger Values				
Monitoring Parameter ID	Trigger Value	Basis		
Initiation of Brittle Deformation	None	Qualitative COMPs can be subjective and are not conducive to the development of meaningful TVs.		

Displacement of Deformation Features:

Trigger Value Derivation				
COMP Title:	Displacement of Deformation Features			
COMP Units:	Length			
Related Monitoring Data				
Monitoring Program	Monitoring Parameter ID	Characteristics (e.g., number, observation)	Compliance Baseline Value	
Geotechnical	Delta D/D_o	Observational	Not established	
COMP Derivation Procedure				
Observational – Lateral deformation across boreholes.,				
Related PA Elements				
Element Title	Type and ID	Derivation Procedure	Compliance Baseline	Impact of Change
Not directly related to PA	NA	NA	NA	NA
Monitoring Data Trigger Values				
Monitoring Parameter ID	Trigger Value	Basis		
Borehole diameter closure	None	Impact assessed as part of operational safety program. Not a PA parameter		

5.0 Conclusions

This report is the second revision of the *Trigger Value Derivation Report* and documents a reassessment of the values determined in the last revision of the report. SP 9-8 was used for this reassessment. TVs are to be used as a tool for the annual COMPs assessment process described in SP 9-8. The COMPs program is expected to evolve over the WIPP operational period. Changes to the compliance monitoring program are expected to include new monitoring parameters and assessment practices which will likely result in further changes to the TV concept.

The assessment made in this report modified five COMPs TVs. Three COMPs TVs were removed because the assessment of these TVs determined that their associated COMPs no longer needed a TV. The drilling rate TV was removed because a new rate based on monitoring results is included in each recertification PA. The extent of deformation features TV was removed because these features cannot be directly applied to the current conceptual model's numerical implementation such that observed changes in fracture lengths do not indicate a condition outside of PA expectations. The TV for displacement of deformation features COMP also was removed because this parameter is not currently associated with a PA parameter or modeling assumption.

Two other COMP's TVs were modified during this revisions assessment. The waste activity COMP revised the timing for which the COMP would be assessed from a time when a panel was half filled with waste to annually. The COMP, change in Culebra groundwater flow was modified. The CRA 2009 PABC revised the Culebra conceptual model and approach used to generate T-fields such that freshwater heads are parameterized as a fixed value, not a range. Since the TV for groundwater flow used this range, a new TV was necessary.

A summary of the TVs and the modification made by each revision of this report is shown in Table 5.1 below.

Table 5.1
Trigger Value Revision Log

COMP	Rev 0. Trigger Value	Rev 1. Trigger Value	Rev 2. Trigger Value	Notes for Latest Revision
Probability of Encountering a Castile Brine Reservoir	None	No Change	No Change	
Drilling Rate	53.5 boreholes per km^2 per 10K yrs.	No Change – Correction made in "Basis" of TV, 10% changes to 15%, TV was not changed.	TV Deleted	Impacts of drilling rate assessed every 5 years in recertification PAs
Waste Activity	Panel half-full 5.1 million curies	No Change	Changed to annual assessment	Annual monitoring assessment occurs more often
Subsidence	1.0×10^{-2} m per year subsidence	No Change	No Change	
Changes in Culebra	See Table 4.1	No Change	Predicted travel	Implementation of a

COMP	Rev 0. Trigger Value	Rev 1. Trigger Value	Rev 2. Trigger Value	Notes for Latest Revision
Groundwater Flow			time are compared to the distribution predicted by the current PA	new groundwater conceptual model caused the change in TV
Culebra Groundwater Composition	Not assigned in Rev. 0	Both duplicate analyses for any major ion falling outside the 95% C.I.s given in Table 4.2 for three consecutive sampling periods	No Change	
Creep Closure	Greater than one order of magnitude increase in closure rate.	No Change	No Change	
Extent of Deformation	Growth of 1 m/year	No Change	TV Deleted	Qualitative COMP, Not comparable to a PA parameter
Initiation of Brittle Deformation	None	No Change	No Change	
Displacement of Deformation Features	Occluded borehole	No Change	TV Deleted	Not comparable to a PA parameter

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