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Subject: Isolation of Waste from Non-Waste Regions in the SDI WIPP Configuration

A FEPs analysis was conducted as part of the salt disposal investigations (SDI) impact assessment prior to the commencement of SDI PA calculations (Kirkes 2011). The analysis performed concluded that the FEPs baseline utilized in the PABC-2009, and every WIPP PA performed prior, was also appropriate for the SDI PA. In particular, consideration of drilling intrusions into non-waste containing repository regions was screened out during the SDI FEPs analysis.

SDI Scenario Sufficiency

Four primary release mechanisms are considered in WIPP PA. The first mechanism is that of cuttings and cavings, and is the dominant release mechanism in both the SDI impact assessment (Camphouse et al 2011) and the PABC-2009 (Clayton et al 2010) for releases less than roughly 0.2 EPA units. Cuttings and cavings releases are those releases resulting from solid waste material being extracted to the ground surface during an inadvertent human drilling intrusion into the repository. If pressure is sufficiently high (≥ 10 MPa) in the waste panel at the time of intrusion, additional solid waste material in the form of spallings may also be released. The third release mechanism is that of direct brine release (DBR). DBRs are releases to the ground surface of waste material that has been dissolved in brine. Two necessary conditions must be met for a DBR to occur. First, there must be sufficient pressure (≥ 8 MPa) near the intrusion location at the time of intrusion. Second, the brine saturation of the waste in a given vector realization must be greater than the sampled residual brine saturation value for that vector. If both of these conditions (sufficient pressure and brine saturation) are not met at the time of intrusion, then a DBR cannot occur. For the SDI impact assessment, as well as the PABC-2009, cuttings and cavings releases and DBRs are the two most dominant release mechanisms. The fourth release mechanism considered in WIPP PA is that of transport releases through the Culebra, across the Land

Withdrawal Boundary. Culebra transport releases had an inconsequential contribution to total normalized releases in the PABC-2009.

By definition, transuranic waste is not emplaced in non-waste containing repository regions. Consequently, a drilling intrusion into a non-waste region will (at most) result in negligible releases due to cuttings and cavings or spallings as there is no solid waste present at the time of intrusion. Sufficient pressure and brine saturation in the non-waste region at the time of intrusion could result in a nonzero volume of brine being released to the ground surface, however. In order for this released volume of brine to be contaminated with waste, it is necessary that contaminated brine in the waste area migrate to the non-waste area prior to intrusion. Waste panels in the repository are separated from non-waste containing regions by at least one panel closure. This is also true of the SDI and PABC-2009 repository representations implemented in BRAGFLO, as seen in Figures 6-1 and 6-2 of Camphouse et al (2011). For the sake of clarity in what follows, waste areas of the SDI and PABC-2009 BRAGFLO repository representations are shown in Figure 1. Intact Salado halite, with very low permeability, lies below and above the repository subregion shown in that figure, while non-waste containing repository areas are located to the north. For waste-contaminated brine to be located in a non-waste area and then released by an intrusion in that region, it must first migrate north, out of the repository subregion shown in Figure 1.

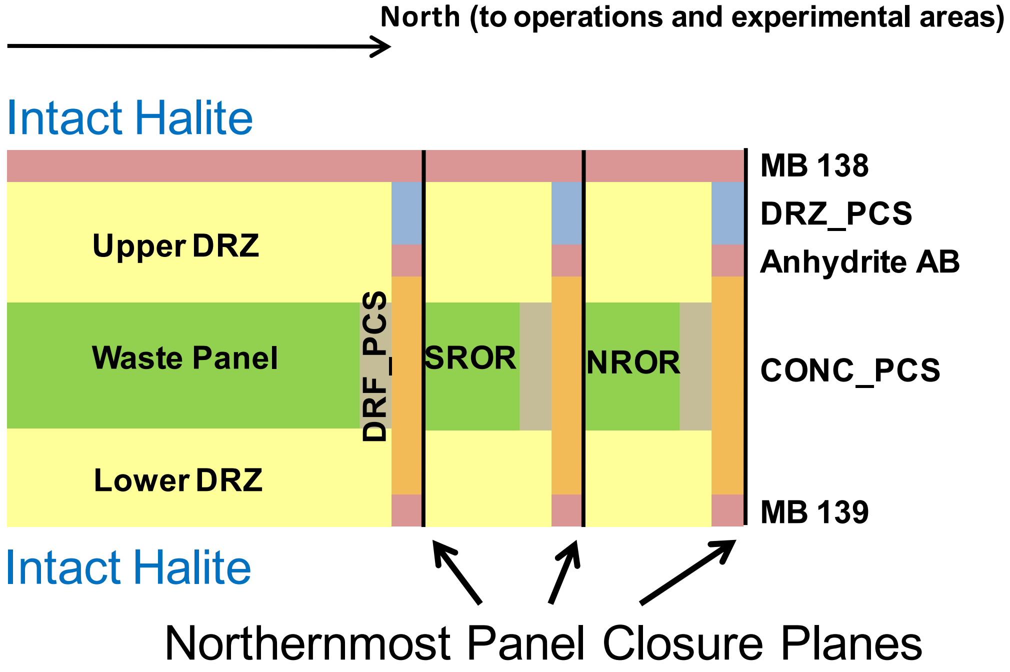

Figure 1: BRAGFLO Representation of the WIPP Waste Areas in the PABC-2009 and SDI Impact Assessment

Calculations aimed at quantifying the brine migration northward out of repository waste regions have been performed using the PABC-2009 and SDI BRAGFLO results. In particular, south-to-north brine flow rates out of the northernmost plane of each panel closure were calculated. These panel closure planes are denoted by solid black vertical lines in Figure 1, and include all repository and geologic elements between the underlying and overlaying Salado halite. Calculating the northward brine flow rates across these panel closure planes required additional post-processing of BRAGFLO results than was done previously in the SDI and PABC-2009 calculations. In particular, the input file used in the ALGEBRA post-processing routine was expanded to include calculation of northward brine flow rates. ALGEBRA was then executed, using the modified input file, on previously obtained SDI and PABC-2009 BRAGFLO results. The modified ALGEBRA input files used to obtain the results that follow are ALG2_BF_PABC09_PCS_RATES.INP and ALG2_BF_SDI_PCS_RATES.INP in CMS library LIBSDI_BF, class COMMENT_CALCS.

The volumetric brine flow rate, or flux as it is commonly referred to, is calculated over a time interval. BRAGFLO employs dynamic time-stepping during its calculations, and so the time-step used is not constant for the duration of a 10,000 year BRAGFLO simulation. As a result, flow rates are given units of m^3 in the results that follow (rather than m^3 per time length) as the time interval over which they are calculated varies during the BRAGLO calculation. For the sake of comparison, PA code SUMMARIZE was used to output brine flow rates calculated in the BRAGFLO post-processing step at common values of time. The execution of SUMMARIZE results in a comma-delimited table file for each BRAGFLO replicate and scenario. These table files were then imported into Matlab, a commercial off-the-shelf software package, for plotting purposes. Representative SUMMARIZE files used to generate tables of post-processed BRAGFLO results are PABC2009_VAR_VS_TIME.SMZ and SDI_VAR_VS_TIME.SMZ in CMS library LIBDI_BF, class COMMENT_CALCS. Matlab files used to import the generated table files are PABC09_DATA_IMPORT.M and SDI_DATA_IMPORT.M in the same library and class.

In the results that follow, south-to-north brine flow rates out of the northernmost panel closure planes are denoted by BNWPNPC (brine rate from the waste panel, northward out of the panel closure), BNSRNPC (brine rate from the south rest-of-repository, northward out of the panel closure), and BNNRNPC (brine rate from the north rest-of-repository, northward out of the panel closure). Results obtained for the brine flow rate northward out of the waste panel are shown in Figure 2 and Figure 3 for undisturbed and disturbed conditions, respectively, and contain all 300 realizations (3 replicates, 100 vectors per replicate) calculated with BRAGFLO. As is evident in Figure 2, very little brine migrates northward out of the waste panel for undisturbed conditions. For the undisturbed scenario (BRAGFLO scenario S1-BF), the northward brine flow rate for all vectors is bounded above by 2.5×10^{-7} m^3. When the waste panel undergoes an E1 intrusion at 350 years (BRAGFLO scenario S2-BF), an increase in the northward flow rate out of the panel is apparent when compared to undisturbed results. However, the northward brine flow rate for all vectors obtained remains below 2.5×10^{-7} m^3. For undisturbed or disturbed conditions, the rate of flow northward out of the waste panel is extremely small, and is on roughly the same order for both cases.

Results depicting northward brine flow rates out of the southern repository region are shown in Figure 4 and Figure 5 for undisturbed and disturbed conditions, respectively. As seen by comparing those figures, a drilling intrusion into the waste panel has essentially no impact on flow rates from the southern to northern repository waste areas. Northward flow rates from the southern repository region are essentially identical for undisturbed and disturbed conditions, and are extremely small. The same conclusion can be made regarding flow rates out of the northern repository waste region, toward the operations and experimental areas. As seen in Figure 6 and Figure 7, drilling intrusions into the waste panel have essentially no impact, with flow rates remaining virtually the same (and very small) for undisturbed and disturbed conditions.

A drilling intrusion into a non-waste containing region will result in negligible cuttings and cavings releases, negligible spallings releases, and a possible release to the ground surface (or the Culebra) of a volume of essentially uncontaminated brine. With regard to total normalized releases from the repository, this comprises a drilling intrusion of zero consequence. Moreover, as seen in the results above, WIPP panel closures are very effective at isolating the impact of intrusion to the repository region being intruded. As seen in the results shown in Figure 3, an E1 intrusion into the waste panel, and the subsequent sharp increases in brine saturation and pressure associated with that type of intrusion, does not result in a consequential increase in the rate of brine flow from the intruded panel toward other repository areas. Brine flow rates northward from the intruded panel remain on the same order as those observed in undisturbed conditions. The volume of the expanded experimental region proposed for SDI is significantly greater than that of a single waste panel. Gas generation does not occur in the experimental area. Consequently, the increase in volume of the experimental area translates to a reduction in pressure in that region. In particular, the pressure in the experimental area following an E1 (or an E1E2) intrusion in that region will be lower than that observed following an identical intrusion into a single waste panel due to the larger volume of the experimental area and lack of gas generation therein. This lower pressure will result in a reduction in the rate of brine flow from the experimental area toward other areas of the repository as compared to brine flow rates outward from an intruded waste panel. As seen in the results above, brine flow rates outward from an intruded waste panel are very small, with rates being on the same order for undisturbed and disturbed conditions. An E1 or E1E2 intrusion into a non-waste containing repository region will not have a consequential impact on other areas of the repository. The conclusions of the SDI FEPs analysis, particularly its conclusion that drilling intrusions into non-waste regions be screened out during the SDI impact assessment, are valid and justified.

Sufficiency of SDI Expansion Representation

The current WIPP performance assessment baseline is the PABC-2009, approved by the U.S. EPA on November 18, 2010 (U.S. EPA 2010). In that baseline, and every performance assessment done prior in support of regulatory compliance demonstration, the repository operations and experimental regions were assigned constant porosity and permeability properties. The property values used were developed in the original WIPP Compliance Certification Application (CCA), and have remained the same since. The SDI impact assessment quantifies the impact of an expanded repository experimental region on regulatory compliance by directly comparing SDI results to those calculated in the current baseline, namely the PABC-2009. The porosity and permeability properties specified for the operations and experimental areas in the PABC-2009 are also used in the SDI impact assessment. To capture the effects of SDI expansion of the repository experimental region, the volume of this region in the SDI repository representation was increased by over 67%. This value was derived by a direct calculation of the additional volume planned and outlined in schematics contained in the SDI work proposal (U.S. DOE 2011). This was done to match the repository representation implemented in the SDI impact assessment as closely as possible to the physical expansion planned in the experimental region.

As discussed in the SDI summary report (Camphouse et al 2011), the expansion of the experimental area results in a reduction in the mean pressure in that region. This is an expected result. Gas generation does not occur in the repository experimental area. As a result, an increased volume in this region translates directly to a reduction in pressure. This expansion effect was captured by the SDI BRAGFLO calculations. The reduced pressure in the experimental region eventually results in a reduction in the mean pressure of the waste panel. However, SDI mean northward flow rates from repository waste areas are virtually unchanged from those calculated in the PABC-2009 configuration. The overall means, calculated over all 300 vector realizations, of the northward brine flow rates shown in Figure 2 - Figure 7 are compared to PABC-2009 results in Figure 8 - Figure 13. As is evident, very good agreement is seen between the two analyses. The proposed expansion of the experimental region, and the consequent drop in pressure in that region and the waste panel in the SDI results, does not significantly change the flow of brine leaving the waste area when compared to the current baseline. This corresponds well with the SDI total normalized release results discussed in the SDI summary report. As discussed in that report, total normalized releases calculated in the SDI impact assessment are practically identical to those found in the PABC-2009. Slight pressure changes in the waste panel resulting from changes to the experimental region have at most a negligible impact on total releases. The expansion of the experimental area proposed for SDI also has a negligible impact on brine flow rates from one repository region to another. This behavior is consistent with the original FEPs screening conclusions that resulted in assigning fixed material properties for the northern part of the repository that reduced the storativity of that area. Conditions that increase the brine and gas storage capability in the northern part of the repository reduce a driving force for releases, specifically by lowering pressures. The analysis and results discussed in this memo and the SDI PA summary report provide an additional means of validating conclusions reached in the original 1995-1996 FEPS DR3 and DR7 screening exercise, and the suitability of those conclusions in regard to the proposed SDI expansion. Therefore, it is intended that the discussion contained herein sufficiently addresses the appropriateness of parameters specified for the northern part of the repository in the PABC-2009, and the use of these same parameters in the SDI impact assessment.

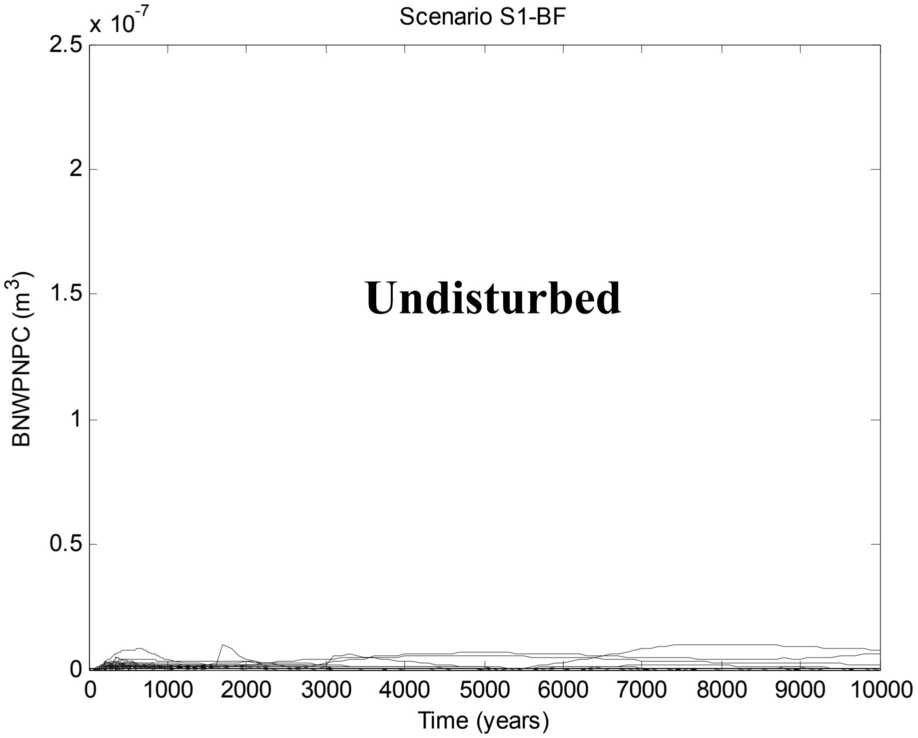

Figure 2: Brine Flow Rates from the Waste Panel, Northward out of the Panel Closure for Undisturbed Conditions

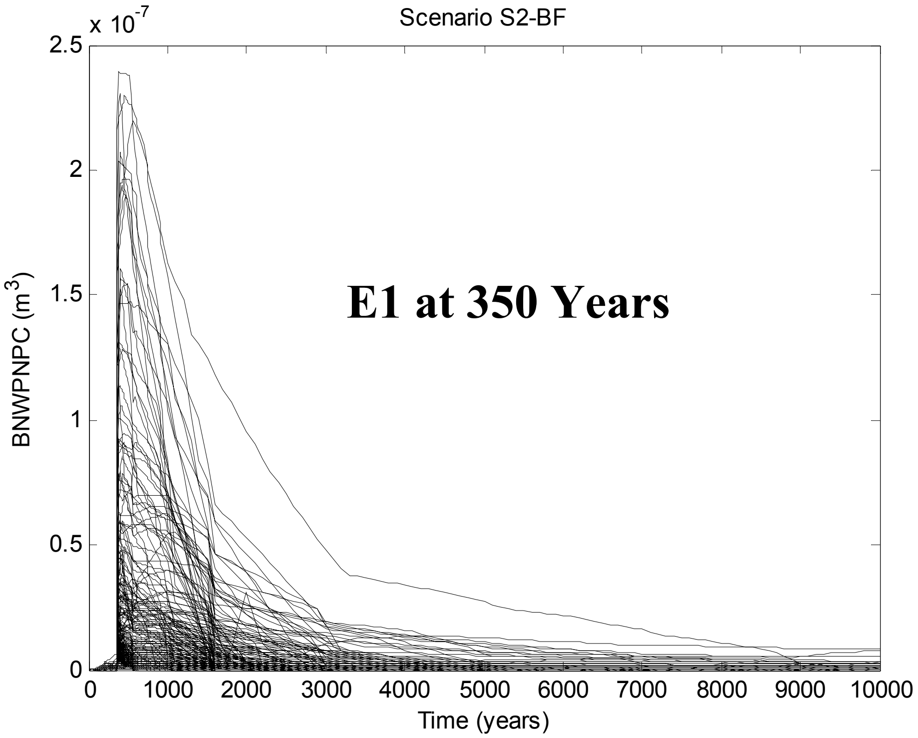

Figure 3: Brine Flow Rates from the Waste Panel, Northward out of the Panel Closure for Disturbed Conditions

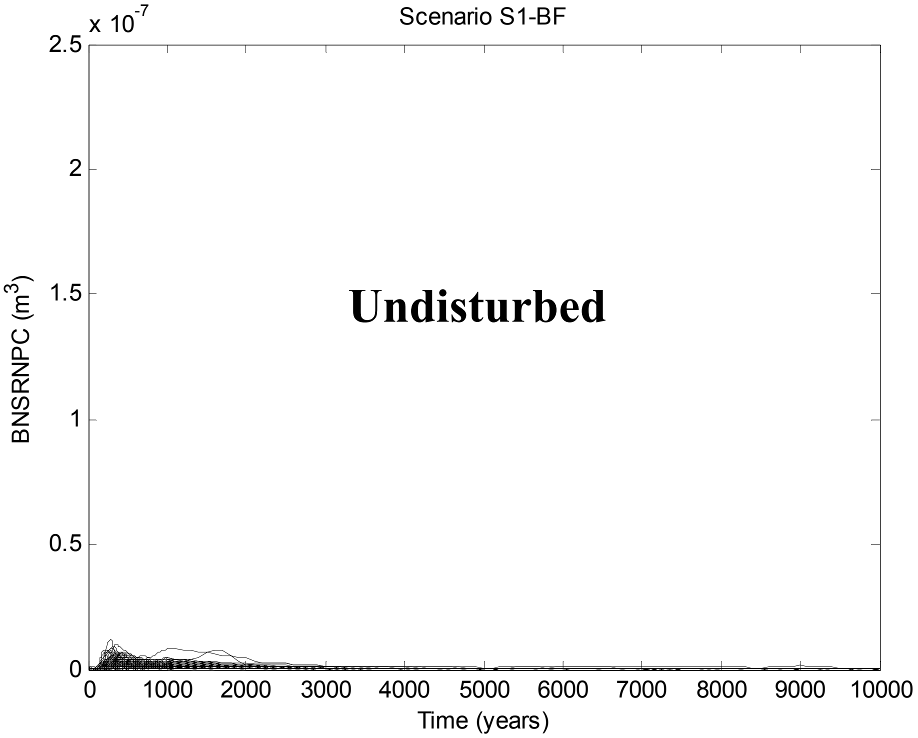

Figure 4: Brine Flow Rates Northward out of the Southern Repository Region, Undisturbed Conditions

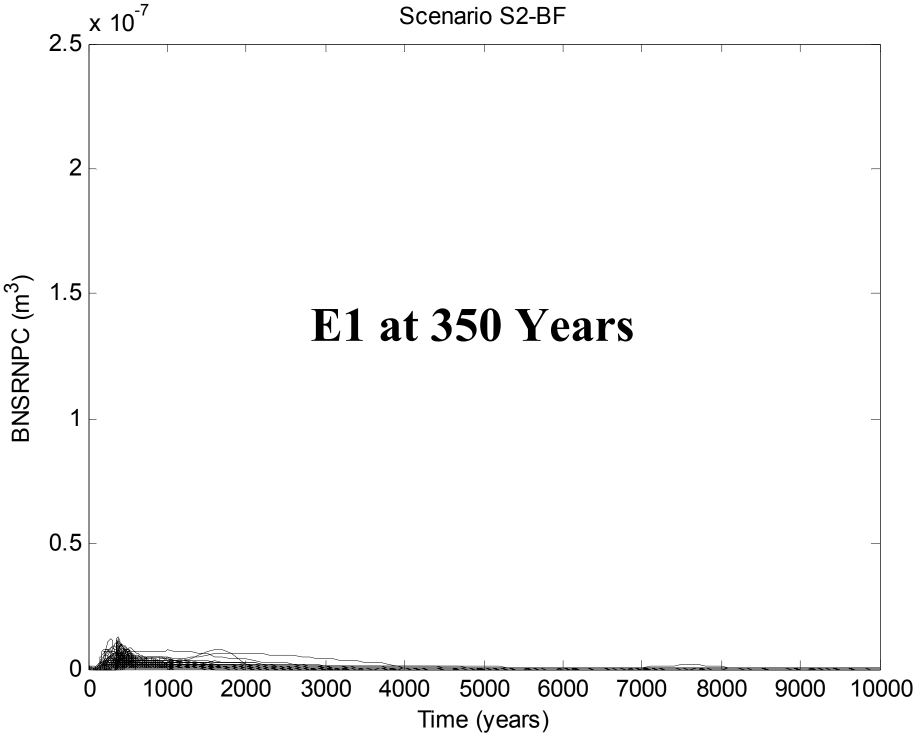

Figure 5: Brine Flow Rates Northward out of the Southern Repository Region, Disturbed Conditions

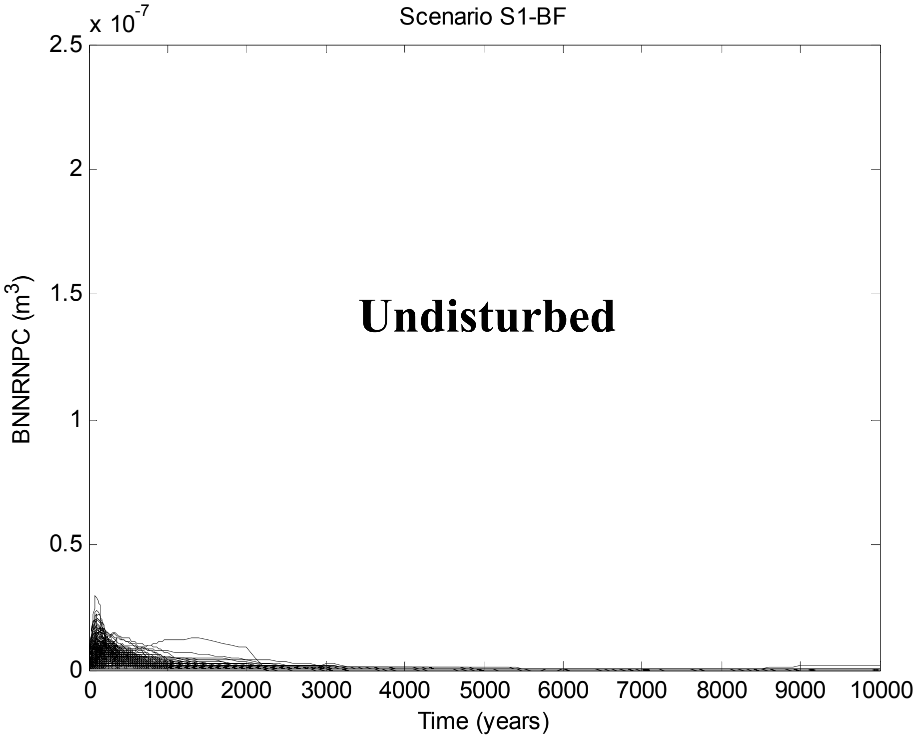

Figure 6: Brine Flow Rates Northward out of the Northern Repository Region, Undisturbed Conditions

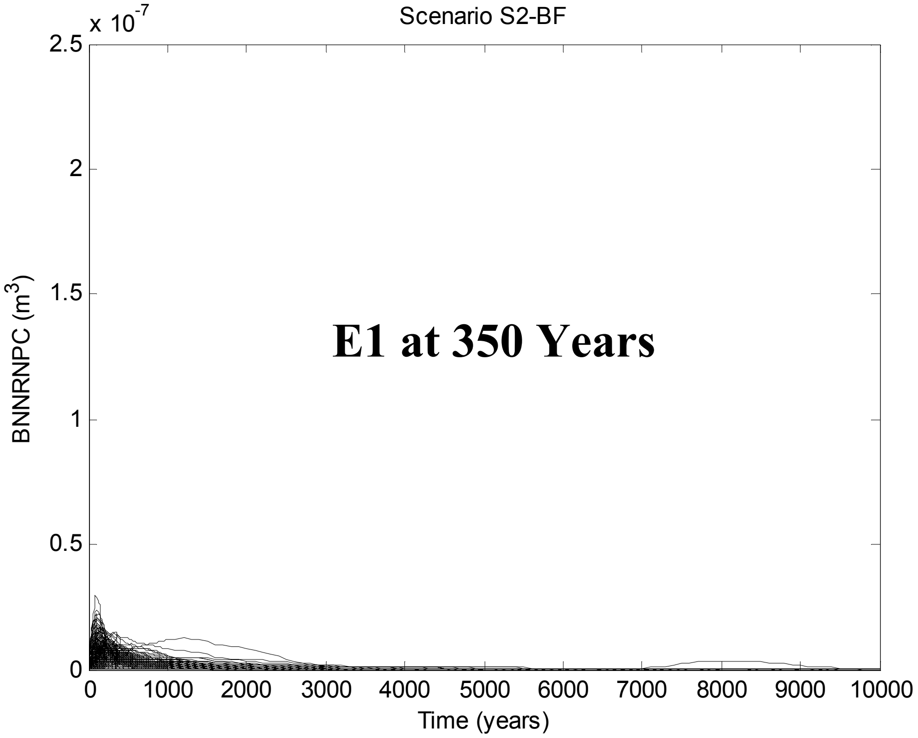

Figure 7: Brine Flow Rates Northward out of the Northern Repository Region, Disturbed Conditions

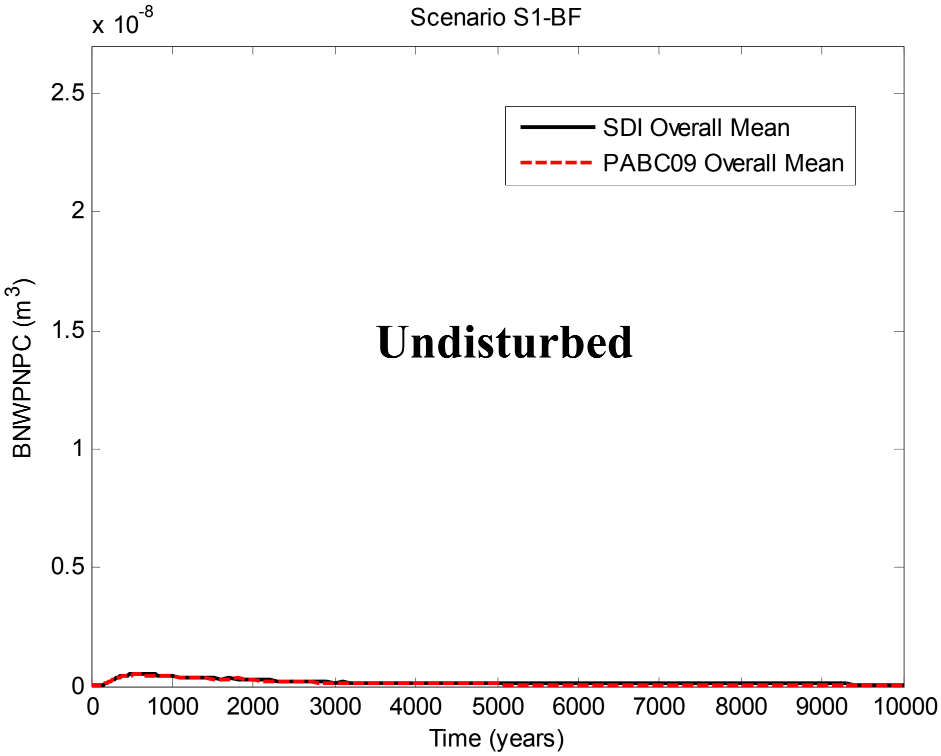

Figure 8: Comparison of Overall Mean Brine Flow Rates from the Waste Panel, Northward out of the Panel Closure for Undisturbed Conditions

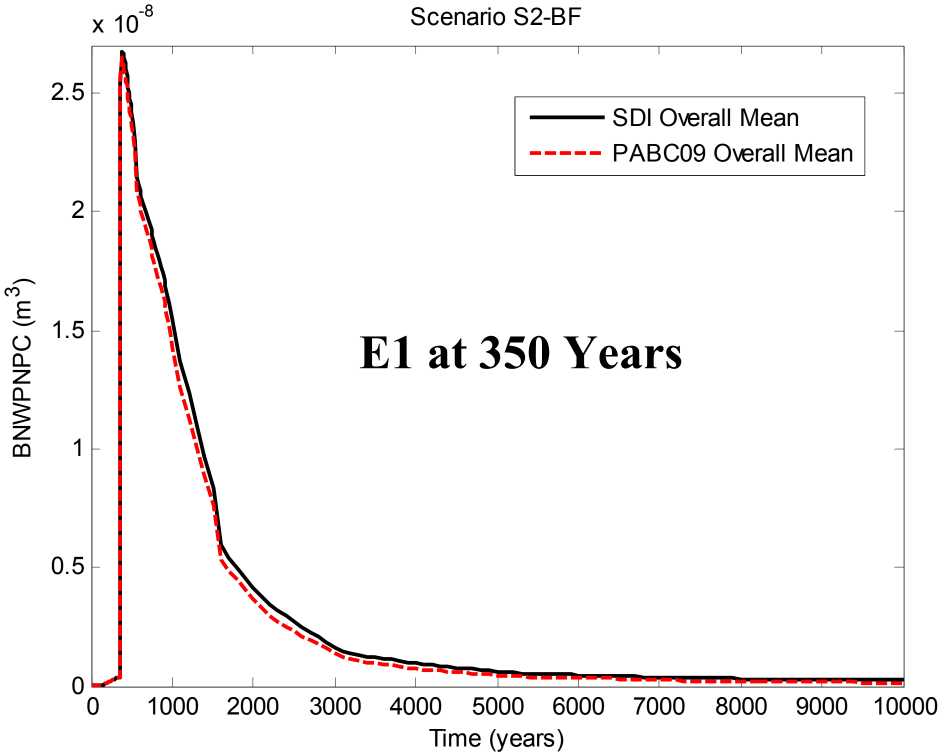

Figure 9: Comparison of Overall Mean Brine Flow Rates from the Waste Panel, Northward out of the Panel Closure for Disturbed Conditions

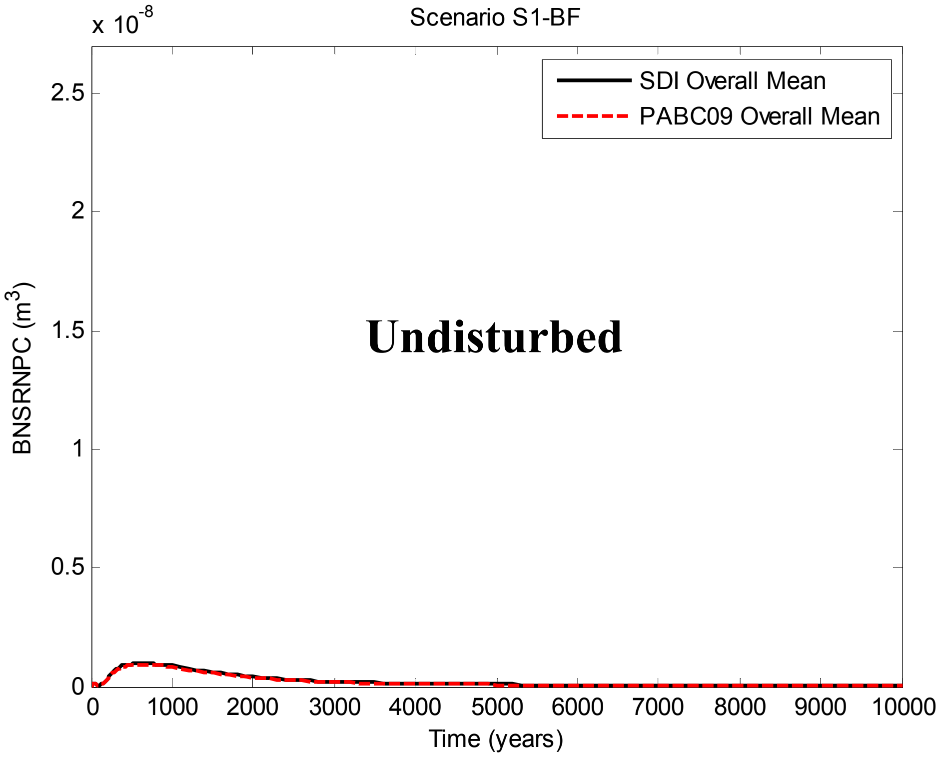

Figure 10: Comparison of Overall Mean Brine Flow Rates from the Southern Repository Region, Northward out of the Panel Closure for Undisturbed Conditions

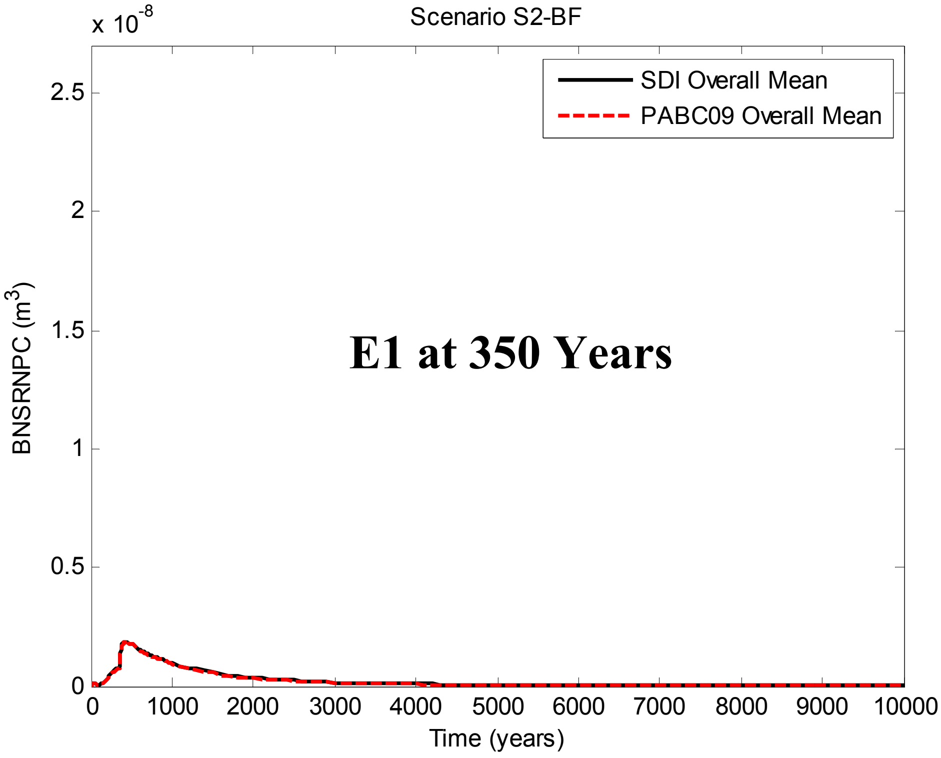

Figure 11: Comparison of Overall Mean Brine Flow Rates from the Southern Repository Region, Northward out of the Panel Closure for Disturbed Conditions

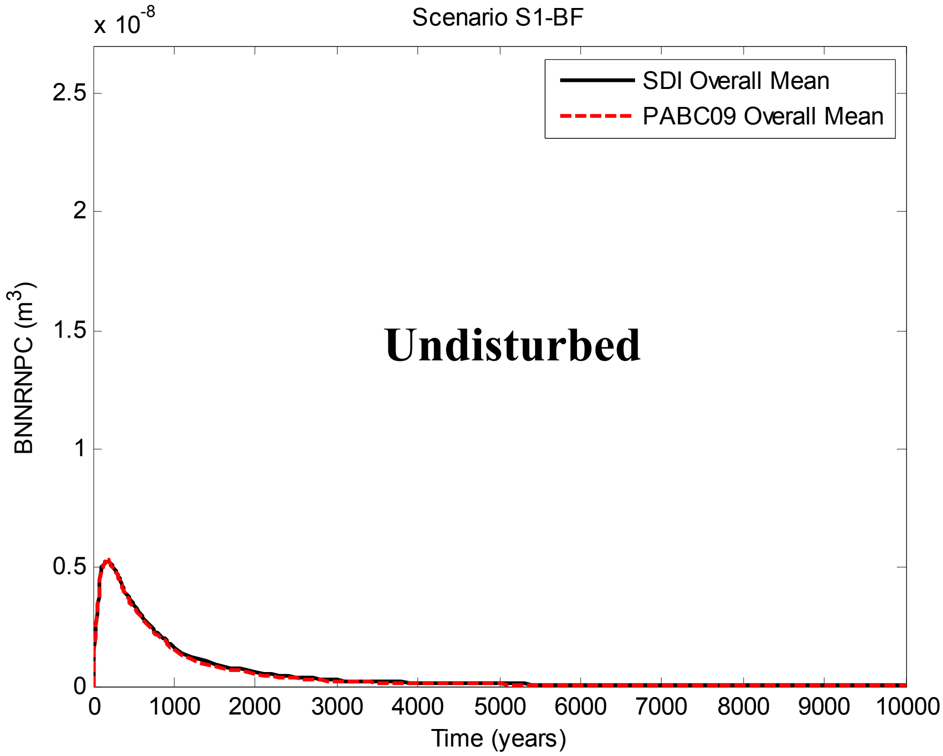

Figure 12: Comparison of Overall Mean Brine Flow Rates from the Northern Repository Region, Northward out of the Panel Closure for Undisturbed Conditions

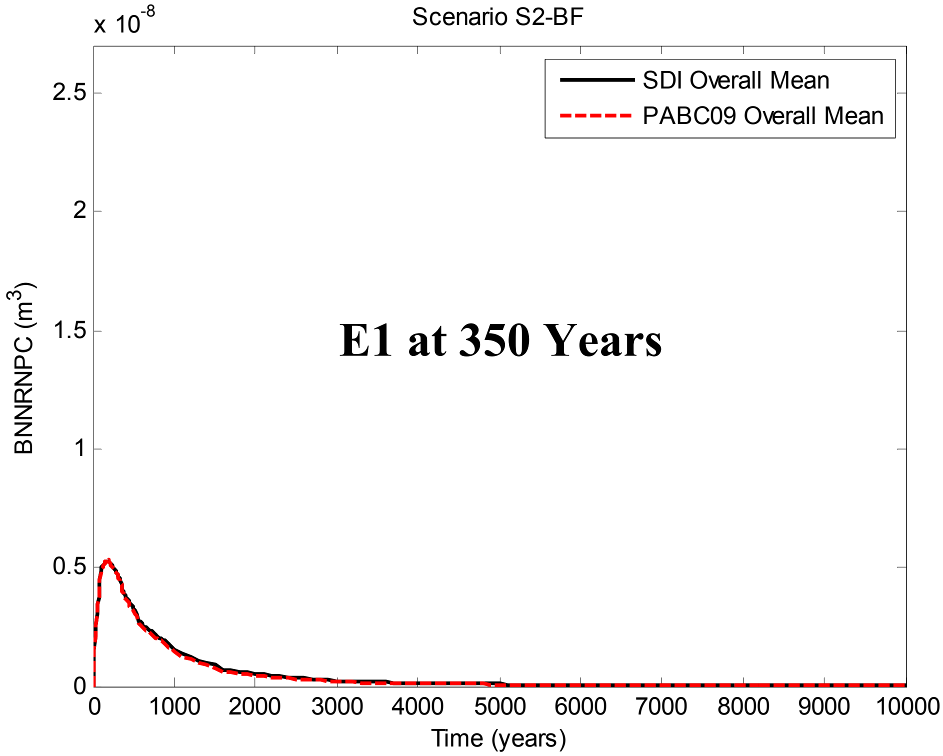

Figure 13: Comparison of Overall Mean Brine Flow Rates from the Northern Repository Region, Northward out of the Panel Closure for Disturbed Conditions

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