DR-7: PERMEABILITY VARYING WITH POROSITY IN CLOSURE REGIONS
Summary Memo of Record

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Subject: FEP Screening Issue DR-7

STATEMENT OF SCREENING DECISION

FEP Screening Issue DR-7 need not be included in future system-level performance assessment calculations.

STATEMENT OF SCREENING ISSUE

This screening effort determines if dynamic variations in permeability with porosity and consolidation should be included in future system-level performance assessment calculations. In past calculations, the dynamic effects of halite creep and room consolidation on room porosity were only modeled in the waste disposal region. In addition, the permeability of the waste disposal region was uniformly fixed at a high value so that fluid flow would not be impeded. Direct releases to the surface via cuttings and spallings depend in part on the permeability of the waste region at the time of intrusion. These direct releases were calculated conditioned on a permeability that was consistent with the porosity and degree of consolidation at the time of intrusion. The determination of this permeability was done outside of the flow field calculations and was not the same value of permeability used to estimate the flow fields.

Other portions of the repository, such as the experimental region in the north end and the hallways, have been modeled assuming fixed (invariant with time) values for both porosity and permeability. In these regions the permeability was held at a fixed high value representative of nearly unconsolidated or modestly consolidated material. The porosity in these regions was maintained at relatively low values associated with highly consolidated material. It was assumed that this combination of low porosity and high permeability would conservatively overestimate flow through these regions and minimize the capacity of these regions to store fluids, thus providing a maximized release to the environment. This assumption is evaluated.

The impact of permeability varying with porosity in all repository regions on direct releases to the surface during a drilling intrusion into the repository is also considered. Direct releases to the surface may occur during drilling due to cuttings and spallings in the drilling fluid and brine circulation from the repository to the surface in the wellbore. These releases are controlled by the prevailing pressure, permeability, and saturation conditions in the disposal room at the time of intrusion. The effect of permeability varying with porosity in repository regions which consolidate on these conditions may be important and needs to be evaluated.

APPROACH

A model for estimating the change in permeability with porosity in all repository regions (waste disposal region, north end, and hallways) was implemented in BRAGFLO. This model is described in Appendix 2 of the records package entitled "FEPs Screening Analysis for FEPs DR2, DR3, DR6, DR7, and S6". A series of BRAGFLO simulations were then performed to determine if permeability varying with porosity in all regions had the potential to enhance contaminant migration (compared to using a time invariant permeability representation of unconsolidated material) to the accessible environment. Effects of all other FEP issues were disabled in the simulations. Two basic scenarios were considered in the screening analysis, undisturbed performance and disturbed performance. Both

SWCF-A:1.1.6.3:PA:QA:TSK:DR2,DR3,DR6,DR7,S6   December 21, 1995
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scenarios included a 1.0 degree formation dip downward to the south. Intrusion event E1 is considered in the disturbed scenario and consists of a borehole that penetrates the repository and pressurized brine in the underlying Castile Formation. Two variations of intrusion event E1 are examined, E1 Up-Dip and E1 Down-Dip. In the E1 Up-Dip event the intruded panel region is located on the up-dip (north) end of the repository, whereas in the E1 Down-Dip event the intruded panel region is located on the down-dip (south) end of the repository. These two E1 events permit evaluation of the possiblity of increased brine flow into the panel region due to higher brine saturations down-dip of the borehole and the potential for subsequent impacts on contaminant migration. To incorporate the effects of uncertainty in each case (E1 Up-Dip, E1 Down-Dip, and undisturbed), a Latin hypercube sample size of 20 was used resulting in a total of sixty simulations. To assess the sensitivity of system performance on dynamic permeability in the closure regions, conditional complementary cumulative distribution functions (CCDFs) of normalized contaminated brine releases to the Culebra via human intrusion and shaft system, as well as releases to the subsurface boundary of the accessible environment, were constructed and compared to the corresponding baseline model CCDFs. In the baseline model calculations, the effects of all FEP issues were disabled. These comparisons provide direct information about how the inclusion dynamic permeability in all repository regions may influence repository performance. In addition, performance measures are examined for direct releases during drilling due to cuttings and spallings and brine circulation from the repository to the surface. Potential releases to the surface during drilling are strongly influenced by three drivers, brine pressures, brine saturations, and permeability in the waste disposal area. Spallings, cuttings, and brine releases tend to increase with an increase in each of these drivers. The exception to this trend is that at high brine saturations (or low gas saturations) brine releases tend to decrease because gas volumes become to small to maintain an appreciable gas drive (gas expansion).

RESULTS AND DISCUSSION

CCDFs for releases to the Culebra and lateral land withdrawal boundary for E1 Up-Dip, E1 Down-Dip, and undisturbed cases are provided in Figure 7 of Appendix 1. Each figure compares CCDFs of normalized releases predicted by the baseline model and normalized releases predicted with dynamic permeability. Note that releases to the Culebra via the shaft and intrusion borehole are shown on the left side of the figure whereas releases to the lateral land withdrawal boundary are presented on the right side of the figure. In all three cases (E1 Up-Dip, E1 Down-Dip, undisturbed), the varying permeability curves for releases to the Culebra are very close to the baseline curves for most of their lengths. The CCDFs for releases to the subsurface boundary of the accessible environment via the marker beds show only minor differences between the varying permeability and baseline results with the baseline CCDFs consistently above and to the right of the varying permeability CCDFs. These results are similar to those obtained in the analysis of dynamic consolidation of the north-end and hallways and can be explained in part by the fact that time-varying porosities of the north-end and hallways exceed the conservative cavity porosity (0.075) used in the baseline model for most of the 10000 yrs. This results in greater storage volume capacity and lower repository pressure. Lower pressures result in a lower driving force for release. The time-varying porosities are initially set to 1.0 and during the course of simulation they gradually decrease. For a short duration (500 to 1000 yrs), starting at around 500 yrs, cavity porosities drop slightly below 0.075 and then experience a gradual increase to values well above the value of 0.075. In summary, the reduction in permeability accompanying closure in the waste region and north-end and hallways appears to have little effect on releases to the accessible environment.

Performance measures for direct release during drilling, which include maximum, mean, medium, and minimum values of volume averaged brine pressures, brine saturations, porosity, and permeability in the waste region for undisturbed conditions at 100, 1000, and 10000 years, are given in Table 6 of Appendix 1. Comparison of these table values with the baseline values given in Table 2 indicate that brine pressures tend to be higher in the baseline case. However, the maximum, median, and mean brine saturations for varying permeability at 100 yrs are only slightly higher than the corresponding baseline values. It is also important to note that these saturations, although slightly higher than the corresponding baseline values, are small and releases to the intruding wellbore will be small because of low brine mobility at these low saturations, both in the fixed permeability baseline and dynamically varying permeability cases. This condition is further compounded by the fact that, besides pressures being less than the baseline case, the

brine pressures are well below hydrostatic pressure in the wellbore (approximately 7.8 MPa). Pressures must exceed hydrostatic pressure before direct releases up the borehole during drilling can occur (based on a hydrostatic column of drilling mud). In summary, permeability varying with closure has a negligible effect on waste room conditions relevant to releases due to adrilling intrusion.

BASIS FOR RECOMMENDED SCREENING DECISION

Based on the CCDFs, the inclusion of dynamic permeability with closure of the waste region, north-end, and hallways in BRAGFLO results in computed releases to the accessible environment that are essentially equivalent to the baseline case. In addition, dynamic permeability has an insignificant effect on waste room conditions relevant to releases during a drilling intrusion As a result, the baseline model is conservative in its treatment of closure and dynamic permeability can be eliminated from consideration in the baseline PA model.