1.0 INTRODUCTION

The conceptual model of the hydrogeology at Yucca Mountain as presented in the previous Subtask 1.4 reports remains essentially the same. As currently presented by the Department of Energy (DOE), the conceptual flow model at Yucca Mountain allows relatively large pulses of water to be transmitted through the Tiva Canyon welded unit. The model accounts for the possibility of two barriers within the unsaturated zone to divert water laterally thereby retarding it from entering the Topopah Springs welded unit. The source of the water in the unsaturated zone is from precipitation events which can be either rainfall or snowmelt at the surface of Yucca Mountain. The amount of precipitation at the Yucca Mountain Site is several orders of magnitude greater than predicted recharge. The DOE attributes the difference between the precipitation and the recharge to the following reasons:

1. Evapotranspiration,

2. Diversion of infiltration by unsaturated lateral flow, and

3. Upward (negative) water fluxes by vapor transport in the fractures of the Topopah Springs welded unit.

The amount of water flowing through the unsaturated Topopah Springs welded unit has a direct influence on whether matrix or fracture flow predominates. This flux of water thus is a primary factor in the determination of the timing and amounts of radionuclides which can be released to the accessible environment. Because of this direct relationship, the data which the DOE has utilized in the development of the conceptual model will be further described.

2.0 PRECIPITATION/INFILTRATION

Two meterological monitoring stations have been operating at Yucca Mountain since mid-1982. However, because of the short time of record keeping, the value used by the DOE for site precipitation is based on weather records from a station at Yucca Flat, located approximately 40 kilometers to the northeast of Yucca Mountain. Using a relationship for precipitation as a function of altitude, combined with data from 1964 - 1981 at the Nevada Test Site, Montazer and Wilson (1984) estimated the precipitation at Yucca Mountain to be between 138 to 166 mm/yr. Based on these values, the DOE has assumed an average value of 150 mm/yr for the site precipitation.

The DOE has indicated that large precipitation events may cause water to move past the zone influenced by evapotranspiration and become net infiltration. An overview of the 10 year climatological summary (1962-1971) for Yucca Flat indicates that such large events do occur and, therefore, may have an affect on the net infiltration. During this ten year period, the greatest monthly precipitation of 4.02 inches (102 mm) and the greatest daily precipitation of 2.13 inches (54 mm) both occurred in September, 1969. During the ten year period, 14 days each year had 0.10 inch (2.54 mm) or more of precipitation and 3 days each year had greater than 0.50 inches (12.7 mm) of precipitation. The DOE acknowledges in the Environmental Assessment (EA) "that evidence is lacking to support infiltration estimates at this time" (DOE, 1986).

3.0 RECHARGE RATE

The DOE has assumed that the average annual recharge rate can be considered approximately equal to the flux in the lower part of the unsaturated zone at Yucca Mountain. The DOE has applied the Maxey-Eakin (Wilson, 1985) method to obtain an estimate of the recharge rate at the site. The Maxey-Eakin method applies relationships that were developed among altitude, precipitation, and percentage of precipitation that infiltrates to become recharge. Using this method, Czarnecki (1984) calculated a recharge rate of 0.5 mm/yr. Czarnecki (1984) points out that the method ignores topographic slope and aspect and is suitable for obtaining only "a very approximate estimate of recharge".

Other approaches have also been used to calculate the recharge rate. Montazer (1985) estimated the flux in the repository host rock unit ranged from 0.1 to 0.5 mm/yr. A relatively constant matrix potential existed within the Topopah Spring welded unit at borehole UZ-1 and it was assumed that this indicated a unit hydraulic gradient existed in this interval (Montazer et al., 1985). At this matrix potential, the average relative permeability ranged between 0.1 to 0.5. Since the Topopah Springs welded unit was assumed to have a saturated matrix conductivity of 1 mm/yr, direct application of Darcy's law yielded an estimated flux of 0.1 to 0.5 mm/yr.

4.0 DIVERSION OF INFILTRATION

Diversion of the infiltration of water due to the contrasting properties of the nonwelded and welded units is still considered as part of the conceptual model for flow in Yucca Mountain. The potential for lateral flow is presumed to occur between:

1. The matrix of the Paintbrush nonwelded unit and the fractures of the Topopah Spring welded unit, and

2. the upper contact of the Paintbrush nonwelded unit.

However, the DOE states that "there is no direct evidence yet for permeability and capillary barriers" (DOE, 1986). Because the estimate for net infiltration in the Tiva Canyon welded unit is greater than can be accounted for by the matrix potential in the Topopah Spring welded unit, the DOE suggests that lateral flow has diverted some flux before it reaches the Topopah Springs unit.

5.0 VAPOR TRANSPORT

The DOE recognizes that the possibility of vapor transport of waste elements exists within Yucca Mountain. Only certain waste elements are presumed to be able to be transported in significant quantities in the gas phase through the unsaturated zone. The DOE considers the following gases to be potentially transportable:

1. Noble gases such as xenon, krypton, or radon,

2. Carbon as carbon dioxide,

3. Tritium as H_2 gas or as water vapor, and

4. Iodine as I_2 vapor.

Because the fission-product isotopes of xenon and krypton are stable or have a half life less than 11 years, with the exception of krypton-81, the majority of the noble gas radionuclides will decay away during the period of substantially complete containment of the waste (DOE, 1986). Tritium is also assumed to decay away during the containment period. Therefore, the two radionuclides which will be present for long periods of time and may by transported in the gas phase are carbon-14 and iodine-129. It is presumed that the likely gaseous forms of these radionuclides will be CO_2 and I_2. Both of these gases are soluble in water and, therefore, may be absorbed into the water phase retarding the transport by gas.

The transport of radionuclides in the vapor phase can occur by convection and diffusion/dispersion or by aerosols. Aerosol formation leads to water droplets containing radionuclide concentrations equivalent to what might be expected in the ground water, possibly leading to large release rates. Work performed by Smith et al., (1986) shows that, based upon the given assumptions used in their study, aerosol formation will not occur. Bounding calculations for the vapor phase transport indicate that "vapor phase transport will not be important for radionuclides such as cesium and heavier species." However, the lighter radionuclides still need further investigation as to the role they will play in the overall release scenario.

6.0 DETAILED WORK PLAN FOR NUMERICAL EVALUATION

As has been indicated in the preceding sections, the amount of water flowing through the repository horizon is strongly dependent upon the amount of surface precipitation which becomes net infiltration and the effectiveness of the lateral diversion at the presumed permeability and capillary barriers. Therefore, these issues have been targeted for further study as part of the Subtask 1.5, Numerical Evaluation of Conceptual Models. Four mini-reports are scheduled for release as part of the Subtask 1.5 update. The first two of these concentrate on the estimation and measurement techniques for vertical flux determination. The third mini-report will contain a thorough analysis of the hydrogeologic data contained in the WWL data base. The fourth mini-report explores the capillary barrier effects which may contribute to the lateral diversion of water from the repository horizon. A more detailed description of the four mini-reports is given in the following sections.

6.1 Technical Report #7 - An Overview of Recharge Estimates

The objective of this report is to provide a summary of recharge values for all types of environment around the world as reported in the literature. A detailed literature review will be performed with emphasis on, but not confined to, arid regions. The methods used to estimate recharge will be reviewed. Recharge estimates will be compared to precipitation, potential evapotranspiration, temperature and other available parameters.

6.2 Technical Report #8 - The Use of Environmental Tracers for the Estimation of Recharge: A Summary

Certain isotopes can yield information about water movement in the unsaturated zone. From this information recharge estimates can be determined. The objective of this report is to provide an overview of the chemical species, testing methods, and data analysis currently available for use at the Nevada Test Site (NTS). A detailed literature review of the types of environmental tracers, testing and monitoring procedures, and any other related information will be provided.

6.3 Technical Report #9 - Analysis of Data Available for the Evaluation of Flow and Transport at Yucca Mountain

The objective of this report is to analyze the hydrogeologic data base created under Subtask 1.2 to determine statistical information on the available matrix and fracture data. The statistical parameters obtained will then be compared to reported DOE parameters.

6.4 Technical Report #10 - Capillary Barrier Effects at Hydrogeologic Unit Interfaces in the Unsaturated Zone at Yucca Mountain

The objective of this report is to determine the extent which the differing physical properties of adjoining hydrogeologic units have as to diverting the vertical flux from the repository horizon. The analysis of the permeability and capillary barrier effects will be performed using a two-dimensional, finite element computer model.

6.5 Additional Topics

Further reports, tentatively to be issued as part of Subtask 1.5 will include:

1. The analysis of unsaturated flow and transport at Yucca Mountain using a stochastic model,
2. An overview of non-isothermal liquid and vapor transport within the unsaturated zone at Yucca Mountain, and,
3. A summary of fracture distribution and connectivity and the implications for repository siting at Yucca Mountain.
4. Effect of perched water tables on repository performance and data needs.
5. Effect of boundary conditions with respect to solute transport.
6. Effect of heterogeneity on unsaturated flow.
7. A two-dimensional (vertical) unsaturated flow model of Yucca Mountain.
8. A two-dimensional (vertical) unsaturated transport model of Yucca Mountain.
9. A two-dimensional (horizontal) saturated flow model of the Yucca Mountain region.
10. A two-dimensional (horizontal) saturated transport model of the Yucca Mountain region.
11. The significance of vapor phase transport to the repository.

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