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Hydrogeology • Mineral Resources Waste Management • Geological Engineering • Mine Hydrology

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Contract NRC-02-85-008
Fin No. D-1020
Communication No. 80

Mr. Jeff Pohle
Division of Waste Management
Mail Stop 623-SS
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Jeff:

This document constitutes a summary of the work conducted by Williams and Associates, Inc. during the first year of contract NRC-02-85-008. The work described was completed between October 1, 1985 and September 1, 1986; work conducted (reviews, proposals, and reports) is presented in chronological order. Work in progress is not described. The following description of work is presented by Task number as described in the Statement of Work in our contract.

TASK 1

The following work was conducted under Task 1.

Subtask 1.1

Williams and Associates, Inc. attended the kickoff meeting for Contract No. NRC-02-85-008, from October 22-24, 1985, in Silver Spring, Maryland.

Williams and Associates, Inc. has prepared a list of documents obtained for NNWSI. In addition, we have prepared recommendations for the addition, deletion, and/or modification of issues identified in Exhibit 1.

We have reviewed the DOE NNWSI issue hierarchy and DOE Mission Plan developed for NNWSI; our comments on the issue hierarchy approach were forwarded to the NRC as Communication No. 25.

Subtask 1.2

Williams and Associates, Inc. reviewed the following documents. Written reviews of these documents were forwarded to the NRC.

1. Peters, R.R., and others, 1984, Fracture and Matrix Hydrologic Characteristics of Tuffaceous Materials from Yucca Mountain, Nye County, Nevada: SAND84-1471, Sandia National Laboratories, Albuquerque, New Mexico and Livermore, California.

   The results of this report show the absolute necessity for determining an accurate value for the percolation rate through Yucca Mountain; the paper demonstrates the high sensitivity of the travel time calculations to the flux rate.

2. Kilbury, R.K., 1984, Water Intake at the Atmosphere-Earth Interface in a Fractured Rock System: Dept. of Hydrology and Water Resources, University of Arizona.

   This report is a topical report of the research being conducted at the University of Arizona. The final results of this research undoubtedly will be important to the NRC Waste Management Program.

3. Bixler, N.E., 1985, NORIA--A Finite Element Computer Program for Analyzing Water, Vapor, Air and Energy Transport in Porous Media: SAND84-2057, Sandia National Laboratories, Albuquerque, New Mexico and Livermore, California.

   This report is one of many computer models that are being developed to simulate multiphase flow in porous media.

4. Muller, D.C., and Kibler, J.E., 1984, Preliminary Analysis of Geophysical Logs from Drill Hole UE-25p#1, Yucca Mountain, Nye County, Nevada: USGS Open-file Report 84-649, Denver, 14 p.

   This report presented a preliminary analysis of the geophysical logs recorded in test well UE-25p#1. The data presented in the report are important with respect to the correlation of geophysical logs between test holes and wells at Yucca Mountain.

5. Barr, G.E., 1985, Reduction of the Well Test Data for Test Well USW H-1, Adjacent to Nevada Test Site, Nye County, Nevada: SAND 85-0637, Sandia National Laboratories, Albuquerque, New Mexico and Livermore, California, 36 p.

   The report does not present any new data or new interpretations of the data collected from test well USW H-1.

6. Travis, B.J., Hodson, S.W., Nuttall, H.E., Cook, T.L., Runberg, R.S., 1984, Preliminary Estimates of Water Flow and Radionuclide Transport in Yucca Mountain: NNWSI Milestone Report, Department of Energy, Nevada Operations Office.

   The report presents a preliminary conceptual model of the expected conditions in the vicinity of the repository. The report presents a preliminary analysis of water flow and radionuclide transport in Yucca Mountain.

7. Travis, B.J., 1984, TRACR3D: A Model of Flow and Transport in Porous/Fractured Media: LA-0667-MS, Los Alamos National Laboratory, Los Alamos, New Mexico.

   This report presents a discussion of one of many computer models that are being developed to simulate multiphase flow in porous media.

8. Ogard, A.E., and Kerrisk, J.F., 1984, Groundwater Chemistry Along Flow Paths between a Proposed Repository Site in the Accessible Environment: LA-10188-MS, Los Alamos National Laboratory, Los Alamos, New Mexico.

   The report presents groundwater chemistry data and interpretations of the data in the vicinity of Yucca Mountain. These data are important with respect to understanding the chemical factors that will control migration of wastes from the repository to the accessible environment.

9. Kerrisk, J.F., 1983, Reaction-Path Calculations of Ground Water Chemistry and Mineral Formation at Rainer Mesa, Nevada: LA-9912-MS, Los Alamos National Laboratory, Los Alamos, New Mexico, 41 p.

   This report presents reaction-path calculations of groundwater chemistry and mineral formation at Rainer Mesa based on a model developed by Claassen and White (1978). The report is significant with respect to understanding the precipitation of certain minerals along the reaction path.

10. Claassen, H.C. 1983. Sources and Mechanisms of Recharge for Ground Water in the West-Central Amargosa Desert, Nevada - A Geochemical Interpretation. U.S. Geological Survey, Open-File Report 83-542, Denver, 61 p.

    The report presents very significant data and interpretations with respect to conceptual models of groundwater flow in the vicinity of Yucca Mountain. The report is significant with respect to understanding the mechanisms of recharge to tuff aquifers. This document is considered to be particularly significant with respect to the development of a conceptual model of regional ground water flow in the vicinity of the NTS.

11. Eaton, R.R., Gartling, D.K., and Larson, D.E., June 1983, SAGUARO--A Finite Element Computer Program for Partially Saturated Porous Flow Problems. Sandia National Laboratories, Albuquerque, NM, SAND82-2772.

The report presents a computer program (SAGUARO) which may be useful for investigating unsaturated flux in the profile of Yucca Mountain.

12. Eaton, R.R., Martinez, M.J., Wilson, R.K., and Nunziato, J.W., July 1983, Code Development in Support of Nuclear Waste Storage Investigations for a Repository in Tuff. Sandia National Laboratories, Albuquerque, NM, SAND82-2771.

This report consists of a series of memos which were circulated through the staff at Sandia National Laboratories for the purpose of discussing the various types of models that should be developed for use in the study of water and heat flow in Yucca Mountain.

13. Freshley, M.D., Dove, F.H., and Fernandez, J.A., June 1985, Hydrologic Calculations to Evaluate Backfilling Shafts and Drifts for a Prospective Nuclear Waste Repository in Unsaturated Tuff. Sandia National Laboratories, Albuquerque, NM, SAND83-2465, PNL-5117.

The report consists of numerical simulations using the code TRUST to evaluate the effect of waste package orientation on repository performance.

14. Hadley, G.R., May 1985, PETROS--A Program for Calculating Transport of Heat, Water, Water Vapor and Air Through a Porous Material. Sandia National Laboratories, Albuquerque, NM, SAND84-0878.

The report presents a computer program (PETROS) which is a contribution toward the simulation of water vapor and heat movement in Yucca Mountain.

15. Jacobson, E.A., Freshley, M.D., and Dove, F.H., 1985, Investigations of Sensitivity and Uncertainty in Some Hydrologic Models of Yucca Mountain and Vicinity. Sandia National Laboratories, Albuquerque, NM and Livermore, CA, SAND84-7212.

The report presents hypothetical analyses of travel time in the unsaturated zone and in the saturated zone in the vicinity of Yucca Mountain. The purpose of the report was to demonstrate methods that relate uncertainty in hydrologic parameters to variations in groundwater travel time.

16. Johnson, R.L., October 1982. Thermal Analysis for a Nuclear Waste Repository in Tuff Using USW-G1 Borehole Data. Sandia National Laboratories, Albuquerque, NM, SAND82-0170.

The report describes the use of a finite element code on the cross section of an emplacement room to study heat flow produced by either spent fuel or other types of high level wastes. The report has no significance to the location of the repository in the unsaturated zone.

17. Monde, L.A., Baker, B.L., Eaton, R.L., July 1985, Vadose Water Flow Around A Backfilled Drift Located in Tuff. Sandia National Laboratories, Albuquerque, NM, SAND84-0369.

The report presents the results of use of the computer code SAGUARO for unsaturated flow around vertically emplaced waste containers beneath a drift in tuff. Modeling of unsaturated flow around a canister is the first step in the determination of flux. This determination is required for evaluation of compliance with the EPA Standard 40 CFR 191.

18. Montazer, Parviz, and Wilson, W.E., 1984, Conceptual Hydrologic Model of Flow in the Unsaturated Zone, Yucca Mountain, Nevada. U.S. Geological Survey, Water Resources Investigations Report 84-4345.

This report presents the first draft of a conceptual model for flow in the unsaturated zone at Yucca Mountain. The conceptual model has not been verified and much of it is very speculative at the present time.

19. Benson, L.V., and McKinley, P.W., 1985, Chemical Composition of Groundwater in the Yucca Mountain Area, Nevada, 1971-84. USGS Open-file Report 85-484, Denver.

The report presents basic geochemistry data for groundwater samples collected in the vicinity of Yucca Mountain. The report is significant with respect to the NRC Waste Management Program in that it presents in tabular form the chemical analyses of 25 groundwater samples collected in the vicinity of Yucca Mountain.

20. Byerlee, J., Morrow, C., and Moore, D., 1983, Permeability and Pore Fluid Chemistry of the Bullfrog Tuff in a Temperature Gradient. U.S.D.A. Geological Survey, USGS-OF-83-475.

The report presents the results of an investigation to evaluate permeability and water chemistry changes associated with water flowing through heated samples of the Bullfrog Member of the Crater Flat tuff. Data that are potentially useful are presented in this paper concerning the effect of heated water on the permeability of the porous matrix.

21. Erdal, B.R., and others, November 16, 1981, Nuclide Migration Field Experiments in Tuff, G Tunnel, Nevada Test Site. International Symposium on the Scientific Basis for Nuclear Waste Management Materials Research Society, Boston, Mass., LA-UR-81-3141.

The purpose of the report is to propose an experiment to be conducted to develop techniques for defining radionuclide migration through fractured rock. The report does not discuss research that has been conducted. The report discusses a proposed in-situ experiment in tuff at G-Tunnel.

22. Langkopf, B.S., August 1982, Thermal Analysis of Nuclear Waste Emplacement in Welded Tuff. Sandia National Laboratories, Albuquerque, NM, SAND80-2639.

The report presents a theoretical analysis of thermal conditions for a repository 300 meters below the water table. The calculations presented in the report are for a repository below the water table. Therefore, the value of the information in the report is limited.

23. Lappin, A.R., and Nimick, F.B., April 1985, Bulk and Thermal Properties of the Functional Tuffaceous Beds in Holes USW G-1, UE-25a#1, and USW G-2, Yucca Mountain, Nevada. Sandia National Laboratories, Albuquerque, NM, SAND82-1434.

This report presents a study of the thermal and mechanical properties of the zeolitized tuffs which probably will be of use in determining the structural characteristics of the repository. However, the proposed repository would not be located in the material which was investigated.

24. Martinez, M.J., January 1985, FEMTRAN-A Finite Element Computer Program for Simulating Radionuclide Transport Through Porous Media. Sandia National Laboratories, Albuquerque, NM, SAND84-0747.

The report presents the finite element code FEMTRAN for numerical simulation of two-dimensional transport of radionuclide decay chains through saturated/unsaturated adsorbing porous media. This program appears to be useful for estimating the travel time to the accessible environment if the solution for water flow velocity is available, and if the actual water travel times are large enough that the time for adsorption and decay is not significant.

25. Moore, D.E., Morrow, C.A., and Byerlee, J.D., June 1984. Changes in Permeability and Fluid Chemistry of the Topopah Spring Member of the Paintbrush Tuff (Nevada Test Site) When Held in a Temperature Gradient: Summary of Results. Lawrence Livermore National Laboratory, UCRL-15620, SANL 324-001.

The report presents results of permeability experiments that were conducted to determine the effect of heat from radioactive decay on tuffaceous rock. Information contained in the report on the effect of heating of the tuffaceous material may be of interest when the actual repository is designed.

26. Moore, D.E., Morrow, C.A., and Byerlee, J.D., 1984, Permeability and Fluid Chemistry Studies of the Topopah Spring Member of the Paintbrush Tuff, Nevada Test Site, Part II. U.S.D.I. Geological Survey, USGS-OF-84-848.

This report is an extension of work done previously by the same authors concerning the effect of heat on permeability and on the chemical composition of water flowing through samples of tuff. Some information in this report may be significant for the analysis of flow through the Topopah Spring Member.

27. Peters, R.R., Gauthier, J.H., and Dudley, A.L., 1985, The Effect of Percolation Rate on Water Travel Time in Deep, Partially Saturated Zones. Sandia National Laboratories, Albuquerque, NM, SAND85-0854C.

The results of this report show the absolute necessity for determining an accurate value for the percolation rate through Yucca Mountain; the paper demonstrates the high sensitivity of the travel time calculation to the flux rate.

28. Rechard, R.P., and Schuler, K.W., 1982, Permeability Change Near Instrumentation Holes in Jointed Rock. Sandia National Laboratories, Albuquerque, NM, SAND81-2584, 19 p.

The report presents a simplified analysis of the effects that a tangential intersection of a joint by a drill hole would have on joint permeability in the field nuclide migration experiment.

29. Sass, J.H., Lachenbruch, A.H., and Mase, C.W., 1980, Analysis of Thermal Data from Drill Holes UE25a-3 and UE25a-1, Calico Hills and Yucca Mountain, Nevada Test Site. U.S.D.I. Geological Survey, USGS-OF-80-826.

This report describes temperature profiles measured in borehole UE25a-1 in Yucca Mountain and borehole UE25a-3 in the Calico Hills stratigraphic unit. This report has been used as evidence that vapor flow may occur in the unsaturated region of Yucca Mountain. However, we do not find any support for this conclusion in the report.

30. Waddell, R.K., Robison, J.H., and Blankennagel, R.K., 1984, Hydrology of Yucca Mountain and Vicinity, Nevada-California--Investigative Results Through Mid-1983. USGS Water Resources Investigations Report 84-4267.

The report presents a summary of the results of hydrogeologic investigations conducted by the USGS in the vicinity of Yucca Mountain. The report summarizes the results of hydrogeologic investigations completed through mid-1983.

31. Daniels, J.J., Scott, J.H., and Hagstrum, J.T., 1981, Interpretation of Geophysical Well-Log Measurements in Drill Holes UE25a-1, -5, -6, and -7, Yucca Mountain, Nevada Test Site: USGS Open-File Report 81-615, 29 p.

    The report presents interpretations of geophysical logs recorded for test wells UE25a-1, UE25a-5, UE25a-6, and UE25a-7. The report is significant primarily with respect to understanding the lithology and possibly the hydrostratigraphy penetrated by the test wells.

32. Hagstrum, J.T., Daniels, J.J., and Scott, J.H., 1980, Interpretation of Geophysical Well-Log Measurements in Drill Hole UE25a-1, Nevada Test Site, Radioactive Waste Program: USGS Open-File Report 80-941, 32 p.

    The report presents interpretations of the geophysical logs recorded for test well UE25a-1. The geophysical logs are interpreted primarily with respect to the major lithologic variations. Interpretations presented in the report may be of value in the detailed evaluation of the hydrogeologic characteristics of the tuff units in the vicinity of test hole UE25a-1.

33. Healey, D.L., Clutsom, F.G., and Glover, D.A., 1984, Borehole Gravity Meter Surveys in Drill Holes USW G-3, UE-25p#1, UE25c#1, Yucca Mountain Area, Nevada: USGS Open-File Report 84-672, 16 p.

    The reports presents valuable data with respect to the density measurements of stratigraphic units penetrated by test holes USW G-3, UE-25p#1, and UE-25c#1. The borehole gravity meter may prove to be a valuable tool for use in measuring porosity and in delineating faults in the subsurface.

34. Klavetter, E.A. and Peters, R.R., 1985, Fluid Flow in a Fractured Rock Mass. Nevada Nuclear Waste Storage Investigations Project Department, Sandia National Laboratories, Albuquerque, NM.

    This report includes the most comprehensive development to date for the theory of partially saturated flow through the matrix and fractures in Yucca Mountain. The relationships developed between pressure and relative conductivity should facilitate the use of several different mathematical models for describing the magnitude of flux, and the pressure and moisture content distributions in the unsaturated zone in Yucca Mountain.

35. Ortiz, T.S. and others, 1985, A Three-Dimensional Model of Reference Thermal/Mechanical and Hydrological Stratigraphy at Yucca Mountain, Southern Nevada. Sandia National Laboratories, Albuquerque, NM, and Livermore, CA, SAND84-1076, 72 p.

    The report presents a geometric representation of the rocks at Yucca Mountain. The model is an attempt to simulate the stratigraphy in the

vicinity of Yucca Mountain based on limited data. The primary use for the model appears to be the interpolation of geologic characteristics among data points (drill holes).

36. Thompson, F.L., Dove, F.H., and Krupka, K.M., 1984, Preliminary Upper-Bound Consequence Analysis for a Waste Repository at Yucca Mountain, Nevada. Sandia National Laboratories, Albuquerque, NM, and Livermore, CA.

    The analysis presented in the report attempts to quantify a "natural" release scenario for the repository at Yucca Mountain within the limits of the data available. The report is a good example of the type of analyses that the NRC probably will have to evaluate in the future as additional data become available.

37. Walter, G.R., October 1982, Theoretical and Experimental Determination of Matrix Diffusion and Related Solute Transport Properties of Fractured Tuffs from the Nevada Test Site. Department of Hydrology and Water Resources, University of Arizona, Tucson, AZ, for Los Alamos National Laboratory, Los Alamos, NM, LA-9471-MS.

    The report investigates molecular diffusion as a mechanism for transporting dissolved substances from pores and fractures into a rock matrix. This work may be of significance to the NRC Waste Management Program because of the impact that tracer selection might have on the measurements of effective porosity for purposes of calculating groundwater travel time.

38. Carlos, B.A., 1985, Minerals in Fractures of the Unsaturated Zone from Drill Core USW G-4, Yucca Mountain, Nye County, Nevada. Los Alamos National Laboratories, Los Alamos, NM, 55 p.

    The report presents a description of the minerals present within fractures in core from test hole USW G-4. This document is significant with respect to evaluating the potential for retardation of radionuclide movement through the unsaturated zone beneath the proposed repository in Yucca Mountain.

39. Czarnecki, J.B., and Waddell, R.K., 1984, Finite Element Simulation of Ground Water Flow in the Vicinity of Yucca Mountain, Nevada-California. USGS Water Resources Investigations Report 84-4349.

    The report describes the use of a groundwater flow model and its application to the region of Yucca Mountain at the Nevada Test Site. The report is significant because detailed knowledge of the groundwater flow system is needed to determine the groundwater travel time.

40. Czarnecki, J.B., 1984, Simulated Effects of Increased Recharge on the Ground Water Flow System of Yucca Mountain and Vicinity, Nevada-California. USGS Water Resources Investigations Report 84-4344.

The report presents the results of a mathematical model used to evaluate the potential effects of possible changes in climatic conditions on the groundwater flow system at Yucca Mountain. For the adequate design of the repository it is necessary to know the effect of climatic changes on the groundwater flow systems beneath Yucca Mountain. The report presents a preliminary analysis of such changes.

41. Johnstone, J.K., Peters, R.R., and Gnirk, P.F., 1984, Unit Evaluation at Yucca Mountain, Nevada Test Site: Summary Report and Recommendation. Sandia National Laboratories, Albuquerque, NM, and Livermore, CA, SAND83-0372.

    The report is of little value to the NRC Waste Management Program with respect to a repository in the Topopah Spring Member at Yucca Mountain. The Topopah Spring Member was selected as the proposed repository horizon before the report was completed.

42. Johnstone, J.K., and Wolfsberg, K., Eds., 1980, Evaluation of Tuff as a Medium for a Nuclear Waste Repository: Interim Status Report on the Properties of Tuff. Sandia National Laboratories, SAND80-1464.

    This report describes the status of studies conducted up to 1980 pertaining to the evaluation of tuff as a medium for a nuclear waste repository. Some of the basic information presented in the report is of value to the NRC Waste Management Program.

Williams and Associates, Inc. has reviewed the following reports and document reviews by Water, Waste and Land, Inc. for Nuclear Waste Consultants, Inc.:

1. NNWSI Data Inventory and Management Report--Subtask 1.2.

2. NNWSI Conceptual Model Evaluation Report--Subtask 1.4.

3. NNWSI Numerical and Analytical Evaluations of Conceptual Models (Mini Reports 1, 2 and 3)--Subtask 1.5.

    a) Mini Report #1--Theoretical Description of Steady, Downward Flow In Layered, Fractured Porous Media.

    b) Mini Report #2--Travel Time Calculations, Yucca Mountain, Nevada.

    c) Mini Report #3--Estimates of Cumulative Radioactive Flux at Yucca Mountain, Nevada.

4. Document review of Montazer, Parviz, and Wilson, W.E., 1984, Conceptual Hydrologic Model of Flow in the Unsaturated Zone, Yucca Mountain, Nevada. U.S. Geological Survey, Water Resources Investigations Report 84-4345.

5. Document review of Wang, J.S.Y., and Narasimhan, T.N., 1985, Hydrologic Mechanisms Governing Fluid Flow in Partially Saturated, Fractured, Porous Tuff at Yucca Mountain. SAND84-7202.

6. Document review of Peters, R.R., Gauthier, J.H., and Dudley, A.L., 1985, The Effect of Percolation Rate on Water-Travel Time in Deep, Partially Saturated Zones. SAND85-0845C.

7. Document review of Klavetter, E.A., and Peters, R.R., 1985, Fluid Flow in a Fractured Rock Mass. SAND85-0855.

8. Document review of Sinnock, S., Lin, Y.T., and Brannen, 1984, Preliminary Bounds on the Expected Postclosure Performance of the Yucca Mountain Repository Site, Southern Nevada. SAND85-1492.

In addition to the aforementioned document reviews, Williams and Associates, Inc. performed the following work under Subtask 1.2.

Williams and Associates, Inc. reviewed the information pertaining to the NNWSI Exploratory Shaft as requested.

Williams and Associates, Inc. conducted a detailed review of the Final Environmental Assessment (FEA) for Yucca Mountain during the month of June, 1986. Review of the FEA consisted of the development of a major comment dealing with travel time calculations and an evaluation of DOE responses to NRC detailed comments on the draft EA.

Williams and Associates, Inc. took part in an FEA review meeting in Silver Spring, Maryland, during the week of June 15 to June 20, 1986. Most of the major comment on the Yucca Mountain FEA was completed during this meeting.

In addition to the draft EA, Williams and Associates, Inc. revisited several FEA support documents during the month of June, 1986. Several of these documents also were revisited during the FEA review meeting in Silver Spring.

Williams and Associates, Inc. reviewed the NRC comments on the Final Environmental Assessment (FEA) for Yucca Mountain. We had no changes to incorporate into the comments. The comments are technically defensible.

Subtask 1.3

Williams and Associates, Inc. completed an initial letter report of our evaluation of conceptual models for NNWSI as required by Subtask 1.3. This letter report was forwarded as Communication No. 41.

Williams and Associates, Inc. made a presentation of conceptual models of ground water flow in the saturated and unsaturated zones in the vicinity of Yucca Mountain on April 14, 1986, in Silver Spring.

Williams and Associates, Inc. forwarded a letter report (Communication No. 68) of calculations performed on the flux through Yucca Mountain. These calculations suggest that it may not be possible to estimate flux rates to the nearest 0.5 mm at the present time due to the heterogeneity of the tuffs at Yucca Mountain. The calculations suggest also that the concept of capillary barriers is not needed to explain the low saturation levels in the Topopah Springs member as suggested by Montazer and Wilson (1984).

Williams and Associates, Inc. completed a letter report of our semi-annual evaluation (update) of conceptual models for NNSWI as required by Subtask 1.3. This letter report was forwarded as Communication No. 76.

Williams and Associates, Inc. is continuing to review the literature pertaining to potential conceptual models for NNWSI. We will continue to evaluate and update existing conceptual models as new data become available.

TASK 2

The following work was conducted under Task 2.

Subtask 2.1

Williams and Associates, Inc. attended the contract kickoff meeting in Silver Spring held October 22-24, 1985. The purpose of the meeting was to familiarize the contractors with the contract organization and administration. Topics related to each media (tuff, basalt, and salt) were discussed and references were cross checked between the NRC and Williams and Associates, Inc. The trip report was forwarded as Communication #3.

Williams and Associates, Inc. completed a review of past interactions between the NRC and DOE. These interactions were reviewed with respect to their relevance to the issues. Our review of the issues was forwarded as Communication #17. The BWIP document list was revised and updated. The document list was included with the review of the issues.

We reviewed the issue hierarchy approach developed for NNWSI; this issue approach was reviewed with respect to its applicability to the BWIP site. Our comments on the issue hierarchy approach were forwarded to the NRC as Communication No. 25.

Subtask 2.2

Williams and Associates, Inc. generated a list of topics that should be addressed during the review of a technical document (Communication #5). This communication also lists four suggested categories for cataloging technical documents.

Williams and Associates, Inc. reviewed several documents for the BWIP site. Documents reviewed include:

1. Stone, R., Rogers, P.M., Jackson, R.L., Lu, A.H., and Moak, D.J., October 1984, Strategy and Preliminary Plans for Large-Scale Hydraulic Stress Testing of Selected Hydrogeologic Units at the RRL-2 Location. Rockwell Hanford Operations.

   This revisit of the aforementioned document was conducted in anticipation of the NRC/DOE workshop scheduled for December 9, 1985. This document is important because it outlines the strategy and test plans for the first large-scale hydraulic stress test at the BWIP site. The first test is planned for the RRL-2 location.

2. Stone, R., Lu, A.H., Rogers, P.H., and Bryce, R.W., November 1985, Test Plan for Multiple-Well Hydraulic Testing of Selected Hydrogeologic Units at the RRL-2 Site, Basalt Waste Isolation Project, Reference Repository Location. Rockwell Hanford Operations, SD-BWI-TP-040.

   This document outlines the revised test strategy for the first large-scale multiple well hydraulic stress test at the BWIP site. The document outlines both the hydraulic stress test procedures and a concurrent tracer test planned for the test horizon. This document constitutes the most recent effort at producing a test plan document (August 28, 1986).

3. Rockwell Hanford Operations, December 7, 1984, Exploratory Shaft Test Plan, Volume I: Exploratory Shaft Test Program. SD-BWI-TP-007, 256 p., and

   Rockwell Hanford Operations, December 7, 1985, Exploratory Shaft Test Plan, Volume II: Preliminary Test Description. SD-BWI-TP-007, 569 p.

   The two-volume test plan outlines the proposed in-situ tests that will be conducted from the Phase I shaft and the underground facilities. Underground testing will be conducted from the test drifts after completion of the second shaft. Test data will be collected for geological, hydrogeological, and geomechanical characterization. This document is important because it constitutes the current thinking with respect to in-situ testing from the test facility in the interior of a basalt flow.

4. Spane, F.A. Jr. and Mercer, R.B., 1985, HEADCO: A Program for Converting Observed Water Levels and Pressure Measurements to Formation Pressure and Standard Hydraulic Head. Rockwell Hanford Operations, RHO-BW-ST-71 P.

   The document presents a program (HEADCO) for converting static water level and pressure measurements to formation pressure and "standard" hydraulic head. The conversions take into account variable fluid density based primarily upon in-situ temperatures. Variable fluid densities create difficulties in interpreting hydraulic gradients and directions of groundwater flow.

5. Jackson, R.L., Diediker, L.D., Ledgerwood, R.K., and Veatch, M.D., July 1984, Piezometer Completion Report for Borehole Cluster Sites DC-19,DC-20 and DC-22. Rockwell Hanford Operations, RHO-BWI-TI-226, 379 p.

   This document describes the design and installation of the multi-piezometers at three locations designated DC-19, DC-20, and DC-22. The multi-level piezometers monitor different vertical horizons at a cluster well location. Nine hydrogeologic units are monitored in the Columbia River Basalt Group extending from the basal Ringold sediments down to the Umtanum flow top. This report is important because it describes the first installations at the site that are capable of obtaining hydraulic head data over extended periods of time.

6. Spane, F.A., Jr., March 1986, Preliminary Evaluation of Piezometer Responses at DC-19, DC-20, and DC-22, During Construction of DC-23W. Rockwell Hanford Operations, Richland, WA, SD-BWI-TI-313.

   The document describes the water level and pressure responses at the Referenced Repository Location piezometer sites DC-19, DC-20, and DC-22. Dr. Spane examined the record over a four-month period (August through November 1985). The hydraulic responses were evaluated with respect to construction activities at DC-23W and the major earthquake that occurred in Mexico on September 19, 1985. This report is significant because it represents the first attempt by Rockwell Hanford Operations to interpret the long-term hydraulic head data that have been collected at the DC-19, DC-20, and DC-22 cluster sites.

7. Clifton, P.M., January 1986, Groundwater Travel Time Analysis for the Reference Repository Location at the Hanford Site. Rockwell Hanford Operations, SD-BWI-TI-303.

   The document reports the results of a study that expands earlier work conducted by Clifton and others (1984) regarding the prediction of groundwater travel times in the deep basalt sequence beneath the Hanford site. The results are compared to a DOE travel time criteria. The report presents a stochastic framework which allows a probability of occurrence to be associated with the predicted travel times. This document is important because Rockwell Hanford Operations has led all

the sites in the use of stochastic analyses for predicting groundwater travel time.

Williams and Associates, Inc. conducted a detailed review of the Final Environmental Assessment (FEA) for BWIP. Review of the FEA consisted of the development of a major comment dealing with travel time calculations and an evaluation of DOE responses to NRC detailed comments on the draft EA. Williams and Associates, Inc. took part in a FEA review meeting in Silver Spring during the week of June 15 to June 20, 1986. A major comment on the BWIP FEA was outlined during this meeting. A final version of the travel time comment was completed and forwarded to the NRC as Communication #65. In addition to the draft EA, Williams and Associates, Inc. revisited several FEA support documents. Several of these documents also were revisited during the FEA review meeting in Silver Spring. Detailed review comment sheets on the FEA were forwarded to the NRC as Communication #67.

Williams and Associates, Inc. reviewed the major comment prepared by the NRC on the Final Environmental Assessment (FEA) for BWIP. We suggested that one change be made in the comment; this change was conveyed to Mr. Coleman by phone.

A BWIP workshop was held December 9, 10, and 11, 1985, in Richland, Washington. A pre-meeting was held December 5 in Richland. We created a list of discussion topics (Communication #8) for this meeting. A trip report was forwarded as Communication #15. Additional comments on the meeting were forwarded as Communication #16.

We reviewed the head data that was available for the BWIP site (January 1986). We reviewed the changes in gradient and direction of groundwater flow at the BWIP site per instructions received from the NRC. We forwarded a letter report as Communication #29.

We submitted a proposal to investigate the hydraulic gradient relationships evident from the analysis of data from borehole clusters DC-19, DC-20, and DC-22. This proposal was submitted as Communication #48. This investigation was initiated recently.

Subtask 2.3

Williams and Associates, Inc. completed a letter report (Communication #46) on conceptual models. We reviewed the existing concepts regarding groundwater flow at the BWIP site; these concepts were evaluated based upon the water level data collected in the multi-piezometer clusters (DC-19, DC-20, and DC-22). Our concepts of ground water flow in the basalt have been revised based on the additional water level data presented during the DOE/NRC consultation meeting held December 1985. The water level perturbations created by pulling the bridge plugs at borehole RRL-14 and by

drilling borehole DC-23W provided additional insight into the conceptual model(s) of groundwater flow.

Williams and Associates, Inc. is continuing to review the literature pertaining to potential conceptual models for BWIP. We will evaluate and update existing conceptual models as new data become available.

TASK 3

The following work was conducted under Task 3.

Subtask 3.1

Williams and Associates, Inc. attended the contract kickoff meeting in Silver Spring held October 22-24, 1985. The purpose of the meeting was to familiarize the contractors with the contract organization and administration. Topics related to each media (tuff, basalt, and salt) were discussed and references were cross checked between the NRC and Williams and Associates, Inc. The trip report was forwarded as Communication #3.

The issues for the three salt sites were reviewed. Our comments were submitted to the NRC as Communication #22. An updated list of documents was included; the list contains all references in our files for the Palo Duro Basin, the Paradox Basin, the salt domes (Vacherie, Richton, and Cypress Creek), and a generic category for relevant documents not site-related.

We reviewed the issue hierarchy approach developed for NNWSI. Our comments on the issue hierarchy approach were forwarded to you as Communication #25.

On November 19, 20, and 21, 1985, key personnel of Williams and Associates, Inc. attended a joint DOE-NRC workshop on the status of geologic investigations for the salt repository program in Columbus, Ohio. The workshop provided considerable insight on the current level of knowledge on the detailed structure and stratigraphy of the Palo Duro Basin and on related problems and limitations. These knowledge limitations have significant impact on the development of accurate conceptual groundwater flow models for the basin. A trip report was forwarded as Communication #14.

Subtask 3.2

Williams and Associates, Inc. reviewed several technical reports as part of the site familiarization process. The reports reviewed are:

1. Wyatt, A.W., Bell, A.E., and Morrison, S., May 1977, Analytical Study of the Ogallala Aquifer in Deaf Smith County, Texas. Texas Water Development Board, Report No. 213.

This report describes the groundwater depletion of the High Plains aquifer. The report is basically nontechnical in nature but it does in a quantitative sense assess the amount of water level decline occurring in the High Plains aquifer. This report is important because it quantifies the depletion which is important for site characterization activities which demand a potable water supply.

2. Orr, E.D. and Kreitler, C.W., April 1985, Interpretation of Pressure-Depth Data from Confined Underpressured Aquifers Exemplified by the Deep-Basin Brine Aquifer, Palo Duro Basin, Texas. Water Resources Research, vol. 21, no. 4.

The report summarizes the efforts by the Texas Bureau of Economic Geology to interpret the pressure-depth data from the confined groundwater flow systems found in the Palo Duro Basin. The data were analyzed and areas were designated for potential downward, parallel, and upward flow in the "Deep Basin Brine Aquifer".

3. Kaiser, W.R., 1985, Cross-formational Flow in the Palo Duro Basin, Texas Panhandle: Texas Bureau of Economic Geology, Austin, Texas, OF-WTWI-1985-33.

The report compiles and collates a position based on various pieces of information regarding the movement of groundwater through the evaporite sequence in the Palo Duro Basin. The report cites evidence derived from head distributions, numerical modeling, water chemistry, isotopic data, and core analyses to support a finding that there is little vertical flow through the evaporite sequence. This report is important because it is the first attempt at comprehensively describing the potential movement of groundwater through the evaporite sequence.

4. Orr, E.E., and Senger, R.K., 1984, Vertical Hydraulic Conductivity, Flux and Flow in the Deep-Basin Brine Aquifer, Palo Duro Basin, Texas: Texas Bureau of Economic Geology, Austin, Texas, OF-WTWI-1984-44, 19 p.

The report examines fluid potential distribution in the "Deep Basin Brine Aquifer" in the Palo Duro Basin. The report deals specifically with evaluation of vertical fluid potentials and the resultant gradients with respect to the possibility of cross-formational flow in various locations within the Palo Duro Basin.

5. Senger, Rainer K., 1984, Hydrodynamic Development of the Palo Duro Basin and Other Mechanisms Creating Possible Transient Flow Conditions: Texas Bureau of Economic Geology, Austin, Texas, OF-WTWI-1984-54.

The report describes the investigation of transient flow conditions that were modeled to identify possible flow patterns that could result from changing hydrogeologic conditions with time. The report describes simulations of steady state hydrodynamic conditions prior to uplift of the basin, during uplift and tilting of the basin, and during deposition of the Ogalalla Formation. The report investigates the possible effects created by the erosion of the Pecos River Valley and the westward retreat of the caprock escarpment. The possible effect of hydrocarbon production is simulated also.

6. Dutton, A.R., Fisher, R.S., Richter, B.C., and Smith, D.A. 1985. Hydrologic Testing in the Salt-Dissolution Zone of the Palo Duro Basin, Texas Panhandle. Texas Bureau of Economic Geology, Austin, Texas, OF-WTWI-1985-3.

   The report summarizes data collected at the Sawyer #2 and Mansfield #2 wells. The wells were constructed to conduct hydrogeologic testing in the salt-dissolution zone of the Palo Duro Basin. The report is important because it contains data collected from the wells constructed by the Department of Energy for the Waste Storage Program.

7. Parizek, R., Mink, L., Domenico, P., and Robertson, J. July 1985. Report of the Panel on Evaluation of Ground-Water Flow in Fractures at the Palo Duro Basin. Transmittal letter from J. Tracy to T. Naymik.

   The document presents a summary of the basic information generated by a panel convened to discuss groundwater flow in the Palo Duro Basin. The report concluded that the most probable flow path should be considered as a porous media flow path through the sedimentary strata. The panel believes that the porous media flow paths and resultant travel times should be evaluated stochastically.

8. Conti, R.D. and Senger, R.K. 1985. Hydrostratigraphy of the Wolfcamp Aquifer, Palo Duro Basin, Texas Panhandle. Texas Bureau of Economic Geology, Austin, Texas, OF-WTWI-1985-38.

   The report presents a methodology for delineating hydrostratigraphic units in the Palo Duro Basin. The methodology delineates the distribution of porosity and permeability within the strata of the Wolfcamp Series that lies below the evaporite sequence. The methodology uses data derived from drill cuttings, sample logs, core logs, porosity-log cross plots, and empirical porosity-permeability relationships. The report constitutes a significant contribution to the definition of hydrostratigraphic units in the Palo Duro Basin.

9. Conti, R.D., Herron, M.J., Senger, R.K., and Wirojanagud, P. 1985. Stratigraphy and Influence of Porosity on Ground-Water Flow in the Wolfcamp Brine Aquifer, Palo Duro Basin, Texas Panhandle. Texas Bureau of Economic Geology, Austin, Texas, OF-WTWI-1985-19.

The report describes the lithology of the Wolfcamp strata in the Palo Duro Basin. The role of tectonics and sedimentation are described with respect to the development of the Palo Duro Basin. Geophysical log data are used to determine the distribution of porosity in the Wolfcampian Series and the Brown Dolomite. The neutron-density log responses are cross-plotted with porosity values obtained from laboratory analyses of core. The results of the study are used as an indicator of petroleum reservoir potential. The results also are used to enhance the calculation of groundwater travel time through the Palo Duro Basin.

10. Senger, R.F. and Fogg, G.E. 1984. Modeling of the Effects of Regional Hydrostratigraphy and Topography on Ground-Water Flow, Palo Duro Basin, Texas. Texas Bureau of Economic Geology, Austin, Texas, OF-WTWI-1984-32.

    The report discusses a cross sectional groundwater flow model of the Palo Duro Basin. The model was constructed to analyze available hydrogeologic data and to better understand the causes of underpressuring below the evaporite aquitard. The report also discusses the mechanisms of recharge and discharge to and from the "Deep-Basin Brine Aquifer."

11. Bair, E.S., O'Donnell, T.P., and Picking, L.W. 1985. Hydrogeologic Investigations Based on Drill-Stem Test Data: Palo Duro Basin Area, Texas and New Mexico. Office of Nuclear Waste Isolation, Technical Report, BMI/ONWI-566.

    The report presents potentiometric surface maps for the aquifers associated with the Wolfcamp Series and Pennsylvanian System in the Palo Duro Basin of Texas and New Mexico. The report assumes the existence of one homogeneous aquifer in each of the two stratigraphic sequences. Drill stem test data were selected and used to produce initial potentiometric surface maps. Two more sets of maps were produced following extensive data culling procedures. The culling procedures supposedly removed overpressured and underpressured data which are a reflection of other than steady state flow conditions.

12. Senger, Rainer K., 1985, Investigation of the Possible Effect of Fracture Zones on Ground-Water Flow in the Palo Duro Basin, West Texas: Texas Bureau of Economic Geology, Austin, Texas, OF-WTWI-1985-36.

    The report uses a numerical model to assess theoretically the possible effects of fracture flow on the hydrodynamics of the Palo Duro Basin. The report outlines both geologic and hydrogeologic evidence for the existence of fracture flow in the basin. The implications of fracture flow and the hydrodynamics of the basin are investigated using a two-dimensional cross sectional model. The report concludes that if a distinct fracture zone through the evaporite aquitard existed it would

have a significant effect on the overall hydrodynamics of the basin if the fracture zone is located near the caprock escarpment. A distinct fracture zone located in the central part of the basin would have much less effect on the regional potentiometric surface.

13. Andrews, R.W., Kelley, V.A., McNeish, J.A., LaVenue, A.M., Campbell, J.E., November 1985, Travel Path/Travel Time Uncertainties at Salt Sites Proposed for High Level Waste Repositories. INTERA Technologies, Inc., Austin, TX, ONWI/E512-02900/TR-36.

    A two-dimensional simulation model is used in the travel path/time analysis. Porous media flow is assumed to control groundwater flow. Several analyses are conducted for fracture zone related flow. The two-dimensional model is used to stochastically predict groundwater travel times. The predicted travel paths are highly dependent upon the vertical gradients and the permeabilities assigned to the geologic units. This report is important because it represents the first attempt at stochastically predicting groundwater travel time at the salt sites.

14. Orr, E.D., 1984, Investigation of Underpressuring in the Deep-Basin Brine Aquifer, Palo Duro Basin, Using Pressure/Depth Profiles. Texas Bureau of Economic Geology, Austin, TX, OF-WTWI-1984-6.

    The report analyzes problems in the use of pressure versus depth relationships, including terminology confusion, pressure versus depth data quality, and the effects of hydrologic setting and data distribution. The analysis is applied to pressure versus depth relationships for the "Deep-Basin Brine Aquifer" in the Palo Duro Basin of Texas. The report divides the basin into seventeen assumed homogeneous subareas. Each subarea is used in the application of a model to evaluate aquifer pressure conditions. The report addresses underpressure, hydrostatically pressured, and overpressured conditions in the basin.

15. Thompson, B.M., Campbell, J.E., and Longsine, D.E., November 1985, PTRACK A Particle Tracking Program for Evaluating Travel Path/Travel Time Uncertainties. INTERA Technologies, Inc., Austin, TX, ONWI-E512-02900/CD-27.

    The report describes PTRACK, a computer program that simulates the path of a radionuclide particle released from a nuclear waste repository into a groundwater flow system in a two-dimensional stratified hydrogeologic medium. The program calculates the travel time required for a particle to move from the release point to a specified horizontal or vertical boundary. Repeated trials using PTRACK reflect the effects of parameter variations on travel paths/travel times. This report is important because this report, in conjunction with reference no. 13, constitute the first attempt to stochastically predict groundwater travel times at the salt sites.

16. Smith, Andy, and Orr, E.D., December 1982, Use of Kriging to Estimate the Wolfcampian and San Andres Potentiometric Surfaces,, Palo Duro Basin, Texas Panhandle. Texas Bureau of Economic Geology, University of Texas, Austin, TX, OF-WTWI-1982-3.

    The report applies kriging, a statistical approach, to potentiometric data for the Palo Duro Basin. Kriging was used to estimate the groundwater potentiometric surfaces of the San Andres Cycle 4 dolomite and of the so-called "Wolfcampian Aquifer." Kriging was used to interpret a regional potentiometric surface for both the San Andres Formation and the Wolfcampian Series rocks. The report is significant because it represents a geostatistical approach to the interpretation of potentiometric data in the Palo Duro Basin.

17. Dutton, A.R., and Orr, E.D., 1984, Geostatistical Analysis of Potentiometric Surface of the San Andres Formation, Texas Panhandle. Texas Bureau of Economic Geology, Austin, TX, OF-WTWI-1984-22.

    The report describes a further effort to study the potentiometric surface of the San Andres Formation. The report uses a single variogram model for the data set. The variogram is used in conjunction with block kriging to determine the direction of groundwater flow in the San Andres Formation in the Palo Duro Basin area.

18. Smith, D.A., Akhter, S., and Kreitler, C.W., 1985, Ground-Water Hydraulics of the Deep-Basin Aquifer System, Palo Duro Basin, Texas Panhandle. Texas Bureau of Economic Geology, Austin, TX, OF-WTWI-1985-16.

    The document compiles the most recently available information as required for predicting groundwater travel times in the Palo Duro Basin. The report outlines methods that have been used during the DOE well testing program. The report summarizes permeability data and geophysical log analyses that were used to a great extent for evaluating the distribution of porosity. The report also describes methods used to estimate the potentiometric surfaces of the "Deep-Basin Brine Aquifer."

19. Harper, W.V., and Furr, J.M., April 1986, Geostatistical Analysis of Potentiometric Data in the Wolfcamp Aquifer of the Palo Duro Basin, Texas. Office of Nuclear Waste Isolation, Columbus, OH, BMI/ONWI-587.

    The report uses kriging to estimate the potentiometric surface of the Wolfcamp Aquifer in the Palo Duro Basin. The report addresses the uncertainty in estimating the potentiometric surface. The geostatistical techniques result in the ability to identify those data that do not fit a general pattern exhibited by the rest of the data. This report is important because it represents the most technically

sound report reviewed to date which geostatistically analyses potentiometric data in the Palo Duro Basin.

20. The Earth Technology Corporation, March 1985, Regional Ground-Water Flow Near Richton and Cypress Creek Domes, Mississippi: Annual Status Report for Fiscal Year 1984, Contract No. E512-05700 under Contract DE-AC02-83CH10140 with U.S. Department of Energy.

    The report presents the status on work being conducted in the vicinity of Richton and Cypress Creek Domes located in Mississippi. The conceptual and numerical models of regional groundwater flow in the vicinity of the domes have been refined based on a detailed review and evaluation of available hydrogeologic and hydrologic data. A three-dimensional finite element program was used for the modeling. This report is important because it represents the latest efforts at regional groundwater flow modeling in the vicinity of the Mississippi salt domes.

21. Wirojanagud, P., Kreitler, C.W., and Smith, D.A., 1985, Numerical Modeling of Regional Ground-Water Flow in the Deep-Basin Aquifers of the Palo Duro Basin, Texas Panhandle. Texas Bureau of Economic Geology, Open-File Report, OF-WTWI-1984-8, Revision 1, 37 p.

    The report describes the finite element, steady state two-dimensional model of an aquifer in the Palo Duro Basin. Two sets of simulations were run. One set used the Wolfcamp rocks as a single aquifer. The second set uses the Permian and Pennsylvanian rocks as a single aquifer termed the Deep-Basin Brine Aquifer. The report determined that head values in the Wolfcamp rocks are most closely approximated by a vertical permeability value of 8×10^{-5} md for the aquitard. The modeling effort results in conclusions based on limited field data. The conclusions are a reflection of current thinking and modeling efforts on the permeability of the evaporite aquitard.

22. Senger, R.K. and Richter, B.C., 1983, Identification of Recharge-Discharge Areas of the Palo Duro Basin, Texas Panhandle. Texas Bureau of Economic Geology, Open-File Report, OF-WTWI-1983-4.

    The report presents preliminary results in the research effort identifying recharge and discharge areas of major aquifers in the Palo Duro Basin. The report is important because recharge and discharge areas are required in order to define groundwater flow systems in both conceptual and numerical model approaches. Isotopic and hydrochemical data were reviewed in the report.

23. Wilton, D.E., and Picking, L.W., July 1985, Analysis of Pumping Test Data, Sawyer No. 1 and Mansfield No. 1 Wells. Prepared by Stone and Webster Engineering Corporation for Battelle Memorial Institute, Interim Topical Report ONWI/SUB/85/E512-05000-T39, 119 p.

The report is an interim report used to "manifest the methodology developed, analyze the data, and to present the preliminary results of analyses from Sawyer No. 1 and Mansfield No. 1." The report outlines numerical simulation and type curve comparison techniques used to analyze pumping test data from test zones in the two aforementioned wells. The report is important because it outlines the test procedures which will be used in the DOE test wells in the Palo Duro Basin.

24. Bair, E.S., June 1985, Hydrodynamic Investigations in the Texas Panhandle Area. Report prepared by Stone and Webster Engineering Corporation for Battelle Memorial Institute, Topical Report, ONWI/SUB/85/E512-05000-T42, 68 p.

    This report describes the hydrodynamic relationships between major aquifers and the evaporite and shale aquitard in the Palo Duro Basin. A primary direction of the report is in determining the direction of groundwater flow as indicated by hydraulic gradients in the host rock and in the shale and evaporite aquitard.

25. Conti, R.D., Senger, R.K., Wiroganagud, P., and Herron, M.J., 1984, Wolfcampian Series Porosity Distribution: Implications for Deep-Basin Ground-Water Flow in the Palo Duro Basin, Texas Panhandle. Texas Bureau of Economic Geology, Austin, TX (Revision 1), OF-WTWI-1984-33.

    The report presents an advanced use of borehole geophysical logs to estimate the porosity of the Wolfcampian Series rock in the Palo Duro Basin. Standard cross plotting techniques are used in conjunction with neutron density logs and neutron sonic logs for quantitative determinations of porosity and lithology. Porosity distributions are derived for the volumetric estimation of porosity in the Wolfcampian Series. The porosity distributions are used to estimate exchange rates for groundwater flow in the deep basin groundwater flow system.

26. Senger, R.K., Fogg, G.E., and Kreitler, C.W., 1985, Effects of Hydrostratigraphy and Basin Development on Hydrodynamics of the Palo Duro Basin, Texas. Texas Bureau of Economic Geology, Austin, TX, OF-WTWI-1985-37.

    The report describes the results of a two-dimensional groundwater flow model study of the Palo Duro Basin. A cross sectional model was constructed to characterize regional groundwater flow paths and to investigate the causes of underpressuring and flow through the evaporite aquitard. The model also was used to study the mechanisms of recharge and discharge to and from the deep basin brine aquifer.

Williams and Associates, Inc. conducted a detailed review of the Final Environmental Assessments (FEA's) for Deaf Smith, Davis Canyon, and Richton Dome. Our review of the FEA resulted in the development of a major comment for each site dealing with travel time calculations. We reviewed the FEA for DOE responses to NRC detailed comments on the draft EA. Williams and

Associates, Inc. took part in an FEA review meeting in Silver Spring, Maryland, during the week of June 15 to June 20, 1986. A draft of the major comment on the Deaf Smith, Davis Canyon and Richton Dome FEA's was completed during this meeting. In addition to the draft EA, Williams and Associates, Inc. revisited several FEA support documents.

Williams and Associates, Inc. reviewed the comments prepared by the NRC on the Final Environmental Assessments (FEA's) for the SALT sites (Palo Duro Basin, Paradox Basin, and Richton Dome). Suggested changes to the comments were conveyed to Mr. Ross by phone.

Subtask 3.3

Williams and Associates, Inc. evaluated the conceptual groundwater flow models we developed under contract NRC-02-83-033. We considered the implications of those documents we have reviewed that reflect on the conceptual models of groundwater flow in the Palo Duro Basin. A letter report was forwarded as Communication #51. We have not seen any new information on the Paradox Basin or the salt dome sites that warrants altering our views (Contract NRC-02-83-033) on the conceptual models for these sites. We believe that our conceptual models on the Paradox Basin and salt dome sites are still valid.

Williams and Associates, Inc. continues to review the literature pertaining to potential conceptual models for the Palo Duro Basin. We will continue to evaluate and update existing conceptual models as new data become available.

TASK 4

This task has not been initiated. We are accumulating relevant documents during the course of our other activities under Tasks 1, 2, and 3.

TASK 5

Williams and Associates, Inc. attended the contract kickoff meeting in Silver Spring held October 22-24, 1985. The purpose of the meeting was to familiarize the contractors with the contract organization and administration. Topics related to each media (tuff, basalt, and salt) were discussed and references were cross checked between the NRC and Williams and Associates, Inc. The trip report was forwarded as Communication #3.

Williams and Associates, Inc. submitted Communication No. 2 (in October) to the NRC requesting further consideration of a proposal initially submitted under the previous contract. This request presents additional information pertaining to the determination of effective porosity from field data. Effective porosity is a parameter required for calculating groundwater velocities and travel times.

Williams and Associates, Inc. reviewed two generic technical position papers as Communication #12. These papers are entitled "Draft Generic Technical Position on Groundwater Travel Time (GWTT)" and "Draft Generic Technical Position: Interpretation and Identification of the Extent of the Disturbed Zone in the High-Level Waste Rule (10 CFR 60)."

Williams and Associates, Inc. attended two pre-meetings (December 5 and December 8, 1985) in Richland, Washington, prior to the DOE/NRC consultation meeting (December 9-11, 1985). Dr. Williams, Dr. Ralston, and Mr. Winter attended these meetings. The meetings are described in our trip report (Communication #15). We prepared several detailed comments that are based on the information we gained at the consultation meeting and site visit. The detailed comments were forwarded as Communication #16. Available water level data and pertinent documents were reviewed prior to attending these meetings.

Dr. Bloomsburg attended the Unsaturated Rock/Contaminant Transport Workshop #3, sponsored by the University of Arizona, Nuclear Regulatory Commission and Sandia National Laboratories on January 6-9, 1986. A trip report was forwarded to the NRC as Communication No. 20.

Dr. Williams attended the Waste Management Conference held in Tucson, Arizona; the topic of the conference was radioactive waste disposal. A trip report was not required. Dr. Williams reviewed the paper presented by Dr. Codell at this conference. Dr. Williams' comments on the paper have been forwarded to Dr. Codell.

Williams and Associates, Inc. attended a two-day (April 14 and 15, 1986) NRC meeting in Silver Spring. The company was represented by Dr. Williams, Dr. Ralston, Dr. Osiensky, Dr. Sharp, Dr. Parizek, and Mr. Winter. Our trip report was forwarded to the NRC as Communication #49.

Williams and Associates, Inc. prepared two papers for the NRC. The first paper defines "uncertainty" with respect to hydrogeologic considerations and prediction of groundwater travel times. The second paper presents our views on the relationship of scale, hydrogeologic parameter quantification, and prediction of groundwater travel time.

Williams and Associates, Inc. have reviewed the Yakima Indian Nation comments on the "Draft Generic Technical Position on Groundwater Travel Time." This was an informal review for our information.

Sincerely,

Roy E. Williams

Roy E. Williams

REW:sl