U.S GEOLOGICAL SURVEY - YUCCA MOUNTAIN PROJECT BRANCH

1997 MILESTONE REPORT SP24CBM3

Preliminary Saturated-Zone Flow Model

by

John B. Czarnecki

PREFACE

This model is being submitted to the U.S. Department of Energy (DOE) to fulfill Level 3 Milestone SP24CBM3: *Site Saturated-Zone Flow Model*, in Summary Account OG33133FB3, Planning and Scheduling Account (PACS) 1.2.3.3.1.3.3, Site Saturated Zone Flow Model. This milestone consists of an updated 3-Dimensional Site Saturated-Zone Groundwater Flow Model. Included in the deliverable are directions for accessing the electronic media containing the executable code as of 6/10/97 (version number 97-06-10-sun4, qualified status), and model inputs and outputs in the format required by FEHMN, via FTP. The accompanying text includes discussions of the major features of the model, the features of FEHMN that were determined to be important to simulation of the saturated-zone flow system in the absence of repository heat, and a discussion of how closely the model calibration outputs match field observations.

The milestone required extensive coordination among Dr. Czarnecki and personnel at Los Alamos National Laboratory to ensure fulfillment of the milestone criteria described in the PACS Participant Planning Sheet. As a guide for reviewers, Table A has been prepared to indicate which sections of the deliverable meet particular milestone description/completion criteria. The completion criteria determined the overall scope of the deliverable. This package is considered, in terms of the criteria requirements in PACS, to be the final product that meets the definition of the deliverable.

The flow model has received two YMP-USGS technical reviews, by Claudia Faunt of the USGS, and Bill Arnold of Sandia National Laboratory. These reviews have been conducted and documented in accordance with the requirements of Quality Management Procedure YMP-USGS-QMP-3.04, R9. All data used as sources or for comparison during the development of the model are identified in Table B, Source Data/Information Table. The data are identified by the Automated Technical Data Tracking system (ATDT) Data Tracking Numbers (DTN) and/or

Records Information System Record Accession (RA) numbers where applicable. Data sources are clearly labeled as qualified (Q) or non-qualified (non-Q) based on the ATDT system. The data are either in the public domain (existing or non-YMP data) or else have been or are in the process of being released by the YMP-USGS Technical Project Officer in compliance with YMP-USGS-QMP-3.04. Non-qualified data from non-YMP sources that have been published in the public domain outside of the Yucca Mountain Project have been identified as being widely accepted and used throughout the scientific community.

Table A. Description/completion acceptance criteria and location summary for U.S. Department of Energy Level 3 Milestone SP24CBM3 - Site Saturated-Zone Flow Model

CRITERIA		TEXT LOCATION
TECHNICAL REQUIREMENTS		
A.	This milestone will consist of an updated 3-Dimensional Saturated-Zone Groundwater Flow Model. It will consist primarily of electronic media with minimal supporting paper documents.	Page 1
B.	Electronic media will consist of an executable version of the model code as of 4/30/97. *(LANL is responsible for FEHMN and will do the QA verification and validation of the code.)*	Page 23
C.	Electronic media will also contain model inputs in the format required by FEHMN.	Pages 21-23
D.	Those features of FEHMN that [were] determined to be important to simulation of the SZ flow system in the absence of repository heat will be incorporated into this deliverable.	Pages 1-5
E.	Electronic media also will contain model outputs in the format generated by FEHMN. Model output will represent the state of calibration as of April 1997 which is projected to be close to the final calibration with information available through February 1997.	Pages 21-23
F.	Supporting paper documents will identify the version of FEHMN that the executable code represents, the latest version of the User's Manual from LANL, and the QA status of the version of the code.	version: 97-06-10-sun4 User's Documentation: Release 1.0 Q Status: Released, "Q"
G.	The major features of the model that were selected will be identified.	Pages 1-5
H.	An index of the files containing model inputs will b e supplied with the paper documents.	Pages 21-23

TECHNICAL REQUIREMENTS		
I.	A short discussion about the status of model calibration as of 4/30/97 will be included. The discussion will indicate how closely the model outputs match field observations. The discussion will also indicate if ir would be productive to continue calibration.	Pages 3-7
J.	The model will be consistent with the three-dimensional site geologic model but will extend beyond the area of the geologic model.	Page 1
K.	The model will incorporate information obtained from testing of WT-series boreholes, the C-hole complex, borehole USW G-2, and other boreholes as appropriate through February 1997.	Page 7
L.	The model will incorporate the most plausible explanation for the large hydraulic gradient based on data available through February 1997 and simulations through April 1997.	Page 3
REGULATORY REQUIREMENTS		
A.	The Q status of data used or cited in the report shall be appropriately noted.	Table B
B.	Stratigraphic nomenclature cited in the deliverable shall be consistent with the Reference Base Section 1.12(a), "Stratigraphy: Geologic/Lithologic Stratigraphy"	Appendix A
C.	Within the reports reference section, references to data used in the report shall include Accession Numbers or Data Tracking Numbers when available.	Table B
D.	Technical Data contained within the deliverable and not already incorporated in GENESIS shall be submitted for incorporation in accordance with YAP-SIII.3Q	Table B, and attached TDB transmittal memoranda
E.	The deliverable will be submitted to YMSCO in accordance with YAP-5.1Q.	Transmittal Memorandum

TABLE B: Source Data Table for Milestone SP24CBM3, "Site-Saturated Zone Flow Model"

TITLE OF SOURCE	DATA TRACKING NUMBER ACCESSION NUMBER	Q STATUS	TDB STATUS
Direct Data Sources:			
Ciesnik, M.S., 1995, Ground-water altitudes and well data, Nye County, Nevada, and Inyo County, California: USGS OFR 93-89	GS931008312132.004 MOL.19940908.0078	Non-Q	Submitted 3/25/94
LaCamera, R.J, and Westenberg, C.L., Selected ground-water data for the Yucca Mountain Region, Southern Nevada and Eastern California, through December 1992: USGS OFR 94-54	GS931100121347.007 MOL.19941006.0012 MOL.19960531.0138 MOL.19960531.0611	Non-Q	Submitted 1/23/96
Hale, G.S, and Westenberg, C.L., Selected ground-water data for Yucca Mountain Region, Southern Nevada and Eastern California, Calendar Year 1993: USGS OFR 95-158	GS940900121347.002 MOL.19951003.0426 MOL.19960214.0317 MOL.19960214.0320 - .0321	Non-Q	Submitted 5/6/96
Graves, R.P., and Goemaat, R.L., Water levels in the Yucca Mountain area, Nevada, 1995: **DRAFT** USGS OFR 97-101	GS970208312312.002 report in process	Non-Q	Report in process. Not submitted to the TDB yet. All source data have been submitted.
Graves, R.P, Tucci, P., and O'Brien, G.M., Analysis of water-level data in the Yucca Mountain area, Nevada, 1985-1995: **DRAFT** USGS WRIR 96-4256	GS960908312312.010 report in process	Non-Q	Report in process. Not submitted to the TDB yet. All source data have been submitted.

TITLE OF SOURCE	DATA TRACKING NUMBER ACCESSION NUMBER	Q STATUS	TDB STATUS
Data Package:Water-level altitude data from the Periodic Network, first quater 1995	GS950408312312.003 MOL.19951219.0132 - .0133 MOL.19960531.0044	Non-Q	Submitted 6/23/95
Data Package: Water-level altitude data from the Periodic Network, third quarter 1995	GS951108312312.010 MOL.19960315.0141 MOL.19960327.0366	Non-Q	Submitted 11/20/95
Data Package: Water-level altitude data from the periodic Network, July through December, 1996	GS970108312312.001 MOL.19970610.0645	Non-Q	Submitted 2/6/97
Data Package: Water-level altitude data collected by the Water Resources Monitoring Program, 12/12/96 - 12/18/96 and 3/14/96 (GEXA Well 4); and water-level altitude data collected by YMP-USGS SCP at USW G-4 on 1/26/90	GS970600121347.001 in process	Non-Q	Data Package in process; to be submitted to the TDB by 7/15/97
Data Sources Used for Comparison Purposes Only: Reports			
Anderson, L.A., 1981, Rock property analysis of core samples from the Yucca Mountain UE25a-1 borehole, Nevada Test Site, Nevada: USGS OFR 81-1338.	GS930408314213.006 NNA.19870406.0031	Non-Q	Submitted 1/14/88
Anderson, L.A., 1994, Water permeability and related rock properties measured on core samples from the Yucca Mountain USW GU-3/G-3 and USW G-4 boreholes, Nevada Test Site, Nevada: USGS OFR 92-201.	GS931108314213.010 MOL.19950117.0143	Non-Q	Submitted 9/7/94

TITLE OF SOURCE	DATA TRACKING NUMBER ACCESSION NUMBER	Q STATUS	TDB STATUS
Craig, R.W., and Robison, J.H., 1984, Geohydrology of rocks penetrated by test well UE25p#1, Yucca Mountain, Nevada: USGS WRIR 84-4248.	GS920408312314.009 NNA.19890905.0209	Non-Q	Submitted 4/27/87
Craig, R.W., and Reed, R.L., 1991, Geohydrology of rocks penetrated by test well USW H-6, Yucca Mountain, Nye County, Nevada: USGS WRIR 89-4025.	GS911108312313.009 NNA.19900615.0030	Non-Q	Submitted 5/12/95
Czarnecki, J.B., 1990, Geohydrology and evapotranspiration at Franklin Lake Playa, Inyo County, California: USGS OFR 90-356.	GS950508312134.001 MOL.19960229.0032	Non-Q	Submitted 7/14/95
D'Agnese, F.A, Faunt, C.C., Turner, A.K., and Hill, M.C, 1996, Hydrogeologic evaluation and numerical simulation of the Death Valley regional ground-water flow system, Nevada and California, using Geoscientific Information Systems: USGS WRIR 96-4300.	GS960808312144.003 MOL.19970206.0203	Non-Q	not data contained "within the deliverable;" to be submitted to the TDB by 7/31/97
Flint, L.E., and Flint, A.L., 1990, Preliminary permeability and water-retention data for nonwelded and bedded tuff samples, Yucca Mountain, area, Nye County, Nevada: USGS OFR 90-569.	GS920108312231.001 NNA.19920417.0018	Non-Q	Submitted 3/8/94
Geldon, A.L., 1993, Preliminary hydrogeologic assessment of boreholes UE-25c#1, UE-25c#2, and UE-25c#3, Yucca Mountain, Nye County, Nevada: unpublished USGS WRIR 92-4016.	GS930308312313.002 NNA.19930112.0130	Non-Q	Submitted via USGS GP-1001: TDIF DTN GS920108314213.001

TITLE OF SOURCE	DATA TRACKING NUMBER ACCESSION NUMBER	Q STATUS	TDB STATUS
Lahoud, R.R., Lobmeyer, D.H., and Whitfield, M.S., Jr., 1984, Geohydrology of volcanic tuff penetrated by test well UE-25b#1, Yucca Mountain, Nevada: USGS WRIR 84-4253.	GS920408312314.013 NNA.19890511.0117	Non-Q	Submitted 4/24/87
Lobmeyer, D.H., 1986, Geohydrology of rocks penetrated by USW G-4, Yucca Mountain, Nevada: USGS WRIR 86-4015.	GS930408312132.005 NNA.19890918.0510	Non-Q	Submitted 4/5/88
Luckey and others, 1996, Status of understanding of the saturated-zone ground-water flow system at Yucca Mountain, Nevada as of 1995: USGS WRIR 96-4077	GS950808312331.001 MOL.19970513.0209 MOL.19970513.0213	Non-Q	Applicable sections submitted to the TDB as part of this deliverable
O'Brien, G.M., 1997, Analysis of aquifer tests conducted in boreholes USW WT-10, UE-25 WT #12, and USW SD-7, 1995-96, Yucca Mountain, Nevada: USGS WRIR 96-4293.	GS960708312312.007 Backlog	Q	All source data submitted to the TDB under TDIF DTNs GS951108312312.011, GS960308312312.004, and GS960108312312.002
O'Brien, G.M., in press, Analysis of aquifer tests conducted in borehole USW G-2, 1996, Yucca Mountain, Nevada: **DRAFT** USGS WRIR	TDIF not assigned yet	Q	Source data have been submitted to the TDB under TDIF DTNs GS960508312312.006 and GS970208312312.003

TITLE OF SOURCE	DATA TRACKING NUMBER ACCESSION NUMBER	Q STATUS	TDB STATUS
Robison, J.H., and Craig, R.W., 1991, Geohydrology of rocks penetrated by test well USW H-5, Yucca Mountain, Nye County, Nevada: USGS WRIR 88-4168.	GS910908312313.007 NNA.19900110.0400	Non-Q	Not a TDB candidate. Data went forward with OFR 83-853
Rush, F.E., Thordarson, W., and Pyles, D.G., 1984, Geohydrology of test well USW H-1, Yucca Mountain, Nevada: USGS WRIR 84-4032.	GS920408312314.011 NNA.19870518.0067	Non-Q	Submitted 8/21/87
Thordarson, W., 1983, Geohydrologic data and test results from well J-13, Nevada Test Site: USGS WRIR 83-4171.	GS930408312132.007 NNA.19870518.0071	Non-Q	Submitted 4/22/87
Thordarson, W., Rush, F.E., and Waddell, S.J., 1985, Geohydrology of test well USW H-3, Yucca Mountain, Nye County, Nevada: USGS WRIR 84-4272.	GS920408312314.004 NNA.19870407.0318	Non-Q	Submitted 4/7/87
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 WRIR 84-4267.	GS930108312132.001 NNA.19900618.0074	Non-Q	Submitted 6/1/87
Weeks, E.P., and Wilson, W.E., 1984, Preliminary evaluation of hydrologic properties of cores of unsaturated tuff, test well USW H-1, Yucca Mountain, Nevada: USGS WRIR 84-4193.	GS920508312231.015 NNA.19870407.0037	Non-Q	Submitted 4/24/87

TITLE OF SOURCE	DATA TRACKING NUMBER ACCESSION NUMBER	Q STATUS	TDB STATUS
Whitfield, M.S., Eshom, E.P., Thordarson, W., and Schaefer, D.H., 1985, Geohydrology of rocks penetrated by USW H-4, Yucca Mountain, Nevada: USGS WRIR 85-4030.	GS920408312314.008 NNA.19870407.0328	Non-Q	Submitted 4/24/87
Data Sources Used for Comparison Purposes Only: Data Packages			
5/2295 280 Gallon Per Minute Pump test at the c-hole complex. Pre-test data also included.	GS960108312313.001 MOL.19960924.0689 - 0690 MOL.19960924.0692 - 0700 MOL.19960924.0705	Q	Submitted 5/20/97 (see attached memorandum)
6/12/95 356 GPM test in UE-25c#3 with c#1 and c#2 packed off. Test conducted at the c-hole complex.	GS960108312313.002 MOL.19960924.0703 MOL.19960924.0807 - 0808 MOL.19960924.0810 - 0812	Q	Submitted 5/29/97 (see attached memorandum)
Data obtained from the analysis of the iodide-tracer-test water samples collected during the 2/13/96 convergent tracer test conducted at the c-well complex. The test was in the Bullfrog-Tram zone with pumping in boreholes UE-25 c#3 and injection in borehole UE-25c#2.	GS960808312315.001 MOL.19961216.0160 MOL.19961216.0162 - 0163 MOL.19961216.0165 - 0167	Q	Submitted 12/10/96
Pumping test data collected at the c-hole complex, September 28, 1995, and January through April, 1996	GS960808312314.002 MOL.199612160174 - 0181	Q	Not TDB-appropriate

TITLE OF SOURCE	DATA TRACKING NUMBER ACCESSION NUMBER	Q STATUS	TDB STATUS
Pumping test data collected at the c-well complex, 5/7/96 - 12/31/96	GS970308312314.001 Backlog	Q	Submitted 3/18/97
Water-level altitude data from four wells in the Continuous Network, May through December, 1996	GS970308312314.002 Backlog	Non-Q	Submitted 3/18/97

Introduction

This milestone consists of an updated fully 3D model of ground-water flow within the saturated zone at Yucca Mountain, Nevada. All electronic files pertaining to this deliverable have been transferred via ftp transmission to Steve Bodnar (M&O) and the technical data base. The model was developed using a flow and transport simulator, FEHMN, developed at Los Alamos National Laboratory, and represents a collaborative effort between staff from the U.S. Geological Survey and Los Alamos National Laboratory. The model contained in this deliverable is minimally calibrated and represents work in progress. The flow model developed for this milestone is designed to feed subsequent transport modeling studies at Los Alamos which also use the FEHMN software. In addition, a general-application parameter estimation routine, PEST, was used in conjunction with FEHMN to reduce the difference between observed and simulated values of hydraulic head through the adjustment of model variables. This deliverable in large part consists of the electronic files for Yucca Mountain Site saturated-zone flow model as it existed as of 6/6/97, including the executable version of FEHMN (accession no. MOL.19970610.0204) used to run the code on a Sun Ultrasparc I workstation. It is expected that users of the contents of this deliverable be knowledgeable about the operation of FEHMN.

Model Components

For the current simulation, fully saturated conditions were imposed on the simulation. However, to implement these conditions, the air/water macro (air) within FEHMN was invoked which resulted in faster convergence for this fully saturated configuration. Hydraulic head conditions were imposed using the 'head' macro with FEHMN. To facilitate output readable by PEST, the 'pest' macro was invoked which writes a file after each forward run with results for user specified nodes corresponding to hydraulic head observation points.

Model Domain

The domain of the current model represents a rectangular area that extends from 533,340 W to 563,340 W and 4,046,782 N to 4,091,782 N in the UTM coordinate system. The model embodied in this milestone is consistent with the three-dimensional site geologic model but is larger than the area of the site geologic model developed to support the site unsaturated zone model. The current model domain is delimited by a rectagular box: 45 kilometers long, 30 kilometers wide, and about 1.5 kilometers thick. The domain was selected to be: (1) coincident with grid cells in the regional ground-water flow model; (2) sufficiently large to minimize the effects of flow and pressure boundary conditions on estimating perme ability values at Yucca Mountain; (3) sufficiently large to be able to assess ground- water flow at distances 30 km downgradient from the design repository area; (4) small enough to minimize the number of computational nodes used in the model; (5) thick enough to include the regional Paleozoic carbonate aquifer; and (6) large enough to include well control in the Amargosa Desert at the southern end of the model. Tests done using a model developed by Sandia National Laboratory

of a much smaller area that included Yucca Mountain indicated that specified pressure (constant head) boundary conditions could be applied while still observing changes in model simulated pressures as a result of changes in model permeability values (B.W. Arnold, Sandia National Laboratory, written communication)..

Boundary Conditions

Specified hydraulic-head boundary conditions were derived from a conventional representation for the water table with the large hydraulic gradient represented. This surface was used as the top of the model mesh, the top edges of which were used as the 'seed' values of for the hydraulic head boundary conditions. To get these boundary conditions to be specified properly, low permeability values (1e-29 m**2) were specified within the interior and the faces were given permeability values of 1e-14 for all components; the top edges were specified with the 'head' from the potentiometric surface and the side nodes allowed to equilibrate to the resulting head distribution. (These head distributions are in figures contained in 000*.plt files). Once the faces were at equilibrium, the interior node permeability values were relaxed according to the distributions of the various hydrogeologic units, and the model run in forward mode to get a head solution at all nodes. An .ini file (restart file) corresponding to a time of 0.0 days containing the specified head values on all faces was used in all subsequent simulations. Head observations appear in table 1.

Parameter Estimation

For the current head-based (as opposed to pressure-based) model, 38 different parameter estimation runs were done for various configurations of parameters. These files are of the form h*rec* and generally follow a naming sequence of letter-number-letter-number (out to four places). The results of the PEST simulations include 95% confidence intervals for the adjustable parameters, which may or may not be meaningful depending on many factors in the parameter estimation process. An overall decrease in the objective function (phi) occurred through the sequence of .rec files, although not necessarily in the same sequence as the rec files.

Permeability Estimates

There are several zone lists used in the model that define nodes pertaining to hydrogeologic units with specific permeability and porosity values. Zones 2 through 19 correspond to material properties of the units (Table 2). Parameter names for each material-property zone also appear in table 2.

Additional zone lists (see h4o1.dat) are:

00061 -- East-West barrier at approximate southern extent of large hydraulic gradient
00062 -- North-South barrier at approximate location of Solitario Canyon fault
00071 --All top nodes of mesh (not used)
00072 -- All bottom nodes of mesh (not used)
00073 -- All west nodes
00074 -- All south nodes
00075 -- All east nodes
00076 -- All north nodes
00077-- All nodes on the bottom of the upper volcanic confining unit
00078 -- Nodes along the top of Fortymile Wash
00096 -- East-West plane to examine pressures ~1.5 km from north of model
00097 -- East-West plane to examine pressures ~3.0 km from north of model

Zone 00061 was required to better represent the large hydraulic gradient located on the north end of Yucca Mountain at which the apparent water-table altitude changes about 300 meters in a distance of less than 2 km. The cause of the large hydraulic gradient remains unknown, but for purposes of this model is considered to be a buried fault of low permeability. Zone 00062 was included to better represent the approximately 50 meter change in hydraulic head across the Solitario Canyon fault system.

File h4o1.dat has the values last used in pest run h4o1.pst which are not the optimized values determined using pest, rather the last perturbation of the values. In this particular run, mva, uva, and lkns (Solitario Canyon fault permeabilty) were specified as parameters with the following outcome:

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                    OPTIMISATION RESULTS

Adjustable parameters ----->

Parameter       Estimated          95% percent confidence limits
                value              lower limit       upper limit
 mva          2.556685E-14         2.458739E-14      2.654632E-14
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lkns          8.795841E-16          5.419461E-16          1.217222E-15

Note: confidence limits provide only an indication of parameter uncertainty.
      They rely on a linearity assumption which may not extend as far in
      parameter space as the confidence limits themselves - see PEST manual.


Tied parameters ----->


Parameter       Estimated value
 uva             2.556685E-14


Objective function ----->

Sum of squared weighted residuals (ie phi) =  2.2405E+04
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The next pest run, h4o2.rec001, produces a similar objective function value (2.2416E+04) but with a markedly different estimate for both mva and uva (1.626692E-14), although in that run the lower carbonate aquifer (tied to qal, alluvium) is added as an adjustable parameter. When lkns is removed as an adjustable parameter, the estimates change still further (h4o2.rec.002) with mva/uva estimated as 5.946981E-15 (a value less than would be expected to representative of tuff aquifers). Note that these two parameters are tied to help insure a PEST estimate (somthing far from guaranteed given the number of head observations). All of this information should be kept in mind when trying to evaluate confidence in parameters. In addition, all *.rec* files report the covariance of the adjustable parameters at the end of the run record.

Permeability estimates which resulted in the lowest sum of squared residuals for hydraulic head are as follows:

Parameter Name	Permeability estimate ($meters^2$)
gran	3.5E-14
lca	5.5E-12
qcu	2.0E-15
ecu	5.5E-19
uca	6.7E-13
lvcu	1.0E-16
lva	5.0E-13
mvcu	1.9E-16
lcu	2.9E-14
uvcu	1.0E-18
b	4.5E-14
tlim	1.0E-14

tpla	3.0E-16
qal	1.1E-13
kz	2.2E-15
lkew	1.6E-17
lkns	8.8E-16
mva	2.6E-14
uva	2.6E-14

Residuals

The difference between measured and calculated values of hydraulic head are listed below (excerpted from file h4o1.rec):

Observation	Measured value	Calculated value	Residual	Weight
o1	1187.8001	1182.0042	5.79581	1.000
o2	1010.0500	1047.1587	-37.1087	1.000
o3	1034.5200	1022.2099	12.3101	1.000
o4	1019.7900	1026.7325	-6.94255	1.000
o5	738.51001	845.04110	-106.531	1.000
o6	778.42999	757.84558	20.5844	1.000
o7	730.26001	743.72399	-13.4640	1.000
o8	754.20001	763.07293	-8.87292	1.000
o9	748.28003	755.04432	-6.76429	1.000
o10	730.84003	736.07490	-5.23487	1.000
o11	729.15002	732.00070	-2.85068	1.000
o12	730.15002	744.20387	-14.0539	1.000
o13	730.96997	736.41781	-5.44784	1.000
o14	729.97998	732.51180	-2.53182	1.000
o15	730.81000	740.77164	-9.96164	1.000
o16	730.09003	735.81578	-5.72575	1.000
o17	730.19000	732.80422	-2.61422	1.000
o18	730.06000	733.46738	-3.40738	1.000
o19	729.17999	732.57162	-3.39163	1.000
o20	775.96002	790.05615	-14.0961	1.000
o21	730.64001	732.22176	-1.58175	1.000
o22	730.52002	738.04262	-7.52260	1.000
o23	728.21997	748.42988	-20.2099	1.000
o24	775.96997	765.20885	10.7611	1.000
o25	729.40002	728.56301	0.837011	1.000
o26	833.16998	854.09337	-20.9234	1.000
o27	729.65997	727.71651	1.94346	1.000
o28	779.46002	814.46740	-35.0074	1.000
o29	729.37000	726.71168	2.65832	1.000
o30	730.67999	728.15616	2.52383	1.000

o31	727.34003	726.74400	0.596035	1.000
o32	727.79999	726.51704	1.28295	1.000
o33	729.81000	714.37224	15.4378	1.000
o34	718.40997	717.49911	0.910859	1.000
o35	705.40002	717.21142	-11.8114	1.000
o36	704.09003	717.06728	-12.9772	1.000
o37	705.60999	717.25011	-11.6401	1.000
o38	701.65002	717.11553	-15.4655	1.000
o39	705.47998	716.51713	-11.0372	1.000
o40	705.44000	713.90694	-8.46694	1.000
o41	705.35999	716.27754	-10.9175	1.000
o42	724.96002	724.60053	0.359492	1.000
o43	706.09998	711.94196	-5.84198	1.000
o44	704.39001	709.15891	-4.76890	1.000
o45	695.81000	700.17615	-4.36615	1.000
o46	694.03003	695.24941	-1.21938	1.000
o47	693.76001	696.53729	-2.77728	1.000
o48	693.76001	696.83156	-3.07155	1.000
o49	722.25000	714.02664	8.22336	1.000
o50	696.92999	697.72501	-0.795019	1.000
o51	689.97998	692.38452	-2.40454	1.000
o52	707.67999	693.64901	14.0310	1.000
o53	693.21997	694.02495	-0.804984	1.000
o54	690.46002	691.70584	-1.24582	1.000
o55	692.20001	696.91664	-4.71663	1.000
o56	705.58002	692.32349	13.2565	1.000
o57	693.69000	693.13458	0.555421	1.000
o58	690.41998	690.53386	-0.113880	1.000
o59	692.98999	691.57895	1.41104	1.000
o60	692.44000	692.66700	-0.227001	1.000
o61	689.15002	686.23348	2.91654	1.000
o62	686.38000	694.54378	-8.16378	1.000
o63	696.15997	695.33197	0.828004	1.000
o64	690.07001	690.71432	-0.644315	1.000
o65	709.00000	706.99340	2.00660	1.000
o66	692.14001	692.23666	-9.664981E-02	1.000
o67	706.56000	692.16586	14.3941	1.000
o68	720.32001	711.06986	9.25015	1.000
o69	718.40997	713.67572	4.73425	1.000
o70	688.29999	695.65825	-7.35826	1.000
o71	688.84998	695.29829	-6.44831	1.000
o72	691.20001	698.73950	-7.53949	1.000
o73	713.98999	709.75534	4.23465	1.000
o74	723.63000	712.74595	10.8841	1.000
o75	701.34003	695.67466	5.66537	1.000
o76	696.46997	691.36917	5.10080	1.000
o77	692.40002	692.02870	0.371319	1.000
o78	692.73999	692.07524	0.664751	1.000
o79	698.51001	702.85468	-4.34467	1.000
o80	785.79999	760.05816	25.7418	1.000
o81	735.25000	753.97200	-18.7220	1.000
o82	730.58002	754.61332	-24.0333	1.000

o83	730.78003	750.04648	-19.2665	1.000
o84	775.40997	761.61023	13.7997	1.000
o85	775.67999	761.15074	14.5292	1.000
o86	730.10999	738.79200	-8.68201	1.000
o87	730.56000	737.86532	-7.30532	1.000
o88	775.75000	765.73327	10.0167	1.000
o89	775.63000	768.80843	6.82157	1.000
o90	730.15997	739.47575	-9.31578	1.000
o91	730.27002	736.21915	-5.94913	1.000
o92	731.03998	741.39835	-10.3584	1.000
o93	759.33002	742.32448	17.0055	1.000
o94	752.62000	742.74114	9.87886	1.000

Objective function ----->

Sum of squared weighted residuals (ie phi) = 2.2405E+04

All head and residual values are in meters above sea level. In general, the model fits the observations well in flat gradient areas but less well in larger gradient areas. The observation points (table 1) used in the model are derived in large part from Ciesnik (1995) which includes measurements from the WT holes, C-holes, USW G-2, and 91 other observation points. Hydraulic-test data from these and other holes were used for comparison against model estimates of permeability. This model is minimally calibrated given the number of actual optimization runs that were done (38) and the number of adjustable parameter combinations that were used.

There are several other features that should be included in subsequent models including: 1) areally distributed recharge based on values derived by J. Hevesi (U.S. Geological Survey, written communication, 1997); 2) recharge along Yucca Wash and other tributaries of Fortymile Wash; 3) specification of flux explicitely along the southern and/or northern boundary of the model based on estimates from the USGS regional model of the Death Valley ground-water flow system; 4) characterization of different water table configurations which might offer different explanations for the presence of the large hydraulic gradient north of Yucca Mountain (one of which would be the treatment of the higher water levels as being associated with a perched water body); 5) use of a higher-resolution stratigraphic framework model sampled at 250-m grid centers which captures the distribution of hydrogeologic units better than the current 1500-m grid sampling; 6) use of temperature and C-14 ground-water ages as potential additional constraining data sets against which model calibration and comparisons could be made. Also included is a postscript file to help view the residuals: h4o1.residuals.pasted.plt. Unfortunately some of the values get stacked on the figure because of crowded residuals, but you can get an idea of some of values. Largest residuals occur at WT-6 and at wells in Crater Flat.

Running the model

To run the model embodied in h4o1.dat on a Sun Ultra sparc computer, use the following commands after transferring the files via ftp:

```
chmod 755 xfehm*
chmod 755 r*
rerp_ultra h4o1
```

Other script files are included in the ftp directory for running alternate executable versions of FEHMN. Verification that the model results produced by using the 4/28/97 version of xfehmn for Sun Solaris systems were identical to those obtained using the 6/10/97 Ultrasparc version was done using the 'diff' unix system command which was used to compare the .fin files produced for the h4o1.dat input data set which was run on separate platforms. The only difference between the two .fin files was the version of FEHMN reported.

Transferring Files Using FTP

The files associated with this deliverable may be transferred through an ftp link using the following commands:

ftp ympbserv1.cr.usgs.gov
user: anonymous
password: <your e-mail address>
cd /pub/sz_model
prompt -
mget *

The contents of the directory are listed in Table 3.

Table 1: Observation wells used in the construction of the Yucca Mountain site saturated-zone model

[MPa, megapascals; well names are those contained in the USGS Ground-Water Site Inventory data base; midpoint of water column is midpoint of packed off interval for multiply completed wells]

Well Name	Latitude	Longitude	Measuring point altitude (meters)	Altitude of midpoint of water column (meters)	Hydraulic head (meters)	Pressure of water column at midpoint (MPa)	Date of Measurement
UE-29a 2	36°56′29″	116°22′26″	1215.39	1024.05	1187.80	0.4909	02/19/84
GEXA 4	36°55′20″	116°37′03″	1198.14	860.25	1010.05	0.44906	03/14/96
GEXA 3	36°54′45″	116°38′39″	1243.86	1111.56	1192.62	0.24301	12/17/96
UE-25 WT-6	36°53′40″	116°26′46″	1314.79	988.57	1034.52	0.13775	12/04/95
USW G-2	36°53′22″	116°27′35″	1553.90	371.53	1019.79	1.9434	12/11/95
UE-25 WT-16	36°52′39″	116°25′34″	1210.91	719.59	738.51	0.056716	12/04/95
USW UZ-14	36°52′08″	116°27′40″	1349.11	724.77	778.43	0.16086	12/16/96
UE-25 WT-18	36°52′07″	116°26′42″	1336.40	721.83	730.26	0.025242	08/30/95
USW G-1	36°52′00″	116°27′29″	1325.91	125.65	754.20	1.8843	03/23/82
UE-25a 3	36°51′47″	116°18′53″	1385.62	681.46	748.28	0.20034	12/19/79
UE-25 WT-4	36°51′40″	116°26′03″	1169.21	711.21	730.84	0.058826	12/05/95
UE-25 WT-15	36°51′16″	116°23′38″	1083.20	698.91	729.15	0.090647	12/10/96
USW G-4	36°51′14″	116°27′04″	1269.49	542.16	730.15	0.56355	01/26/90

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Well Name	Latitude	Longitude	Measuring point altitude (meters)	Altitude of midpoint of water column (meters)	Hydraulic head (meters)	Pressure of water column at midpoint (MPa)	Date of Measurement
UE-25a 1	36°51′05″	116°26′24″	1199.21	583.94	730.97	0.44079	04/29/85
UE-25 WT-14	36°50′32″	116°24′35″	1076.40	704.61	729.98	0.076041	12/04/95
USW WT-2	36°50′23″	116°27′18″	1301.31	705.16	730.81	0.076873	12/12/95
UE-25c 1	36°49′47″	116°25′43″	1130.59	479.08	730.09	0.75246	04/20/84
UE-25c 3	36°49′47″	116°25′43″	1132.30	474.05	730.19	0.76788	07/13/95
UE-25c 2	36°49′45″	116°25′43″	1132.21	473.65	730.06	0.76869	01/09/95
UE-25 WT-13	36°49′43″	116°23′51″	1032.51	704.06	729.18	0.075297	12/09/96
USW WT-7	36°49′33″	116°28′57″	1196.89	745.78	775.96	0.09046	12/06/95
USW WT-1	36°49′16″	116°26′56″	1201.40	712.27	730.64	0.055062	12/12/95
USW G-3	36°49′05″	116°28′01″	1480.51	339.02	730.52	1.1737	06/27/95
J-13	36°48′28″	116°23′40″	1011.30	338.19	728.22	1.1693	12/16/96
USW WT-10	36°48′25″	116°29′05″	1123.40	748.36	775.97	0.082753	12/06/95
UE-25 WT-17	36°48′22″	116°26′26″	1124.01	717.00	729.40	0.037166	06/28/95
USW VH-2	36°48′21″	116°34′37″	974.45	294.21	833.17	1.6157	03/10/85

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Well Name	Latitude	Longitude	Measuring point altitude (meters)	Altitude of midpoint of water column (meters)	Hydraulic head (meters)	Pressure of water column at midpoint (MPa)	Date of Measurement
UE-25 WT-3	36°47′57″	116°24′58″	1030.01	708.39	729.66	0.063779	12/12/95
USW VH-1	36°47′32″	116°33′07″	963.50	490.33	779.46	0.86676	12/17/96
J -11	36°47′06″	116°17′06″	1049.37	688.54	732.19	0.13084	12/16/96
UE-25 WT-12	36°46′56″	116°26′16″	1074.69	709.40	729.37	0.059873	12/13/95
USW WT-11	36°46′49″	116°28′02″	1094.11	704.37	730.68	0.078878	12/06/95
	36°46′22″	116°16′43″	1049.43	687.78	731.52	0.13112	09/13/57
U.S. Ecology -	36°46′15″	116°41′24″	848.42	729.39	755.76	0.079038	10/10/90
MW 315	36°45′57″	116°41′18″	844.70	748.62	751.89	0.0098227	05/15/89
J -12	36°45′54″	116°23′24″	953.54	666.86	727.34	0.18133	12/05/83
JF- 3	36°45′28″	116°23′22″	944.36	662.65	727.80	0.19532	12/12/96
ASH-B Deep	36°43′29″	116°40′29″	815.95	583.00	720.08	0.41094	12/18/96
ASH-B Shallow	36°43′29″	116°40′29″	815.95	698.44	720.22	0.065305	12/18/96
NA-6	36°41′30″	116°41′12″	800.98	613.61	718.85	0.31548	12/17/96
Cind-R-Lite	36°41′05″	116°30′26″	830.76	710.18	729.81	0.05884	12/17/96

Table 1: Observation wells used in the construction of the Yucca Mountain site saturated-zone model

[MPa, megapascals; well names are those contained in the USGS Ground-Water Site Inventory data base; midpoint of water column is midpoint of packed off interval for multiply completed wells]

Well Name	Latitude	Longitude	Measuring point altitude (meters)	Altitude of midpoint of water column (meters)	Hydraulic head (meters)	Pressure of water column at midpoint (MPa)	Date of Measurement
	36°39′07″	116°23′57″	819.91	697.38	718.41	0.063048	05/20/61
	36°38′42″	116°23′53″	811.38	676.85	705.40	0.085572	09/12/90
	36°38′40″	116°23′50″	813.82	681.99	704.09	0.066246	02/28/55
	36°38′40″	116°23′40″	810.77	697.99	705.61	0.022843	05/03/52
	36°38′38″	116°23′45″	811.38	679.25	701.65	0.06716	03/08/55
NDOT	36°38′35″	116°23′58″	809.79	682.20	705.48	0.069796	12/16/96
	36°38′25″	116°26′32″	795.53	663.61	705.44	0.12537	01/15/87
Airport	36°38′25″	116°24′33″	804.31	640.53	705.36	0.19434	12/16/96
TW- 5	36°38′15″	116°17′59″	931.47	706.30	724.96	0.055962	12/16/96
	36°37′44″	116°26′37″	783.95	669.13	706.10	0.11084	07/12/62
	36°37′01″	116°26′40″	774.19	671.93	704.39	0.097313	10/18/58
	36°35′49″	116°30′50″	742.19	639.29	695.81	0.16942	01/07/87
	36°35′48″	116°35′37″	731.82	674.83	694.03	0.057566	01/05/60
	36°35′47″	116°32′43″	735.18	676.37	693.76	0.052129	01/07/87

Table 1: Observation wells used in the construction of the Yucca Mountain site saturated-zone model

[MPa, megapascals; well names are those contained in the USGS Ground-Water Site Inventory data base; midpoint of water column is midpoint of packed off interval for multiply completed wells]

Well Name	Latitude	Longitude	Measuring point altitude (meters)	Altitude of midpoint of water column (meters)	Hydraulic head (meters)	Pressure of water column at midpoint (MPa)	Date of Measurement
	36°35′45″	116°32′09″	737.01	664.79	693.76	0.086855	01/08/87
	36°35′40″	116°24′08″	771.14	699.30	722.25	0.068805	03/13/73
	36°35′27″	116°29′25″	744.02	667.13	696.93	0.089318	01/16/87
Davidson	36°35′26″	116°35′29″	730.09	673.46	689.98	0.049529	12/18/96
	36°35′15″	116°33′55″	740.66	677.24	707.68	0.091282	07/02/62
	36°35′11″	116°31′42″	733.65	649.12	693.22	0.13219	01/07/87
	36°35′03″	116°35′15″	727.86	684.02	690.46	0.019326	01/07/87
	36°35′03″	116°28′40″	740.66	685.95	692.20	0.018732	01/12/87
	36°34′57″	116°34′23″	740.66	686.24	705.58	0.057977	01/07/87
	36°34′57″	116°33′09″	731.52	666.89	693.69	0.080359	01/07/87
DeFir	36°34′56″	116°35′25″	727.07	671.71	690.42	0.05609	03/24/93
	36°34′55″	116°34′59″	726.03	667.91	692.99	0.075201	07/02/62
	36°34′45″	116°32′46″	727.86	661.39	692.44	0.09311	01/07/87
	36°34′42″	116°36′33″	725.73	676.96	689.15	0.03655	04/21/82

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Well Name	Latitude	Longitude	Measuring point altitude (meters)	Altitude of midpoint of water column (meters)	Hydraulic head (meters)	Pressure of water column at midpoint (MPa)	Date of Measurement
	36°34'40"	116°28'24"	731.52	664.60	686.38	0.065287	06/29/62
	36°34'34"	116°27'51"	741.88	673.30	696.16	0.06853	07/15/58
	36°34'32"	116°34'42"	723.29	653.80	690.07	0.10873	01/20/84
	36°34'30"	116°24'52"	762.00	667.22	709.00	0.12523	06/29/62
	36°34'29"	116°31'59"	729.08	664.89	692.14	0.081688	01/07/87
	36°34'28"	116°32'15"	740.66	679.72	706.56	0.080455	07/04/62
Cooks West	36°34'28"	116°24'03"	754.26	689.74	720.32	0.091671	04/09/91
Cooks East	36°34'28"	116°23'47"	755.23	695.82	718.41	0.067699	12/18/96
	36°34'22"	116°25'34"	755.90	704.09	713.23	0.027412	07/31/62
	36°34'17"	116°27'30"	740.66	685.53	688.30	0.008315	01/20/84
Amargosa Town C	36°34'11"	116°27'29"	739.14	668.27	688.85	0.061677	11/19/80
	36°34'10"	116°26'11"	743.71	615.35	691.20	0.2274	01/15/87
	36°34'10"	116°24'03"	748.59	700.81	713.99	0.039515	03/16/87
	36°34'10"	116°24'00"	749.81	709.89	723.63	0.041164	03/16/87

Table 1: Observation wells used in the construction of the Yucca Mountain site saturated-zone model

[MPa, megapascals; well names are those contained in the USGS Ground-Water Site Inventory data base; midpoint of water column is midpoint of packed off interval for multiply completed wells]

Well Name	Latitude	Longitude	Measuring point altitude (meters)	Altitude of midpoint of water column (meters)	Hydraulic head (meters)	Pressure of water column at midpoint (MPa)	Date of Measurement
Amargosa Valley	36°34′07″	116°27′33″	737.92	673.91	701.34	0.082236	12/10/88
	36°34′05″	116°33′45″	723.90	672.08	696.47	0.073099	08/15/58
	36°34′04″	116°33′12″	724.20	662.28	692.40	0.090305	01/08/87
	36°34′04″	116°32′39″	724.20	685.61	692.74	0.021372	02/26/74
	36°34′04″	116°25′04″	746.76	678.44	698.51	0.06017	06/29/62
	36°33′56″	116°29′45″	726.95	645.26	691.59	0.13889	06/28/62
	36°33′53″	116°30′33″	727.28	670.59	690.09	0.058466	01/08/87
Tracer 3	36°32′13″	116°13′38″	732.22	622.54	719.52	0.29072	12/16/96
USW H-1 Tube1	36°51′57″	116°27′12″	1302.99	-495.50	785.80	3.8411	12/05/95
USW H-1 Tube2	36°51′57″	116°27′12″	1302.99	192.98	735.25	1.6256	12/05/95
USW H-1 Tube3	36°51′57″	116°27′12″	1302.99	562.49	730.58	0.5039	12/05/95
USW H-1 Tube4	36°51′57″	116°27′12″	1302.99	680.39	730.78	0.15108	12/05/95
USW H-5 Upper	36°51′22″	116°27′55″	1478.89	704.15	775.41	0.21362	02/07/95
USW H-5 Lower	36°51′22″	116°27′55″	1478.89	446.39	775.68	0.98713	06/14/95

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Well Name	Latitude	Longitude	Measuring point altitude (meters)	Altitude of midpoint of water column (meters)	Hydraulic head (meters)	Pressure of water column at midpoint (MPa)	Date of Measurement
UE-25b 1 Lower	36°51′08″	116°26′23″	1200.70	-8.79	730.11	2.2151	07/18/95
UE-25b 1 Upper	36°51′08″	116°26′23″	1200.70	366.13	730.56	1.0925	12/05/95
USW H-6 Upper	36°50′49″	116°28′55″	1301.71	662.73	775.75	0.33882	12/06/95
USW H-6 Lower	36°50′49″	116°28′55″	1301.71	315.71	775.63	1.3788	12/06/95
USW H-4 Upper	36°50′32″	116°26′54″	1248.49	395.33	730.16	1.0038	12/12/95
USW H-4 Lower	36°50′32″	116°26′54″	1248.49	45.00	730.27	2.0543	12/12/95
USW H-3 Upper	36°49′42″	116°28′00″	1483.19	550.12	731.04	0.54235	07/26/95
USW H-3 Lower	36°49′42″	116°28′00″	1483.19	316.70	759.33	1.3269	12/12/95
UE-25p 1 PTH	36°49′38″	116°25′21″	1114.20	-410.29	752.62	3.4862	12/03/96

Table 2.--Hydrogeologic units, equivalent units, and associated lithologies in the vicinity of Yucca Mountain

[--, no units identified; hydrologic-unit names listed in parentheses; Q, Quaternary; T, Tertiary; Pz, Paleozoic; pC, Precambrian]

Hydrogeologic Unit (Age)	Model Unit Number (Parameter Name)	Equivalent Unit			Lithology
		Winograd and Thordarson (1975)	Laczniak and others (1996)	Luckey and others (1996)	
Valley-Fill Aquifer (Q, T)	19 (qal)	Valley Fill (Valley-fill aquifer)	Alluvial deposits (Valley-fill aquifer)	Alluvium	Alluvial fan, fluvial, fanglomerate, lakebed, colian and mudflow deposits
Valley-Fill Confining Unit (Q, T)	18 (tpla)	--	--	--	Playa deposits
Limestone Aquifer (T)	17 (tlim)	Rocks of Pavits Spring Horse Spring Formation	Rocks of Pavits Spring Horse Spring Formation	--	Lacustrine limestones, calcareous spring deposits
Lava-Flow Aquifer (Q,T)	16 (b)	Basalt of Kiwi Mesa Basalt of Skull Mountain (Lava-flow aquifer)	Basalt	--	Basalt flows, dikes and cinder cones,latite dikes
Upper Volcanic Aquifer (T)	15 (uva)	Timber Mountain Tuff Paintbrush Tuff (Welded-tuff aquifer)	Thirsty Canyon Group Timber Mountain Group Paintbrush Group (Welded-tuff and lava-flow aquifers)	Paintbrush Tuff (Upper Yucca Mt. Volcanic Aquifer)	Variably welded ash-flow tuffs and rhyolite lavas (non-welded tuffs)
Upper Volcanic Confining Unit (T)	14 (uvcu)	Wahmonie Formation Salyer Formation (Lava-flow aquitard - Tuff aquitard)	Volcanics of Area 20 Wahmonie Formation (Lava-flow aquifers)	Tuffaceous Beds of Calico Hills (Upper Yucca Mt. Confining Unit)	Rhyolite lavas, volcanic breccias, non-welded to welded tuffs, commonly argillaceous or zeolitic

Hydrogeologic Unit (Age)	Model Unit Number (Parameter Name)	Equivalent Unit			Lithology
		Winograd and Thordarson (1975)	Laczniak and others (1996)	Luckey and others (1996)	
Middle Volcanic Aquifer (T)	13 (mva)	Grouse Canyon Tuff Tuff of Crater Flat (Tuff aquitard)	Crater Flat Group Belted Range Group (Welded-tuff and lava-flow aquifers)	Crater Flat Tuff (Lower Yucca Mt. Volcanic Aquifer)	Variably welded ash-flow tuffs and rhyolite lavas
Middle Volcanic Confining Unit (T)	12 (mvcu	Local informal units of Indian Trail Formation (Tuff aquitard)	Tunnel Formation (Tuff confining unit)	Flow Breccia Lithic Ridge Tuff (Lower Yucca Mt. Confining Unit)	Non-welded tuff, commonly zeolitized
Lower Volcanic Aquifer (T)	11 (lva)	Tub Spring Tuff (Tuff aquitard)	Volcanics of Big Dome (Lava-flow and welded-tuff aquifer)	--	Variably welded ash-flow tuffs, rhyolite lavas
Lower Volcanic Confining Unit (T)	10 (lvcu)	? (Tuff aquitard)	Older Volcanics (Tuff confining unit)	Older Tuffs (Lower Yucca Mt. Confining Unit)	Non-welded tuff, commonly zeolitized
Lower Valley-Fill Confining Unit (T)	9 (lcu)	Rocks of Pavits Spring Horse Spring Formation (Tuff aquitard)	Pavits Spring Formation Horse Spring Formation Paleocolluvium	--	Tuffaceous sandstone, tuff breccia, siltstone, claystone, conglomerate, lacustrine limestone, commonly argillaceous or calcareous. Sedimentary breccia.
Upper Carbonate Aquifer (Pz)	8 (uca)	Tippipah Limestone (Upper carbonate aquifer)	Bird Spring Formation (Upper carbonate aquifer)	--	Limestone
Upper Clastic Confining Unit (Pz)	6 (ccu)	Eleana Formation (Upper clastic aquitard)	Eleana Formation (Eleana confining unit)	--	Siliceous siltstone, sandstone, quartzite, conglomerate, limestone

Hydrogeologic Unit (Age)	Model Unit Number (Parameter Name)	Equivalent Unit			Lithology
		Winograd and Thordarson (1975)	Laczniak and others (1996)	Luckey and others (1996)	
Lower Carbonate Aquifer (Pz)	3, 5, 7 (lca)	Devils Gate Limestone Nevada Formation Ely Springs Dolomite Eureka Quartzite Pogonip Group Nopah Formation Dunderberg Shale Bonanza King Upper Carrara Formation (Lower carbonate aquifer)	Guilmette Formation Simonson Dolomite Sevy, Laketown, and Lone Mountain Dolomite Roberts Mountain Formation Dolomite of the Spotted Range Ely Springs Dolomite Eureka Quartzite Pogonip Group Nopah Formation Bonanza King Formation Upper Carrara Formation (Lower carbonate aquifer)	Lone Mt. Dolomite Roberts Mt. Dolomite (Carbonate Aquifer)	Dolomite and limestone, locally cherty and silty
Lower Clastic Confining Unit (Pz, pC)	4 (qcu)	Lower Carrara Formation Zabriskie Quartzite Wood Canyon Formation Stirling Quartzite Johnnie Formation (Lower clastic aquitard)	Lower Carrara Formation Zabriskie Quartzite Wood Canyon Formation Stirling Quartzite Johnnie Formation Noonday (?) Dolomite (Quartzite confining unit)	--	Quartzite, siltstone, shale, dolomite
Granitic Confining Unit (T)	2 (gran)	Granitic Stocks (A minor aquitard)	Granite	--	Granodiorite and quartz monzonite in stocks, dikes and sills

Table 3: Files contained in ftp directory

File Name	Description
README	Guidance document for contents of directory
directory	Files contained in this ftp directory
ff.h4o1	fehmn control file
ff.h4o1_verify	fehmn control file
ff.x1	fehmn control file
h2.rec	PEST parameter estimation record
h4.rec	PEST parameter estimation record
h4a.rec	PEST parameter estimation record
h4b.rec	PEST parameter estimation record
h4b2.tpl	PEST template file
h4c.rec	PEST parameter estimation record
h4d.rec	PEST parameter estimation record
h4f.ini	Initialization file containing specified head boundary condition values
h4g.rec	PEST parameter estimation record
h4h.rec	PEST parameter estimation record
h4j.rec	PEST parameter estimation record
h4k.rec	PEST parameter estimation record
h4k1.rec	PEST parameter estimation record
h4k1.rec.001	PEST parameter estimation record
h4l.rec	PEST parameter estimation record
h4m.rec	PEST parameter estimation record
h4n.rec	PEST parameter estimation record
h4n.rec.001	PEST parameter estimation record
h4n.rec.002	PEST parameter estimation record
h4n.rec.003	PEST parameter estimation record

Table 3: Files contained in ftp directory

File Name	Description
h4n.rec.004	PEST parameter estimation record
h4o.rec	PEST parameter estimation record
h4o1.chk	FEHMN check file
h4o1.con	FEHMN concentration file (not used)
h4o1.dat	FEHMN input file; contains permeability input based on last iteration from PEST run
h4o1.dp	FEHMN artifact (not used)
h4o1.fin	FEHMN output file containing hydraulic head values for final time step of simulation
h4o1.his	FEHMN history file containing values of hydraulic head for nodes specified for requested output
h4o1.out	FEHMN primary output file
h4o1.pst	PEST primary input file
h4o1.rec	PEST parameter estimation record
h4o1.residuals.pasted.plt	Postscript file of residuals for current lowest sum of squared errors between simulated and observed hydraulic head values
h4o1.trc	FEHMN artifact (not used)
h4o1_verify.chk	FEHMN check file for verification run
h4o1_verify.con	FEHMN concentration file (not used)
h4o1_verify.dat	FEHMN input file
h4o1_verify.dp	FEHMN artifact (not used)
h4o1_verify.fin	FEHMN output file containing hydraulic head values for final time step of simulation
h4o1_verify.his	FEHMN history file
h4o1_verify.ini	FEHMN file containing initial hydraulic head values
h4o1_verify.out	FEHMN primary output file
h4o1_verify.trc	FEHMN artifact (not used)

Table 3: Files contained in ftp directory

File Name	Description
h4o2.dat	FEHMN input file
h4o2.rec.002	PEST parameter estimation record
h4o2.rec001	PEST parameter estimation record
h4p.rec	PEST parameter estimation record
prepest	Unix script file to run PEST
readme2.fm5	Frame 5.0 containing additional information on directory contents
readme2.txt	ASCII file containing additional information on directory contents
rerp	Unix script file to run FEHMN
rerp2	Unix script file to run FEHMN
rerp_solaris	Unix script file to run FEHMN
rerp_ultra	Unix script file to run FEHMN
tet6_addpts.fehmn	3D finite-element mesh data file containing nodal coordinates and element connections
tet6_tr_addpts_material.zone	Zone lists identifying hydrogeologic units
tet6_tr_addpts_vor.stor	3D finite-element volumes
xfehmn-o-970428	FEHMN executable code for Solaris operating system and use on Sun Supersparc 20
xfehmn_ultra	FEHMN executable code for Sun Ultrasparc systems

Appendix A.--Correlation of RIB and ISM2.0 to Hydrogeologic Units

Site Saturated Zone Hydrogeologic Unit	Geologic/Lithologic Strat						ISM2.0
	Definition/Buesch (1996)	Group	Formation	Member	Zone	Subzone	
Valley-Fill Aquifer							
Valley-Fill Confining Unit							
Limestone Aquifer							
Lava-Flow Aquifer							
Upper Volcanic Aquifer	Timber Mountain Group	Tm					
Upper Volcanic Aquifer	Rainier Mesa Tuff		Tmr				44tmr
Upper Volcanic Aquifer	Paintbrush Group	Tp					
Upper Volcanic Aquifer	Post tuff unit '"x" bedded tuff			Tpbt6			
Upper Volcanic Aquifer	Tuff unit '"x"			Tpki (informal)			44tpk
Upper Volcanic Aquifer	Pre-tuff unit '"x" bedded tuff			Tpbt5			44tpc
Upper Volcanic Aquifer	Tiva Canyon Tuff		Tpc				
Upper Volcanic Aquifer	Crystal-Rich Member			Tpcr			
Upper Volcanic Aquifer	Vitric zone				Tpcrv		
Upper Volcanic Aquifer	Nonwelded subzone					Tpcrv3	
Upper Volcanic Aquifer	Moderately welded subzone					Tpcrv2	
Upper Volcanic Aquifer	Densely welded subzone					Tpcrv1	
Upper Volcanic Aquifer	Nonlithophysal zone				Tpcrn		
Upper Volcanic Aquifer	Subvitrophyre transition subzone					Tpcrn4	
Upper Volcanic Aquifer	Pumice-poor subzone					Tpcrn3	
Upper Volcanic Aquifer	Mixed pumice subzone					Tpcrn2	
Upper Volcanic Aquifer	Crystal transition subzone (not always present)					Tpcrn1	
Upper Volcanic Aquifer	Lithophysal zone				Tpcrl		
Upper Volcanic Aquifer	Crystal transition subzone (not always present)					Tpcrl1	
Upper Volcanic Aquifer	Crystal-Poor Member			Tpcp			
Upper Volcanic Aquifer	Upper lithophysal zone				Tpcpul		
Upper Volcanic Aquifer	Spherulite-rich subzone					Tpcpul1	
Upper Volcanic Aquifer	Middle nonlithophysal zone				Tpcpmn		
Upper Volcanic Aquifer	Upper subzone					Tpcpmn3	
Upper Volcanic Aquifer	Lithophysal subzone					Tpcplnn2	
Upper Volcanic Aquifer	Lower subzone					Tpcpmn1	
Upper Volcanic Aquifer	Lower lithophysal zone				Tpcpll		
Upper Volcanic Aquifer	Hackly-fractured subzone					Tpcpllh	
Upper Volcanic Aquifer	Lower nonlithophysal zone				Tpcpln		
Upper Volcanic Aquifer	Hackly subzone					Tpcplnh	
Upper Volcanic Aquifer	Columnar subzone					Tpcplnc	
Upper Volcanic Aquifer	Vitric zone				Tpcpv		
Upper Volcanic Aquifer	Densely welded subzone					Tpcpv3	44tpcpv3
Upper Volcanic Aquifer	Moderately welded subzone					Tpcpv2	44tpcpv12
Upper Volcanic Aquifer	Nonwelded subzone					Tpcpv1	44tpcpv12
Upper Volcanic Aquifer	Pre-Tiva Canyon bedded tuff			Tpbt4			44tpbt4
Upper Volcanic Aquifer	Yucca Mountain Tuff		Tpy				44tpy
Upper Volcanic Aquifer	Pre-Yucca Mountain bedded tuff			Tpbt3			44tpbt3
Upper Volcanic Aquifer	Pah Canyon Tuff		Tpp				44tpp
Upper Volcanic Aquifer	Pre-Pah Canyon bedded tuff			Tpbt2			44tpbt2
Upper Volcanic Aquifer	Topopah Spring Tuff		Tpt				
Upper Volcanic Aquifer	Crystal-Rich Member			Tptr			
Upper Volcanic Aquifer	Vitric zone				Tptrv		
Upper Volcanic Aquifer	Nonwelded subzone					Tptrv3	44tptrv23

Appendix A.--Correlation of RIB and ISM2.0 to Hydrogeologic Units

Site Saturated Zone Hydrogeologic Unit	Geologic/Lithologic Strat						ISM2.0
	Definition/Buesch (1996)	Group	Formation	Member	Zone	Subzone	
Upper Volcanic Aquifer	Moderately welded subzone					Tptrv2	44tptrv23
Upper Volcanic Aquifer	Densely welded subzone					Tptrv1	44tptrv1
Upper Volcanic Aquifer	Nonlithophysal zone				Tptrn		44tptrn
Upper Volcanic Aquifer	Dense subzone					Tptrn3	
Upper Volcanic Aquifer	Vapor-phase corroded subzone					Tptrn2	
Upper Volcanic Aquifer	Crystal transition subzone (not always present)					Tptrn1	
Upper Volcanic Aquifer	Lithophysal zone				Tptrl		
Upper Volcanic Aquifer	Crystal transition subzone (not always present)					Tptrl1	44tptrl
Upper Volcanic Aquifer	Crystal-Poor Member			Tptp			
Upper Volcanic Aquifer	Lithic-rich zone			Tptpf or Tptrf			44tptf
Upper Volcanic Aquifer	Upper lithophysal zone				Tptpul		44tptpul
Upper Volcanic Aquifer	Middle nonlithophysal zone				Tptpmn		44tptpmn
Upper Volcanic Aquifer	Nonlithophysal subzone					Tptpmn3	
Upper Volcanic Aquifer	Lithophysal-bearing subzone					Tptpmn2	
Upper Volcanic Aquifer	Nonlithophysal subzone					Tptpmn1	
Upper Volcanic Aquifer	Lower lithophysal zone				Tptpll		44tptpll
Upper Volcanic Aquifer	Lower nonlithophysal zone				Tptpln		44tptpln
Upper Volcanic Aquifer	Vitric zone				Tptpv		
Upper Volcanic Aquifer	Densely welded subzone					Tptpv3	44tptpv3
Upper Volcanic Aquifer	Moderately welded subzone					Tptpv2	44tptpv12
Upper Volcanic Aquifer	Nonwelded subzone					Tptpv1	44tptpv12
Upper Volcanic Aquifer	Pre-Topopah Spring bedded tuff			Tpbt1			44tpbt
Upper Volcanic Confining Unit	Calico Hills Formation		Ta				44tac
Upper Volcanic Confining Unit	Bedded tuff			Thtbt			44tacbt
Middle Volcanic Aquifer	Crater Flat Group	Tc					
Middle Volcanic Aquifer	Prow Pass		Tcp				44tcplnw, 44tcpunw, 44tcpw
Middle Volcanic Aquifer	Bedded tuff			Tcpbt			44tcpbt
Middle Volcanic Aquifer	Bullfrog Tuff		Tcb				44tcblnw, 44tcbunw, 44tcbw
Middle Volcanic Aquifer	Bedded tuff			Tcbbt			44tcbbt
Middle Volcanic Aquifer	Tram Tuff		Tct				44tct
Middle Volcanic Aquifer	Bedded tuff			Tctbt			44tctbt
Middle Volcanic Aquifer	Lava and flow breccia (informal)			Tl1			
Middle Volcanic Aquifer	Bedded tuff			Tl1bt			
Middle Volcanic Aquifer	Lithic Ridge Tuff		Tr				
Middle Volcanic Aquifer	Bedded tuff			Tlrbt			
Middle Volcanic Aquifer	Lava and flow breccia (informal)			TII2			
Middle Volcanic Aquifer	Bedded tuff			TI12bt			
Middle Volcanic Aquifer	Lava and flow breccia (informal)			T113			
Middle Volcanic Aquifer	Bedded tuff			T113bt			
Middle Volcanic Aquifer	Older tuffs (informal)			Tt			
Middle Volcanic Aquifer	Unit a (informal)			Tta			
Middle Volcanic Aquifer	Unit b (informal)			Ttb			
Middle Volcanic Aquifer	Unit c (informal)			Ttc			
Middle Volcanic Aquifer	Sedimentary rocks and calcified tuff (informal)			Tca			
Middle Volcanic Aquifer	Tuff of Yucca Flat (informal)			Tyf			
Middle Volcanic Confining Unit							
Lower Volcanic Aquifer							
Lower Volcanic Confining Unit							

Appendix A.--Correlation of RIB and ISM2.0 to Hydrogeologic Units

Site Saturated Zone Hydrogeologic Unit	Geologic/Lithologic Strat					ISM2.0
	Definition/Buesch (1996)	Group	Formation	Member	Zone	Subzone	
Lower Valley-Fill Confining Unit							
Upper Carbonate Aquifer							
Upper Clastic Confining Unit							
Lower Carbonate Aquifer	Lone Mountain Dolomite		Slm				paleozoicGrav (not used)
Lower Carbonate Aquifer	Roberts Mountain Formation		Srm				paleozoicGrav (not used)
Lower Clastic Confining Unit							
Granitic Confining Unit							

United States Department of the Interior

U. S. GEOLOGICAL SURVEY
Box 25046 M.S. 425
Denver Federal Center
Denver, Colorado 80225

IN REPLY REFER TO

June 12, 1997

NON-QA
WBS:1.2.5.3.5

Phill Jones
Acting Technical Data Base Administrator
M&O/TRW
Yucca Mountain Project Office
1180 Town Center Drive
Las Vegas, NV 89134

SUBJECT: Geographic Nodal Information Study and Evaluation System (GENISES) Data Transmittal - **Preliminary Site Saturated-Zone Flow Model.**

DTN: None **WBS 1.2.3.3.1.3.3** **Destination: Model Warehouse**

The subject model was transfered via FTP from John Czarnecki to Steve Bodnar on 6-11-97.

The attached data have not received confirmation of QA compliance, which includes a complete technical review; therefore, these data are considered to be preliminary. If used, these data must be clearly identified as preliminary in nature and tracked by the using Affected Organization until QA compliance has been confirmed and the data have been reported to the ATDT system.

Please label the subject model you recieved on 6-11-97 as "preliminary" as required by YAP-SIII.3Q.

If you have any questions, please contact me at (303) 236-0516, X271.

Sincerely,

Patrick W. McKinley

Patrick W. McKinley
Data Management Coordinator
Yucca Mountain Project Branch
U.S. Geological Survey

PWM:crw
Enclosures
Copy w/o enc. to: S.J. Bodnar, M&O/TRW, Las Vegas
R.W. Craig, USGS, Las Vegas

United States Department of the Interior

U. S. GEOLOGICAL SURVEY
Box 25046 M.S. 425
Denver Federal Center
Denver, Colorado 80225

IN REPLY REFER TO:

May 20, 1997

NON-QA
WBS:1.2.5.3.5

Phill Jones
Technical Data Base Administrator
M&O/TRW
Yucca Mountain Project Office
1180 Town Center Drive
Las Vegas, NV 89134

SUBJECT: Geographic Nodal Information Study and Evaluation System (GENISES) Data Transmittal - 5/22/95 280 Gallon Per Minute Pump Test at the C-Hole Complex. Pre-Test Data also Included.

DTN:GS960108312313.001 TDIF:305143

The subject Data Transmittal Package is being submitted to the YMP GENISES in accordance with YMP Administrative Procedure (YAP)-SIII.3Q, Revision 1, ICN 0. All data have been technically reviewed as required. The category for the TDIF: Subsurface Hydrology (2.2), Fluid Transmitting Properties (2.2.4). The following items are enclosed:

1. Technical Data Information Form, 2p.

2. Explanation, Supporting Information and Disclaimers and Limitations Pages. 2p.

3. Example of the submitted data annotated with parameters and attributes, 1p.

4. Hard Copy of Subject Data. 36p.

5. YMP-USGS Surrogate Record. 2p.

6. One 1/2" diskette containing the subject data in ASCII format.

Please note that the pre-test data included on the TDIF title is not being submitted.

Please capture the annotated supporting information and the abbreviations page in GENISES. If you have any questions, please contact me at (303) 236-0516, X271, or Craig R. Walker at X278.

Sincerely,

Patrick W. McKinley

Patrick W. McKinley
Data Management Coordinator
Yucca Mountain Project Branch
U.S. Geological Survey

PWM:crw
Enclosures
Copy w/o enc. to: C.M. Newbury, DOE/YMP, Las Vegas
S.J. Bodnar, M&O/TRW, Las Vegas
R.W. Craig, USGS, Las Vegas
M.J. Umari, USGS, Denver
J.D. Earle, USGS, Denver
Copy w/ enc. to: Records Processing Center, Las Vegas, Items 3 & 5

United States Department of the Interior

U. S. GEOLOGICAL SURVEY
Box 25046 M.S. 425
Denver Federal Center
Denver, Colorado 80225

IN REPLY REFER TO

May 29, 1997

NON-QA
WBS:1.2.5.3.5

Phill Jones
Technical Data Base Administrator
M&O/TRW
Yucca Mountain Project Office
1180 Town Center Drive
Las Vegas, NV 89134

SUBJECT: Geographic Nodal Information Study and Evaluation System (GENISES) Data Transmittal - 6/12/95 356 **GMP Test in UE-25 C#3 with C#1 and C#2 Packed Off. Test Conducted at the C-Hole Complex.**

DTN:GS960108312313.002 TDIF:305142

The subject Data Transmittal Package is being submitted to the YMP GENISES in accordance with YMP Administrative Procedure (YAP)-SIII.3Q, Revision 1, ICN 0. All data have been technically reviewed as required. The category for the TDIF: Subsurface Hydrology (2.2), Fluid Transmitting Properties (2.2.4). The following items are enclosed:

1. Technical Data Information Form. 2p.

2. Explanation. Supporting Information and Disclaimers and Limitations Pages. 2p.

3. Example of the submitted data annotated with parameters and attributes. 2p.

4. Hard copy of subject data, first and last pages only, 2p.

5. YMP-USGS Surrogate Record, 2p.

6. One 1/2" diskette containing the subject data in ASCII format.

Please capture the annotated supporting information in GENISES. If you have any questions, please contact me at (303) 236-0516, X271, or Craig R. Walker at X278.

Sincerely,

Patrick W. McKinley

Patrick W. McKinley
Data Management Coordinator
Yucca Mountain Project Branch
U.S. Geological Survey

PWM:crw
Enclosures
Copy w/o enc. to: C.M. Newbury, DOE/YMP, Las Vegas
S.J. Bodnar, M&O/TRW, Las Vegas
R.W. Craig, USGS, Las Vegas
M.J. Umari, USGS, Denver
M.F. Fahy, USGS, Denver
Copy w/ enc. to: Records Processing Center, Las Vegas, Items 3 & 5

DRAFT DISCLAIMER

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TRW Environmental
Safety Systems Inc.

1180 Town Center Drive
Las Vegas, NV 89134
702.295.5400

WBS: 1.2.5.7
QA: N/A

Contract #: DE-AC01-91RW00134
LV.TE.JLY.06/97-075

June 18, 1997

Stephan J. Brocoum
Assistant Manager, Licensing
U. S. Department of Energy
Yucca Mountain Site Characterization Office
P.O. Box 30307
North Las Vegas, Nevada 89036-0307

Attention: Technical Publications Management Department

Dear Dr. Brocoum:

Subject: Transmittal of Deliverable, I.D. # SLSR500M, TSPA-VA Peer Review Panel First Interim Letter Report

This letter transmits Planning and Control System (PACS) Deliverable No. SLSR500M that was due for delivery to the U.S. Department on Energy on or before June 20, 1997. This first interim letter report from the Total System Performance Assessment - Viability Assessment (TSPA-VA) peer review panel documents their initial impressions of the plans for TSPA-VA and presents their comments, concerns, conclusions, and recommendations associated with Phase 1 of the peer review.

Phase 1 of the TSPA-VA peer review (conducted February to June 1997) was intended to provide the Panel members with an orientation to TSPA. They were introduced to the high-level radioactive waste program, the Yucca Mountain Site Characterization Office (YMSCO), and the performance assessment program. Panel members became familiar with previous iterations of the TSPA (i.e., TSPA-91, -93, and -95) and other related documents in order to consider the overall scope and approach planned for the TSPA-VA. Individual Panel members, by areas of expertise, attended various abstraction workshops and other pertinent PA interactions. They were provided total access to the information necessary for them to effectively perform their review. Phase 1 of the peer review is concluded by the Panel's issuance of the first interim letter report.

If you have any questions regarding this deliverable, please call Thomas E. Rodgers at 295-4894.

Sincerely,

for Jean E. Younker, Manager
Regulatory Operations
Management and Operating Contractor

Enclosures:
1. TSPA-VA Peer Review Panel First Interim Letter Report
2. Yucca Mountain Site Characterization Project Deliverable Acceptance Review
3. Participant Planning Sheets

cc w/encls:
E. T. Smistad, DOE/YMSCO, Las Vegas, Nevada
A. E. Van Luik, DOE/YMSCO, Las Vegas, Nevada
M. W. Pendleton, M&O, Las Vegas, Nevada
T. E. Rodgers, M&O, Las Vegas, Nevada
J. T. Sullivan, DOE/YMSCO, Las Vegas, Nevada

cc w/o encls:
S. L. Klapproth, M&O, Las Vegas, Nevada
K. K. Shrivastava, M&O, Las Vegas, Nevada