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WBS: 1.2.22.6.3
QA: QA

Civilian Radioactive Waste Management System
Management & Operating Contractor

INFIL
VERSION A_2.a1

VALIDATION TEST REPORT

SAN: SNL-2001-247
STN: 10253-A_2.a1-00
SMN: 10253-DEC-A_2.a1-00
SDN: 10253-VTR-A_2.a1-00

November 2001

Prepared for:

U.S. Department of Energy
Yucca Mountain Site Characterization Office
P.O. Box 30307
North Las Vegas, Nevada 89036-0307

PREPARED BY:

Sandia National Laboratories
Albuquerque, New Mexico 87185

NMSS07
WM-11
Add Darlene Higgs
Melissa Wyatt

DISCLAIMER

Civilian Radioactive Waste Management System
Management & Operating Contractor

INFIL
VERSION A_2.a1

VALIDATION TEST REPORT

SAN: SNL-2001-247
STN: 10253-A_2.a1-00
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SDN: 10253-VTR-A_2.a1-00

Prepared by:

Harold Rizzolino
Independent Validation Tester

11/21/01
Date

Verified:

Noël Simpson
Independent Technical Reviewer

11/21/01
Date

Approved by:

Ron McCurley
Responsible Manager

11/21/2001
Date

Reviewed:

ITSMA
EDWARD MILLER

11/21/01
Date

CHANGE HISTORY

Revision Number	Interim Change No.	Effective Date	Description of Change
0	0	11/21/2001	Initial issue

CONTENTS

ACRONYMS AND ABBREVIATIONS

AMR	Analysis and Model Report
DD	Design Document
DEC	Digital Equipment Corporation
ITP	Installation Test Plan
ITSMA	Information Technology Software Management Analyst
PC	Personal Computer
RD	Requirements Document
SAP	Software Activity Plan
SBRF	Software Baseline Request Form
SNL	Sandia National Laboratories
UM	Users' Manual
USGS	U.S. Geological Survey
VMS	Virtual Memory System (DEC operating system)
VTP	Validation Test Plan
VTR	Validation Test Report

1. SOFTWARE IDENTIFICATION

The software being qualified in this Validation Test Report (VTR) is INFIL Version A_2.a1. It is being qualified on the DEC Alpha platform using the operating system open VMS AXP V7.2-1, at Sandia National Laboratories (SNL).

2. INDEPENDENT VALIDATION TESTERS

While INFIL Version A_2.a1 is the code being qualified, the qualification process depends directly on comparisons of the results of INFIL Version A_2.a1, and the results from the qualified code INFIL Version 2.0 for the same test case. Two independent validation testers participated in this effort.

For INFIL Version A_2.a1, the independent validation tester at SNL is Harold Iuzzolino, whose position is Senior Scientist with GRAM, Inc., contractor to Sandia National Laboratories.

For runs with the qualified code INFIL Version 2.0, the independent validation tester at the M&O in Las Vegas was William E. Tracy who is in the Software Configuration Management organization.

3. SPECIAL TOOLS AND EQUIPMENT

Since the qualified code INFIL Version 2.0 is validated for the PC platform, and INFIL Version A_2.a1 is being qualified for use on the DEC Alpha platform, both computer platforms were used in the qualification effort. Specifics are provided as follows:

PC Platform

Type nomenclature:	Dual Pentium, 600 Mhz running NT 4.0, SP5
Model number:	Dell Precision 420
Serial number:	H6PJ00B, CPU tag # 114902
Location:	YMP, Las Vegas, Nevada, Summerlin Office 504F

DEC Alpha Platform

Type nomenclature:	DEC Alpha with Open VMS AXP 7.2-1 OS
Model number:	Not applicable
Serial numbers:	S712688, S712689, S712690, S715504, S715505, S773104, S778392, S778614, S778615, S794667, S794668, S797512, S797513.
Location:	Sandia National Laboratories, Albuquerque, New Mexico

4. TEST RESULTS LINKED TO THE UNIQUE TEST IDENTIFIER FROM THE VTP

There is one test identified in the VTP. The unique test identifier assigned to that test is **TEST #1.**

5. DOCUMENTATION RESULTS OF ITP AND VTP

This section provides the documentation of the results of the execution of the individual test steps within the ITP and VTP.

5.1 COMPARISON OF OUTPUTS BETWEEN VERSIONS

Table 1 is a comparison between Summary Output results from execution of the code INFIL Version A_2.a1 on the DEC ALPHA using the operating system open VMS AXP V7.2-1 at Sandia National Laboratories and the qualified code INFIL Version 2.0 using Windows NT 4.0 on a PC platform. Table 1 shows the difference in the results to be negligible. Sections 5.12 and 5.13 below show output details.

5.1.1 Results of TEST #1

These listings indicate that the PC (Windows NT) version predicts a net infiltration of 21.305166 and the DEC Alpha (VMS) version predicts a net infiltration of 21.305163. The difference is less than 0.15 parts per million (ppm). This satisfies the acceptance criterion for **TEST # 1** of less than 1 ppm difference.

Table 1. Comparison of Summary Output Results from INFIL Version A_2.a1 and INFIL Version 2.0

Output Parameter	Version		Relative Error
	V A_2.a1	V 2.0	
Precipitation	290.532770	290.532762	2.75356E-08
Rain	233.901757	233.901750	2.99271E-08
Snowfall	56.631013	56.631012	1.76582E-08
Snow-cover	631.284972	631.285751	1.23399E-06
Snow-melt	50.640619	50.640612	1.38229E-07
Sublimation	5.261948	5.261954	1.14026E-06
Potential Evapotranspiration	832.586015	832.585923	1.10499E-07
Actual Evapotranspiration	262.509388	262.509371	6.47596E-08
Change in Soil Moisture	0.727825	0.727825	0
*Net Infiltration**	21.305163	21.305166	1.40811E-07
Runoff Generation	0.690760	0.690760	0
Cumulative Daily Run-on	0.094091	0.094091	0

NOTE: Net Infiltration is the output parameter of importance.

5.1.2 Output from INFIL Version A_2.a1

Summary Output Produced on DEC Alpha platform running Open VMS AXP V7.2-1

```
INFIL2a1.ctl: Solitario East, Tule Lake, se10-2a1-gm1-k2-w20 (11/18/1999)
Daily precipitation input:          Tulelake.inp
Watershed modeling domain parameters:  se10.w20
Average daily mass balance terms:    se10-gm1.2a1
24-hour mass balance map:          se10-gm1.2a2
Annual mass balance map:           se10-gm1.1
Average annual mass balance map:    se10-gm1.2a4
```

Summary statistics output: se10-gm1.2a3
Debugging output: se10-gm1.2a5
Total number of days read in = 12053
Total daily precip = 9660.7
Average annual precip (mm) = 292.8
Maximum daily precip (mm) = 51.3
TOTAL NUMBER OF LOCATIONS = 69
AVERAGE ELEVATION OF SAMPLE = 1339.3
MAXIMUM ELEVATION OF SAMPLE = 1377.0
MINIMUM ELEVATION OF SAMPLE = 1301.0
AVERAGE SOIL DEPTH (M) = 2.124
AVERAGE SLOPE OF SAMPLE = 12.8
MAXIMUM SLOPE OF SAMPLE = 23.0
NUMBER OF ACTIVE LOCATIONS = 17

Yr	Dy	Precip	Rain	Snow	Sn-cover	Snowmelt	Sublim	PET	PETRS	Evapotrs	Del-soil	Net-inf	Runoff	Out-flow	Mass-balance
1950	365	288.823	218.232	70.591	432.356	60.488	5.658	835.723	663.272	242.653	36.067	0.000	0.000	0.000	-0.896813276E-10
1951	365	212.451	120.978	91.473	736.623	54.355	7.819	842.857	668.934	194.543	-19.922	0.711	0.000	0.000	-0.670113706E-09
1952	366	271.664	232.269	39.395	354.124	64.979	4.581	812.532	644.867	292.275	-8.315	13.289	0.000	0.000	-0.118735058E-08
1953	365	367.872	313.935	53.937	178.650	51.584	5.932	799.670	634.659	315.938	37.982	11.599	0.000	0.000	-0.161001923E-08
1954	365	212.451	135.956	76.495	495.140	53.006	7.244	813.631	645.739	223.574	-55.092	20.480	0.000	0.000	-0.254417724E-08
1955	365	254.902	127.629	127.273	1372.195	91.170	8.873	832.747	660.911	156.121	58.930	3.748	0.000	0.000	-0.116435381E-09
1956	366	310.147	281.781	28.367	1903.177	65.457	6.385	828.810	657.786	324.945	-38.969	61.261	8.775	0.000	-0.183099313E-08
1957	365	381.163	363.570	17.592	37.571	15.850	1.742	845.560	671.079	327.175	36.173	16.072	0.000	0.000	-0.249317704E-08
1958	365	341.291	301.092	40.198	154.009	29.814	3.133	818.516	649.616	358.730	-51.929	24.106	0.000	0.000	-0.363462775E-08
1959	365	120.607	110.988	9.619	86.665	14.498	2.372	862.267	684.339	156.361	-30.875	0.000	0.000	0.000	-0.408099911E-08
1960	366	282.276	271.893	10.384	33.734	8.881	1.503	845.880	671.334	218.626	61.323	0.826	0.000	0.000	-0.741168510E-10
1962	365	338.712	312.850	25.862	224.619	22.460	3.402	830.644	659.242	267.587	36.307	31.416	0.176	0.000	-0.634508074E-09
1963	365	233.379	179.558	53.821	1076.487	39.313	9.210	811.546	644.085	260.099	-53.651	12.423	0.000	0.000	-0.143827826E-08
1964	366	378.187	225.224	152.963	1169.237	47.514	4.296	825.651	655.279	254.243	14.771	3.723	0.000	0.000	-0.201924445E-08
1966	365	232.387	189.844	42.543	2289.880	128.425	9.780	843.435	669.393	229.022	41.116	48.131	0.000	0.000	-0.403216082E-08
1967	365	206.302	174.810	31.492	232.016	38.340	3.713	852.245	676.385	279.375	-83.650	17.425	0.000	0.000	-0.648956358E-09
1968	366	290.905	277.997	12.908	34.296	10.462	2.565	839.402	666.192	247.988	40.471	0.000	0.000	0.000	-0.852496186E-09
1969	365	333.356	234.815	98.541	1113.232	29.055	4.130	845.652	671.152	264.208	-17.865	17.527	0.000	0.000	-0.138001286E-08
1970	365	258.175	179.126	79.049	1328.668	124.590	8.793	833.578	661.570	228.047	30.552	45.117	1.920	0.000	-0.350565337E-08
1971	365	281.384	242.377	39.006	323.340	45.848	4.291	836.134	663.598	291.648	-13.915	10.492	0.000	0.000	-0.431267944E-08
1974	365	167.323	131.266	36.057	171.037	31.414	4.643	837.322	664.541	187.377	-26.855	2.157	0.000	0.000	-0.259751234E-09
1975	365	267.498	230.968	36.530	91.871	31.777	4.753	830.917	659.458	262.708	-3.118	3.155	0.000	0.000	-0.708225371E-09
1976	366	227.329	194.598	32.731	545.162	27.352	5.379	822.342	652.653	241.625	-19.755	0.080	0.000	0.000	-0.103352604E-08
1977	365	313.618	235.905	77.713	498.200	31.490	3.201	834.295	662.139	230.039	37.357	0.000	0.000	0.000	-0.137197357E-08
1978	365	257.877	208.165	49.713	721.268	87.363	5.371	849.230	673.992	271.385	-17.794	41.937	0.000	0.000	-0.283669747E-08
1979	365	313.519	282.240	31.280	67.986	29.239	2.041	843.151	669.167	227.781	69.200	14.497	0.000	0.000	-0.261695151E-09
1980	366	257.877	237.226	20.651	128.283	18.391	2.150	857.524	680.574	289.409	-69.175	35.383	0.299	0.000	-0.280423179E-08
1981	365	390.486	276.116	114.370	406.011	72.334	8.066	814.972	646.803	254.882	71.770	21.798	0.000	0.000	-0.366651546E-08
1982	365	328.694	297.352	31.342	446.031	55.426	4.752	816.770	648.230	346.565	-25.551	31.765	0.000	0.000	-0.594888706E-08
1983	365	450.889	307.306	143.583	1341.380	70.336	8.617	813.936	645.981	297.566	29.337	50.739	0.464	0.000	-0.843875677E-08
1987	365	238.933	199.277	39.656	1924.282	94.977	7.509	848.007	673.021	294.840	-52.029	51.443	5.062	0.000	-0.210783399E-08
1995	365	412.604	368.866	43.738	277.639	46.667	4.115	824.088	654.038	312.516	50.800	52.217	0.237	0.000	-0.439056246E-08
1996	366	364.301	254.389	109.912	636.803	78.251	7.623	825.734	655.345	312.781	-39.681	59.540	5.863	0.000	-0.763445402E-08

Global Summary Statistics (mm/year):

```
Precipitation..................      290.532770
Rain...........................      233.901757
Snowfall.......................       56.631013
Snow-cover.....................      631.284972
Snow-melt......................       50.640619
Sublimation....................        5.261948
Potential Evapotranspiration....     832.586015
Actual Evapotranspiration.......     262.509388
Change in Soil Moisture.........       0.727825
Net Infiltration................      21.305163
Runoff Generation...............       0.690760
Cumulative Daily Run-on.........       0.094091
Outflow.........................       0.000000
Average Mass Balance Error......   -0.264155E-12
Average Max Daily Error (mm/dy).   -0.386456E-13
```

5.1.3 Output from INFIL Version 2.0

Summary Output File Produced on PC Platform using Windows NT 4.0

INFIL2a1.ctl: Solitario East, Tule Lake, se10-2a1-gm1-k2-w20 (11/18/1999)
Daily precipitation input: Tulelake.inp
Watershed modeling domain parameters: se10.w20
Average daily mass balance terms: se10-gm1.2a1
24-hour mass balance map: se10-gm1.2a2
Annual mass balance map: se10-gm1.1
Average annual mass balance map: se10-gm1.2a4
Summary statistics output: se10-gm1.2a3
Debugging output: se10-gm1.2a5

Total number of days read in - 12053
Total daily precip - 9660.7
Average annual precip (mm) - 292.8
Maximum daily precip (mm) - 51.3

TOTAL NUMBER OF LOCATIONS - 69
AVERAGE ELEVATION OF SAMPLE - 1339.3
MAXIMUM ELEVATION OF SAMPLE - 1377.0
MINIMUM ELEVATION OF SAMPLE - 1301.0
AVERAGE SOIL DEPTH (M) - 2.124
AVERAGE SLOPE OF SAMPLE - 12.8
MAXIMUM SLOPE OF SAMPLE - 23.0
NUMBER OF ACTIVE LOCATIONS - 17

Yr	Dy	Precip	Rain	Snow	Sn-cover	Snowmelt	Sublim	PET	PETRS	Evapotrs	Del-soil	Net-inf	Runoff	Out-flow	Mass-balance
1950	365	288.823	218.232	70.591	432.356	60.488	5.658	835.723	663.272	242.653	36.067	0.000	0.000	0.000	0.175624822E-09
1951	365	212.451	120.978	91.473	736.625	54.355	7.819	842.857	668.934	194.543	-19.922	0.711	0.000	0.000	0.218118841E-09
1952	366	271.664	232.269	39.395	354.124	64.979	4.581	812.532	644.867	292.275	-8.315	13.289	0.000	0.000	0.192151030E-09
1953	365	367.872	313.935	53.937	178.650	51.584	5.932	799.670	634.659	315.938	37.982	11.599	0.000	0.000	0.263993153E-09
1954	365	212.451	135.956	76.495	495.141	53.006	7.244	813.631	645.739	223.574	-55.092	20.480	0.000	0.000	0.241319896E-09
1955	365	254.902	127.629	127.273	1372.197	91.170	8.873	832.747	660.910	156.121	58.930	3.748	0.000	0.000	-0.112246360E-09
1956	366	310.147	281.781	28.367	1903.180	65.457	6.385	828.810	657.786	324.945	-38.969	61.261	8.775	0.000	-0.156601933E-09
1957	365	381.162	363.570	17.592	37.572	15.850	1.742	845.560	671.079	327.175	36.173	16.072	0.000	0.000	-0.164860299E-09
1958	365	341.291	301.092	40.198	154.009	29.814	3.133	818.516	649.616	358.730	-51.929	24.106	0.000	0.000	0.444154606E-10
1959	365	120.607	110.988	9.619	86.666	14.498	2.372	862.267	684.339	156.361	-30.875	0.000	0.000	0.000	0.187447951E-09
1960	366	282.276	271.893	10.384	33.734	8.881	1.503	845.880	671.334	218.626	61.323	0.826	0.000	0.000	-0.364036219E-10
1962	365	338.712	312.850	25.862	224.620	22.460	3.402	830.644	659.241	267.587	36.307	31.416	0.176	0.000	0.156433114E-09
1963	365	233.379	179.558	53.821	1076.488	39.313	9.210	811.546	644.084	260.099	-53.651	12.423	0.000	0.000	0.137249349E-09
1964	366	378.187	225.224	152.963	1169.237	47.514	4.296	825.651	655.279	254.243	14.771	3.723	0.000	0.000	0.531510373E-10
1966	365	232.387	189.844	42.543	2289.883	128.425	9.780	843.435	669.393	229.022	41.116	48.131	0.000	0.000	-0.619987124E-10
1967	365	206.302	174.810	31.492	232.017	38.340	3.713	852.245	676.385	279.375	-83.650	17.425	0.000	0.000	0.923037274E-10
1968	366	290.905	277.997	12.908	34.296	10.462	2.565	839.402	666.192	247.988	40.471	0.000	0.000	0.000	0.614522354E-10
1969	365	333.356	234.815	98.541	1113.233	29.055	4.130	845.652	671.152	264.208	-17.865	17.527	0.000	0.000	0.656519736E-10
1970	365	258.175	179.126	79.049	1328.669	124.590	8.793	833.578	661.570	228.047	30.552	45.117	1.920	0.000	-0.883941765E-10
1971	365	281.384	242.377	39.006	323.340	45.848	4.291	836.133	663.598	291.648	-13.915	10.492	0.000	0.000	-0.168360502E-09
1974	365	167.323	131.266	36.057	171.037	31.414	4.643	837.322	664.541	187.377	-26.855	2.157	0.000	0.000	-0.687992874E-10
1975	365	267.498	230.968	36.530	91.871	31.777	4.753	830.917	659.458	262.708	-3.118	3.155	0.000	0.000	-0.182410852E-09
1976	366	227.329	194.598	32.731	545.162	27.352	5.379	822.342	652.653	241.625	-19.755	0.080	0.000	0.000	-0.218551604E-09
1977	365	313.618	235.905	77.713	498.201	31.490	3.201	834.295	662.139	230.039	37.357	0.000	0.000	0.000	-0.180917354E-09
1978	365	257.877	208.165	49.713	721.270	87.363	5.371	849.229	673.992	271.385	-17.794	41.937	0.000	0.000	-0.114093109E-09
1979	365	313.519	282.240	31.280	67.986	29.239	2.041	843.151	669.167	227.781	69.200	14.497	0.000	0.000	0.100798462E-09
1980	366	257.877	237.226	20.651	128.283	18.391	2.150	857.524	680.574	289.409	-69.175	35.383	0.299	0.000	0.193833364E-09
1981	365	390.486	276.116	114.370	406.012	72.334	8.066	814.972	646.803	254.882	71.770	21.798	0.000	0.000	0.557352754E-10
1982	365	328.694	297.352	31.342	446.031	55.426	4.752	816.770	648.230	346.565	-25.551	31.765	0.000	0.000	-0.160379148E-09
1983	365	450.889	307.306	143.583	1341.381	70.336	8.617	813.935	645.981	297.566	29.337	50.739	0.464	0.000	-0.492668107E-09
1987	365	238.933	199.277	39.656	1924.285	94.977	7.509	848.007	673.021	294.840	-52.029	51.443	5.062	0.000	-0.710995995E-10
1995	365	412.604	368.866	43.738	277.639	46.667	4.115	824.088	654.038	312.516	50.800	52.217	0.237	0.000	-0.251104930E-09
1996	366	364.301	254.389	109.912	636.804	78.251	7.623	825.734	655.345	312.781	-39.681	59.540	5.863	0.000	-0.259870723E-09

```
Global Summary Statistics (mm/year):
------------------------------------------------

Precipitation..................     290.532762
Rain...........................     233.901750
Snowfall.......................      56.631012
Snow-cover.....................     631.285751
Snow-melt......................      50.640612
Sublimation....................       5.261954
Potential Evapotranspiration....    832.585923
Actual Evapotranspiration.......    262.509371
Change in Soil Moisture.........      0.727825
Net Infiltration................     21.305166
Runoff Generation...............      0.690760
Cumulative Daily Run-on.........      0.094091
Outflow.........................      0.000000
Average Mass Balance Error......  -0.998939E-13
Average Max Daily Error (mm/dy).  -0.109569E-13
```

6. INDICATION OF PASS/FAIL

Code INFIL Version A_2.a1 passed the installation and validation tests.

6.1 INSTALLATION TEST

In the ITP, the user is required to check that that the output file designated in the model control file is created, and that the results provided in that output file match the results contained in Attachment A of the ITP.

The installation test produced output file SE10-GM1.2A3. That is the correct output file as specified in the model control file. As required by the ITP, the file contents matched the file listed in Attachment A of the ITP; therefore, the installation was successful.

6.2 VALIDATION TEST

As specified in the VTP, the code is required to read data from the model control file. Using these data, the code is required to read specified input files, calculate the net infiltration rate and provide output data to a file specified in the model control file. Meeting the acceptance criterion when comparing output files from INFIL Version 2.0 and INFIL Version A_2.a1 shows that requirements are met. The acceptance criterion is that the resulting net mean infiltration rate is different by less than 1 part in a million (i.e., have a relative error less that 10E-6)

The net infiltration rates from Version 2.0 on the PC platform and Version A_2.a1 on the DEC Alpha (VMS) platform differ by less than 1 part per million; therefore, the validation test was successful. See Section 5.11 above for details of the test.

6.3 TEST LOG

6.3.1 Installation Test

Passed (circled)   Failed   Initials HNJ   Date 11/21/01

Initialed for Harold Iuzzolino by Hong-Nian Jow

initialed for Harold Iuzzolino

6.3.2 Validation test

by Hong-Nian Jow

Passed   Failed   Initials HNJ   Date 11/21/01

7. DESCRIPTION OF FAILURE CONDITIONS, OCCURRENCE, RESOLUTION

Not applicable. The execution of all installation and validation tests was satisfactory.

8. OVERALL CONCLUSIONS

INFIL Version A_2.a1 passed all of the installation and validation tests. Comparisons with the output of the qualified code INFIL Version 2.0 meet the acceptance criterion specified in the VTP. Due to the limited use of INFIL Version A_2.a1 in the AMR ANL-NBS-HS-000027 Rev 00 (Analysis of Infiltration Uncertainty) there are restrictions on the validation of INFIL Version A_2.a1. These are discussed below in Section 11 of this VTR.

9. DOCUMENTATION AND JUSTIFICATION OF REMAINING TEST EXCEPTIONS OR FAILURES

Not applicable. The execution of all installation and validation tests was satisfactory.

10. SUMMARY OF UNIT TESTING

Not applicable. No unit testing was necessary for this qualification effort.

11. GENERAL REMARKS

As noted above, the use of INFIL VERSIONA_2.a1 in the "Analysis of Infiltration Uncertainty" AMR was limited to calculations of spatially averaged infiltration rates over watersheds located in the region of the repository footprint. Since this information was used, for the uncertainty analysis of infiltration, directly with infiltration rates calculated by INFIL VERSION2.0 for AMR "Simulation of Net Infiltration for Modern and Potential Future Climates", it was required that INFIL VERSIONA_2.a1 produce equivalent infiltration rate results over this region. The modifications resulting in the differences in these two versions were made so that the code would execute successfully on the computer platform used and satisfy the requirement above. A 'diff' was run on INFIL Version 2.0 and INFIL Version A_2.a1. The only difference of substance between the two codes is that in INFIL Version 2.0 the parameter OPTMASSB is read as input, in INFIL Version A_2.a1 this parameter is hardwired to be 1. In order to account for this difference when comparing output of the two codes, OPTMASSB is set to 1 in the input control file for INFIL Version 2.0 before running the comparison test. The remaining differences between the code are cosmetic in nature (changes in comment lines), and to account for platform dependent differences in file open statements.

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
SOFTWARE BASELINE REQUEST
Complete Only Applicable Items

QA: QA

1. Software Tracking Number:	2. Software Name and Version:	3. Software Activity Number:
10396-2.3-00	TOUGHREACT V. 2.3	LBNL-2000-242

SECTION I - Software Activity Designation (Description of software project [users of software, user location, CPU and platform identification]

This activity will consist of the unqualified use planning, testing and close-out documentation of ~~T~~OUGHREACT V2.3. The qualified version of this code will be designated as TOUGHREACT V 2.4 in order to differentiate the versions. The qualification of TOUGHREACT V2.4 will be accomplished under another activity.

End Users: Nicolas Spycher, Eric Sonnenthal, Tianfu Xu, Patrick Dobson

Computer Platform: SUN and DEC-Alpha with UNIX

User Location: Lawrence Berkeley National Laboratory (LBNL) Computer Platform ID: Unknown

SECTION II - Software Identification (Supplier/Source Name, Address, and Point of Contact and Telephone number (if available):

5. Source:

☐ Acquired

x☐ Developed or Modified

6. Media Number: 10396-MED-2.3-00 (unqualified)

Media Type: ☐ Tape - Specify x☐ CD ROM

☐ Disk - Specify ☐ Other

Software Baseline Documentation Numbers:

7. Title and version number:		Number:
TOUGHREACT V. 2.3	Software Grading Classification	1 x☐ 2 ☐ 3 ☐
TOUGHREACT V. 2.3	☐ SMR or x☐ SAP	10396-SAP-2.3-00
TOUGHREACT V2.4	☐ SDR or ☒ RD	10396-RD-2.4-00
TOUGHREACT V2.4	DD	10396-DD-2.4-00
TOUGHREACT V2.4	ITP	10396-ITP-2.4-00
TOUGHREACT V2.4	VTP	10396-VTP-2.4-00
TOUGHREACT V2.4	☐ SIR or ☒ UM	10396-UM-2.4-00
TOUGHREACT V2.4	VTR	10396-VTR-2.4-00
	~~VTR~~ (initials) 10/31/01	

8. Responsible Manager Name:	Responsible Managers Organization:	Date:
Nick Spycher	Lawrence Berleley National Laboratory	10/23/01

9. Software Configuration Management (SCM) Name:	Date:
Jeff Mason	10/26/2001
10. ITSMA Representative Name:	**Date:**
Lyle Southworth	10/26/2001

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
SOFTWARE BASELINE REQUEST
Complete Only Applicable Items

QA: QA

1. Software Tracking Number:	2. Software Name and Version:	3. Software Activity Number:
10396-2.3-00	TOUGHREACT V. 2.3	LBNL-2000-242

11. x☐ **SECTION III - Control Point 1, Planning and Requirements and Design Phase Baselining**

12. ☐ **SECTION IV - Control Point 2, Implementation and Validation Phase Baselining**

- X☐ Add to Baseline
- ☐ Change to Baseline
- ☐ Superseded by Previous Version
- ☐ Retire from Baseline
- ☐ Canceled from Baseline
- ☐ Remove from Baseline

13. Description of Baseline Activity:

This SBRF is intended to bring closure to the unqualified use of this code at LBNL. This package includes the submittal of the Record-Copy of the unqualified use SAP and close-out testing documentation for TOUGHREACT V2.3 in accordance with Section 5.10.3.e of AP-SI.1Q, Rev.3, ICN1.

14. Rationale for Baseline Activity:

This work is required in support of the YMP Analysis and Modeling Report (AMR) N0120/U0110, *Drift Scale Coupled Processes (DST,THC Seepage) Models* (MDL-MNBS-HS-000001), Rev.01 and Rev.01, ICN1. The work is authorized under Work Package number 4301213UMH as part of the TWP for UZ Flow and Transport Report, TWP-NBS-HS-000001, Rev.00. As prescribed in the unqualified use SAP (record-copy attached), comparison testing was performed to determine the impact of using the unqualified software. The attached SBRF continuation page documents this testing.

15. Request the Following Documents to be Controlled:

1) SBRF for SAP, 10396-SAP-2.3-00
2) SBRF Continuation Page -Comparison of Unqualified TOUGHREACT V2.3 with Qualified TOUGHREACT V2.4
3) Record-copy of unqualified use SAP, 10396-SAP-2.3-00
4) Resubmittal of media 10396-MED-2.3-00 for TOUGHREACT V2.3

16. Remarks: Such as Known Copyright and License Issues, Abstract etc:

Uses proprietory Harwell subroutine MA28. LBNL has purchased limited rights for the use of this software by YMP staff. The specific provisions of this agreement are in the LBNL-AEA Technology Engineering Software Ltd. License agreement which was submitted to SCM on August 17, 2001.

Justification for the differences that exist between TOUGHREACT V2.3 and TOUGHREACT V2.4 is included on the attached SBRF Continuation Page.

Name	Signature	Date
17. Responsible Manager Name and Organization: Nicolas Spycher, LBNL	Responsible Manager Signature: [signature]	Date: 10/24/01
18. ITSMA Representative Name: Lyle Southworth	ITSMA Representative Signature: [signature]	Date: 10/26/01
19. SCM Representative Name: Jeff Mason	SCM Representative Signature: [signature]	Date: 10/26/2001
20. Software Management Name: Steve Splawn	Software Management Signature: [signature]	Date: 10/26/01

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
SOFTWARE BASELINE REQUEST

Complete Only Applicable Items

1. Software Tracking Number:	2. Software Name and Version:	3. Software Activity Number:
10396-2.3-00	TOUGHREACT V. 2.3	LBNL-2000-242

SECTION V - Software Baselining and Release for Use

21. Remarks:

It is intended that TOUGHREACT V2.3 be baselined and then immediately retired.

Baseline Approved
Date/Int.: 10/26/01 [initials]
AP-SI.1Q Rev. 3
eff. 04/01/01
Level: (1) 2 3

22. Disposition:

- [X] Approved
- [ ] Rejected
- [ ] Canceled
- [ ] Removed
- [X] Retired
- [ ] Disapproved
- [ ] Change to Baseline
- [ ] Superseded by Previous version
- [ ] Removed for use by Software Defect Notification
- [ ] Software Defect Notification Resolved Approved for use

23. SCM Status Accounting Name: Jeff Mason	SCM Status Accounting Signature: [signature]	Date: 10/26/2001
24. SQA Software Verification Name: Lyle C. Southworth	SQA Software Verification Signature: [signature]	Date: 10/26/01
25. SCM Library Baseline Elements Processed Date: 10/26/2001		
26. Software Management Manager Name: Steve Splawn	Software Management Manager Signature: [signature]	Date: 10/24/01

The unqualified version of TOUGREACT V2.3 that was submitted to Software Configuration Management (SCM) by LBNL on 11/17/00 (an updated UnQ media was subsequently submitted on 5/30/01) was used to support two separate modeling activities: 1) Analysis/Model Report (AMR) N0120/U0110 (MDL-NBS-HS-000001), *Drift-Scale Coupled Processes (DST, THC Seepage) Models,* Rev.01, and Rev.01, ICN1, and 2) FY01 Supplemental Science and Performance Analyses (SSPA) Report, Volume 1 (TDR-MGR-MD-000007), Rev.00. An upgraded, qualified, TOUGHREACT V2.4 of the software has since been baselined, obtained from SCM and installed on all applicable machines at LBNL. As outlined in the Interim Unqualified Use Software Activity Plan (SAP) for TOUGHREACT V2.3 (Software Activity Number [SAN]: LBNL-2000-242), the following comparison testing was performed to determine the impact of using unqualified software prior to full qualification.

This write up is broken into three sections: 1.0 Summary of Unqualified Use and Impact, 2.0 Validation Criteria, and 3.0 Validation Testing and Results

1.0 Summary of Unqualified Use and Impact

The unqualified TOUGHREACT V2.3 has been tested against the qualified TOUGHREACT V2.4 by Nicolas Spycher. The unqualified version of TOUGHREACT V2.3 was used for simulations (cases without backfill) presented in AMR N0120/U0110, Rev.01 and Rev.01/ICN1, and all post-Rev.01, ICN1 THC simulations in the SSPA report. These simulations include all the post-Rev.00 Drift Scale Test and THC seepage simulations (no-backfill scenario and repository host units in either the middle non-lithophysal hydrogeologic unit (Tptpmn) or lower lithophysal hydrogeologic unit (Tptpll) of the Tpopopah Spring Tuff were used).

Changes made to TOUGHREACT V2.4 since V2.3, affected primarily new features not used in the AMR or SSPA-related work. In this respect, results of original V2.3 simulations presented in AMR and SSPA-related work should be similar to reruns with V2.4, within ranges discussed below.

The method for weighting thermal conductivities between matrix and fractures was originally changed in V2.3, compared to older versions, but was then changed back in V2.4 to the same method used in pre-V2.3 versions for consistency with currently qualified TOUGH2 modules. For this reason, reruns of V2.3 simulations using V2.4 will yield slightly different predicted temperatures (within a couple degrees). This will have some effect on predicted liquid saturations and fluid chemistries, most primarily in near-dryout conditions. Another anticipated difference between V2.3 and V2.4 relates to water density. Water compositions output by V2.4 are in mol/l (molar) and are converted from mol/kg (molal) taking into account the true water density, which departs from 1 l/kg at elevated temperatures (e.g. ~0.95 l/kg at 100 C). In V2.3, the conversion from molality to molarity assumes a solution density of 1 l/kg. Other significant differences in results between V2.3 and V2.4 are not anticipated. It should be noted that the unqualified V2.3 of the software was validated (but not qualified) against measured data from the Drift Scale Test and laboratory experiments, with results presented in AMR N0120/U0110, Rev.01 and Rev.01, ICN1.

2.0 Validation Criteria

Given the considerations discussed in Section 1.0 above, the criteria for validating the unqualified TOUGHREACT V2.3 against the qualified V2.4 were established as follows:

(1) Rerun with V2.4 one complete THC seepage simulation presented in AMR N0120/U0110 or the SSPA report.

Here we choose the high-temperature simulation *thc6_ht1* discussed in Section 6.3 of the SSPA report because this simulation:

a) Covers the typical temperature and liquid saturation ranges simulated to date for the Yucca Mountain project

b) Takes into account all complex coupled THC processes simulated to date for the project

c) Uses the same setup as another high-temperature THC seepage simulation (*thc6_16_25_g4)* presented in Section 6.6 of AMR N0120/U0110, Rev.01, and Rev.01, ICN1, thus providing validation of the AMR work in addition to the SSPA work.

This simulation considers a waste-emplacement drift in the main repository host unit (Tptpll) at a location near the center of the repository.

(2) Plot time profiles for pH, CO2 gas, aqueous species, and temperature, liquid saturation and other THC parameters such as those presented in AMR N0120/U0110 Rev.01and Rev.01, ICN1 and in Section 6.3 of the SSPA report, and compare with results of V2.3. These plots are for points located at the crown, side, and base of the drift and cover a 100,000-year time window.

(3) Verify that predicted temperature and liquid saturation profiles are similar between V2.3 and V2.4, within ranges that can be accounted for by the difference in thermal conductivity calculations between versions (in this case, no more than 5% difference in temperatures, liquid saturations, or air mass fractions). Note that for saturations directly following or preceding dryout, greater differences could possibly occur due to the temperature difference.

(4) Verify that predicted trends and values of CO2 and aqueous species concentrations are similar between versions. Because of the slightly different temperatures computed with V2.3 and V2.4, and their effect on liquid saturations near dryout conditions, a rigorous criteria for acceptance cannot be established. Nevertheless, concentrations should be within an order of magnitude (within the model uncertainty), and trends should be nearly identical. Note that the model uncertainty cannot be quantified exactly because of the large number of uncertain input parameters.

3.0 Validation Testing and Results

Steps 1 though 4 in Section 2.0 were performed. Time profiles for various predicted THC parameters such as temperature, liquid saturation, CO2 gas concentrations, pH, and

aqueous species concentrations were generated for a time window of 100,000 years (covering the range of data presented in AMR N0120/U0110 and in the SSPA report) (Figures 1 through 12). Profiles calculated with the unqualified version (labeled V2.3) and with the qualified version (labeled V2.4) were plotted on the same graphs for comparison. Blank parts on some of the curves indicate times of dryout when no water is present; values on these curves are shown to indicate the first output saturation after rewetting. There are slight differences in predicted temperatures, liquid saturations, and air mass fractions (Figures 1 to 4), but these do not generally exceed 5 %, except at the time of rewetting because this time changes somewhat due to the change in thermal conductivity weighting discussed in Section 1. A difference in liquid saturations greater than 5% is noticeable for one point at the drift crown at 100,000 years on Figure 2 (fractures only). Such difference can easily be caused by slight differences in precipitated minerals amounts and has no significance on predicted water compositions. Small differences exist in predicted concentrations of CO_2 and aqueous species because of the slight difference in predicted temperatures mentioned in Section 1 (Figures 5 to 12). These differences are mostly observed directly preceding or following dryout conditions. These differences remain within the model uncertainty and criteria established in Section 2.0. Therefore, it can be concluded that simulations with unqualified V2.3 are verified with the qualified V2.4 and, for this reason, a full impact analysis (as per step 3.2 in the SAP) is not required.

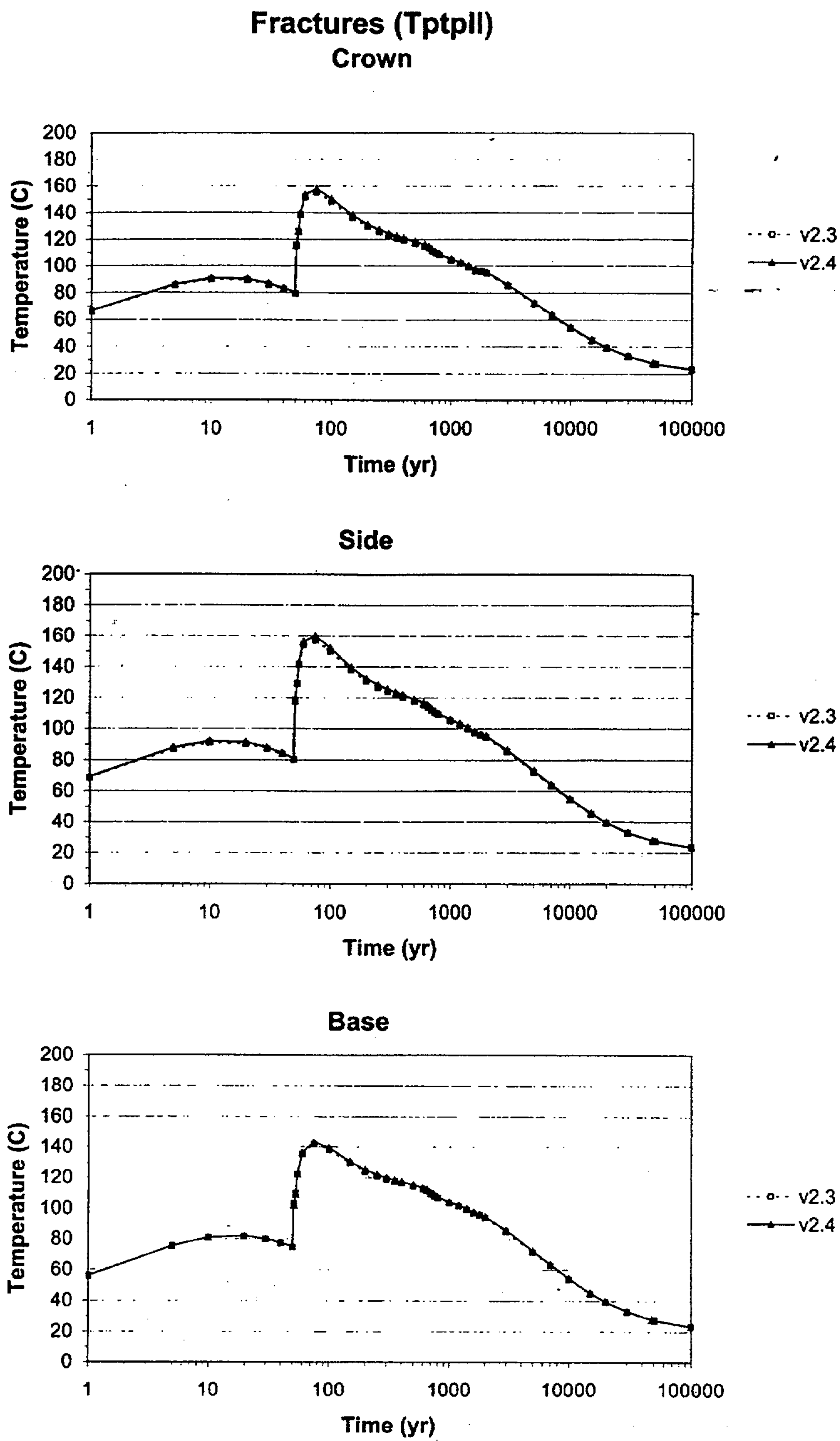

Fractures (Tptpll)
Crown
Temperature (C)
Time (yr)
v2.3
v2.4
Side
Temperature (C)
Time (yr)
v2.3
v2.4
Base
Temperature (C)
Time (yr)
v2.3
v2.4

Figure1

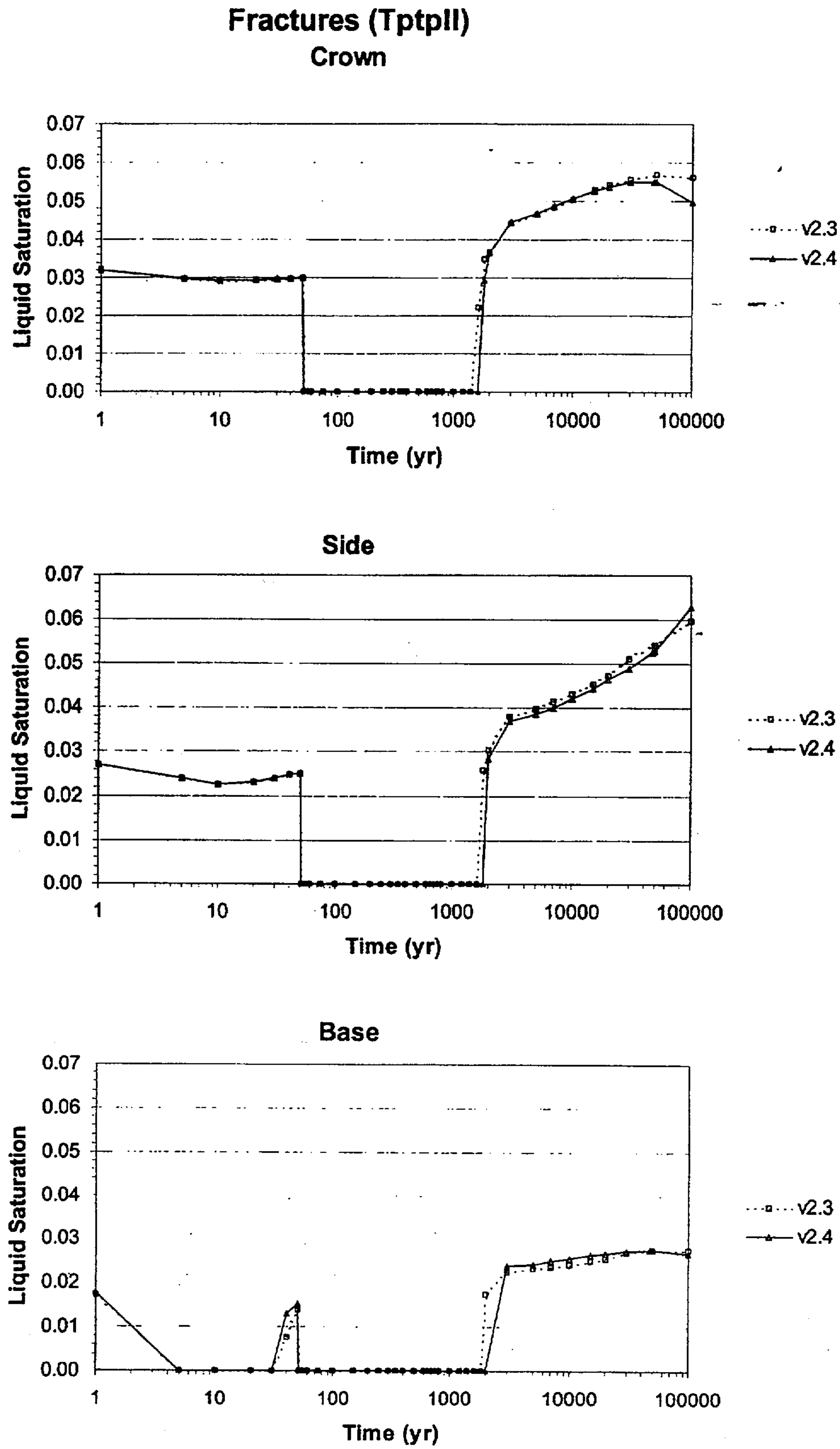

Fractures (TptpII)
Crown
Liquid Saturation
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
1
10
100
1000
10000
100000
Time (yr)
v2.3
v2.4
Side
Liquid Saturation
Time (yr)
v2.3
v2.4
Base
Liquid Saturation
Time (yr)
v2.3
v2.4

Figure 2

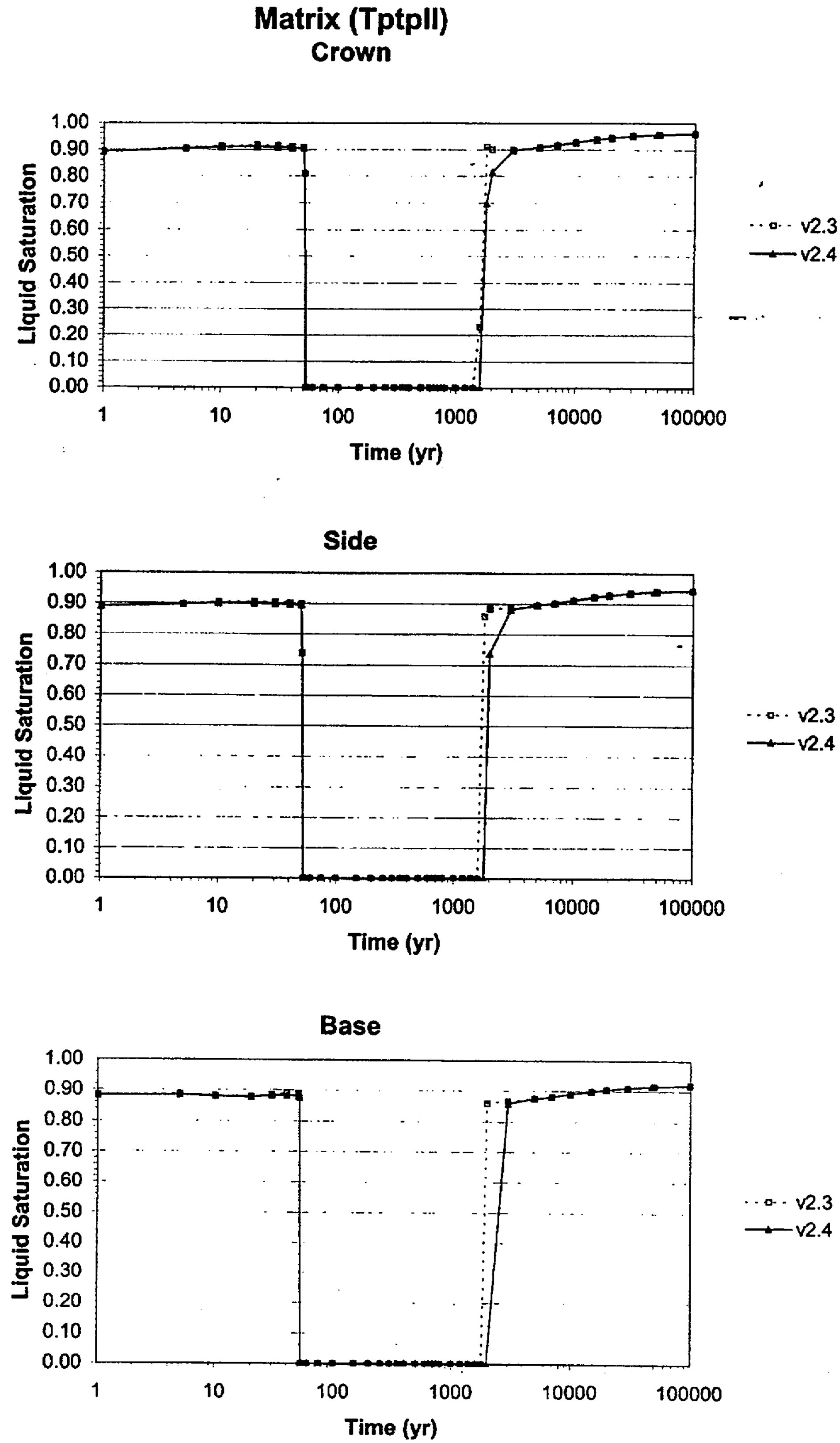

Matrix (Tptpll)
Crown
Liquid Saturation
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1
10
100
1000
10000
100000
Time (yr)
v2.3
v2.4
Side
Liquid Saturation
Time (yr)
v2.3
v2.4
Base
Liquid Saturation
Time (yr)
v2.3
v2.4

Figure 3

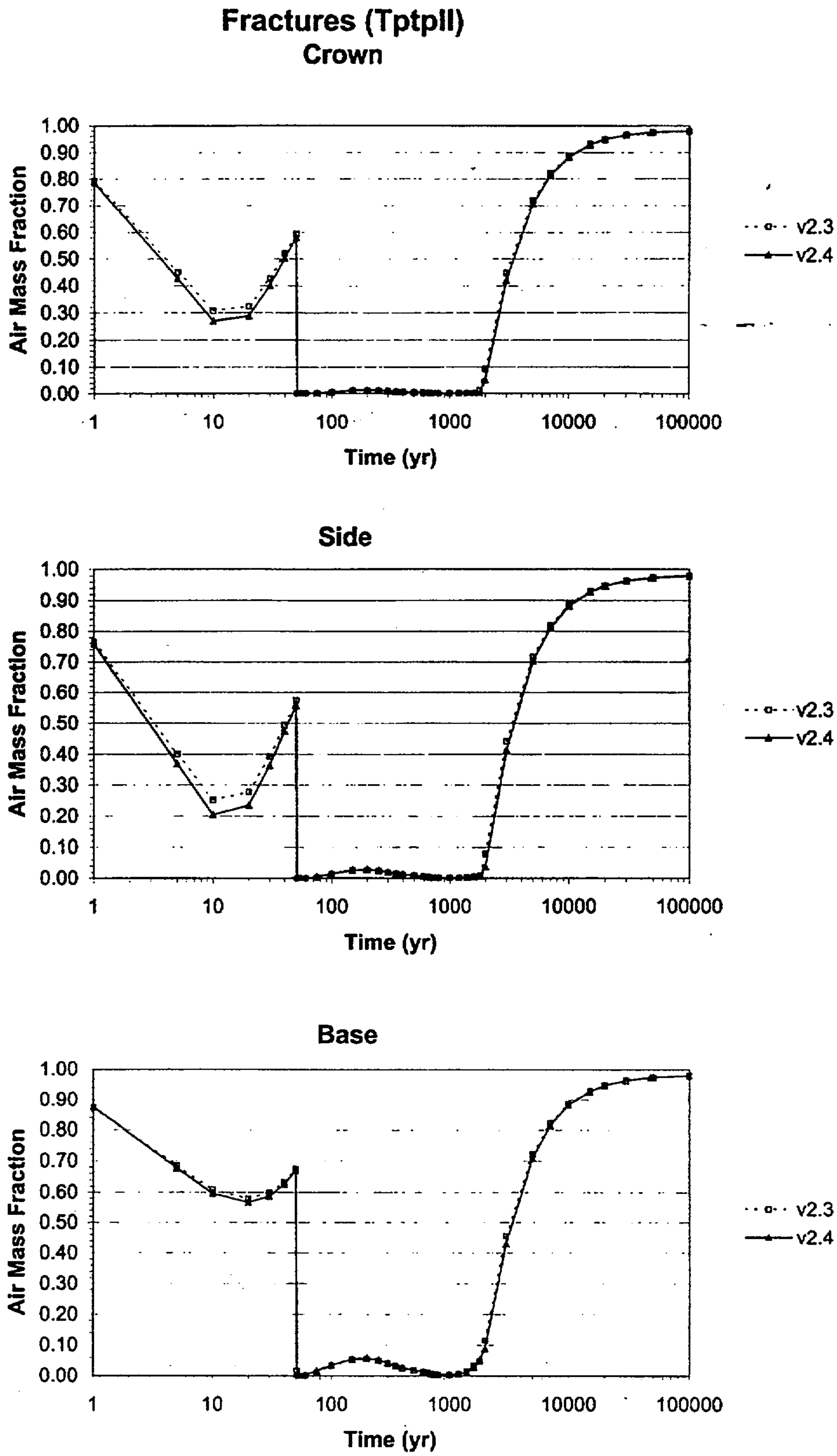

Fractures (Tptpll)
Crown
Air Mass Fraction
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1
10
100
1000
10000
100000
Time (yr)
v2.3
v2.4
Side
Air Mass Fraction
Time (yr)
v2.3
v2.4
Base
Air Mass Fraction
Time (yr)
v2.3
v2.4

Figure4

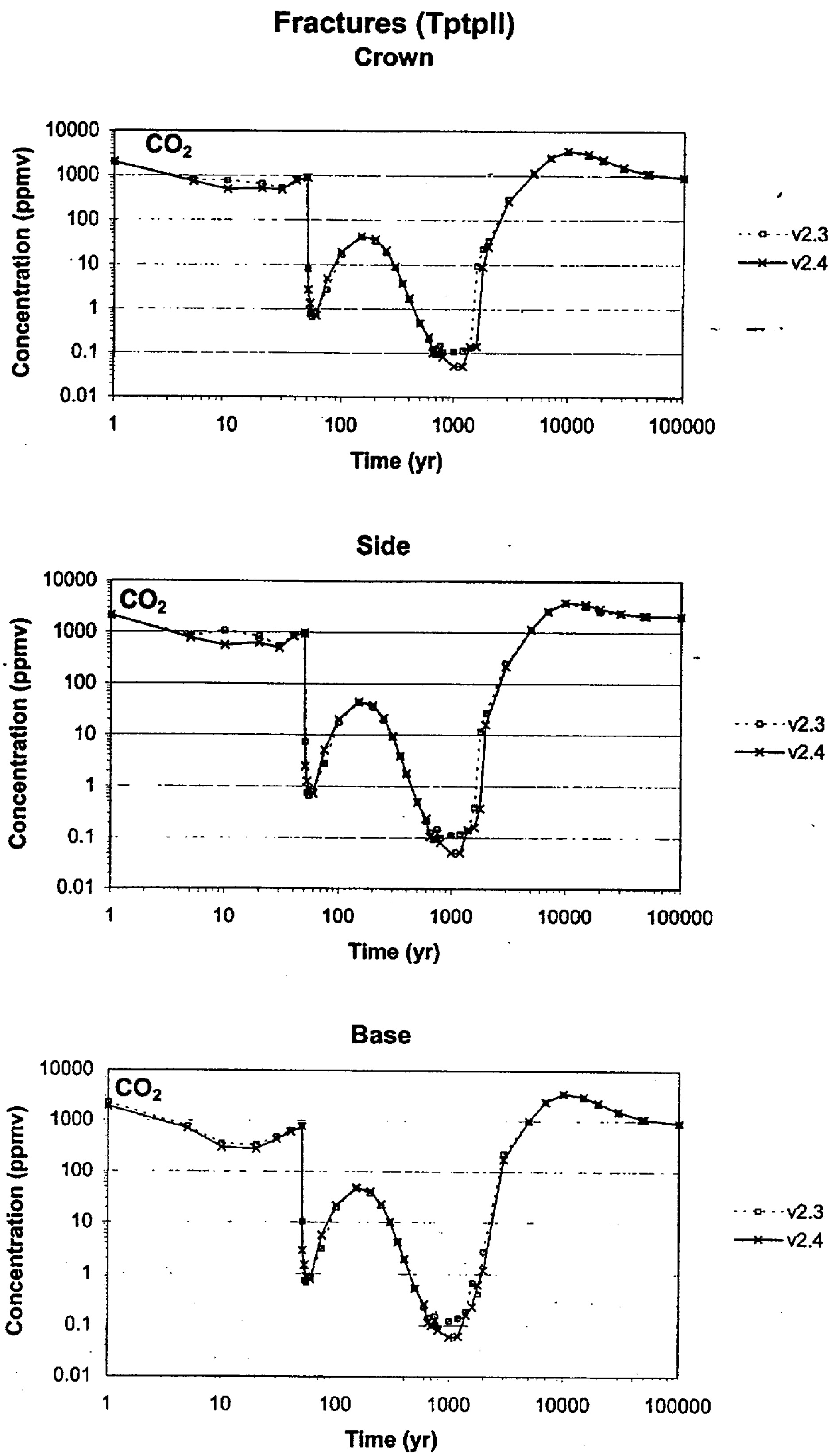

Fractures (Tptpll)
Crown
CO_2
Concentration (ppmv)
10000
1000
100
10
1
0.1
0.01
1
10
100
1000
10000
100000
Time (yr)
v2.3
v2.4
Side
CO_2
Concentration (ppmv)
Time (yr)
v2.3
v2.4
Base
CO_2
Concentration (ppmv)
Time (yr)
v2.3
v2.4

Figure5

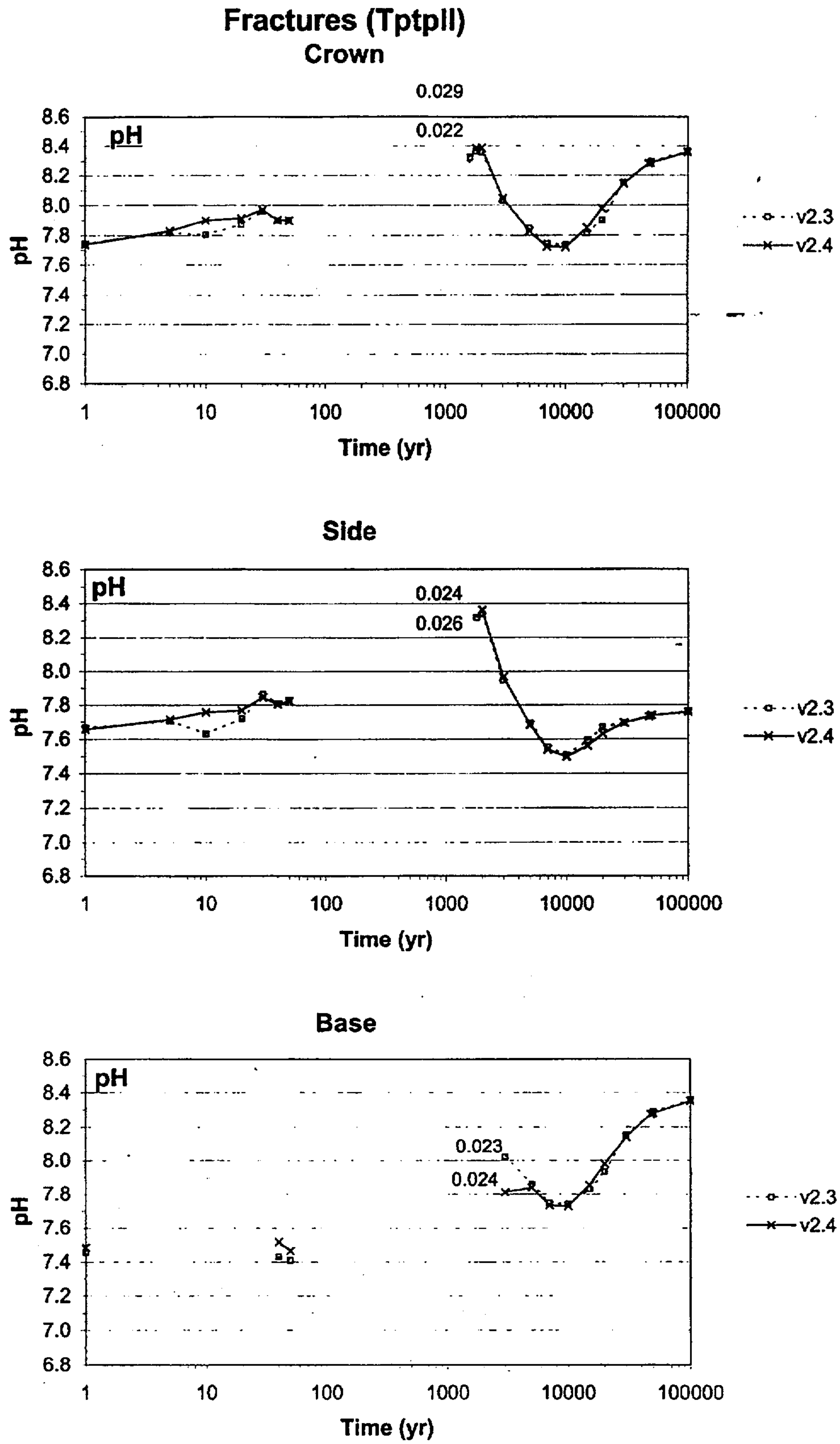

Fractures (Tptpll)
Crown
pH
0.029
0.022
pH
Time (yr)
v2.3
v2.4
Side
pH
0.024
0.026
pH
Time (yr)
v2.3
v2.4
Base
pH
0.023
0.024
pH
Time (yr)
v2.3
v2.4

Figure6

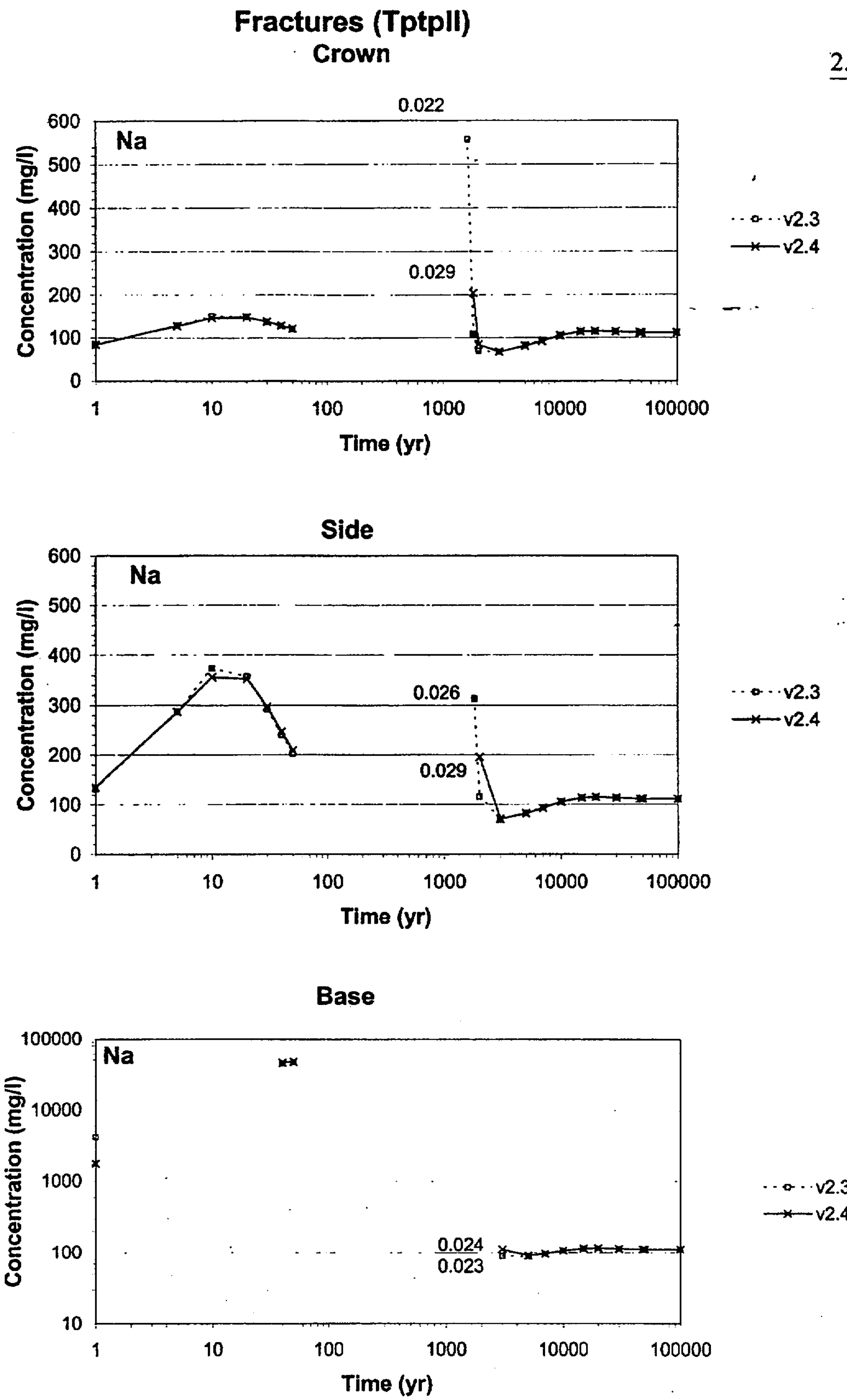
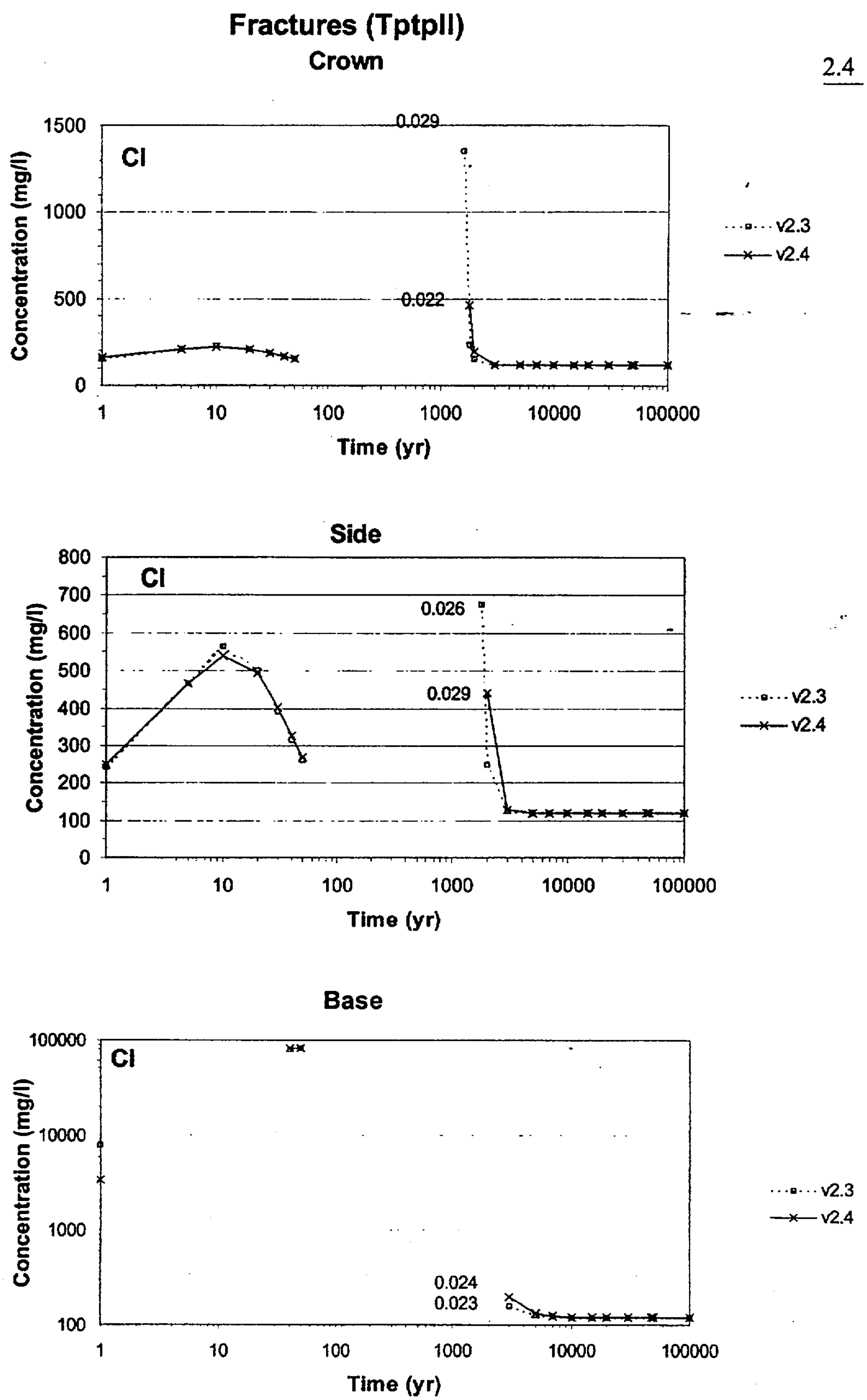

Fractures (Tptpll)
Crown
Na
0.022
0.029
Concentration (mg/l)
Time (yr)
v2.3
v2.4
Side
Na
0.026
0.029
Concentration (mg/l)
Time (yr)
v2.3
v2.4
Base
Na
0.024
0.023
Concentration (mg/l)
Time (yr)
v2.3
v2.4

Figure7



Fractures (Tptpll)
Crown
Cl
0.029
0.022
Concentration (mg/l)
Time (yr)
v2.3
v2.4
Side
Cl
0.026
0.029
Concentration (mg/l)
Time (yr)
v2.3
v2.4
Base
Cl
0.024
0.023
Concentration (mg/l)
Time (yr)
v2.3
v2.4

Figure8

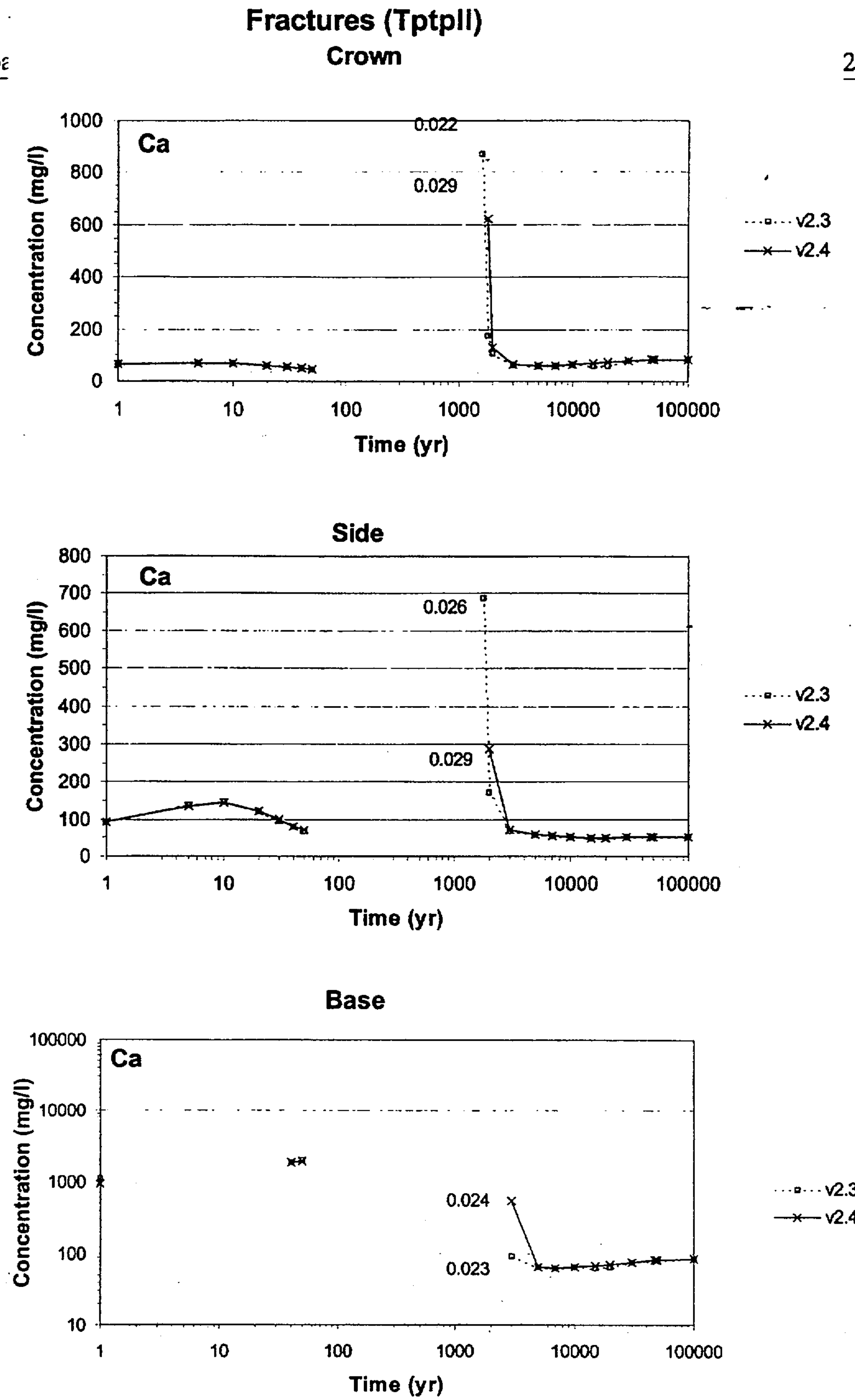

Fractures (Tptpll)
Crown
Ca
0.022
0.029
Concentration (mg/l)
Time (yr)
v2.3
v2.4
Side
Ca
0.026
0.029
Concentration (mg/l)
Time (yr)
v2.3
v2.4
Base
Ca
0.024
0.023
Concentration (mg/l)
Time (yr)
v2.3
v2.4

Figure 9

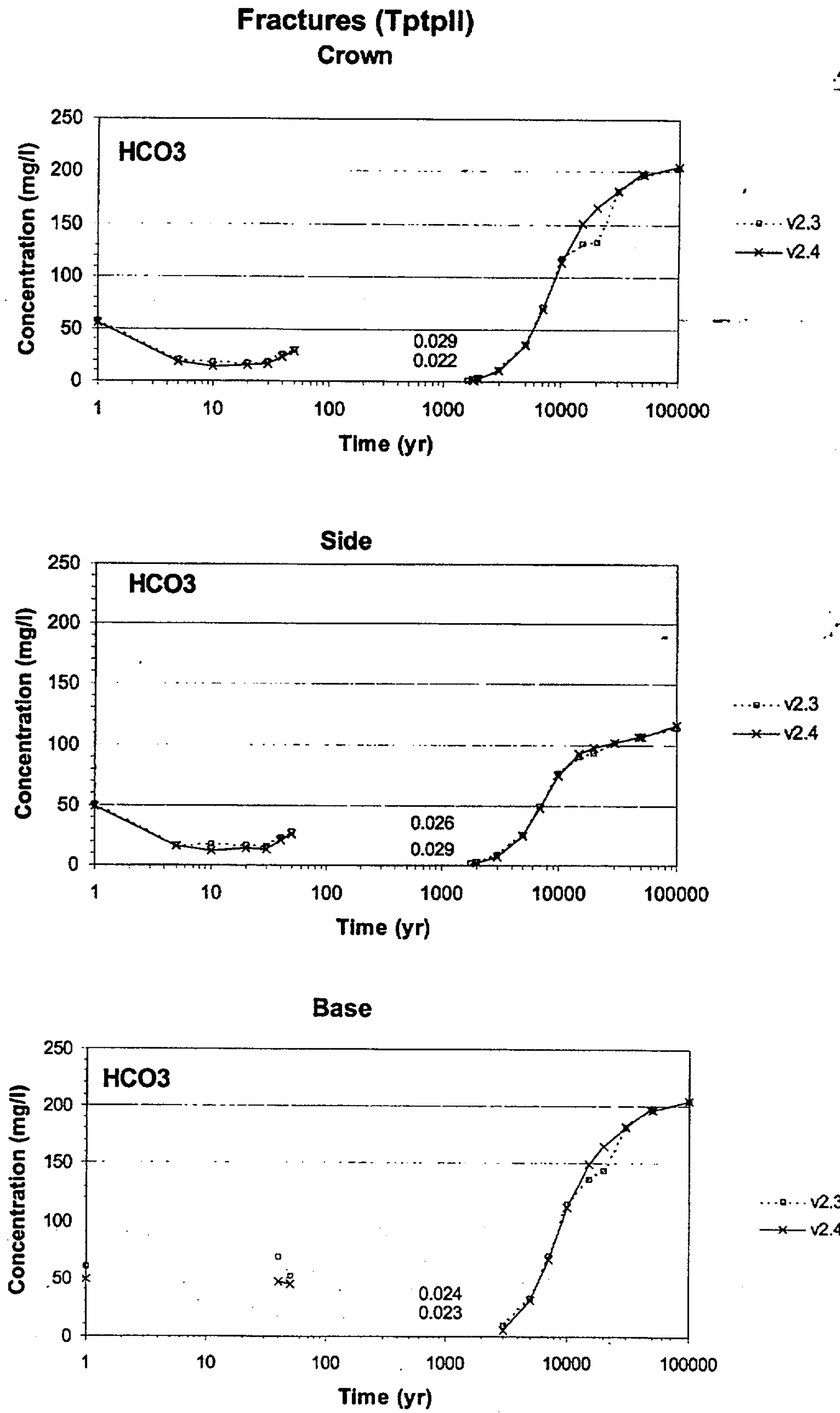

Fractures (Tptpll)
Crown
HCO3
Concentration (mg/l)
Time (yr)
0.029
0.022
v2.3
v2.4
Side
HCO3
Concentration (mg/l)
Time (yr)
0.026
0.029
v2.3
v2.4
Base
HCO3
Concentration (mg/l)
Time (yr)
0.024
0.023
v2.3
v2.4

Figure 10

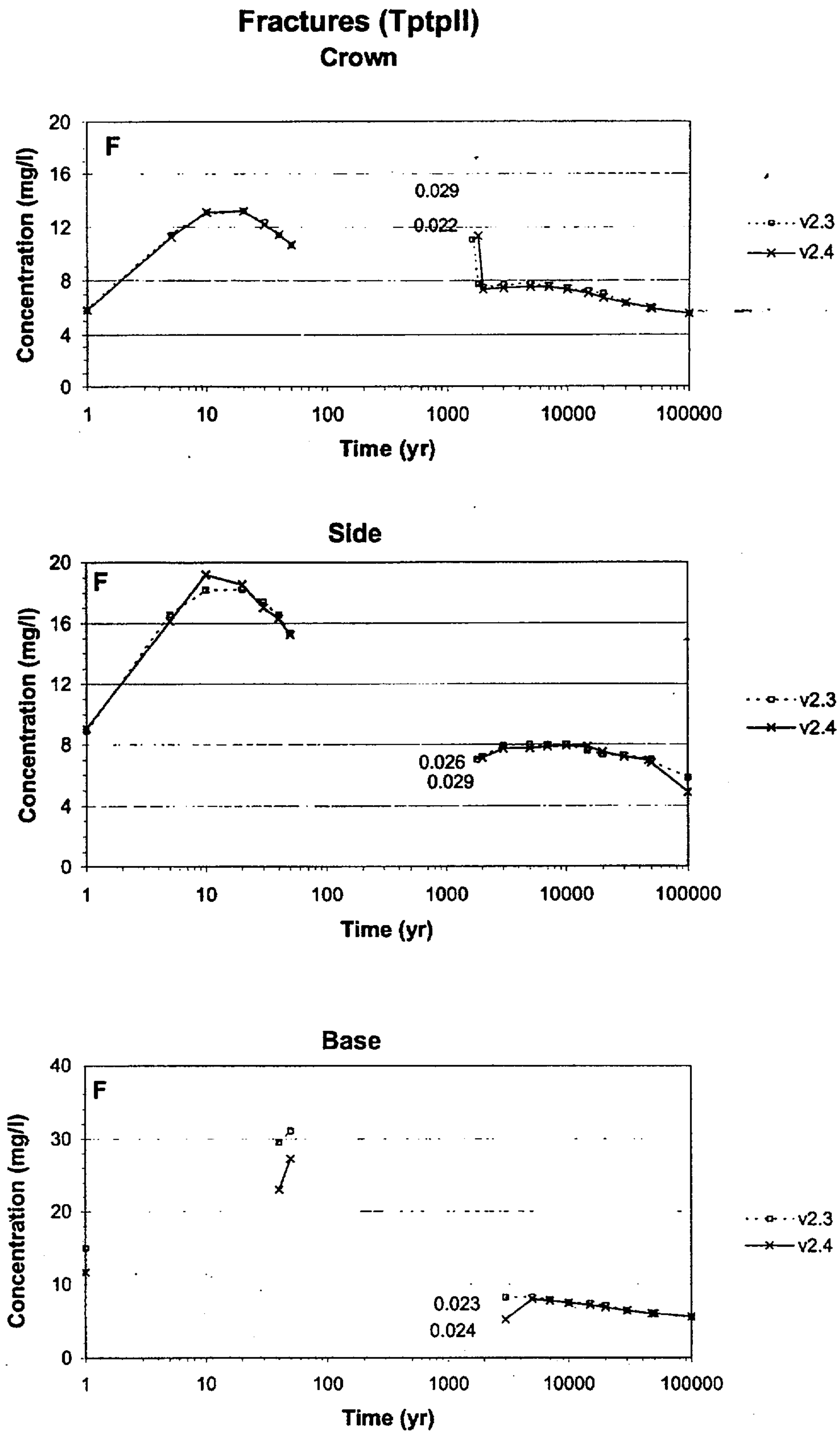
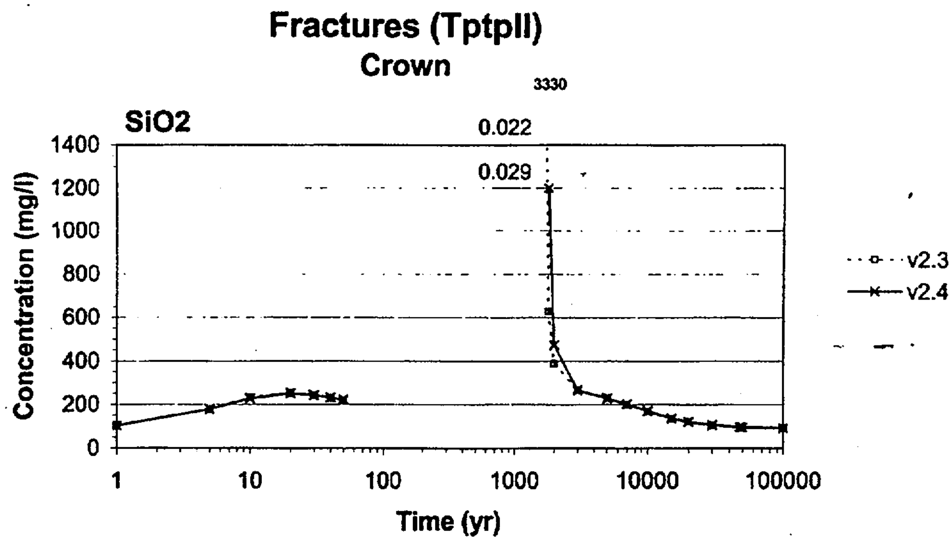
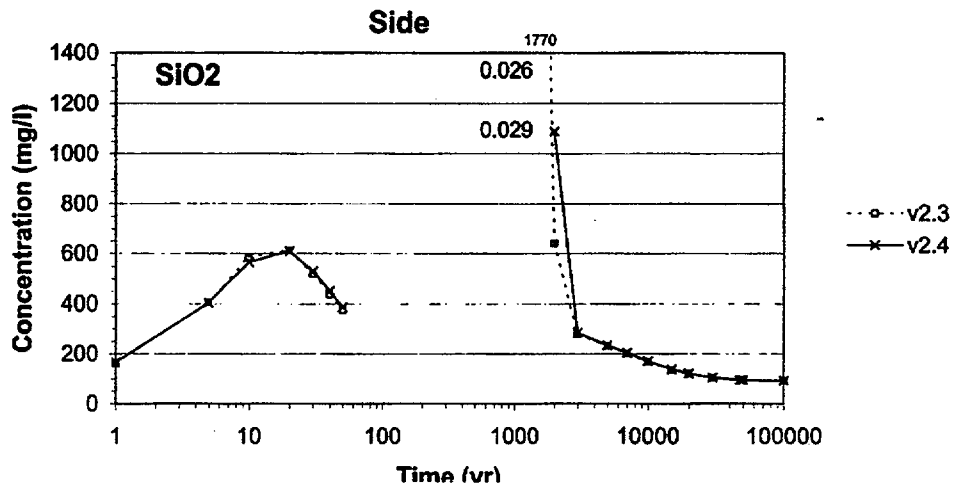

Fractures (TptpII)
Crown
F
0.029
0.022
v2.3
v2.4
Concentration (mg/l)
Time (yr)
Side
F
0.026
0.029
v2.3
v2.4
Concentration (mg/l)
Time (yr)
Base
F
0.023
0.024
v2.3
v2.4
Concentration (mg/l)
Time (yr)

Figure 11


Fractures (TptpII)
Crown
SiO2
3330
0.022
0.029
Concentration (mg/l)
1400
1200
1000
800
600
400
200
0
1
10
100
1000
10000
100000
Time (yr)
v2.3
v2.4


Side
SiO2
1770
0.026
0.029
Concentration (mg/l)
1400
1200
1000
800
600
400
200
0
1
10
100
1000
10000
100000
v2.3
v2.4

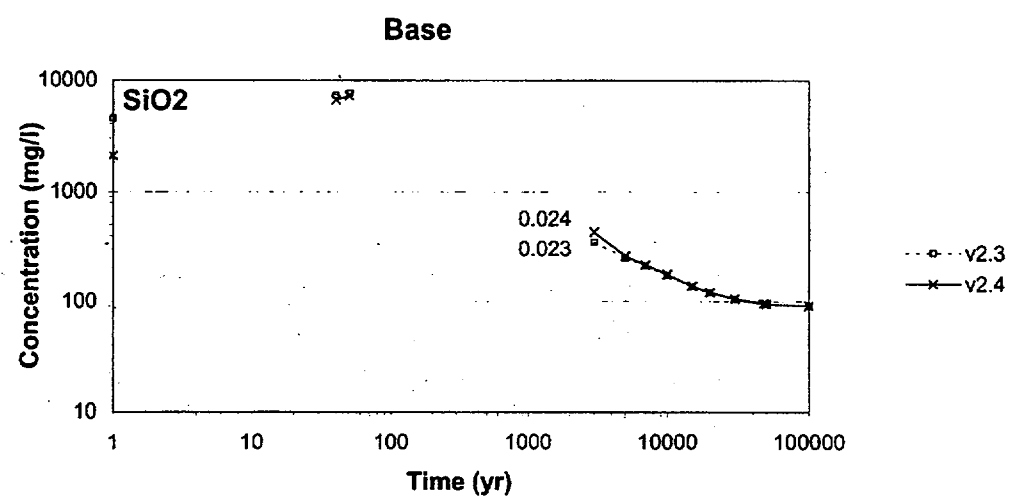

Base
SiO2
0.024
0.023
Concentration (mg/l)
10000
1000
100
10
1
10
100
1000
10000
100000
Time (yr)
v2.3
v2.4

Figure 12

QA: QA

MOL.20011030.0452

VALIDATION TEST REPORT (VTR)
for
TOUGHREACT V2.4

SAN: LBNL-2001-169
Document Identifier: 10396-VTR-2.4-00
STN: 10396-2.4-00
SMN: 10396-MED-2.4-00

Prepared by: [signature] Date 9/28/01
Eric Sonnenthal
Responsible Manager

☒ No Comment Verified by: [signature] Date 9/28/01
Patrick Dobson
Technical Reviewer

Reviewed by: [signature] Date 9/28/01
Randall Hedegaard
Management Reviewer

Approved by: [signature] for G.S. Bodvarsson Date 9/28/01
G. S. Bodvarsson
Responsible Manager Supervisor

Reviewed by: [signature] Date 09/28/01
~~Dianne Spence~~ EDWARD MILLER 09/28/01 EM
Information Technology
Software Management Analyst (ITSMA)

CHANGE HISTORY

Revision Number	Effective Date	Description of Change
00	9/28/01	Initial issue.

This Validation Test Report (VTR) is based upon the Software Activity Plan (SAP) 10396-SAP-2.4-00, Requirements Document (RD) 10396-RD-2.4-00, the Design Document (DD) 10396-DD-2.4-00, the Installation Test Plan (ITP) 10396-ITP-2.4-00, and the Validation Test Plan (VTP) 10396-VTP-2.4-00 in accordance with the Office of Civilian Radioactive Waste Management (OCRWM) Administrative Procedure (AP)-SI.1Q, *Software Management*, Rev. 3, ICN 1, ECN 1. TOUGHREACT V2.4 is an
upgrade of TOUGHREACT V2.2 (STN: 10154-2.2-00).

1. SOFTWARE IDENTIFICATION

This report documents the installation and validation testing of TOUGHREACT V2.4 on the following platforms, operating systems and compilers listed:

SunOS 5.5.1 and Fortran 77 v5.0 on SUN system
Compaq Tru64 UNIX v5.0A and Compaq Fortran v5.3 on DEC-Alpha system
DEC OS1 V4.0 and Compaq Fortran 77 on DEC-Alpha system

2. INDEPENDENT VALIDATION TESTER

Guoping Lu confirmed the tests at Lawrence Berkeley National Laboratory.

3. SPECIAL TOOLS AND EQUIPMENT

No special tools or equipment was used in conducting the validation test.

4. TEST RESULTS LINKED TO VTP

The results of the execution of the validation test cases are documented in Appendix A. Within Appendix A, a unique identifier is provided in column 1 of Table 1 which corresponds to the test number identified in the Validation Test Plan (VTP).

5. TEST RESULTS

The results of the execution of the validation test cases are documented in Appendix A. The results for all platforms listed in Section 1 are identical. The results of the execution of the test steps within the ITP are provided below:

1. Pre-installation tasks completed (independent machines identified, target directories established, files transferred, and files extracted properly)
2. Installation and testing completed (makefiles executed and test cases run on target platforms)
3. Acceptance Criteria met for all platforms (no difference between contents of newly created TIME.DAT and reference TIME.DAT)

6. INDICATION OF PASS/FAIL

The results of the validation test cases are documented in Appendix A. The pass/fail annotation with initial and date are provided in the margin of Table 1 next to each test case number.

7. FAILURE CONDITIONS, OCCURRENCE, RESOLUTION
No installation or validation failure condition(s) were found to exist while executing the ITP & VTP.

8. OVERALL CONCLUSIONS
The overall conclusion of these tests is that the software adequately and correctly performs all intended functions and does not perform any unintended functions either by itself or in combination with other functions.

9. DOCUMENTATION AND JUSTIFICATION OF REMAINING TEST EXCEPTIONS OR FAILURES
On the DEC platforms error messages appear when running Test #1 (floating-point exception underflow) and Test #3 (divide by zero). On the SUN platform error messages appear when running Test #1. These errors do not affect output results. There are no other remaining test exceptions or failures based on the execution of these tests.

10. SUMMARY OF UNIT TESTING
For the purposes of this validation effort, no unit tests were performed by the developer.

11. GENERAL REMARKS
None

APPENDIX A- TOUGHREACT V2.4 Validation Test Documentation

This appendix presents the results of verification and validation tests to confirm that TOUGHREACT V2.4 meets the requirements set forth in the Validation Test Plan. Table 1 summarizes testing results. Part of the testing of TOUGHREACT V2.4 relies on running validation/verification tests developed for previous qualified versions of TOUGHREACT, and ensuring that V2.4 produces equivalent results. New test problems are developed to verify new V2.4 features listed below:

1) Supersaturation "windows" for kinetically inhibited minerals.
2) New HKF (1981) activity coefficient model
3) Ideal solid solutions for minerals
4) New k-ϕ aperture model for mineral precipitation
5) Ability to input initial heterogeneous k and ϕ field
6) Permeability law zones
7) Precipitation of amorphous silica into dry nodes

Table 1. Summary of Validation Testing for TOUGHREACT V2.4

Test Status	#	Requirements	Problem Type	Acceptance Criteria	Dimension	Reference/Test Problem Name
GL- 9/28/01 Pass	1	Verification of equivalence to TOUGH2 EOS3. Run with V2.4 previous test problems used to qualify V2.1. Ensure both versions yield results within the acceptance criteria.	(a) Flow to a geothermal well (b) Transient heat pipe (c) Two-phase flow	Match results of V2.1 (within 0.1%)	3-D, cylindrical 3-D, cylindrical 1-D, linear	Test Problem 1 in Spycher et al. (1999)/ no_outer_ring out-ring geothermal2.4 heat-pipe2.4
GL- 9/28/01 Pass	2	Verification of proper chemical mass-balance and mass-action for the chemical solver (no transport) for an unsaturated case. Run with V2.4 previous test problems used to qualify V2.1. Ensure both versions yield results within the acceptance criteria.	Heat water and gas (two-phase) from 25 to approximately 100°C at near atmospheric pressure.	Match results of V2.1 within 5%, after correction for water density changes not accounted for in V2.1.	1 grid block (no transport)	Test Problem 2b in Spycher et al. (1999)/ heat_unsat1_2.4
GL- 9/28/01 Pass	3	Verification of evaporative concentration due to boiling. Run with V2.4 a previous test problem used to qualify V2.1. Ensure both versions yield results within the acceptance criteria.	Boil water near 100°C at pressure approximately atmospheric.	Match results of V2.1 for chloride (within 1%), after correction for water density changes not accounted for in V2.1	2 grid blocks (steam transport only)	Test Problem 3 in Spycher et al. (1999)/ boil100_2.4
GL- 9/28/01 Pass	4	Verification of aqueous transport (advection/diffusion). Run with V2.4 previous test problems used to qualify V2.1. Ensure both versions yield results within the acceptance criteria.	Simulate transport of a chemical tracer at 25°C, 1 bar (version 1.0 test problem 4).	Match results of V2.1 (within 1%) (correction for water density changes not needed at the considered temperature)	1-D, linear	Test Problem 4 in Spycher et al. (1999)/ aqtrans_2.4
GL- 9/28/01 Pass	5	Verification of gas transport (advection/diffusion). Run with V2.4 previous test problems used to qualify V2.2. Ensure both versions yield results within the acceptance criteria.	Simulate CO_2 transport in a constant, steady state flow field, with option set to calculate the CO_2 diffusion coefficient.	Match results of V2.2 (within 1%) for concentration ratios ($C/C_{initial}$)	1-D, linear	Test Problem 8 in Spycher et al. (1999), as rerun for V2.2 qualification./ gas_diffus_2.4
GL-	6	Verification of activity coefficients and water activity calculation.	Simulate chemical speciation (no flow) in a one-block problem for	Plot calculated mean salt activities, activity	1 grid block (no transport)	This report/ qa_hkf81

9/28/01 Pass			electrolyte solutions of various composition and ionic strengths for which activity coefficients and water activity have been independently determined.	coefficients, and water activities and compare with measured data. For NaCl, match calculated and measured activities within 10% up to 6M NaCl. For other salts, plot results and qualitatively compare results against measured data (no strict criteria can be set because the method assumes NaCl-dominant solutions).		
GL- 9/28/01 Pass	7	Verification of supersaturation window	Run quartz plug flow reactor using arbitrary rate such that equilibrium is reached quickly, then vary supersaturation window. Repeat for equilibrium case.	Hand-calculate solubility for given saturation window and ensure these values match within 1% the values calculated by V2.4.	1-D, linear, liquid saturated	This report/ supsatwin2.4
GL- 9/28/01 Pass	8	Verification of ideal solid solution option	Run problem similar to test#2 using clay minerals in solid solution and under kinetic constraints. Use arbitrary rate such that equilibrium is reached quickly.	Check output to verify that the sum of Q/K values of each endmember equals zero at equilibrium (within 0.1%).	1 grid block (no transport)	This report/ solid_sol2.4
GL- 9/28/01 Pass	9	Verification of correct fracture permeability calculations (permeability law 3 – cubic law)	Run 1-D fracture plugging problem using permeability law 3.	Use porosity change to hand calculate permeability change. Check that permeability change is within 0.1% of calculated value based on porosity change	1-D vertical fracture plugging problem – nonisothermal, boiling and complete dryout	This report/ test_boilfrac_1
GL- 9/28/01 Pass	10	Verification of correct fracture permeability calculations (permeability law 4 – fracture aperture law)	Run 1-D fracture plugging problem using permeability law 4. Use a range of possible *a* and *b* parameters (Based on range of AMR N0120 values; Sonnenthal and Spycher, 2001) and porosity change to hand calculate permeability change	Use porosity change to hand calculate permeability change. Check that permeability change is within 1.0% of calculated value based on *a* and *b* parameters and porosity change	1-D vertical fracture plugging problem – nonisothermal, boiling and complete dryout	This report/ test_boilfrac_2 test_boilfrac_3 test_boilfrac_4

GL- 9/28/01 Pass	11	Verification of correct permeability porosity coupling for permeability law 1 (Carman-Kozeny law)	Run quartz plug flow reactor and hand check permeability changes and porosity changes	Use porosity change to hand calculate permeability change. Check that permeability change is within 0.1% of calculated value based on porosity change	1-D, linear, liquid saturated, plug flow reactor problem	This report/ k-phicoupling
GL- 9/28/01 Pass	12	Verification of correct input of heterogeneous porosity and permeability fields	Restart of 1-D fracture plugging problem after strong initial heterogeneity in permeability and porosity has developed	Show that after restart, with no permeability-porosity coupling that the output permeabilities and porosities in the SAVE file are identical to those input in the INCON file	1-D vertical fracture problem – nonisothermal, boiling and complete dryout	This report/ test_boilfrac_5
GL- 9/28/01 Pass	13	Verification of correct input of permeability zones	Run 1-D fracture plugging problem, using zones block in CHEMICAL.INP and in SOLUTE.INP	Show that permeability zone is correctly assigned to grid blocks, with correct permeability law (associated with problems 9, 10, and 11)	1-D vertical fracture problem – nonisothermal, boiling and complete dryout	This report/ Same problems as tests # 11 through # 15
GL- 9/28/01 Pass	14	Verification of correct match to analytical solution for 1-D reaction-transport, for V2.4 consideration of liquid density changes in reaction calculations	Run quartz plug flow reactor compare concentrations to that of analytical solution	Compare results to analytical solution. Check that output concentrations match within 5 % of analytical solution.	1-D, linear, liquid saturated, plug flow reactor problem	This report/ nok-phicoupling
GL- 9/28/01 Pass	15	Verification of option to precipitate amorphous silica into dry nodes	Run 1-D fracture plugging problem setting flag 4 (after mineral name) to 1 and using permeability laws 3 and 4. All other minerals must have their flag set to zero	Show that amorphous silica precipitates in the dry node that is just ahead of the first wet node in the boiling front and that the mass balance for silica precipitated in the entire system is within 5% of the input value (in Mbalance.out)	1-D vertical fracture problem – nonisothermal, boiling and complete dryout	This report/ test_boilfrac_1 test_boilfrac_2 test_boilfrac_3 test_boilfrac_4 test_boilfrac_5

is unique software validation test problem number

A. Test Problem Results

A.1 TOUGHREACT V2.4 Verification Against TOUGH2 EOS3 (Test Problem 1)

Test problem 1 in Table 1 has three test problems: (a) flow to a geothermal well; (b) transient heat pipe; and (c) two-phase flow. In the two-phase flow, two tests were performed, the test "outer-ring" includes 100 extra elements in the test "outer ring" in the computational mesh to simulate a constant temperature ring around the core created by the oven. Test problems were run with version V2.4, produced results consistent with those of V2.2 and met the acceptance criteria listed in that table. In each of the four tests, the output file FLOW.OUT run with V2.4 was renamed as FLOW.OUTq2.4, and output with V2.1 as FLOW.OUTq2.1. The results are identical for both versions with the exception of the differences because of output format. Examples of these differences include code's internal assigned array sizes, time steps, notes of version updates, simulation run's elapsed time. The tests meet the acceptance criteria in Table 1.

A.2 Verification of Proper Chemical Mass Balance and Mass Action (Test Problem 2)

Test problem 2 in Table 1 was run with version V2.4. The results were corrected for water density changes at elevated temperature (V2.4). Results from V2.4 were matched with those of V2.1 within 5%. Output files chdump.dat and TIME.DAT were checked for several minerals and CO_2 gas, and mass balances of several component species. The test met the acceptance criteria listed in that table.

Test folder and data files used:

heat_unsat1:	FLOW.INP	input
	SOLUTE.INP	input
	CHEMICAL.INP	input
	thermok2.dat	
	TIME.DAT	output
	FLOW.OUT	output

This test is the same as Test #2b in the qualification documents of V2.1. This test was rerun with the same input files as for V2.1 but modified for any new V2.4 format requirements. Calculated concentrations with V2.1 and V2.4 were compared. Because aqueous concentrations calculated with V2.4 are output in mol/L, while V2.1 output is in mol/kg (ppm), concentrations from V2.1 were multiplied by the water density (from the FLOW.OUT file) before the comparison was made. The difference in concentrations calculated between V2.4 and V2.1 was less than 5%, as shown in Table A-1. The difference is more pronounced for double charged species such as calcium because of the activity coefficient changes in V2.4 compared to V2.1 (See Test #6).

Table A-1

T (C)	density		Calcium				Sodium		
	(kg/l)	V2.1	V2.1	V2.4	%diff	V2.1	V2.1	V2.4	%diff
		(mol/kg)	(mol/L)	(mol/L)		(mol/kg)	(mol/L)	(mol/L)	
33.338	0.9947	8.973E-05	8.93E-05	9.111E-05	-2.08	1.61E-02	1.597E-02	1.59E-02	0.34
61.470	0.9824	1.164E-04	1.14E-04	1.161E-04	-1.53	1.10E-02	1.085E-02	1.08E-02	0.05
103.105	0.9559	1.615E-04	1.54E-04	1.580E-04	-2.34	4.32E-03	4.125E-03	4.06E-03	1.50

A.3 Verification of Evaporative Concentration due to Boiling (Test Problem 3)

This test problem was to verify evaporative concentration due to boiling. It was set up in a two grid blocks. One was used to simulate heating of an initially liquid-saturated at 100°C near atmospheric pressure (Problem 3 in Table 1). This grid block was connected to another large grid block containing essentially gas. As water in the first block was evaporated, steam was displaced from the first block into the second block, thus resulting in decreasing the liquid saturation in the first block. The chloride concentrations $C/C_{initial}$ from V2.4 were corrected for water density changes and matched well with those of V2.1. The run with version V2.4 met the acceptance criteria listed in that table.

Test folder and data files used:

boil100_2.4

- FLOW.INP
- SOLUTE.INP
- CHEMICAL.INP
- thermok2.dat] input
- time.dat — output

This test is the same as Test #3 in the qualification documents of V2.1. This test was rerun with the same input files as for V2.1 but modified for any new V2.4 format requirements. Using output data from the TIME.DAT file, chloride concentrations were plotted as C/Co versus liquid saturation for both V2.1 and V2.4 results, where Co is the initial concentration (Figure A-1). The results of V2.1 and V2.4 overlap and match within < 1%, and therefore the acceptance criteria is met.

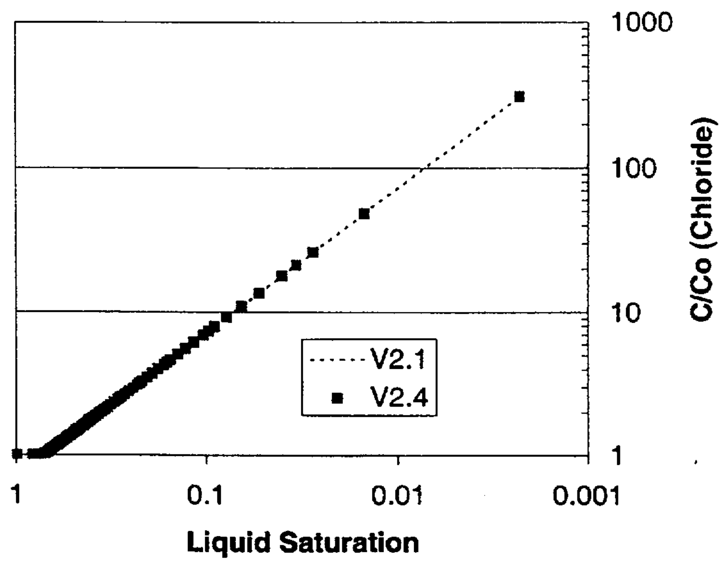


Figure A-1

A.4 Verification of Aqueous Transport (Advection/Diffusion) (Test Problem 4)

This test problem (Test problem 4 in Table 1) was to test the transport of aqueous species (Wu et al., 1999) by advection and diffusion (for T = 25°C). This test is the same as Test #4 in the qualification documents of V2.1. This test was rerun with the same input files as for V2.1 but modified for any new TOUGHREACTV2.4 format requirements. It was run with version V2.4 and the result was shown in the file TEC_CONC.DAT.

Test folder and data files used:

aqtrans_2.4	FLOW.INP	
	SOLUTE.INP	
	CHEMICAL.INP	input
	thermok2.dat	
	TEC_CONC.DAT	output

Calculated concentrations with V2.1 and V2.4 were compared by plotting calculated C/Co values for both versions (Figure A-2) as a function of distance. Both curves overlap and the difference in concentrations is less than 1%, and therefore the acceptance criteria are met.

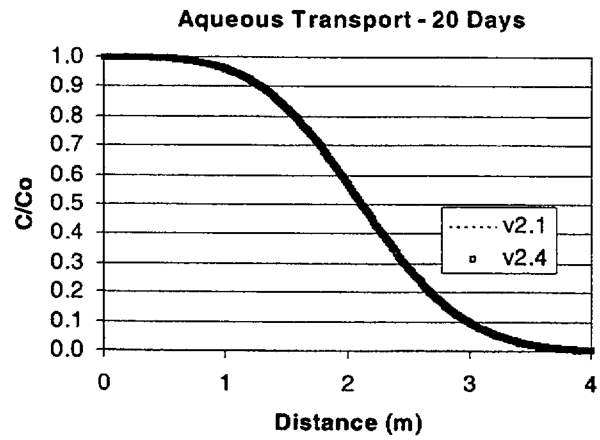


Figure A-2

A.5 Verification of Gas Diffusion Coefficient and Gas Transport (Test Problem 5)

This problem (Test problem 5 in Table 1) verifies the calculation of effective gas diffusion coefficients.

Test folder and data files used:

	ThermoU2.07dat	
gas_diffus_2.4		
	FLOW.INP	input
	SOLUTE.INP	input
	CHEMICAL.INP	input
	TIME.DAT	
	TEC_GAS.DAT	output

This test is the same as Test #8 in the qualification documents of V2.2. This test was rerun with the same input files as for V2.2 but modified for any new V2.4 format requirements. Calculated gas concentrations from the TEC_GAS.DAT files of both versions and were identical (i.e. the unix "diff" command showed that these files were identical), and therefore the acceptance criteria are met.

A.6 Verification of Activity Coefficients and Water Activity Calculation (Test Problem 6)

Test problem 6 simulates chemical speciation (no transport) in a one-block problem for electrolyte solutions of various compositions and ionic strengths for which activity coefficients and water activity have been independently determined in Table 1. The test was run with version V2.4 and met the acceptance criteria listed in that table.

Test folder and data files used:

qa_hkf81/	FLOW.INP	input
	CHEMICAL.INP	
	SOLUTE.INP	
	thermok2.07.dat	
	chdump.dat	output

Testing of activity coefficient calculation subroutines (hkfpar and dh_hkf81) was originally carried out by the developer by calculating activity coefficients and water activities with V2.2.3 for various electrolyte solutions, and comparing with values measured by Robinson and Stokes (1965).. Calculated and measured data for NaCl solutions are shown as an example in Figures A-3 and A-4 (see scientific notebook YMP-LBNL-YWT-NS-1.2 p. 28-30 and p.32 which was included on media with test case).

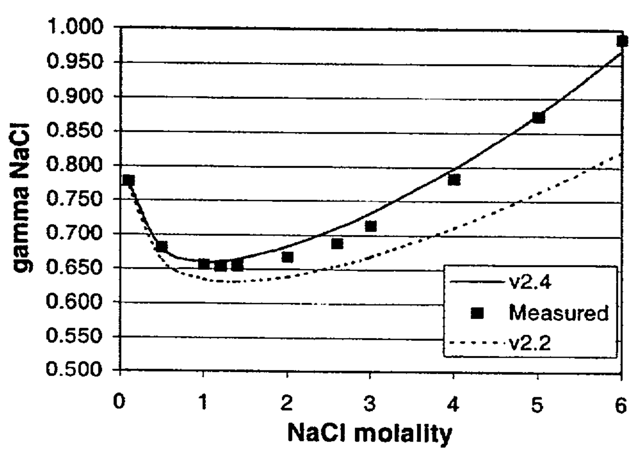


Figure A-3

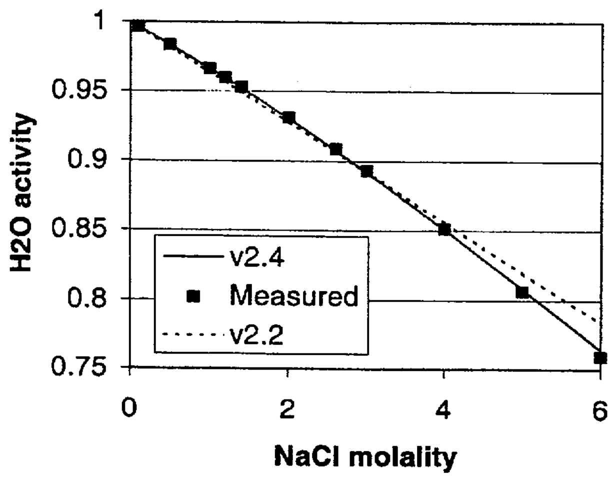


Figure A-4

To verify the correct implementation of the activity coefficient routines in V2.4, activities and activity coefficients of dissolved species and water activity were computed with V.4 for a 6m NaCl solution. The results were compared with existing results as well as with the data measured by Robinson and Stokes. Water activity and NaCl activities calculated with V2.4 were identical to those calculated with the existing results provided, as expected, and within 10% of the Robinson and Stokes values, as shown below.

From ouput data in the chdump.dat file, we get:

a H_2O = 0.7644 (note, output gamma H_2O is activity for water)

a Na^+ = $10^{0.739}$ = 5.48

• Na^+ = 0.913

a Cl^- = $10^{0.791}$ = 6.18

• Cl^- = 1.029

To check against the measured data, we need to calculate mean activities and mean activity coefficients as follows:

• $_{\pm}$NaCl = (• Na^+ · • Cl^-)^{½} = 0.9693
a NaCl = (m NaCl · • $_{\pm}$NaCl)^2 = (6 · 0.9693)^2 = 33.8

Robinson and Stokes give the following values:

a H_2O = 0.7598

• $_{\pm}$NaCl = 0.986

which gives a NaCl = (m NaCl · • $_{\pm}$NaCl)^2 = 35.0

The data computed by V2.4 are within 10% of these values, and therefore the acceptance criteria is met.

A.7 Verification of Supersaturation Window (Test Problem 7)

This test problem Table 1 was run with a quartz plug flow reactor (Spycher et al., 1999) using an arbitrary rate such that equilibrium is reached quickly, then varying the supersaturation window. Tests were repeated for the equilibrium case. The test problem 7 was run with version V2.4 and met the acceptance criteria listed in that table.

This new test made use of the same general setup as Test #11 (quartz plug-flow reactor, also similar to one of the V2.2 sample problems). Here, we use amorphous silica instead of quartz, using arbitrary, very high, precipitation and dissolution rates such that equilibrium is reached quickly. The temperature is maintained constant at 200°C. We first run a simulation without a supersaturation window, and verify that equilibrium is quickly reached by checking that log(Q/K) for amorphous silica becomes zero. The SiO_2 solubility is hand-calculated and compared to the computed value. The test is then repeated for two cases of superaturation windows.

1) Check without saturation window

Test folder and data files used:

	FLOW.INP	
supsatwin2.4/ssq0/		
	SOLUTE.INP	
	CHEMICAL.INP	input
	thermok3.dat	
	FLOW.OUT	output
	TIME.DAT	output

Setup: 200°C
log(K) for amorphous silica = -1.819 (given input data)
This log(K) value is for the reaction: $SiO_{2am(s)} \Leftrightarrow SiO_{2(aq)}$

Therefore: a $SiO_{2(aq)}$ ~ m $SiO_{2(aq)} = 10^{-1.819}$ = 1.51705 E-2 mol/kg

Water density from the FLOW.OUT file (here in kg/l – i.e., divided by 1000)

time = 100 sec d = 0.86998
1000 sec d = 0.87142

From the TIME.DAT file we get the following computed solubilities:

At t = 100 sec (0.115741 E-2 days) m $SiO_{2(aq)}$ = 0.1318 E-1 mol/l
Convert to mol/kg: 0.1318 E-1/0.86998 = 0.15150 E-1 mol/kg

At t = 1000 sec (0.115741 E-1 days) m $SiO_{2(aq)}$ = 0.1323 E-1 mol/l
Convert to mol/kg: 0.1323 E-1/0.87142 = 1.5180 E-2 mol/kg

Hand-calculated and computed solubilities match within 1%, and therefore the acceptance criteria are met.

2) Check with saturation window = 1.5

Test folder and data files used:

supatwin2.4/ssq-1.5/	FLOW.INP	input
	SOLUTE.INP	input
	CHEMICAL.INP	input
	thermok3.dat	input
	FLOW.OUT	output
	TIME.DAT	output

Set the supersaturation window (ssq) = 1.5
Set T_1 = 200° C and T_2 = 300° C. These temperatures are the brackets for the supersaturation window (i.e., at T_1 ssq=1.5 and at T_2 ssq=ssq/100). Here, the run temperature is 200° C, therefore the full window (=1.5) is used.

Set inlet SiO_2 high, at 1 m/kg (arbitrary concentration to force precipitation)
Set reactor SiO_2 at 0.5 m/kg (arbitrary concentration to force precipitation)
Run at T = 200° C so we get full window of 1.5 (see above)

We should get log (Q/K) = 1.5 (can be verified in the chdump.dat file)

Therefore, log(Q) = log(K) + 1.5 = log (m SiO_2)
$\Rightarrow$ m $SiO_2 = 10^{(-1.819+1.5)}$ = 0.4973 E-1 m/kg

From the TIME.DAT file we get the following computed solubility:
At t = 1000 sec m $SiO_{2(aq)}$ = 0.4175 m/l
Convert to mol/kg: 0.4175/0.87142 = 0.4791 m/kg

Hand-calculated and computed solubilities match within 1%, and therefore the acceptance criteria was met.

3) Check as before (ssq = 1.5) but consider temperature effect on ssq

Test folder and data files used:

supsatwin2.4/ssq_1.5a/	FLOW.INP	input
	SOLUTE.INP	input
	CHEMICAL.INP	input
	thermok3.dat	input
	FLOW.OUT	output
	TIME.DAT	output

This is the same test as 2) above but we set the temperature brackets such that the supersaturation window value (ssq) changes as function of temperature:

Set $T_1 = 100°C$ and $T_2 = 300°C$, with ssq = 1.5

The value of ssq decreases exponentially between T_1 and T_2, such that at T_1 ssq=1.5 (full value) and at T_2 ssq = 1/100 of original value. The equation implemented in V2.4 to achieve this exponential decrease is (see YMP-LBNL-YWT-NS-1.2 p.33):

$$ssq_{(T)} = ssq \cdot e\ \left[-4.61 \cdot \left(\frac{T-T1}{T2-T1}\right)\ \right]$$

The run temperature is T = 200°C and because ssq=1.5, we have:

$$ssq_{\ (200°C)} = 1.5\ e\left[-4.61 \cdot \left(\frac{200-100}{300-100}\right)\ \right] = 0.1496$$

Therefore, the log (Q/K) should be 0.1496. We write, as before:

$\log(Q) = 0.1496 + \log(K) = 0.1496 - 1.819 = 1.6694 = \log(m\ SiO_2)$
$\Rightarrow m\ SiO_2 = 10^{-1.6694} = 0.2141$ E–1 mol/kg

From the TIME.DAT file we get the following computed solubility:
At t = 1000 sec: $SiO_{2(aq)} = 0.1861$E–1 mol/l
Convert to mol/kg: 0.1861E–1/0.87142 = 0.2136E–1 mol/kg

Hand-calculated and computed solubilities match within 1%, and therefore the acceptance criteria is met.

A.8 Verification of Ideal Solid Solution Option (Test Problem 8)

Test problem 8 in Table 1 is similar to test problem 2 using clay minerals in solid solution and under kinetic constraints. An arbitrary rate was used such that equilibrium is reached quickly. The test was run with version V2.4 and met the acceptance criteria listed in that table.

This test uses a one-block setup (actually, there are two connected identical blocks, because at least one connection is needed for the code to compute surface areas; the two blocks, each with identical properties and initial conditions, can be regarded as one larger block). The block is heated up from 25° C to ~ 130° C. The initial solution composition is arbitrarily chosen as a Yucca Mountain pore water, and the block mineralogy corresponds to a tuff, with an arbitrarily elevated percentage of smectite minerals. We set the precipitation and dissolution rates of smectites very high (~10-5 mol/s·m2) such that equilibrium is quickly reached.

1) Baseline verification of clay saturation without solid solution

Test folder and data files used:

solid_sol2.4/no_ss	FLOW.INP SOLUTE.INP CHEMICAL.INP ThermoU2.07.dat	input
	chdump.dat TIME.DAT	output

There are no solid solutions in this first test. We examine the log(Q/K) values in the chdump.dat file and precipitated/dissolved amounts in the TIME.DAT file for smectite end-members as individual minerals. The following log(Q/K) values are computed:

Table A-2

Log Q/K			
T (°C)	smect-ca	smect-na	smect-mg
28	0.0837	-0.246	0.0837
129.077	0.000	0.000	0.000
	precipitates	dissolves	precipitates

Equilibrium is reached when log Q/K = 0 for each individual mineral, and the precipitated/dissolved trends are consistent with original log (Q/K) values.

2) Verify saturation of smectite ideal solid solution

Test folder and data files used:

solid_sol2.4/clay_ss	FLOW.INP CHEMICAL.INP SOLUTE.INP ThermoU2.07.dat	input
	chdump.dat	output

Here, we run the same simulation as in 1) above, but specify the smectite minerals (Na-, Ca-, and Mg-smectite) as an ideal solid solution. Because we treat the smectites as an ideal solid solution, saturation of the solid solution should occur when the sum of the (Q/K) values for each end-member equals 1 (• $(Q/K)_i = 1$). We examine log(Q/K) values in the chdump.dat file, as previously:

Table A-3

Log (Q/K)			
T (°C)	smect-ca	smect-na	smect-mg
27.084	-0.3935	-0.7388	-0.3836
	• $(Q/K)_i = 10^{-.3935} + 10^{-.7388} + 10^{-.3836} = 1.00$		
51.052	-0.3989	-0.8100	-0.3506
	• $(Q/K)_i = 10^{-.3989} + 10^{-.8100} + 10^{-.3506} = 1.00$		
103.105	-0.4057	-0.9410	-0.3076
	• $(Q/K)_i = 10^{-.4057} + 10^{-.9410} + 10^{-.3076} = 1.00$		
129.077	-0.4026	-0.9898	-0.2994
	• $(Q/K)_i = 10^{-.4026} + 10^{-.9898} + 10^{-.2994} = 1.00$		

Equilibrium is reached when • $(Q/K)_i = 1$, as expected. Also, in this case, the smectite solid solution originally precipitates, even though each individual end member is undersaturated (as would be expected). Hand-calculated and computed saturation indexes match within 0.1%, and therefore the acceptance criteria is met.

A.9 Verification of Correct Fracture Permeability Calculations (Permeability Law 3 – Cubic Law)

Test problem 9 (test_boilfrac_1) was run with V2.4 using permeability law 3 and the option to change porosity and permeability over time. At grid block **A 1** at the last time step, porosity has changed from the initial value of 0.08 to 0.7999. This decrease in porosity is in good agreement with the mineral volume fraction 0.1154e-4 (precipitation). The permeability has changed from the initial value of 0.133e-13 to 0.13294e-13. This is also supported by permeability law 3, which yields a value of 0.13294e-13. The acceptance criterion in Table 1 was met.

A.10 Verification of Correct Fracture Permeability Calculations (Permeability Law 4 – Fracture Aperture Law)

Test problem 10 is comprised of 3 test simulations (test_boilfrac_2-4) that were run with V2.4 using permeability law 4 and the option to change porosity and permeability over time. In test_boilfrac_2, the porosity of a node at the last time step has changed from the initial value of 0.08 to 0.07711. This decrease in porosity is in good agreement with the mineral volume fraction change 0.2887e-2 (precipitation). A permeability change from 0.13300e-15 m2 to 0.10605e-15 m2 was observed, with a hand-calculated value of 0.10590e-15. These results meet the acceptance criterion in Table 1.

A.11 Verification of Correct Permeability Porosity Coupling for Permeability Law 1 (Carman-Kozeny Law)

Test problem 11 in Table 1 was run with V2.4. The concentration of SiO_2(aq) read at the end of TIME.DAT at the outlet (grid block rk 31) is 0.3139e-2 mol/lliquid. This is equivalent to 0.3827e-2 mol/l, after the density of the liquid 0.82021 g/l at elevated temperature 239°C for the experiment (density read from file FLOW.OUT as DL) is factored in. This simulated concentration 0.3827e-2 mol/l is close to analytical value of 0.3774e-2 mol/l (equivalent to 106 ppm Si) and meets acceptance criteria (5%). Furthermore, changes in porosity and permeability were also checked. At outlet at grid block rk 31, the porosity has changed from an initial value of 0.425002 to 0.425442 (read from file SAVE), an increase of 0.442e-4. The change in mineral amount is –0.442e-4 (volume fraction) (negative means dissolution) (read from file TEC_MIN.DAT). The identical numbers in mineral (quartz) dissolution is translated into an increase in porosity. The hand calculated permeability is calculated with Karmen-Kozeny law:

$$k = k_0 \times \frac{(1-\varphi_0)^2}{(1-\varphi)^2} = 0.651e-11 \times \frac{(1-0.425000)^2}{(1-0.425442)^2} = 0.65110e-11$$

where k, k_0 are simulated and initial permeabilities (m^2), φ, φ_0 are simulated and initial porosities. This is identical to the simulated permeability of 0.65110e-11. Acceptance criteria for porosity and permeability changes are both met.

A.12 Verification of Correct Input of Heterogeneous Porosity and Permeability Fields

Test problem 12 in Table 1 was run with V2.4. This option was tested by restarting the output of test problem 9 (1-D fracture plugging problem) that had previously developed heterogeneity in permeability and porosity. The value of kcpl in the SOLUTE.INP file was changed such that no subsequent changes would occur to porosity or permeability. The simulation was restarted and stopped after a few iterations. The permeability and porosity values were compared at all nodes in the input INCON and the output SAVE file using the UNIX "diff" command. The values were identical. Acceptance criteria for porosity and permeability changes are therefore both met.

A.13 Verification of Correct Input of Permeability Zones

Test problem 13 in Table 1 was run with version 2.4. This is the same 1-D fracture plugging problem as used in test problems 11 through 15. Zones blocks were used in CHEMICAL.INP and in SOLUTE.INP. The successful tests for the permeability equations in A.9, A.10, and A.11 demonstrate that the permeability zones were assigned correctly to grid blocks.

A.14 Verification of Correct Match to 1-D Reaction Transport

Test problem 14 was run with version V2.4. The permeability porosity coupling flag kcpl in SOLUTE.INP is set to "0". The concentration at outlet (grid block rk 31) is 0.3140e-2 mol/l_{liquid}. This is equivalent to 0.3828e-2 mol/l, after the density of the liquid 0.82021 g/l at elevated temperature 239°C for the experiment (density read from FLOW.OUT as DL) is considered. This simulated concentration is close to analytical value of 0.3774e-2 mol/l and meets acceptance criteria (<5%).

A.15 Verification of Option to Precipitate Amorphous Silica into Dry Nodes

Test problem 15 was run with V2.4. This was tested with 1-D fracture plugging problem setting flag 4 (after mineral name) to 1 and using permeability law 3 and 4. All other minerals must have their flags set to zero. It must be checked that amorphous silica precipitates in the dry node that is just ahead of the first wet node in the boiling front and that the mass balance for silica precipitated in the entire system is within 5% of the input value (in Mbalance.out). The initial condition is that the nodes are wet down to 'A 8', with 'A 9' being the first dry node below the boiling front. Checking the output tec_min.dat file, amorphous silica is found to precipitate in the first dry node. Checking the Mbalance.out file for the mass balance of SiO_2, we get:

	Input+Initial	Output+Current	Difference	Rel. Dif.(%)	Del Solid/liq %
sio2(aq)	0.4075E+00	0.4075E+00	-0.2033E-04	-0.4989E-02	-0.1000E+01

Therefore, the mass balance for all SiO_2 in the system (under Rel. Dif.(%)) is about -0.005% and the balance for the amount of solid precipitated/dissolved compared to the changes in solute concentrations is 1%. Hence the criteria for less than 5% mass balance error on the amount of amorphous silica precipitated is met.

5. References

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COPY WBS: 1.2.5.4
QA: QA

Civilian Radioactive Waste Management System
Management & Operating Contractor

GoldSim Version 6.03

VALIDATION TEST REPORT

Software Document Number: ~~10344-SAP-6.03-00~~ 10344-VTR-6.03-00 9/21/01

Software Media Number: 10344-PC-6.03-00

Software Tracking Number: 10344-6.03-00

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Prepared for:

U.S. Department of Energy
Yucca Mountain Site Characterization Office
P.O. Box 30307
North Las Vegas, Nevada 89036-0307

Prepared by:
BSC
1180 Town Center Drive
Las Vegas, Nevada 89134-6352

DISCLAIMER

Civilian Radioactive Waste Management System
Management & Operating Contractor
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September 2001

Verified by:

Noel Simpson
Performance Assessment Department

Date 9/18/2001

Approved by:

David Sevougian
Performance Assessment Department

Date 9/18/01

Reviewed by:

~~Dianne Spence~~ Lyle C. Southworth
ITSMA

LCS
9/21/2001

Date 9/21/2001

CHANGE HISTORY

Revision Number	Effective Date	Description of Change
00	9/14/01	Initial issue

CONTENTS

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ATTACHMENTS

FIGURES

TABLES

Page

1 SOFTWARE IDENTIFICATION

Software GoldSim Version 6.03
Operating Platform PC
Operating System Windows NT Version 4.0

2 VALIDATION TESTER

The validation tester was Norm Graves. The validation tests were conducted in Las Vegas in November 2000.

3 SPECIAL TOOLS AND EQUIPMENT

No special tools or equipment were needed to install the code and run the tests. The software was installed on a network PC, CPU Number 117181, with the Windows NT Version 4.0 operating system.

4 TEST RESULTS LINKED TO THE UNIQUE TEST IDENTIFIER FROM THE VTP

Each test case that follows is uniquely identified and correlated to its associated test case in the VTP.

5 DOCUMENTATION OF ITP AND VTP

5.1 INTRODUCTION

GoldSim is a probabilistic software program that is designed to simulate the release, transport and fate of contaminates in environmental and engineered systems. GoldSim is an update of the Repository Integration Program (RIP) which was used by the Performance Assessment group to evaluate the performance of a potential nuclear waste repository at Yucca Mountain. GoldSim now has a highly graphical user interface and several added features. The *Validation Test Plan for GoldSim Version 6.04.007* describes the validation process.

5.2 ITP DOCUMENTATION

The Installation Test Plan specifies the use of the vendor's User's Manual for installation instructions and an installation test case. The installation instructions in the GoldSim User's Manual (Golder 2000a, Section 1) were followed, and there were no problems encountered during the installation. The installation test problem that was provided with the software was run as described in the User's Manual. The result, shown in Figure 1, is the same as that given in the User's Manual and indicates GoldSim was installed correctly.

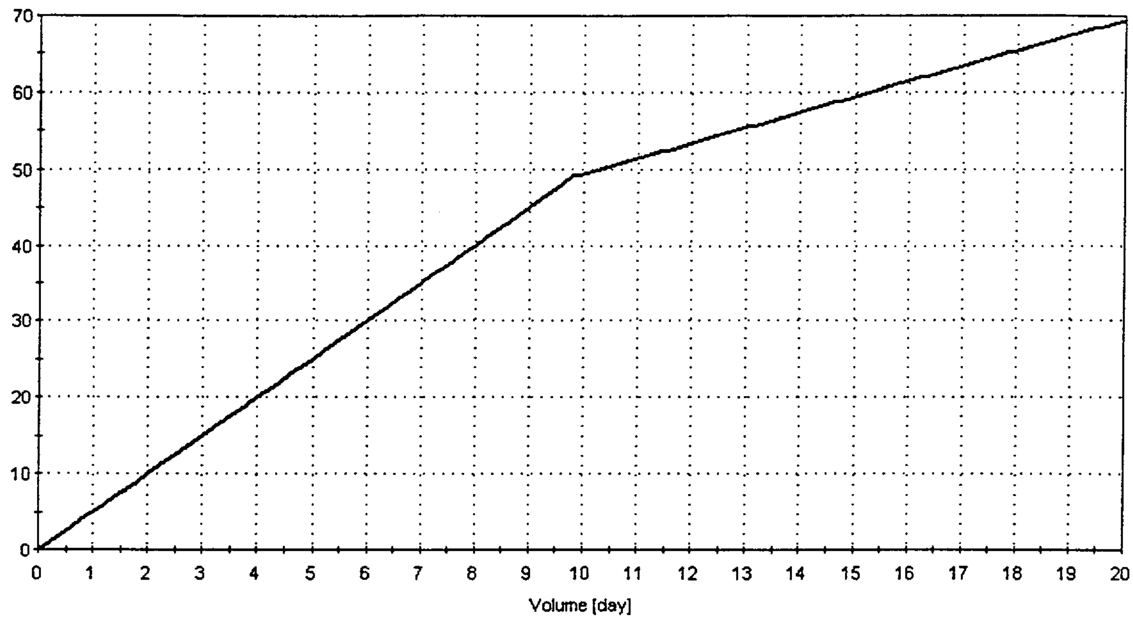

Figure 1. Result of the GoldSim version 6.03 installation test problem.

All validation tests were executed on CPU 117181. The workstation uses the Windows NT 4.0 operating system.

5.3 VTP DOCUMENTATION

The steps to be used for validating GoldSim are delineated in the Validation Test Plan (VTP) for GoldSim Version 6.04.007. The VTP provides six tests that test various capabilities of the software; these tests are designated in the following subsections as Tests 1 through 6. The VTP also instructs the validation tester to select additional tests from those provided by the vendor. The tests selected from those supplied from the vendor should test the functions that were not tested in the six VTP tests. Those functions not tested by the six VTP tests are listed in the VTP.

The VTP has supplied six independent test cases to test some of the computational requirements of GoldSim. These tests were run as described in the VTP, and the results are documented in the following subsections.

5.3.1 Test 1: Diffusive Transport

This test consists of two cases that are designed to test the requirement that GoldSim simulate diffusive mass transport through partially saturated to fully saturated porous media. The test of diffusive mass transport through a fully saturated porous medium (designated as Test 1, Case 1

in the VTP) was simulated as described in the VTP. The expected result is a mass flux rate of 5.0E-03 grams/year (CRWMS M&O 2000a, Section 4.1.1).

The simulation of Case 1 produced the result shown in Figure 2. As the figure shows, the mass flux rate quickly increases from zero to a steady-state flux of 5.0E-03 grams/year.

The time history result table, given in Attachment I, shows that the flux rate reaches a steady state of 4.995E-3 grams/year. The acceptance criteria defined in the VTP for this test case is +/- 10% (4.5E-03 to 5.5E-05 grams/year). This result is within the acceptance criteria range, and indicates that the program is correctly calculating diffusive mass transport flux rates through a fully saturated medium.

The second case of the diffusive mass transport test (designated as Test 1, Case 2 in the VTP) is transport through a partially saturated medium. The VTP states that the expected result for this case is 6.9347E-5 grams/year (CRWMS M&O 2000a, Section 4.1.1). The acceptance criteria given in the VTP for this result is +/- 10% (6.237E-5 to 7.623E-5 grams/year).

Simulation of Case 2 produced the mass flux curve shown in
Figure 3. The curve shows that the mass flux reaches a steady state at just under 7E-05 grams/year.

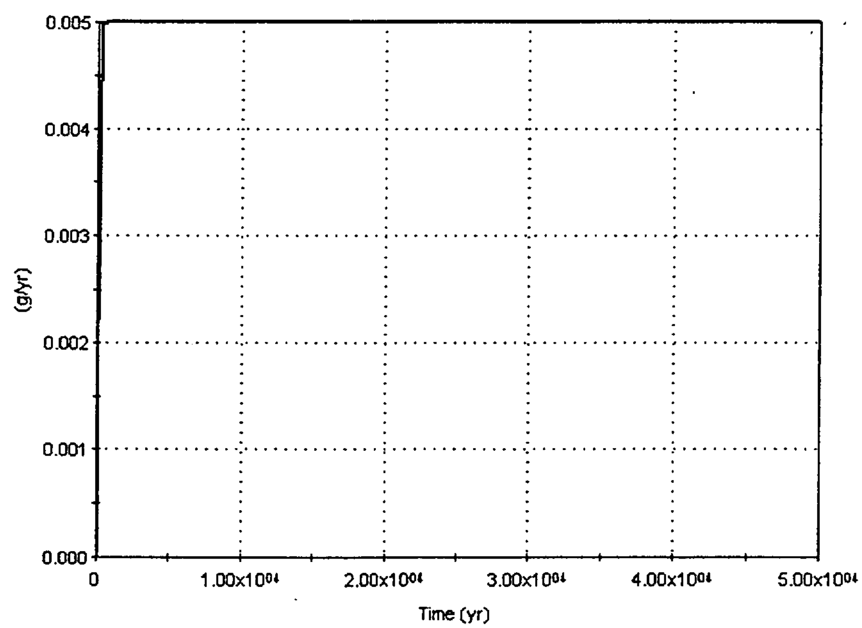

Figure 2. Diffusive mass transport through a fully saturated medium, VTP Test 1, Case 1.

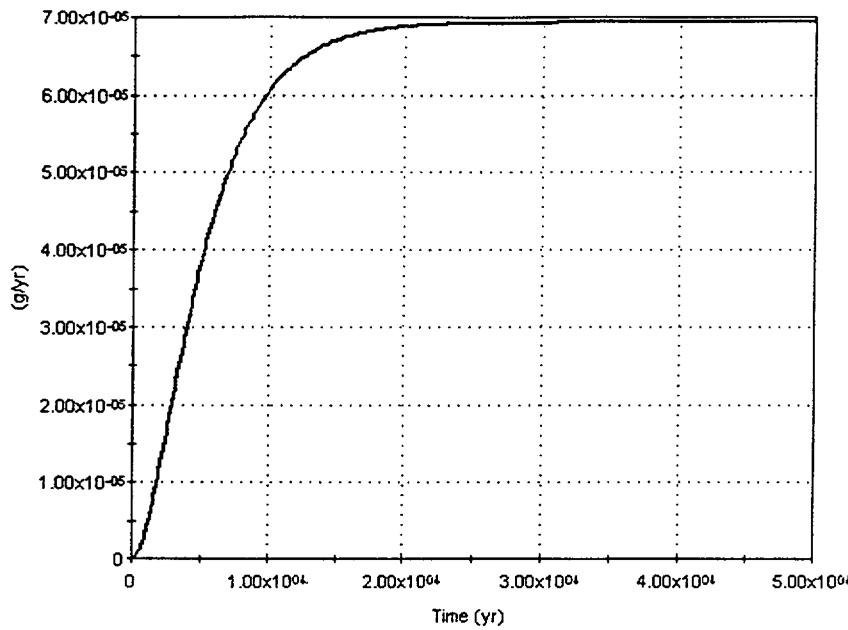

Figure 3. Diffusive mass transport through a partially saturated medium, VTP Test 1, Case 2.

The time history results, given in Attachment I, for Case 2 show that steady state is reached at a mass flux rate of 6.9278E-5 grams/year. The simulation result is within the acceptance criteria range, and this indicates that the program is correctly calculating diffusive mass transport flux rates through a partially saturated medium.

GoldSim passed both cases of VTP Test 1, Diffusive Transport.

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5.3.2 Test 2: Advective Transport

Validation testing of the advective transport capabilities of GoldSim consists of three cases, 1) one-dimensional advection with dispersion, 2) one-dimensional advection with dispersion with the addition of sorbing material within the advective pathway, and 3) advection out of a mixing cell (CRWMS M&O 2000a, Section 4.1.2). The acceptance criterion for all three cases is that the GoldSim results should be within +/- 10% of the expected results (CRWMS M&O 2000a, Section 2.1.2).

The expected results for Case 1, one-dimensional advection with dispersion, are shown in Table 1.

Table 1. Expected Values for Test 2, Case 1: One-dimensional Advection with Dispersion (CRWMS M&O 2000a, Section 4.1.2.1)

Time (years)	Concentration (g/m^3)
500	8.006677
1000	58.52889
1500	87.45247
2000	96.62204
2500	99.12365
3000	99.77509

The results generated by GoldSim for the times shown in Table 1 are given in Table 2. The complete set of GoldSim results is given in Attachment II.

Table 2. GoldSim Results for Test 2, Case 1: One-dimensional Advection with Dispersion

Time (years)	Conc. (g/m3)	Percent Deviation from Expected
500	7.9626	0.55
1000	58.426	0.18
1500	87.349	0.12
2000	96.521	0.10
2500	99.023	0.10
3000	99.675	0.10

These results are all well within the +/- 10% acceptance criteria set in the VTP. It is concluded from this test that GoldSim can correctly calculate advective transport with dispersion.

Case 2 is similar to Case 1 with the addition of a sorbing material. The velocity of the water was increased for this case such that the results for Case 2 would be identical to those of Case 1 (CRWMS M&O 2000a, Section 4.1.2.2). The results generated by GoldSim for this case are given in
Table 3, and can be compared with the expected results shown in Table 1.

Table 3. GoldSim Results for Test 2, Case 2: One-dimensional Advection with Dispersion and the Addition of a Sorbing Material within the Advective Pathway

Time (years)	Conc. (g/m^3)	Percent Deviation from Expected
500	7.9626	0.55
1000	58.426	0.18
1500	87.349	0.12
2000	96.521	0.10
2500	99.023	0.10

Time (years)	Conc. (g/m^3)	Percent Deviation from Expected
3000	99.676	0.10

The results for Case 2 are all well within the +/- 10% acceptance criteria set in the VTP. It is concluded from this test that GoldSim can correctly calculate advective transport with dispersion through a sorbing material.

The third case tests the advective release from a batch reactor "mixing cell". The expected results for this simulation are given in Table 4.

Table 4. Expected Results for VTP Test 2, Case 3: Advection Out of a Mixing Cell (CRWMS M&O 2000a, Section 4.1.2.3)

Time (years)	Mass in Cell (g)
500	60.653
1000	36.788
2000	13.534
5000	0.674

The results generated by the GoldSim run, shown in **Table 5**, are nearly identical to the expected results (see Attachment II for the full listing of the Case 3 simulation results). Thus, it is concluded that GoldSim can correctly calculate advective release from a batch reactor "mixing cell". GoldSim passed all three cases of Test 2, Advective Transport.

Table 5. GoldSim Results for Test 2, Case 3: Advection Out of a Mixing Cell

Time (years)	Mass in Cell (g)
500	60.653
1000	36.788
2000	13.534
5000	0.6738

GoldSim passed all three cases of Test 2, Advective Transport.

[signature] 9/14/01

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5.3.3 Test 3: Source Term

This test was designed to test the requirement that GoldSim be capable of simulating a release from three layers of containment – release from a waste matrix, and releases from an inner and an outer barrier (see CRWMS M&O 2000a, Section 4.1.3 for more details).

Source 1 tests the use of the 'inner barrier', which is used to represent the fuel cladding barrier. The inventory is 1.0E+05 g of Species A located outside the waste matrix, but inside the inner barrier. The solubility of Species A is 1 g/m^3. The expected results for unexposed mass at selected times is shown in **Table 6**, and the expected steady-state mass transport of Species A is expected to be 5.0E-03 g/year (CRWMS M&O 2000a, Section 4.1.3.1).

Table 6. Expected Results at Selected Times for VTP Test 3, Source 1: Inner Barrier (CRWMS M&O 2000a, Section 4.1.3.1)

Time (years)	Unexposed Mass (g)
2000	8.0E+04
4000	6.0E+04
6000	4.0E+04
8000	2.0E+04
10000	0.0

The results generated by GoldSim for these selected times are identical to those given in Table 6 above (the results are given in Attachment III). As can be seen in Figure 4, the mass transport rate quickly reaches steady state at about 5.0E-03 grams/year.

The time histories for the mass transport rate, also given in Attachment III, show a steady-state transport rate of 4.995E-03 grams/years. This is well within the +/- 10% acceptance criterion established by the VTP. These results indicate that GoldSim can correctly simulate loss of containment from an 'inner barrier' and the subsequent mass transport rate.

Source 2 was designed to test release from the 'outer barrier'. The outer barrier is used to represent the discrete failure of waste packages. For this validation test, Source 2 contains 10 packages, and each package contains 100 g of Species B. The packages are to fail uniformly from 0 to 10,000 years, refer to CRWMS M&O 2000a, Section 4.1.3.2 for more details. The acceptance criterion for Source 2 is that a single package fails and a pulse of Species B is released at each of the following times: 500, 1500, 2500, 3500, 4500, 5500, 6500, 7500, 8500, and 9500 years (CRWMS M&O 2000a, Section 4.1.3.2).

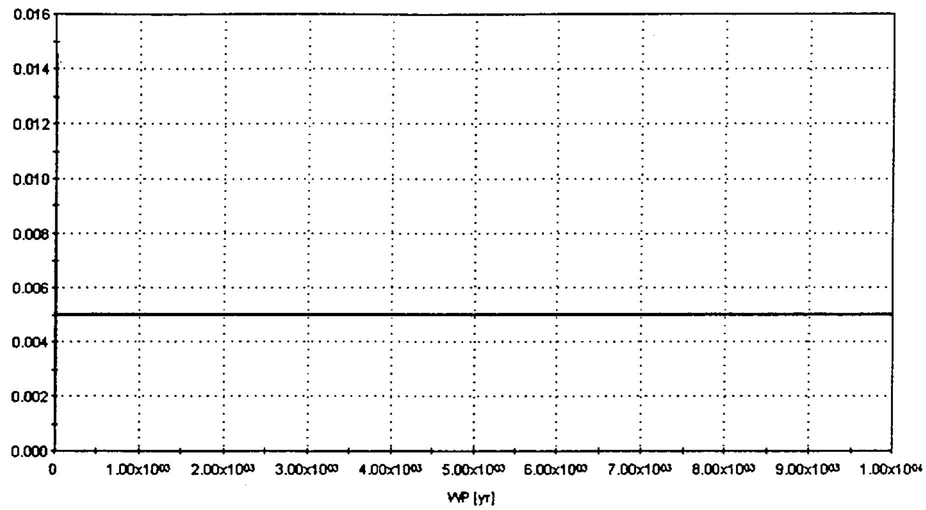

Figure 4. Mass transport rate for Test 3, Source 1.

The results of the GoldSim run for this source are shown in Figure 5. As can be seen from the figure, there are discrete releases at the times expected. The data listing (provided in Attachment III) shows that 10 grams/year of Species B is released for each 10 year time step interval. This result indicates that GoldSim can correctly simulate a release from an outer barrier.

Source 3 was developed to test the matrix degradation of a source term. Source 3 contains a single waste package that has an inventory of 100 grams of Species C within a matrix. A matrix degradation rate of 1.0E-04 per year is defined. Species C is also defined with a decay rate of 1.0E-05 per year. The expect results (CRWMS M&O 2000a, Section 4.1.3.3) are shown in Table 7 along with the results from the GoldSim run (the complete listing of the GoldSim results can be found in Attachment III). The acceptance criterion specified in the VTP is +/- 10%.

Table 7. Comparison of Expected Results with Results Generated in GoldSim, Test 3, Source 3

Time (years)	Unexposed Mass Expected (g)	Unexposed Mass GoldSim (g)	Percent Deviation From Expected
0	100.0	100.0	0.00
100	98.90	99.005	0.11
1000	89.58	89.669	0.10
10000	33.29	33.304	0.04

As can be seen from the table, the GoldSim results are well within the acceptance criteria established in the VTP. This indicates that GoldSim can correctly simulate the release from a matrix. GoldSim passed all three of the cases of Test 3, Source Term.

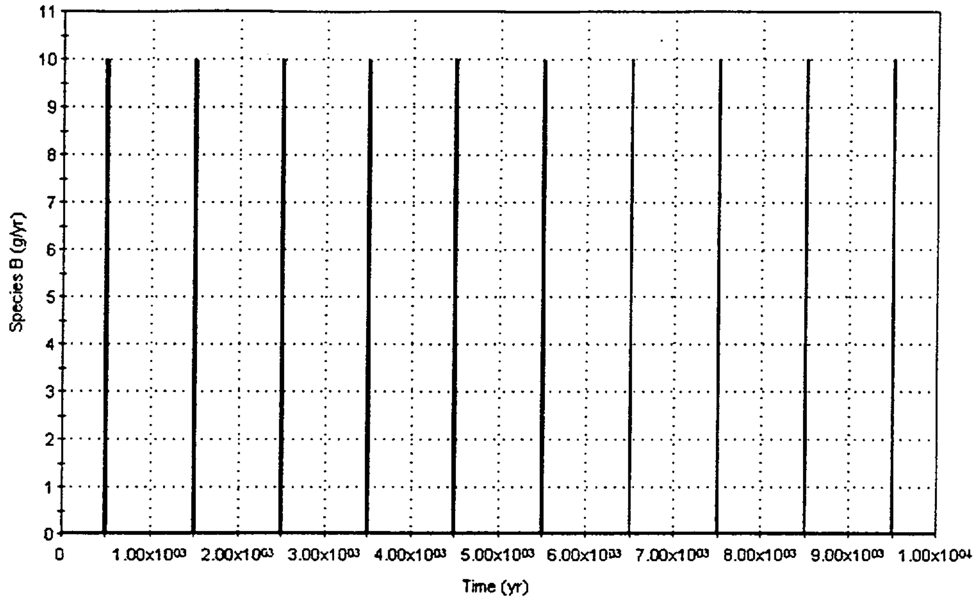

Figure 5. Mass release rate from an outer barrier, Test 3, Source 1.

GoldSim passed all three of the cases of Test 3, Source Term..

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5.3.4 Test 4: Dose Rate

This test was design to test the requirement that GoldSim be able to calculate a dose rate to an individual or a population. This test sums the dose rate from two separate species to give a total dose rate. Species A is defined with the following properties: a decay rate of 3.0E-04 per year, an initial inventory of 100 grams, and a dose conversion factor of 3.0E+03 (rem/year)/(g/m^3). Species B is defined with the following properties: decay rate of 1.0E-03 per year, an initial inventory of 1000 grams, and a dose conversion factor of 5.0E+02 (rem/year)/(g/m^3).

The expected results as given in the VTP (CRWMS M&O 2000a, Section 4.1.4) along with the results generated in GoldSim are given in Table 8. The complete listing of results of the test are given in Attachment IV.

Table 8. Comparison of Expected Results with Results Generated in GoldSim, Test 4

Time (years)	Total Dose Rate Expected (rem/year)	Total Dose Rate GoldSim (rem/year)	Percent Deviation from Expected
0	8.000E+05	8.00E+05	0.00
100	7.435E+05	7.44E+05	0.07
1000	4.062E+05	4.06E+05	0.05

10000	1.495E+04	1.4959E+04	0.06

These results are well within the +/- 10% criterion established for the GoldSim results by the VTP (CRWMS M&O 2000a, Section 4.1.4). These results show that GoldSim can correctly calculate the dose rate to an individual or a population.

GoldSim passed Test 4, Dose Rate.

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5.3.5 Test 5: Stochastic Parameters

VTP Test 5 is used to evaluate the ability of GoldSim to define stochastic parameters and to correlate parameters (CRWMS M&O 2000a, Section 4.1.5). This test consists of two normal distributions that are fully correlated. Distribution "Normal1" is defined with a mean of zero and a standard deviation of one. Distribution "Normal2" is defined with a mean of one and a standard deviation of one. This test simulation was run using random sampling for 100 realizations as described in the VTP. The acceptance criterion specified in the VTP is that the value of "Normal2" be equal to the value of "Normal1" +1 for all 100 realizations. Also, to test the output requirements associated with stochastic parameters and multiple realizations, the following outputs are required by the VTP: 1) a plot of the CDF and CCDF of stochastic parameters, and 2) the ability to save all of the time histories of a parameter to an ASCII file.

Selected simulation results for the correlation of distribution "Normal1" with distribution "Normal2" are shown in Table 9 (the full listing of the results is given in Attachment V).

Table 9. GoldSim Results for Distributions Normal1 and Normal2

Realization	Normal1	Normal2
1	-0.63019	0.36981
25	-1.1797	-0.17968
50	-1.5809	-0.5809
75	0.59879	1.5988
100	0.015646	1.0156

The "Normal2" values are equal to "Normal1" + 1 as expected. The ability of GoldSim to provide CDF and CCDF plots of stochastic parameters is shown in Figure 6 and Figure 7, respectively.

Finally, the last result is the ability of GoldSim to save all of the generated time histories of a parameter to an ASCII file. As described in the VTP (CRWMS M&O 1999a, Section 6.5) an ASCII file was created of the time history results for distribution "Normal3", which is a uniform distribution. The ASCII file of the time histories was created correctly, and is given in Attachment V. GoldSim passed all aspects of VTP Test 5.

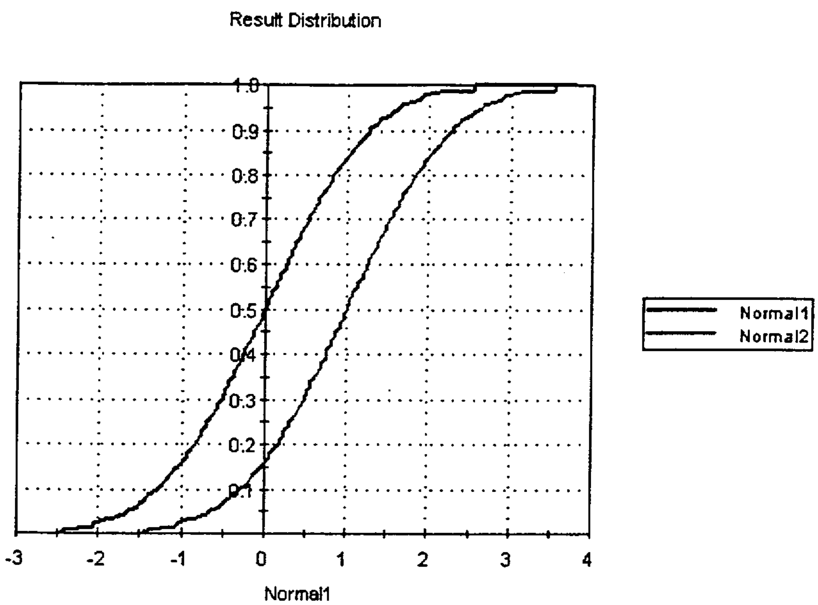

Figure 6. CDF plot of distributions "Normal1" and "Normal2".

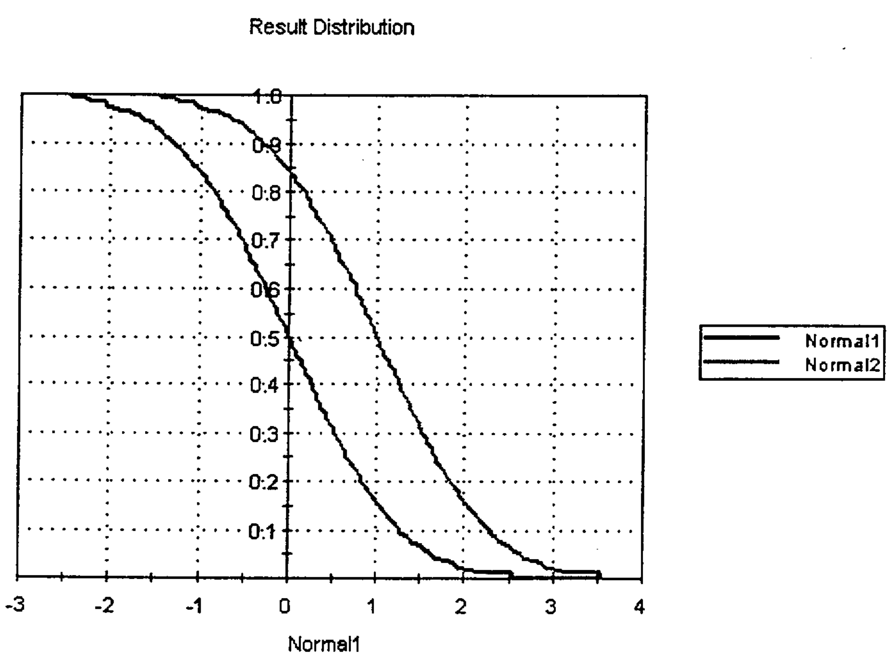

Figure 7. CCDF plot of distributions "Normal1" and "Normal2".

GoldSim passed Test 5.

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5.3.6 Test 6: Loading Values from a Database

This test was designed to evaluate the requirement that GoldSim be able to load values from a database. A Microsoft Access database was created for this test (CRWMS M&O 2000a, Section 4.1.6). GoldSim is to read from the database a constant value, a distribution, a one-dimensional table, and a two-dimensional table. The constant value to be read from the database is the "Area of the Repository Region 1", which is 429314 m^2. The distribution to be read from the database is a uniform distribution that corresponds to the CSNF zircaloy corrosion cladding failure, with a minimum equal to zero meters, and a maximum equal to 1 meter. The one-dimensional table gives the mean seepage fraction in LTA region 1, and the two-dimensional table provides the waste package failure history CDF for no drip packages.

The test case was run as described in VTP Section 6.6 (CRWMS M&O 2000a). The constant value and the distribution type with the minimum and maximum values loaded correctly. The one-dimensional and two-dimensional tables also loaded correctly. Table 10 lists a few of the points for the one-dimensional table (CRWMS M&O 2000a, Section 4.1.6) along with the values obtained from GoldSim. As can seen from Table 10, GoldSim correctly loaded the one-dimensional table values.

Table 10. Comparison of Database Values with the Values Loaded by GoldSim for a One-dimensional Table

Database Values		Values Loaded by GoldSim	
Independent Variable	Dependent Variable	Independent Variable	Dependent Variable
0	0	0	0
2.2	0	2.2	0
3.9	0.00844	3.9	0.00844
9.2	0.0462	9.2	0.0462

Table 11 shows the results for the two-dimensional table. This shows that GoldSim can also correctly load a two-dimensional table from a database.

Table 11. Comparison of Database Values with the Values Loaded by GoldSim for a One-dimensional Table

Database Values				Values Loaded by GoldSim			
	Columns				Columns		
Rows	1	2	3	Rows	1	2	3
0	0	0	0	**0**	0	0	0
794327.2	0	0	0	**794327.2**	0	0	0
794328.2	0.0053	0	1.4022	**794328.2**	0.0053	0	1.4022
803526.1	0.0062	0	2.8174	**803526.1**	0.0062	0	2.8174

GoldSim passed all aspects of Test 6, "Loading Values from a Database".

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5.3.7 Vendor Supplied Test Cases

The VTP instructs the validation tester to select five test cases from the vendor's verification plan to run. The VTP indicates that the test cases from the vendor's verification plan should test the functions listed below:

1. Change in mass of radioactive species due to decay and ingrowth in decay chains
2. Advection through partially saturated media
3. Diffusion through sorptive material
4. Transport of colloids (suspended solids)

5. Interpolation of values between data entries in multidimensional tables

6. Calculation of mathematical expressions to determine the values of derived parameters. Mathematical operations that should be supported include addition, subtraction, multiplication, division, exponents, and logical tests.

7. Calculation of mathematical functions including trigonometric functions, absolute value, exponential, logarithms, modulus, rounding, truncating, and square root functions.

8. Ability to define parameters as distribution functions

9. Ability to use the expected value of all stochastic variables for a given simulation

10. Ability to perform Monte Carlo simulations by sampling all stochastic parameters using Latin Hypercube Sampling (LHS)

11. Ability to perform up to 1000 realizations for a single simulation.

There are not five vendor tests cases that would test all these functions, so seven vendor tests were selected so that all the above functions would be tested. **Table 12** lists the vendor test cases selected for each of the functions to be tested (from the list above).

Table 12. Vendor Test Cases Chosen for GoldSim Verification

Vendor Test Case	Description	Functions Tested
CT_SourceDecay-1	Decay within a source	Decay and ingrowth in decay chains (1)
CT_Pipes-1	Single-porosity test problem	Advection through partially saturated media and transport of colloids (2 and 4)
CT_Cells3-01	Simple diffusion	Diffusion through a sorptive material (3)
GS8_LOOK	Look-up tables	Interpolation in multidimensional tables (5)
GS2_EXP	Expressions and data	Mathematical expressions (6 and 7)
GS4_STOC	Stochastic distributions	Stochastic distributions and expected value simulations (8 and 9)
TMC-02	Monte-Carlo tests	Latin-Hypercube sampling and multiple realizations (10 and 11)

5.3.7.1 Decay Within a Source

This test case is intended to evaluate the ability of GoldSim to calculate the change in mass of radioactive species due to decay and ingrowth in decay chains. This vendor-supplied test is designated as *CT_SourceDecay-1* (Golder 1999b, Section 4.6.4). This test starts with an ^{241}Am source (10,000 Ci) and defines a single daughter, ^{237}Np. To evaluate split decay, ^{237}Np is defined with two equally probable daughters, ^{233}U(a) and ^{233}U(b). The simulation time is 1,000 years.

The results of the GoldSim simulation agree well with the expected results (Golder 1999b, Section 4.6.4). **Table 13** shows the results of the GoldSim simulation along with the expected results.

Table 13. Comparison of GoldSim Results for the Decay of a Radionuclide and the Ingrowth of the Daughters with the Expected Results

Radionuclide	Expected Value (Ci)	GoldSim Result (Ci)	Percent Deviation From Expected
^{241}Am	2029	2012.9	0.8
^{237}Np	1.610	1.613	0.2
^{233}U(a)	2.194E-03	2.2116E-03	0.8
^{233}U(b)	2.194E-03	2.2116E-03	0.8

This result indicates that GoldSim can correctly simulate the decay and ingrowth of radionuclides within decay chains.

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5.3.7.2 Advection Through Partially Saturated Media and Transport of Colloids

The vendor test that contains these problems is *CT_Pipes-1* (Golder 1999b, Section 4.1). For the advection through a partially saturated medium problem, transport is through a pipe element with a flow rate of 1.0 m^3/day. The pipe's flow area is 1.0 m^2, the longitudinal dispersivity is 1.0 m, the constant flux boundary condition is 1 g/day, and the fluid saturation is 10 percent.

For the transport of colloids problem, transport is through a pipe element with a flow rate of 1.0 m^3/day. The pipe's flow area is 1.0 m^2, the longitudinal dispersivity is 0.5 m, the constant flux boundary condition is 1 g/day, and the fluid saturation is 100 percent. The pipe has a 1-mm coating and the suspended solid concentration is 1.78E-03 kg/m^3.

The expected results for both the advection problem and the colloid problem are the same (refer to Golder 1999b, Section 4.1 for details) and are given along with the GoldSim results in **Table 14**. The complete listing of results for this simulation is given in Attachment VI.

Table 14. Advection through Partially Saturated Media and Transport of Colloids

Time (days)	Concentration – Expected Results	GoldSim Results – Advection	GoldSim Results – Colloids
25	0.0215	0.0215	0.0215
50	0.8679	0.8679	0.8679
75	0.9986	0.9986	0.9986

The GoldSim results match the expected results. GoldSim passed the tests for calculation advection through a partially saturated medium and for transport of colloids.

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5.3.7.3 Diffusion Through a Sorptive Material

This vendor test problem is *CT_Cells3-01* – Simple Diffusion. In this problem, two cells each contain two fluid media, water and oil, and two solid media, sand and clay. The initial inventory (cell 1 only) is 100 Ci each of ^{241}Am (29.09 g), ^{242}Am (10.27 g), and ^{243}Am (500.8 g). The solubility of Am in water is unlimited. There is one diffusive connection between the two cells (water to water). **Table 15** gives the volume, masses, and partition coefficients for the media. **Table 16** gives the diffusive connection properties. Refer to Golder 1999b, Section 4.2.3 for more information.

Table 15. Media Properties for *CT_Cells3-01* Test Problem

Medium	Volume (m^3) or Mass (kg)	Partition Coefficient Relative to Water (m^3/m^3) for fluids; (m^3/kg) for solids
Water	10	1
Oil	5	0.1
Sand	10	0.2
Clay	20	5

Table 16. Diffusive Connection Properties for *CT_Cells3-01* Test Problem

	Diffusive Length (m)	Tortuosity	Porosity
Cell 1	0.02	0.1 (sand)	0.3 (sand)
Cell 2	0.02	0.15 (clay)	0.4 (clay)

The diffusive area is 20 m^2 and the diffusivity for all species in water is 1E-3m^2/year.

Table 17 gives the expected results for each cell at various times (Golder 1999b, Section 4.2.3).

Table 17. Expected Concentrations in Water for Each Cell

	Cell 1		
Time (years)	^{241}Am (g/m^3)	^{242}Am (g/m^3)	^{243}Am (g/m^3)
100	2.54E-1	8.97E-2	4.37
1,000	2.20E-1	7.76E-2	3.79
10,000	1.33E-1	4.70E-2	2.29
	Cell2		
Time (years)	^{241}Am (g/m^3)	^{242}Am (g/m^3)	^{243}Am (g/m^3)
100	4.52E-3	1.59E-3	7.77E-2
1,000	3.87E-2	1.37E-2	6.66E-1
10,000	1.26E-1	4.43E-2	2.16

The results produced by GoldSim shown in **Table 18** match the expected results shown above in **Table 17**. The complete output listing for this test case is given in Attachment VII.

Table 18. GoldSim Results for Concentrations in Water for Each Cell

Cell 1			
Time (years)	**^{241}Am (g/m^3)**	**^{242} Am (g/m^3)**	**^{243} Am (g/m^3)**
100	2.54E-1	8.97E-2	4.37
1,000	2.20E-1	7.76E-2	3.79
10,000	1.33E-1	4.70E-2	2.29
Cell2			
Time (years)	**^{241}Am (g/m^3)**	**^{242} Am (g/m^3)**	**^{243} Am (g/m^3)**
100	4.52E-3	1.59E-3	7.77E-2
1,000	3.87E-2	1.37E-2	6.66E-1
10,000	1.26E-1	4.43E-2	2.16

GoldSim passed this test.

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5.3.7.4 Interpolation in Multidimensional Tables

The GoldSim verification problem *GS8_LOOK* is used to test GoldSim's ability to look-up and interpolate data in one, two, and three-dimensional tables (Golder 1999b, Section 3.1).

5.3.7.4.1 One-dimensional Look-up Tables

The verification problems for a one-dimensional table include tests of GoldSim's ability to look-up table values, interpolate between table data points, and extrapolate outside table data points. There are four verification tests for the one-dimensional table look-up as follows:

1. Look-up data point at, between, and outside table data points, linear interpolation and extrapolation.
2. Look-up data point at, between, and outside table data points, linear interpolation and no extrapolation.
3. Look-up data point at, between, and outside table data points, linear interpolation and extrapolation on the dependent variable axis, log interpolation and extrapolation on the independent axis.
4. Look-up data point at, between, and outside table data points, log interpolation and extrapolation on the dependent variable axis, linear interpolation and extrapolation on the independent axis.

The table defined for these one-dimensional look-up tests is shown in Table 19.

Table 19. One-dimensional Look-up Table

Time (s)	Value (dimensionless)
10	1
20	2
30	3
40	4

The test of GoldSim's ability to look-up table values, linear interpolation between table values, and linear extrapolation outside the table values was executed using a 50-second simulation time (0-50) with half-second time steps. The results of the simulation are given in Attachment VIII. It can be seen by inspection that GoldSim correctly performed these functions. The second test was similar, except that no extrapolation was allowed. These results are also given in Attachment VIII. It can be seen that these calculation were carried out correctly, and that values outside those defined by the look-up table, 0-10 and 40-50 were not calculated.

Table 20 gives the expected results (Golder 1999b, Section 3.1, Table *GS8_LOOK*) and GoldSim results for the third test of a one-dimensional look-up table, which uses linear interpolation and extrapolation on the dependent axis, and log interpolation and extrapolation on the independent axis (time). The complete GoldSim result listing is given in Attachment VIII. As can be seen from the table, GoldSim passed this test.

Table 20. Results for Linear Interpolation and Extrapolation on the Dependent Axis and Log Interpolation and Extrapolation on the Independent Axis

Time (s)	Expected Value	GoldSim Results
0	1	1
10	10	10
20	100	100
30	1000	1000
40	10000	10000
50	100000	100000

Table 21 shows the expected results (Golder 1999b, Section 3.1, Table *GS8_LOOK*) and GoldSim results for the fourth test of a one-dimensional look-up table, which uses log interpolation and extrapolation on the dependent axis, and linear interpolation and extrapolation on the independent axis (time). The complete GoldSim result listing is given in Attachment VIII. As can be seen from the table, GoldSim passed this test.

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Table 21. Results for Log Interpolation and Extrapolation on the Dependent Axis and Linear Interpolation and Extrapolation on the Independent Axis

Time (s)	Expected Value	GoldSim Results
0.5	6.9897	6.9897
1	10	10
10	20	20
40	26.021	26.021

5.3.7.4.2 Two-dimensional Look-up Tables

The verification tests for a two-dimensional table includes the following 1) look-up data point at table data point, 2) look-up data point between table data points, 3) look-up data point outside table data point, and 4) time dependent look-up points at, between, and outside table data points. The two-dimensional look-up table defined for these tests is shown in Table 22.

Table 22. Two-dimensional Look-up Table

	10	20
10	1	3
20	3	5
30	5	7

The first two-dimensional look-up table test requires GoldSim to look-up the table value for row value 20 and column value 10. The value obtain by GoldSim is 3, which is the expected value (Golder 1999b, Section 3.1, Table *GS8_LOOK*). The second two-dimensional look-up table test is to obtain the value for row value 15 and column value 15. GoldSim obtain a value of 3, which is the expected value (Golder 1999b, Section 3.1, Table *GS8_LOOK*). The third two-dimensional look-up table test will find a data point outside the table data points; row value 40 and column value 20. The GoldSim result for this test is 7, which is the expected result (Golder 1999b, Section 3.1, Table *GS8_LOOK*).

For the final two-dimensional look-up table test, time histories were saved for a 50-second simulation time (0-50) with half-second time steps. The expected results from the verification plan (Golder 1999b, Section 3.1, Table *GS8_LOOK*) and the GoldSim results are shown in Table 23.

Table 23. Expected Results and GoldSim Results for Time Dependent Two-dimensional Look-up Table

Time (s)	Expected Value	GoldSim Results
< 10	2	2
10	2	2
15	3	3
20	4	4
25	5	5
30	6	6
> 30	6	6

As can be seen from Table 23, GoldSim performed as expected. The complete listing of GoldSim results for this fourth two-dimensional table look-up test is given in Attachment VIII.

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5.3.7.4.3 Three-dimensional Look-up Tables

The verification problems for the three-dimensional look-up tables are 1) look-up data point at table data point, 2) look-up data point between table data points, 3) look-up data point outside table data point, and 4) time dependent look-up points at, between, and outside table data points. The three-dimensional look-up table defined for these tests is shown in Table 24.

Table 24. Three-dimensional Look-up Table

3D Layer = 10	10	20	3D Layer = 20	10	20
10	1	3	10	3	5
20	3	5	20	5	7
30	5	7	30	7	9

For the first test, GoldSim is to look-up a value at table point layer 10, row 10, and column 10. GoldSim obtained the value 1, which is the expected value (Golder 1999b, Section 3.1, Table *GS8_LOOK*). For the second test, GoldSim is to find the value between table data points at layer 15, row 15, and column 15. GoldSim calculated a value of 4, which is the expected value (Golder 1999b, Section 3.1, Table *GS8_LOOK*). In the third test GoldSim is to look-up a value outside the table data points at layer 5, row 5, and column 5. GoldSim calculated a value of 1, which is the expected result (Golder 1999b, Section 3.1, Table *GS8_LOOK*).

The final three-dimensional look-up table test finds time dependent look-up points at, between, and outside the table data points using a layer value of 10, column value of 15, and time values for the row values. The simulation was run for 50 seconds with half-second time steps. The expected results (Golder 1999b, Section 3.1, Table *GS8_LOOK*) and the GoldSim results are shown in Table 25.

Table 25. Expected Results and GoldSim Results for Time Dependent Three-dimensional Look-up Table

Time (s)	Expected Value	GoldSim Result
< 10	2	2
10	2	2
15	3	3
20	4	4
25	5	5
30	6	6

As can be seen from Table 25, GoldSim performed as expected. The complete listing of GoldSim results for this fourth two-dimensional table look-up test is given in Attachment VIII. GoldSim passed all tests of one, two, and three-dimensional table look-up.

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5.3.7.5 Mathematical Expressions

The VTP requires that GoldSim support mathematical operations such as addition, subtraction, multiplication, division, exponents, and logical tests. GoldSim should also support mathematical functions such as trigonometric functions, absolute value, exponential, logarithms, modulus, rounding, truncating, and square root functions. (CRWMS M&O 2000a, Section 4.2)

These functions and operations are tested using vendor test problem *GS2_EXP* – Expressions and Data. The test and the expected results (Golder 1999b, Section 3.1.1, Table GS2_EXP) are shown in Table 26 along with the GoldSim results (note that the financial functions were not tested since they are not planned be used in the TSPA).

Table 26. GoldSim Test Results of Mathematical Operations.

Type	Test	Expected Result	GoldSim Result
Trigonometric Functions	SIN function	0.84147	0.84147
	COS function	0.54030	0.54030
	TAN	1.5574	1.5574
	ASIN	48.590 deg	48.590 deg
	ACOS	41.410 deg	41.410 deg
	ATAN	36.870 deg	36.870 deg
	SINH	0.52110 rad	0.52110 rad
	COSH	1.1276 rad	1.1276 rad
	TANH	0.46212 rad	0.46212 rad
	COT	0.64209 rad	0.64209 rad
Math Functions	Add	5	5
	Subtract	3	3
	Multiply	10	10
	Divide	2.5	2.5
	Square root	2	2
	Power	25	25
	Absolute value	2	2
	Logarithm	2.3463	2.3463
	Minimum value	1	1
	Maximum value	5	5
	Modulus	2	2

Type	Test	Expected Result	GoldSim Result
	Exponential	2.7183	2.7183
	Truncation	1	1
	Rounding	1	1
Special Functions	Bessel function	2.5153e-007	2.5153e-007
	Beta function	0.50000	0.50000
	Error function	0.84271	0.84271
	If function (expression)	1	1
	If function2 (expression)	1	1
Special Operators	Equality operator	0	0
	Inequality operator	1	1
	Greater operator	0	0
	Less than operator	1	1
	Greater than or equal to operator	0	0
	Less than or equal to operator	1	1
	And operator	0	0
	Or operator	1	1
	Not operator	0	0
	Complex dimension change operator	0.86602	0.86602

GoldSim Passed the mathematical functions test.

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5.3.7.6 Stochastic Distributions and Expected Values

The vendor supplied test problem *GS4_STOC* was used to test the stochastic elements supported by GoldSim. The vendor test problem is a model that contains each of the 18 probability distributions supported by GoldSim. The values shown by GoldSim for each of these 18 distributions is compared with analytical results, numerical integration, or results generated from the code At Risk® (refer to Golder 1999b, Section 3.1 for more details). The results generated using the GoldSim Calculator are also verified in these tests. The GoldSim Calculator allows the user to compute the value associated with a particular cumulative probability or the cumulative probability associated with a particular value (refer to Section 4 of the GoldSim user's manual for more details, Golder 2000a).

The 18 distributions supported by GoldSim and verified by this test problem are the following:

- Uniform
- Log-Uniform
- Triangular
- Log-Triangular
- Normal
- Log-Normal
- Truncated-Normal
- Truncated Log-Normal
- Beta
- Binomial
- Boolean
- Cumulative
- Discrete
- Gamma
- Truncated Gamma
- Poisson
- Weibull
- Truncated Weibull

The table in Attachment IX shows the expected values for each distribution (Golder 1999b, Section 3.1, Table *GS4_STOC*) along with the results given by GoldSim. By inspection, it can be seen that the GoldSim results are well within +/-10% of the expected values (it appears that the slight differences are due to rounding of the expected values) for all the distributions except for the probability density in the Boolean distribution. I contacted the vendor about the probability density results given by the Boolean distribution. This is a known bug with the probability density display that will be fixed in a subsequent version of GoldSim. The probability density value is for display purposes only; the cumulative probability values are what are used in the calculations. The cumulative probability values are calculated correctly.
These results also show that GoldSim is correctly calculating the expected value (mean) for these distributions. This test shows that GoldSim can be used to define parameters as distribution functions.

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5.3.7.7 Latin Hypercube Sampling and Multiple Realizations

The vendor test problem *TMC-02* (Monte Carlo Tests) will be used to verify GoldSim's ability to perform Monte Carlo simulations by sampling stochastic parameters using Latin Hypercube Sampling (LHS). This test will also verify GoldSim's ability to run up to 1,000 realizations for a single simulation.

TMC-02 uses a stochastic distribution (Uniform 0-1), and carries out three tests. For the first test, the model is run for 100 realizations with LHS enabled. The expected result is that there be exactly one value between the interval 0.00 – 0.01, one between 0.01 – 0.02, and so on up to 0.99 – 1.00 (Golder 1999b, Section 3.2, TMC-02). The results generated by GoldSim are given in Attachment X.

The second test is to repeat the first test, but without LHS sampling. The GoldSim Verification Plan (Golder 1999b, Section 3.2, *TMC-02* Monte Carlo Test) indicates that there should be on the order of 10 results that lie outside the 5% - 95% confidence bounds, and any number less than 20 is reasonable. The simulation results are given in Attachment X, and they show eight excursions below 5% and one excursion above 95% for a total of nine excursions outside the 5% - 95% confidence bounds.

The final test was to repeat the second test (no LHS sampling) for 5,000 realizations. The expected result is that there should be on the order of 500 excursions outside the 5% - 95% confidence interval, and any value under 1,000 is acceptable (Golder 1999b, Section 3.2, *TMC-02* Monte Carlo Test). This test also verifies that GoldSim can perform "up to 1,000 realizations for a single simulation" as specified in the GoldSim Validation Test Plan (CRWMS M&O 2000a, Section 4.2). The results of this simulation are given in Attachment X. The simulation results show that there are 239 excursions below 5%, and 231 excursions above 95% for a total of 470 excursions outside the 5% - 95% confidence bounds.

These test results show that GoldSim can correctly perform Monte Carlo simulations, including LHS, and run at least 1,000 realizations in a single simulation (this test ran 5,000 realizations).

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6. INDICATION OF PASS FAIL

GoldSim version 6.03 passed all the validation tests given in the VTP and all those selected from the vendor's verification plan. As noted in Section 3.2.6, this version of GoldSim does not display the correct probability density for the Boolean distribution, but this is insignificant because the probability density is not used in any calculations.

7. FAILURE CONDITIONS, OCCURRENCE RESOLUTION

As noted in Section 3.2.6, this version of GoldSim calculates the correct probability density for the Boolean distribution it does not display it correctly. This is of no consequence to the TSPA since the probability density is not used in any calculations. The vendor has been notified of the discrepancy and will correct the problem.

8. OVERALL CONCLUSIONS

GoldSim version 6.03 is validated for the Performance Assessment Department of the Management and Operating (M&O) Contractor of the Civilian Radioactive Waste Management

System (CRWMS) to be used to evaluate the performance of a potential nuclear waste repository. It is recommended that GoldSim version 6.03 be qualified for use for the evaluation of the performance of a potential nuclear waste repository.

9DOCUMENTATION AND JUSTIFICATION OF TEST EXCEPTIONS AND FAILURES

Exceptions are noted in Section 6.

10. SUMMARY OF UNIT TESTING

No unit testing was performed for this software.

11. GENERAL REMARKS

None

12. REFERENCES

CRWMS M&O 2000b. *Installation Test Plan for GoldSim Version 6.04.007*, Software Activity Number (SAN) LV-2000-190, Software Document Number (SDN) 10344-ITP-6.04-000. Las Vegas, Nevada: CRWMS M&O.

Golder Associates 1999b. *Verification Report for GoldSim Version 6.01,* Golder Associates Inc., Redmond Washington, October 1999. ACC: MOL.19991220.0333

Golder Associates 2000a. *GoldSim Graphical Simulation Environment, User's Guide,* Golder Associates Inc., Redmond Washington,

CRWMS M&O 2000a. Validation Test Plan for GoldSim Version 604.007, Software Activity Number (SAN) LV-2000-190, Software Document Number (SDN) 10344-VTP-6.04.007-00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001120.0185.

Attachment I Results For VTP Test 1, Diffusive Transport

This Attachment lists the GoldSim results for VTP Test 1, Cases 1 and 2. Case 1 is diffusive mass transport flux rates through a fully saturated medium, and Case 2 is diffusive mass transport flux rates through a partially saturated medium.

Time (years)	Fully Saturated Medium Mass Flux Rate (g/year)	Partially Saturated Medium Mass Flux Rate (g/year)	Time (years)	Fully Saturated Medium Mass Flux Rate (g/year)	Partially Saturated Medium Mass Flux Rate (g/year)
0	0	0	25200	0.004995	6.91E-05
200	0.004432	1.19E-07	25400	0.004995	6.92E-05
400	0.004984	5.97E-07	25600	0.004995	6.92E-05
600	0.004995	1.39E-06	25800	0.004995	6.92E-05
800	0.004995	2.45E-06	26000	0.004995	6.92E-05
1000	0.004995	3.72E-06	26200	0.004995	6.92E-05
1200	0.004995	5.17E-06	26400	0.004995	6.92E-05
1400	0.004995	6.76E-06	26600	0.004995	6.92E-05
1600	0.004995	8.46E-06	26800	0.004995	6.92E-05
1800	0.004995	1.02E-05	27000	0.004995	6.92E-05
2000	0.004995	1.21E-05	27200	0.004995	6.92E-05
2200	0.004995	1.40E-05	27400	0.004995	6.92E-05
2400	0.004995	1.59E-05	27600	0.004995	6.92E-05
2600	0.004995	1.78E-05	27800	0.004995	6.92E-05
2800	0.004995	1.97E-05	28000	0.004995	6.92E-05
3000	0.004995	2.16E-05	28200	0.004995	6.92E-05
3200	0.004995	2.35E-05	28400	0.004995	6.92E-05
3400	0.004995	2.54E-05	28600	0.004995	6.92E-05
3600	0.004995	2.72E-05	28800	0.004995	6.92E-05
3800	0.004995	2.90E-05	29000	0.004995	6.92E-05
4000	0.004995	3.07E-05	29200	0.004995	6.92E-05
4200	0.004995	3.24E-05	29400	0.004995	6.92E-05
4400	0.004995	3.40E-05	29600	0.004995	6.92E-05
4600	0.004995	3.56E-05	29800	0.004995	6.92E-05
4800	0.004995	3.71E-05	30000	0.004995	6.92E-05
5000	0.004995	3.86E-05	30200	0.004995	6.92E-05
5200	0.004995	4.01E-05	30400	0.004995	6.92E-05
5400	0.004995	4.14E-05	30600	0.004995	6.92E-05
5600	0.004995	4.27E-05	30800	0.004995	6.93E-05
5800	0.004995	4.40E-05	31000	0.004995	6.93E-05
6000	0.004995	4.52E-05	31200	0.004995	6.93E-05
6200	0.004995	4.64E-05	31400	0.004995	6.93E-05
6400	0.004995	4.75E-05	31600	0.004995	6.93E-05
6600	0.004995	4.86E-05	31800	0.004995	6.93E-05
6800	0.004995	4.96E-05	32000	0.004995	6.93E-05

Time (years)	Fully Saturated Medium Mass Flux Rate (g/year)	Partially Saturated Medium Mass Flux Rate (g/year)	Time (years)	Fully Saturated Medium Mass Flux Rate (g/year)	Partially Saturated Medium Mass Flux Rate (g/year)
7000	0.004995	5.06E-05	**32200**	0.004995	6.93E-05
7200	0.004995	5.15E-05	**32400**	0.004995	6.93E-05
7400	0.004995	5.24E-05	**32600**	0.004995	6.93E-05
7600	0.004995	5.33E-05	**32800**	0.004995	6.93E-05
7800	0.004995	5.41E-05	**33000**	0.004995	6.93E-05
8000	0.004995	5.48E-05	**33200**	0.004995	6.93E-05
8200	0.004995	5.56E-05	**33400**	0.004995	6.93E-05
8400	0.004995	5.63E-05	**33600**	0.004995	6.93E-05
8600	0.004995	5.70E-05	**33800**	0.004995	6.93E-05
8800	0.004995	5.76E-05	**34000**	0.004995	6.93E-05
9000	0.004995	5.82E-05	**34200**	0.004995	6.93E-05
9200	0.004995	5.88E-05	**34400**	0.004995	6.93E-05
9400	0.004995	5.93E-05	**34600**	0.004995	6.93E-05
9600	0.004995	5.98E-05	**34800**	0.004995	6.93E-05
9800	0.004995	6.03E-05	**35000**	0.004995	6.93E-05
10000	0.004995	6.08E-05	**35200**	0.004995	6.93E-05
10200	0.004995	6.12E-05	**35400**	0.004995	6.93E-05
10400	0.004995	6.17E-05	**35600**	0.004995	6.93E-05
10600	0.004995	6.21E-05	**35800**	0.004995	6.93E-05
10800	0.004995	6.24E-05	**36000**	0.004995	6.93E-05
11000	0.004995	6.28E-05	**36200**	0.004995	6.93E-05
11200	0.004995	6.31E-05	**36400**	0.004995	6.93E-05
11400	0.004995	6.35E-05	**36600**	0.004995	6.93E-05
11600	0.004995	6.38E-05	**36800**	0.004995	6.93E-05
11800	0.004995	6.41E-05	**37000**	0.004995	6.93E-05
12000	0.004995	6.43E-05	**37200**	0.004995	6.93E-05
12200	0.004995	6.46E-05	**37400**	0.004995	6.93E-05
12400	0.004995	6.48E-05	**37600**	0.004995	6.93E-05
12600	0.004995	6.51E-05	**37800**	0.004995	6.93E-05
12800	0.004995	6.53E-05	**38000**	0.004995	6.93E-05
13000	0.004995	6.55E-05	**38200**	0.004995	6.93E-05
13200	0.004995	6.57E-05	**38400**	0.004995	6.93E-05
13400	0.004995	6.59E-05	**38600**	0.004995	6.93E-05
13600	0.004995	6.61E-05	**38800**	0.004995	6.93E-05
13800	0.004995	6.63E-05	**39000**	0.004995	6.93E-05
14000	0.004995	6.64E-05	**39200**	0.004995	6.93E-05
14200	0.004995	6.66E-05	**39400**	0.004995	6.93E-05
14400	0.004995	6.67E-05	**39600**	0.004995	6.93E-05
14600	0.004995	6.69E-05	**39800**	0.004995	6.93E-05

Time (years)	Fully Saturated Medium Mass Flux Rate (g/year)	Partially Saturated Medium Mass Flux Rate (g/year)	Time (years)	Fully Saturated Medium Mass Flux Rate (g/year)	Partially Saturated Medium Mass Flux Rate (g/year)
14800	0.004995	6.70E-05	**40000**	0.004995	6.93E-05
15000	0.004995	6.71E-05	**40200**	0.004995	6.93E-05
15200	0.004995	6.72E-05	**40400**	0.004995	6.93E-05
15400	0.004995	6.73E-05	**40600**	0.004995	6.93E-05
15600	0.004995	6.74E-05	**40800**	0.004995	6.93E-05
15800	0.004995	6.75E-05	**41000**	0.004995	6.93E-05
16000	0.004995	6.76E-05	**41200**	0.004995	6.93E-05
16200	0.004995	6.77E-05	**41400**	0.004995	6.93E-05
16400	0.004995	6.78E-05	**41600**	0.004995	6.93E-05
16600	0.004995	6.79E-05	**41800**	0.004995	6.93E-05
16800	0.004995	6.80E-05	**42000**	0.004995	6.93E-05
17000	0.004995	6.80E-05	**42200**	0.004995	6.93E-05
17200	0.004995	6.81E-05	**42400**	0.004995	6.93E-05
17400	0.004995	6.82E-05	**42600**	0.004995	6.93E-05
17600	0.004995	6.82E-05	**42800**	0.004995	6.93E-05
17800	0.004995	6.83E-05	**43000**	0.004995	6.93E-05
18000	0.004995	6.83E-05	**43200**	0.004995	6.93E-05
18200	0.004995	6.84E-05	**43400**	0.004995	6.93E-05
18400	0.004995	6.84E-05	**43600**	0.004995	6.93E-05
18600	0.004995	6.85E-05	**43800**	0.004995	6.93E-05
18800	0.004995	6.85E-05	**44000**	0.004995	6.93E-05
19000	0.004995	6.86E-05	**44200**	0.004995	6.93E-05
19200	0.004995	6.86E-05	**44400**	0.004995	6.93E-05
19400	0.004995	6.86E-05	**44600**	0.004995	6.93E-05
19600	0.004995	6.87E-05	**44800**	0.004995	6.93E-05
19800	0.004995	6.87E-05	**45000**	0.004995	6.93E-05
20000	0.004995	6.87E-05	**45200**	0.004995	6.93E-05
20200	0.004995	6.88E-05	**45400**	0.004995	6.93E-05
20400	0.004995	6.88E-05	**45600**	0.004995	6.93E-05
20600	0.004995	6.88E-05	**45800**	0.004995	6.93E-05
20800	0.004995	6.88E-05	**46000**	0.004995	6.93E-05
21000	0.004995	6.89E-05	**46200**	0.004995	6.93E-05
21200	0.004995	6.89E-05	**46400**	0.004995	6.93E-05
21400	0.004995	6.89E-05	**46600**	0.004995	6.93E-05
21600	0.004995	6.89E-05	**46800**	0.004995	6.93E-05
21800	0.004995	6.89E-05	**47000**	0.004995	6.93E-05
22000	0.004995	6.90E-05	**47200**	0.004995	6.93E-05
22200	0.004995	6.90E-05	**47400**	0.004995	6.93E-05
22400	0.004995	6.90E-05	**47600**	0.004995	6.93E-05

Time (years)	Fully Saturated Medium Mass Flux Rate (g/year)	Partially Saturated Medium Mass Flux Rate (g/year)	Time (years)	Fully Saturated Medium Mass Flux Rate (g/year)	Partially Saturated Medium Mass Flux Rate (g/year)
22600	0.004995	6.90E-05	**47800**	0.004995	6.93E-05
22800	0.004995	6.90E-05	**48000**	0.004995	6.93E-05
23000	0.004995	6.90E-05	**48200**	0.004995	6.93E-05
23200	0.004995	6.91E-05	**48400**	0.004995	6.93E-05
23400	0.004995	6.91E-05	**48600**	0.004995	6.93E-05
23600	0.004995	6.91E-05	**48800**	0.004995	6.93E-05
23800	0.004995	6.91E-05	**49000**	0.004995	6.93E-05
24000	0.004995	6.91E-05	**49200**	0.004995	6.93E-05
24200	0.004995	6.91E-05	**49400**	0.004995	6.93E-05
24400	0.004995	6.91E-05	**49600**	0.004995	6.93E-05
24600	0.004995	6.91E-05	**49800**	0.004995	6.93E-05
24800	0.004995	6.91E-05	**50000**	0.004995	6.93E-05
25000	0.004995	6.91E-05			

Attachment II Results for VTP Test 2, Advective Transport

This Attachment lists the GoldSim results VTP Test 2, Cases 1, 2, and 3. Case 1 is one-dimensional advection with dispersion, Case 2 is one-dimensional advection with dispersion and the addition of a sorbing material, and Case 3 is the advective release from a batch reactor "mixing cell".

Time (years)	Case 1 Concentration (g/m³)	Case 2 Concentration (g/m³)	Case 3 Mass in Cell (g)	Time (years)	Case 1 Concentration (g/m³)	Case 2 Concentration (g/m³)	Case 3 Mass in Cell (g)
0	0	0	100	2510	99.047	99.047	8.1268
10	9.31E-14	9.31E-14	99.005	2520	99.07	99.07	8.046
20	1.33E-13	1.33E-13	98.02	2530	99.092	99.092	7.9659
30	1.84E-13	1.84E-13	97.045	2540	99.114	99.114	7.8867
40	2.49E-13	2.49E-13	96.079	2550	99.135	99.135	7.8082
50	3.31E-13	3.31E-13	95.123	2560	99.155	99.155	7.7305
60	4.32E-13	4.32E-13	94.176	2570	99.175	99.175	7.6536
70	8.32E-13	8.32E-13	93.239	2580	99.195	99.195	7.5774
80	2.75E-11	2.75E-11	92.312	2590	99.213	99.213	7.502
90	9.31E-10	9.31E-10	91.393	2600	99.232	99.232	7.4274
100	1.58E-08	1.59E-08	90.484	2610	99.25	99.25	7.3535
110	1.60E-07	1.60E-07	89.583	2620	99.267	99.267	7.2803
120	1.10E-06	1.10E-06	88.692	2630	99.284	99.284	7.2079
130	5.64E-06	5.64E-06	87.81	2640	99.301	99.301	7.1361
140	2.28E-05	2.28E-05	86.936	2650	99.317	99.317	7.0651
150	7.63E-05	7.63E-05	86.071	2660	99.332	99.332	6.9948
160	0.00022	0.00022	85.214	2670	99.348	99.348	6.9252
170	0.000557	0.000557	84.366	2680	99.362	99.362	6.8563
180	0.001273	0.001273	83.527	2690	99.377	99.377	6.7881
190	0.002663	0.002663	82.696	2700	99.391	99.391	6.7206
200	0.005171	0.005171	81.873	2710	99.405	99.405	6.6537
210	0.009414	0.009414	81.058	2720	99.418	99.418	6.5875
220	0.016213	0.016213	80.252	2730	99.431	99.431	6.5219
230	0.026609	0.026609	79.453	2740	99.443	99.443	6.457
240	0.041863	0.041863	78.663	2750	99.456	99.456	6.3928
250	0.063458	0.063458	77.88	2760	99.468	99.468	6.3292
260	0.093077	0.093077	77.105	2770	99.479	99.479	6.2662
270	0.13259	0.13259	76.338	2780	99.49	99.49	6.2039
280	0.18399	0.18399	75.578	2790	99.501	99.501	6.1421
290	0.24942	0.24942	74.826	2800	99.512	99.512	6.081
300	0.33104	0.33104	74.082	2810	99.523	99.523	6.0205
310	0.43109	0.43109	73.345	2820	99.533	99.533	5.9606
320	0.55176	0.55176	72.615	2830	99.543	99.543	5.9013
330	0.69521	0.69521	71.892	2840	99.552	99.552	5.8426

Time (years)	Case 1 Concentration (g/m³)	Case 2 Concentration (g/m³)	Case 3 Mass in Cell (g)	Time (years)	Case 1 Concentration (g/m³)	Case 2 Concentration (g/m³)	Case 3 Mass in Cell (g)
340	0.86348	0.86348	71.177	2850	99.562	99.562	5.7844
350	1.0585	1.0585	70.469	2860	99.571	99.571	5.7269
360	1.2822	1.2822	69.768	2870	99.579	99.579	5.6699
370	1.536	1.536	69.073	2880	99.588	99.588	5.6135
380	1.8215	1.8215	68.386	2890	99.596	99.596	5.5576
390	2.1398	2.1398	67.706	2900	99.605	99.605	5.5023
400	2.4921	2.4921	67.032	2910	99.613	99.613	5.4476
410	2.8792	2.8792	66.365	2920	99.62	99.62	5.3934
420	3.3016	3.3016	65.705	2930	99.628	99.628	5.3397
430	3.7598	3.7598	65.051	2940	99.635	99.635	5.2866
440	4.2539	4.2539	64.404	2950	99.642	99.642	5.234
450	4.7841	4.7841	63.763	2960	99.649	99.649	5.1819
460	5.3501	5.3501	63.128	2970	99.656	99.656	5.1303
470	5.9515	5.9515	62.5	2980	99.662	99.662	5.0793
480	6.5879	6.5879	61.878	2990	99.669	99.669	5.0288
490	7.2585	7.2585	61.263	3000	99.675	99.675	4.9787
500	7.9626	7.9626	60.653	3010	99.681	99.681	4.9292
510	8.6993	8.6993	60.05	3020	99.687	99.687	4.8801
520	9.4674	9.4674	59.452	3030	99.693	99.693	4.8316
530	10.266	10.266	58.861	3040	99.698	99.698	4.7835
540	11.094	11.094	58.275	3050	99.704	99.704	4.7359
550	11.949	11.949	57.695	3060	99.709	99.709	4.6888
560	12.831	12.831	57.121	3070	99.714	99.714	4.6421
570	13.738	13.738	56.553	3080	99.719	99.719	4.5959
580	14.669	14.669	55.99	3090	99.724	99.724	4.5502
590	15.622	15.622	55.433	3100	99.729	99.729	4.5049
600	16.595	16.595	54.881	3110	99.733	99.733	4.4601
610	17.588	17.588	54.335	3120	99.738	99.738	4.4157
620	18.599	18.599	53.794	3130	99.742	99.742	4.3718
630	19.626	19.626	53.259	3140	99.746	99.746	4.3283
640	20.667	20.667	52.729	3150	99.75	99.75	4.2852
650	21.722	21.722	52.205	3160	99.754	99.754	4.2426
660	22.789	22.789	51.685	3170	99.758	99.758	4.2004
670	23.866	23.866	51.171	3180	99.762	99.762	4.1586
680	24.952	24.952	50.662	3190	99.766	99.766	4.1172
690	26.046	26.046	50.158	3200	99.769	99.769	4.0762
700	27.147	27.147	49.659	3210	99.773	99.773	4.0357
710	28.252	28.252	49.164	3220	99.776	99:776	3.9955
720	29.361	29.361	48.675	3230	99.78	99.78	3.9558

Time (years)	Case 1 Concentration (g/m³)	Case 2 Concentration (g/m³)	Case 3 Mass in Cell (g)	Time (years)	Case 1 Concentration (g/m³)	Case 2 Concentration (g/m³)	Case 3 Mass in Cell (g)
730	30.474	30.474	48.191	**3240**	99.783	99.783	3.9164
740	31.587	31.587	47.711	**3250**	99.786	99.786	3.8774
750	32.701	32.701	47.237	**3260**	99.789	99.789	3.8388
760	33.815	33.815	46.767	**3270**	99.792	99.792	3.8006
770	34.927	34.927	46.301	**3280**	99.795	99.795	3.7628
780	36.036	36.036	45.841	**3290**	99.798	99.798	3.7254
790	37.143	37.143	45.384	**3300**	99.801	99.801	3.6883
800	38.244	38.244	44.933	**3310**	99.803	99.803	3.6516
810	39.341	39.341	44.486	**3320**	99.806	99.806	3.6153
820	40.432	40.432	44.043	**3330**	99.808	99.808	3.5793
830	41.516	41.516	43.605	**3340**	99.811	99.811	3.5437
840	42.593	42.593	43.171	**3350**	99.813	99.813	3.5084
850	43.662	43.662	42.742	**3360**	99.816	99.816	3.4735
860	44.722	44.722	42.316	**3370**	99.818	99.818	3.439
870	45.774	45.774	41.895	**3380**	99.82	99.82	3.4048
880	46.815	46.815	41.478	**3390**	99.822	99.822	3.3709
890	47.847	47.847	41.066	**3400**	99.824	99.824	3.3373
900	48.868	48.868	40.657	**3410**	99.826	99.826	3.3041
910	49.878	49.878	40.252	**3420**	99.828	99.828	3.2712
920	50.877	50.877	39.852	**3430**	99.83	99.83	3.2387
930	51.864	51.864	39.455	**3440**	99.832	99.832	3.2065
940	52.84	52.84	39.063	**3450**	99.834	99.834	3.1746
950	53.803	53.803	38.674	**3460**	99.836	99.836	3.143
960	54.753	54.753	38.289	**3470**	99.837	99.837	3.1117
970	55.691	55.691	37.908	**3480**	99.839	99.839	3.0807
980	56.616	56.616	37.531	**3490**	99.841	99.841	3.0501
990	57.527	57.527	37.158	**3500**	99.842	99.842	3.0197
1000	58.426	58.426	36.788	**3510**	99.844	99.844	2.9897
1010	59.311	59.311	36.422	**3520**	99.845	99.845	2.9599
1020	60.183	60.183	36.06	**3530**	99.847	99.847	2.9305
1030	61.041	61.041	35.701	**3540**	99.848	99.848	2.9013
1040	61.885	61.885	35.345	**3550**	99.85	99.85	2.8725
1050	62.716	62.716	34.994	**3560**	99.851	99.851	2.8439
1060	63.533	63.533	34.646	**3570**	99.852	99.852	2.8156
1070	64.337	64.337	34.301	**3580**	99.854	99.854	2.7876
1080	65.127	65.127	33.96	**3590**	99.855	99.855	2.7598
1090	65.903	65.903	33.622	**3600**	99.856	99.856	2.7324
1100	66.666	66.666	33.287	**3610**	99.857	99.857	2.7052
1110	67.414	67.414	32.956	**3620**	99.858	99.858	2.6783

Time (years)	Case 1 Concentration (g/m³)	Case 2 Concentration (g/m³)	Case 3 Mass in Cell (g)	Time (years)	Case 1 Concentration (g/m³)	Case 2 Concentration (g/m³)	Case 3 Mass in Cell (g)
1120	68.15	68.15	32.628	3630	99.859	99.859	2.6516
1130	68.872	68.872	32.303	3640	99.861	99.861	2.6252
1140	69.581	69.581	31.982	3650	99.862	99.862	2.5991
1150	70.276	70.276	31.664	3660	99.863	99.863	2.5733
1160	70.958	70.958	31.349	3670	99.864	99.864	2.5477
1170	71.627	71.627	31.037	3680	99.865	99.865	2.5223
1180	72.284	72.284	30.728	3690	99.866	99.866	2.4972
1190	72.927	72.927	30.422	3700	99.867	99.867	2.4724
1200	73.558	73.558	30.119	3710	99.867	99.867	2.4478
1210	74.176	74.176	29.82	3720	99.868	99.868	2.4234
1220	74.781	74.781	29.523	3730	99.869	99.869	2.3993
1230	75.375	75.375	29.229	3740	99.87	99.87	2.3754
1240	75.956	75.956	28.938	3750	99.871	99.871	2.3518
1250	76.525	76.525	28.65	3760	99.872	99.872	2.3284
1260	77.083	77.083	28.365	3770	99.872	99.872	2.3052
1270	77.629	77.629	28.083	3780	99.873	99.873	2.2823
1280	78.163	78.163	27.804	3790	99.874	99.874	2.2596
1290	78.686	78.686	27.527	3800	99.874	99.874	2.2371
1300	79.198	79.198	27.253	3810	99.875	99.875	2.2148
1310	79.698	79.698	26.982	3820	99.876	99.876	2.1928
1320	80.188	80.188	26.714	3830	99.876	99.876	2.171
1330	80.667	80.667	26.448	3840	99.877	99.877	2.1494
1340	81.136	81.136	26.185	3850	99.878	99.878	2.128
1350	81.595	81.595	25.924	3860	99.878	99.878	2.1068
1360	82.043	82.043	25.666	3870	99.879	99.879	2.0858
1370	82.481	82.481	25.411	3880	99.879	99.879	2.0651
1380	82.91	82.91	25.158	3890	99.88	99.88	2.0445
1390	83.329	83.329	24.908	3900	99.881	99.881	2.0242
1400	83.738	83.738	24.66	3910	99.881	99.881	2.0041
1410	84.138	84.138	24.414	3920	99.882	99.882	1.9841
1420	84.529	84.529	24.171	3930	99.882	99.882	1.9644
1430	84.911	84.911	23.931	3940	99.883	99.883	1.9448
1440	85.285	85.285	23.693	3950	99.883	99.883	1.9255
1450	85.649	85.649	23.457	3960	99.883	99.883	1.9063
1460	86.005	86.005	23.224	3970	99.884	99.884	1.8873
1470	86.353	86.353	22.993	3980	99.884	99.884	1.8686
1480	86.693	86.693	22.764	3990	99.885	99.885	1.85
1490	87.025	87.025	22.537	4000	99.885	99.885	1.8316
1500	87.349	87.349	22.313	4010	99.886	99.886	1.8133

Time (years)	Case 1 Concentration (g/m³)	Case 2 Concentration (g/m³)	Case 3 Mass in Cell (g)	Time (years)	Case 1 Concentration (g/m³)	Case 2 Concentration (g/m³)	Case 3 Mass in Cell (g)
1510	87.665	87.665	22.091	4020	99.886	99.886	1.7953
1520	87.974	87.974	21.871	4030	99.886	99.886	1.7774
1530	88.276	88.276	21.654	4040	99.887	99.887	1.7598
1540	88.57	88.57	21.438	4050	99.887	99.887	1.7422
1550	88.858	88.858	21.225	4060	99.887	99.887	1.7249
1560	89.138	89.138	21.014	4070	99.888	99.888	1.7077
1570	89.412	89.412	20.805	4080	99.888	99.888	1.6907
1580	89.679	89.679	20.598	4090	99.888	99.888	1.6739
1590	89.939	89.939	20.393	4100	99.889	99.889	1.6573
1600	90.194	90.194	20.19	4110	99.889	99.889	1.6408
1610	90.442	90.442	19.989	4120	99.889	99.889	1.6245
1620	90.684	90.684	19.79	4130	99.89	99.89	1.6083
1630	90.92	90.92	19.593	4140	99.89	99.89	1.5923
1640	91.15	91.15	19.398	4150	99.89	99.89	1.5764
1650	91.375	91.375	19.205	4160	99.89	99.89	1.5608
1660	91.594	91.594	19.014	4170	99.891	99.891	1.5452
1670	91.808	91.808	18.825	4180	99.891	99.891	1.5299
1680	92.017	92.017	18.637	4190	99.891	99.891	1.5146
1690	92.22	92.22	18.452	4200	99.891	99.891	1.4996
1700	92.418	92.418	18.268	4210	99.892	99.892	1.4846
1710	92.612	92.612	18.087	4220	99.892	99.892	1.4699
1720	92.8	92.8	17.907	4230	99.892	99.892	1.4552
1730	92.984	92.984	17.728	4240	99.892	99.892	1.4408
1740	93.164	93.164	17.552	4250	99.892	99.892	1.4264
1750	93.338	93.338	17.377	4260	99.893	99.893	1.4122
1760	93.509	93.509	17.205	4270	99.893	99.893	1.3982
1770	93.675	93.675	17.033	4280	99.893	99.893	1.3843
1780	93.837	93.837	16.864	4290	99.893	99.893	1.3705
1790	93.995	93.995	16.696	4300	99.893	99.893	1.3569
1800	94.148	94.148	16.53	4310	99.894	99.894	1.3434
1810	94.298	94.298	16.365	4320	99.894	99.894	1.33
1820	94.445	94.445	16.203	4330	99.894	99.894	1.3168
1830	94.587	94.587	16.041	4340	99.894	99.894	1.3037
1840	94.726	94.726	15.882	4350	99.894	99.894	1.2907
1850	94.861	94.861	15.724	4360	99.894	99.894	1.2778
1860	94.993	94.993	15.567	4370	99.895	99.895	1.2651
1870	95.122	95.122	15.412	4380	99.895	99.895	1.2525
1880	95.247	95.247	15.259	4390	99.895	99.895	1.2401
1890	95.369	95.369	15.107	4400	99.895	99.895	1.2277

Time (years)	Case 1 Concentration (g/m^3)	Case 2 Concentration (g/m^3)	Case 3 Mass in Cell (g)	Time (years)	Case 1 Concentration (g/m^3)	Case 2 Concentration (g/m^3)	Case 3 Mass in Cell (g)
1900	95.488	95.488	14.957	4410	99.895	99.895	1.2155
1910	95.604	95.604	14.808	4420	99.895	99.895	1.2034
1920	95.716	95.716	14.661	4430	99.895	99.895	1.1915
1930	95.826	95.826	14.515	4440	99.895	99.895	1.1796
1940	95.934	95.934	14.37	4450	99.896	99.896	1.1679
1950	96.038	96.038	14.227	4460	99.896	99.896	1.1562
1960	96.14	96.14	14.086	4470	99.896	99.896	1.1447
1970	96.239	96.239	13.946	4480	99.896	99.896	1.1333
1980	96.335	96.335	13.807	4490	99.896	99.896	1.1221
1990	96.429	96.429	13.67	4500	99.896	99.896	1.1109
2000	96.521	96.521	13.534	4510	99.896	99.896	1.0998
2010	96.61	96.61	13.399	4520	99.896	99.896	1.0889
2020	96.697	96.697	13.266	4530	99.896	99.896	1.0781
2030	96.782	96.782	13.134	4540	99.897	99.897	1.0673
2040	96.864	96.864	13.003	4550	99.897	99.897	1.0567
2050	96.944	96.944	12.874	4560	99.897	99.897	1.0462
2060	97.023	97.023	12.745	4570	99.897	99.897	1.0358
2070	97.099	97.099	12.619	4580	99.897	99.897	1.0255
2080	97.173	97.173	12.493	4590	99.897	99.897	1.0153
2090	97.245	97.245	12.369	4600	99.897	99.897	1.0052
2100	97.316	97.316	12.246	4610	99.897	99.897	0.99518
2110	97.384	97.384	12.124	4620	99.897	99.897	0.98528
2120	97.451	97.451	12.003	4630	99.897	99.897	0.97548
2130	97.516	97.516	11.884	4640	99.897	99.897	0.96577
2140	97.579	97.579	11.765	4650	99.897	99.897	0.95616
2150	97.641	97.641	11.648	4660	99.898	99.898	0.94665
2160	97.701	97.701	11.533	4670	99.898	99.898	0.93723
2170	97.759	97.759	11.418	4680	99.898	99.898	0.9279
2180	97.816	97.816	11.304	4690	99.898	99.898	0.91867
2190	97.872	97.872	11.192	4700	99.898	99.898	0.90953
2200	97.926	97.926	11.08	4710	99.898	99.898	0.90048
2210	97.978	97.978	10.97	4720	99.898	99.898	0.89152
2220	98.029	98.029	10.861	4730	99.898	99.898	0.88265
2230	98.079	98.079	10.753	4740	99.898	99.898	0.87387
2240	98.128	98.128	10.646	4750	99.898	99.898	0.86517
2250	98.175	98.175	10.54	4760	99.898	99.898	0.85656
2260	98.221	98.221	10.435	4770	99.898	99.898	0.84804
2270	98.265	98.265	10.331	4780	99.898	99.898	0.8396
2280	98.309	98.309	10.228	4790	99.898	99.898	0.83125

Time (years)	Case 1 Concentration (g/m³)	Case 2 Concentration (g/m³)	Case 3 Mass in Cell (g)	Time (years)	Case 1 Concentration (g/m³)	Case 2 Concentration (g/m³)	Case 3 Mass in Cell (g)
2290	98.351	98.351	10.127	4800	99.898	99.898	0.82298
2300	98.393	98.393	10.026	4810	99.898	99.898	0.81479
2310	98.433	98.433	9.9261	4820	99.898	99.898	0.80668
2320	98.472	98.472	9.8274	4830	99.898	99.898	0.79865
2330	98.51	98.51	9.7296	4840	99.898	99.898	0.79071
2340	98.547	98.547	9.6328	4850	99.899	99.899	0.78284
2350	98.583	98.583	9.5369	4860	99.899	99.899	0.77505
2360	98.619	98.619	9.442	4870	99.899	99.899	0.76734
2370	98.653	98.653	9.3481	4880	99.899	99.899	0.7597
2380	98.686	98.686	9.2551	4890	99.899	99.899	0.75214
2390	98.719	98.719	9.163	4900	99.899	99.899	0.74466
2400	98.75	98.75	9.0718	4910	99.899	99.899	0.73725
2410	98.781	98.781	8.9815	4920	99.899	99.899	0.72991
2420	98.811	98.811	8.8922	4930	99.899	99.899	0.72265
2430	98.84	98.84	8.8037	4940	99.899	99.899	0.71546
2440	98.868	98.868	8.7161	4950	99.899	99.899	0.70834
2450	98.896	98.896	8.6294	4960	99.899	99.899	0.70129
2460	98.923	98.923	8.5435	4970	99.899	99.899	0.69432
2470	98.949	98.949	8.4585	4980	99.899	99.899	0.68741
2480	98.974	98.974	8.3743	4990	99.899	99.899	0.68057
2490	98.999	98.999	8.291	5000	99.899	99.899	0.6738
2500	99.023	99.023	8.2085				

Attachment III Results for VTP Test 3, Source Term

This Attachment lists the GoldSim results for VTP Test 3, Sources 1, 2, and 3. Source 1 tests the use of the inner barrier of source term containment, often defined as cladding for nuclear fuel. The GoldSim results for Source 1 show the amount of "unexposed mass" and the mass transport rate. Source 2 tests the use of the outer barrier, used to represent discrete failures of waste packages. The GoldSim results for Source 2 show the release from discrete waste package failures. The third source represents the release from a matrix, and the source also decays radioactively. The GoldSim results give the amount of "unexposed mass" of radioactive Species C.

Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)	Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)
0	1.00E+05	0	0	100	5010	49900	0.004995	0	57.675
10	99900	0.01456	0	99.99	5020	49800	0.004995	0	57.611
20	99800	0.004995	0	99.88	5030	49700	0.004995	0	57.548
30	99700	0.004995	0	99.77	5040	49600	0.004995	0	57.485
40	99600	0.004995	0	99.66	5050	49500	0.004995	0	57.421
50	99500	0.004995	0	99.551	5060	49400	0.004995	0	57.358
60	99400	0.004995	0	99.441	5070	49300	0.004995	0	57.295
70	99300	0.004995	0	99.332	5080	49200	0.004995	0	57.232
80	99200	0.004995	0	99.223	5090	49100	0.004995	0	57.169
90	99100	0.004995	0	99.114	5100	49000	0.004995	0	57.106
100	99000	0.004995	0	99.005	5110	48900	0.004995	0	57.044
110	98900	0.004995	0	98.896	5120	48800	0.004995	0	56.981
120	98800	0.004995	0	98.787	5130	48700	0.004995	0	56.918
130	98700	0.004995	0	98.678	5140	48600	0.004995	0	56.856
140	98600	0.004995	0	98.57	5150	48500	0.004995	0	56.793
150	98500	0.004995	0	98.461	5160	48400	0.004995	0	56.731
160	98400	0.004995	0	98.353	5170	48300	0.004995	0	56.668
170	98300	0.004995	0	98.245	5180	48200	0.004995	0	56.606
180	98200	0.004995	0	98.137	5190	48100	0.004995	0	56.544
190	98100	0.004995	0	98.029	5200	48000	0.004995	0	56.481
200	98000	0.004995	0	97.921	5210	47900	0.004995	0	56.419
210	97900	0.004995	0	97.813	5220	47800	0.004995	0	56.357
220	97800	0.004995	0	97.706	5230	47700	0.004995	0	56.295
230	97700	0.004995	0	97.598	5240	47600	0.004995	0	56.233
240	97600	0.004995	0	97.491	5250	47500	0.004995	0	56.171
250	97500	0.004995	0	97.384	5260	47400	0.004995	0	56.11
260	97400	0.004995	0	97.277	5270	47300	0.004995	0	56.048
270	97300	0.004995	0	97.17	5280	47200	0.004995	0	55.986
280	97200	0.004995	0	97.063	5290	47100	0.004995	0	55.925

Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)	Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)
290	97100	0.004995	0	96.956	5300	47000	0.004995	0	55.863
300	97000	0.004995	0	96.849	5310	46900	0.004995	0	55.802
310	96900	0.004995	0	96.743	5320	46800	0.004995	0	55.74
320	96800	0.004995	0	96.636	5330	46700	0.004995	0	55.679
330	96700	0.004995	0	96.53	5340	46600	0.004995	0	55.618
340	96600	0.004995	0	96.424	5350	46500	0.004995	0	55.557
350	96500	0.004995	0	96.318	5360	46400	0.004995	0	55.496
360	96400	0.004995	0	96.212	5370	46300	0.004995	0	55.434
370	96300	0.004995	0	96.106	5380	46200	0.004995	0	55.374
380	96200	0.004995	0	96	5390	46100	0.004995	0	55.313
390	96100	0.004995	0	95.895	5400	46000	0.004995	0	55.252
400	96000	0.004995	0	95.789	5410	45900	0.004995	0	55.191
410	95900	0.004995	0	95.684	5420	45800	0.004995	0	55.13
420	95800	0.004995	0	95.579	5430	45700	0.004995	0	55.07
430	95700	0.004995	0	95.474	5440	45600	0.004995	0	55.009
440	95600	0.004995	0	95.369	5450	45500	0.004995	0	54.949
450	95500	0.004995	0	95.264	5460	45400	0.004995	0	54.888
460	95400	0.004995	0	95.159	5470	45300	0.004995	0	54.828
470	95300	0.004995	0	95.054	5480	45200	0.004995	0	54.767
480	95200	0.004995	0	94.95	5490	45100	0.004995	0	54.707
490	95100	0.004995	0	94.845	5500	45000	0.004995	10	54.647
500	95000	0.004995	10	94.741	5510	44900	0.004995	1.00E-12	54.587
510	94900	0.004995	1.00E-12	94.637	5520	44800	0.004995	0	54.527
520	94800	0.004995	0	94.533	5530	44700	0.004995	0	54.467
530	94700	0.004995	0	94.429	5540	44600	0.004995	0	54.407
540	94600	0.004995	0	94.325	5550	44500	0.004995	0	54.347
550	94500	0.004995	0	94.221	5560	44400	0.004995	0	54.287
560	94400	0.004995	0	94.117	5570	44300	0.004995	0	54.228
570	94300	0.004995	0	94.014	5580	44200	0.004995	0	54.168
580	94200	0.004995	0	93.91	5590	44100	0.004995	0	54.108
590	94100	0.004995	0	93.807	5600	44000	0.004995	0	54.049
600	94000	0.004995	0	93.704	5610	43900	0.004995	0	53.99
610	93900	0.004995	0	93.601	5620	43800	0.004995	0	53.93
620	93800	0.004995	0	93.498	5630	43700	0.004995	0	53.871
630	93700	0.004995	0	93.395	5640	43600	0.004995	0	53.812
640	93600	0.004995	0	93.292	5650	43500	0.004995	0	53.752
650	93500	0.004995	0	93.19	5660	43400	0.004995	0	53.693
660	93400	0.004995	0	93.087	5670	43300	0.004995	0	53.634

Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)	Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)
670	93300	0.004995	0	92.985	**5680**	43200	0.004995	0	53.575
680	93200	0.004995	0	92.883	**5690**	43100	0.004995	0	53.516
690	93100	0.004995	0	92.78	**5700**	43000	0.004995	0	53.457
700	93000	0.004995	0	92.678	**5710**	42900	0.004995	0	53.399
710	92900	0.004995	0	92.576	**5720**	42800	0.004995	0	53.34
720	92800	0.004995	0	92.475	**5730**	42700	0.004995	0	53.281
730	92700	0.004995	0	92.373	**5740**	42600	0.004995	0	53.223
740	92600	0.004995	0	92.271	**5750**	42500	0.004995	0	53.164
750	92500	0.004995	0	92.17	**5760**	42400	0.004995	0	53.106
760	92400	0.004995	0	92.068	**5770**	42300	0.004995	0	53.047
770	92300	0.004995	0	91.967	**5780**	42200	0.004995	0	52.989
780	92200	0.004995	0	91.866	**5790**	42100	0.004995	0	52.931
790	92100	0.004995	0	91.765	**5800**	42000	0.004995	0	52.872
800	92000	0.004995	0	91.664	**5810**	41900	0.004995	0	52.814
810	91900	0.004995	0	91.563	**5820**	41800	0.004995	0	52.756
820	91800	0.004995	0	91.463	**5830**	41700	0.004995	0	52.698
830	91700	0.004995	0	91.362	**5840**	41600	0.004995	0	52.64
840	91600	0.004995	0	91.261	**5850**	41500	0.004995	0	52.582
850	91500	0.004995	0	91.161	**5860**	41400	0.004995	0	52.524
860	91400	0.004995	0	91.061	**5870**	41300	0.004995	0	52.467
870	91300	0.004995	0	90.961	**5880**	41200	0.004995	0	52.409
880	91200	0.004995	0	90.861	**5890**	41100	0.004995	0	52.351
890	91100	0.004995	0	90.761	**5900**	41000	0.004995	0	52.294
900	91000	0.004995	0	90.661	**5910**	40900	0.004995	0	52.236
910	90900	0.004995	0	90.561	**5920**	40800	0.004995	0	52.179
920	90800	0.004995	0	90.462	**5930**	40700	0.004995	0	52.121
930	90700	0.004995	0	90.362	**5940**	40600	0.004995	0	52.064
940	90600	0.004995	0	90.263	**5950**	40500	0.004995	0	52.007
950	90500	0.004995	0	90.163	**5960**	40400	0.004995	0	51.95
960	90400	0.004995	0	90.064	**5970**	40300	0.004995	0	51.892
970	90300	0.004995	0	89.965	**5980**	40200	0.004995	0	51.835
980	90200	0.004995	0	89.866	**5990**	40100	0.004995	0	51.778
990	90100	0.004995	0	89.767	**6000**	40000	0.004995	0	51.721
1000	90000	0.004995	0	89.669	**6010**	39900	0.004995	0	51.664
1010	89900	0.004995	0	89.57	**6020**	39800	0.004995	0	51.608
1020	89800	0.004995	0	89.471	**6030**	39700	0.004995	0	51.551
1030	89700	0.004995	0	89.373	**6040**	39600	0.004995	0	51.494
1040	89600	0.004995	0	89.275	**6050**	39500	0.004995	0	51.438

Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)	Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)
1050	89500	0.004995	0	89.177	**6060**	39400	0.004995	0	51.381
1060	89400	0.004995	0	89.078	**6070**	39300	0.004995	0	51.324
1070	89300	0.004995	0	88.98	**6080**	39200	0.004995	0	51.268
1080	89200	0.004995	0	88.883	**6090**	39100	0.004995	0	51.212
1090	89100	0.004995	0	88.785	**6100**	39000	0.004995	0	51.155
1100	89000	0.004995	0	88.687	**6110**	38900	0.004995	0	51.099
1110	88900	0.004995	0	88.59	**6120**	38800	0.004995	0	51.043
1120	88800	0.004995	0	88.492	**6130**	38700	0.004995	0	50.987
1130	88700	0.004995	0	88.395	**6140**	38600	0.004995	0	50.931
1140	88600	0.004995	0	88.298	**6150**	38500	0.004995	0	50.875
1150	88500	0.004995	0	88.201	**6160**	38400	0.004995	0	50.819
1160	88400	0.004995	0	88.104	**6170**	38300	0.004995	0	50.763
1170	88300	0.004995	0	88.007	**6180**	38200	0.004995	0	50.707
1180	88200	0.004995	0	87.91	**6190**	38100	0.004995	0	50.651
1190	88100	0.004995	0	87.813	**6200**	38000	0.004995	0	50.595
1200	88000	0.004995	0	87.717	**6210**	37900	0.004995	0	50.54
1210	87900	0.004995	0	87.62	**6220**	37800	0.004995	0	50.484
1220	87800	0.004995	0	87.524	**6230**	37700	0.004995	0	50.429
1230	87700	0.004995	0	87.427	**6240**	37600	0.004995	0	50.373
1240	87600	0.004995	0	87.331	**6250**	37500	0.004995	0	50.318
1250	87500	0.004995	0	87.235	**6260**	37400	0.004995	0	50.262
1260	87400	0.004995	0	87.139	**6270**	37300	0.004995	0	50.207
1270	87300	0.004995	0	87.043	**6280**	37200	0.004995	0	50.152
1280	87200	0.004995	0	86.948	**6290**	37100	0.004995	0	50.097
1290	87100	0.004995	0	86.852	**6300**	37000	0.004995	0	50.042
1300	87000	0.004995	0	86.757	**6310**	36900	0.004995	0	49.987
1310	86900	0.004995	0	86.661	**6320**	36800	0.004995	0	49.932
1320	86800	0.004995	0	86.566	**6330**	36700	0.004995	0	49.877
1330	86700	0.004995	0	86.471	**6340**	36600	0.004995	0	49.822
1340	86600	0.004995	0	86.375	**6350**	36500	0.004995	0	49.767
1350	86500	0.004995	0	86.28	**6360**	36400	0.004995	0	49.712
1360	86400	0.004995	0	86.186	**6370**	36300	0.004995	0	49.658
1370	86300	0.004995	0	86.091	**6380**	36200	0.004995	0	49.603
1380	86200	0.004995	0	85.996	**6390**	36100	0.004995	0	49.548
1390	86100	0.004995	0	85.901	**6400**	36000	0.004995	0	49.494
1400	86000	0.004995	0	85.807	**6410**	35900	0.004995	0	49.44
1410	85900	0.004995	0	85.713	**6420**	35800	0.004995	0	49.385
1420	85800	0.004995	0	85.618	**6430**	35700	0.004995	0	49.331

Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)	Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)
1430	85700	0.004995	0	85.524	**6440**	35600	0.004995	0	49.277
1440	85600	0.004995	0	85.43	**6450**	35500	0.004995	0	49.222
1450	85500	0.004995	0	85.336	**6460**	35400	0.004995	0	49.168
1460	85400	0.004995	0	85.242	**6470**	35300	0.004995	0	49.114
1470	85300	0.004995	0	85.149	**6480**	35200	0.004995	0	49.06
1480	85200	0.004995	0	85.055	**6490**	35100	0.004995	0	49.006
1490	85100	0.004995	0	84.961	**6500**	35000	0.004995	10	48.952
1500	85000	0.004995	10	84.868	**6510**	34900	0.004995	1.00E-12	48.898
1510	84900	0.004995	1.00E-12	84.775	**6520**	34800	0.004995	0	48.845
1520	84800	0.004995	0	84.681	**6530**	34700	0.004995	0	48.791
1530	84700	0.004995	0	84.588	**6540**	34600	0.004995	0	48.737
1540	84600	0.004995	0	84.495	**6550**	34500	0.004995	0	48.684
1550	84500	0.004995	0	84.402	**6560**	34400	0.004995	0	48.63
1560	84400	0.004995	0	84.309	**6570**	34300	0.004995	0	48.577
1570	84300	0.004995	0	84.217	**6580**	34200	0.004995	0	48.523
1580	84200	0.004995	0	84.124	**6590**	34100	0.004995	0	48.47
1590	84100	0.004995	0	84.031	**6600**	34000	0.004995	0	48.416
1600	84000	0.004995	0	83.939	**6610**	33900	0.004995	0	48.363
1610	83900	0.004995	0	83.847	**6620**	33800	0.004995	0	48.31
1620	83800	0.004995	0	83.754	**6630**	33700	0.004995	0	48.257
1630	83700	0.004995	0	83.662	**6640**	33600	0.004995	0	48.204
1640	83600	0.004995	0	83.57	**6650**	33500	0.004995	0	48.151
1650	83500	0.004995	0	83.478	**6660**	33400	0.004995	0	48.098
1660	83400	0.004995	0	83.387	**6670**	33300	0.004995	0	48.045
1670	83300	0.004995	0	83.295	**6680**	33200	0.004995	0	47.992
1680	83200	0.004995	0	83.203	**6690**	33100	0.004995	0	47.939
1690	83100	0.004995	0	83.112	**6700**	33000	0.004995	0	47.887
1700	83000	0.004995	0	83.02	**6710**	32900	0.004995	0	47.834
1710	82900	0.004995	0	82.929	**6720**	32800	0.004995	0	47.781
1720	82800	0.004995	0	82.838	**6730**	32700	0.004995	0	47.729
1730	82700	0.004995	0	82.747	**6740**	32600	0.004995	0	47.676
1740	82600	0.004995	0	82.656	**6750**	32500	0.004995	0	47.624
1750	82500	0.004995	0	82.565	**6760**	32400	0.004995	0	47.571
1760	82400	0.004995	0	82.474	**6770**	32300	0.004995	0	47.519
1770	82300	0.004995	0	82.383	**6780**	32200	0.004995	0	47.467
1780	82200	0.004995	0	82.293	**6790**	32100	0.004995	0	47.415
1790	82100	0.004995	0	82.202	**6800**	32000	0.004995	0	47.362
1800	82000	0.004995	0	82.112	**6810**	31900	0.004995	0	47.31

Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)	Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)
1810	81900	0.004995	0	82.021	6820	31800	0.004995	0	47.258
1820	81800	0.004995	0	81.931	6830	31700	0.004995	0	47.206
1830	81700	0.004995	0	81.841	6840	31600	0.004995	0	47.154
1840	81600	0.004995	0	81.751	6850	31500	0.004995	0	47.103
1850	81500	0.004995	0	81.661	6860	31400	0.004995	0	47.051
1860	81400	0.004995	0	81.571	6870	31300	0.004995	0	46.999
1870	81300	0.004995	0	81.482	6880	31200	0.004995	0	46.947
1880	81200	0.004995	0	81.392	6890	31100	0.004995	0	46.896
1890	81100	0.004995	0	81.302	6900	31000	0.004995	0	46.844
1900	81000	0.004995	0	81.213	6910	30900	0.004995	0	46.793
1910	80900	0.004995	0	81.124	6920	30800	0.004995	0	46.741
1920	80800	0.004995	0	81.034	6930	30700	0.004995	0	46.69
1930	80700	0.004995	0	80.945	6940	30600	0.004995	0	46.638
1940	80600	0.004995	0	80.856	6950	30500	0.004995	0	46.587
1950	80500	0.004995	0	80.767	6960	30400	0.004995	0	46.536
1960	80400	0.004995	0	80.679	6970	30300	0.004995	0	46.485
1970	80300	0.004995	0	80.59	6980	30200	0.004995	0	46.434
1980	80200	0.004995	0	80.501	6990	30100	0.004995	0	46.382
1990	80100	0.004995	0	80.413	7000	30000	0.004995	0	46.331
2000	80000	0.004995	0	80.324	7010	29900	0.004995	0	46.28
2010	79900	0.004995	0	80.236	7020	29800	0.004995	0	46.23
2020	79800	0.004995	0	80.148	7030	29700	0.004995	0	46.179
2030	79700	0.004995	0	80.059	7040	29600	0.004995	0	46.128
2040	79600	0.004995	0	79.971	7050	29500	0.004995	0	46.077
2050	79500	0.004995	0	79.883	7060	29400	0.004995	0	46.027
2060	79400	0.004995	0	79.796	7070	29300	0.004995	0	45.976
2070	79300	0.004995	0	79.708	7080	29200	0.004995	0	45.925
2080	79200	0.004995	0	79.62	7090	29100	0.004995	0	45.875
2090	79100	0.004995	0	79.533	7100	29000	0.004995	0	45.824
2100	79000	0.004995	0	79.445	7110	28900	0.004995	0	45.774
2110	78900	0.004995	0	79.358	7120	28800	0.004995	0	45.724
2120	78800	0.004995	0	79.27	7130	28700	0.004995	0	45.673
2130	78700	0.004995	0	79.183	7140	28600	0.004995	0	45.623
2140	78600	0.004995	0	79.096	7150	28500	0.004995	0	45.573
2150	78500	0.004995	0	79.009	7160	28400	0.004995	0	45.523
2160	78400	0.004995	0	78.922	7170	28300	0.004995	0	45.473
2170	78300	0.004995	0	78.835	7180	28200	0.004995	0	45.423
2180	78200	0.004995	0	78.749	7190	28100	0.004995	0	45.373

Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)	Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)
2190	78100	0.004995	0	78.662	7200	28000	0.004995	0	45.323
2200	78000	0.004995	0	78.576	7210	27900	0.004995	0	45.273
2210	77900	0.004995	0	78.489	7220	27800	0.004995	0	45.223
2220	77800	0.004995	0	78.403	7230	27700	0.004995	0	45.173
2230	77700	0.004995	0	78.317	7240	27600	0.004995	0	45.124
2240	77600	0.004995	0	78.23	7250	27500	0.004995	0	45.074
2250	77500	0.004995	0	78.144	7260	27400	0.004995	0	45.025
2260	77400	0.004995	0	78.058	7270	27300	0.004995	0	44.975
2270	77300	0.004995	0	77.973	7280	27200	0.004995	0	44.926
2280	77200	0.004995	0	77.887	7290	27100	0.004995	0	44.876
2290	77100	0.004995	0	77.801	7300	27000	0.004995	0	44.827
2300	77000	0.004995	0	77.716	7310	26900	0.004995	0	44.777
2310	76900	0.004995	0	77.63	7320	26800	0.004995	0	44.728
2320	76800	0.004995	0	77.545	7330	26700	0.004995	0	44.679
2330	76700	0.004995	0	77.459	7340	26600	0.004995	0	44.63
2340	76600	0.004995	0	77.374	7350	26500	0.004995	0	44.581
2350	76500	0.004995	0	77.289	7360	26400	0.004995	0	44.532
2360	76400	0.004995	0	77.204	7370	26300	0.004995	0	44.483
2370	76300	0.004995	0	77.119	7380	26200	0.004995	0	44.434
2380	76200	0.004995	0	77.034	7390	26100	0.004995	0	44.385
2390	76100	0.004995	0	76.95	7400	26000	0.004995	0	44.336
2400	76000	0.004995	0	76.865	7410	25900	0.004995	0	44.287
2410	75900	0.004995	0	76.78	7420	25800	0.004995	0	44.239
2420	75800	0.004995	0	76.696	7430	25700	0.004995	0	44.19
2430	75700	0.004995	0	76.612	7440	25600	0.004995	0	44.141
2440	75600	0.004995	0	76.527	7450	25500	0.004995	0	44.093
2450	75500	0.004995	0	76.443	7460	25400	0.004995	0	44.044
2460	75400	0.004995	0	76.359	7470	25300	0.004995	0	43.996
2470	75300	0.004995	0	76.275	7480	25200	0.004995	0	43.948
2480	75200	0.004995	0	76.191	7490	25100	0.004995	0	43.899
2490	75100	0.004995	0	76.107	7500	25000	0.004995	10	43.851
2500	75000	0.004995	10	76.024	7510	24900	0.004995	1.00E-12	43.803
2510	74900	0.004995	1.00E-12	75.94	7520	24800	0.004995	0	43.754
2520	74800	0.004995	0	75.857	7530	24700	0.004995	0	43.706
2530	74700	0.004995	0	75.773	7540	24600	0.004995	0	43.658
2540	74600	0.004995	0	75.69	7550	24500	0.004995	0	43.61
2550	74500	0.004995	0	75.607	7560	24400	0.004995	0	43.562
2560	74400	0.004995	0	75.523	7570	24300	0.004995	0	43.514

Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)	Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)
2570	74300	0.004995	0	75.44	7580	24200	0.004995	0	43.467
2580	74200	0.004995	0	75.357	7590	24100	0.004995	0	43.419
2590	74100	0.004995	0	75.274	7600	24000	0.004995	0	43.371
2600	74000	0.004995	0	75.192	7610	23900	0.004995	0	43.323
2610	73900	0.004995	0	75.109	7620	23800	0.004995	0	43.276
2620	73800	0.004995	0	75.026	7630	23700	0.004995	0	43.228
2630	73700	0.004995	0	74.944	7640	23600	0.004995	0	43.18
2640	73600	0.004995	0	74.861	7650	23500	0.004995	0	43.133
2650	73500	0.004995	0	74.779	7660	23400	0.004995	0	43.086
2660	73400	0.004995	0	74.697	7670	23300	0.004995	0	43.038
2670	73300	0.004995	0	74.615	7680	23200	0.004995	0	42.991
2680	73200	0.004995	0	74.533	7690	23100	0.004995	0	42.944
2690	73100	0.004995	0	74.451	7700	23000	0.004995	0	42.896
2700	73000	0.004995	0	74.369	7710	22900	0.004995	0	42.849
2710	72900	0.004995	0	74.287	7720	22800	0.004995	0	42.802
2720	72800	0.004995	0	74.205	7730	22700	0.004995	0	42.755
2730	72700	0.004995	0	74.124	7740	22600	0.004995	0	42.708
2740	72600	0.004995	0	74.042	7750	22500	0.004995	0	42.661
2750	72500	0.004995	0	73.961	7760	22400	0.004995	0	42.614
2760	72400	0.004995	0	73.879	7770	22300	0.004995	0	42.567
2770	72300	0.004995	0	73.798	7780	22200	0.004995	0	42.52
2780	72200	0.004995	0	73.717	7790	22100	0.004995	0	42.474
2790	72100	0.004995	0	73.636	7800	22000	0.004995	0	42.427
2800	72000	0.004995	0	73.555	7810	21900	0.004995	0	42.38
2810	71900	0.004995	0	73.474	7820	21800	0.004995	0	42.334
2820	71800	0.004995	0	73.393	7830	21700	0.004995	0	42.287
2830	71700	0.004995	0	73.312	7840	21600	0.004995	0	42.24
2840	71600	0.004995	0	73.232	7850	21500	0.004995	0	42.194
2850	71500	0.004995	0	73.151	7860	21400	0.004995	0	42.148
2860	71400	0.004995	0	73.071	7870	21300	0.004995	0	42.101
2870	71300	0.004995	0	72.99	7880	21200	0.004995	0	42.055
2880	71200	0.004995	0	72.91	7890	21100	0.004995	0	42.009
2890	71100	0.004995	0	72.83	7900	21000	0.004995	0	41.962
2900	71000	0.004995	0	72.75	7910	20900	0.004995	0	41.916
2910	70900	0.004995	0	72.67	7920	20800	0.004995	0	41.87
2920	70800	0.004995	0	72.59	7930	20700	0.004995	0	41.824
2930	70700	0.004995	0	72.51	7940	20600	0.004995	0	41.778
2940	70600	0.004995	0	72.43	7950	20500	0.004995	0	41.732

Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)	Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)
2950	70500	0.004995	0	72.351	**7960**	20400	0.004995	0	41.686
2960	70400	0.004995	0	72.271	**7970**	20300	0.004995	0	41.64
2970	70300	0.004995	0	72.191	**7980**	20200	0.004995	0	41.595
2980	70200	0.004995	0	72.112	**7990**	20100	0.004995	0	41.549
2990	70100	0.004995	0	72.033	**8000**	20000	0.004995	0	41.503
3000	70000	0.004995	0	71.954	**8010**	19900	0.004995	0	41.458
3010	69900	0.004995	0	71.874	**8020**	19800	0.004995	0	41.412
3020	69800	0.004995	0	71.795	**8030**	19700	0.004995	0	41.366
3030	69700	0.004995	0	71.716	**8040**	19600	0.004995	0	41.321
3040	69600	0.004995	0	71.637	**8050**	19500	0.004995	0	41.275
3050	69500	0.004995	0	71.559	**8060**	19400	0.004995	0	41.23
3060	69400	0.004995	0	71.48	**8070**	19300	0.004995	0	41.185
3070	69300	0.004995	0	71.401	**8080**	19200	0.004995	0	41.139
3080	69200	0.004995	0	71.323	**8090**	19100	0.004995	0	41.094
3090	69100	0.004995	0	71.244	**8100**	19000	0.004995	0	41.049
3100	69000	0.004995	0	71.166	**8110**	18900	0.004995	0	41.004
3110	68900	0.004995	0	71.088	**8120**	18800	0.004995	0	40.959
3120	68800	0.004995	0	71.01	**8130**	18700	0.004995	0	40.914
3130	68700	0.004995	0	70.931	**8140**	18600	0.004995	0	40.869
3140	68600	0.004995	0	70.853	**8150**	18500	0.004995	0	40.824
3150	68500	0.004995	0	70.776	**8160**	18400	0.004995	0	40.779
3160	68400	0.004995	0	70.698	**8170**	18300	0.004995	0	40.734
3170	68300	0.004995	0	70.62	**8180**	18200	0.004995	0	40.689
3180	68200	0.004995	0	70.542	**8190**	18100	0.004995	0	40.644
3190	68100	0.004995	0	70.465	**8200**	18000	0.004995	0	40.6
3200	68000	0.004995	0	70.387	**8210**	17900	0.004995	0	40.555
3210	67900	0.004995	0	70.31	**8220**	17800	0.004995	0	40.51
3220	67800	0.004995	0	70.232	**8230**	17700	0.004995	0	40.466
3230	67700	0.004995	0	70.155	**8240**	17600	0.004995	0	40.421
3240	67600	0.004995	0	70.078	**8250**	17500	0.004995	0	40.377
3250	67500	0.004995	0	70.001	**8260**	17400	0.004995	0	40.332
3260	67400	0.004995	0	69.924	**8270**	17300	0.004995	0	40.288
3270	67300	0.004995	0	69.847	**8280**	17200	0.004995	0	40.244
3280	67200	0.004995	0	69.77	**8290**	17100	0.004995	0	40.2
3290	67100	0.004995	0	69.693	**8300**	17000	0.004995	0	40.155
3300	67000	0.004995	0	69.617	**8310**	16900	0.004995	0	40.111
3310	66900	0.004995	0	69.54	**8320**	16800	0.004995	0	40.067
3320	66800	0.004995	0	69.464	**8330**	16700	0.004995	0	40.023

Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)	Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)
3330	66700	0.004995	0	69.387	**8340**	16600	0.004995	0	39.979
3340	66600	0.004995	0	69.311	**8350**	16500	0.004995	0	39.935
3350	66500	0.004995	0	69.235	**8360**	16400	0.004995	0	39.891
3360	66400	0.004995	0	69.159	**8370**	16300	0.004995	0	39.847
3370	66300	0.004995	0	69.083	**8380**	16200	0.004995	0	39.803
3380	66200	0.004995	0	69.007	**8390**	16100	0.004995	0	39.76
3390	66100	0.004995	0	68.931	**8400**	16000	0.004995	0	39.716
3400	66000	0.004995	0	68.855	**8410**	15900	0.004995	0	39.672
3410	65900	0.004995	0	68.779	**8420**	15800	0.004995	0	39.629
3420	65800	0.004995	0	68.703	**8430**	15700	0.004995	0	39.585
3430	65700	0.004995	0	68.628	**8440**	15600	0.004995	0	39.541
3440	65600	0.004995	0	68.552	**8450**	15500	0.004995	0	39.498
3450	65500	0.004995	0	68.477	**8460**	15400	0.004995	0	39.454
3460	65400	0.004995	0	68.402	**8470**	15300	0.004995	0	39.411
3470	65300	0.004995	0	68.326	**8480**	15200	0.004995	0	39.368
3480	65200	0.004995	0	68.251	**8490**	15100	0.004995	0	39.324
3490	65100	0.004995	0	68.176	**8500**	15000	0.004995	10	39.281
3500	65000	0.004995	10	68.101	**8510**	14900	0.004995	1.00E-12	39.238
3510	64900	0.004995	1.00E-12	68.026	**8520**	14800	0.004995	0	39.195
3520	64800	0.004995	0	67.952	**8530**	14700	0.004995	0	39.152
3530	64700	0.004995	0	67.877	**8540**	14600	0.004995	0	39.109
3540	64600	0.004995	0	67.802	**8550**	14500	0.004995	0	39.066
3550	64500	0.004995	0	67.728	**8560**	14400	0.004995	0	39.023
3560	64400	0.004995	0	67.653	**8570**	14300	0.004995	0	38.98
3570	64300	0.004995	0	67.579	**8580**	14200	0.004995	0	38.937
3580	64200	0.004995	0	67.504	**8590**	14100	0.004995	0	38.894
3590	64100	0.004995	0	67.43	**8600**	14000	0.004995	0	38.851
3600	64000	0.004995	0	67.356	**8610**	13900	0.004995	0	38.809
3610	63900	0.004995	0	67.282	**8620**	13800	0.004995	0	38.766
3620	63800	0.004995	0	67.208	**8630**	13700	0.004995	0	38.723
3630	63700	0.004995	0	67.134	**8640**	13600	0.004995	0	38.681
3640	63600	0.004995	0	67.06	**8650**	13500	0.004995	0	38.638
3650	63500	0.004995	0	66.986	**8660**	13400	0.004995	0	38.596
3660	63400	0.004995	0	66.913	**8670**	13300	0.004995	0	38.553
3670	63300	0.004995	0	66.839	**8680**	13200	0.004995	0	38.511
3680	63200	0.004995	0	66.766	**8690**	13100	0.004995	0	38.468
3690	63100	0.004995	0	66.692	**8700**	13000	0.004995	0	38.426
3700	63000	0.004995	0	66.619	**8710**	12900	0.004995	0	38.384

Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)	Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)
4090	59100	0.004995	0	63.82	**9100**	9000	0.004995	0	36.771
4100	59000	0.004995	0	63.75	**9110**	8900	0.004995	0	36.731
4110	58900	0.004995	0	63.68	**9120**	8800	0.004995	0	36.69
4120	58800	0.004995	0	63.61	**9130**	8700	0.004995	0	36.65
4130	58700	0.004995	0	63.54	**9140**	8600	0.004995	0	36.61
4140	58600	0.004995	0	63.47	**9150**	8500	0.004995	0	36.569
4150	58500	0.004995	0	63.4	**9160**	8400	0.004995	0	36.529
4160	58400	0.004995	0	63.33	**9170**	8300	0.004995	0	36.489
4170	58300	0.004995	0	63.261	**9180**	8200	0.004995	0	36.449
4180	58200	0.004995	0	63.191	**9190**	8100	0.004995	0	36.409
4190	58100	0.004995	0	63.121	**9200**	8000	0.004995	0	36.369
4200	58000	0.004995	0	63.052	**9210**	7900	0.004995	0	36.329
4210	57900	0.004995	0	62.983	**9220**	7800	0.004995	0	36.289
4220	57800	0.004995	0	62.913	**9230**	7700	0.004995	0	36.249
4230	57700	0.004995	0	62.844	**9240**	7600	0.004995	0	36.209
4240	57600	0.004995	0	62.775	**9250**	7500	0.004995	0	36.169
4250	57500	0.004995	0	62.706	**9260**	7400	0.004995	0	36.129
4260	57400	0.004995	0	62.637	**9270**	7300	0.004995	0	36.09
4270	57300	0.004995	0	62.568	**9280**	7200	0.004995	0	36.05
4280	57200	0.004995	0	62.499	**9290**	7100	0.004995	0	36.01
4290	57100	0.004995	0	62.431	**9300**	7000	0.004995	0	35.971
4300	57000	0.004995	0	62.362	**9310**	6900	0.004995	0	35.931
4310	56900	0.004995	0	62.293	**9320**	6800	0.004995	0	35.892
4320	56800	0.004995	0	62.225	**9330**	6700	0.004995	0	35.852
4330	56700	0.004995	0	62.156	**9340**	6600	0.004995	0	35.813
4340	56600	0.004995	0	62.088	**9350**	6500	0.004995	0	35.773
4350	56500	0.004995	0	62.02	**9360**	6400	0.004995	0	35.734
4360	56400	0.004995	0	61.952	**9370**	6300	0.004995	0	35.695
4370	56300	0.004995	0	61.883	**9380**	6200	0.004995	0	35.655
4380	56200	0.004995	0	61.815	**9390**	6100	0.004995	0	35.616
4390	56100	0.004995	0	61.747	**9400**	6000	0.004995	0	35.577
4400	56000	0.004995	0	61.679	**9410**	5900	0.004995	0	35.538
4410	55900	0.004995	0	61.612	**9420**	5800	0.004995	0	35.499
4420	55800	0.004995	0	61.544	**9430**	5700	0.004995	0	35.46
4430	55700	0.004995	0	61.476	**9440**	5600	0.004995	0	35.421
4440	55600	0.004995	0	61.409	**9450**	5500	0.004995	0	35.382
4450	55500	0.004995	0	61.341	**9460**	5400	0.004995	0	35.343
4460	55400	0.004995	0	61.274	**9470**	5300	0.004995	0	35.304

Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)	Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)
4470	55300	0.004995	0	61.206	**9480**	5200	0.004995	0	35.265
4480	55200	0.004995	0	61.139	**9490**	5100	0.004995	0	35.226
4490	55100	0.004995	0	61.072	**9500**	5000	0.004995	10	35.188
4500	55000	0.004995	10	61.004	**9510**	4900	0.004995	1.00E-12	35.149
4510	54900	0.004995	1.00E-12	60.937	**9520**	4800	0.004995	0	35.11
4520	54800	0.004995	0	60.87	**9530**	4700	0.004995	0	35.072
4530	54700	0.004995	0	60.803	**9540**	4600	0.004995	0	35.033
4540	54600	0.004995	0	60.736	**9550**	4500	0.004995	0	34.995
4550	54500	0.004995	0	60.67	**9560**	4400	0.004995	0	34.956
4560	54400	0.004995	0	60.603	**9570**	4300	0.004995	0	34.918
4570	54300	0.004995	0	60.536	**9580**	4200	0.004995	0	34.879
4580	54200	0.004995	0	60.47	**9590**	4100	0.004995	0	34.841
4590	54100	0.004995	0	60.403	**9600**	4000	0.004995	0	34.803
4600	54000	0.004995	0	60.337	**9610**	3900	0.004995	0	34.764
4610	53900	0.004995	0	60.27	**9620**	3800	0.004995	0	34.726
4620	53800	0.004995	0	60.204	**9630**	3700	0.004995	0	34.688
4630	53700	0.004995	0	60.138	**9640**	3600	0.004995	0	34.65
4640	53600	0.004995	0	60.072	**9650**	3500	0.004995	0	34.612
4650	53500	0.004995	0	60.006	**9660**	3400	0.004995	0	34.573
4660	53400	0.004995	0	59.94	**9670**	3300	0.004995	0	34.535
4670	53300	0.004995	0	59.874	**9680**	3200	0.004995	0	34.497
4680	53200	0.004995	0	59.808	**9690**	3100	0.004995	0	34.46
4690	53100	0.004995	0	59.742	**9700**	3000	0.004995	0	34.422
4700	53000	0.004995	0	59.676	**9710**	2900	0.004995	0	34.384
4710	52900	0.004995	0	59.611	**9720**	2800	0.004995	0	34.346
4720	52800	0.004995	0	59.545	**9730**	2700	0.004995	0	34.308
4730	52700	0.004995	0	59.48	**9740**	2600	0.004995	0	34.27
4740	52600	0.004995	0	59.414	**9750**	2500	0.004995	0	34.233
4750	52500	0.004995	0	59.349	**9760**	2400	0.004995	0	34.195
4760	52400	0.004995	0	59.284	**9770**	2300	0.004995	0	34.157
4770	52300	0.004995	0	59.218	**9780**	2200	0.004995	0	34.12
4780	52200	0.004995	0	59.153	**9790**	2100	0.004995	0	34.082
4790	52100	0.004995	0	59.088	**9800**	2000	0.004995	0	34.045
4800	52000	0.004995	0	59.023	**9810**	1900	0.004995	0	34.007
4810	51900	0.004995	0	58.958	**9820**	1800	0.004995	0	33.97
4820	51800	0.004995	0	58.893	**9830**	1700	0.004995	0	33.933
4830	51700	0.004995	0	58.829	**9840**	1600	0.004995	0	33.895
4840	51600	0.004995	0	58.764	**9850**	1500	0.004995	0	33.858

Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)	Time (years)	Source 1 Unexposed Mass (grams)	Source 1 Mass Transport Rate (g/yr)	Source 2 Outer Barrier Releases (g/yr)	Source 3 Unexposed Mass of Species C (grams)
4850	51500	0.004995	0	58.699	**9860**	1400	0.004995	0	33.821
4860	51400	0.004995	0	58.635	**9870**	1300	0.004995	0	33.784
4870	51300	0.004995	0	58.57	**9880**	1200	0.004995	0	33.746
4880	51200	0.004995	0	58.506	**9890**	1100	0.004995	0	33.709
4890	51100	0.004995	0	58.441	**9900**	1000	0.004995	0	33.672
4900	51000	0.004995	0	58.377	**9910**	900	0.004995	0	33.635
4910	50900	0.004995	0	58.313	**9920**	800	0.004995	0	33.598
4920	50800	0.004995	0	58.249	**9930**	700	0.004995	0	33.561
4930	50700	0.004995	0	58.185	**9940**	600	0.004995	0	33.524
4940	50600	0.004995	0	58.121	**9950**	500	0.004995	0	33.488
4950	50500	0.004995	0	58.057	**9960**	400	0.004995	0	33.451
4960	50400	0.004995	0	57.993	**9970**	300	0.004995	0	33.414
4970	50300	0.004995	0	57.929	**9980**	200	0.004995	0	33.377
4980	50200	0.004995	0	57.866	**9990**	100	0.004995	0	33.34
4990	50100	0.004995	0	57.802	**10000**	0	0.004995	0	33.304
5000	50000	0.004995	0	57.738					

Attachment IV Results for VTP Test 4, Dose Rate

This Attachment lists the GoldSim results for VTP Test 4, Calculation of Dose Rate. This test requires that GoldSim calculate the total dose rate to an individual from two different radioactive species. The results are given below for a 10,000 year simulation with 10 year time steps.

Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)
0	8.00E+05	2510	1.82E+05	5020	69841	7530	31605
10	7.94E+05	2520	1.81E+05	5030	69609	7540	31508
20	7.88E+05	2530	1.80E+05	5040	69378	7550	31412
30	7.83E+05	2540	1.79E+05	5050	69147	7560	31316
40	7.77E+05	2550	1.79E+05	5060	68918	7570	31221
50	7.71E+05	2560	1.78E+05	5070	68689	7580	31125
60	7.66E+05	2570	1.77E+05	5080	68462	7590	31030
70	7.60E+05	2580	1.76E+05	5090	68235	7600	30936
80	7.54E+05	2590	1.75E+05	5100	68009	7610	30841
90	7.49E+05	2600	1.75E+05	5110	67784	7620	30747
100	7.44E+05	2610	1.74E+05	5120	67560	7630	30653
110	7.38E+05	2620	1.73E+05	5130	67337	7640	30560
120	7.33E+05	2630	1.72E+05	5140	67115	7650	30467
130	7.28E+05	2640	1.72E+05	5150	66893	7660	30374
140	7.22E+05	2650	1.71E+05	5160	66673	7670	30281
150	7.17E+05	2660	1.70E+05	5170	66453	7680	30189
160	7.12E+05	2670	1.69E+05	5180	66234	7690	30097
170	7.07E+05	2680	1.69E+05	5190	66016	7700	30005
180	7.02E+05	2690	1.68E+05	5200	65799	7710	29913
190	6.97E+05	2700	1.67E+05	5210	65583	7720	29822
200	6.92E+05	2710	1.66E+05	5220	65368	7730	29731
210	6.87E+05	2720	1.66E+05	5230	65153	7740	29641
220	6.82E+05	2730	1.65E+05	5240	64939	7750	29551
230	6.77E+05	2740	1.64E+05	5250	64726	7760	29460
240	6.72E+05	2750	1.63E+05	5260	64514	7770	29371
250	6.68E+05	2760	1.63E+05	5270	64303	7780	29281
260	6.63E+05	2770	1.62E+05	5280	64092	7790	29192
270	6.58E+05	2780	1.61E+05	5290	63883	7800	29103
280	6.54E+05	2790	1.61E+05	5300	63674	7810	29015
290	6.49E+05	2800	1.60E+05	5310	63466	7820	28926
300	6.45E+05	2810	1.59E+05	5320	63258	7830	28838
310	6.40E+05	2820	1.59E+05	5330	63052	7840	28751
320	6.36E+05	2830	1.58E+05	5340	62846	7850	28663
330	6.31E+05	2840	1.57E+05	5350	62641	7860	28576
340	6.27E+05	2850	1.57E+05	5360	62437	7870	28489

Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)
350	6.22E+05	**2860**	1.56E+05	**5370**	62234	**7880**	28402
360	6.18E+05	**2870**	1.55E+05	**5380**	62031	**7890**	28316
370	6.14E+05	**2880**	1.55E+05	**5390**	61829	**7900**	28230
380	6.10E+05	**2890**	1.54E+05	**5400**	61628	**7910**	28144
390	6.05E+05	**2900**	1.53E+05	**5410**	61428	**7920**	28058
400	6.01E+05	**2910**	1.53E+05	**5420**	61228	**7930**	27973
410	5.97E+05	**2920**	1.52E+05	**5430**	61029	**7940**	27888
420	5.93E+05	**2930**	1.51E+05	**5440**	60831	**7950**	27803
430	5.89E+05	**2940**	1.51E+05	**5450**	60634	**7960**	27719
440	5.85E+05	**2950**	1.50E+05	**5460**	60437	**7970**	27634
450	5.81E+05	**2960**	1.49E+05	**5470**	60242	**7980**	27550
460	5.77E+05	**2970**	1.49E+05	**5480**	60047	**7990**	27467
470	5.73E+05	**2980**	1.48E+05	**5490**	59852	**8000**	27383
480	5.69E+05	**2990**	1.47E+05	**5500**	59659	**8010**	27300
490	5.65E+05	**3000**	1.47E+05	**5510**	59466	**8020**	27217
500	5.61E+05	**3010**	1.46E+05	**5520**	59273	**8030**	27134
510	5.58E+05	**3020**	1.46E+05	**5530**	59082	**8040**	27052
520	5.54E+05	**3030**	1.45E+05	**5540**	58891	**8050**	26970
530	5.50E+05	**3040**	1.44E+05	**5550**	58701	**8060**	26888
540	5.47E+05	**3050**	1.44E+05	**5560**	58512	**8070**	26806
550	5.43E+05	**3060**	1.43E+05	**5570**	58323	**8080**	26725
560	5.39E+05	**3070**	1.43E+05	**5580**	58135	**8090**	26644
570	5.36E+05	**3080**	1.42E+05	**5590**	57948	**8100**	26563
580	5.32E+05	**3090**	1.41E+05	**5600**	57761	**8110**	26482
590	5.29E+05	**3100**	1.41E+05	**5610**	57575	**8120**	26402
600	5.25E+05	**3110**	1.40E+05	**5620**	57390	**8130**	26322
610	5.22E+05	**3120**	1.40E+05	**5630**	57206	**8140**	26242
620	5.18E+05	**3130**	1.39E+05	**5640**	57022	**8150**	26162
630	5.15E+05	**3140**	1.39E+05	**5650**	56839	**8160**	26083
640	5.11E+05	**3150**	1.38E+05	**5660**	56656	**8170**	26004
650	5.08E+05	**3160**	1.37E+05	**5670**	56474	**8180**	25925
660	5.05E+05	**3170**	1.37E+05	**5680**	56293	**8190**	25846
670	5.01E+05	**3180**	1.36E+05	**5690**	56113	**8200**	25768
680	4.98E+05	**3190**	1.36E+05	**5700**	55933	**8210**	25690
690	4.95E+05	**3200**	1.35E+05	**5710**	55754	**8220**	25612
700	4.91E+05	**3210**	1.35E+05	**5720**	55575	**8230**	25534
710	4.88E+05	**3220**	1.34E+05	**5730**	55397	**8240**	25457
720	4.85E+05	**3230**	1.34E+05	**5740**	55220	**8250**	25380
730	4.82E+05	**3240**	1.33E+05	**5750**	55043	**8260**	25303
740	4.79E+05	**3250**	1.33E+05	**5760**	54868	**8270**	25226

Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)
750	4.76E+05	3260	1.32E+05	5770	54692	8280	25150
760	4.73E+05	3270	1.31E+05	5780	54518	8290	25073
770	4.70E+05	3280	1.31E+05	5790	54343	8300	24997
780	4.67E+05	3290	1.30E+05	5800	54170	8310	24922
790	4.64E+05	3300	1.30E+05	5810	53997	8320	24846
800	4.61E+05	3310	1.29E+05	5820	53825	8330	24771
810	4.58E+05	3320	1.29E+05	5830	53654	8340	24696
820	4.55E+05	3330	1.28E+05	5840	53483	8350	24621
830	4.52E+05	3340	1.28E+05	5850	53312	8360	24546
840	4.49E+05	3350	1.27E+05	5860	53143	8370	24472
850	4.46E+05	3360	1.27E+05	5870	52973	8380	24398
860	4.43E+05	3370	1.26E+05	5880	52805	8390	24324
870	4.41E+05	3380	1.26E+05	5890	52637	8400	24250
880	4.38E+05	3390	1.25E+05	5900	52470	8410	24177
890	4.35E+05	3400	1.25E+05	5910	52303	8420	24104
900	4.32E+05	3410	1.24E+05	5920	52137	8430	24031
910	4.30E+05	3420	1.24E+05	5930	51971	8440	23958
920	4.27E+05	3430	1.23E+05	5940	51807	8450	23886
930	4.24E+05	3440	1.23E+05	5950	51642	8460	23813
940	4.22E+05	3450	1.22E+05	5960	51478	8470	23741
950	4.19E+05	3460	1.22E+05	5970	51315	8480	23669
960	4.16E+05	3470	1.21E+05	5980	51153	8490	23598
970	4.14E+05	3480	1.21E+05	5990	50991	8500	23526
980	4.11E+05	3490	1.21E+05	6000	50829	8510	23455
990	4.09E+05	3500	1.20E+05	6010	50668	8520	23384
1000	4.06E+05	3510	1.20E+05	6020	50508	8530	23313
1010	4.04E+05	3520	1.19E+05	6030	50348	8540	23243
1020	4.01E+05	3530	1.19E+05	6040	50189	8550	23173
1030	3.99E+05	3540	1.18E+05	6050	50030	8560	23103
1040	3.96E+05	3550	1.18E+05	6060	49872	8570	23033
1050	3.94E+05	3560	1.17E+05	6070	49715	8580	22963
1060	3.92E+05	3570	1.17E+05	6080	49558	8590	22894
1070	3.89E+05	3580	1.16E+05	6090	49402	8600	22824
1080	3.87E+05	3590	1.16E+05	6100	49246	8610	22755
1090	3.84E+05	3600	1.16E+05	6110	49090	8620	22687
1100	3.82E+05	3610	1.15E+05	6120	48936	8630	22618
1110	3.80E+05	3620	1.15E+05	6130	48781	8640	22550
1120	3.78E+05	3630	1.14E+05	6140	48628	8650	22481
1130	3.75E+05	3640	1.14E+05	6150	48475	8660	22413
1140	3.73E+05	3650	1.13E+05	6160	48322	8670	22346

Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)
1150	3.71E+05	**3660**	1.13E+05	**6170**	48170	**8680**	22278
1160	3.69E+05	**3670**	1.13E+05	**6180**	48018	**8690**	22211
1170	3.66E+05	**3680**	1.12E+05	**6190**	47867	**8700**	22144
1180	3.64E+05	**3690**	1.12E+05	**6200**	47717	**8710**	22077
1190	3.62E+05	**3700**	1.11E+05	**6210**	47567	**8720**	22010
1200	3.60E+05	**3710**	1.11E+05	**6220**	47417	**8730**	21944
1210	3.58E+05	**3720**	1.10E+05	**6230**	47268	**8740**	21877
1220	3.56E+05	**3730**	1.10E+05	**6240**	47120	**8750**	21811
1230	3.54E+05	**3740**	1.10E+05	**6250**	46972	**8760**	21745
1240	3.52E+05	**3750**	1.09E+05	**6260**	46824	**8770**	21680
1250	3.49E+05	**3760**	1.09E+05	**6270**	46678	**8780**	21614
1260	3.47E+05	**3770**	1.08E+05	**6280**	46531	**8790**	21549
1270	3.45E+05	**3780**	1.08E+05	**6290**	46385	**8800**	21484
1280	3.43E+05	**3790**	1.08E+05	**6300**	46240	**8810**	21419
1290	3.41E+05	**3800**	1.07E+05	**6310**	46095	**8820**	21354
1300	3.39E+05	**3810**	1.07E+05	**6320**	45951	**8830**	21290
1310	3.37E+05	**3820**	1.06E+05	**6330**	45807	**8840**	21226
1320	3.35E+05	**3830**	1.06E+05	**6340**	45663	**8850**	21161
1330	3.34E+05	**3840**	1.06E+05	**6350**	45520	**8860**	21098
1340	3.32E+05	**3850**	1.05E+05	**6360**	45378	**8870**	21034
1350	3.30E+05	**3860**	1.05E+05	**6370**	45236	**8880**	20970
1360	3.28E+05	**3870**	1.04E+05	**6380**	45094	**8890**	20907
1370	3.26E+05	**3880**	1.04E+05	**6390**	44954	**8900**	20844
1380	3.24E+05	**3890**	1.04E+05	**6400**	44813	**8910**	20781
1390	3.22E+05	**3900**	1.03E+05	**6410**	44673	**8920**	20718
1400	3.20E+05	**3910**	1.03E+05	**6420**	44533	**8930**	20656
1410	3.19E+05	**3920**	1.02E+05	**6430**	44394	**8940**	20593
1420	3.17E+05	**3930**	1.02E+05	**6440**	44256	**8950**	20531
1430	3.15E+05	**3940**	1.02E+05	**6450**	44118	**8960**	20469
1440	3.13E+05	**3950**	1.01E+05	**6460**	43980	**8970**	20408
1450	3.11E+05	**3960**	1.01E+05	**6470**	43843	**8980**	20346
1460	3.10E+05	**3970**	1.01E+05	**6480**	43706	**8990**	20285
1470	3.08E+05	**3980**	1.00E+05	**6490**	43570	**9000**	20223
1480	3.06E+05	**3990**	99880	**6500**	43434	**9010**	20162
1490	3.05E+05	**4000**	99516	**6510**	43299	**9020**	20102
1500	3.03E+05	**4010**	99155	**6520**	43164	**9030**	20041
1510	3.01E+05	**4020**	98795	**6530**	43029	**9040**	19981
1520	3.00E+05	**4030**	98436	**6540**	42895	**9050**	19920
1530	2.98E+05	**4040**	98080	**6550**	42762	**9060**	19860
1540	2.96E+05	**4050**	97725	**6560**	42629	**9070**	19800

Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)
1550	2.95E+05	**4060**	97371	**6570**	42496	**9080**	19741
1560	2.93E+05	**4070**	97020	**6580**	42364	**9090**	19681
1570	2.91E+05	**4080**	96670	**6590**	42232	**9100**	19622
1580	2.90E+05	**4090**	96321	**6600**	42101	**9110**	19563
1590	2.88E+05	**4100**	95974	**6610**	41970	**9120**	19504
1600	2.87E+05	**4110**	95629	**6620**	41840	**9130**	19445
1610	2.85E+05	**4120**	95286	**6630**	41710	**9140**	19386
1620	2.83E+05	**4130**	94944	**6640**	41580	**9150**	19328
1630	2.82E+05	**4140**	94604	**6650**	41451	**9160**	19269
1640	2.80E+05	**4150**	94265	**6660**	41323	**9170**	19211
1650	2.79E+05	**4160**	93928	**6670**	41194	**9180**	19153
1660	2.77E+05	**4170**	93592	**6680**	41067	**9190**	19096
1670	2.76E+05	**4180**	93258	**6690**	40939	**9200**	19038
1680	2.74E+05	**4190**	92925	**6700**	40812	**9210**	18981
1690	2.73E+05	**4200**	92594	**6710**	40686	**9220**	18924
1700	2.71E+05	**4210**	92265	**6720**	40560	**9230**	18867
1710	2.70E+05	**4220**	91937	**6730**	40434	**9240**	18810
1720	2.69E+05	**4230**	91610	**6740**	40309	**9250**	18753
1730	2.67E+05	**4240**	91285	**6750**	40184	**9260**	18696
1740	2.66E+05	**4250**	90962	**6760**	40059	**9270**	18640
1750	2.64E+05	**4260**	90640	**6770**	39935	**9280**	18584
1760	2.63E+05	**4270**	90319	**6780**	39812	**9290**	18528
1770	2.62E+05	**4280**	90000	**6790**	39688	**9300**	18472
1780	2.60E+05	**4290**	89682	**6800**	39566	**9310**	18417
1790	2.59E+05	**4300**	89366	**6810**	39443	**9320**	18361
1800	2.57E+05	**4310**	89051	**6820**	39321	**9330**	18306
1810	2.56E+05	**4320**	88737	**6830**	39200	**9340**	18251
1820	2.55E+05	**4330**	88425	**6840**	39078	**9350**	18196
1830	2.53E+05	**4340**	88115	**6850**	38958	**9360**	18141
1840	2.52E+05	**4350**	87805	**6860**	38837	**9370**	18086
1850	2.51E+05	**4360**	87498	**6870**	38717	**9380**	18032
1860	2.50E+05	**4370**	87191	**6880**	38598	**9390**	17977
1870	2.48E+05	**4380**	86886	**6890**	38479	**9400**	17923
1880	2.47E+05	**4390**	86582	**6900**	38360	**9410**	17869
1890	2.46E+05	**4400**	86280	**6910**	38241	**9420**	17815
1900	2.44E+05	**4410**	85978	**6920**	38123	**9430**	17762
1910	2.43E+05	**4420**	85679	**6930**	38006	**9440**	17708
1920	2.42E+05	**4430**	85380	**6940**	37888	**9450**	17655
1930	2.41E+05	**4440**	85083	**6950**	37772	**9460**	17602
1940	2.39E+05	**4450**	84787	**6960**	37655	**9470**	17549

Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)
1950	2.38E+05	**4460**	84492	**6970**	37539	**9480**	17496
1960	2.37E+05	**4470**	84199	**6980**	37423	**9490**	17443
1970	2.36E+05	**4480**	83907	**6990**	37308	**9500**	17391
1980	2.35E+05	**4490**	83616	**7000**	37193	**9510**	17338
1990	2.33E+05	**4500**	83327	**7010**	37078	**9520**	17286
2000	2.32E+05	**4510**	83039	**7020**	36964	**9530**	17234
2010	2.31E+05	**4520**	82752	**7030**	36850	**9540**	17182
2020	2.30E+05	**4530**	82466	**7040**	36737	**9550**	17131
2030	2.29E+05	**4540**	82181	**7050**	36624	**9560**	17079
2040	2.28E+05	**4550**	81898	**7060**	36511	**9570**	17028
2050	2.27E+05	**4560**	81616	**7070**	36399	**9580**	16976
2060	2.25E+05	**4570**	81335	**7080**	36287	**9590**	16925
2070	2.24E+05	**4580**	81055	**7090**	36175	**9600**	16874
2080	2.23E+05	**4590**	80777	**7100**	36064	**9610**	16824
2090	2.22E+05	**4600**	80500	**7110**	35953	**9620**	16773
2100	2.21E+05	**4610**	80224	**7120**	35842	**9630**	16722
2110	2.20E+05	**4620**	79949	**7130**	35732	**9640**	16672
2120	2.19E+05	**4630**	79675	**7140**	35622	**9650**	16622
2130	2.18E+05	**4640**	79402	**7150**	35513	**9660**	16572
2140	2.17E+05	**4650**	79131	**7160**	35404	**9670**	16522
2150	2.16E+05	**4660**	78861	**7170**	35295	**9680**	16472
2160	2.15E+05	**4670**	78592	**7180**	35187	**9690**	16423
2170	2.14E+05	**4680**	78324	**7190**	35079	**9700**	16373
2180	2.13E+05	**4690**	78057	**7200**	34971	**9710**	16324
2190	2.11E+05	**4700**	77791	**7210**	34864	**9720**	16275
2200	2.10E+05	**4710**	77526	**7220**	34757	**9730**	16226
2210	2.09E+05	**4720**	77263	**7230**	34650	**9740**	16177
2220	2.08E+05	**4730**	77000	**7240**	34544	**9750**	16129
2230	2.07E+05	**4740**	76739	**7250**	34438	**9760**	16080
2240	2.06E+05	**4750**	76479	**7260**	34332	**9770**	16032
2250	2.05E+05	**4760**	76219	**7270**	34227	**9780**	15984
2260	2.04E+05	**4770**	75961	**7280**	34122	**9790**	15935
2270	2.03E+05	**4780**	75704	**7290**	34017	**9800**	15888
2280	2.03E+05	**4790**	75448	**7300**	33913	**9810**	15840
2290	2.02E+05	**4800**	75193	**7310**	33809	**9820**	15792
2300	2.01E+05	**4810**	74940	**7320**	33705	**9830**	15745
2310	2.00E+05	**4820**	74687	**7330**	33602	**9840**	15697
2320	1.99E+05	**4830**	74435	**7340**	33499	**9850**	15650
2330	1.98E+05	**4840**	74184	**7350**	33397	**9860**	15603
2340	1.97E+05	**4850**	73935	**7360**	33294	**9870**	15556

Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)	Time (years)	Total Dose Rate (rem/year)
2350	1.96E+05	**4860**	73686	**7370**	33192	**9880**	15509
2360	1.95E+05	**4870**	73438	**7380**	33091	**9890**	15463
2370	1.94E+05	**4880**	73192	**7390**	32989	**9900**	15416
2380	1.93E+05	**4890**	72946	**7400**	32888	**9910**	15370
2390	1.92E+05	**4900**	72701	**7410**	32788	**9920**	15324
2400	1.91E+05	**4910**	72458	**7420**	32688	**9930**	15278
2410	1.91E+05	**4920**	72215	**7430**	32588	**9940**	15232
2420	1.90E+05	**4930**	71973	**7440**	32488	**9950**	15186
2430	1.89E+05	**4940**	71732	**7450**	32388	**9960**	15140
2440	1.88E+05	**4950**	71493	**7460**	32289	**9970**	15095
2450	1.87E+05	**4960**	71254	**7470**	32191	**9980**	15049
2460	1.86E+05	**4970**	71016	**7480**	32092	**9990**	15004
2470	1.85E+05	**4980**	70779	**7490**	31994	**10000**	14959
2480	1.84E+05	**4990**	70543	**7500**	31896		
2490	1.84E+05	**5000**	70308	**7510**	31799		
2500	1.83E+05	**5010**	70074	**7520**	31702		

Attachment V Results for Test 5, Stochastic Parameters

This attachment contains the GoldSim results from VTP Test 5 (Stochastic Parameters). The first set of results is the test of the GoldSim correlation function. Two normal distributions ("Normal1" and "Normal2") are defined as fully correlated. "Normal1" is defined with a mean of zero and a standard deviation of one, and "Normal2" is defined with a mean of 1 and a standard deviation of one. The simulation is run for 100 realizations. The acceptance criterion for this test is that the value of "Normal2" should be equal to the value of "Normal1" + 1 for all 100 realizations.

The second set of results tests the ability of GoldSim to output the time histories from a multiple realization run to an ASCII file. These results are shown in the right half of the table below for a parameter defined with a uniform distribution.

	Results of Distribution Correlation		ASCII File Creation Time History Results		
Realization	Normal1	Normal2	0	0.5	1
1	-0.63019	0.36981	0.3958	0.3958	0.3958
2	1.925	2.925	0.69158	0.69158	0.69158
3	-0.2553	0.7447	0.851	0.851	0.851
4	0.51945	1.5195	0.74311	0.74311	0.74311
5	1.0542	2.0542	0.47739	0.47739	0.47739
6	0.64377	1.6438	0.80056	0.80056	0.80056
7	-0.05571	0.94429	0.005464	0.005464	0.005464
8	0.84755	1.8476	0.45277	0.45277	0.45277
9	-2.4453	-1.4453	0.6133	0.6133	0.6133
10	-0.10812	0.89188	0.78313	0.78313	0.78313
11	0.29958	1.2996	0.75036	0.75036	0.75036
12	0.79132	1.7913	0.2405	0.2405	0.2405
13	0.67633	1.6763	0.49438	0.49438	0.49438
14	-0.70149	0.29851	0.46263	0.46263	0.46263
15	-0.00902	0.99098	0.9451	0.9451	0.9451
16	-0.08443	0.91557	0.96773	0.96773	0.96773
17	1.6	2.6	0.31549	0.31549	0.31549
18	1.8287	2.8287	0.36055	0.36055	0.36055
19	-0.48988	0.51012	0.92153	0.92153	0.92153
20	-0.34377	0.65623	0.41309	0.41309	0.41309
21	1.4127	2.4127	0.18563	0.18563	0.18563
22	-0.22206	0.77794	0.83381	0.83381	0.83381
23	-0.91105	0.088945	0.11856	0.11856	0.11856
24	0.96491	1.9649	0.27311	0.27311	0.27311
25	-1.1797	-0.17968	0.3748	0.3748	0.3748
26	-0.58286	0.41714	0.15854	0.15854	0.15854
27	-0.32028	0.67972	0.71736	0.71736	0.71736

	Results of Distribution Correlation		ASCII File Creation Time History Results		
Realization	Normal1	Normal2	0	0.5	1
28	-1.0098	-0.00984	0.35636	0.35636	0.35636
29	0.57434	1.5743	0.95349	0.95349	0.95349
30	-0.37409	0.62591	0.89665	0.89665	0.89665
31	1.6572	2.6572	0.088066	0.088066	0.088066
32	1.2794	2.2794	0.68185	0.68185	0.68185
33	-1.3913	-0.3913	0.93357	0.93357	0.93357
34	0.46785	1.4679	0.1756	0.1756	0.1756
35	1.5128	2.5128	0.54955	0.54955	0.54955
36	-0.93503	0.064969	0.2981	0.2981	0.2981
37	0.1051	1.1051	0.76934	0.76934	0.76934
38	-0.53155	0.46845	0.015893	0.015893	0.015893
39	0.70872	1.7087	0.87581	0.87581	0.87581
40	-2.0598	-1.0598	0.40201	0.40201	0.40201
41	1.1531	2.1531	0.64493	0.64493	0.64493
42	-0.23875	0.76125	0.59678	0.59678	0.59678
43	0.3609	1.3609	0.9984	0.9984	0.9984
44	0.24807	1.2481	0.10171	0.10171	0.10171
45	2.5473	3.5473	0.13052	0.13052	0.13052
46	-1.2609	-0.26086	0.56622	0.56622	0.56622
47	-1.1113	-0.11135	0.093211	0.093211	0.093211
48	0.16499	1.165	0.05749	0.05749	0.05749
49	-1.3316	-0.33161	0.777	0.777	0.777
50	-1.5809	-0.5809	0.44667	0.44667	0.44667
51	0.7668	1.7668	0.52762	0.52762	0.52762
52	-0.14942	0.85058	0.25605	0.25605	0.25605
53	0.050302	1.0503	0.9122	0.9122	0.9122
54	-0.66774	0.33226	0.3233	0.3233	0.3233
55	1.3577	2.3577	0.81956	0.81956	0.81956
56	-0.44786	0.55214	0.55469	0.55469	0.55469
57	0.90674	1.9067	0.22708	0.22708	0.22708
58	0.14065	1.1406	0.16026	0.16026	0.16026
59	-0.75953	0.24047	0.42549	0.42549	0.42549
60	-0.97516	0.024844	0.036655	0.036655	0.036655
61	-0.19341	0.80659	0.071302	0.071302	0.071302
62	-1.7976	-0.79757	0.20373	0.20373	0.20373
63	-1.4402	-0.44021	0.043507	0.043507	0.043507
64	-0.81161	0.18839	0.8667	0.8667	0.8667
65	-1.6925	-0.69254	0.28344	0.28344	0.28344

	Results of Distribution Correlation		ASCII File Creation Time History Results		
Realization	Normal1	Normal2	0	0.5	1
66	1.119	2.119	0.3483	0.3483	0.3483
67	-0.56939	0.43061	0.73213	0.73213	0.73213
68	-0.41131	0.58869	0.12476	0.12476	0.12476
69	0.63743	1.6374	0.51809	0.51809	0.51809
70	-1.1701	-0.17008	0.63009	0.63009	0.63009
71	0.041945	1.0419	0.21152	0.21152	0.21152
72	0.34867	1.3487	0.65823	0.65823	0.65823
73	-0.77368	0.22632	0.72572	0.72572	0.72572
74	0.39095	1.3909	0.98925	0.98925	0.98925
75	0.59879	1.5988	0.33836	0.33836	0.33836
76	2.1191	3.1191	0.58585	0.58585	0.58585
77	-0.43842	0.56158	0.67056	0.67056	0.67056
78	0.21708	1.2171	0.23652	0.23652	0.23652
79	0.46361	1.4636	0.3842	0.3842	0.3842
80	-0.73811	0.26189	0.022108	0.022108	0.022108
81	-0.28165	0.71835	0.43507	0.43507	0.43507
82	-2.0402	-1.0402	0.90058	0.90058	0.90058
83	-0.15082	0.84918	0.82128	0.82128	0.82128
84	1.287	2.287	0.30218	0.30218	0.30218
85	0.93348	1.9335	0.19594	0.19594	0.19594
86	-0.49562	0.50438	0.53116	0.53116	0.53116
87	-0.84888	0.15112	0.48969	0.48969	0.48969
88	0.077948	1.0779	0.79403	0.79403	0.79403
89	-0.03657	0.96343	0.57506	0.57506	0.57506
90	0.82004	1.82	0.066771	0.066771	0.066771
91	0.19849	1.1985	0.88304	0.88304	0.88304
92	-1.4995	-0.49952	0.70891	0.70891	0.70891
93	1.185	2.185	0.14484	0.14484	0.14484
94	0.53255	1.5325	0.62975	0.62975	0.62975
95	-1.0733	-0.07327	0.60937	0.60937	0.60937
96	0.31621	1.3162	0.84438	0.84438	0.84438
97	0.27096	1.271	0.66962	0.66962	0.66962
98	1.0323	2.0323	0.50423	0.50423	0.50423
99	0.42146	1.4215	0.26214	0.26214	0.26214
100	0.015646	1.0156	0.97711	0.97711	0.97711

Attachment VI — Results for Advection through Partially Saturated Media and Transport of Colloids

This attachment provides the full GoldSim result listing for the advection through a partially saturated medium test and the transport of colloids test. The simulation time was 75 days with 5 day time step intervals.

Time (days)	Concentration (mg/l) Advection	Concentration (mg/l) Colloids
0	0	0
5	1.00E-12	1.00E-12
10	1.68E-11	1.68E-11
15	3.68E-06	3.68E-06
20	0.001063	0.001063
25	0.021469	0.021469
30	0.11731	0.11731
35	0.31183	0.31183
40	0.54407	0.54407
45	0.73921	0.73921
50	0.86787	0.86788
55	0.93932	0.93932
60	0.97422	0.97422
65	0.9897	0.9897
70	0.99609	0.99609
75	0.99857	0.99857

Attachment VII Diffusion through a Sorptive Material

This attachment provides the full GoldSim result listing of the concentrations of ^{241}Am, ^{242}Am, and ^{243}Am in Cells 1 and 2 (Cell 2 is called 'Sink' in the GoldSim file) for the *CT_Cells3-01* test problem. Refer to Section 3.2.2 *Diffusion through a Sorptive Material* for a discussion of this test problem.

	Cell 1			Cell 2		
Time (yr)	^{241}Am (mg/l)	^{242}Am (mg/l)	^{243}Am (mg/l)	^{241}Am (mg/l)	^{242}Am (mg/l)	^{243}Am (mg/l)
0	0.25858	0.091289	4.4516	0	0	0
100	0.25406	0.089695	4.3738	0.004516	0.001594	0.077747
200	0.2497	0.088156	4.2988	0.008874	0.003133	0.15278
300	0.2455	0.086671	4.2264	0.013081	0.004618	0.22519
400	0.24144	0.085238	4.1565	0.01714	0.006051	0.29507
500	0.23752	0.083855	4.089	0.021057	0.007434	0.36251
600	0.23374	0.08252	4.024	0.024838	0.008769	0.42759
700	0.23009	0.081232	3.9612	0.028486	0.010057	0.49041
800	0.22657	0.079989	3.9005	0.032007	0.0113	0.55102
900	0.22317	0.078789	3.842	0.035405	0.0125	0.60952
1000	0.21989	0.077632	3.7856	0.038685	0.013657	0.66598
1100	0.21673	0.076514	3.7311	0.04185	0.014775	0.72046
1200	0.21367	0.075436	3.6785	0.044904	0.015853	0.77304
1300	0.21073	0.074395	3.6278	0.047851	0.016894	0.82379
1400	0.20788	0.073391	3.5788	0.050696	0.017898	0.87276
1500	0.20514	0.072422	3.5315	0.053441	0.018867	0.92002
1600	0.20249	0.071486	3.4859	0.056091	0.019802	0.96563
1700	0.19993	0.070584	3.4419	0.058648	0.020705	1.0096
1800	0.19746	0.069713	3.3994	0.061115	0.021576	1.0521
1900	0.19508	0.068872	3.3584	0.063496	0.022417	1.0931
2000	0.19278	0.068061	3.3189	0.065795	0.023228	1.1327
2100	0.19057	0.067278	3.2807	0.068012	0.024011	1.1709
2200	0.18842	0.066522	3.2438	0.070153	0.024767	1.2077
2300	0.18636	0.065793	3.2083	0.072218	0.025496	1.2433
2400	0.18437	0.065089	3.174	0.074212	0.0262	1.2776
2500	0.18244	0.06441	3.1408	0.076136	0.026879	1.3107
2600	0.18059	0.063754	3.1089	0.077992	0.027535	1.3427
2700	0.17879	0.063122	3.078	0.079784	0.028167	1.3735
2800	0.17706	0.062511	3.0483	0.081513	0.028778	1.4033
2900	0.1754	0.061922	3.0195	0.083182	0.029367	1.432
3000	0.17378	0.061353	2.9918	0.084793	0.029935	1.4598
3100	0.17223	0.060805	2.965	0.086347	0.030484	1.4865
3200	0.17073	0.060275	2.9392	0.087847	0.031014	1.5123
3300	0.16928	0.059764	2.9143	0.089295	0.031525	1.5373

	Cell 1			Cell 2		
Time (yr)	^{241}Am (mg/l)	^{242}Am (mg/l)	^{243}Am (mg/l)	^{241}Am (mg/l)	^{242}Am (mg/l)	^{243}Am (mg/l)
3400	0.16789	0.059271	2.8903	0.090692	0.032018	1.5613
3500	0.16654	0.058795	2.867	0.09204	0.032494	1.5845
3600	0.16524	0.058336	2.8446	0.093341	0.032953	1.6069
3700	0.16398	0.057892	2.823	0.094597	0.033397	1.6285
3800	0.16277	0.057464	2.8022	0.095808	0.033824	1.6494
3900	0.1616	0.057052	2.782	0.096978	0.034237	1.6695
4000	0.16047	0.056653	2.7626	0.098107	0.034636	1.689
4100	0.15938	0.056269	2.7438	0.099196	0.03502	1.7077
4200	0.15833	0.055897	2.7258	0.10025	0.035391	1.7258
4300	0.15732	0.055539	2.7083	0.10126	0.03575	1.7433
4400	0.15634	0.055194	2.6914	0.10224	0.036095	1.7601
4500	0.15539	0.05486	2.6752	0.10319	0.036429	1.7764
4600	0.15448	0.054538	2.6595	0.1041	0.036751	1.7921
4700	0.1536	0.054228	2.6443	0.10498	0.037061	1.8072
4800	0.15275	0.053928	2.6297	0.10583	0.037361	1.8219
4900	0.15193	0.053638	2.6156	0.10665	0.03765	1.836
5000	0.15114	0.053359	2.602	0.10744	0.03793	1.8496
5100	0.15038	0.05309	2.5888	0.1082	0.038199	1.8627
5200	0.14964	0.05283	2.5762	0.10894	0.038459	1.8754
5300	0.14893	0.052579	2.5639	0.10965	0.03871	1.8876
5400	0.14824	0.052336	2.5521	0.11033	0.038952	1.8995
5500	0.14758	0.052103	2.5407	0.111	0.039186	1.9109
5600	0.14694	0.051877	2.5297	0.11163	0.039412	1.9219
5700	0.14633	0.051659	2.5191	0.11225	0.039629	1.9325
5800	0.14573	0.051449	2.5088	0.11285	0.03984	1.9427
5900	0.14516	0.051247	2.499	0.11342	0.040042	1.9526
6000	0.1446	0.051051	2.4894	0.11398	0.040238	1.9621
6100	0.14407	0.050862	2.4802	0.11451	0.040427	1.9714
6200	0.14355	0.05068	2.4713	0.11503	0.040609	1.9802
6300	0.14305	0.050504	2.4627	0.11552	0.040785	1.9888
6400	0.14257	0.050334	2.4545	0.11601	0.040955	1.9971
6500	0.14211	0.05017	2.4465	0.11647	0.041119	2.0051
6600	0.14166	0.050012	2.4388	0.11692	0.041277	2.0128
6700	0.14123	0.04986	2.4313	0.11735	0.041429	2.0202
6800	0.14081	0.049712	2.4241	0.11777	0.041576	2.0274
6900	0.14041	0.04957	2.4172	0.11817	0.041719	2.0343
7000	0.14002	0.049433	2.4105	0.11856	0.041856	2.041
7100	0.13965	0.049301	2.4041	0.11893	0.041988	2.0475

	Cell 1			Cell 2		
Time (yr)	^{241}Am (mg/l)	^{242}Am (mg/l)	^{243}Am (mg/l)	^{241}Am (mg/l)	^{242}Am (mg/l)	^{243}Am (mg/l)
7200	0.13928	0.049173	2.3978	0.11929	0.042116	2.0537
7300	0.13893	0.04905	2.3918	0.11964	0.042239	2.0597
7400	0.1386	0.048931	2.386	0.11998	0.042358	2.0655
7500	0.13827	0.048816	2.3804	0.12031	0.042473	2.0711
7600	0.13796	0.048705	2.375	0.12062	0.042584	2.0765
7700	0.13766	0.048598	2.3698	0.12092	0.04269	2.0817
7800	0.13736	0.048495	2.3648	0.12121	0.042794	2.0868
7900	0.13708	0.048396	2.3599	0.1215	0.042893	2.0916
8000	0.13681	0.0483	2.3553	0.12177	0.042989	2.0963
8100	0.13655	0.048207	2.3507	0.12203	0.043082	2.1008
8200	0.13629	0.048117	2.3464	0.12228	0.043172	2.1052
8300	0.13605	0.048031	2.3422	0.12253	0.043258	2.1094
8400	0.13581	0.047948	2.3381	0.12277	0.043341	2.1135
8500	0.13558	0.047867	2.3342	0.12299	0.043422	2.1174
8600	0.13536	0.047789	2.3304	0.12321	0.043499	2.1212
8700	0.13515	0.047715	2.3267	0.12343	0.043574	2.1248
8800	0.13495	0.047642	2.3232	0.12363	0.043647	2.1284
8900	0.13475	0.047572	2.3198	0.12383	0.043716	2.1318
9000	0.13456	0.047505	2.3165	0.12402	0.043784	2.135
9100	0.13438	0.04744	2.3133	0.1242	0.043849	2.1382
9200	0.1342	0.047377	2.3103	0.12438	0.043911	2.1413
9300	0.13403	0.047317	2.3073	0.12455	0.043972	2.1442
9400	0.13386	0.047258	2.3045	0.12472	0.04403	2.1471
9500	0.1337	0.047202	2.3017	0.12488	0.044087	2.1498
9600	0.13355	0.047148	2.2991	0.12503	0.044141	2.1525
9700	0.1334	0.047095	2.2965	0.12518	0.044194	2.155
9800	0.13325	0.047044	2.294	0.12532	0.044244	2.1575
9900	0.13312	0.046996	2.2917	0.12546	0.044293	2.1599
10000	0.13298	0.046948	2.2894	0.1256	0.044341	2.1622

Attachment VIII Look-Up Tables

One-dimensional Tables

The complete listing of GoldSim results for the four one-dimensional look-up table tests are given below. Shown in the "Value" columns are the look-up table results for tests one through four.

Time (s)	Value [a]	Value [b]	Value [c]	Value [d]	Time (s)	Value [a]	Value [b]	Value [c]	Value [d]
0	0	1	1	10	**25.5**	2.55	2.55	354.81	24.065
0.5	0.05	1	1.122	6.9897	**26**	2.6	2.6	398.11	24.15
1	0.1	1	1.2589	10	**26.5**	2.65	2.65	446.68	24.232
1.5	0.15	1	1.4125	11.761	**27**	2.7	2.7	501.19	24.314
2	0.2	1	1.5849	13.01	**27.5**	2.75	2.75	562.34	24.393
2.5	0.25	1	1.7783	13.979	**28**	2.8	2.8	630.96	24.472
3	0.3	1	1.9953	14.771	**28.5**	2.85	2.85	707.95	24.548
3.5	0.35	1	2.2387	15.441	**29**	2.9	2.9	794.33	24.624
4	0.4	1	2.5119	16.021	**29.5**	2.95	2.95	891.25	24.698
4.5	0.45	1	2.8184	16.532	**30**	3	3	1000	24.771
5	0.5	1	3.1623	16.99	**30.5**	3.05	3.05	1122	24.843
5.5	0.55	1	3.5481	17.404	**31**	3.1	3.1	1258.9	24.914
6	0.6	1	3.9811	17.782	**31.5**	3.15	3.15	1412.5	24.983
6.5	0.65	1	4.4668	18.129	**32**	3.2	3.2	1584.9	25.052
7	0.7	1	5.0119	18.451	**32.5**	3.25	3.25	1778.3	25.119
7.5	0.75	1	5.6234	18.751	**33**	3.3	3.3	1995.3	25.185
8	0.8	1	6.3096	19.031	**33.5**	3.35	3.35	2238.7	25.25
8.5	0.85	1	7.0795	19.294	**34**	3.4	3.4	2511.9	25.315
9	0.9	1	7.9433	19.542	**34.5**	3.45	3.45	2818.4	25.378
9.5	0.95	1	8.9125	19.777	**35**	3.5	3.5	3162.3	25.441
10	1	1	10	20	**35.5**	3.55	3.55	3548.1	25.502
10.5	1.05	1.05	11.22	20.212	**36**	3.6	3.6	3981.1	25.563
11	1.1	1.1	12.589	20.414	**36.5**	3.65	3.65	4466.8	25.623
11.5	1.15	1.15	14.125	20.607	**37**	3.7	3.7	5011.9	25.682
12	1.2	1.2	15.849	20.792	**37.5**	3.75	3.75	5623.4	25.74
12.5	1.25	1.25	17.783	20.969	**38**	3.8	3.8	6309.6	25.798
13	1.3	1.3	19.953	21.139	**38.5**	3.85	3.85	7079.5	25.855
13.5	1.35	1.35	22.387	21.303	**39**	3.9	3.9	7943.3	25.911
14	1.4	1.4	25.119	21.461	**39.5**	3.95	3.95	8912.5	25.966
14.5	1.45	1.45	28.184	21.614	**40**	4	4	10000	26.021
15	1.5	1.5	31.623	21.761	**40.5**	4.05	4	11220	26.075
15.5	1.55	1.55	35.481	21.903	**41**	4.1	4	12589	26.128
16	1.6	1.6	39.811	22.041	**41.5**	4.15	4	14125	26.18
16.5	1.65	1.65	44.668	22.175	**42**	4.2	4	15849	26.232
17	1.7	1.7	50.119	22.304	**42.5**	4.25	4	17783	26.284
17.5	1.75	1.75	56.234	22.43	**43**	4.3	4	19953	26.335

Time (s)	Value [a]	Value [b]	Value [c]	Value [d]	Time (s)	Value [a]	Value [b]	Value [c]	Value [d]
18	1.8	1.8	63.096	22.553	**43.5**	4.35	4	22387	26.385
18.5	1.85	1.85	70.795	22.672	**44**	4.4	4	25119	26.435
19	1.9	1.9	79.433	22.788	**44.5**	4.45	4	28184	26.484
19.5	1.95	1.95	89.125	22.9	**45**	4.5	4	31623	26.532
20	2	2	100	23.01	**45.5**	4.55	4	35481	26.58
20.5	2.05	2.05	112.2	23.118	**46**	4.6	4	39811	26.628
21	2.1	2.1	125.89	23.222	**46.5**	4.65	4	44668	26.675
21.5	2.15	2.15	141.25	23.324	**47**	4.7	4	50119	26.721
22	2.2	2.2	158.49	23.424	**47.5**	4.75	4	56234	26.767
22.5	2.25	2.25	177.83	23.522	**48**	4.8	4	63096	26.812
23	2.3	2.3	199.53	23.617	**48.5**	4.85	4	70795	26.857
23.5	2.35	2.35	223.87	23.711	**49**	4.9	4	79433	26.902
24	2.4	2.4	251.19	23.802	**49.5**	4.95	4	89125	26.946
24.5	2.45	2.45	281.84	23.892	**50**	5	4	1.00E+05	26.99
25	2.5	2.5	316.23	23.979					

NOTES: [a] This column shows the results for obtaining values at, between, and outside a look-up table using linear interpolation and linear extrapolation.

[b] This column shows the results for obtaining values at, between, and outside a look-up table using linear interpolation, but no extrapolation.

[c] This column shows the results for linear interpolation and extrapolation on the dependent axis, log interpolation and extrapolation on the independent axis (time).

[d] This column shows the results for log interpolation and extrapolation on the dependent axis, linear interpolation and extrapolation on the independent axis (time).

Two-dimensional Table

The table below gives the results for the fourth two-dimensional look-up table test, time dependent look-up points at, between, and outside table data points.

Time (s)	2-D Look-up Value	Time (s)	2-D Look-up Value	Time (s)	2-D Look-up Value
0	2	17	3.4	34	6
0.5	2	17.5	3.5	34.5	6
1	2	18	3.6	35	6
1.5	2	18.5	3.7	35.5	6
2	2	19	3.8	36	6
2.5	2	19.5	3.9	36.5	6
3	2	20	4	37	6
3.5	2	20.5	4.1	37.5	6
4	2	21	4.2	38	6
4.5	2	21.5	4.3	38.5	6
5	2	22	4.4	39	6
5.5	2	22.5	4.5	39.5	6
6	2	23	4.6	40	6
6.5	2	23.5	4.7	40.5	6
7	2	24	4.8	41	6
7.5	2	24.5	4.9	41.5	6
8	2	25	5	42	6
8.5	2	25.5	5.1	42.5	6
9	2	26	5.2	43	6
9.5	2	26.5	5.3	43.5	6
10	2	27	5.4	44	6
10.5	2.1	27.5	5.5	44.5	6
11	2.2	28	5.6	45	6
11.5	2.3	28.5	5.7	45.5	6
12	2.4	29	5.8	46	6
12.5	2.5	29.5	5.9	46.5	6
13	2.6	30	6	47	6
13.5	2.7	30.5	6	47.5	6
14	2.8	31	6	48	6
14.5	2.9	31.5	6	48.5	6
15	3	32	6	49	6
15.5	3.1	32.5	6	49.5	6
16	3.2	33	6	50	6
16.5	3.3	33.5	6		

Three-dimensional Look-up Table

The table below gives the results for the fourth three-dimensional look-up table test, time dependent look-up points at, between, and outside table data points.

Time (s)	3-D Look-up Value	Time (s)	3-D Look-up Value	Time (s)	3-D Look-up Value
0	2	17	3.4	34	6
0.5	2	17.5	3.5	34.5	6
1	2	18	3.6	35	6
1.5	2	18.5	3.7	35.5	6
2	2	19	3.8	36	6
2.5	2	19.5	3.9	36.5	6
3	2	20	4	37	6
3.5	2	20.5	4.1	37.5	6
4	2	21	4.2	38	6
4.5	2	21.5	4.3	38.5	6
5	2	22	4.4	39	6
5.5	2	22.5	4.5	39.5	6
6	2	23	4.6	40	6
6.5	2	23.5	4.7	40.5	6
7	2	24	4.8	41	6
7.5	2	24.5	4.9	41.5	6
8	2	25	5	42	6
8.5	2	25.5	5.1	42.5	6
9	2	26	5.2	43	6
9.5	2	26.5	5.3	43.5	6
10	2	27	5.4	44	6
10.5	2.1	27.5	5.5	44.5	6
11	2.2	28	5.6	45	6
11.5	2.3	28.5	5.7	45.5	6
12	2.4	29	5.8	46	6
12.5	2.5	29.5	5.9	46.5	6
13	2.6	30	6	47	6
13.5	2.7	30.5	6	47.5	6
14	2.8	31	6	48	6
14.5	2.9	31.5	6	48.5	6
15	3	32	6	49	6
15.5	3.1	32.5	6	49.5	6
16	3.2	33	6	50	6
16.5	3.3	33.5	6		

Attachment IX Stochastic Distributions and Expected Values

The table below lists the expected values and the GoldSim results for the vendor test problems, which verify the correct functioning of the stochastic elements supported by GoldSim. These results are for test problem GS4_STOC, and the expected results are from Section 3.1, Table GS4_STOC of the GoldSim Verification Plan (Golder, 1999b).

Distribution Type	Result Type	Expected Values	GoldSim Results
Uniform		Mean=500 St. Dev. = 289 5%: x = 50.0 25%: x = 250 50%: x = 500 75%: x = 750 90%: x = 900	Mean = 500 St. Dev. = 288.675 5%: x= 50 25%: x = 250 50%: x = 500 75%: x = 750 90%: x = 900
	calculator value input 900	Cum. Prob. =0.900 Prob. Density = 0.001	Cum. Prob. = 0.9 Prob. Density = 0.001
	calculator cumulative probability input 0.9	Value = 900 Prob. Density =0.001	Cum. Prob. = 900 Prob. Density = 0.001
Log-Uniform		Mean = 215 St. Dev. = 250 5%: x = 12.6 25%: x = 31.6 50%: x=100 75%: x = 316 90%: x=631	Mean = 214.976 St. Dev. = 249.696 5%: x= 12.58925 25%: x = 31.62278 50%: x = 100 75%: x = 316.2278 90%: x = 630.9573
	calculator value input 100	Cum. Prob. = 0.500 Prob. Density =0.00217	Cum. Prob. = 0.5 Prob. Density = 0.00217147
	calculator cumulative probability input 0.9	Value = 631 Prob. Density = 0.000344	Cum. Prob. = 630.957 Prob. Density = 0.000344155
Triangular		Mean = 46.7 St. Dev. = 19.3 5%: x= 19.5 25%: x = 31.3 50%: x = 43.9 75%: x = 60.3 90%: x = 74.9	Mean = 46.6667 St. Dev. = 19.2931 5%: x= 19.48683 25%: x = 31.26136 50%: x = 43.87514 75%: x = 60.31373 90%: x = 74.9002
	calculator value input 50	Cum. Prob. = 0.603 Prob. Density = 0.0159	Cum. Prob. = 0.603175 Prob. Density = 0.015873
	calculator cumulative probability input 0.9	Value = 74.9 Prob. Density = 0.00797	Value = 74.9002 Prob. Density = 0.00796819
Log-Triangular		Mean = 34.7 St. Dev. = 16.7 5%: x= 14.3 25%: x = 22.1 50%: x = 30.8 75%: x = 43.5 90%: x = 59.1	Mean = 34.688 St. Dev. = 16.7297 5%: x= 14.27099 25%: x = 22.1498 50%: x = 30.80978 75%: x = 43.49589 90%: x = 59.06559

Distribution Type	Result Type	Expected Values	GoldSim Results
	calculator value input 50	Cum. Prob. = 0.827 Prob. Density = 0.01	Cum. Prob. = 0.826692 Prob. Density = 0.0100012
	calculator cumulative probability input 0.9	Value = 59.1 Prob. Density = 0.00643	Value = 59.0656 Prob. Density = 0.00643101
Normal		5%: x= 67.1 25%: x = 86.5 50%: x = 100 75%: x = 113 90%: x = 126	5%: x= 67.09577 25%: x = 86.51622 50%: x = 100 75%: x = 113.4838 90%: x = 125.6346
	calculator value input 80	Cum. Prob. = 0.159 Prob. Density = 0.0121	Cum. Prob. = 0.158876 Prob. Density = 0.0120985
	calculator cumulative probability input 0.9	Value = 126 Prob. Density = 0.00877	Value = 125.635 Prob. Density = 0.00877292
Log-Normal		geo. Mean = 89.4 geo. St. Dev. = 1.60 5%: x= 41.1 25%: x = 65.0 50%: x = 89.4 75%: x = 123 90%: x = 164	geo. Mean = 89.44273 geo. St. Dev. = 1.603808 5%: x= 41.11743 25%: x = 65.04794 50%: x = 89.44273 75%: x = 122.9862 90%: x = 163.8682
	calculator value input 80	Cum. Prob. = 0.407 Prob. Density = 0.0103	Cum. Prob. = 0.406704 Prob. Density = 0.0102663
	calculator cumulative probability input 0.9	Value = 164 Prob. Density = 0.00227	Value = 163.868 Prob. Density = 0.00226667
Normal-Truncated		5%: x= 70.6 25%: x = 87.2 50%: x = 100 75%: x = 113 90%: x = 124	5%: x= 70.52407 25%: x = 87.21854 50%: x = 100 75%: x = 112.7815 90%: x = 123.698
	calculator value input 80	Cum. Prob. = 0.142 Prob. Density = 0.0127	Cum. Prob. = 0.142755 Prob. Density = 0.0126703
	calculator cumulative probability input 0.9	Value = 124 Prob. Density = 0.0104	Value = 123.698 Prob. Density = 0.0103529
Log-Normal-Truncated		geo. Mean = 89.4 geo. St. Dev. = 1.60 5%: x= 54.5 25%: x = 69.6 50%: x = 88.0 75%: x = 111 90%: x = 130	geo. Mean = 89.4427 geo. St. Dev. = 1.60381 5%: x= 54.48063 25%: x = 69.61232 50%: x = 87.98693 75%: x = 110.7303 90%: x = 130.3778
	calculator value input 80	Cum. Prob. = 0.395 Prob. Density = 0.0136	Cum. Prob. = 0.39464 Prob. Density = 0.0136229

Distribution Type	Result Type	Expected Values	GoldSim Results
	calculator cumulative probability input 0.9	Value = 130 Prob. Density = 0.00624	Value = 130.378 Prob. Density = 0.00625286
Beta		5%: x= 9.76 25%: x = 24.3 50%: x = 38.6 75%: x = 54.4 90%: x = 68.0	5%: x= 9.760884 25%: x = 24.30354 50%: x = 38.57638 75%: x = 54.37435 90%: x = 67.96383
	calculator value input 30	Cum. Prob. = 0.348 Prob. Density = 0.0176	Cum. Prob. = 0.348262 Prob. Density = 0.01764
	calculator cumulative probability input 0.9	Value = 68.0 Prob. Density = 0.00837	Value = 67.9636 Prob. Density = 0.00837037
Binomial		Mean = 25.0 St. Dev. = 4.33 5%: x= 18 25%: x = 22 50%: x = 25 75%: x = 28 90%: x = 31	Mean = 25 St. Dev. = 4.33013 5%: x= 18 25%: x = 22 50%: x = 25 75%: x = 28 90%: x = 31
	calculator value input 20	Cum. Prob. = 0.149 Prob. Density = 0.0493	Cum. Prob. = 0.148831 Prob. Density = 0.0493006
	calculator cumulative probability input 0.9	Value = 31 Prob. Density = 0.0344	Value = 31 Prob. Density = 0.0344383
Boolean		Mean = 1 5%: x= 0 25%: x = 1 50%: x = 1 75%: x = 1 90%: x = 1	Mean = 1 5%: x= 0 25%: x = 1 50%: x = 1 75%: x = 1 90%: x = 1
	calculator value input 0	Cum. Prob. = 0.25 Prob. Density = 0.25	Cum. Prob. = 0.25 Prob. Density = 0
	calculator cumulative probability input 0.25	Value = 1 Prob. Density = 0.75	Value = 1 Prob. Density = 1
Cumulative		Mean = 50 5%: x= 5 25%: x = 25 50%: x = 50 75%: x = 75 90%: x = 90	Mean = 50 5%: x= 5 25%: x = 25 50%: x = 50 75%: x = 75 90%: x = 90
	calculator value input 60	Cum. Prob. = 0.60 Prob. Density = 0.01	Cum. Prob. = 0.6 Prob. Density = 0.01
	calculator cumulative probability input 0.9	Value = 90 Prob. Density = 0.01	Value = 90 Prob. Density = 0.01

Distribution Type	Result Type	Expected Values	GoldSim Results
Discrete		Mean = 50 St. Dev. = 28.4 5%: x= 5 25%: x = 25 50%: x = 50 75%: x = 75 90%: x = 95	Mean = 50 St. Dev. = 28.377 5%: x= 5 25%: x = 25 50%: x = 50 75%: x = 75 90%: x = 95
	calculator value input 26	Cum. Prob. = 0.252 Prob. Density = 0	Cum. Prob. = 0.252 Prob. Density = 0
	calculator cumulative probability input 0.9	Value = 95 Prob. Density = 0.200	Value = 95 Prob. Density = 0.2
Gamma		5%: x= 5.47 25%: x = 10.1 50%: x = 14.7 75%: x = 20.4 90%: x = 26.7	5%: x= 5.465274 25%: x = 10.14128 50%: x = 14.68824 75%: x = 20.43768 90%: x = 26.72313
	calculator value input 20	Cum. Prob. = 0.735 Prob. Density = 0.0351	Cum. Prob. = 0.734974 Prob. Density = 0.0350935
	calculator cumulative probability input 0.9	Value = 26.7 Prob. Density = 0.0156	Value = 26.7231 Prob. Density = 0.0155899
Gamma-Truncated		5%: x= 6.43 25%: x = 10.1 50%: x = 13.8 75%: x = 18.1 90%: x = 21.6	5%: x= 6.429784 25%: x = 10.06941 50%: x = 13.82705 75%: x = 18.0994 90%: x = 21.59638
	calculator value input 20	Cum. Prob. = 0.838 Prob. Density = 0.0422	Cum. Prob. = 0.837909 Prob. Density = 0.042206
	calculator cumulative probability input 0.9	Value = 21.6 Prob. Density = 0.0357	Value = 21.5964 Prob. Density = 0.0356535
Poisson		Mean = 25 St. Dev. = 5.00 5%: x= 17 25%: x = 22 50%: x = 25 75%: x = 28 90%: x = 32	Mean = 25 St. Dev. = 5 5%: x= 17 25%: x = 22 50%: x = 25 75%: x = 28 90%: x = 32
	calculator value input 20	Cum. Prob. = 0.185 Prob. Density = 0.0519	Cum. Prob. = 0.185492 Prob. Density = 0.0519175
	calculator cumulative probability input 0.9	Value = 32 Prob. Density = 0.0286	Value = 32 Prob. Density = 0.0286119
Weibull		Mean = 18.9 St. Dev. = 4.63 5%: x= 12.3 25%: x = 15.4 50%: x = 18.3 75%: x = 21.8 90%: x = 25.2	Mean = 18.8625 St. Dev. = 4.63263 5%: x= 12.26486 25%: x = 15.36374 50%: x = 18.32576 75%: x = 21.77441 90%: x = 25.17467

Distribution Type	Result Type	Expected Values	GoldSim Results
	calculator value input 25	Cum. Prob. = 0.895 Prob. Density = 0.0316	Cum. Prob. = 0.894588 Prob. Density = 0.0316218
	calculator cumulative probability input 0.9	Value = 25.2 Prob. Density = 0.0303	Value = 25.1747 Prob. Density = 0.0303478
Weibull-Truncated		Mean = 17.7 5%: x= 12.1 25%: x = 15.0 50%: x = 17.7 75%: x = 20.5 90%: x = 22.8	Mean = 17.7004 5%: x= 12.1392 25%: x = 15.0315 50%: x = 17.7004 75%: x = 20.5431 90%: x = 22.7887
	calculator value input 20	Cum. Prob. = 0.707 Prob. Density = 0.0822	Cum. Prob. = 0.706583 Prob. Density = 0.0822455
	calculator cumulative probability input 0.9	Value = 22.8 Prob. Density = 0.0557	Value = 22.7887 Prob. Density = 0.0557129

Attachment X Latin Hypercube Sampling and Multiple Realizations

The table below gives the results of the first Monte Carlo test where 100 realizations were run with LHS enabled. As expected, there is a single value in each interval (0.00 – 0.01, 0.01 – 0.02, etc.).

No.	Value	No.	Value	No.	Value	No.	Value
1	0.008648	26	0.25838	51	0.50114	76	0.7573
2	0.016932	27	0.26875	52	0.51427	77	0.76374
3	0.021075	28	0.27215	53	0.52051	78	0.77381
4	0.034111	29	0.28597	54	0.53082	79	0.7844
5	0.044781	30	0.29325	55	0.54451	80	0.79873
6	0.051513	31	0.30017	56	0.55628	81	0.80859
7	0.066765	32	0.31744	57	0.56001	82	0.81728
8	0.075811	33	0.32824	58	0.57471	83	0.82529
9	0.086451	34	0.33074	59	0.58686	84	0.83629
10	0.096334	35	0.34601	60	0.5969	85	0.84208
11	0.10137	36	0.35106	61	0.60938	86	0.85852
12	0.11184	37	0.36471	62	0.61025	87	0.86069
13	0.12222	38	0.37965	63	0.62808	88	0.87791
14	0.13326	39	0.38049	64	0.63511	89	0.88964
15	0.14425	40	0.39781	65	0.64877	90	0.89204
16	0.15239	41	0.4	66	0.6527	91	0.90854
17	0.16439	42	0.41729	67	0.66399	92	0.91634
18	0.1786	43	0.42946	68	0.67941	93	0.92738
19	0.18824	44	0.43954	69	0.68457	94	0.93072
20	0.19138	45	0.44179	70	0.6913	95	0.9479
21	0.2007	46	0.45385	71	0.70669	96	0.95939
22	0.21611	47	0.46417	72	0.71804	97	0.96981
23	0.22687	48	0.47944	73	0.72917	98	0.97135
24	0.23435	49	0.48549	74	0.7304	99	0.98925
25	0.2451	50	0.4983	75	0.74261	100	0.99309

This table shows the results for the second Monte Carlo test where 100 realizations were run without LHS enabled. The GoldSim Verification Plan (Golder 1999b, Section 3.2, TMC-02 Monte Carlo Test) indicates that there should be on the order of 10 results that lie outside the 5% - 95% confidence bounds, and any number less than 20 is reasonable. The simulation results given in the table below show eight excursions below 5% and one excursion above 95% for a total of nine excursions outside the 5% - 95% confidence bounds.

No.	Value	No.	Value	No.	Value	No.	Value
1	0.005957	26	0.21407	51	0.4334	76	0.74237
2	0.006942	27	0.21505	52	0.43725	77	0.75739
3	0.011513	28	0.22863	53	0.44469	78	0.76147
4	0.023162	29	0.2288	54	0.45675	79	0.7639
5	0.031003	30	0.23447	55	0.47313	80	0.77106
6	0.03968	31	0.23778	56	0.47571	81	0.78208
7	0.040646	32	0.24768	57	0.47912	82	0.81274
8	0.043155	33	0.26306	58	0.50108	83	0.81637
9	0.075204	34	0.27643	59	0.51258	84	0.84182
10	0.083816	35	0.30236	60	0.51275	85	0.84818
11	0.083885	36	0.30976	61	0.51598	86	0.85282
12	0.090291	37	0.32117	62	0.53785	87	0.86152
13	0.10474	38	0.33625	63	0.55969	88	0.86448
14	0.12408	39	0.34	64	0.57681	89	0.86696
15	0.12791	40	0.36811	65	0.5801	90	0.8687
16	0.13699	41	0.36921	66	0.60347	91	0.87018
17	0.1557	42	0.37006	67	0.60608	92	0.88515
18	0.1575	43	0.37606	68	0.61934	93	0.90033
19	0.16266	44	0.39042	69	0.66389	94	0.9062
20	0.1753	45	0.39246	70	0.66543	95	0.90902
21	0.18594	46	0.39688	71	0.70708	96	0.93346
22	0.19289	47	0.39905	72	0.71796	97	0.93874
23	0.19416	48	0.4102	73	0.73324	98	0.94348
24	0.20511	49	0.42369	74	0.74156	99	0.95412
25	0.21223	50	0.43021	75	0.74182	100	0.98086

This table shows the results of the third Monte Carlo test where 5000 realizations were run without LHS enabled. The GoldSim Verification Plan (Golder 1999b, Section 3.2, TMC-02 Monte Carlo Test) indicates that there should be on the order of 500 results that lie outside the 5% - 95% confidence bounds, and any number less than 1000 is reasonable. The simulation results given in the table below show 239 excursions below 5% and 231 excursions above 95% for a total of 470 excursions outside the 5% - 95% confidence bounds.

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
1	0.000249	835	0.16918	1669	0.33369	2503	0.4953	3337	0.66222	4171	0.83162
2	0.000271	836	0.16938	1670	0.33375	2504	0.49533	3338	0.66243	4172	0.83227
3	0.000896	837	0.16971	1671	0.33399	2505	0.49546	3339	0.66257	4173	0.83229
4	0.001029	838	0.17004	1672	0.33404	2506	0.49551	3340	0.66313	4174	0.83267
5	0.001085	839	0.17007	1673	0.3345	2507	0.49602	3341	0.66317	4175	0.83331
6	0.001143	840	0.17015	1674	0.33492	2508	0.49646	3342	0.66326	4176	0.83339
7	0.001186	841	0.17024	1675	0.3351	2509	0.49646	3343	0.66381	4177	0.8336
8	0.001251	842	0.17029	1676	0.33533	2510	0.49701	3344	0.66408	4178	0.83385
9	0.001273	843	0.17073	1677	0.33666	2511	0.49712	3345	0.66467	4179	0.83426
10	0.00138	844	0.17113	1678	0.33683	2512	0.49762	3346	0.66477	4180	0.83434
11	0.00162	845	0.1713	1679	0.33685	2513	0.49763	3347	0.66492	4181	0.83445
12	0.001666	846	0.17152	1680	0.33696	2514	0.49812	3348	0.66494	4182	0.83486
13	0.002038	847	0.17218	1681	0.33742	2515	0.49825	3349	0.66549	4183	0.83496
14	0.002108	848	0.17268	1682	0.33787	2516	0.49863	3350	0.66591	4184	0.83544
15	0.002232	849	0.17281	1683	0.33801	2517	0.49878	3351	0.66599	4185	0.83547
16	0.002555	850	0.17284	1684	0.33801	2518	0.4988	3352	0.66602	4186	0.83562
17	0.002649	851	0.17309	1685	0.33858	2519	0.49941	3353	0.6661	4187	0.83567
18	0.003325	852	0.17353	1686	0.33859	2520	0.50007	3354	0.66611	4188	0.83583
19	0.003386	853	0.1738	1687	0.33876	2521	0.50025	3355	0.66627	4189	0.83587
20	0.003441	854	0.17399	1688	0.33883	2522	0.50035	3356	0.66637	4190	0.83594
21	0.003716	855	0.17425	1689	0.3389	2523	0.50071	3357	0.66647	4191	0.83613
22	0.003966	856	0.17461	1690	0.33896	2524	0.50097	3358	0.6669	4192	0.83632
23	0.003998	857	0.17502	1691	0.33897	2525	0.50134	3359	0.66693	4193	0.83632
24	0.004012	858	0.17532	1692	0.33907	2526	0.50221	3360	0.66721	4194	0.83662
25	0.004172	859	0.17536	1693	0.33921	2527	0.50254	3361	0.66724	4195	0.83694
26	0.004212	860	0.17569	1694	0.33936	2528	0.50314	3362	0.66734	4196	0.837
27	0.004371	861	0.17604	1695	0.33978	2529	0.50324	3363	0.66745	4197	0.83718
28	0.004677	862	0.1761	1696	0.33981	2530	0.50326	3364	0.66751	4198	0.8376
29	0.005018	863	0.17676	1697	0.3407	2531	0.50379	3365	0.66782	4199	0.83775
30	0.00522	864	0.17709	1698	0.34071	2532	0.50381	3366	0.66784	4200	0.83791
31	0.005274	865	0.17711	1699	0.34123	2533	0.50386	3367	0.66797	4201	0.83791
32	0.005454	866	0.17717	1700	0.34131	2534	0.50397	3368	0.66805	4202	0.8384
33	0.005618	867	0.17729	1701	0.34141	2535	0.5041	3369	0.66811	4203	0.83884
34	0.005736	868	0.17732	1702	0.34165	2536	0.50448	3370	0.66883	4204	0.83922
35	0.006063	869	0.17739	1703	0.34167	2537	0.50463	3371	0.66898	4205	0.83924

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
36	0.00607	**870**	0.17746	**1704**	0.34168	**2538**	0.50479	**3372**	0.6691	**4206**	0.83934
37	0.006199	**871**	0.17748	**1705**	0.34174	**2539**	0.50485	**3373**	0.66927	**4207**	0.83951
38	0.006232	**872**	0.17783	**1706**	0.34203	**2540**	0.50487	**3374**	0.66929	**4208**	0.83965
39	0.007191	**873**	0.17814	**1707**	0.34207	**2541**	0.50541	**3375**	0.67071	**4209**	0.83978
40	0.007209	**874**	0.17854	**1708**	0.34249	**2542**	0.50551	**3376**	0.67102	**4210**	0.84016
41	0.007793	**875**	0.1786	**1709**	0.34271	**2543**	0.50561	**3377**	0.67103	**4211**	0.84038
42	0.007987	**876**	0.17919	**1710**	0.34296	**2544**	0.50639	**3378**	0.67105	**4212**	0.84077
43	0.008265	**877**	0.17971	**1711**	0.34335	**2545**	0.5066	**3379**	0.6711	**4213**	0.84084
44	0.008421	**878**	0.17972	**1712**	0.34339	**2546**	0.50684	**3380**	0.67122	**4214**	0.84116
45	0.008449	**879**	0.17977	**1713**	0.3435	**2547**	0.5069	**3381**	0.67127	**4215**	0.84126
46	0.008569	**880**	0.17982	**1714**	0.34356	**2548**	0.50693	**3382**	0.67145	**4216**	0.84167
47	0.009179	**881**	0.17984	**1715**	0.34358	**2549**	0.50696	**3383**	0.67166	**4217**	0.84202
48	0.009814	**882**	0.17991	**1716**	0.34434	**2550**	0.50741	**3384**	0.67176	**4218**	0.84202
49	0.010005	**883**	0.17992	**1717**	0.34443	**2551**	0.50752	**3385**	0.67197	**4219**	0.84269
50	0.010188	**884**	0.18015	**1718**	0.34454	**2552**	0.50784	**3386**	0.672	**4220**	0.84272
51	0.010232	**885**	0.18061	**1719**	0.34468	**2553**	0.5079	**3387**	0.67221	**4221**	0.84285
52	0.010795	**886**	0.18094	**1720**	0.3448	**2554**	0.5083	**3388**	0.67222	**4222**	0.84347
53	0.010824	**887**	0.18107	**1721**	0.34487	**2555**	0.50849	**3389**	0.67241	**4223**	0.8441
54	0.010977	**888**	0.18121	**1722**	0.34496	**2556**	0.5086	**3390**	0.67281	**4224**	0.84417
55	0.011165	**889**	0.1814	**1723**	0.34497	**2557**	0.50864	**3391**	0.67301	**4225**	0.84434
56	0.011334	**890**	0.18192	**1724**	0.34513	**2558**	0.50867	**3392**	0.67306	**4226**	0.84467
57	0.0115	**891**	0.18193	**1725**	0.3452	**2559**	0.50876	**3393**	0.67306	**4227**	0.84474
58	0.011621	**892**	0.1823	**1726**	0.34523	**2560**	0.50902	**3394**	0.67321	**4228**	0.8451
59	0.011992	**893**	0.18272	**1727**	0.34575	**2561**	0.50937	**3395**	0.6733	**4229**	0.84523
60	0.012228	**894**	0.18278	**1728**	0.34577	**2562**	0.50939	**3396**	0.6734	**4230**	0.84526
61	0.012288	**895**	0.1829	**1729**	0.34581	**2563**	0.5094	**3397**	0.6735	**4231**	0.84536
62	0.01309	**896**	0.18301	**1730**	0.34587	**2564**	0.50952	**3398**	0.67363	**4232**	0.84539
63	0.013188	**897**	0.18333	**1731**	0.34623	**2565**	0.5097	**3399**	0.67388	**4233**	0.84572
64	0.013459	**898**	0.18335	**1732**	0.34649	**2566**	0.50984	**3400**	0.67405	**4234**	0.84583
65	0.014183	**899**	0.18357	**1733**	0.34651	**2567**	0.51024	**3401**	0.67411	**4235**	0.84595
66	0.01431	**900**	0.18359	**1734**	0.34743	**2568**	0.51047	**3402**	0.67421	**4236**	0.84606
67	0.014376	**901**	0.18376	**1735**	0.34756	**2569**	0.51063	**3403**	0.67431	**4237**	0.84644
68	0.01439	**902**	0.18394	**1736**	0.3477	**2570**	0.51063	**3404**	0.67453	**4238**	0.84649
69	0.01471	**903**	0.18432	**1737**	0.34806	**2571**	0.5109	**3405**	0.67453	**4239**	0.84652
70	0.01486	**904**	0.18459	**1738**	0.34815	**2572**	0.51107	**3406**	0.67494	**4240**	0.84714
71	0.015064	**905**	0.18467	**1739**	0.34825	**2573**	0.51131	**3407**	0.67508	**4241**	0.84728
72	0.015228	**906**	0.18524	**1740**	0.34853	**2574**	0.51147	**3408**	0.67514	**4242**	0.84729
73	0.01525	**907**	0.18532	**1741**	0.34918	**2575**	0.51209	**3409**	0.6756	**4243**	0.84743
74	0.015493	**908**	0.18573	**1742**	0.34954	**2576**	0.51221	**3410**	0.67562	**4244**	0.84805
75	0.016177	**909**	0.18615	**1743**	0.34968	**2577**	0.51224	**3411**	0.67562	**4245**	0.84883
76	0.01618	**910**	0.187	**1744**	0.35015	**2578**	0.51252	**3412**	0.67572	**4246**	0.84889

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
77	0.016391	911	0.18736	1745	0.35017	2579	0.51259	3413	0.67573	4247	0.84889
78	0.016507	912	0.18746	1746	0.35025	2580	0.51284	3414	0.67583	4248	0.84949
79	0.01668	913	0.1875	1747	0.35036	2581	0.51301	3415	0.67591	4249	0.8495
80	0.016713	914	0.18754	1748	0.35051	2582	0.51304	3416	0.67608	4250	0.84963
81	0.017012	915	0.1879	1749	0.35052	2583	0.5133	3417	0.67618	4251	0.84979
82	0.017324	916	0.18806	1750	0.35057	2584	0.51334	3418	0.67628	4252	0.84984
83	0.017468	917	0.18811	1751	0.35058	2585	0.5136	3419	0.67655	4253	0.85004
84	0.017765	918	0.18813	1752	0.35059	2586	0.51416	3420	0.67658	4254	0.85017
85	0.018042	919	0.18816	1753	0.35074	2587	0.51445	3421	0.67728	4255	0.85048
86	0.018366	920	0.18826	1754	0.35102	2588	0.51468	3422	0.67738	4256	0.8507
87	0.018405	921	0.18848	1755	0.35104	2589	0.51485	3423	0.67743	4257	0.85141
88	0.018536	922	0.18893	1756	0.35121	2590	0.51518	3424	0.67759	4258	0.85162
89	0.018723	923	0.18901	1757	0.35151	2591	0.51535	3425	0.67764	4259	0.85179
90	0.018723	924	0.18941	1758	0.35161	2592	0.51578	3426	0.67772	4260	0.85192
91	0.018794	925	0.18983	1759	0.35171	2593	0.51606	3427	0.6779	4261	0.852
92	0.018943	926	0.19006	1760	0.35174	2594	0.51631	3428	0.67792	4262	0.85201
93	0.019071	927	0.19026	1761	0.35199	2595	0.5165	3429	0.67891	4263	0.85217
94	0.01945	928	0.19047	1762	0.35204	2596	0.51693	3430	0.67892	4264	0.85288
95	0.019517	929	0.19089	1763	0.3523	2597	0.51698	3431	0.67919	4265	0.85302
96	0.019896	930	0.19103	1764	0.35232	2598	0.51706	3432	0.67921	4266	0.85323
97	0.019907	931	0.19111	1765	0.35273	2599	0.5171	3433	0.67974	4267	0.85346
98	0.019908	932	0.19117	1766	0.35283	2600	0.51731	3434	0.67977	4268	0.85379
99	0.020026	933	0.1914	1767	0.35294	2601	0.5174	3435	0.6799	4269	0.85407
100	0.020196	934	0.19152	1768	0.353	2602	0.51781	3436	0.67993	4270	0.85409
101	0.020448	935	0.19171	1769	0.35309	2603	0.51868	3437	0.68003	4271	0.8541
102	0.020466	936	0.19174	1770	0.35395	2604	0.51884	3438	0.68013	4272	0.85418
103	0.020473	937	0.1922	1771	0.35424	2605	0.51926	3439	0.6803	4273	0.85422
104	0.020818	938	0.19318	1772	0.35433	2606	0.5195	3440	0.68054	4274	0.85427
105	0.021096	939	0.19331	1773	0.35444	2607	0.51977	3441	0.68066	4275	0.85437
106	0.021286	940	0.19339	1774	0.35468	2608	0.51999	3442	0.68102	4276	0.85514
107	0.021289	941	0.19387	1775	0.35476	2609	0.52006	3443	0.68111	4277	0.8552
108	0.021308	942	0.19448	1776	0.35476	2610	0.52038	3444	0.68133	4278	0.8556
109	0.021536	943	0.19455	1777	0.35504	2611	0.52093	3445	0.68134	4279	0.85585
110	0.021605	944	0.19455	1778	0.35527	2612	0.52094	3446	0.68147	4280	0.85586
111	0.021805	945	0.19457	1779	0.35614	2613	0.52102	3447	0.68149	4281	0.85596
112	0.022072	946	0.19459	1780	0.35614	2614	0.52118	3448	0.68212	4282	0.85597
113	0.022081	947	0.19507	1781	0.35627	2615	0.52126	3449	0.68222	4283	0.85604
114	0.022496	948	0.19512	1782	0.35681	2616	0.5213	3450	0.68225	4284	0.8561
115	0.022547	949	0.19523	1783	0.35693	2617	0.52141	3451	0.68248	4285	0.85638
116	0.022782	950	0.19556	1784	0.35716	2618	0.5215	3452	0.68322	4286	0.85683
117	0.022981	951	0.19615	1785	0.35722	2619	0.52154	3453	0.68335	4287	0.85689

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
118	0.02308	**952**	0.19618	**1786**	0.35746	**2620**	0.52166	**3454**	0.68349	**4288**	0.85721
119	0.023477	**953**	0.1962	**1787**	0.35812	**2621**	0.52176	**3455**	0.6837	**4289**	0.85726
120	0.02358	**954**	0.19629	**1788**	0.35819	**2622**	0.52194	**3456**	0.68442	**4290**	0.85731
121	0.024011	**955**	0.19646	**1789**	0.35829	**2623**	0.52216	**3457**	0.68455	**4291**	0.85739
122	0.024097	**956**	0.19647	**1790**	0.35849	**2624**	0.52223	**3458**	0.68458	**4292**	0.85765
123	0.024266	**957**	0.19647	**1791**	0.35866	**2625**	0.52261	**3459**	0.68478	**4293**	0.85769
124	0.024305	**958**	0.19668	**1792**	0.35868	**2626**	0.52272	**3460**	0.68489	**4294**	0.85782
125	0.024752	**959**	0.19673	**1793**	0.35869	**2627**	0.52295	**3461**	0.68497	**4295**	0.85796
126	0.025222	**960**	0.19697	**1794**	0.35904	**2628**	0.52308	**3462**	0.685	**4296**	0.85798
127	0.025492	**961**	0.19698	**1795**	0.35904	**2629**	0.52323	**3463**	0.68512	**4297**	0.85836
128	0.025496	**962**	0.197	**1796**	0.35913	**2630**	0.52334	**3464**	0.68518	**4298**	0.85868
129	0.025633	**963**	0.19702	**1797**	0.35914	**2631**	0.52344	**3465**	0.68586	**4299**	0.85886
130	0.025766	**964**	0.19765	**1798**	0.3595	**2632**	0.52373	**3466**	0.68587	**4300**	0.85941
131	0.026276	**965**	0.19774	**1799**	0.36002	**2633**	0.52379	**3467**	0.68599	**4301**	0.85963
132	0.026345	**966**	0.19782	**1800**	0.36048	**2634**	0.52381	**3468**	0.6861	**4302**	0.86001
133	0.026392	**967**	0.19834	**1801**	0.36057	**2635**	0.52423	**3469**	0.6865	**4303**	0.86025
134	0.026694	**968**	0.19848	**1802**	0.36074	**2636**	0.52424	**3470**	0.68733	**4304**	0.86071
135	0.026859	**969**	0.19857	**1803**	0.3608	**2637**	0.52428	**3471**	0.68736	**4305**	0.86077
136	0.026952	**970**	0.19886	**1804**	0.36101	**2638**	0.52456	**3472**	0.68778	**4306**	0.86084
137	0.02696	**971**	0.19901	**1805**	0.36128	**2639**	0.52457	**3473**	0.68823	**4307**	0.86156
138	0.027214	**972**	0.19904	**1806**	0.36167	**2640**	0.5246	**3474**	0.68833	**4308**	0.86158
139	0.027336	**973**	0.19917	**1807**	0.3622	**2641**	0.52518	**3475**	0.68837	**4309**	0.86176
140	0.027455	**974**	0.19924	**1808**	0.36223	**2642**	0.52523	**3476**	0.68841	**4310**	0.86182
141	0.027519	**975**	0.19963	**1809**	0.36277	**2643**	0.52538	**3477**	0.68865	**4311**	0.86192
142	0.027538	**976**	0.19974	**1810**	0.36307	**2644**	0.52579	**3478**	0.68872	**4312**	0.86219
143	0.02772	**977**	0.19987	**1811**	0.36333	**2645**	0.52605	**3479**	0.68878	**4313**	0.86257
144	0.027846	**978**	0.19987	**1812**	0.36359	**2646**	0.52636	**3480**	0.68915	**4314**	0.86274
145	0.027909	**979**	0.19991	**1813**	0.36375	**2647**	0.52645	**3481**	0.68943	**4315**	0.86283
146	0.028185	**980**	0.2	**1814**	0.3642	**2648**	0.52695	**3482**	0.68962	**4316**	0.86324
147	0.028474	**981**	0.20003	**1815**	0.36435	**2649**	0.52719	**3483**	0.6897	**4317**	0.86326
148	0.028664	**982**	0.20037	**1816**	0.36468	**2650**	0.52742	**3484**	0.68974	**4318**	0.86328
149	0.028918	**983**	0.20063	**1817**	0.36516	**2651**	0.52753	**3485**	0.68987	**4319**	0.86366
150	0.029081	**984**	0.20072	**1818**	0.36517	**2652**	0.52764	**3486**	0.69007	**4320**	0.86367
151	0.029118	**985**	0.20074	**1819**	0.36541	**2653**	0.52802	**3487**	0.69008	**4321**	0.86369
152	0.029605	**986**	0.20082	**1820**	0.36575	**2654**	0.52806	**3488**	0.69017	**4322**	0.8637
153	0.029664	**987**	0.20116	**1821**	0.36579	**2655**	0.52867	**3489**	0.69048	**4323**	0.8638
154	0.029737	**988**	0.20122	**1822**	0.36612	**2656**	0.52893	**3490**	0.69056	**4324**	0.86408
155	0.029929	**989**	0.20135	**1823**	0.36673	**2657**	0.53	**3491**	0.69103	**4325**	0.86409
156	0.030057	**990**	0.20141	**1824**	0.36721	**2658**	0.53006	**3492**	0.69104	**4326**	0.86425
157	0.030168	**991**	0.20141	**1825**	0.36722	**2659**	0.53015	**3493**	0.69148	**4327**	0.86481
158	0.03033	**992**	0.20199	**1826**	0.36781	**2660**	0.53029	**3494**	0.69148	**4328**	0.86499

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
159	0.03052	**993**	0.20207	**1827**	0.36794	**2661**	0.53029	**3495**	0.69154	**4329**	0.86513
160	0.030836	**994**	0.20214	**1828**	0.36816	**2662**	0.53055	**3496**	0.6922	**4330**	0.86516
161	0.031035	**995**	0.20233	**1829**	0.36838	**2663**	0.53056	**3497**	0.69309	**4331**	0.86519
162	0.031693	**996**	0.2026	**1830**	0.36926	**2664**	0.53118	**3498**	0.69367	**4332**	0.86529
163	0.031975	**997**	0.20284	**1831**	0.36926	**2665**	0.53139	**3499**	0.69407	**4333**	0.86553
164	0.032032	**998**	0.20289	**1832**	0.36932	**2666**	0.53147	**3500**	0.69422	**4334**	0.86562
165	0.032195	**999**	0.20291	**1833**	0.36934	**2667**	0.53162	**3501**	0.69497	**4335**	0.86583
166	0.0326	**1000**	0.20302	**1834**	0.36939	**2668**	0.53162	**3502**	0.69517	**4336**	0.86614
167	0.032681	**1001**	0.20337	**1835**	0.36948	**2669**	0.53216	**3503**	0.69654	**4337**	0.86614
168	0.032782	**1002**	0.20433	**1836**	0.36978	**2670**	0.53247	**3504**	0.69655	**4338**	0.86621
169	0.033281	**1003**	0.2044	**1837**	0.37011	**2671**	0.53273	**3505**	0.69673	**4339**	0.86663
170	0.033343	**1004**	0.2048	**1838**	0.37046	**2672**	0.53311	**3506**	0.69673	**4340**	0.86664
171	0.033871	**1005**	0.20483	**1839**	0.37103	**2673**	0.53469	**3507**	0.69691	**4341**	0.8668
172	0.033927	**1006**	0.20549	**1840**	0.37114	**2674**	0.53483	**3508**	0.69773	**4342**	0.86687
173	0.033954	**1007**	0.20557	**1841**	0.37202	**2675**	0.53498	**3509**	0.69774	**4343**	0.86702
174	0.034253	**1008**	0.20594	**1842**	0.37227	**2676**	0.53504	**3510**	0.69793	**4344**	0.86746
175	0.034522	**1009**	0.20601	**1843**	0.37234	**2677**	0.53515	**3511**	0.69819	**4345**	0.86771
176	0.034584	**1010**	0.20614	**1844**	0.37258	**2678**	0.53538	**3512**	0.69825	**4346**	0.86837
177	0.034656	**1011**	0.20649	**1845**	0.37286	**2679**	0.53596	**3513**	0.69828	**4347**	0.86844
178	0.03471	**1012**	0.20655	**1846**	0.37302	**2680**	0.53641	**3514**	0.69832	**4348**	0.86847
179	0.035559	**1013**	0.20672	**1847**	0.37313	**2681**	0.53669	**3515**	0.69889	**4349**	0.86859
180	0.035617	**1014**	0.20741	**1848**	0.3735	**2682**	0.53717	**3516**	0.69895	**4350**	0.86878
181	0.035806	**1015**	0.2076	**1849**	0.37358	**2683**	0.53725	**3517**	0.69933	**4351**	0.86926
182	0.035838	**1016**	0.20818	**1850**	0.37364	**2684**	0.53728	**3518**	0.6995	**4352**	0.86929
183	0.035977	**1017**	0.20818	**1851**	0.37367	**2685**	0.53735	**3519**	0.69952	**4353**	0.86937
184	0.03643	**1018**	0.20846	**1852**	0.37387	**2686**	0.53793	**3520**	0.69954	**4354**	0.86937
185	0.036491	**1019**	0.20848	**1853**	0.37399	**2687**	0.53813	**3521**	0.69973	**4355**	0.86945
186	0.036773	**1020**	0.20885	**1854**	0.37414	**2688**	0.53815	**3522**	0.69973	**4356**	0.86952
187	0.03683	**1021**	0.20929	**1855**	0.37447	**2689**	0.5386	**3523**	0.69983	**4357**	0.86969
188	0.036873	**1022**	0.20929	**1856**	0.3746	**2690**	0.53861	**3524**	0.69991	**4358**	0.86986
189	0.037123	**1023**	0.20939	**1857**	0.3749	**2691**	0.53874	**3525**	0.70001	**4359**	0.87078
190	0.037254	**1024**	0.20953	**1858**	0.37509	**2692**	0.539	**3526**	0.70017	**4360**	0.87084
191	0.037731	**1025**	0.20981	**1859**	0.37511	**2693**	0.53914	**3527**	0.7003	**4361**	0.87092
192	0.037768	**1026**	0.21036	**1860**	0.3753	**2694**	0.53927	**3528**	0.70049	**4362**	0.87096
193	0.038741	**1027**	0.21041	**1861**	0.37563	**2695**	0.53947	**3529**	0.70066	**4363**	0.87105
194	0.038954	**1028**	0.21066	**1862**	0.3758	**2696**	0.53983	**3530**	0.70089	**4364**	0.87111
195	0.039323	**1029**	0.21068	**1863**	0.37583	**2697**	0.53991	**3531**	0.7009	**4365**	0.87121
196	0.039687	**1030**	0.21086	**1864**	0.37587	**2698**	0.54006	**3532**	0.70098	**4366**	0.87122
197	0.039956	**1031**	0.21087	**1865**	0.3765	**2699**	0.54012	**3533**	0.70155	**4367**	0.87126
198	0.041185	**1032**	0.21103	**1866**	0.37697	**2700**	0.54019	**3534**	0.70165	**4368**	0.87131
199	0.041242	**1033**	0.21139	**1867**	0.37721	**2701**	0.5403	**3535**	0.7018	**4369**	0.87138

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
200	0.041639	**1034**	0.21155	**1868**	0.37724	**2702**	0.54085	**3536**	0.70188	**4370**	0.87141
201	0.041791	**1035**	0.21158	**1869**	0.37759	**2703**	0.54093	**3537**	0.70207	**4371**	0.87156
202	0.042109	**1036**	0.21163	**1870**	0.3778	**2704**	0.54106	**3538**	0.70232	**4372**	0.87158
203	0.042325	**1037**	0.21174	**1871**	0.37784	**2705**	0.54142	**3539**	0.70243	**4373**	0.87172
204	0.042484	**1038**	0.21176	**1872**	0.3784	**2706**	0.54164	**3540**	0.70257	**4374**	0.87226
205	0.042747	**1039**	0.21184	**1873**	0.37885	**2707**	0.54193	**3541**	0.70261	**4375**	0.87236
206	0.04313	**1040**	0.21194	**1874**	0.379	**2708**	0.54256	**3542**	0.7029	**4376**	0.8726
207	0.043285	**1041**	0.21258	**1875**	0.37925	**2709**	0.54264	**3543**	0.70293	**4377**	0.87282
208	0.043358	**1042**	0.21276	**1876**	0.37926	**2710**	0.54283	**3544**	0.70307	**4378**	0.87327
209	0.043513	**1043**	0.2128	**1877**	0.37945	**2711**	0.54286	**3545**	0.70307	**4379**	0.87376
210	0.043897	**1044**	0.21308	**1878**	0.37957	**2712**	0.54305	**3546**	0.70308	**4380**	0.87393
211	0.044145	**1045**	0.21309	**1879**	0.37963	**2713**	0.54308	**3547**	0.70338	**4381**	0.87406
212	0.044175	**1046**	0.21329	**1880**	0.37974	**2714**	0.54315	**3548**	0.70352	**4382**	0.87412
213	0.044724	**1047**	0.21334	**1881**	0.37977	**2715**	0.54357	**3549**	0.70368	**4383**	0.87417
214	0.044763	**1048**	0.2135	**1882**	0.37981	**2716**	0.54369	**3550**	0.70381	**4384**	0.87421
215	0.044942	**1049**	0.21359	**1883**	0.37993	**2717**	0.54377	**3551**	0.70414	**4385**	0.87433
216	0.0451	**1050**	0.2141	**1884**	0.38014	**2718**	0.54412	**3552**	0.70427	**4386**	0.87477
217	0.045111	**1051**	0.21415	**1885**	0.38033	**2719**	0.54432	**3553**	0.70428	**4387**	0.87509
218	0.045278	**1052**	0.21421	**1886**	0.38071	**2720**	0.54432	**3554**	0.70437	**4388**	0.87514
219	0.045315	**1053**	0.21464	**1887**	0.38079	**2721**	0.54433	**3555**	0.70442	**4389**	0.87519
220	0.045372	**1054**	0.21486	**1888**	0.38092	**2722**	0.54472	**3556**	0.70461	**4390**	0.87573
221	0.045781	**1055**	0.21518	**1889**	0.38097	**2723**	0.54472	**3557**	0.70492	**4391**	0.87577
222	0.046117	**1056**	0.21523	**1890**	0.38104	**2724**	0.54526	**3558**	0.70521	**4392**	0.876
223	0.046128	**1057**	0.21557	**1891**	0.38133	**2725**	0.54533	**3559**	0.70522	**4393**	0.87698
224	0.046367	**1058**	0.21587	**1892**	0.38159	**2726**	0.54537	**3560**	0.70529	**4394**	0.87718
225	0.046699	**1059**	0.2163	**1893**	0.38171	**2727**	0.54555	**3561**	0.7054	**4395**	0.8772
226	0.046906	**1060**	0.21637	**1894**	0.38205	**2728**	0.54571	**3562**	0.7065	**4396**	0.87722
227	0.047434	**1061**	0.21657	**1895**	0.38251	**2729**	0.54574	**3563**	0.70665	**4397**	0.87725
228	0.047515	**1062**	0.21713	**1896**	0.3827	**2730**	0.54584	**3564**	0.70675	**4398**	0.87729
229	0.047759	**1063**	0.21787	**1897**	0.38275	**2731**	0.54598	**3565**	0.70696	**4399**	0.87748
230	0.047926	**1064**	0.21789	**1898**	0.38293	**2732**	0.54601	**3566**	0.70721	**4400**	0.8776
231	0.048295	**1065**	0.21791	**1899**	0.38299	**2733**	0.54636	**3567**	0.70749	**4401**	0.87798
232	0.048347	**1066**	0.2185	**1900**	0.38321	**2734**	0.54639	**3568**	0.70888	**4402**	0.87821
233	0.048766	**1067**	0.21869	**1901**	0.38346	**2735**	0.54646	**3569**	0.70889	**4403**	0.87827
234	0.048812	**1068**	0.21875	**1902**	0.38367	**2736**	0.54668	**3570**	0.70927	**4404**	0.87829
235	0.049076	**1069**	0.21891	**1903**	0.38395	**2737**	0.54668	**3571**	0.7093	**4405**	0.87829
236	0.049373	**1070**	0.21917	**1904**	0.38405	**2738**	0.54718	**3572**	0.70946	**4406**	0.87843
237	0.049448	**1071**	0.21991	**1905**	0.38407	**2739**	0.54759	**3573**	0.70947	**4407**	0.87843
238	0.049686	**1072**	0.22012	**1906**	0.38424	**2740**	0.54802	**3574**	0.70987	**4408**	0.87846
239	0.049718	**1073**	0.22017	**1907**	0.38428	**2741**	0.54826	**3575**	0.71014	**4409**	0.87857
240	0.05014	**1074**	0.22049	**1908**	0.38433	**2742**	0.54827	**3576**	0.71019	**4410**	0.87862

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
241	0.050326	1075	0.22058	1909	0.38445	2743	0.54835	3577	0.71031	4411	0.87868
242	0.050438	1076	0.22061	1910	0.38463	2744	0.54855	3578	0.71051	4412	0.87891
243	0.050466	1077	0.22068	1911	0.38517	2745	0.54876	3579	0.71053	4413	0.87926
244	0.050519	1078	0.22098	1912	0.38523	2746	0.54878	3580	0.71079	4414	0.87934
245	0.050926	1079	0.22099	1913	0.38555	2747	0.54882	3581	0.71115	4415	0.87948
246	0.051465	1080	0.22117	1914	0.38597	2748	0.54901	3582	0.71195	4416	0.87978
247	0.051576	1081	0.2217	1915	0.38682	2749	0.54907	3583	0.71219	4417	0.87984
248	0.051895	1082	0.22175	1916	0.38693	2750	0.54921	3584	0.71242	4418	0.88037
249	0.052076	1083	0.2218	1917	0.38788	2751	0.54937	3585	0.71247	4419	0.88041
250	0.052219	1084	0.22253	1918	0.38794	2752	0.54984	3586	0.71261	4420	0.88046
251	0.052285	1085	0.22292	1919	0.38863	2753	0.54987	3587	0.71342	4421	0.88066
252	0.0524	1086	0.223	1920	0.38929	2754	0.55011	3588	0.71369	4422	0.88079
253	0.052448	1087	0.22307	1921	0.38947	2755	0.55021	3589	0.71399	4423	0.88089
254	0.052725	1088	0.22335	1922	0.38954	2756	0.55024	3590	0.71404	4424	0.88107
255	0.052758	1089	0.22363	1923	0.38989	2757	0.55088	3591	0.7141	4425	0.88136
256	0.052904	1090	0.2237	1924	0.39046	2758	0.55136	3592	0.71411	4426	0.88147
257	0.053675	1091	0.22372	1925	0.39069	2759	0.55142	3593	0.71443	4427	0.88204
258	0.053804	1092	0.22386	1926	0.39084	2760	0.55176	3594	0.71447	4428	0.88253
259	0.054077	1093	0.22399	1927	0.39086	2761	0.55187	3595	0.71454	4429	0.88254
260	0.054112	1094	0.22403	1928	0.39088	2762	0.5519	3596	0.71487	4430	0.88275
261	0.054417	1095	0.22451	1929	0.39098	2763	0.55225	3597	0.715	4431	0.8829
262	0.054964	1096	0.22465	1930	0.39115	2764	0.55246	3598	0.71562	4432	0.88306
263	0.055083	1097	0.22469	1931	0.39128	2765	0.55282	3599	0.71566	4433	0.88328
264	0.05556	1098	0.2247	1932	0.39136	2766	0.55302	3600	0.71582	4434	0.88336
265	0.055599	1099	0.2251	1933	0.39139	2767	0.55328	3601	0.71659	4435	0.88345
266	0.055631	1100	0.22512	1934	0.39161	2768	0.55334	3602	0.71681	4436	0.88351
267	0.056993	1101	0.22524	1935	0.39169	2769	0.55352	3603	0.71686	4437	0.88387
268	0.057202	1102	0.22582	1936	0.39218	2770	0.55394	3604	0.71687	4438	0.88389
269	0.05735	1103	0.22597	1937	0.39249	2771	0.55406	3605	0.71716	4439	0.88461
270	0.057495	1104	0.22632	1938	0.39282	2772	0.55415	3606	0.71728	4440	0.88482
271	0.0576	1105	0.22655	1939	0.39297	2773	0.55435	3607	0.71762	4441	0.88583
272	0.057805	1106	0.22667	1940	0.39306	2774	0.55435	3608	0.7179	4442	0.88588
273	0.057905	1107	0.2269	1941	0.39312	2775	0.55461	3609	0.71792	4443	0.88629
274	0.057957	1108	0.22734	1942	0.39325	2776	0.55472	3610	0.71806	4444	0.88646
275	0.058516	1109	0.22781	1943	0.39325	2777	0.55475	3611	0.71816	4445	0.88708
276	0.058695	1110	0.22848	1944	0.39325	2778	0.55493	3612	0.71846	4446	0.88714
277	0.058749	1111	0.22853	1945	0.39334	2779	0.5551	3613	0.71851	4447	0.88725
278	0.058889	1112	0.22889	1946	0.39337	2780	0.55553	3614	0.71874	4448	0.88753
279	0.059003	1113	0.22892	1947	0.3934	2781	0.55555	3615	0.7188	4449	0.88758
280	0.059081	1114	0.22903	1948	0.3935	2782	0.55668	3616	0.72008	4450	0.88764
281	0.059357	1115	0.22948	1949	0.39375	2783	0.55683	3617	0.72023	4451	0.88784

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
282	0.059402	**1116**	0.22953	**1950**	0.39377	**2784**	0.5569	**3618**	0.72049	**4452**	0.88796
283	0.059823	**1117**	0.22958	**1951**	0.3939	**2785**	0.55695	**3619**	0.72055	**4453**	0.88801
284	0.060447	**1118**	0.2296	**1952**	0.39391	**2786**	0.55708	**3620**	0.72097	**4454**	0.88805
285	0.060607	**1119**	0.22985	**1953**	0.394	**2787**	0.55727	**3621**	0.72118	**4455**	0.88808
286	0.060928	**1120**	0.23072	**1954**	0.394	**2788**	0.55754	**3622**	0.7213	**4456**	0.88843
287	0.061029	**1121**	0.23083	**1955**	0.39409	**2789**	0.55789	**3623**	0.72176	**4457**	0.88874
288	0.061638	**1122**	0.23085	**1956**	0.39416	**2790**	0.55799	**3624**	0.72199	**4458**	0.88908
289	0.061931	**1123**	0.23113	**1957**	0.39469	**2791**	0.5584	**3625**	0.72208	**4459**	0.88928
290	0.061947	**1124**	0.23143	**1958**	0.3949	**2792**	0.55845	**3626**	0.72216	**4460**	0.88931
291	0.062037	**1125**	0.23165	**1959**	0.395	**2793**	0.55856	**3627**	0.72248	**4461**	0.88958
292	0.062909	**1126**	0.23166	**1960**	0.39518	**2794**	0.5588	**3628**	0.72254	**4462**	0.89002
293	0.063064	**1127**	0.23173	**1961**	0.39601	**2795**	0.55882	**3629**	0.72303	**4463**	0.89006
294	0.063491	**1128**	0.23179	**1962**	0.39603	**2796**	0.55882	**3630**	0.72317	**4464**	0.89067
295	0.063671	**1129**	0.23185	**1963**	0.39612	**2797**	0.55947	**3631**	0.7232	**4465**	0.89096
296	0.06386	**1130**	0.23253	**1964**	0.39617	**2798**	0.5595	**3632**	0.72322	**4466**	0.89132
297	0.063918	**1131**	0.23254	**1965**	0.3962	**2799**	0.55954	**3633**	0.7233	**4467**	0.89137
298	0.063919	**1132**	0.23258	**1966**	0.39641	**2800**	0.55961	**3634**	0.72333	**4468**	0.89163
299	0.064129	**1133**	0.2326	**1967**	0.39653	**2801**	0.55971	**3635**	0.72346	**4469**	0.89178
300	0.064138	**1134**	0.23267	**1968**	0.397	**2802**	0.55988	**3636**	0.72366	**4470**	0.89189
301	0.064364	**1135**	0.23268	**1969**	0.39719	**2803**	0.55999	**3637**	0.7237	**4471**	0.89191
302	0.064451	**1136**	0.23298	**1970**	0.39722	**2804**	0.56019	**3638**	0.72384	**4472**	0.89223
303	0.064563	**1137**	0.23312	**1971**	0.39744	**2805**	0.56044	**3639**	0.72407	**4473**	0.89265
304	0.064667	**1138**	0.23315	**1972**	0.39761	**2806**	0.56053	**3640**	0.72418	**4474**	0.89267
305	0.064829	**1139**	0.23357	**1973**	0.39763	**2807**	0.56075	**3641**	0.72444	**4475**	0.8928
306	0.064989	**1140**	0.23374	**1974**	0.39785	**2808**	0.56096	**3642**	0.72468	**4476**	0.89288
307	0.065272	**1141**	0.23412	**1975**	0.39785	**2809**	0.56113	**3643**	0.72499	**4477**	0.89304
308	0.065293	**1142**	0.23413	**1976**	0.39819	**2810**	0.56126	**3644**	0.7251	**4478**	0.89306
309	0.065833	**1143**	0.23439	**1977**	0.39839	**2811**	0.56127	**3645**	0.72514	**4479**	0.8933
310	0.065925	**1144**	0.23468	**1978**	0.39842	**2812**	0.56142	**3646**	0.72527	**4480**	0.89348
311	0.065941	**1145**	0.23494	**1979**	0.39848	**2813**	0.56158	**3647**	0.72529	**4481**	0.89349
312	0.066036	**1146**	0.23495	**1980**	0.39856	**2814**	0.56173	**3648**	0.72561	**4482**	0.89395
313	0.066887	**1147**	0.235	**1981**	0.39857	**2815**	0.56174	**3649**	0.726	**4483**	0.89427
314	0.067209	**1148**	0.23509	**1982**	0.39864	**2816**	0.56208	**3650**	0.726	**4484**	0.89429
315	0.06738	**1149**	0.2353	**1983**	0.39872	**2817**	0.56239	**3651**	0.72629	**4485**	0.89475
316	0.06739	**1150**	0.23545	**1984**	0.39883	**2818**	0.56246	**3652**	0.72629	**4486**	0.89482
317	0.067425	**1151**	0.23549	**1985**	0.39901	**2819**	0.56248	**3653**	0.72634	**4487**	0.8949
318	0.067536	**1152**	0.23577	**1986**	0.39923	**2820**	0.5626	**3654**	0.72655	**4488**	0.89511
319	0.067705	**1153**	0.23584	**1987**	0.39946	**2821**	0.56329	**3655**	0.72675	**4489**	0.89528
320	0.067761	**1154**	0.23599	**1988**	0.39949	**2822**	0.56347	**3656**	0.72677	**4490**	0.89552
321	0.067771	**1155**	0.23604	**1989**	0.39953	**2823**	0.56352	**3657**	0.72694	**4491**	0.89575
322	0.068038	**1156**	0.23627	**1990**	0.39969	**2824**	0.56363	**3658**	0.72732	**4492**	0.89578

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
323	0.068339	1157	0.23631	1991	0.40087	2825	0.56373	3659	0.72737	4493	0.8958
324	0.068381	1158	0.23643	1992	0.40112	2826	0.56381	3660	0.72743	4494	0.8961
325	0.068448	1159	0.23648	1993	0.40114	2827	0.5642	3661	0.7279	4495	0.89672
326	0.068736	1160	0.23662	1994	0.40126	2828	0.56428	3662	0.728	4496	0.89688
327	0.06883	1161	0.23689	1995	0.40131	2829	0.56433	3663	0.72833	4497	0.89711
328	0.068942	1162	0.23696	1996	0.40139	2830	0.56442	3664	0.72839	4498	0.89729
329	0.069387	1163	0.23702	1997	0.40147	2831	0.56448	3665	0.72852	4499	0.898
330	0.06971	1164	0.23718	1998	0.40148	2832	0.56449	3666	0.72867	4500	0.89808
331	0.069905	1165	0.23745	1999	0.40152	2833	0.56467	3667	0.72905	4501	0.89859
332	0.069973	1166	0.23746	2000	0.40188	2834	0.56503	3668	0.72946	4502	0.89859
333	0.070167	1167	0.23757	2001	0.40224	2835	0.56507	3669	0.72953	4503	0.89868
334	0.070454	1168	0.2377	2002	0.40252	2836	0.56509	3670	0.72967	4504	0.89871
335	0.070546	1169	0.2379	2003	0.40257	2837	0.56528	3671	0.72997	4505	0.89898
336	0.070759	1170	0.23847	2004	0.40274	2838	0.5653	3672	0.73005	4506	0.89909
337	0.071066	1171	0.23868	2005	0.40289	2839	0.56543	3673	0.73027	4507	0.89911
338	0.071095	1172	0.23883	2006	0.40298	2840	0.56577	3674	0.73032	4508	0.89924
339	0.072092	1173	0.23883	2007	0.40322	2841	0.56585	3675	0.73055	4509	0.89962
340	0.072131	1174	0.23929	2008	0.40344	2842	0.56595	3676	0.73132	4510	0.89974
341	0.07232	1175	0.23931	2009	0.40369	2843	0.56636	3677	0.73133	4511	0.90018
342	0.072566	1176	0.23962	2010	0.40386	2844	0.56653	3678	0.73136	4512	0.90044
343	0.072586	1177	0.23963	2011	0.40391	2845	0.56718	3679	0.73144	4513	0.90047
344	0.072594	1178	0.23966	2012	0.40447	2846	0.56744	3680	0.73145	4514	0.90069
345	0.072601	1179	0.23966	2013	0.40454	2847	0.56749	3681	0.73146	4515	0.90079
346	0.072907	1180	0.23969	2014	0.40457	2848	0.56753	3682	0.73147	4516	0.9008
347	0.072936	1181	0.23984	2015	0.40461	2849	0.56764	3683	0.73147	4517	0.90089
348	0.07313	1182	0.23999	2016	0.40461	2850	0.56764	3684	0.73152	4518	0.90095
349	0.073277	1183	0.24018	2017	0.40484	2851	0.56772	3685	0.73158	4519	0.90098
350	0.073819	1184	0.24022	2018	0.40535	2852	0.56792	3686	0.7318	4520	0.90115
351	0.073834	1185	0.24041	2019	0.40539	2853	0.56805	3687	0.73192	4521	0.90132
352	0.073894	1186	0.24066	2020	0.40553	2854	0.56805	3688	0.73203	4522	0.90136
353	0.07397	1187	0.24081	2021	0.40558	2855	0.56812	3689	0.73214	4523	0.90164
354	0.074014	1188	0.24091	2022	0.40586	2856	0.56816	3690	0.73215	4524	0.90212
355	0.074062	1189	0.24109	2023	0.40595	2857	0.56816	3691	0.73223	4525	0.90235
356	0.07416	1190	0.24125	2024	0.40611	2858	0.56883	3692	0.73239	4526	0.90238
357	0.074311	1191	0.24144	2025	0.40639	2859	0.56909	3693	0.73245	4527	0.90249
358	0.074372	1192	0.24147	2026	0.40696	2860	0.56922	3694	0.73278	4528	0.90266
359	0.07505	1193	0.24163	2027	0.40724	2861	0.56924	3695	0.73306	4529	0.90285
360	0.075254	1194	0.24169	2028	0.40745	2862	0.56944	3696	0.73328	4530	0.90313
361	0.075857	1195	0.24175	2029	0.40771	2863	0.56945	3697	0.73331	4531	0.90417
362	0.076057	1196	0.24262	2030	0.40772	2864	0.56966	3698	0.73351	4532	0.90418
363	0.076142	1197	0.24288	2031	0.40806	2865	0.56968	3699	0.73357	4533	0.90423

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
364	0.076299	**1198**	0.24289	**2032**	0.40821	**2866**	0.57019	**3700**	0.73397	**4534**	0.9044
365	0.076359	**1199**	0.24296	**2033**	0.40836	**2867**	0.57023	**3701**	0.73409	**4535**	0.90441
366	0.076618	**1200**	0.2431	**2034**	0.4084	**2868**	0.5705	**3702**	0.73462	**4536**	0.90448
367	0.076687	**1201**	0.24329	**2035**	0.40844	**2869**	0.57084	**3703**	0.73538	**4537**	0.90452
368	0.076864	**1202**	0.2434	**2036**	0.40845	**2870**	0.57089	**3704**	0.73553	**4538**	0.90461
369	0.077041	**1203**	0.24403	**2037**	0.40848	**2871**	0.57144	**3705**	0.7356	**4539**	0.90473
370	0.077198	**1204**	0.24408	**2038**	0.40865	**2872**	0.57161	**3706**	0.7356	**4540**	0.90562
371	0.07769	**1205**	0.24452	**2039**	0.40881	**2873**	0.57176	**3707**	0.73563	**4541**	0.90565
372	0.077727	**1206**	0.24476	**2040**	0.40882	**2874**	0.57177	**3708**	0.7357	**4542**	0.906
373	0.077727	**1207**	0.24498	**2041**	0.40898	**2875**	0.57209	**3709**	0.73581	**4543**	0.90602
374	0.07783	**1208**	0.24518	**2042**	0.40904	**2876**	0.57217	**3710**	0.73592	**4544**	0.9061
375	0.07791	**1209**	0.24539	**2043**	0.40923	**2877**	0.57227	**3711**	0.73606	**4545**	0.90626
376	0.078252	**1210**	0.24543	**2044**	0.40958	**2878**	0.57251	**3712**	0.73609	**4546**	0.90631
377	0.078422	**1211**	0.24585	**2045**	0.40965	**2879**	0.57252	**3713**	0.73644	**4547**	0.90663
378	0.078467	**1212**	0.24614	**2046**	0.40974	**2880**	0.57254	**3714**	0.73709	**4548**	0.90695
379	0.07902	**1213**	0.24628	**2047**	0.40984	**2881**	0.57258	**3715**	0.73709	**4549**	0.90716
380	0.079074	**1214**	0.24655	**2048**	0.4101	**2882**	0.57293	**3716**	0.73712	**4550**	0.90728
381	0.079206	**1215**	0.24655	**2049**	0.4106	**2883**	0.57296	**3717**	0.73713	**4551**	0.90747
382	0.079581	**1216**	0.24671	**2050**	0.41082	**2884**	0.57299	**3718**	0.73748	**4552**	0.90781
383	0.079684	**1217**	0.24719	**2051**	0.4109	**2885**	0.57315	**3719**	0.7385	**4553**	0.908
384	0.080102	**1218**	0.24731	**2052**	0.41108	**2886**	0.57362	**3720**	0.73856	**4554**	0.90801
385	0.080103	**1219**	0.24738	**2053**	0.41136	**2887**	0.57403	**3721**	0.73868	**4555**	0.90811
386	0.080121	**1220**	0.24753	**2054**	0.41191	**2888**	0.57442	**3722**	0.7388	**4556**	0.90819
387	0.080147	**1221**	0.24766	**2055**	0.4121	**2889**	0.57453	**3723**	0.73936	**4557**	0.90856
388	0.080187	**1222**	0.2478	**2056**	0.41214	**2890**	0.57456	**3724**	0.73937	**4558**	0.90921
389	0.080351	**1223**	0.24787	**2057**	0.41253	**2891**	0.57474	**3725**	0.73941	**4559**	0.90933
390	0.08069	**1224**	0.24804	**2058**	0.41268	**2892**	0.57505	**3726**	0.73941	**4560**	0.90965
391	0.081137	**1225**	0.2492	**2059**	0.41269	**2893**	0.57511	**3727**	0.73959	**4561**	0.91002
392	0.081318	**1226**	0.24922	**2060**	0.41285	**2894**	0.57515	**3728**	0.74019	**4562**	0.91013
393	0.081446	**1227**	0.2494	**2061**	0.41296	**2895**	0.57517	**3729**	0.74021	**4563**	0.91019
394	0.081825	**1228**	0.24946	**2062**	0.41301	**2896**	0.57534	**3730**	0.74083	**4564**	0.91055
395	0.081827	**1229**	0.25003	**2063**	0.41303	**2897**	0.5754	**3731**	0.74112	**4565**	0.9109
396	0.081934	**1230**	0.25015	**2064**	0.41317	**2898**	0.57544	**3732**	0.74113	**4566**	0.9109
397	0.081936	**1231**	0.25074	**2065**	0.41319	**2899**	0.57573	**3733**	0.74153	**4567**	0.91133
398	0.082016	**1232**	0.2511	**2066**	0.41362	**2900**	0.5763	**3734**	0.74179	**4568**	0.91169
399	0.082156	**1233**	0.25126	**2067**	0.41365	**2901**	0.57675	**3735**	0.74216	**4569**	0.91183
400	0.082313	**1234**	0.25128	**2068**	0.41375	**2902**	0.57682	**3736**	0.74329	**4570**	0.91193
401	0.082684	**1235**	0.25146	**2069**	0.41387	**2903**	0.57732	**3737**	0.74357	**4571**	0.91225
402	0.083072	**1236**	0.25152	**2070**	0.41395	**2904**	0.57742	**3738**	0.74419	**4572**	0.9123
403	0.083208	**1237**	0.25155	**2071**	0.41398	**2905**	0.57792	**3739**	0.74428	**4573**	0.91246
404	0.083252	**1238**	0.25202	**2072**	0.41439	**2906**	0.57792	**3740**	0.74445	**4574**	0.91315

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
405	0.083369	1239	0.25231	2073	0.41469	2907	0.57797	3741	0.7445	4575	0.91318
406	0.083669	1240	0.25258	2074	0.41522	2908	0.57809	3742	0.7448	4576	0.91362
407	0.084322	1241	0.25259	2075	0.41559	2909	0.57828	3743	0.74505	4577	0.91377
408	0.084364	1242	0.2527	2076	0.41562	2910	0.57867	3744	0.74522	4578	0.91408
409	0.084428	1243	0.25275	2077	0.41572	2911	0.57869	3745	0.74551	4579	0.9143
410	0.084613	1244	0.25285	2078	0.41572	2912	0.5787	3746	0.74567	4580	0.91449
411	0.084836	1245	0.25291	2079	0.41579	2913	0.57921	3747	0.74587	4581	0.91458
412	0.084975	1246	0.2533	2080	0.41606	2914	0.57927	3748	0.74613	4582	0.91476
413	0.085328	1247	0.25341	2081	0.41637	2915	0.57956	3749	0.74618	4583	0.91495
414	0.085559	1248	0.25346	2082	0.41668	2916	0.57978	3750	0.74622	4584	0.91505
415	0.085811	1249	0.25363	2083	0.41672	2917	0.57982	3751	0.74636	4585	0.91526
416	0.08584	1250	0.25379	2084	0.41682	2918	0.57997	3752	0.74693	4586	0.91553
417	0.085844	1251	0.25387	2085	0.41701	2919	0.57999	3753	0.74707	4587	0.91577
418	0.086021	1252	0.25405	2086	0.41702	2920	0.5806	3754	0.74719	4588	0.9159
419	0.086054	1253	0.25422	2087	0.41713	2921	0.58061	3755	0.74723	4589	0.91616
420	0.086949	1254	0.25438	2088	0.41724	2922	0.58085	3756	0.74736	4590	0.91618
421	0.087234	1255	0.25453	2089	0.41728	2923	0.58094	3757	0.7475	4591	0.91642
422	0.087471	1256	0.25461	2090	0.41748	2924	0.58109	3758	0.74759	4592	0.91649
423	0.087502	1257	0.25466	2091	0.41754	2925	0.58117	3759	0.7476	4593	0.91649
424	0.08767	1258	0.25474	2092	0.41783	2926	0.58167	3760	0.74774	4594	0.91673
425	0.088264	1259	0.25475	2093	0.41801	2927	0.58168	3761	0.74814	4595	0.91688
426	0.088545	1260	0.25517	2094	0.41812	2928	0.58184	3762	0.74848	4596	0.91708
427	0.089112	1261	0.25529	2095	0.41847	2929	0.5822	3763	0.74864	4597	0.9171
428	0.089141	1262	0.2553	2096	0.41877	2930	0.58224	3764	0.7487	4598	0.91726
429	0.0892	1263	0.25553	2097	0.41921	2931	0.58224	3765	0.74903	4599	0.9175
430	0.08935	1264	0.25628	2098	0.41927	2932	0.58227	3766	0.74947	4600	0.91755
431	0.089475	1265	0.25629	2099	0.41935	2933	0.58231	3767	0.74952	4601	0.91758
432	0.089523	1266	0.25645	2100	0.41944	2934	0.58235	3768	0.74984	4602	0.91763
433	0.090341	1267	0.25677	2101	0.41996	2935	0.583	3769	0.75003	4603	0.91767
434	0.090344	1268	0.25682	2102	0.41996	2936	0.58369	3770	0.75025	4604	0.91768
435	0.090436	1269	0.25685	2103	0.42036	2937	0.58369	3771	0.75028	4605	0.91773
436	0.090541	1270	0.25726	2104	0.42069	2938	0.58384	3772	0.75037	4606	0.91787
437	0.090549	1271	0.25759	2105	0.4207	2939	0.58415	3773	0.75041	4607	0.9182
438	0.090814	1272	0.25778	2106	0.42078	2940	0.58418	3774	0.7508	4608	0.91825
439	0.090839	1273	0.25821	2107	0.42085	2941	0.58427	3775	0.7509	4609	0.91834
440	0.090916	1274	0.25857	2108	0.42111	2942	0.58432	3776	0.75092	4610	0.91859
441	0.09094	1275	0.25865	2109	0.42112	2943	0.58485	3777	0.75096	4611	0.91863
442	0.091043	1276	0.25866	2110	0.42115	2944	0.58488	3778	0.75103	4612	0.91904
443	0.09126	1277	0.25919	2111	0.4212	2945	0.58509	3779	0.75186	4613	0.91911
444	0.091349	1278	0.25944	2112	0.42124	2946	0.58542	3780	0.75187	4614	0.91913
445	0.0917	1279	0.25954	2113	0.4214	2947	0.58571	3781	0.75195	4615	0.91932

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
446	0.091963	**1280**	0.25978	**2114**	0.42186	**2948**	0.58601	**3782**	0.75202	**4616**	0.91975
447	0.09247	**1281**	0.26046	**2115**	0.42196	**2949**	0.5866	**3783**	0.75211	**4617**	0.9208
448	0.092588	**1282**	0.2605	**2116**	0.42253	**2950**	0.5869	**3784**	0.75231	**4618**	0.92081
449	0.09385	**1283**	0.2606	**2117**	0.42292	**2951**	0.58705	**3785**	0.75277	**4619**	0.92095
450	0.094062	**1284**	0.26092	**2118**	0.42298	**2952**	0.58723	**3786**	0.75347	**4620**	0.92117
451	0.094101	**1285**	0.26163	**2119**	0.42318	**2953**	0.58745	**3787**	0.75365	**4621**	0.92142
452	0.094499	**1286**	0.26206	**2120**	0.42326	**2954**	0.58795	**3788**	0.75392	**4622**	0.92146
453	0.094829	**1287**	0.26228	**2121**	0.42342	**2955**	0.58801	**3789**	0.75414	**4623**	0.92154
454	0.094932	**1288**	0.26229	**2122**	0.42363	**2956**	0.58809	**3790**	0.75423	**4624**	0.92227
455	0.095096	**1289**	0.26246	**2123**	0.42369	**2957**	0.58815	**3791**	0.75427	**4625**	0.92229
456	0.095293	**1290**	0.26247	**2124**	0.42376	**2958**	0.58822	**3792**	0.75447	**4626**	0.92254
457	0.095898	**1291**	0.26248	**2125**	0.4239	**2959**	0.58829	**3793**	0.75458	**4627**	0.92282
458	0.09657	**1292**	0.26253	**2126**	0.42397	**2960**	0.58847	**3794**	0.7549	**4628**	0.92301
459	0.096649	**1293**	0.26254	**2127**	0.42403	**2961**	0.58854	**3795**	0.75517	**4629**	0.9231
460	0.0967	**1294**	0.26254	**2128**	0.42403	**2962**	0.58889	**3796**	0.75531	**4630**	0.92349
461	0.096826	**1295**	0.2626	**2129**	0.4243	**2963**	0.58894	**3797**	0.75543	**4631**	0.92357
462	0.097004	**1296**	0.26279	**2130**	0.42445	**2964**	0.58895	**3798**	0.75554	**4632**	0.92375
463	0.097266	**1297**	0.26292	**2131**	0.42454	**2965**	0.58904	**3799**	0.75573	**4633**	0.92376
464	0.097442	**1298**	0.26309	**2132**	0.42463	**2966**	0.58935	**3800**	0.75579	**4634**	0.92382
465	0.097539	**1299**	0.26345	**2133**	0.42479	**2967**	0.58941	**3801**	0.75618	**4635**	0.92463
466	0.097565	**1300**	0.26346	**2134**	0.42486	**2968**	0.58961	**3802**	0.75654	**4636**	0.92475
467	0.097597	**1301**	0.26357	**2135**	0.42487	**2969**	0.58975	**3803**	0.75656	**4637**	0.92527
468	0.097648	**1302**	0.26376	**2136**	0.42511	**2970**	0.59013	**3804**	0.75684	**4638**	0.92588
469	0.098272	**1303**	0.26401	**2137**	0.42522	**2971**	0.59055	**3805**	0.75702	**4639**	0.92599
470	0.098353	**1304**	0.26417	**2138**	0.42523	**2972**	0.59088	**3806**	0.75721	**4640**	0.92609
471	0.098456	**1305**	0.26438	**2139**	0.42543	**2973**	0.59112	**3807**	0.75721	**4641**	0.92652
472	0.099407	**1306**	0.26461	**2140**	0.42556	**2974**	0.5917	**3808**	0.7573	**4642**	0.92697
473	0.099579	**1307**	0.26468	**2141**	0.42557	**2975**	0.59186	**3809**	0.75754	**4643**	0.92722
474	0.099757	**1308**	0.26472	**2142**	0.42694	**2976**	0.59189	**3810**	0.75759	**4644**	0.9273
475	0.099786	**1309**	0.26481	**2143**	0.42709	**2977**	0.592	**3811**	0.75812	**4645**	0.92778
476	0.099952	**1310**	0.26522	**2144**	0.42721	**2978**	0.5921	**3812**	0.75815	**4646**	0.92791
477	0.099994	**1311**	0.26552	**2145**	0.42804	**2979**	0.59217	**3813**	0.75833	**4647**	0.92792
478	0.1002	**1312**	0.26554	**2146**	0.42809	**2980**	0.5922	**3814**	0.7587	**4648**	0.92795
479	0.10076	**1313**	0.26562	**2147**	0.42838	**2981**	0.59224	**3815**	0.7588	**4649**	0.92812
480	0.10092	**1314**	0.26576	**2148**	0.42859	**2982**	0.5928	**3816**	0.75902	**4650**	0.92824
481	0.10107	**1315**	0.26576	**2149**	0.4293	**2983**	0.59293	**3817**	0.75909	**4651**	0.92827
482	0.10121	**1316**	0.26578	**2150**	0.42943	**2984**	0.59293	**3818**	0.75911	**4652**	0.92834
483	0.10125	**1317**	0.26602	**2151**	0.42944	**2985**	0.593	**3819**	0.75929	**4653**	0.92846
484	0.10143	**1318**	0.26608	**2152**	0.42944	**2986**	0.59318	**3820**	0.75935	**4654**	0.92869
485	0.10146	**1319**	0.26613	**2153**	0.42982	**2987**	0.59337	**3821**	0.75941	**4655**	0.92929
486	0.10153	**1320**	0.26626	**2154**	0.42986	**2988**	0.59342	**3822**	0.75941	**4656**	0.92943

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
487	0.1017	**1321**	0.26659	**2155**	0.43005	**2989**	0.59347	**3823**	0.75972	**4657**	0.92973
488	0.10172	**1322**	0.26703	**2156**	0.43057	**2990**	0.59357	**3824**	0.75984	**4658**	0.92974
489	0.10172	**1323**	0.26736	**2157**	0.43058	**2991**	0.59359	**3825**	0.75989	**4659**	0.92995
490	0.10177	**1324**	0.26747	**2158**	0.4306	**2992**	0.5936	**3826**	0.76016	**4660**	0.93032
491	0.10191	**1325**	0.26761	**2159**	0.43068	**2993**	0.59375	**3827**	0.76074	**4661**	0.93064
492	0.10272	**1326**	0.26764	**2160**	0.43101	**2994**	0.59378	**3828**	0.76093	**4662**	0.93094
493	0.10312	**1327**	0.26777	**2161**	0.43115	**2995**	0.59405	**3829**	0.76095	**4663**	0.93111
494	0.10315	**1328**	0.26799	**2162**	0.43133	**2996**	0.59412	**3830**	0.76102	**4664**	0.93135
495	0.10343	**1329**	0.2683	**2163**	0.43137	**2997**	0.59423	**3831**	0.76134	**4665**	0.93142
496	0.10367	**1330**	0.26844	**2164**	0.43159	**2998**	0.59442	**3832**	0.76177	**4666**	0.93143
497	0.1037	**1331**	0.26851	**2165**	0.43163	**2999**	0.5946	**3833**	0.76209	**4667**	0.93144
498	0.10386	**1332**	0.26852	**2166**	0.43185	**3000**	0.59477	**3834**	0.76234	**4668**	0.93144
499	0.1045	**1333**	0.26897	**2167**	0.43196	**3001**	0.59492	**3835**	0.76287	**4669**	0.93154
500	0.10458	**1334**	0.26927	**2168**	0.43228	**3002**	0.59503	**3836**	0.76314	**4670**	0.93173
501	0.10537	**1335**	0.26935	**2169**	0.43236	**3003**	0.59517	**3837**	0.76342	**4671**	0.93203
502	0.10591	**1336**	0.26965	**2170**	0.43276	**3004**	0.59553	**3838**	0.76342	**4672**	0.93212
503	0.106	**1337**	0.26987	**2171**	0.43288	**3005**	0.59591	**3839**	0.76348	**4673**	0.93271
504	0.10605	**1338**	0.2699	**2172**	0.43314	**3006**	0.59594	**3840**	0.7637	**4674**	0.93297
505	0.10659	**1339**	0.27021	**2173**	0.43333	**3007**	0.59604	**3841**	0.7638	**4675**	0.93325
506	0.10668	**1340**	0.27027	**2174**	0.43334	**3008**	0.59627	**3842**	0.76396	**4676**	0.93325
507	0.10668	**1341**	0.27029	**2175**	0.43354	**3009**	0.59638	**3843**	0.76398	**4677**	0.93368
508	0.10687	**1342**	0.2704	**2176**	0.43368	**3010**	0.59663	**3844**	0.76478	**4678**	0.93437
509	0.1069	**1343**	0.27083	**2177**	0.43433	**3011**	0.59678	**3845**	0.76481	**4679**	0.93441
510	0.10691	**1344**	0.27084	**2178**	0.43464	**3012**	0.59697	**3846**	0.76524	**4680**	0.93446
511	0.10703	**1345**	0.27129	**2179**	0.43492	**3013**	0.5971	**3847**	0.76553	**4681**	0.93457
512	0.10704	**1346**	0.27149	**2180**	0.43502	**3014**	0.59724	**3848**	0.76564	**4682**	0.93465
513	0.10713	**1347**	0.27152	**2181**	0.43504	**3015**	0.59754	**3849**	0.76569	**4683**	0.93473
514	0.10724	**1348**	0.27183	**2182**	0.43591	**3016**	0.59756	**3850**	0.76577	**4684**	0.93477
515	0.10726	**1349**	0.27206	**2183**	0.43616	**3017**	0.5976	**3851**	0.76598	**4685**	0.93494
516	0.10782	**1350**	0.27219	**2184**	0.43617	**3018**	0.59864	**3852**	0.76599	**4686**	0.93504
517	0.10798	**1351**	0.27222	**2185**	0.43668	**3019**	0.59875	**3853**	0.76603	**4687**	0.93516
518	0.10809	**1352**	0.27225	**2186**	0.4367	**3020**	0.59876	**3854**	0.7663	**4688**	0.93518
519	0.10817	**1353**	0.27252	**2187**	0.43677	**3021**	0.59878	**3855**	0.76663	**4689**	0.93521
520	0.10836	**1354**	0.27313	**2188**	0.43691	**3022**	0.59893	**3856**	0.76693	**4690**	0.93526
521	0.10871	**1355**	0.27316	**2189**	0.43701	**3023**	0.59909	**3857**	0.76697	**4691**	0.93548
522	0.10879	**1356**	0.27348	**2190**	0.43717	**3024**	0.59929	**3858**	0.76719	**4692**	0.93568
523	0.10883	**1357**	0.27361	**2191**	0.43729	**3025**	0.59935	**3859**	0.76746	**4693**	0.93604
524	0.1089	**1358**	0.2741	**2192**	0.43731	**3026**	0.59962	**3860**	0.76788	**4694**	0.93652
525	0.10929	**1359**	0.2742	**2193**	0.43764	**3027**	0.59989	**3861**	0.76802	**4695**	0.93658
526	0.11005	**1360**	0.27433	**2194**	0.43771	**3028**	0.59994	**3862**	0.76874	**4696**	0.93713
527	0.11035	**1361**	0.27434	**2195**	0.43771	**3029**	0.60001	**3863**	0.76895	**4697**	0.93756

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
528	0.11047	1362	0.27462	2196	0.4379	3030	0.60005	3864	0.76919	4698	0.93756
529	0.11075	1363	0.27482	2197	0.4379	3031	0.6002	3865	0.76966	4699	0.93758
530	0.11147	1364	0.27496	2198	0.43807	3032	0.60039	3866	0.76992	4700	0.93763
531	0.11159	1365	0.27498	2199	0.43867	3033	0.6004	3867	0.77013	4701	0.93786
532	0.11159	1366	0.27521	2200	0.43906	3034	0.60053	3868	0.77019	4702	0.93791
533	0.11173	1367	0.27539	2201	0.43919	3035	0.60072	3869	0.77028	4703	0.93804
534	0.11208	1368	0.27566	2202	0.43933	3036	0.6008	3870	0.77038	4704	0.93829
535	0.11215	1369	0.27586	2203	0.43966	3037	0.60102	3871	0.77098	4705	0.93841
536	0.11222	1370	0.27632	2204	0.44008	3038	0.60105	3872	0.77102	4706	0.93857
537	0.11277	1371	0.27707	2205	0.44032	3039	0.60119	3873	0.77103	4707	0.93866
538	0.11295	1372	0.27752	2206	0.44096	3040	0.60128	3874	0.77116	4708	0.93877
539	0.11297	1373	0.27753	2207	0.441	3041	0.60129	3875	0.77136	4709	0.93895
540	0.11302	1374	0.27764	2208	0.44104	3042	0.60131	3876	0.77161	4710	0.93947
541	0.11308	1375	0.27795	2209	0.44105	3043	0.60145	3877	0.77168	4711	0.9397
542	0.1133	1376	0.2785	2210	0.44109	3044	0.60162	3878	0.7717	4712	0.93987
543	0.11363	1377	0.27871	2211	0.44138	3045	0.60186	3879	0.77181	4713	0.93995
544	0.11365	1378	0.27873	2212	0.44144	3046	0.60186	3880	0.77183	4714	0.94024
545	0.11378	1379	0.27884	2213	0.44164	3047	0.60232	3881	0.77216	4715	0.9403
546	0.1138	1380	0.27917	2214	0.44201	3048	0.60233	3882	0.77226	4716	0.94033
547	0.11386	1381	0.27942	2215	0.44213	3049	0.60328	3883	0.77238	4717	0.94048
548	0.11406	1382	0.28007	2216	0.44222	3050	0.60332	3884	0.77297	4718	0.94075
549	0.11443	1383	0.28014	2217	0.44224	3051	0.60349	3885	0.77298	4719	0.94094
550	0.11448	1384	0.28044	2218	0.4424	3052	0.60362	3886	0.773	4720	0.94097
551	0.11451	1385	0.28064	2219	0.44254	3053	0.60363	3887	0.77319	4721	0.94151
552	0.11491	1386	0.2807	2220	0.44282	3054	0.60373	3888	0.77344	4722	0.9416
553	0.11588	1387	0.28077	2221	0.44292	3055	0.60385	3889	0.77351	4723	0.94167
554	0.1164	1388	0.28097	2222	0.44319	3056	0.60413	3890	0.77363	4724	0.94207
555	0.11644	1389	0.28116	2223	0.44337	3057	0.60487	3891	0.77367	4725	0.94224
556	0.11665	1390	0.28119	2224	0.44341	3058	0.60496	3892	0.77383	4726	0.94245
557	0.11679	1391	0.28138	2225	0.44381	3059	0.60497	3893	0.7744	4727	0.94274
558	0.11683	1392	0.28147	2226	0.44394	3060	0.60518	3894	0.77469	4728	0.94283
559	0.11712	1393	0.28188	2227	0.4441	3061	0.60535	3895	0.77482	4729	0.94289
560	0.11735	1394	0.28201	2228	0.44449	3062	0.60578	3896	0.77498	4730	0.94325
561	0.11758	1395	0.2822	2229	0.44468	3063	0.60579	3897	0.7751	4731	0.94336
562	0.11773	1396	0.28225	2230	0.44473	3064	0.60583	3898	0.77515	4732	0.94342
563	0.11782	1397	0.28243	2231	0.44493	3065	0.60596	3899	0.77518	4733	0.94354
564	0.11804	1398	0.28266	2232	0.44501	3066	0.60639	3900	0.77523	4734	0.94365
565	0.11858	1399	0.28293	2233	0.44531	3067	0.60681	3901	0.77527	4735	0.94371
566	0.1186	1400	0.28301	2234	0.44568	3068	0.60701	3902	0.77609	4736	0.94377
567	0.11876	1401	0.2834	2235	0.44577	3069	0.60742	3903	0.77623	4737	0.94383
568	0.11915	1402	0.28345	2236	0.44588	3070	0.60754	3904	0.77651	4738	0.94383

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
569	0.11928	1403	0.28386	2237	0.44618	3071	0.60766	3905	0.77677	4739	0.94384
570	0.11949	1404	0.28389	2238	0.44621	3072	0.60817	3906	0.77678	4740	0.94449
571	0.1199	1405	0.28407	2239	0.44647	3073	0.60826	3907	0.77728	4741	0.94461
572	0.12051	1406	0.28436	2240	0.44651	3074	0.60828	3908	0.77793	4742	0.94468
573	0.12057	1407	0.28452	2241	0.44687	3075	0.60828	3909	0.77795	4743	0.94492
574	0.12092	1408	0.28514	2242	0.44705	3076	0.60829	3910	0.77845	4744	0.94538
575	0.12095	1409	0.28549	2243	0.44724	3077	0.60831	3911	0.77886	4745	0.94548
576	0.12132	1410	0.28558	2244	0.4476	3078	0.60859	3912	0.77909	4746	0.94551
577	0.12148	1411	0.28573	2245	0.44778	3079	0.60864	3913	0.77929	4747	0.94563
578	0.12156	1412	0.28579	2246	0.44779	3080	0.60935	3914	0.77933	4748	0.94571
579	0.12171	1413	0.28604	2247	0.44791	3081	0.60944	3915	0.77957	4749	0.94583
580	0.12172	1414	0.28635	2248	0.44799	3082	0.60973	3916	0.77957	4750	0.94635
581	0.12174	1415	0.28646	2249	0.4484	3083	0.61021	3917	0.77968	4751	0.94636
582	0.12174	1416	0.28665	2250	0.44848	3084	0.61041	3918	0.77986	4752	0.94662
583	0.12186	1417	0.28686	2251	0.44862	3085	0.61048	3919	0.78001	4753	0.94665
584	0.12197	1418	0.28748	2252	0.44864	3086	0.61084	3920	0.78007	4754	0.94673
585	0.12205	1419	0.28776	2253	0.4488	3087	0.61102	3921	0.78056	4755	0.94673
586	0.12206	1420	0.2878	2254	0.44883	3088	0.61145	3922	0.7808	4756	0.94696
587	0.12255	1421	0.28801	2255	0.44917	3089	0.61162	3923	0.78111	4757	0.94705
588	0.12258	1422	0.28865	2256	0.44963	3090	0.61162	3924	0.78114	4758	0.94712
589	0.12267	1423	0.2888	2257	0.44971	3091	0.61192	3925	0.78119	4759	0.94737
590	0.12277	1424	0.28887	2258	0.4498	3092	0.61237	3926	0.78132	4760	0.94741
591	0.12329	1425	0.2889	2259	0.4501	3093	0.6124	3927	0.7817	4761	0.94802
592	0.12347	1426	0.28918	2260	0.45025	3094	0.61264	3928	0.78175	4762	0.94813
593	0.12397	1427	0.28948	2261	0.45026	3095	0.61298	3929	0.78183	4763	0.94836
594	0.12411	1428	0.28956	2262	0.45027	3096	0.61336	3930	0.78184	4764	0.9485
595	0.12419	1429	0.28961	2263	0.45028	3097	0.6136	3931	0.78184	4765	0.94877
596	0.12449	1430	0.2899	2264	0.45048	3098	0.6142	3932	0.78211	4766	0.94891
597	0.12464	1431	0.28996	2265	0.45071	3099	0.61448	3933	0.78224	4767	0.9496
598	0.12469	1432	0.29013	2266	0.45113	3100	0.6149	3934	0.78255	4768	0.94978
599	0.12503	1433	0.29016	2267	0.45115	3101	0.61503	3935	0.78258	4769	0.95014
600	0.12517	1434	0.29026	2268	0.45153	3102	0.61503	3936	0.78266	4770	0.95018
601	0.12535	1435	0.2903	2269	0.45193	3103	0.61521	3937	0.78288	4771	0.95028
602	0.12539	1436	0.29047	2270	0.45223	3104	0.61522	3938	0.78303	4772	0.95054
603	0.12542	1437	0.29048	2271	0.45237	3105	0.61576	3939	0.78314	4773	0.95088
604	0.12551	1438	0.29059	2272	0.45251	3106	0.61582	3940	0.78314	4774	0.95098
605	0.12569	1439	0.29059	2273	0.45269	3107	0.61627	3941	0.78334	4775	0.95113
606	0.12594	1440	0.29078	2274	0.45276	3108	0.61633	3942	0.78342	4776	0.95124
607	0.126	1441	0.29124	2275	0.4528	3109	0.61637	3943	0.78375	4777	0.95124
608	0.1261	1442	0.29141	2276	0.45287	3110	0.61695	3944	0.78409	4778	0.95129
609	0.12614	1443	0.29158	2277	0.45353	3111	0.61715	3945	0.78547	4779	0.95139

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
610	0.12625	1444	0.29161	2278	0.45385	3112	0.61716	3946	0.78549	4780	0.9519
611	0.12684	1445	0.29191	2279	0.45421	3113	0.61732	3947	0.78562	4781	0.95192
612	0.12692	1446	0.29196	2280	0.4545	3114	0.61772	3948	0.78579	4782	0.95201
613	0.12701	1447	0.29204	2281	0.45452	3115	0.61773	3949	0.78582	4783	0.9526
614	0.12721	1448	0.29223	2282	0.45464	3116	0.61776	3950	0.78584	4784	0.95274
615	0.12736	1449	0.29271	2283	0.45479	3117	0.61782	3951	0.78615	4785	0.9528
616	0.12749	1450	0.29283	2284	0.45486	3118	0.61815	3952	0.78616	4786	0.95284
617	0.12797	1451	0.29311	2285	0.45494	3119	0.61826	3953	0.7862	4787	0.95291
618	0.12848	1452	0.29313	2286	0.45539	3120	0.61842	3954	0.78659	4788	0.953
619	0.12896	1453	0.2934	2287	0.45568	3121	0.61851	3955	0.78668	4789	0.95329
620	0.12937	1454	0.29344	2288	0.45584	3122	0.61852	3956	0.78669	4790	0.95359
621	0.12957	1455	0.2935	2289	0.4559	3123	0.61871	3957	0.78671	4791	0.95393
622	0.12965	1456	0.29354	2290	0.45606	3124	0.61936	3958	0.78777	4792	0.95442
623	0.13023	1457	0.29392	2291	0.4562	3125	0.61937	3959	0.78815	4793	0.95446
624	0.13027	1458	0.2942	2292	0.45633	3126	0.61958	3960	0.78827	4794	0.95446
625	0.13053	1459	0.29427	2293	0.45637	3127	0.61963	3961	0.78837	4795	0.9545
626	0.13062	1460	0.29436	2294	0.45638	3128	0.61968	3962	0.78838	4796	0.9546
627	0.13065	1461	0.29466	2295	0.45679	3129	0.61968	3963	0.78873	4797	0.95498
628	0.1314	1462	0.29491	2296	0.45784	3130	0.61978	3964	0.78875	4798	0.95542
629	0.1315	1463	0.29503	2297	0.45794	3131	0.61983	3965	0.78889	4799	0.95615
630	0.13157	1464	0.2951	2298	0.45806	3132	0.62004	3966	0.78893	4800	0.95656
631	0.1317	1465	0.29522	2299	0.45823	3133	0.62023	3967	0.789	4801	0.95684
632	0.1319	1466	0.29523	2300	0.45829	3134	0.62032	3968	0.7893	4802	0.95697
633	0.13226	1467	0.29524	2301	0.45843	3135	0.62038	3969	0.78949	4803	0.95703
634	0.13228	1468	0.29548	2302	0.45873	3136	0.62042	3970	0.78957	4804	0.95707
635	0.13304	1469	0.29561	2303	0.45877	3137	0.62065	3971	0.79001	4805	0.95708
636	0.13316	1470	0.29561	2304	0.45887	3138	0.6207	3972	0.79029	4806	0.9576
637	0.13336	1471	0.29563	2305	0.45909	3139	0.62088	3973	0.79032	4807	0.95815
638	0.1334	1472	0.29566	2306	0.45917	3140	0.62117	3974	0.79034	4808	0.95819
639	0.13353	1473	0.29577	2307	0.45924	3141	0.62145	3975	0.79061	4809	0.95826
640	0.13367	1474	0.29604	2308	0.45952	3142	0.62148	3976	0.7908	4810	0.95837
641	0.13369	1475	0.29604	2309	0.45973	3143	0.62157	3977	0.79081	4811	0.95917
642	0.13402	1476	0.29624	2310	0.4598	3144	0.62157	3978	0.79082	4812	0.95925
643	0.13425	1477	0.29635	2311	0.46047	3145	0.62203	3979	0.79093	4813	0.9594
644	0.13444	1478	0.29636	2312	0.46048	3146	0.62282	3980	0.79097	4814	0.95982
645	0.13458	1479	0.29638	2313	0.46129	3147	0.62288	3981	0.79105	4815	0.95987
646	0.13459	1480	0.2966	2314	0.46134	3148	0.62289	3982	0.79146	4816	0.96019
647	0.13465	1481	0.29686	2315	0.46138	3149	0.62367	3983	0.79159	4817	0.96028
648	0.13501	1482	0.29688	2316	0.46148	3150	0.62396	3984	0.79162	4818	0.96051
649	0.13503	1483	0.29692	2317	0.46155	3151	0.62398	3985	0.7917	4819	0.96089
650	0.1351	1484	0.29718	2318	0.46174	3152	0.62408	3986	0.79176	4820	0.96106

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
651	0.13511	**1485**	0.29766	**2319**	0.46212	**3153**	0.62412	**3987**	0.79182	**4821**	0.96123
652	0.13511	**1486**	0.29779	**2320**	0.46275	**3154**	0.62412	**3988**	0.79194	**4822**	0.96143
653	0.13513	**1487**	0.29798	**2321**	0.46299	**3155**	0.62437	**3989**	0.79217	**4823**	0.96149
654	0.13545	**1488**	0.29879	**2322**	0.46299	**3156**	0.62438	**3990**	0.79268	**4824**	0.9617
655	0.13566	**1489**	0.29901	**2323**	0.46303	**3157**	0.62514	**3991**	0.79318	**4825**	0.96188
656	0.13588	**1490**	0.29925	**2324**	0.46317	**3158**	0.62522	**3992**	0.79357	**4826**	0.96205
657	0.13589	**1491**	0.29928	**2325**	0.46318	**3159**	0.62529	**3993**	0.79364	**4827**	0.96219
658	0.13593	**1492**	0.2995	**2326**	0.46327	**3160**	0.62529	**3994**	0.79402	**4828**	0.96232
659	0.136	**1493**	0.29952	**2327**	0.46344	**3161**	0.62545	**3995**	0.79467	**4829**	0.96239
660	0.13607	**1494**	0.29952	**2328**	0.46357	**3162**	0.6257	**3996**	0.79467	**4830**	0.96249
661	0.1364	**1495**	0.29967	**2329**	0.46359	**3163**	0.62593	**3997**	0.79476	**4831**	0.96262
662	0.13643	**1496**	0.2999	**2330**	0.46359	**3164**	0.62596	**3998**	0.79526	**4832**	0.96263
663	0.13657	**1497**	0.30031	**2331**	0.46372	**3165**	0.62626	**3999**	0.79542	**4833**	0.96277
664	0.13658	**1498**	0.30049	**2332**	0.46379	**3166**	0.62631	**4000**	0.79552	**4834**	0.96296
665	0.13663	**1499**	0.30049	**2333**	0.46394	**3167**	0.62632	**4001**	0.79582	**4835**	0.96307
666	0.13668	**1500**	0.30054	**2334**	0.46394	**3168**	0.62634	**4002**	0.79595	**4836**	0.96382
667	0.13685	**1501**	0.30065	**2335**	0.46395	**3169**	0.62729	**4003**	0.796	**4837**	0.9639
668	0.13721	**1502**	0.30071	**2336**	0.46455	**3170**	0.62751	**4004**	0.79618	**4838**	0.96409
669	0.13734	**1503**	0.3008	**2337**	0.46459	**3171**	0.62855	**4005**	0.79626	**4839**	0.96416
670	0.13743	**1504**	0.30139	**2338**	0.46472	**3172**	0.62867	**4006**	0.79629	**4840**	0.96433
671	0.13743	**1505**	0.30141	**2339**	0.46505	**3173**	0.62878	**4007**	0.79649	**4841**	0.96446
672	0.13754	**1506**	0.30147	**2340**	0.46525	**3174**	0.62908	**4008**	0.7967	**4842**	0.96488
673	0.13763	**1507**	0.30181	**2341**	0.46559	**3175**	0.62908	**4009**	0.79679	**4843**	0.96511
674	0.13818	**1508**	0.30196	**2342**	0.46566	**3176**	0.62912	**4010**	0.79684	**4844**	0.96555
675	0.1387	**1509**	0.30202	**2343**	0.46573	**3177**	0.62914	**4011**	0.79714	**4845**	0.96583
676	0.13877	**1510**	0.30214	**2344**	0.46592	**3178**	0.62954	**4012**	0.7972	**4846**	0.96614
677	0.13901	**1511**	0.30291	**2345**	0.46625	**3179**	0.62976	**4013**	0.79763	**4847**	0.96637
678	0.1391	**1512**	0.30309	**2346**	0.46643	**3180**	0.6299	**4014**	0.79776	**4848**	0.96639
679	0.13955	**1513**	0.30329	**2347**	0.46655	**3181**	0.62998	**4015**	0.79801	**4849**	0.96675
680	0.13997	**1514**	0.30344	**2348**	0.46667	**3182**	0.63049	**4016**	0.79811	**4850**	0.96693
681	0.14034	**1515**	0.3036	**2349**	0.46696	**3183**	0.63085	**4017**	0.79823	**4851**	0.96727
682	0.14037	**1516**	0.30362	**2350**	0.46703	**3184**	0.63088	**4018**	0.79826	**4852**	0.96727
683	0.14057	**1517**	0.30381	**2351**	0.46703	**3185**	0.63125	**4019**	0.79827	**4853**	0.96739
684	0.14082	**1518**	0.30441	**2352**	0.46714	**3186**	0.63137	**4020**	0.79864	**4854**	0.96746
685	0.14135	**1519**	0.30478	**2353**	0.46715	**3187**	0.63156	**4021**	0.79889	**4855**	0.96758
686	0.1415	**1520**	0.30519	**2354**	0.46737	**3188**	0.63162	**4022**	0.79896	**4856**	0.96767
687	0.14166	**1521**	0.30535	**2355**	0.46737	**3189**	0.63163	**4023**	0.79912	**4857**	0.96768
688	0.14179	**1522**	0.30539	**2356**	0.46771	**3190**	0.63194	**4024**	0.79968	**4858**	0.96773
689	0.1418	**1523**	0.30548	**2357**	0.46796	**3191**	0.63198	**4025**	0.79969	**4859**	0.96806
690	0.14182	**1524**	0.30558	**2358**	0.4684	**3192**	0.63203	**4026**	0.7999	**4860**	0.96849
691	0.14237	**1525**	0.30582	**2359**	0.46858	**3193**	0.63206	**4027**	0.80013	**4861**	0.96863

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
692	0.1425	1526	0.30605	2360	0.46878	3194	0.63231	4028	0.80022	4862	0.96874
693	0.14261	1527	0.30607	2361	0.46903	3195	0.63237	4029	0.80029	4863	0.96914
694	0.14272	1528	0.30647	2362	0.46911	3196	0.63244	4030	0.80053	4864	0.96919
695	0.14332	1529	0.30654	2363	0.46937	3197	0.6328	4031	0.80194	4865	0.96953
696	0.14363	1530	0.30692	2364	0.46967	3198	0.6328	4032	0.80231	4866	0.96991
697	0.14369	1531	0.30696	2365	0.46976	3199	0.63306	4033	0.8026	4867	0.96996
698	0.14396	1532	0.30701	2366	0.46994	3200	0.63313	4034	0.80264	4868	0.97047
699	0.1444	1533	0.3071	2367	0.47016	3201	0.63352	4035	0.80319	4869	0.97047
700	0.14465	1534	0.30718	2368	0.47027	3202	0.63409	4036	0.80343	4870	0.97065
701	0.14488	1535	0.30732	2369	0.47065	3203	0.63446	4037	0.8038	4871	0.97088
702	0.14498	1536	0.30744	2370	0.47096	3204	0.63452	4038	0.80432	4872	0.97102
703	0.14529	1537	0.30802	2371	0.47107	3205	0.6347	4039	0.80468	4873	0.97181
704	0.14538	1538	0.30809	2372	0.47119	3206	0.63477	4040	0.80592	4874	0.97186
705	0.14567	1539	0.30818	2373	0.47124	3207	0.63486	4041	0.80628	4875	0.97192
706	0.14583	1540	0.30829	2374	0.47163	3208	0.6353	4042	0.80675	4876	0.9721
707	0.14592	1541	0.30847	2375	0.47198	3209	0.63581	4043	0.8068	4877	0.97221
708	0.14598	1542	0.30848	2376	0.47219	3210	0.63584	4044	0.8073	4878	0.9727
709	0.14675	1543	0.3086	2377	0.47293	3211	0.63586	4045	0.80769	4879	0.97275
710	0.14701	1544	0.30872	2378	0.47344	3212	0.63616	4046	0.8077	4880	0.97278
711	0.14711	1545	0.30908	2379	0.47369	3213	0.6364	4047	0.80775	4881	0.97284
712	0.14757	1546	0.30923	2380	0.47375	3214	0.63667	4048	0.80803	4882	0.97304
713	0.14786	1547	0.3096	2381	0.47403	3215	0.63688	4049	0.80815	4883	0.97375
714	0.14788	1548	0.30965	2382	0.47414	3216	0.63696	4050	0.8082	4884	0.97391
715	0.14811	1549	0.30971	2383	0.47442	3217	0.63708	4051	0.80884	4885	0.9742
716	0.14848	1550	0.30985	2384	0.47443	3218	0.63734	4052	0.80907	4886	0.97496
717	0.14865	1551	0.31003	2385	0.47494	3219	0.63745	4053	0.80945	4887	0.97513
718	0.14901	1552	0.31035	2386	0.47496	3220	0.63771	4054	0.80978	4888	0.97516
719	0.14902	1553	0.31053	2387	0.47507	3221	0.638	4055	0.80984	4889	0.97521
720	0.14942	1554	0.31056	2388	0.47511	3222	0.63811	4056	0.80992	4890	0.97522
721	0.14972	1555	0.31109	2389	0.47601	3223	0.63859	4057	0.81006	4891	0.97532
722	0.14973	1556	0.31109	2390	0.47623	3224	0.63868	4058	0.81006	4892	0.97559
723	0.14981	1557	0.31119	2391	0.47625	3225	0.63941	4059	0.81015	4893	0.97602
724	0.14985	1558	0.31121	2392	0.47626	3226	0.63986	4060	0.81017	4894	0.97643
725	0.15026	1559	0.31125	2393	0.47644	3227	0.63993	4061	0.81018	4895	0.97646
726	0.15029	1560	0.31126	2394	0.47644	3228	0.64056	4062	0.8108	4896	0.97664
727	0.15041	1561	0.31154	2395	0.47647	3229	0.64159	4063	0.81086	4897	0.97696
728	0.15045	1562	0.3117	2396	0.47651	3230	0.64205	4064	0.81108	4898	0.97717
729	0.15049	1563	0.3118	2397	0.47694	3231	0.64239	4065	0.8113	4899	0.97723
730	0.15077	1564	0.31181	2398	0.47704	3232	0.64245	4066	0.81141	4900	0.9777
731	0.15078	1565	0.31198	2399	0.47707	3233	0.64258	4067	0.81143	4901	0.97774
732	0.15097	1566	0.31228	2400	0.47729	3234	0.64296	4068	0.81146	4902	0.97803

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
733	0.15113	**1567**	0.31252	**2401**	0.47733	**3235**	0.6441	**4069**	0.81154	**4903**	0.97853
734	0.15161	**1568**	0.31259	**2402**	0.47739	**3236**	0.64416	**4070**	0.8116	**4904**	0.97855
735	0.15162	**1569**	0.3128	**2403**	0.47742	**3237**	0.64447	**4071**	0.81192	**4905**	0.97872
736	0.15182	**1570**	0.31288	**2404**	0.47757	**3238**	0.64459	**4072**	0.81197	**4906**	0.9788
737	0.15228	**1571**	0.31291	**2405**	0.47784	**3239**	0.64511	**4073**	0.81208	**4907**	0.97888
738	0.15239	**1572**	0.31302	**2406**	0.47788	**3240**	0.64535	**4074**	0.81216	**4908**	0.97911
739	0.15247	**1573**	0.31307	**2407**	0.47793	**3241**	0.64537	**4075**	0.81219	**4909**	0.97948
740	0.15255	**1574**	0.31355	**2408**	0.47799	**3242**	0.64575	**4076**	0.81245	**4910**	0.9797
741	0.15262	**1575**	0.31386	**2409**	0.47827	**3243**	0.64622	**4077**	0.81289	**4911**	0.97971
742	0.15275	**1576**	0.31388	**2410**	0.47841	**3244**	0.64624	**4078**	0.81293	**4912**	0.9801
743	0.15279	**1577**	0.31396	**2411**	0.47908	**3245**	0.64644	**4079**	0.81314	**4913**	0.9805
744	0.15305	**1578**	0.31418	**2412**	0.47925	**3246**	0.64648	**4080**	0.81331	**4914**	0.98111
745	0.15317	**1579**	0.3142	**2413**	0.47936	**3247**	0.64667	**4081**	0.81355	**4915**	0.98111
746	0.15329	**1580**	0.31422	**2414**	0.47953	**3248**	0.64691	**4082**	0.81356	**4916**	0.98116
747	0.15343	**1581**	0.31427	**2415**	0.47976	**3249**	0.64693	**4083**	0.81374	**4917**	0.98122
748	0.15378	**1582**	0.31456	**2416**	0.47992	**3250**	0.64718	**4084**	0.81388	**4918**	0.98148
749	0.15451	**1583**	0.31489	**2417**	0.48035	**3251**	0.64725	**4085**	0.81406	**4919**	0.98183
750	0.15493	**1584**	0.31515	**2418**	0.48039	**3252**	0.64749	**4086**	0.81415	**4920**	0.98195
751	0.15518	**1585**	0.31571	**2419**	0.48045	**3253**	0.64756	**4087**	0.81446	**4921**	0.98232
752	0.15533	**1586**	0.31572	**2420**	0.48066	**3254**	0.6476	**4088**	0.8147	**4922**	0.98239
753	0.1555	**1587**	0.31577	**2421**	0.48077	**3255**	0.64762	**4089**	0.81493	**4923**	0.98249
754	0.15558	**1588**	0.31587	**2422**	0.48086	**3256**	0.64763	**4090**	0.81495	**4924**	0.98342
755	0.15573	**1589**	0.31605	**2423**	0.48119	**3257**	0.64811	**4091**	0.81527	**4925**	0.98385
756	0.15579	**1590**	0.31672	**2424**	0.48143	**3258**	0.6482	**4092**	0.81549	**4926**	0.98393
757	0.15585	**1591**	0.31696	**2425**	0.4816	**3259**	0.64838	**4093**	0.81561	**4927**	0.98413
758	0.15602	**1592**	0.31724	**2426**	0.48169	**3260**	0.64841	**4094**	0.81565	**4928**	0.98426
759	0.15626	**1593**	0.31729	**2427**	0.48177	**3261**	0.64886	**4095**	0.81578	**4929**	0.98437
760	0.15627	**1594**	0.31811	**2428**	0.48205	**3262**	0.64887	**4096**	0.81652	**4930**	0.98469
761	0.15653	**1595**	0.31861	**2429**	0.48233	**3263**	0.64887	**4097**	0.81674	**4931**	0.98472
762	0.1566	**1596**	0.31867	**2430**	0.48245	**3264**	0.6496	**4098**	0.81698	**4932**	0.9848
763	0.15663	**1597**	0.31956	**2431**	0.48254	**3265**	0.64971	**4099**	0.81698	**4933**	0.98491
764	0.15682	**1598**	0.3199	**2432**	0.48265	**3266**	0.64973	**4100**	0.81699	**4934**	0.98508
765	0.15693	**1599**	0.32062	**2433**	0.483	**3267**	0.64987	**4101**	0.81731	**4935**	0.98532
766	0.15726	**1600**	0.32068	**2434**	0.48302	**3268**	0.65018	**4102**	0.81741	**4936**	0.98553
767	0.15732	**1601**	0.3207	**2435**	0.48305	**3269**	0.65076	**4103**	0.81748	**4937**	0.9856
768	0.1576	**1602**	0.32087	**2436**	0.4831	**3270**	0.65081	**4104**	0.81759	**4938**	0.9862
769	0.15784	**1603**	0.32103	**2437**	0.48373	**3271**	0.65105	**4105**	0.81765	**4939**	0.98631
770	0.15802	**1604**	0.32142	**2438**	0.48406	**3272**	0.65108	**4106**	0.81782	**4940**	0.98677
771	0.15831	**1605**	0.3215	**2439**	0.48417	**3273**	0.65115	**4107**	0.81798	**4941**	0.98681
772	0.15832	**1606**	0.32171	**2440**	0.48432	**3274**	0.65121	**4108**	0.8183	**4942**	0.98691
773	0.1584	**1607**	0.32205	**2441**	0.48453	**3275**	0.65135	**4109**	0.8188	**4943**	0.98707

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
774	0.15863	1608	0.32234	2442	0.48473	3276	0.65158	4110	0.81884	4944	0.98739
775	0.15874	1609	0.32235	2443	0.48502	3277	0.65159	4111	0.81927	4945	0.98775
776	0.15878	1610	0.32243	2444	0.48514	3278	0.65168	4112	0.8195	4946	0.98793
777	0.15891	1611	0.32248	2445	0.48515	3279	0.652	4113	0.81951	4947	0.98806
778	0.15893	1612	0.32283	2446	0.48526	3280	0.65274	4114	0.81974	4948	0.98809
779	0.15915	1613	0.3237	2447	0.48549	3281	0.65283	4115	0.81976	4949	0.98819
780	0.15942	1614	0.32382	2448	0.48564	3282	0.65291	4116	0.81977	4950	0.98862
781	0.15961	1615	0.32408	2449	0.48571	3283	0.65312	4117	0.81994	4951	0.98924
782	0.15966	1616	0.32463	2450	0.48632	3284	0.65342	4118	0.82005	4952	0.98929
783	0.1597	1617	0.32468	2451	0.48642	3285	0.65369	4119	0.82027	4953	0.98938
784	0.1602	1618	0.32487	2452	0.48643	3286	0.65383	4120	0.8204	4954	0.98977
785	0.16021	1619	0.32501	2453	0.48652	3287	0.65388	4121	0.82043	4955	0.98986
786	0.16049	1620	0.32516	2454	0.48667	3288	0.6539	4122	0.82061	4956	0.9901
787	0.16059	1621	0.32528	2455	0.48675	3289	0.65395	4123	0.82073	4957	0.99025
788	0.16061	1622	0.32542	2456	0.48675	3290	0.65397	4124	0.82073	4958	0.99031
789	0.16078	1623	0.32546	2457	0.48706	3291	0.65472	4125	0.82118	4959	0.99035
790	0.16122	1624	0.3255	2458	0.48709	3292	0.65483	4126	0.82124	4960	0.99067
791	0.16123	1625	0.32612	2459	0.48711	3293	0.65486	4127	0.82222	4961	0.9907
792	0.16138	1626	0.3263	2460	0.48746	3294	0.65487	4128	0.8225	4962	0.99089
793	0.16163	1627	0.3263	2461	0.48762	3295	0.65523	4129	0.82318	4963	0.99096
794	0.16188	1628	0.32646	2462	0.4877	3296	0.65565	4130	0.82325	4964	0.99102
795	0.16221	1629	0.32653	2463	0.48799	3297	0.65581	4131	0.82338	4965	0.99144
796	0.1623	1630	0.32692	2464	0.48815	3298	0.65599	4132	0.82408	4966	0.99214
797	0.1624	1631	0.32725	2465	0.48816	3299	0.656	4133	0.82409	4967	0.99323
798	0.16256	1632	0.32759	2466	0.48824	3300	0.65613	4134	0.82436	4968	0.99333
799	0.16266	1633	0.32808	2467	0.48834	3301	0.65621	4135	0.8245	4969	0.99338
800	0.16266	1634	0.32818	2468	0.48856	3302	0.65634	4136	0.82455	4970	0.9935
801	0.16274	1635	0.32835	2469	0.48859	3303	0.65641	4137	0.82512	4971	0.99378
802	0.16282	1636	0.32869	2470	0.48864	3304	0.65646	4138	0.82538	4972	0.994
803	0.16313	1637	0.32875	2471	0.48871	3305	0.65675	4139	0.82542	4973	0.9942
804	0.16329	1638	0.32885	2472	0.48933	3306	0.65697	4140	0.82543	4974	0.9945
805	0.16356	1639	0.32951	2473	0.48948	3307	0.65713	4141	0.82546	4975	0.99525
806	0.16383	1640	0.32959	2474	0.48975	3308	0.65723	4142	0.82581	4976	0.99587
807	0.1645	1641	0.32985	2475	0.49001	3309	0.6574	4143	0.82583	4977	0.9959
808	0.16452	1642	0.32996	2476	0.49006	3310	0.6576	4144	0.82584	4978	0.99625
809	0.16458	1643	0.33013	2477	0.49009	3311	0.65776	4145	0.82586	4979	0.99635
810	0.16471	1644	0.33022	2478	0.49109	3312	0.65783	4146	0.82599	4980	0.99645
811	0.16497	1645	0.33026	2479	0.4911	3313	0.65787	4147	0.826	4981	0.99676
812	0.16499	1646	0.33054	2480	0.49116	3314	0.65802	4148	0.82617	4982	0.99678
813	0.16502	1647	0.33057	2481	0.49152	3315	0.65814	4149	0.82636	4983	0.99704
814	0.16518	1648	0.33063	2482	0.49189	3316	0.65829	4150	0.82684	4984	0.9972

No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
815	0.16527	**1649**	0.33071	**2483**	0.49208	**3317**	0.65829	**4151**	0.82695	**4985**	0.99728
816	0.16543	**1650**	0.33088	**2484**	0.49239	**3318**	0.65843	**4152**	0.82697	**4986**	0.99728
817	0.16561	**1651**	0.33116	**2485**	0.49247	**3319**	0.65885	**4153**	0.82737	**4987**	0.99732
818	0.16622	**1652**	0.33123	**2486**	0.49258	**3320**	0.65941	**4154**	0.82743	**4988**	0.99735
819	0.16643	**1653**	0.33128	**2487**	0.49263	**3321**	0.65942	**4155**	0.82761	**4989**	0.9978
820	0.16644	**1654**	0.33135	**2488**	0.4927	**3322**	0.65963	**4156**	0.82765	**4990**	0.99785
821	0.16649	**1655**	0.33146	**2489**	0.49282	**3323**	0.6602	**4157**	0.82862	**4991**	0.99802
822	0.1667	**1656**	0.3317	**2490**	0.49284	**3324**	0.66026	**4158**	0.82866	**4992**	0.99831
823	0.16671	**1657**	0.33172	**2491**	0.49343	**3325**	0.66046	**4159**	0.82886	**4993**	0.99849
824	0.16732	**1658**	0.33181	**2492**	0.49357	**3326**	0.66066	**4160**	0.82915	**4994**	0.99904
825	0.16736	**1659**	0.33183	**2493**	0.49362	**3327**	0.66095	**4161**	0.82922	**4995**	0.99905
826	0.16759	**1660**	0.33207	**2494**	0.4937	**3328**	0.66131	**4162**	0.82948	**4996**	0.9991
827	0.16763	**1661**	0.33214	**2495**	0.49382	**3329**	0.66136	**4163**	0.83008	**4997**	0.9993
828	0.16767	**1662**	0.33222	**2496**	0.49387	**3330**	0.6615	**4164**	0.83018	**4998**	0.99954
829	0.16776	**1663**	0.33243	**2497**	0.49396	**3331**	0.66151	**4165**	0.83037	**4999**	0.99976
830	0.16821	**1664**	0.33247	**2498**	0.494	**3332**	0.66175	**4166**	0.83042	**5000**	0.99981
831	0.16835	**1665**	0.33248	**2499**	0.49419	**3333**	0.66185	**4167**	0.83108		
832	0.16889	**1666**	0.33254	**2500**	0.49453	**3334**	0.66193	**4168**	0.83122		
833	0.16896	**1667**	0.33271	**2501**	0.49513	**3335**	0.66202	**4169**	0.83134		
834	0.16915	**1668**	0.33283	**2502**	0.49522	**3336**	0.66216	**4170**	0.83149		

COPY

QA: QA

Civilian Radioactive Waste Management System
Management & Operating Contractor

FEHM, V2.10
REV 01

VALIDATION TEST REPORT

Software Document Number: 10086-VTR-2.10-01

Software Media Number: 10086-PC-2.10-01

Software Tracking Number: 10086-2.10-01

Software Activity Number: LV-2001-158

AUGUST 2001

Prepared for:

U.S. Department of Energy
Yucca Mountain Site Characterization Office
P.O. Box 30307
North Las Vegas, Nevada 89036-0307

DISCLAIMER

Civilian Radioactive Waste Management System
Management & Operating Contractor

FEHM, V2.10
REV 01

VALIDATION TEST REPORT

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AUGUST 2001

Verified by:
Norman Graves — Date 8/27/01

Approved by:
[signature] for David Sevougian
David Sevougian — Date 27 Aug 01

Reviewed by:
[signature]
~~Dianne Spence~~ (ITSMA) 08/28/01
Edward Miller EM — Date 08/28/01

CHANGE HISTORY

Revision Number	Effective Date	Description of Change
00	12/11/2000	Initial issue.
01	08/27/2001	Sections 1-12 were extensively revised to qualify the FEHM V2.10 program for Windows NT 4.0 environment.

CONTENTS

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ACRONYMS AND ABBREVIATIONS

ECM	Equivalent Continuum Method
EKM	Double Porosity/Double Permeability Method
LANL	Los Alamos National Laboratory
RIS	Record Information System
SAP	Software Activity Plan
SCM	Software Configuration Management
TSPA	Total System Performance Assessment
VTR	Validation Test Report

1. SOFTWARE IDENTIFICATION

FEHM Version 2.10 was originally installed and verified for PC/Windows 2000 platform and the validation test plan 10086-VTP-2.10-00 was conducted for that platform. Per AP-SI.1Q section 5.8.4, this VTR is generated to qualify it on the Windows NT 4.0 operating system. The same VTP that was used Windows 2000 is applicable to Windows NT 4.0 platform.

2. VALIDATION TESTER

Bradley Gundlach of Los Alamos National Laboratory (LANL) performed the validation tests. Mr. Gundlach was assigned to support TSPA project and retest the FEHM V2.10 code with the PC/Windows NT 4.0 platform and document the test results.

3. SPECIAL TOOLS AND EQUIPMENT

Validation tests were conducted at LANL using PC/Windows NT 4.0 platform. An installation test per the ITP was performed at BSC in Las Vegas, NV to verify the installation test. The CPU number that the installation test was performed is 112371.

4. TEST RESULTS LINKED TO THE UNIQUE TEST IDENTIFIER FROM THE VTP

FEHM version 2.10 was previously qualified using PC/Windows 2000 platform. MOL.20001219.0100 and MOL.20001219.0102 provide the RIS Accession numbers for the VTP and VTR qualifications of code, respectively, using PC/Windows 2000 platform.

Per section 5.8.4 of AP-SI.1Q procedure (Operating Environment Changes), regression testing was performed at LANL using the PC/Windows NT4.0 platform. Table 1 summarizes the test identifier, description and the results of the tests. A summary of the regression tests is given in Attachment 1.

Table 1 – Summary of the Results		
Test Identifier and Description	Pass	Fail
1. Thermodynamic Functions	✓	
2. heat Conduction	✓	
3. Temperature in a Wellbore	✓	
4. Hydraulic Head	✓	
5. Pressure Transient Analysis	✓	
6. Infiltration into a One Dimensional, Layered, Unsaturated Medium	✓	
7. Vapor Extraction from an Unsaturated Reservoir	✓	
8. Barometric Pumping Mechanisms	✓	
9. Dual Porosity	✓	
10. Heat and Mass Transfer in Porous Media	✓	
11. Toronyl Two-Phase Problem	✓	
12. DOE Code Comparison Project Problem Five, Case A	✓	
13. Dry-out of a Partially Saturated Medium	✓	
14. One Dimensional Reactive Solute Transport	✓	
15. Henry's Law Species	✓	
16. Fracture Transport with Matrix Diffusion	✓	
17. Movement of a Dissolved Mineral Front	✓	
18. Multi-Solute Transport with Chemical Reaction	✓	
19. Three dimensional Radionuclide Transport	✓	
20. Streamline Particle Tracking Model	✓	
21. Cell-Based particle Tracking Model	✓	

5. DOCUMENTATION OF ITP AND VTP (ANY ADDITIONAL PLATFORMS OR OPERATING SYSTEMS)

Per section 5.8.4 of AP-SI.1Q procedure, the existing ITP and VTP (MOL.20001219.0099 and MOL.20001219.0100) are valid for the present VTR. No new ITP and VTP are required for the present VTR.

Installation Test

In order to verify the installation, the ITP was repeated in the PC/Windows NT 4.0 environment. The ITP consists of using Explorer in Windows NT 4.0 system to complete the installation tasks.

Testing the installation test is accomplished by running a test case (One Dimensional Reactive Transport Model test number 14 in Table 1). From Windows NT, a directory was made as:

C:\FEHMNT

The executable **FEHM_V2_10.exe,** and the dynamic link library (DLL) files of **fehmn.dll, Dforrt.dll, Msvcrt.dll** and all sorption files were installed from the Fehm/Bin directory of the media into the above directory.

From Windows NT, the executable was run by typing: **FEHM_V2_10.exe**

In response to interactive query, "**sorption.files**" was used.

The input file is: **sorption.in**

Execution of the test problem generates the following output files: **sorption.out, sorption.trc.**

sorption.out is the output file for all 5 isotherm cases of:

Conservative,

Linear,

Langmuir,

Freundlich, and

Modified Freundlich

sorption.trc contains the data for plotting the concentration at the outlet node of each species versus time.

Since the output file is very large, only the results for time of 39.966 seconds (randomly picked) was extracted from **sorption.trc** and is repeated here:

```
4.625708999999980E-004          1
0.997870209755906
4.625708999999980E-004          2
6.891537624976829E-002
4.625708999999980E-004          3
0.541263629606992
4.625708999999980E-004          4
0.551999291477854
4.625708999999980E-004          5
1.000000000000000E-090
```

Note that the time unit is in days for 4.6257089999E-4 (or 39.966 seconds) and the values are the concentration for the five species.

Validation Test

The following section summarizes the results of each test step for each validation test contained in the VTP for FEHM 2.10. These tests were performed by Bradley Gundlach at Los Alamos National Laboratory.

6. INDICATION OF PASS/FAIL

Indicate the Pass/Fail, initial, and date for each Validation Test Plan (VTP) test step:

Test Identifier: 1. Thermodynamic Functions
- Step 1 (Enthalpy): PASS — Initial and Date: G 13 Jun 2001
- Step 2 (Density): PASS — Initial and Date: G 13 Jun 2001
- Step 3 (Compressibility): PASS — Initial and Date: G 13 Jun 2001
- Step 4 (Viscosity): PASS — Initial and Date: G 13 Jun 2001
- Step 5 (Pressure & Temperature): PASS — Initial and Date: G 13 Jun 2001

Test Identifier: 2. Infiltration into a One Dimensional, Layered, Unsaturated Medium
- Step 1 (2-D heat Conduction): PASS — Initial and Date: G 13 Jun 2001
- Step 2 (3-D Heat Conduction): PASS — Initial and Date: G 13 Jun 2001

Test Identifier: 3. Temperature in a Wellbore
- Step 1 (Injection in a Wellbore): PASS — Initial and Date: G 13 Jun 2001

Test Identifier: 4. Hydraulic Head
- Step 1 (Head Pressure): PASS — Initial and Date: G 13 Jun 2001

Test Identifier: 5. Pressure Transient Analysis
- Step 1 (Radial Flow): PASS — Initial and Date: G 13 Jun 2001

Test Identifier: 6. Infiltration into a One Dimensional, Layered, Unsaturated Medium
- Step 1 (Infiltration using ECM): PASS — Initial and Date: G 13 Jun 2001
- Step 2 (Infiltration using DKM): PASS — Initial and Date: G 13 Jun 2001

Test Identifier: 7. Vapor Extraction from an Unsaturated Reservoir
- Step 1 (Vapor Extraction): PASS — Initial and Date: G 13 Jun 2001

Test Identifier: 8. Barometric Pumping Mechanisms
- Step 1 (Pore-Scale Velocity): PASS — Initial and Date: G 13 Jun 2001
- Step 2 (Contaminant Mass Transfer): PASS — Initial and Date: G 13 Jun 2001

Test Identifier: 9. . Dual Porosity
- Step 1 (Dual Porosity): PASS — Initial and Date: G 13 Jun 2001

Test Identifier: 10. Heat and Mass Transfer in Porous Media
- Step 1 (1-D Radial Aquifer): PASS — Initial and Date: G 13 Jun 2001

Test Identifier: 11. Toronyl Two-Phase Problem
- Step 1 (2-D Phase Problem): PASS — Initial and Date: G 13 Jun 2001

Test Identifier: 12. DOE Code Comparison Project Problem Five, Case A
Step 1 (DOE Code Comparison): PASS Initial and Date: G 13 Jun 2001

Test Identifier: 13. Dry-out of a Partially Saturated Medium
Step 1 (Without Pressure Lowering): PASS Initial and Date: G 13 Jun 2001
Step 2 (With Pressure Lowering): PASS Initial and Date: G 13 Jun 2001

Test Identifier: 14. One Dimensional Reactive Solute Transport
Step 1 (Reactive Tracer Transport): PASS Initial and Date: G 13 Jun 2001

Test Identifier: 15. Henry's Law Species
Step 1 (Air Movement): PASS Initial and Date: G 13 Jun 2001
Step 2 (Water Movement): PASS Initial and Date: G 13 Jun 2001

Test Identifier: 16. Fracture Transport with Matrix Diffusion
Step 1 (No Sorption): PASS Initial and Date: G 13 Jun 2001
Step 2 (Sorption in the Matrix): PASS Initial and Date: G 13 Jun 2001
Step 3 (Sorption in the Fracture&Matrix): PASS Initial and Date: G 13 Jun 2001
Step 4 (Dual Porosity): PASS Initial and Date: G 13 Jun 2001

Test Identifier: 17. . Movement of a Dissolved Mineral Front
Step 1 (Calcite Dissolution in 1-D System): PASS Initial and Date: G 13 Jun 2001

Test Identifier: 18. Multi-Solute Transport with Chemical Reaction
Step 1 (Cobalt Transport): PASS Initial and Date: G 13 Jun 2001

Test Identifier: 19. Three dimensional Radionuclide Transport
Step 1 (Decay Chain Transport): PASS Initial and Date: G 13 Jun 2001

Test Identifier: 20. Streamline Particle Tracking Model
Step 1 (Breakthrough Curve): PASS Initial and Date: G 13 Jun 2001
Step 2 (Situ Concentration Profile): PASS Initial and Date: G 13 Jun 2001

Test Identifier: 21. Cell-Based particle Tracking Model
Step 1 (Breakthrough Curve): PASS Initial and Date: G 13 Jun 2001
Step 2 (Sorbing & Matrix Diffusion Model): PASS Initial and Date: G 13 Jun 2001
Step 3 (Sorption of Intermediate Species): PASS Initial and Date: G 13 Jun 2001
Step 4 (GoldSim Interface): PASS Initial and Date: G 13 Jun 2001

7. FAILURE CONDITIONS, OCCURRENCE, RESOLUTION

None

8. OVERALL CONCLUSIONS

FEHM V2.10 did not require any source code modification or recompilation to run Windows NT 4.0 operating system. The same executable that was used for Windows 2000 was used for Windows NT 4.0. Comparison of the test results (Attachment 1) shows that they are identical using the two operating systems.

9. DOCUMENTATION AND JUSTIFICATION OF TEST

A copy of the validation tests for FEHM V2.10 using Windows NT 4.0 operating system are provided in Attachment 1.

10. SUMMARY OF UNIT TESTING

Results of the reinstallation of FEHM V2.10 on the PC/Windows NT 4.0 operating system indicate that the change in operating system did not change the results of the software to properly execute when compared to that of the same tests using the baseline qualified PC/Windows 2000 operating system.

11. GENERAL REMARKS

The FEHM V2.10 computer program has previously been tested and qualified using PC/Windows 2000 platform (MOL.20001219.0095). An impact assessment was performed by LANL for FEHM V2.10 to run on the Windows NT version 4.0 operating system and it was concluded that the results were identical for Windows 2000 and Window NT 4.0 operating systems (See Reference below). The comparison was performed without any changes to the source code.

> *"Impact Assessment for Software FEHM Version 2.10 (Windows NT, Version 4.0 Operating System," Z.V. Dash, B. Robinson, August 2001.*

The present VTR supports qualification of the code using PC/Windows NT 4.0 platform. No changes to the code were accomplished by the effort. The testing and qualification were accomplished in accordance with AP-SI.1Q section 5.8.

ATTACHMENT 1

Comparison of the Test Results between Windows 2000 and Windows NT 4.0

Results of FEHM Version 2.10 Comparison Tests
PC Windows NT

SUMMARY of COMPARISON TESTS for FEHM V2.10PC00-10-26 run 010613

\---

************* AVDONIN *************

Avdonin Radial Heat and Mass Transfer Problem
Comparison of Model and Analytical Solution for Temperature vs Time
At R coordinate (m) 37.5000

Test Case	Maximum Error	Maximum % Error	RMS Error
84 nodes	1.2560	0.7744	3.162E-04
400 nodes	0.4036	0.2470	6.951E-05
800 nodes	0.3892	0.2380	6.744E-05

Avdonin Radial Heat and Mass Transfer Problem
Comparison of Model and Analytical Solution for Temperature vs Position
At Time 0.100000E+10

Test Case	Maximum Error	Maximum % Error	RMS Error
84 nodes	0.5233	0.3239	1.746E-04
400 nodes	0.2818	0.1745	3.417E-05
800 nodes	0.2819	0.1746	2.214E-05

************* BAROMETRIC *************

Barometric Pumping Test - effects on pore-scale velocity
Comparison of Model and Analytical Solution for Velocity vs Depth during cycle

Test Case	Maximum Error	Maximum % Error	RMS Error
Time 1.75 days	2.936E-08	33.0800	6.577E-03
Time 3.5 days	3.937E-08	48.9900	3.644E-03
Time 5.25 days	1.451E-08	40.8400	4.018E-03
Time 7 days	4.666E-08	47.9800	3.503E-03

Barometric Pumping Test - Contaminant Transport
Comparison of Model and Analytical Solution for MFR vs Time

Test Case	Maximum Error	Maximum % Error	RMS Error
Alpha 0.0	3.779E-03	0.3978	5.803E-04
Alpha 0.1	2.699E-03	0.3033	4.158E-04
Alpha 0.2	1.088E-03	0.1137	2.261E-04

************* CELLBASED *************

Cell-Based Particle Tracking w/Advection, Dispersion & Matrix Diffusion
Comparison of Model and Analytical Solution for Breakthrough Conc. vs Time

Test Case	Maximum Error	Maximum % Error	RMS Error
No Sorption	3.948E-02	10.9800	7.055E-03
Matrix Sorption	4.073E-02	9.5000	6.158E-03
Diffusion, Matrix&Fracture Sorption	8.112E-03	3.3980	6.206E-04

Cell-Based Particle Tracking - Decay-chain Test
Comparison of Model and CHAIN Solution for Concentration vs Time

Test Case	Maximum Error	Maximum % Error	RMS Error
Species 1	806.3000	38.6100	3.534E-02
Species 2	240.6000	34.8300	2.991E-02
Species 3	156.0000	18.7200	1.111E-02
Species 4	138.6000	43.9200	3.656E-02

************* DISSOLUTION *************

Calcite Dissolution in a One-Dimensional System

Comparison of Model and Analytical Solution for Dissolution Front vs Time

Test Case	Maximum Error	Maximum % Error	RMS Error
Time 20000. seconds	2.161E-03	3.2250	3.225E-02
Time 60000. seconds	3.323E-03	1.6530	1.653E-02
Time 100000. seconds	6.281E-04	0.1875	1.875E-03

************* DOE *************

DOE Code Comparison Project, Problem 5, Case A

Comparison of FEHM and Other Code Solutions for Temperature vs Time

At X, Y coordinates (m) 62.5000 62.5000

Test Case	Maximum Error	Maximum % Error	RMS Error
Code 1	1.3560	0.6532	7.746E-04
Code 2	1.5190	0.6471	1.070E-03
Code 3	1.6230	0.6867	1.259E-03
Code 4	2.0030	0.8528	1.139E-03
Code 5	1.4980	0.7299	9.932E-04
Code 6	1.3680	0.5906	1.379E-03

DOE Code Comparison Project, Problem 5, Case A

Comparison of FEHM and Other Code Solutions for Pressure vs Time

At X, Y coordinates (m) 62.5000 62.5000

Test Case	Maximum Error	Maximum % Error	RMS Error
Code 1	5.124E-02	1.5810	1.908E-03
Code 2	6.127E-02	2.0220	3.137E-03
Code 3	5.347E-02	1.7700	3.234E-03
Code 4	6.233E-02	2.0570	3.017E-03
Code 5	2.149E-02	0.7164	1.199E-03
Code 6	2.828E-02	0.9395	1.637E-03

DOE Code Comparison Project, Problem 5, Case A

Comparison of FEHM and Other Code Solutions for Pressure vs Time

At X, Y coordinates (m) 162.500 137.500

Test Case	Maximum Error	Maximum % Error	RMS Error
Code 1	2.530E-02	0.7312	8.878E-04
Code 2	2.534E-02	0.7610	7.676E-04
Code 3	1.656E-02	0.4842	8.250E-04
Code 4	2.215E-02	0.6651	7.065E-04
Code 5	3.449E-02	1.0420	1.879E-03
Code 6	3.445E-02	1.0410	2.547E-03

************* DRYOUT *************

Dry-Out of a Partially Saturated Medium

Comparison of Dryout Front vs Time without Vapor Pressure Lowering

Test Case	Maximum Error	Maximum % Error	RMS Error
Time 100 days	4.637E-05	0.1903	1.903E-03
Time 200 days	2.889E-04	0.5927	5.927E-03
Time 300 days	6.240E-04	0.8534	8.534E-03
Time 400 days	1.064E-03	1.0910	1.091E-02
Time 500 days	1.571E-03	1.2890	1.289E-02

Dry-Out of a Partially Saturated Medium

Comparison of Dryout Front vs Time with Vapor Pressure Lowering

Test Case	Maximum Error	Maximum % Error	RMS Error
Time 200 days	2.813E-04	1.1540	1.154E-02
Time 400 days	2.582E-04	0.5297	5.297E-03
Time 600 days	4.542E-05	6.212E-02	6.212E-04
Time 800 days	2.941E-04	0.3017	3.017E-03
Time 1000 days	7.099E-04	0.5826	5.826E-03

************ DUAL *************

Dual Porosity Problem

Comparison of Model and Analytical Solution - Pressure vs Time (nondimensional)

At R coordinate (m) 0.139800

Test Case	Maximum Error	Maximum % Error	RMS Error
Case 1	3.784E-02	1.1770	7.994E-04
Case 2	1.858E-02	0.6075	5.318E-04
Case 3	1.995E-02	0.6331	5.482E-04

************ FRACTURE_TRANSPORT *************

Fracture Transport with Matrix Diffusion

Comparison of Model and Analytical Solution for Concentration vs Time

At X, Y coordinates (m) 0.00000 5000.00

Test Case	Maximum Error	Maximum % Error	RMS Error
No Sorption	2.804E-02	9.0820	1.410E-03
Matrix Sorption	1.758E-02	13.3700	2.204E-03
Matrix & Fracture Sorption	1.707E-02	4.6630	2.108E-03

Fracture Transport with Matrix Diffusion - GDPM formulation

Comparison of Model and Analytical Solution for Concentration vs Time

At X, Y coordinates (m) 5000.00 0.00000

Test Case	Maximum Error	Maximum % Error	RMS Error
No Sorption	3.043E-02	11.7200	1.553E-03
Matrix Sorption	2.357E-02	19.1600	2.662E-03

************ HEAD *************

Head Pressure Problem

Comparison of Head and Pressure Formulation for Pressure vs Position

At Time 365.000

Test Case	Maximum Error	Maximum % Error	RMS Error
Depth 0 meters	4.116E-04	3.010E-02	1.505E-04
Depth 25 meters	2.606E-04	2.321E-02	1.160E-04
Depth 50 meters	1.419E-04	1.614E-02	8.071E-05
Depth 75 meters	5.531E-05	8.714E-03	4.357E-05
Depth 100 meters	9.260E-07	2.371E-04	1.185E-06
Node by node comparison	4.116E-04	3.010E-02	1.702E-05

************ HEAT2D *************

2-D Heat Conduction Problem

Comparison of Model and Analytical Solution for Temperature vs Time

At X, Y coordinates (m) 0.00000 0.00000

Test Case	Maximum Error	Maximum % Error	RMS Error
3-node Triangles	0.5805	0.4162	7.661E-05
4-node Quadrilaterals	0.7140	0.3666	4.060E-05

Mixed Elements	0.5530	0.2815	5.129E-05
Refined Elements	0.8345	0.4313	4.253E-05

2-D Heat Conduction Problem
Comparison of Model and Analytical Solution for Temperature vs Position
At Time 21600.0

Test Case	Maximum Error	Maximum % Error	RMS Error
3-node Triangles	0.5978	0.3423	7.415E-04
4-node Quadrilaterals	0.7066	0.3649	8.162E-04
Mixed Elements	0.6671	0.3466	7.644E-04
Refined Elements	0.8615	0.4452	8.725E-04

************* HEAT3D *************
3-D Heat Conduction Problem
Comparison of Model and Analytical Solution for Temperature vs Time
At X, Y, Z coordinates (m) 0.00000 0.00000 0.00000

Test Case	Maximum Error	Maximum % Error	RMS Error
6-node Triangular Prisms	0.7860	0.5670	1.164E-04
8-node Quadrilateral Polyhedrons	1.0190	0.5275	6.811E-05
4-node Tetrahedrals	1.2450	0.6520	7.690E-05
Mixed Elements	0.8470	0.4349	7.936E-05
Refined Elements	1.2670	0.6632	7.874E-05
Polyhedrons, Finite Volume Option	1.0190	0.5275	6.811E-05
Ref. Elements, Finite Volume Option	1.0320	0.5343	6.892E-05

3-D Heat Conduction Problem
Comparison of Model and Analytical Solution for Temperature vs Position
At Time 21600.0

Test Case	Maximum Error	Maximum % Error	RMS Error
6-node Triangular Prisms	0.7957	0.5284	1.056E-03
8-node Quadrilateral Polyhedrons	0.9912	0.5200	1.065E-03
4-node Tetrahedrals	1.2430	0.6523	1.157E-03
Mixed Elements	0.8211	0.4403	9.982E-04
Refined Elements	1.2650	0.6634	1.124E-03
Polyhedrons, Finite Volume Option	0.9912	0.5200	1.065E-03
Ref. Elements, Finite Volume Option	1.0050	0.5273	1.075E-03

************* HENRYS_LAW *************
1-D Henry's Law Species
Comparison of Model and Analytical Solution for Concentration vs Time
At R coordinate (m) 1.00000

Test Case	Maximum Error	Maximum % Error	RMS Error
Air Movement Through Stagnant Water	9.947E-03	7.4640	4.910E-04
Water Movement Through Stagnant Air	7.292E-03	2.7220	2.904E-04

************* INFILTRATION *************
Infiltration Problem using the Equivalent Continuum Method
Comparison of FEHM and TOUGH2 Solution for Saturation vs Elevation
At Time 0.100000E+10

Test Case	Maximum Error	Maximum % Error	RMS Error
ECM	5.639E-02	8.1690	1.423E-03

Infiltration Problem using the Double Porosity/Double Permeability Method

Comparison of FEHM and TOUGH2 Solution for Saturation vs Elevation
At Time 0.100000E+10

Test Case	Maximum Error	Maximum % Error	RMS Error
DPM - matrix	8.151E-02	17.1200	2.068E-03
DPM - fracture	1.022E-02	355.0000	3.679E-03

************ MULTI_SOLUTE ************

Multi-Solute Transport with Chemical Reaction
Comparison of FEHM and PDREACT Solution for Concentration vs Time
At R coordinate (m) 10.0000

Test Case	Maximum Error	Maximum % Error	RMS Error
Species Co_aq	3.916E-06	0.7115	3.879E-04
Species Fe_aq	1.652E-15	1.0250	1.031E-03
Species EDTA_aq	9.630E-13	11.2100	5.986E-03
Species CoEDTA_aq	1.442E-04	3.6850	2.222E-03
Species FeEDTA_aq	3.667E-05	2.6400	1.747E-03
Species CoEDTA_s	7.826E-05	5.8390	3.178E-03
Species Co_s	1.866E-05	0.9680	6.416E-04
Species FeEDTA_s	1.438E-05	3.2470	2.229E-03

************ RAMEY ************

Temperature in a Wellbore (Ramey) Problem
Comparison of Model and Analytical Solution for Temperature vs Time

Test Case	Maximum Error	Maximum % Error	RMS Error
Depth 0. meters	2.573E-02	0.1286	3.112E-05
Depth 1000. meters	1.3450	2.8150	1.556E-03
Depth 2000. meters	1.0570	1.3580	1.061E-03

Temperature in a Wellbore (Ramey) Problem
Comparison of Model and Analytical Solution for Temperature vs Depth
At Time 0.216000E+07

Test Case	Maximum Error	Maximum % Error	RMS Error
Time 25 days	0.6971	1.0260	5.203E-04

************ SORPTION ************

One Dimensional Reactive Solute Transport
Comparison of FEHM and SORBEQ for Concentration vs Time
At R coordinate (m) 1.00000

Test Case	Maximum Error	Maximum % Error	RMS Error
Isotherm: Conservative	9.711E-03	9.4930	2.902E-04
Isotherm: Linear	4.509E-03	2.2250	1.787E-04
Isotherm: Langmuir	9.151E-03	5.4050	2.385E-04
Isotherm: Freundlich	1.166E-02	2.1270	2.504E-04
Isotherm: Modified Freundlich	2.568E-02	8.0140	7.802E-04

************ STREAMLINE ************

Streamline Particle Tracking w/Advection, Dispersion & Matrix Diffusion
Comparison of Model and Analytical Solution for Concentration vs Time

Test Case	Maximum Error	Maximum % Error	RMS Error
No Sorption	9.481E-02	54.4000	2.993E-03
Matrix Sorption	9.437E-02	45.0500	5.560E-03
Matrix Diffusion, No Sorption	4.811E-02	21.7400	3.973E-03

Streamline Particle Tracking w/Longitudinal & Tranverse Dispersion
Comparison of Model and Analytical Solution for Concentration Profiles

Test Case	Maximum Error	Maximum % Error	RMS Error
Profile at 4800 m 10,000 Particles	1.192E-02	4.6640	1.350E-02
Profile at 4800 m 100,000 Particles	5.900E-03	11.7900	1.918E-02
Profile at 10000 m 10,000 Particles	2.524E-02	10.2200	1.914E-02
Profile at 10000 m 100,000 Particles	7.824E-03	6.2610	1.273E-02

************* THEIS *************
Pressure Transient Analysis (Theis) Problem
Comparison of Model and Analytical Solution for Pressure vs Time

Test Case	Maximum Error	Maximum % Error	RMS Error
Radius 0.00144 meters	1.101E-05	1.100E-03	6.681E-08
Radius 3.44825 meters	6.010E-06	6.010E-04	7.722E-08

Pressure Transient Analysis (Theis) Problem
Comparison of Model and Analytical Solution for Pressure vs Position
At Time 86400.0

Test Case	Maximum Error	Maximum % Error	RMS Error
Time 1 day	2.843E-06	2.842E-04	1.742E-07

************* THERMODYNAMICS *************
Comparison of Steam Table vs FEHM Values
Thermodynamic property as a Function of Pressure and Temperature

Test Case	Maximum Error	Maximum % Error	RMS Error
Liquid enthalpy	2.100E-03	0.1319	1.732E-05
Vapor enthalpy	9.000E-05	3.125E-03	3.130E-06
Liquid density	1.5220	0.2482	2.018E-05
Vapor density	2.550E-02	5.794E-02	6.295E-05
Liquid compressibility	2.160E-03	16.0000	5.182E-03
Vapor compressibility	1.2870	0.1297	4.074E-04
Liquid viscosity	3.224E-06	0.5244	9.222E-05
Vapor viscosity	3.650E-08	0.1601	1.687E-04
Saturation pressures	2.575E-02	0.3000	4.687E-04
Saturation temperatures	1.1000	0.4000	5.943E-04

************* TORONYI *************
Toronyi Two-phase Problem
Comparison of FEHM and Thomas & Pierson Solution for Final Saturation
At Time 78.3000

Test Case	Maximum Error	Maximum % Error	RMS Error
Node by node comparison	1.542E-03	1.3180	7.719E-04

************* TRANSPORT3D *************
Three-Dimensional Radionuclide Transport Problem
Comparison of FEHM and TRACRN for Concentration vs Time

Test Case	Maximum Error	Maximum % Error	RMS Error
Conservative Tracer, Point 1	5.296E-02	6.6030	1.308E-03
Conservative Tracer, Point 2	1.607E-02	10.7800	1.813E-03
Conservative Tracer, Point 3	3.646E-03	4.5320	8.533E-04
Conservative Tracer, Point 4	1.016E-03	2.8520	1.261E-03

Am Tracer, Point 1	4.800E-02	7.2750	1.523E-03
Am Tracer, Point 2	1.589E-02	14.8100	3.423E-03
Am Tracer, Point 3	1.042E-03	12.6900	3.293E-03
Am Tracer, Point 4	1.992E-05	15.0200	4.231E-03

************ VAPOR_EXTRACTION ************

Vapor Extraction from an Unsaturated Reservoir

Comparison of Model and Analytical Solution for Vapor Pressure vs Position

Test Case	Maximum Error	Maximum % Error	RMS Error
Isotropic	1.983E-03	2.1950	8.838E-05
Anisotropic	3.066E-03	3.3110	1.436E-04

NOTE: Tests executed on system running Windows NT Version 4.0

Results of FEHM Version 2.10 Comparison Tests
PC Windows 2000

SUMMARY of COMPARISON TESTS for FEHM V2.10PC00-10-26 run 001101

************* AVDONIN *************

Avdonin Radial Heat and Mass Transfer Problem
Comparison of Model and Analytical Solution for Temperature vs Time
At R coordinate (m) 37.5000

Test Case	Maximum Error	Maximum % Error	RMS Error
84 nodes	1.2560	0.7744	2.162E-04
400 nodes	0.4036	0.2470	6.951E-05
800 nodes	0.3892	0.2380	6.744E-05

Avdonin Radial Heat and Mass Transfer Problem
Comparison of Model and Analytical Solution for Temperature vs Position
At Time 0.100000E+10

Test Case	Maximum Error	Maximum % Error	RMS Error
84 nodes	0.5233	0.3239	1.746E-04
400 nodes	0.2818	0.1745	3.417E-05
800 nodes	0.2819	0.1746	2.214E-05

************* BAROMETRIC *************

Barometric Pumping Test - effects on pore-scale velocity
Comparison of Model and Analytical Solution for Velocity vs Depth during cycle

Test Case	Maximum Error	Maximum % Error	RMS Error
Time 1.75 days	2.936E-08	33.0800	6.577E-03
Time 3.5 days	3.937E-08	48.9900	3.644E-03
Time 5.25 days	1.451E-08	40.8400	4.018E-03
Time 7 days	4.666E-08	47.9800	3.503E-03

************* CELLBASED *************

Cell-Based Particle Tracking w/Advection, Dispersion & Matrix Diffusion
Comparison of Model and Analytical Solution for Breakthrough Conc. vs Time

Test Case	Maximum Error	Maximum % Error	RMS Error
No Sorption	3.948E-02	10.9800	7.055E-03
Matrix Sorption	4.073E-02	9.5000	6.158E-03
Diffusion, Matrix&Fracture Sorption	8.112E-03	3.3980	6.206E-04

************* DISSOLUTION *************

Calcite Dissolution in a One-Dimensional System
Comparison of Model and Analytical Solution for Dissolution Front vs Time

Test Case	Maximum Error	Maximum % Error	RMS Error
Time 20000. seconds	2.161E-03	3.2250	3.225E-02
Time 60000. seconds	3.323E-03	1.6530	1.653E-02
Time 100000. seconds	6.281E-04	0.1875	1.875E-03

************* DOE *************

DOE Code Comparison Project, Problem 5, Case A
Comparison of FEHM and Other Code Solutions for Temperature vs Time
At X, Y coordinates (m) 62.5000 62.5000

Test Case	Maximum Error	Maximum % Error	RMS Error
Code 1	1.3560	0.6532	7.746E-04
Code 2	1.5190	0.6471	1.070E-03
Code 3	1.6230	0.6867	1.259E-03
Code 4	2.0030	0.8528	1.139E-03
Code 5	1.4980	0.7299	9.932E-04
Code 6	1.3680	0.5906	1.379E-03

DOE Code Comparison Project, Problem 5, Case A
Comparison of FEHM and Other Code Solutions for Pressure vs Time
At X, Y coordinates (m) 62.5000 62.5000

Test Case	Maximum Error	Maximum % Error	RMS Error
Code 1	5.124E-02	1.5810	1.908E-03
Code 2	6.127E-02	2.0220	3.137E-03
Code 3	5.347E-02	1.7700	3.234E-03
Code 4	6.233E-02	2.0570	3.017E-03
Code 5	2.149E-02	0.7164	1.199E-03
Code 6	2.828E-02	0.9395	1.637E-03

DOE Code Comparison Project, Problem 5, Case A
Comparison of FEHM and Other Code Solutions for Pressure vs Time
At X, Y coordinates (m) 162.500 137.500

Test Case	Maximum Error	Maximum % Error	RMS Error
Code 1	2.530E-02	0.7312	8.878E-04
Code 2	2.534E-02	0.7610	7.676E-04
Code 3	1.656E-02	0.4842	8.250E-04
Code 4	2.215E-02	0.6651	7.065E-04
Code 5	3.449E-02	1.0420	1.879E-03
Code 6	3.445E-02	1.0410	2.547E-03

************ DRYOUT *************
Dry-Out of a Partially Saturated Medium
Comparison of Dryout Front vs Time without Vapor Pressure Lowering

Test Case	Maximum Error	Maximum % Error	RMS Error
Time 100 days	4.637E-05	0.1903	1.903E-03
Time 200 days	2.889E-04	0.5927	5.927E-03
Time 300 days	6.240E-04	0.8534	8.534E-03
Time 400 days	1.064E-03	1.0910	1.091E-02
Time 500 days	1.571E-03	1.2890	1.289E-02

Dry-Out of a Partially Saturated Medium
Comparison of Dryout Front vs Time with Vapor Pressure Lowering

Test Case	Maximum Error	Maximum % Error	RMS Error
Time 200 days	2.813E-04	1.1540	1.154E-02
Time 400 days	2.582E-04	0.5297	5.297E-03
Time 600 days	4.542E-05	6.212E-02	6.212E-04
Time 800 days	2.941E-04	0.3017	3.017E-03
Time 1000 days	7.099E-04	0.5826	5.826E-03

************ DUAL *************
Dual Porosity Problem
Comparison of Model and Analytical Solution - Pressure vs Time (nondimensional)
At R coordinate (m) 0.139800

Test Case	Maximum Error	Maximum % Error	RMS Error
Case 1	3.784E-02	1.1770	7.994E-04
Case 2	1.858E-02	0.6075	5.318E-04
Case 3	1.995E-02	0.6331	5.482E-04

************ FRACTURE_TRANSPORT *************
Fracture Transport with Matrix Diffusion
Comparison of Model and Analytical Solution for Concentration vs Time
At X, Y coordinates (m) 0.00000 5000.00

Test Case	Maximum Error	Maximum % Error	RMS Error
No Sorption	2.804E-02	9.0820	1.410E-03
Matrix Sorption	1.758E-02	13.3700	2.204E-03

Matrix & Fracture Sorption	1.707E-02	4.6630	2.105E-03

Fracture Transport with Matrix Diffusion - GDPM formulation
Comparison of Model and Analytical Solution for Concentration vs Time
At X, Y coordinates (m) 5000.00 0.00000

Test Case	Maximum Error	Maximum % Error	RMS Error
No Sorption	3.043E-02	11.7200	1.553E-03
Matrix Sorption	2.357E-02	19.1600	2.662E-03

************ HEAD *************
Head Pressure Problem
Comparison of Head and Pressure Formulation for Pressure vs Position
At Time 365.000

Test Case	Maximum Error	Maximum % Error	RMS Error
Depth 0 meters	4.116E-04	3.010E-02	1.505E-04
Depth 25 meters	2.606E-04	2.321E-02	1.160E-04
Depth 50 meters	1.419E-04	1.614E-02	8.071E-05
Depth 75 meters	5.531E-05	8.714E-03	4.357E-05
Depth 100 meters	9.260E-07	2.371E-04	1.185E-06
Node by node comparison	4.116E-04	3.010E-02	1.702E-05

************ HEAT2D *************
2-D Heat Conduction Problem
Comparison of Model and Analytical Solution for Temperature vs Time
At X, Y coordinates (m) 0.00000 0.00000

Test Case	Maximum Error	Maximum % Error	RMS Error
3-node Triangles	0.5805	0.4162	7.661E-05
4-node Quadrilaterals	0.7140	0.3666	4.060E-05
Mixed Elements	0.5530	0.2815	5.129E-05
Refined Elements	0.8345	0.4313	4.253E-05

2-D Heat Conduction Problem
Comparison of Model and Analytical Solution for Temperature vs Position
At Time 21600.0

Test Case	Maximum Error	Maximum % Error	RMS Error
3-node Triangles	0.5978	0.3423	7.415E-04
4-node Quadrilaterals	0.7066	0.3649	8.162E-04
Mixed Elements	0.6671	0.3466	7.644E-04
Refined Elements	0.8615	0.4452	8.725E-04

************ HEAT3D *************
3-D Heat Conduction Problem
Comparison of Model and Analytical Solution for Temperature vs Time
At X, Y, Z coordinates (m) 0.00000 0.00000 0.00000

Test Case	Maximum Error	Maximum % Error	RMS Error
6-node Triangular Prisms	0.7860	0.5670	1.164E-04
8-node Quadrilateral Polyhedrons	1.0190	0.5275	6.811E-05
4-node Tetrahedrals	1.2450	0.6520	7.690E-05
Mixed Elements	0.8470	0.4349	7.936E-05
Refined Elements	1.2670	0.6632	7.874E-05
Polyhedrons, Finite Volume Option	1.0190	0.5275	6.811E-05
Ref. Elements, Finite Volume Option	1.0320	0.5343	6.892E-05

3-D Heat Conduction Problem
Comparison of Model and Analytical Solution for Temperature vs Position
At Time 21600.0

Test Case	Maximum Error	Maximum % Error	RMS Error

6-node Triangular Prisms	0.7957	0.5284	1.056E-03
8-node Quadrilateral Polyhedrons	0.9912	0.5200	1.065E-03
4-node Tetrahedrals	1.2430	0.6523	1.157E-03
Mixed Elements	0.8211	0.4403	9.982E-04
Refined Elements	1.2650	0.6634	1.124E-03
Polyhedrons, Finite Volume Option	0.9912	0.5200	1.065E-03
Ref. Elements, Finite Volume Option	1.0050	0.5273	1.075E-03

************* HENRYS_LAW *************

1-D Henry's Law Species
Comparison of Model and Analytical Solution for Concentration vs Time
At R coordinate (m) 1.00000

Test Case	Maximum Error	Maximum % Error	RMS Error
Air Movement Through Stagnant Water	9.947E-03	7.4640	4.910E-04
Water Movement Through Stagnant Air	7.292E-03	2.7220	2.904E-04

************* INFILTRATION *************

Infiltration Problem using the Equivalent Continuum Method
Comparison of FEHM and TOUGH2 Solution for Saturation vs Elevation
At Time 0.100000E+10

Test Case	Maximum Error	Maximum % Error	RMS Error
ECM	5.639E-02	6.1690	1.423E-03

Infiltration Problem using the Double Porosity/Double Permeability Method
Comparison of FEHM and TOUGH2 Solution for Saturation vs Elevation
At Time 0.100000E+10

Test Case	Maximum Error	Maximum % Error	RMS Error
DPM - matrix	8.151E-02	17.1200	2.068E-03
DPM - fracture	1.022E-02	355.0000	3.679E-02

************* MULTI_SOLUTE *************

Multi-Solute Transport with Chemical Reaction
Comparison of FEHM and PDREACT Solution for Concentration vs Time
At R coordinate (m) 10.0000

Test Case	Maximum Error	Maximum % Error	RMS Error
Species Co_aq	3.916E-06	0.7115	3.879E-04
Species Fe_aq	1.652E-15	1.0250	1.031E-03
Species EDTA_aq	9.630E-13	11.2100	5.986E-03
Species CoEDTA_aq	1.442E-04	3.6850	2.222E-03
Species FeEDTA_aq	3.667E-05	2.6400	1.747E-03
Species CoEDTA_s	7.826E-05	5.8390	3.178E-03
Species Co_s	1.866E-05	0.9680	6.416E-04
Species FeEDTA_s	1.438E-05	3.2470	2.229E-03

************* RAMEY *************

Temperature in a Wellbore (Ramey) Problem
Comparison of Model and Analytical Solution for Temperature vs Time

Test Case	Maximum Error	Maximum % Error	RMS Error
Depth 0. meters	2.573E-02	0.1286	3.112E-05
Depth 1000. meters	1.3450	2.8150	1.556E-03
Depth 2000. meters	1.0570	1.3580	1.061E-03

Temperature in a Wellbore (Ramey) Problem
Comparison of Model and Analytical Solution for Temperature vs Depth
At Time 0.216000E+07

Test Case	Maximum Error	Maximum % Error	RMS Error
Time 25 days	0.6971	1.0260	5.203E-04

************* SORPTION *************

One Dimensional Reactive Solute Transport
Comparison of FEHM and SORBEQ for Concentration vs Time
At R coordinate (m) 1.00000

Test Case	Maximum Error	Maximum % Error	RMS Error
Isotherm: Conservative	9.711E-03	9.4930	2.902E-04
Isotherm: Linear	4.509E-03	2.2250	1.787E-04
Isotherm: Langmuir	9.151E-03	5.4050	2.385E-04
Isotherm: Freundlich	1.166E-02	2.1270	2.504E-04
Isotherm: Modified Freundlich	2.568E-02	8.0140	7.802E-04

************* STREAMLINE *************

Streamline Particle Tracking w/Advection, Dispersion & Matrix Diffusion
Comparison of Model and Analytical Solution for Concentration vs Time

Test Case	Maximum Error	Maximum % Error	RMS Error
No Sorption	9.481E-02	54.4000	2.993E-03
Matrix Sorption	9.437E-02	45.0500	5.560E-03
Matrix Diffusion, No Sorption	4.811E-02	21.7400	3.973E-03

Streamline Particle Tracking w/Longitudinal & Tranverse Dispersion
Comparison of Model and Analytical Solution for Concentration Profiles

Test Case	Maximum Error	Maximum % Error	RMS Error
Profile at 4800 m 10,000 Particles	1.192E-02	4.6640	1.350E-02
Profile at 4800 m 100,000 Particles	5.900E-03	11.7900	1.918E-02
Profile at 10000 m 10,000 Particles	2.524E-02	10.2200	1.914E-02
Profile at 10000 m 100,000 Particles	7.824E-03	6.2610	1.273E-02

************* THEIS *************

Pressure Transient Analysis (Theis) Problem
Comparison of Model and Analytical Solution for Pressure vs Time

Test Case	Maximum Error	Maximum % Error	RMS Error
Radius 0.00144 meters	1.101E-05	1.100E-03	6.681E-08
Radius 3.44825 meters	6.010E-06	6.010E-04	7.722E-08

Pressure Transient Analysis (Theis) Problem
Comparison of Model and Analytical Solution for Pressure vs Position
At Time 86400.0

Test Case	Maximum Error	Maximum % Error	RMS Error
Time 1 day	2.843E-06	2.842E-04	1.742E-07

************* THERMODYNAMICS *************

Comparison of Steam Table vs FEHM Values
Thermodynamic property as a Function of Pressure and Temperature

Test Case	Maximum Error	Maximum % Error	RMS Error
Liquid enthalpy	2.100E-03	0.1319	1.732E-05
Vapor enthalpy	9.000E-05	3.125E-03	3.130E-06
Liquid density	1.5220	0.2482	2.018E-05
Vapor density	2.550E-02	5.794E-02	6.295E-05
Liquid compressibility	2.160E-03	16.0000	5.182E-03
Vapor compressibility	1.2870	0.1297	4.074E-04
Liquid viscosity	3.224E-06	0.5244	9.222E-05
Vapor viscosity	3.650E-08	0.1601	1.687E-04
Saturation pressures	2.575E-02	0.3000	4.687E-04
Saturation temperatures	1.1000	0.4000	5.943E-04

************* TORONYI *************

Toronyi Two-phase Problem
Comparison of FEHM and Thomas & Pierson Solution for Final Saturation
At Time 78.3000

Test Case	Maximum Error	Maximum % Error	RMS Error
Node by node comparison	1.542E-03	1.3180	7.719E-04

************ TRANSPORT3D ************

Three-Dimensional Radionuclide Transport Problem
Comparison of FEHM and TRACRN for Concentration vs Time

Test Case	Maximum Error	Maximum % Error	RMS Error
Conservative Tracer, Point 1	5.296E-02	6.6030	1.308E-03
Conservative Tracer, Point 2	1.607E-02	10.7800	1.813E-03
Conservative Tracer, Point 3	3.646E-03	4.5320	8.533E-04
Conservative Tracer, Point 4	1.016E-03	2.8520	1.261E-03
Am Tracer, Point 1	4.800E-02	7.2750	1.523E-03
Am Tracer, Point 2	1.589E-02	14.8100	3.423E-03
Am Tracer, Point 3	1.042E-03	12.6900	3.293E-03
Am Tracer, Point 4	1.992E-05	15.0200	4.231E-03

************ VAPOR_EXTRACTION ************

Vapor Extraction from an Unsaturated Reservoir
Comparison of Model and Analytical Solution for Vapor Pressure vs Position

Test Case	Maximum Error	Maximum % Error	RMS Error
Isotropic	1.983E-03	2.1950	8.838E-05
Anisotropic	3.066E-03	3.3110	1.436E-04

NOTE: Tests executed on system running Microsoft Windows 2000 [Version 5.00.2195]