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A Finite-Line Heat Transfer Code with Automated Sensitivity-Calculation Capability

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A FINITE-LINE HEAT TRANSFER CODE WITH AUTOMATED SENSITIVITY-CALCULATION CAPABILITY

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ABSTRACT

The finite-line heat transfer code, TEMP, is used to calculate temperature distributions within geological repositories for high-level nuclear waste. A capability to concurrently calculate the sensitivity of the temperature distribution to any or all data of interest was incorporated into this code using an automated procedure called GRESS. Only two man-weeks of effort were required for this process. The accuracy of the GRESS-added sensitivity calculation capability was verified using comparisons of GRESS-calculated sensitivities with sensitivities estimated from perturbation analysis for all 189 TEMP sample cases. This successful GRESS enhancement of TEMP and the associated verification analysis contributes to the overall program of validating the GRESS procedure.

INTRODUCTION

TEMP[1] is a heat transfer code for calculating the temperature distribution within geologic repositories for nuclear waste. The code uses a semi-analytical technique for determining the temperature rise from a finite-length line-source in a solid and isotropic medium of infinite extent. The time-dependent temperature distribution in an infinite array of sources and in a source geometry typical of a High Level Waste (HLW) repository can be calculated by superimposing single source temperature distributions. The TEMP code will be used in conjunction with UCBNE10.2[2] and WAPPA[3] in the repository performance assessment. The purpose of this paper is to report on the testing and verification of a version of TEMP that will calculate, on option, the derivative of all responses with respect to any variable used in the code.

BACKGROUND

The Office of Nuclear Waste Isolation (ONWI) is responsible for the characterization and performance assessment of candidate High-Level Waste Salt Repository sites. Because of the large uncertainties generally associated with the data characterizing geological media and waste behavior and because of the predictive nature of the simulations supporting the assessment, sensitivity and uncertainty analysis are necessary components of the overall performance assessment. To date both statistical and deterministic methods have been used to calculate uncertainties associated with the geological disposal of High-Level Waste.[4]

Generally, statistical methods are preferred for codes with a moderate number of parameters; direct deterministic methods when there are many performance measures of interest and a moderate number of parameters; and adjoint deterministic methods when there are a limited number of performance measures and a large number of parameters. For large codes with an extensive data base, such as the computer models used by ONWI for performance assessment, the deterministic approaches are more cost efficient for producing a comprehensive ranking of sensitivities of results to data. Both the direct and adjoint perturbation methods, which have been widely used in analyses of nuclear systems,[5] rely on model reruns for calculating first derivatives. The cost of the reruns can be prohibitively expensive depending upon the scope of the analysis and the number of variables of interest. To circumvent this problem, a procedure[6] was developed to make use of computer calculus and the chain rule of differentiation to calculate first derivatives of any model

variable to any other model variable. In addition, to avoid the costly programming effort of implementing this capability in the various codes of interest to ONWI, a Gradient-Enhanced Software System (GRESS)[7] was developed that automatically adds the necessary lines of coding to any FORTRAN source program. GRESS has already been successfully applied to the SWENT, UCBNE10.2, ORIGEN2, and WAPPA computer codes.[8,9,10,11] The following sections summarize the application of GRESS to TEMP and the testing and verification of TEMPG, the gradient-enhanced version of TEMP.

APPLICATION OF GRESS TO TEMP

The TEMP code is written to execute on a VAX-11/780 computer. The current version of GRESS must precompile on an IBM Q compiler. Therefore several modifications to TEMP were necessary for compatibility with GRESS. Character variables were changed to REAL or REAL*8 as appropriate. Hollerith strings in ASSIGNMENT and IF statements were eliminated and replaced with strings defined as variables in DATA statements. Character strings in write statements were eliminated and put in FORMAT statements. Arithmetic computations in WRITE statements were replaced by variables previously calculated. IF-THEN-ELSE statements were converted to equivalent logic using GO TO statements. Variables with more than 6 characters were shortened to 6 characters.

One problem in calculating sensitivities uncovered in the testing of TEMPG concerns the procedure to determine T given the calculated value of ϕ in the equation

$$\phi = \int_{T_I}^{T} k(t)dt. \tag{1}$$

The original procedure to determine T in TEMP (SUBROUTINE CORRECT) was to make systematic guesses at T until the evaluated integral falls within a given convergence criteria compared to the known value of ϕ. The value of ϕ is calculated in the computer model and depends upon the problem data. Guessing at T introduces a discontinuity in that the final value of T is not computationally related to the value of ϕ. Hence all derivatives of T with respect to ϕ and thus with respect to the data were being lost. To circumvent this problem, we replaced this guessing procedure with a straightforward technique that accounts for the fact that the derivative of the integral in Eq. (1) can be evaluated and used to determine a new estimate of T.

In the new procedure, an initial estimate of T, T_i, is calculated based upon ϕ. The integral in Eq. (1) is then calculated to give ϕ_i. If the value of $|\phi_i - \phi|$ is within a chosen convergence range, then the search for T terminates successfully. If not, Eq. (1) is differentiated such that

$$\left[\frac{d\phi}{dT}\right]_i = k(T_i), \tag{2}$$

and a new estimate of ϕ, ϕ_{i+1}, can be calculated to first order by

$$\phi_{i+1} = \phi_i + \left[\frac{d\phi}{dT}\right]_i (T_{i+1} - T_i).$$

Setting $\phi_{i+1} = \phi$, and using Eq. 2, a new estimate of T is given by

$$T_{i+1} = (\phi - \phi_i)/k(T_i) + T_i. \tag{3}$$

The calculation of the integral in Eq. 1 is repeated by setting $T = T^{i+1}$. This iterative process is carried out until the convergence criteria is met. Since k(+) increases monotonically in the interval of interest, convergence is guaranteed. Note that now T^{i+1} is directly computed from ϕ such that all derivatives are propagated. This procedure also converges much more rapidly than the original guessing technique.

Only two man-weeks effort was required to modify TEMP, identify and implement the iterative procedure to calculate T, and to produce the derivative-enhanced version TEMPG.

TEMPG VERIFICATION

The testing of TEMPG and the verification that first-derivatives are calculated correctly in TEMPG was performed by comparisons against results from reruns of TEMP. The sensitivities of 245 different cases were directly compared using Benchmarks 3 and 4 from Ref. 1. Benchmark 3 is a calculation of temperatures from a single Commercial High Level Waste (CHLW) spent fuel assembly in a medium with temperature dependent thermal conductivity. Benchmark 4 treats an infinite array of CHLW spent fuel assemblies in a medium with temperature dependent thermal conductivity.

The reference input parameters for Benchmarks 3 are listed in Table 1. The temperature is calculated at 14 locations at 10 different times after burial, giving a total of 140 temperatures. The TEMPG version calculates gradients and first-order sensitivities of all variables r_j to the input parameters α_i. The first-order sensitivities are defined by $\frac{dr_j}{d\alpha_i} \frac{\alpha_i}{r_j}$. Since there are 140 temperatures of interest and ten input parameters, the total number of sensitivities is 1400. These sensitivities were also calculated by directly rerunning TEMP ten times (by perturbing each parameter +1%), estimating $\frac{dr_j}{d\alpha_i}$ by $\frac{\Delta r_j}{\Delta \alpha_i}$, and computing the value of $\frac{dr_j}{d\alpha_i} \frac{\alpha_i}{r_j}$. Tables 2-11 compare the TEMPG sensitivities to those calculated by reruns. The good agreement between the sensitivities from TEMPG and those from direct calculations verifies that the derivatives calculated using GRESS are correct.

The reference input parameters for Benchmark 4 are listed in Table 12. Because the cost to run the Benchmark 4 sample problem increases significantly for large burial times, only burial times up to 10 years were used in the verification of derivatives. The temperature is calculated at 7 locations at 7 different times after burial for a total of 49 temperatures. Sensitivities of these 49 temperatures to the twelve input parameters were calculated by TEMPG and estimated by direct recalculations from reruns. Tables 13-24 compare the 588 GRESS-calculated and directly calculated sensitivities for Benchmark 4. The good agreement between these sensitivities further verifies that TEMPG correctly calculates derivatives.

CONCLUSIONS

The TEMP heat transfer code was enhanced by the addition of the capability to calculate the sensitivity of model results to any parameter. The GRESS automated procedure was used to add this capability in only two man-weeks effort. The sample cases comprising Benchmarks 3 and 4 from the TEMP users manual were used to verify that the derivatives were correctly calculated in the enhanced version of TEMPG. A comparison between GRESS-calculated sensitivities and sensitivities estimated from direct recalculation from TEMP showed good agreement for all 189 TEMP cases.

The repository performance assessment will use the TEMP, UCBNE10.2, and WAPPA computer models in a series of calculations in which the results and data will be coupled between these three codes. Immediate future analysis plans are to couple these codes' sensitivities within this series of calculations using an automated feature of the GRESS system.[12] The result will be sensitivities of the ultimate performance measures of interest to the most fundamental data. At this point a systematic uncertainty analysis will be performed that takes into account any correlations between the data, thereby reducing the total calculated uncertainty.[13] As the performance assessment progresses, other computer models will be included in the analysis.

Table 1. Reference Value of Input Parameters for Benchmark 3

ACOND	1243.89	Thermal conductivity correlation parameter
BCOND	0.126	Thermal conductivity correlation parameter
RHO	134.8	Density of geological medium, lb/ft^3
CP	0.215	Specific heat of geological medium, Btu/lbm- F
TINIT	89.6	Initial temperature of geological medium, F
MTHM	9.576	Number of metric tons of heavy metal per cannister
SLEN	12.074	Source length, ft
TCOOL	10.0	Source decay time before burial, yrs

TXCORD (X-coordinate of calculated temperature, ft)	TBUR (Time after burial, yrs)
1.46	0.1
3.281	1.0
6.562	2.0
16.405	5.0
20.014	10.0
32.81	20.0
42.981	30.0
49.215	40.0
65.62	50.0
164.05	75.0
328.1	
492.15	
656.2	
820.25	

Table 2. Sensitivity of Temperature to Parameter A in Conductivity Equation for Benchmark 3

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	1.4600	500.6196	504.7993	-0.8280	-0.8361
1.0000	1.4600	572.7834	578.4497	-0.9796	-0.9906
2.0000	1.4600	562.5459	568.1526	-0.9868	-0.9980
5.0000	1.4600	515.2595	520.2839	-0.9657	-0.9766
10.0000	1.4600	443.6191	447.7085	-0.9134	-0.9236
20.0000	1.4600	338.3247	341.0781	-0.8073	-0.8161
30.0000	1.4600	269.8025	271.7324	-0.7102	-0.7175
40.0000	1.4600	222.5450	223.9227	-0.6153	-0.6215
50.0000	1.4600	192.1340	193.1769	-0.5399	-0.5452
75.0000	1.4600	150.9581	151.5654	-0.4007	-0.4045
0.1000	3.2810	295.6118	297.3396	-0.5811	-0.5860
1.0000	3.2810	356.4844	359.2905	-0.7810	-0.7892
2.0000	3.2810	354.9370	357.7861	-0.7963	-0.8047
5.0000	3.2810	333.4961	336.1367	-0.7856	-0.7940
10.0000	3.2810	296.6965	298.9185	-0.7433	-0.7513
20.0000	3.2810	239.2185	240.7848	-0.6505	-0.6574
30.0000	3.2810	200.0594	201.1926	-0.5632	-0.5692
40.0000	3.2810	173.3117	174.1580	-0.4859	-0.4907
50.0000	3.2810	154.8255	155.4772	-0.4192	-0.4235
75.0000	3.2810	129.1666	129.5553	-0.3000	-0.3032
0.1000	6.5620	176.4417	176.9653	-0.2959	-0.2974
1.0000	6.5620	227.4958	228.7927	-0.5668	-0.5721
2.0000	6.5620	230.2330	231.6078	-0.5936	-0.5994
5.0000	6.5620	222.4574	223.7904	-0.5957	-0.6018
10.0000	6.5620	204.8456	206.0081	-0.5643	-0.5700
20.0000	6.5620	174.9957	175.8511	-0.4864	-0.4915
30.0000	6.5620	153.6831	154.3201	-0.4128	-0.4168
40.0000	6.5620	138.7165	139.2010	-0.3481	-0.3517
50.0000	6.5620	128.1787	128.5579	-0.2950	-0.2977
75.0000	6.5620	113.2631	113.4935	-0.2030	-0.2052
0.1000	16.4050	100.7469	100.7170	0.0297	0.0303
1.0000	16.4050	133.6571	133.9812	-0.2419	-0.2437
2.0000	16.4050	138.6866	139.0932	-0.2923	-0.2946
5.0000	16.4050	139.7101	140.1616	-0.3221	-0.3249
10.0000	16.4050	135.0895	135.5139	-0.3132	-0.3163
20.0000	16.4050	124.7948	125.1309	-0.2686	-0.2710
30.0000	16.4050	116.6856	116.9465	-0.2231	-0.2251
40.0000	16.4050	110.7210	110.9252	-0.1841	-0.1860
50.0000	16.4050	106.3919	106.5552	-0.1533	-0.1544
75.0000	16.4050	100.0672	100.1687	-0.1013	-0.1027
0.1000	20.0140	94.7345	94.6978	0.0388	0.0396
1.0000	20.0140	122.1060	122.3215	-0.1762	-0.1775
2.0000	20.0140	127.2319	127.5260	-0.2306	-0.2323
5.0000	20.0140	129.2195	129.5654	-0.2670	-0.2694
10.0000	20.0140	126.1427	126.4779	-0.2650	-0.2670
20.0000	20.0140	118.2525	118.5231	-0.2283	-0.2305
30.0000	20.0140	111.8106	112.0232	-0.1898	-0.1915
40.0000	20.0140	107.0039	107.1718	-0.1567	-0.1581
50.0000	20.0140	103.4842	103.6189	-0.1300	-0.1312
75.0000	20.0140	98.2943	98.3789	-0.0860	-0.0870

Table 2 (Continued)

TBUR	TXCORD	ERT	CASE BASE	CASE DIRECT	GRESS
0.1000	32.8100	89.8253	89.8188	0.0072	0.0072
1.0000	32.8100	102.6890	102.7377	-0.0474	-0.0475
2.0000	32.8100	107.3939	107.5017	-0.1003	-0.1009
5.0000	32.8100	110.7655	110.9302	-0.1485	-0.1499
10.0000	32.8100	110.3002	110.4778	-0.1608	-0.1622
20.0000	32.8100	106.5920	106.7469	-0.1451	-0.1467
30.0000	32.8100	103.0892	103.2156	-0.1225	-0.1239
40.0000	32.8100	100.3369	100.4397	-0.1023	-0.1031
50.0000	32.8100	98.2609	98.3443	-0.0848	-0.0859
75.0000	32.8100	95.1052	95.1593	-0.0569	-0.0573
0.1000	42.9810	89.6097	89.6092	0.0005	0.0006
1.0000	42.9810	96.3011	96.3070	-0.0061	-0.0056
2.0000	42.9810	100.3120	100.3595	-0.0473	-0.0477
5.0000	42.9810	103.8463	103.9458	-0.0957	-0.0962
10.0000	42.9810	104.2812	104.3998	-0.1136	-0.1148
20.0000	42.9810	102.1217	102.2328	-0.1087	-0.1097
30.0000	42.9810	99.7341	99.8277	-0.0938	-0.0947
40.0000	42.9810	97.7654	97.8426	-0.0789	-0.0798
50.0000	42.9810	96.2436	96.3075	-0.0663	-0.0671
75.0000	42.9810	93.8734	93.9153	-0.0446	-0.0452
0.1000	49.2150	89.6010	89.6010	0.0	0.0001
1.0000	49.2150	94.0396	94.0338	0.0062	0.0061
2.0000	49.2150	97.5594	97.5860	-0.0273	-0.0269
5.0000	49.2150	101.1045	101.1786	-0.0732	-0.0740
10.0000	49.2150	101.8310	101.9261	-0.0933	-0.0941
20.0000	49.2150	100.2977	100.3911	-0.0930	-0.0937
30.0000	49.2150	98.3541	98.4340	-0.0812	-0.0821
40.0000	49.2150	96.7070	96.7740	-0.0692	-0.0698
50.0000	49.2150	95.4132	95.4692	-0.0587	-0.0590
75.0000	49.2150	93.3667	93.4040	-0.0399	-0.0401
0.1000	65.6199	89.6000	89.6000	0.0	0.0000
1.0000	65.6199	91.0461	91.0348	0.0124	0.0125
2.0000	65.6199	93.3132	93.3127	0.0005	0.0010
5.0000	65.6199	96.4325	96.4657	-0.0344	-0.0344
10.0000	65.6199	97.6436	97.6987	-0.0564	-0.0571
20.0000	65.6199	97.1150	97.1767	-0.0635	-0.0642
30.0000	65.6199	95.9490	96.0051	-0.0584	-0.0590
40.0000	65.6199	94.8598	94.9081	-0.0509	-0.0515
50.0000	65.6199	93.9638	94.0048	-0.0436	-0.0444
75.0000	65.6199	92.4837	92.5121	-0.0307	-0.0310
0.1000	164.0500	89.6000	89.6000	0.0	0.0000
1.0000	164.0500	89.6001	89.6001	0.0	0.0000
2.0000	164.0500	89.6161	89.6155	0.0007	0.0007
5.0000	164.0500	89.9545	89.9506	0.0043	0.0044
10.0000	164.0500	90.6407	90.6389	0.0020	0.0021
20.0000	164.0500	91.2772	91.2832	-0.0066	-0.0066
30.0000	164.0500	91.3834	91.3935	-0.0110	-0.0112
40.0000	164.0500	91.2961	91.3078	-0.0128	-0.0129
50.0000	164.0500	91.1465	91.1584	-0.0131	-0.0132
75.0000	164.0500	90.7721	90.7826	-0.0116	-0.0117

Table 2 (Continued)

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	328.1001	89.6000	89.6000	0.0	0.0
1.0000	328.1001	89.6000	89.6000	0.0	0.0000
2.0000	328.1001	89.6000	89.6000	0.0	0.0000
5.0000	328.1001	89.6004	89.6004	0.0	0.0000
10.0000	328.1001	89.6211	89.6205	0.0007	0.0007
20.0000	328.1001	89.7560	89.7544	0.0018	0.0019
30.0000	328.1001	89.8923	89.8911	0.0013	0.0014
40.0000	328.1001	89.9804	89.9802	0.0002	0.0003
50.0000	328.1001	90.0259	90.0266	-0.0008	-0.0008
75.0000	328.1001	90.0359	90.0381	-0.0024	-0.0024
0.1000	492.1499	89.6000	89.6000	0.0	0.0
1.0000	492.1499	89.6000	89.6000	0.0	-0.0000
2.0000	492.1499	89.6000	89.6000	0.0	0.0000
5.0000	492.1499	89.6000	89.6000	0.0	0.0000
10.0000	492.1499	89.6001	89.6001	0.0	0.0000
20.0000	492.1499	89.6080	89.6078	0.0002	0.0003
30.0000	492.1499	89.6345	89.6339	0.0007	0.0007
40.0000	492.1499	89.6696	89.6687	0.0010	0.0010
50.0000	492.1499	89.7027	89.7019	0.0009	0.0009
75.0000	492.1499	89.7561	89.7559	0.0002	0.0003
0.1000	656.2000	89.6000	89.6000	0.0	0.0
1.0000	656.2000	89.6000	89.6000	0.0	-0.0000
2.0000	656.2000	89.6000	89.6000	0.0	0.0000
5.0000	656.2000	89.6000	89.6000	0.0	0.0000
10.0000	656.2000	89.6000	89.6000	0.0	0.0000
20.0000	656.2000	89.6002	89.6002	0.0	0.0000
30.0000	656.2000	89.6025	89.6024	0.0001	0.0001
40.0000	656.2000	89.6090	89.6087	0.0003	0.0003
50.0000	656.2000	89.6190	89.6186	0.0004	0.0004
75.0000	656.2000	89.6474	89.6469	0.0006	0.0005
0.1000	820.2500	89.6000	89.6000	0.0	0.0
1.0000	820.2500	89.6000	89.6000	0.0	0.0
2.0000	820.2500	89.6000	89.6000	0.0	0.0000
5.0000	820.2500	89.6000	89.6000	0.0	0.0000
10.0000	820.2500	89.6000	89.6000	0.0	0.0000
20.0000	820.2500	89.6000	89.6000	0.0	0.0000
30.0000	820.2500	89.6001	89.6001	0.0	0.0000
40.0000	820.2500	89.6008	89.6008	0.0	0.0000
50.0000	820.2500	89.6026	89.6025	0.0001	0.0001
75.0000	820.2500	89.6118	89.6115	0.0003	0.0003

Table 3. Sensitivity of Temperature to Parameter B in Conductivity of Equation for Benchmark 3

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	1.4600	504.4822	504.7993	-0.0628	-0.0628
1.0000	1.4600	578.0034	578.4497	-0.0772	-0.0772
2.0000	1.4600	567.7141	568.1526	-0.0772	-0.0773
5.0000	1.4600	519.9019	520.2839	-0.0734	-0.0736
10.0000	1.4600	447.4099	447.7085	-0.0667	-0.0668
20.0000	1.4600	340.8901	341.0781	-0.0551	-0.0552
30.0000	1.4600	271.6067	271.7324	-0.0463	-0.0462
40.0000	1.4600	223.8362	223.9227	-0.0386	-0.0387
50.0000	1.4600	193.1129	193.1769	-0.0331	-0.0331
75.0000	1.4600	151.5290	151.5654	-0.0240	-0.0238
0.1000	3.2810	297.2253	297.3396	-0.0384	-0.0385
1.0000	3.2810	359.0974	359.2905	-0.0537	-0.0540
2.0000	3.2810	357.5896	357.7861	-0.0549	-0.0550
5.0000	3.2810	335.9570	336.1367	-0.0535	-0.0535
10.0000	3.2810	298.7715	298.9185	-0.0492	-0.0493
20.0000	3.2810	240.6853	240.7848	-0.0413	-0.0414
30.0000	3.2810	201.1230	201.1926	-0.0346	-0.0348
40.0000	3.2810	174.1069	174.1580	-0.0293	-0.0294
50.0000	3.2810	155.4384	155.4772	-0.0250	-0.0250
75.0000	3.2810	129.5326	129.5553	-0.0175	-0.0175
0.1000	6.5620	176.9338	176.9653	-0.0178	-0.0178
1.0000	6.5620	228.7109	228.7927	-0.0357	-0.0357
2.0000	6.5620	231.5212	231.6078	-0.0374	-0.0375
5.0000	6.5620	223.7070	223.7904	-0.0373	-0.0374
10.0000	6.5620	205.9363	206.0081	-0.0349	-0.0350
20.0000	6.5620	175.7993	175.8511	-0.0295	-0.0294
30.0000	6.5620	154.2819	154.3201	-0.0247	-0.0245
40.0000	6.5620	139.1726	139.2010	-0.0204	-0.0204
50.0000	6.5620	128.5358	128.5579	-0.0172	-0.0171
75.0000	6.5620	113.4803	113.4935	-0.0116	-0.0117
0.1000	16.4050	100.7187	100.7170	0.0017	0.0016
1.0000	16.4050	133.9623	133.9812	-0.0141	-0.0141
2.0000	16.4050	139.0695	139.0932	-0.0170	-0.0171
5.0000	16.4050	140.1349	140.1616	-0.0191	-0.0189
10.0000	16.4050	135.4894	135.5139	-0.0181	-0.0183
20.0000	16.4050	125.1115	125.1309	-0.0155	-0.0156
30.0000	16.4050	116.9312	116.9465	-0.0131	-0.0128
40.0000	16.4050	110.9135	110.9252	-0.0106	-0.0105
50.0000	16.4050	106.5459	106.5552	-0.0087	-0.0087
75.0000	16.4050	100.1630	100.1687	-0.0057	-0.0058
0.1000	20.0140	94.6999	94.6978	0.0022	0.0022
1.0000	20.0140	122.3093	122.3215	-0.0100	-0.0102
2.0000	20.0140	127.5088	127.5260	-0.0135	-0.0134
5.0000	20.0140	129.5455	129.5654	-0.0154	-0.0155
10.0000	20.0140	126.4583	126.4779	-0.0155	-0.0153
20.0000	20.0140	118.5077	118.5231	-0.0130	-0.0132
30.0000	20.0140	112.0110	112.0232	-0.0109	-0.0109
40.0000	20.0140	107.1621	107.1718	-0.0091	-0.0089
50.0000	20.0140	103.6112	103.6189	-0.0074	-0.0074
75.0000	20.0140	98.3741	98.3789	-0.0049	-0.0049

Table 3 (Continued)

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	32.8100	89.8191	89.8188	0.0003	0.0004
1.0000	32.8100	102.7350	102.7377	-0.0026	-0.0027
2.0000	32.8100	107.4955	107.5017	-0.0058	-0.0057
5.0000	32.8100	110.9207	110.9302	-0.0086	-0.0085
10.0000	32.8100	110.4680	110.4778	-0.0089	-0.0092
20.0000	32.8100	106.7384	106.7469	-0.0080	-0.0083
30.0000	32.8100	103.2084	103.2156	-0.0070	-0.0070
40.0000	32.8100	100.4340	100.4397	-0.0057	-0.0058
50.0000	32.8100	98.3396	98.3443	-0.0048	-0.0048
75.0000	32.8100	95.1559	95.1593	-0.0036	-0.0032
0.1000	42.9810	89.6092	89.6092	0.0	0.0000
1.0000	42.9810	96.3064	96.3070	-0.0006	-0.0003
2.0000	42.9810	100.3568	100.3595	-0.0027	-0.0027
5.0000	42.9810	103.9405	103.9458	-0.0051	-0.0054
10.0000	42.9810	104.3933	104.3998	-0.0062	-0.0065
20.0000	42.9810	102.2266	102.2328	-0.0061	-0.0062
30.0000	42.9810	99.8225	99.8277	-0.0052	-0.0053
40.0000	42.9810	97.8381	97.8426	-0.0046	-0.0045
50.0000	42.9810	96.3040	96.3075	-0.0036	-0.0038
75.0000	42.9810	93.9132	93.9153	-0.0022	-0.0025
0.1000	49.2150	89.6010	89.6010	0.0	0.0000
1.0000	49.2150	94.0339	94.0338	0.0001	0.0003
2.0000	49.2150	97.5842	97.5860	-0.0018	-0.0015
5.0000	49.2150	101.1745	101.1786	-0.0041	-0.0042
10.0000	49.2150	101.9208	101.9261	-0.0052	-0.0053
20.0000	49.2150	100.3858	100.3911	-0.0053	-0.0053
30.0000	49.2150	98.4298	98.4340	-0.0043	-0.0046
40.0000	49.2150	96.7701	96.7740	-0.0040	-0.0039
50.0000	49.2150	95.4661	95.4692	-0.0032	-0.0033
75.0000	49.2150	93.4019	93.4040	-0.0023	-0.0022
0.1000	65.6199	89.6000	89.6000	0.0	0.0000
1.0000	65.6199	91.0355	91.0348	0.0008	0.0007
2.0000	65.6199	93.3128	93.3127	0.0001	0.0000
5.0000	65.6199	96.4636	96.4657	-0.0022	-0.0019
10.0000	65.6199	97.6956	97.6987	-0.0032	-0.0032
20.0000	65.6199	97.1734	97.1767	-0.0034	-0.0036
30.0000	65.6199	96.0020	96.0051	-0.0032	-0.0033
40.0000	65.6199	94.9053	94.9081	-0.0029	-0.0029
50.0000	65.6199	94.0028	94.0048	-0.0021	-0.0025
75.0000	65.6199	92.5105	92.5121	-0.0017	-0.0017
0.1000	164.0500	89.6000	89.6000	0.0	0.0000
1.0000	164.0500	89.6001	89.6001	0.0	0.0000
2.0000	164.0500	89.6155	89.6155	0.0	0.0000
5.0000	164.0500	89.9508	89.9506	0.0002	0.0002
10.0000	164.0500	90.6390	90.6389	0.0001	0.0001
20.0000	164.0500	91.2829	91.2832	-0.0003	-0.0004
30.0000	164.0500	91.3930	91.3935	-0.0005	-0.0006
40.0000	164.0500	91.3072	91.3078	-0.0007	-0.0007
50.0000	164.0500	91.1578	91.1584	-0.0007	-0.0007
75.0000	164.0500	90.7820	90.7826	-0.0007	-0.0006

Table 3 (Continued)

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	328.1001	89.6000	89.6000	0.0	0.0
1.0000	328.1001	89.6000	89.6000	0.0	0.0000
2.0000	328.1001	89.6000	89.6000	0.0	0.0000
5.0000	328.1001	89.6004	89.6004	0.0	0.0000
10.0000	328.1001	89.6205	89.6205	0.0	0.0000
20.0000	328.1001	89.7545	89.7544	0.0001	0.0001
30.0000	328.1001	89.8912	89.8911	0.0001	0.0001
40.0000	328.1001	89.9802	89.9802	0.0	0.0000
50.0000	328.1001	90.0266	90.0266	0.0	-0.0000
75.0000	328.1001	90.0379	90.0381	-0.0002	-0.0001
0.1000	492.1499	89.6000	89.6000	0.0	0.0
1.0000	492.1499	89.6000	89.6000	0.0	-0.0000
2.0000	492.1499	89.6000	89.6000	0.0	0.0000
5.0000	492.1499	89.6000	89.6000	0.0	0.0000
10.0000	492.1499	89.6001	89.6001	0.0	0.0000
20.0000	492.1499	89.6078	89.6078	0.0	0.0000
30.0000	492.1499	89.6339	89.6339	0.0	0.0000
40.0000	492.1499	89.6687	89.6687	0.0	0.0001
50.0000	492.1499	89.7019	89.7019	0.0	0.0001
75.0000	492.1499	89.7559	89.7559	0.0	0.0000
0.1000	656.2000	89.6000	89.6000	0.0	0.0
1.0000	656.2000	89.6000	89.6000	0.0	-0.0000
2.0000	656.2000	89.6000	89.6000	0.0	0.0000
5.0000	656.2000	89.6000	89.6000	0.0	0.0000
10.0000	656.2000	89.6000	89.6000	0.0	0.0000
20.0000	656.2000	89.6002	89.6002	0.0	0.0000
30.0000	656.2000	89.6024	89.6024	0.0	0.0000
40.0000	656.2000	89.6088	89.6087	0.0001	0.0000
50.0000	656.2000	89.6186	89.6186	0.0	0.0000
75.0000	656.2000	89.6469	89.6469	0.0	0.0000
0.1000	820.2500	89.6000	89.6000	0.0	0.0
1.0000	820.2500	89.6000	89.6000	0.0	0.0
2.0000	820.2500	89.6000	89.6000	0.0	0.0000
5.0000	820.2500	89.6000	89.6000	0.0	0.0000
10.0000	820.2500	89.6000	89.6000	0.0	0.0000
20.0000	820.2500	89.6000	89.6000	0.0	0.0000
30.0000	820.2500	89.6001	89.6001	0.0	0.0000
40.0000	820.2500	89.6008	89.6008	0.0	0.0000
50.0000	820.2500	89.6025	89.6025	0.0	0.0000
75.0000	820.2500	89.6116	89.6115	0.0001	0.0000

Table 4. Sensitivity of Temperature to Density of Geological Medium for Benchmark 3

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	1.4600	504.1487	504.7993	-0.1289	-0.1292
1.0000	1.4600	578.2275	578.4497	-0.0384	-0.0385
2.0000	1.4600	568.0068	568.1526	-0.0257	-0.0257
5.0000	1.4600	520.2119	520.2839	-0.0138	-0.0138
10.0000	1.4600	447.6758	447.7085	-0.0073	-0.0073
20.0000	1.4600	341.0706	341.0781	-0.0022	-0.0023
30.0000	1.4600	271.7317	271.7324	-0.0003	-0.0002
40.0000	1.4600	223.9162	223.9227	-0.0029	-0.0030
50.0000	1.4600	193.1719	193.1769	-0.0026	-0.0023
75.0000	1.4600	151.5634	151.5654	-0.0013	-0.0014
0.1000	3.2810	296.8584	297.3396	-0.1618	-0.1625
1.0000	3.2810	359.1196	359.2905	-0.0476	-0.0478
2.0000	3.2810	357.6726	357.7861	-0.0317	-0.0318
5.0000	3.2810	336.0791	336.1367	-0.0171	-0.0171
10.0000	3.2810	298.8916	298.9185	-0.0090	-0.0091
20.0000	3.2810	240.7780	240.7848	-0.0028	-0.0029
30.0000	3.2810	201.1921	201.1926	-0.0003	-0.0002
40.0000	3.2810	174.1596	174.1580	0.0009	0.0011
50.0000	3.2810	155.4799	155.4772	0.0017	0.0017
75.0000	3.2810	129.5578	129.5553	0.0019	0.0019
0.1000	6.5620	176.6129	176.9653	-0.1991	-0.2000
1.0000	6.5620	228.6527	228.7927	-0.0612	-0.0613
2.0000	6.5620	231.5137	231.6078	-0.0406	-0.0408
5.0000	6.5620	223.7414	223.7904	-0.0219	-0.0219
10.0000	6.5620	205.9843	206.0081	-0.0116	-0.0116
20.0000	6.5620	175.8446	175.8511	-0.0037	-0.0038
30.0000	6.5620	154.3190	154.3201	-0.0007	-0.0005
40.0000	6.5620	139.2030	139.2010	0.0014	0.0011
50.0000	6.5620	128.5599	128.5579	0.0016	0.0018
75.0000	6.5620	113.4959	113.4935	0.0021	0.0020
0.1000	16.4050	100.5739	100.7170	-0.1421	-0.1434
1.0000	16.4050	133.8708	133.9812	-0.0824	-0.0827
2.0000	16.4050	139.0149	139.0932	-0.0563	-0.0565
5.0000	16.4050	140.1183	140.1616	-0.0309	-0.0308
10.0000	16.4050	135.4918	135.5139	-0.0163	-0.0165
20.0000	16.4050	125.1240	125.1309	-0.0055	-0.0057
30.0000	16.4050	116.9447	116.9465	-0.0015	-0.0012
40.0000	16.4050	110.9259	110.9252	0.0006	0.0008
50.0000	16.4050	106.5567	106.5552	0.0014	0.0017
75.0000	16.4050	100.1707	100.1687	0.0020	0.0020
0.1000	20.0140	94.6079	94.6978	-0.0949	-0.0958
1.0000	20.0140	122.2182	122.3215	-0.0845	-0.0850
2.0000	20.0140	127.4504	127.5260	-0.0593	-0.0593
5.0000	20.0140	129.5232	129.5654	-0.0326	-0.0328
10.0000	20.0140	126.4556	126.4779	-0.0176	-0.0177
20.0000	20.0140	118.5155	118.5231	-0.0064	-0.0062
30.0000	20.0140	112.0218	112.0232	-0.0012	-0.0015
40.0000	20.0140	107.1722	107.1718	0.0004	0.0006
50.0000	20.0140	103.6207	103.6189	0.0017	0.0016
75.0000	20.0140	98.3812	98.3789	0.0023	0.0020

Table 4 (Continued)

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	32.8100	89.8099	89.8188	-0.0099	-0.0101
1.0000	32.8100	102.6574	102.7377	-0.0782	-0.0783
2.0000	32.8100	107.4357	107.5017	-0.0614	-0.0615
5.0000	32.8100	110.8897	110.9302	-0.0365	-0.0367
10.0000	32.8100	110.4551	110.4778	-0.0206	-0.0206
20.0000	32.8100	106.7387	106.7469	-0.0077	-0.0079
30.0000	32.8100	103.2130	103.2156	-0.0025	-0.0026
40.0000	32.8100	100.4396	100.4397	-0.0001	-0.0000
50.0000	32.8100	98.3455	98.3443	0.0012	0.0012
75.0000	32.8100	95.1611	95.1593	0.0019	0.0018
0.1000	42.9810	89.6086	89.6092	-0.0007	-0.0007
1.0000	42.9810	96.2458	96.3070	-0.0635	-0.0641
2.0000	42.9810	100.3021	100.3595	-0.0572	-0.0578
5.0000	42.9810	103.9071	103.9458	-0.0372	-0.0376
10.0000	42.9810	104.3771	104.3998	-0.0217	-0.0220
20.0000	42.9810	102.2236	102.2328	-0.0090	-0.0089
30.0000	42.9810	99.8244	99.8277	-0.0033	-0.0033
40.0000	42.9810	97.8419	97.8426	-0.0007	-0.0006
50.0000	42.9810	96.3084	96.3075	0.0009	0.0008
75.0000	42.9810	93.9168	93.9153	0.0016	0.0016
0.1000	49.2150	89.6009	89.6010	-0.0001	-0.0001
1.0000	49.2150	93.9835	94.0338	-0.0535	-0.0538
2.0000	49.2150	97.5333	97.5860	-0.0540	-0.0539
5.0000	49.2150	101.1410	101.1786	-0.0372	-0.0374
10.0000	49.2150	101.9032	101.9261	-0.0225	-0.0226
20.0000	49.2150	100.3812	100.3911	-0.0099	-0.0095
30.0000	49.2150	98.4304	98.4340	-0.0037	-0.0037
40.0000	49.2150	96.7732	96.7740	-0.0008	-0.0009
50.0000	49.2150	95.4696	95.4692	0.0004	0.0005
75.0000	49.2150	93.4052	93.4040	0.0013	0.0015
0.1000	65.6199	89.6000	89.6000	0.0	-0.0000
1.0000	65.6199	91.0088	91.0348	-0.0286	-0.0289
2.0000	65.6199	93.2746	93.3127	-0.0408	-0.0410
5.0000	65.6199	96.4319	96.4657	-0.0350	-0.0353
10.0000	65.6199	97.6763	97.6987	-0.0229	-0.0232
20.0000	65.6199	97.1665	97.1767	-0.0105	-0.0107
30.0000	65.6199	96.0006	96.0051	-0.0047	-0.0048
40.0000	65.6199	94.9069	94.9081	-0.0013	-0.0018
50.0000	65.6199	94.0051	94.0048	0.0003	-0.0001
75.0000	65.6199	92.5132	92.5121	0.0012	0.0012
0.1000	164.0500	89.6000	89.6000	0.0	-0.0000
1.0000	164.0500	89.6001	89.6001	0.0	-0.0000
2.0000	164.0500	89.6147	89.6155	-0.0009	-0.0009
5.0000	164.0500	89.9429	89.9506	-0.0086	-0.0086
10.0000	164.0500	90.6266	90.6389	-0.0136	-0.0137
20.0000	164.0500	91.2728	91.2832	-0.0114	-0.0115
30.0000	164.0500	91.3864	91.3935	-0.0078	-0.0078
40.0000	164.0500	91.3032	91.3078	-0.0050	-0.0050
50.0000	164.0500	91.1556	91.1584	-0.0031	-0.0031
75.0000	164.0500	90.7820	90.7826	-0.0007	-0.0007

Table 4 (Continued)

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	328.1001	89.6000	89.6000	0.0	0.0
1.0000	328.1001	89.6000	89.6000	0.0	-0.0000
2.0000	328.1001	89.6000	89.6000	0.0	-0.0000
5.0000	328.1001	89.6004	89.6004	0.0	-0.0000
10.0000	328.1001	89.6196	89.6205	-0.0010	-0.0009
20.0000	328.1001	89.7511	89.7544	-0.0037	-0.0037
30.0000	328.1001	89.8869	89.8911	-0.0047	-0.0047
40.0000	328.1001	89.9761	89.9802	-0.0045	-0.0045
50.0000	328.1001	90.0231	90.0266	-0.0039	-0.0039
75.0000	328.1001	90.0360	90.0381	-0.0023	-0.0023
0.1000	492.1499	89.6000	89.6000	0.0	0.0
1.0000	492.1499	89.6000	89.6000	0.0	0.0000
2.0000	492.1499	89.6000	89.6000	0.0	-0.0000
5.0000	492.1499	89.6000	89.6000	0.0	-0.0000
10.0000	492.1499	89.6001	89.6001	0.0	-0.0000
20.0000	492.1499	89.6074	89.6078	-0.0004	-0.0004
30.0000	492.1499	89.6328	89.6339	-0.0012	-0.0012
40.0000	492.1499	89.6671	89.6687	-0.0018	-0.0018
50.0000	492.1499	89.7000	89.7019	-0.0021	-0.0021
75.0000	492.1499	89.7541	89.7559	-0.0020	-0.0020
0.1000	656.2000	89.6000	89.6000	0.0	0.0
1.0000	656.2000	89.6000	89.6000	0.0	0.0000
2.0000	656.2000	89.6000	89.6000	0.0	-0.0000
5.0000	656.2000	89.6000	89.6000	0.0	-0.0000
10.0000	656.2000	89.6000	89.6000	0.0	-0.0000
20.0000	656.2000	89.6002	89.6002	0.0	-0.0000
30.0000	656.2000	89.6023	89.6024	-0.0001	-0.0001
40.0000	656.2000	89.6084	89.6087	-0.0003	-0.0004
50.0000	656.2000	89.6180	89.6186	-0.0007	-0.0007
75.0000	656.2000	89.6459	89.6469	-0.0011	-0.0011
0.1000	820.2500	89.6000	89.6000	0.0	0.0
1.0000	820.2500	89.6000	89.6000	0.0	0.0
2.0000	820.2500	89.6000	89.6000	0.0	-0.0000
5.0000	820.2500	89.6000	89.6000	0.0	-0.0000
10.0000	820.2500	89.6000	89.6000	0.0	-0.0000
20.0000	820.2500	89.6000	89.6000	0.0	-0.0000
30.0000	820.2500	89.6001	89.6001	0.0	-0.0000
40.0000	820.2500	89.6007	89.6008	-0.0001	-0.0001
50.0000	820.2500	89.6024	89.6025	-0.0001	-0.0001
75.0000	820.2500	89.6112	89.6115	-0.0003	-0.0004

Table 5. Sensitivity of Temperature to Specific Heat of Geological Medium for Benchmark 3

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	1.4600	504.1487	504.7993	-0.1289	-0.1292
1.0000	1.4600	578.2275	578.4497	-0.0384	-0.0385
2.0000	1.4600	568.0068	568.1526	-0.0257	-0.0257
5.0000	1.4600	520.2119	520.2839	-0.0138	-0.0138
10.0000	1.4600	447.6758	447.7085	-0.0073	-0.0073
20.0000	1.4600	341.0706	341.0781	-0.0022	-0.0023
30.0000	1.4600	271.7317	271.7324	-0.0003	-0.0002
40.0000	1.4600	223.9162	223.9227	-0.0029	-0.0030
50.0000	1.4600	193.1719	193.1769	-0.0026	-0.0023
75.0000	1.4600	151.5634	151.5654	-0.0013	-0.0014
0.1000	3.2810	296.8584	297.3396	-0.1618	-0.1625
1.0000	3.2810	359.1196	359.2905	-0.0476	-0.0478
2.0000	3.2810	357.6726	357.7861	-0.0317	-0.0318
5.0000	3.2810	336.0791	336.1367	-0.0171	-0.0171
10.0000	3.2810	298.8916	298.9185	-0.0090	-0.0091
20.0000	3.2810	240.7780	240.7848	-0.0028	-0.0029
30.0000	3.2810	201.1921	201.1926	-0.0003	-0.0002
40.0000	3.2810	174.1596	174.1580	0.0009	0.0011
50.0000	3.2810	155.4799	155.4772	0.0017	0.0017
75.0000	3.2810	129.5578	129.5553	0.0019	0.0019
0.1000	6.5620	176.6129	176.9653	-0.1991	-0.2000
1.0000	6.5620	228.6527	228.7927	-0.0612	-0.0613
2.0000	6.5620	231.5137	231.6078	-0.0406	-0.0408
5.0000	6.5620	223.7414	223.7904	-0.0219	-0.0219
10.0000	6.5620	205.9843	206.0081	-0.0116	-0.0116
20.0000	6.5620	175.8446	175.8511	-0.0037	-0.0038
30.0000	6.5620	154.3190	154.3201	-0.0007	-0.0005
40.0000	6.5620	139.2030	139.2010	0.0014	0.0011
50.0000	6.5620	128.5599	128.5579	0.0016	0.0018
75.0000	6.5620	113.4959	113.4935	0.0021	0.0020
0.1000	16.4050	100.5739	100.7170	-0.1421	-0.1434
1.0000	16.4050	133.8708	133.9812	-0.0824	-0.0827
2.0000	16.4050	139.0149	139.0932	-0.0563	-0.0565
5.0000	16.4050	140.1183	140.1616	-0.0309	-0.0308
10.0000	16.4050	135.4918	135.5139	-0.0163	-0.0165
20.0000	16.4050	125.1240	125.1309	-0.0055	-0.0057
30.0000	16.4050	116.9447	116.9465	-0.0015	-0.0012
40.0000	16.4050	110.9259	110.9252	0.0006	0.0008
50.0000	16.4050	106.5567	106.5552	0.0014	0.0017
75.0000	16.4050	100.1707	100.1687	0.0020	0.0020
0.1000	20.0140	94.6079	94.6978	-0.0949	-0.0958
1.0000	20.0140	122.2182	122.3215	-0.0845	-0.0850
2.0000	20.0140	127.4504	127.5260	-0.0593	-0.0593
5.0000	20.0140	129.5232	129.5654	-0.0326	-0.0328
10.0000	20.0140	126.4556	126.4779	-0.0176	-0.0177
20.0000	20.0140	118.5155	118.5231	-0.0064	-0.0062
30.0000	20.0140	112.0218	112.0232	-0.0012	-0.0015
40.0000	20.0140	107.1722	107.1718	0.0004	0.0006
50.0000	20.0140	103.6207	103.6189	0.0017	0.0016
75.0000	20.0140	98.3812	98.3789	0.0023	0.0020

Table 5 (Continued)

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	32.8100	89.8099	89.8188	-0.0099	-0.0101
1.0000	32.8100	102.6574	102.7377	-0.0782	-0.0783
2.0000	32.8100	107.4357	107.5017	-0.0614	-0.0615
5.0000	32.8100	110.8897	110.9302	-0.0365	-0.0367
10.0000	32.8100	110.4551	110.4778	-0.0206	-0.0206
20.0000	32.8100	106.7387	106.7469	-0.0077	-0.0079
30.0000	32.8100	103.2130	103.2156	-0.0025	-0.0026
40.0000	32.8100	100.4396	100.4397	-0.0001	-0.0000
50.0000	32.8100	98.3455	98.3443	0.0012	0.0012
75.0000	32.8100	95.1611	95.1593	0.0019	0.0018
0.1000	42.9810	89.6086	89.6092	-0.0007	-0.0007
1.0000	42.9810	96.2458	96.3070	-0.0635	-0.0641
2.0000	42.9810	100.3021	100.3595	-0.0572	-0.0578
5.0000	42.9810	103.9071	103.9458	-0.0372	-0.0376
10.0000	42.9810	104.3771	104.3998	-0.0217	-0.0220
20.0000	42.9810	102.2236	102.2328	-0.0090	-0.0089
30.0000	42.9810	99.8244	99.8277	-0.0033	-0.0033
40.0000	42.9810	97.8419	97.8426	-0.0007	-0.0006
50.0000	42.9810	96.3084	96.3075	0.0009	0.0008
75.0000	42.9810	93.9168	93.9153	0.0016	0.0016
0.1000	49.2150	89.6009	89.6010	-0.0001	-0.0001
1.0000	49.2150	93.9835	94.0338	-0.0535	-0.0538
2.0000	49.2150	97.5333	97.5860	-0.0540	-0.0539
5.0000	49.2150	101.1410	101.1786	-0.0372	-0.0374
10.0000	49.2150	101.9032	101.9261	-0.0225	-0.0226
20.0000	49.2150	100.3812	100.3911	-0.0099	-0.0095
30.0000	49.2150	98.4304	98.4340	-0.0037	-0.0037
40.0000	49.2150	96.7732	96.7740	-0.0008	-0.0009
50.0000	49.2150	95.4696	95.4692	0.0004	0.0005
75.0000	49.2150	93.4052	93.4040	0.0013	0.0015
0.1000	65.6199	89.6000	89.6000	0.0	-0.0000
1.0000	65.6199	91.0088	91.0348	-0.0286	-0.0289
2.0000	65.6199	93.2746	93.3127	-0.0408	-0.0410
5.0000	65.6199	96.4319	96.4657	-0.0350	-0.0353
10.0000	65.6199	97.6763	97.6987	-0.0229	-0.0232
20.0000	65.6199	97.1665	97.1767	-0.0105	-0.0107
30.0000	65.6199	96.0006	96.0051	-0.0047	-0.0048
40.0000	65.6199	94.9069	94.9081	-0.0013	-0.0018
50.0000	65.6199	94.0051	94.0048	0.0003	-0.0001
75.0000	65.6199	92.5132	92.5121	0.0012	0.0012
0.1000	164.0500	89.6000	89.6000	0.0	-0.0000
1.0000	164.0500	89.6001	89.6001	0.0	-0.0000
2.0000	164.0500	89.6147	89.6155	-0.0009	-0.0009
5.0000	164.0500	89.9429	89.9506	-0.0086	-0.0086
10.0000	164.0500	90.6266	90.6389	-0.0136	-0.0137
20.0000	164.0500	91.2728	91.2832	-0.0114	-0.0115
30.0000	164.0500	91.3864	91.3935	-0.0078	-0.0078
40.0000	164.0500	91.3032	91.3078	-0.0050	-0.0050
50.0000	164.0500	91.1556	91.1584	-0.0031	-0.0031
75.0000	164.0500	90.7820	90.7826	-0.0007	-0.0007

Table 5 (Continued)

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	328.1001	89.6000	89.6000	0.0	0.0
1.0000	328.1001	89.6000	89.6000	0.0	-0.0000
2.0000	328.1001	89.6000	89.6000	0.0	-0.0000
5.0000	328.1001	89.6004	89.6004	0.0	-0.0000
10.0000	328.1001	89.6196	89.6205	-0.0010	-0.0009
20.0000	328.1001	89.7511	89.7544	-0.0037	-0.0037
30.0000	328.1001	89.8869	89.8911	-0.0047	-0.0047
40.0000	328.1001	89.9761	89.9802	-0.0045	-0.0045
50.0000	328.1001	90.0231	90.0266	-0.0039	-0.0039
75.0000	328.1001	90.0360	90.0381	-0.0023	-0.0023
0.1000	492.1499	89.6000	89.6000	0.0	0.0
1.0000	492.1499	89.6000	89.6000	0.0	0.0000
2.0000	492.1499	89.6000	89.6000	0.0	-0.0000
5.0000	492.1499	89.6000	89.6000	0.0	-0.0000
10.0000	492.1499	89.6001	89.6001	0.0	-0.0000
20.0000	492.1499	89.6074	89.6078	-0.0004	-0.0004
30.0000	492.1499	89.6328	89.6339	-0.0012	-0.0012
40.0000	492.1499	89.6671	89.6687	-0.0018	-0.0018
50.0000	492.1499	89.7000	89.7019	-0.0021	-0.0021
75.0000	492.1499	89.7541	89.7559	-0.0020	-0.0020
0.1000	656.2000	89.6000	89.6000	0.0	0.0
1.0000	656.2000	89.6000	89.6000	0.0	0.0000
2.0000	656.2000	89.6000	89.6000	0.0	-0.0000
5.0000	656.2000	89.6000	89.6000	0.0	-0.0000
10.0000	656.2000	89.6000	89.6000	0.0	-0.0000
20.0000	656.2000	89.6002	89.6002	0.0	-0.0000
30.0000	656.2000	89.6023	89.6024	-0.0001	-0.0001
40.0000	656.2000	89.6084	89.6087	-0.0003	-0.0004
50.0000	656.2000	89.6180	89.6186	-0.0007	-0.0007
75.0000	656.2000	89.6459	89.6469	-0.0011	-0.0011
0.1000	820.2500	89.6000	89.6000	0.0	0.0
1.0000	820.2500	89.6000	89.6000	0.0	0.0
2.0000	820.2500	89.6000	89.6000	0.0	-0.0000
5.0000	820.2500	89.6000	89.6000	0.0	-0.0000
10.0000	820.2500	89.6000	89.6000	0.0	-0.0000
20.0000	820.2500	89.6000	89.6000	0.0	-0.0000
30.0000	820.2500	89.6001	89.6001	0.0	-0.0000
40.0000	820.2500	89.6007	89.6008	-0.0001	-0.0001
50.0000	820.2500	89.6024	89.6025	-0.0001	-0.0001
75.0000	820.2500	89.6112	89.6115	-0.0003	-0.0004

Table 6. Sensitivity of Temperature to Initial Temperature of Geological Medium for Benchmark 3

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	1.4600	506.2141	504.7993	0.2803	0.2803
1.0000	1.4600	580.0337	578.4497	0.2738	0.2739
2.0000	1.4600	569.7329	568.1526	0.2782	0.2783
5.0000	1.4600	521.8079	520.2839	0.2929	0.2930
10.0000	1.4600	449.1340	447.7085	0.3184	0.3185
20.0000	1.4600	342.3521	341.0781	0.3735	0.3736
30.0000	1.4600	272.9050	271.7324	0.4315	0.4315
40.0000	1.4600	225.0229	223.9227	0.4913	0.4912
50.0000	1.4600	194.2306	193.1769	0.5455	0.5455
75.0000	1.4600	152.5561	151.5654	0.6537	0.6538
0.1000	3.2810	298.4771	297.3396	0.3825	0.3825
1.0000	3.2810	360.5671	359.2905	0.3553	0.3552
2.0000	3.2810	359.0691	357.7861	0.3586	0.3585
5.0000	3.2810	337.3960	336.1367	0.3746	0.3747
10.0000	3.2810	300.1274	298.9185	0.4045	0.4044
20.0000	3.2810	241.9104	240.7848	0.4675	0.4673
30.0000	3.2810	202.2591	201.1926	0.5301	0.5301
40.0000	3.2810	175.1839	174.1580	0.5891	0.5891
50.0000	3.2810	156.4750	155.4772	0.6418	0.6416
75.0000	3.2810	130.5134	129.5553	0.7395	0.7394
0.1000	6.5620	177.9406	176.9653	0.5511	0.5513
1.0000	6.5620	229.8796	228.7927	0.4751	0.4750
2.0000	6.5620	232.7060	231.6078	0.4742	0.4741
5.0000	6.5620	224.8840	223.7904	0.4887	0.4885
10.0000	6.5620	207.0783	206.0081	0.5195	0.5195
20.0000	6.5620	176.8783	175.8511	0.5841	0.5841
30.0000	6.5620	155.3152	154.3201	0.6448	0.6449
40.0000	6.5620	140.1739	139.2010	0.6989	0.6986
50.0000	6.5620	129.5140	128.5579	0.7437	0.7439
75.0000	6.5620	114.4265	113.4935	0.8221	0.8222
0.1000	16.4050	101.6076	100.7170	0.8843	0.8845
1.0000	16.4050	134.9282	133.9812	0.7068	0.7070
2.0000	16.4050	140.0533	139.0932	0.6903	0.6902
5.0000	16.4050	141.1284	140.1616	0.6898	0.6900
10.0000	16.4050	136.4770	135.5139	0.7107	0.7108
20.0000	16.4050	126.0808	125.1309	0.7591	0.7589
30.0000	16.4050	117.8841	116.9465	0.8017	0.8020
40.0000	16.4050	111.8541	110.9252	0.8374	0.8375
50.0000	16.4050	107.4775	106.5552	0.8655	0.8657
75.0000	16.4050	101.0813	100.1687	0.9111	0.9111
0.1000	20.0140	95.5875	94.6978	0.9395	0.9397
1.0000	20.0140	123.2523	122.3215	0.7609	0.7606
2.0000	20.0140	128.4687	127.5260	0.7392	0.7393
5.0000	20.0140	130.5163	129.5654	0.7339	0.7340
10.0000	20.0140	127.4269	126.4779	0.7503	0.7506
20.0000	20.0140	119.4627	118.5231	0.7928	0.7926
30.0000	20.0140	112.9539	112.0232	0.8308	0.8305
40.0000	20.0140	108.0948	107.1718	0.8612	0.8614
50.0000	20.0140	104.5369	103.6189	0.8859	0.8858
75.0000	20.0140	99.2888	98.3789	0.9249	0.9249

Table 6 (Continued)

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	32.8100	90.7137	89.8188	0.9963	0.9964
1.0000	32.8100	103.6414	102.7377	0.8796	0.8798
2.0000	32.8100	108.4152	107.5017	0.8498	0.8497
5.0000	32.8100	111.8529	110.9302	0.8318	0.8317
10.0000	32.8100	111.4026	110.4778	0.8371	0.8370
20.0000	32.8100	107.6684	106.7469	0.8633	0.8629
30.0000	32.8100	104.1323	103.2156	0.8881	0.8880
40.0000	32.8100	101.3525	100.4397	0.9088	0.9087
50.0000	32.8100	99.2540	98.3443	0.9250	0.9250
75.0000	32.8100	96.0639	95.1593	0.9506	0.9509
0.1000	42.9810	90.5051	89.6092	0.9998	0.9998
1.0000	42.9810	97.2038	96.3070	0.9312	0.9312
2.0000	42.9810	101.2634	100.3595	0.9007	0.9004
5.0000	42.9810	104.8581	103.9458	0.8777	0.8775
10.0000	42.9810	105.3151	104.3998	0.8767	0.8767
20.0000	42.9810	103.1471	102.2328	0.8943	0.8941
30.0000	42.9810	100.7392	99.8277	0.9131	0.9129
40.0000	42.9810	98.7515	97.8426	0.9289	0.9287
50.0000	42.9810	97.2140	96.3075	0.9413	0.9412
75.0000	42.9810	94.8181	93.9153	0.9613	0.9614
0.1000	49.2150	90.4970	89.6010	1.0000	1.0000
1.0000	49.2150	94.9286	94.0338	0.9516	0.9518
2.0000	49.2150	98.4859	97.5860	0.9222	0.9225
5.0000	49.2150	102.0867	101.1786	0.8975	0.8974
10.0000	49.2150	102.8378	101.9261	0.8945	0.8942
20.0000	49.2150	101.3020	100.3911	0.9074	0.9076
30.0000	49.2150	99.3433	98.4340	0.9238	0.9235
40.0000	49.2150	97.6807	96.7740	0.9369	0.9372
50.0000	49.2150	96.3740	95.4692	0.9477	0.9481
75.0000	49.2150	94.3060	93.4040	0.9657	0.9658
0.1000	65.6199	90.4960	89.6000	1.0000	1.0000
1.0000	65.6199	91.9290	91.0348	0.9823	0.9822
2.0000	65.6199	94.2086	93.3127	0.9601	0.9600
5.0000	65.6199	97.3671	96.4657	0.9344	0.9344
10.0000	65.6199	98.6037	97.6987	0.9263	0.9263
20.0000	65.6199	98.0826	97.1767	0.9322	0.9324
30.0000	65.6199	96.9101	96.0051	0.9427	0.9428
40.0000	65.6199	95.8119	94.9081	0.9523	0.9524
50.0000	65.6199	94.9077	94.0048	0.9605	0.9604
75.0000	65.6199	93.4127	92.5121	0.9735	0.9736
0.1000	164.0500	90.4960	89.6000	1.0000	1.0000
1.0000	164.0500	90.4961	89.6001	1.0000	1.0000
2.0000	164.0500	90.5114	89.6155	0.9997	0.9997
5.0000	164.0500	90.8459	89.9506	0.9953	0.9954
10.0000	164.0500	91.5346	90.6389	0.9882	0.9882
20.0000	164.0500	92.1802	91.2832	0.9827	0.9826
30.0000	164.0500	92.2912	91.3935	0.9822	0.9822
40.0000	164.0500	92.2058	91.3078	0.9835	0.9834
50.0000	164.0500	92.0564	91.1584	0.9851	0.9851
75.0000	164.0500	91.6804	90.7826	0.9890	0.9889

Table 6 (Continued)

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	328.1001	90.4960	89.6000	1.0000	1.0000
1.0000	328.1001	90.4960	89.6000	1.0000	1.0000
2.0000	328.1001	90.4960	89.6000	1.0000	1.0000
5.0000	328.1001	90.4964	89.6004	1.0000	1.0000
10.0000	328.1001	90.5164	89.6205	0.9997	0.9997
20.0000	328.1001	90.6501	89.7544	0.9980	0.9980
30.0000	328.1001	90.7869	89.8911	0.9965	0.9965
40.0000	328.1001	90.8761	89.9802	0.9957	0.9957
50.0000	328.1001	90.9228	90.0266	0.9955	0.9954
75.0000	328.1001	90.9344	90.0381	0.9955	0.9955
0.1000	492.1499	90.4960	89.6000	1.0000	1.0000
1.0000	492.1499	90.4960	89.6000	1.0000	1.0000
2.0000	492.1499	90.4960	89.6000	1.0000	1.0000
20.0000	492.1499	90.5038	89.6078	0.9999	0.9999
30.0000	492.1499	90.5298	89.6339	0.9995	0.9995
40.0000	492.1499	90.5646	89.6687	0.9991	0.9991
50.0000	492.1499	90.5978	89.7019	0.9987	0.9987
75.0000	492.1499	90.6519	89.7559	0.9983	0.9982
0.1000	656.2000	90.4960	89.6000	1.0000	1.0000
1.0000	656.2000	90.4960	89.6000	1.0000	1.0000
2.0000	656.2000	90.4960	89.6000	1.0000	1.0000
5.0000	656.2000	90.4960	89.6000	1.0000	1.0000
10.0000	656.2000	90.4960	89.6000	1.0000	1.0000
20.0000	656.2000	90.4962	89.6002	1.0000	1.0000
30.0000	656.2000	90.4984	89.6024	1.0000	1.0000
40.0000	656.2000	90.5047	89.6087	0.9999	0.9999
50.0000	656.2000	90.5145	89.6186	0.9997	0.9997
75.0000	656.2000	90.5428	89.6469	0.9994	0.9994
0.1000	820.2500	90.4960	89.6000	1.0000	1.0000
1.0000	820.2500	90.4960	89.6000	1.0000	1.0000
2.0000	820.2500	90.4960	89.6000	1.0000	1.0000
5.0000	820.2500	90.4960	89.6000	1.0000	1.0000
10.0000	820.2500	90.4960	89.6000	1.0000	1.0000
20.0000	820.2500	90.4960	89.6000	1.0000	1.0000
30.0000	820.2500	90.4961	89.6001	1.0000	1.0000
40.0000	820.2500	90.4967	89.6008	0.9999	1.0000
50.0000	820.2500	90.4985	89.6025	1.0000	1.0000
75.0000	820.2500	90.5075	89.6115	0.9999	0.9998

Table 7. Sensitivity of Temperature to Value of TXCORD, Location in Medium for Benchmark 3

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	1.4600	501.8357	504.7993	-0.5871	-0.5911
1.0000	1.4600	575.3423	578.4497	-0.5372	-0.5408
2.0000	1.4600	565.1804	568.1526	-0.5231	-0.5266
5.0000	1.4600	517.7056	520.2839	-0.4956	-0.4988
10.0000	1.4600	445.6506	447.7085	-0.4596	-0.4626
20.0000	1.4600	339.7178	341.0781	-0.3988	-0.4013
30.0000	1.4600	270.7886	271.7324	-0.3473	-0.3492
40.0000	1.4600	223.2424	223.9227	-0.3038	-0.3055
50.0000	1.4600	192.6632	193.1769	-0.2659	-0.2673
75.0000	1.4600	151.2675	151.5654	-0.1965	-0.1975
0.1000	3.2810	295.2253	297.3396	-0.7111	-0.7166
1.0000	3.2810	357.0334	359.2905	-0.6282	-0.6330
2.0000	3.2810	355.6106	357.7861	-0.6081	-0.6127
5.0000	3.2810	334.2126	336.1367	-0.5724	-0.5766
10.0000	3.2810	297.3423	298.9185	-0.5273	-0.5310
20.0000	3.2810	239.6994	240.7848	-0.4508	-0.4538
30.0000	3.2810	200.4177	201.1926	-0.3852	-0.3879
40.0000	3.2810	173.5846	174.1580	-0.3292	-0.3316
50.0000	3.2810	155.0381	155.4772	-0.2824	-0.2844
75.0000	3.2810	129.2953	129.5553	-0.2007	-0.2021
0.1000	6.5620	175.6425	176.9653	-0.7475	-0.7546
1.0000	6.5620	227.3161	228.7927	-0.6454	-0.6509
2.0000	6.5620	230.1754	231.6078	-0.6185	-0.6240
5.0000	6.5620	222.5048	223.7904	-0.5745	-0.5794
10.0000	6.5620	204.9337	206.0081	-0.5215	-0.5259
20.0000	6.5620	175.0882	175.8511	-0.4338	-0.4375
30.0000	6.5620	153.7631	154.3201	-0.3609	-0.3639
40.0000	6.5620	138.7824	139.2010	-0.3007	-0.3031
50.0000	6.5620	128.2335	128.5579	-0.2523	-0.2542
75.0000	6.5620	113.2985	113.4935	-0.1718	-0.1732
0.1000	16.4050	100.3385	100.7170	-0.3758	-0.3822
1.0000	16.4050	133.3376	133.9812	-0.4804	-0.4852
2.0000	16.4050	138.4577	139.0932	-0.4569	-0.4614
5.0000	16.4050	139.5812	140.1616	-0.4141	-0.4183
10.0000	16.4050	135.0199	135.5139	-0.3645	-0.3683
20.0000	16.4050	124.7700	125.1309	-0.2884	-0.2911
30.0000	16.4050	116.6777	116.9465	-0.2298	-0.2318
40.0000	16.4050	110.7204	110.9252	-0.1846	-0.1861
50.0000	16.4050	106.3950	106.5552	-0.1503	-0.1515
75.0000	16.4050	100.0715	100.1687	-0.0970	-0.0982
0.1000	20.0140	94.4759	94.6978	-0.2343	-0.2389
1.0000	20.0140	121.8010	122.3215	-0.4255	-0.4299
2.0000	20.0140	127.0065	127.5260	-0.4074	-0.4116
5.0000	20.0140	129.0878	129.5654	-0.3686	-0.3724
10.0000	20.0140	126.0694	126.4779	-0.3230	-0.3259
20.0000	20.0140	118.2240	118.5231	-0.2524	-0.2548
30.0000	20.0140	111.8003	112.0232	-0.1990	-0.2011
40.0000	20.0140	107.0013	107.1718	-0.1591	-0.1604
50.0000	20.0140	103.4859	103.6189	-0.1284	-0.1299
75.0000	20.0140	98.2976	98.3789	-0.0826	-0.0834

Table 7 (Continued)

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	32.8100	89.7993	89.8188	-0.0217	-0.0226
1.0000	32.8100	102.4483	102.7377	-0.2817	-0.2850
2.0000	32.8100	107.1923	107.5017	-0.2878	-0.2912
5.0000	32.8100	110.6355	110.9302	-0.2657	-0.2685
10.0000	32.8100	110.2233	110.4778	-0.2304	-0.2332
20.0000	32.8100	106.5585	106.7469	-0.1765	-0.1786
30.0000	32.8100	103.0741	103.2156	-0.1371	-0.1385
40.0000	32.8100	100.3313	100.4397	-0.1079	-0.1090
50.0000	32.8100	98.2594	98.3443	-0.0863	-0.0873
75.0000	32.8100	95.1073	95.1593	-0.0546	-0.0551
0.1000	42.9810	89.6079	89.6092	-0.0015	-0.0015
1.0000	42.9810	96.1187	96.3070	-0.1955	-0.1982
2.0000	42.9810	100.1380	100.3595	-0.2207	-0.2238
5.0000	42.9810	103.7253	103.9458	-0.2121	-0.2144
10.0000	42.9810	104.2065	104.3998	-0.1852	-0.1873
20.0000	42.9810	102.0884	102.2328	-0.1413	-0.1427
30.0000	42.9810	99.7196	99.8277	-0.1083	-0.1099
40.0000	42.9810	97.7594	97.8426	-0.0850	-0.0860
50.0000	42.9810	96.2424	96.3075	-0.0676	-0.0685
75.0000	42.9810	93.8752	93.9153	-0.0427	-0.0429
0.1000	49.2150	89.6008	89.6010	-0.0002	-0.0002
1.0000	49.2150	93.8902	94.0338	-0.1527	-0.1548
2.0000	49.2150	97.4025	97.5860	-0.1880	-0.1902
5.0000	49.2150	100.9881	101.1786	-0.1883	-0.1904
10.0000	49.2150	101.7573	101.9261	-0.1656	-0.1671
20.0000	49.2150	100.2642	100.3911	-0.1264	-0.1274
30.0000	49.2150	98.3388	98.4340	-0.0967	-0.0979
40.0000	49.2150	96.7007	96.7740	-0.0757	-0.0764
50.0000	49.2150	95.4120	95.4692	-0.0599	-0.0608
75.0000	49.2150	93.3687	93.4040	-0.0378	-0.0379
0.1000	65.6199	89.6000	89.6000	0.0	-0.0000
1.0000	65.6199	90.9693	91.0348	-0.0720	-0.0736
2.0000	65.6199	93.2004	93.3127	-0.1204	-0.1219
5.0000	65.6199	96.3303	96.4657	-0.1404	-0.1421
10.0000	65.6199	97.5729	97.6987	-0.1288	-0.1298
20.0000	65.6199	97.0804	97.1767	-0.0991	-0.0999
30.0000	65.6199	95.9323	96.0051	-0.0758	-0.0767
40.0000	65.6199	94.8524	94.9081	-0.0587	-0.0597
50.0000	65.6199	93.9610	94.0048	-0.0466	-0.0473
75.0000	65.6199	92.4854	92.5121	-0.0289	-0.0292
0.1000	164.0500	89.6000	89.6000	0.0	-0.0000
1.0000	164.0500	89.6001	89.6001	0.0	-0.0000
2.0000	164.0500	89.6139	89.6155	-0.0018	-0.0019
5.0000	164.0500	89.9321	89.9506	-0.0206	-0.0211
10.0000	164.0500	90.6043	90.6389	-0.0382	-0.0388
20.0000	164.0500	91.2458	91.2832	-0.0410	-0.0415
30.0000	164.0500	91.3616	91.3935	-0.0349	-0.0353
40.0000	164.0500	91.2818	91.3078	-0.0285	-0.0288
50.0000	164.0500	91.1373	91.1584	-0.0231	-0.0233
75.0000	164.0500	90.7696	90.7826	-0.0143	-0.0145

Table 7 (Continued)

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	328.1001	89.6000	89.6000	0.0	0.0
1.0000	328.1001	89.6000	89.6000	0.0	-0.0000
2.0000	328.1001	89.6000	89.6000	0.0	-0.0000
5.0000	328.1001	89.6003	89.6004	-0.0001	-0.0001
10.0000	328.1001	89.6187	89.6205	-0.0020	-0.0021
20.0000	328.1001	89.7464	89.7544	-0.0089	-0.0091
30.0000	328.1001	89.8800	89.8911	-0.0123	-0.0126
40.0000	328.1001	89.9684	89.9802	-0.0131	-0.0132
50.0000	328.1001	90.0155	90.0266	-0.0123	-0.0125
75.0000	328.1001	90.0296	90.0381	-0.0094	-0.0095
0.1000	492.1499	89.6000	89.6000	0.0	0.0
1.0000	492.1499	89.6000	89.6000	0.0	0.0000
2.0000	492.1499	89.6000	89.6000	0.0	-0.0000
5.0000	492.1499	89.6000	89.6000	0.0	-0.0000
10.0000	492.1499	89.6001	89.6001	0.0	-0.0000
20.0000	492.1499	89.6070	89.6078	-0.0009	-0.0009
30.0000	492.1499	89.6315	89.6339	-0.0027	-0.0027
40.0000	492.1499	89.6649	89.6687	-0.0042	-0.0043
50.0000	492.1499	89.6972	89.7019	-0.0052	-0.0053
75.0000	492.1499	89.7508	89.7559	-0.0057	-0.0058
0.1000	656.2000	89.6000	89.6000	0.0	0.0
1.0000	656.2000	89.6000	89.6000	0.0	0.0000
2.0000	656.2000	89.6000	89.6000	0.0	-0.0000
5.0000	656.2000	89.6000	89.6000	0.0	-0.0000
10.0000	656.2000	89.6000	89.6000	0.0	-0.0000
20.0000	656.2000	89.6002	89.6002	0.0	-0.0000
30.0000	656.2000	89.6022	89.6024	-0.0002	-0.0003
40.0000	656.2000	89.6080	89.6087	-0.0008	-0.0009
50.0000	656.2000	89.6172	89.6186	-0.0016	-0.0015
75.0000	656.2000	89.6445	89.6469	-0.0027	-0.0027
0.1000	820.2500	89.6000	89.6000	0.0	0.0
1.0000	820.2500	89.6000	89.6000	0.0	0.0
2.0000	820.2500	89.6000	89.6000	0.0	-0.0000
5.0000	820.2500	89.6000	89.6000	0.0	-0.0000
10.0000	820.2500	89.6000	89.6000	0.0	-0.0000
20.0000	820.2500	89.6000	89.6000	0.0	-0.0000
30.0000	820.2500	89.6001	89.6001	0.0	-0.0000
40.0000	820.2500	89.6007	89.6008	-0.0001	-0.0001
50.0000	820.2500	89.6022	89.6025	-0.0003	-0.0003
75.0000	820.2500	89.6107	89.6115	-0.0009	-0.0010

Table 8. Sensitivity of Temperature to Metric Tons of Heavy Metal Per Canister for Benchmark 3

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	1.4600	510.0005	504.7993	1.0303	1.0281
1.0000	1.4600	584.8669	578.4497	1.1094	1.1063
2.0000	1.4600	574.4243	568.1526	1.1039	1.1010
5.0000	1.4600	525.8342	520.2839	1.0668	1.0640
10.0000	1.4600	452.1853	447.7085	0.9999	0.9977
20.0000	1.4600	344.0627	341.0781	0.8751	0.8736
30.0000	1.4600	273.8105	271.7324	0.7648	0.7639
40.0000	1.4600	225.4096	223.9227	0.6640	0.6632
50.0000	1.4600	194.2991	193.1769	0.5809	0.5807
75.0000	1.4600	152.2166	151.5654	0.4296	0.4297
0.1000	3.2810	299.6824	297.3396	0.7879	0.7869
1.0000	3.2810	362.4983	359.2905	0.8928	0.8910
2.0000	3.2810	360.9817	357.7861	0.8931	0.8915
5.0000	3.2810	339.0476	336.1367	0.8660	0.8646
10.0000	3.2810	301.3425	298.9185	0.8109	0.8097
20.0000	3.2810	242.4764	240.7848	0.7025	0.7018
30.0000	3.2810	202.4093	201.1926	0.6047	0.6042
40.0000	3.2810	175.0626	174.1580	0.5194	0.5190
50.0000	3.2810	156.1726	155.4772	0.4473	0.4468
75.0000	3.2810	129.9684	129.5553	0.3189	0.3188
0.1000	6.5620	177.8777	176.9653	0.5156	0.5153
1.0000	6.5620	230.3249	228.7927	0.6697	0.6692
2.0000	6.5620	233.1786	231.6078	0.6782	0.6776
5.0000	6.5620	225.2718	223.7904	0.6620	0.6611
10.0000	6.5620	207.2794	206.0081	0.6171	0.6166
20.0000	6.5620	176.7745	175.8511	0.5251	0.5247
30.0000	6.5620	155.0020	154.3201	0.4419	0.4418
40.0000	6.5620	139.7182	139.2010	0.3715	0.3710
50.0000	6.5620	128.9604	128.5579	0.3131	0.3130
75.0000	6.5620	113.7374	113.4935	0.2149	0.2148
0.1000	16.4050	100.8293	100.7170	0.1115	0.1114
1.0000	16.4050	134.4372	133.9812	0.3403	0.3405
2.0000	16.4050	139.6057	139.0932	0.3685	0.3682
5.0000	16.4050	140.6871	140.1616	0.3749	0.3746
10.0000	16.4050	135.9900	135.5139	0.3513	0.3512
20.0000	16.4050	125.4968	125.1309	0.2924	0.2923
30.0000	16.4050	117.2264	116.9465	0.2393	0.2392
40.0000	16.4050	111.1423	110.9252	0.1957	0.1957
50.0000	16.4050	106.7273	106.5552	0.1615	0.1614
75.0000	16.4050	100.2753	100.1687	0.1064	0.1065
0.1000	20.0140	94.7490	94.6978	0.0541	0.0541
1.0000	20.0140	122.6553	122.3215	0.2729	0.2726
2.0000	20.0140	127.9151	127.5260	0.3051	0.3050
5.0000	20.0140	129.9773	129.5654	0.3179	0.3177
10.0000	20.0140	126.8572	126.4779	0.2999	0.3001
20.0000	20.0140	118.8195	118.5231	0.2501	0.2498
30.0000	20.0140	112.2516	112.0232	0.2039	0.2039
40.0000	20.0140	107.3500	107.1718	0.1663	0.1664
50.0000	20.0140	103.7610	103.6189	0.1371	0.1369
75.0000	20.0140	98.4675	98.3789	0.0901	0.0899

Table 8 (Continued)

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	32.8100	89.8210	89.8188	0.0024	0.0024
1.0000	32.8100	102.8698	102.7377	0.1286	0.1284
2.0000	32.8100	107.6823	107.5017	0.1680	0.1681
5.0000	32.8100	111.1469	110.9302	0.1953	0.1951
10.0000	32.8100	110.6904	110.4778	0.1924	0.1920
20.0000	32.8100	106.9209	106.7469	0.1630	0.1629
30.0000	32.8100	103.3533	103.2156	0.1334	0.1334
40.0000	32.8100	100.5491	100.4397	0.1089	0.1089
50.0000	32.8100	98.4328	98.3443	0.0900	0.0896
75.0000	32.8100	95.2150	95.1593	0.0585	0.0587
0.1000	42.9810	89.6093	89.6092	0.0001	0.0001
1.0000	42.9810	96.3741	96.3070	0.0697	0.0700
2.0000	42.9810	100.4684	100.3595	0.1085	0.1082
5.0000	42.9810	104.0904	103.9458	0.1391	0.1392
10.0000	42.9810	104.5496	104.3998	0.1435	0.1433
20.0000	42.9810	102.3606	102.2328	0.1250	0.1248
30.0000	42.9810	99.9312	99.8277	0.1037	0.1034
40.0000	42.9810	97.9257	97.8426	0.0849	0.0848
50.0000	42.9810	96.3751	96.3075	0.0702	0.0700
75.0000	42.9810	93.9587	93.9153	0.0462	0.0461
0.1000	49.2150	89.6010	89.6010	0.0	0.0000
1.0000	49.2150	94.0780	94.0338	0.0470	0.0473
2.0000	49.2150	97.6661	97.5860	0.0821	0.0824
5.0000	49.2150	101.2959	101.1786	0.1159	0.1156
10.0000	49.2150	102.0506	101.9261	0.1221	0.1220
20.0000	49.2150	100.5000	100.3911	0.1085	0.1085
30.0000	49.2150	98.5232	98.4340	0.0906	0.0904
40.0000	49.2150	96.8462	96.7740	0.0746	0.0746
50.0000	49.2150	95.5279	95.4692	0.0615	0.0618
75.0000	49.2150	93.4423	93.4040	0.0410	0.0409
0.1000	65.6199	89.6000	89.6000	0.0	0.0000
1.0000	65.6199	91.0492	91.0348	0.0158	0.0158
2.0000	65.6199	93.3497	93.3127	0.0397	0.0399
5.0000	65.6199	96.5344	96.4657	0.0712	0.0716
10.0000	65.6199	97.7800	97.6987	0.0832	0.0835
20.0000	65.6199	97.2533	97.1767	0.0788	0.0785
30.0000	65.6199	96.0698	96.0051	0.0674	0.0671
40.0000	65.6199	94.9619	94.9081	0.0567	0.0562
50.0000	65.6199	94.0490	94.0048	0.0470	0.0470
75.0000	65.6199	92.5415	92.5121	0.0318	0.0316
0.1000	164.0500	89.6000	89.6000	0.0	0.0000
1.0000	164.0500	89.6001	89.6001	0.0	0.0000
2.0000	164.0500	89.6157	89.6155	0.0002	0.0002
5.0000	164.0500	89.9541	89.9506	0.0039	0.0039
10.0000	164.0500	90.6493	90.6389	0.0115	0.0115
20.0000	164.0500	91.3001	91.2832	0.0185	0.0184
30.0000	164.0500	91.4115	91.3935	0.0197	0.0196
40.0000	164.0500	91.3249	91.3078	0.0187	0.0187
50.0000	164.0500	91.1740	91.1584	0.0171	0.0171
75.0000	164.0500	90.7944	90.7826	0.0130	0.0130

Table 8 (Continued)

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	328.1001	89.6000	89.6000	0.0	0.0
1.0000	328.1001	89.6000	89.6000	0.0	0.0000
2.0000	328.1001	89.6000	89.6000	0.0	0.0000
5.0000	328.1001	89.6004	89.6004	0.0	0.0000
10.0000	328.1001	89.6207	89.6205	0.0002	0.0002
20.0000	328.1001	89.7559	89.7544	0.0017	0.0017
30.0000	328.1001	89.8940	89.8911	0.0032	0.0032
40.0000	328.1001	89.9840	89.9802	0.0042	0.0042
50.0000	328.1001	90.0309	90.0266	0.0048	0.0047
75.0000	328.1001	90.0424	90.0381	0.0048	0.0049
0.1000	492.1499	89.6000	89.6000	0.0	0.0
1.0000	492.1499	89.6000	89.6000	0.0	-0.0000
2.0000	492.1499	89.6000	89.6000	0.0	0.0000
5.0000	492.1499	89.6000	89.6000	0.0	0.0000
10.0000	492.1499	89.6001	89.6001	0.0	0.0000
20.0000	492.1499	89.6078	89.6078	0.0	0.0001
30.0000	492.1499	89.6342	89.6339	0.0003	0.0004
40.0000	492.1499	89.6694	89.6687	0.0008	0.0008
50.0000	492.1499	89.7029	89.7019	0.0011	0.0011
75.0000	492.1499	89.7575	89.7559	0.0018	0.0017
0.1000	656.2000	89.6000	89.6000	0.0	0.0
1.0000	656.2000	89.6000	89.6000	0.0	-0.0000
2.0000	656.2000	89.6000	89.6000	0.0	0.0000
5.0000	656.2000	89.6000	89.6000	0.0	0.0000
10.0000	656.2000	89.6000	89.6000	0.0	0.0000
20.0000	656.2000	89.6002	89.6002	0.0	0.0000
30.0000	656.2000	89.6024	89.6024	0.0	0.0000
40.0000	656.2000	89.6088	89.6087	0.0001	0.0001
50.0000	656.2000.	89.6188	89.6186	0.0002	0.0002
75.0000	656.2000	89.6474	89.6469	0.0006	0.0005
0.1000	820.2500	89.6000	89.6000	0.0	0.0
1.0000	820.2500	89.6000	89.6000	0.0	0.0
2.0000	820.2500	89.6000	89.6000	0.0	0.0000
5.0000	820.2500	89.6000	89.6000	0.0	0.0000
10.0000	820.2500	89.6000	89.6000	0.0	0.0000
20.0000	820.2500	89.6000	89.6000	0.0	0.0000
30.0000	820.2500	89.6001	89.6001	0.0	0.0000
40.0000	820.2500	89.6008	89.6008	0.0	0.0000
50.0000	820.2500	89.6025	89.6025	0.0	0.0000
75.0000	820.2500	89.6116	89.6115	0.0001	0.0001

Table 9. Sensitivity of Temperature to Source Length for Benchmark 3

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	1.4600	501.3162	504.7993	-0.6900	-0.6953
1.0000	1.4600	574.7600	578.4497	-0.6379	-0.6426
2.0000	1.4600	564.6233	568.1526	-0.6212	-0.6258
5.0000	1.4600	517.2217	520.2839	-0.5886	-0.5929
10.0000	1.4600	445.2644	447.7085	-0.5459	-0.5498
20.0000	1.4600	339.4626	341.0781	-0.4736	-0.4769
30.0000	1.4600	270.6116	271.7324	-0.4125	-0.4150
40.0000	1.4600	223.1138	223.9227	-0.3612	-0.3637
50.0000	1.4600	192.5661	193.1769	-0.3162	-0.3181
75.0000	1.4600	151.2112	151.5654	-0.2337	-0.2350
0.1000	3.2810	296.1689	297.3396	-0.3937	-0.3953
1.0000	3.2810	358.0247	359.2905	-0.3523	-0.3537
2.0000	3.2810	356.5652	357.7861	-0.3413	-0.3425
5.0000	3.2810	335.0569	336.1367	-0.3212	-0.3223
10.0000	3.2810	298.0344	298.9185	-0.2957	-0.2969
20.0000	3.2810	240.1758	240.7848	-0.2529	-0.2537
30.0000	3.2810	200.7579	201.1926	-0.2161	-0.2168
40.0000	3.2810	173.8364	174.1580	-0.1847	-0.1853
50.0000	3.2810	155.2309	155.4772	-0.1584	-0.1590
75.0000	3.2810	129.4097	129.5553	-0.1124	-0.1130
0.1000	6.5620	176.6809	176.9653	-0.1607	-0.1607
1.0000	6.5620	228.4703	228.7927	-0.1409	-0.1409
2.0000	6.5620	231.2949	231.6078	-0.1351	-0.1351
5.0000	6.5620	223.5096	223.7904	-0.1255	-0.1255
10.0000	6.5620	205.7733	206.0081	-0.1140	-0.1139
20.0000	6.5620	175.6848	175.8511	-0.0946	-0.0947
30.0000	6.5620	154.1983	154.3201	-0.0789	-0.0788
40.0000	6.5620	139.1096	139.2010	-0.0657	-0.0657
50.0000	6.5620	128.4868	128.5579	-0.0553	-0.0551
75.0000	6.5620	113.4508	113.4935	-0.0376	-0.0375
0.1000	16.4050	100.7007	100.7170	-0.0162	-0.0160
1.0000	16.4050	133.9529	133.9812	-0.0211	-0.0208
2.0000	16.4050	139.0658	139.0932	-0.0197	-0.0198
5.0000	16.4050	140.1362	140.1616	-0.0181	-0.0179
10.0000	16.4050	135.4930	135.5139	-0.0154	-0.0158
20.0000	16.4050	125.1151	125.1309	-0.0126	-0.0125
30.0000	16.4050	116.9347	116.9465	-0.0101	-0.0099
40.0000	16.4050	110.9162	110.9252	-0.0081	-0.0080
50.0000	16.4050	106.5478	106.5552	-0.0069	-0.0065
75.0000	16.4050	100.1646	100.1687	-0.0041	-0.0042
0.1000	20.0140	94.6912	94.6978	-0.0070	-0.0068
1.0000	20.0140	122.3061	122.3215	-0.0126	-0.0126
2.0000	20.0140	127.5107	127.5260	-0.0120	-0.0120
5.0000	20.0140	129.5510	129.5654	-0.0111	-0.0109
10.0000	20.0140	126.4654	126.4779	-0.0099	-0.0095
20.0000	20.0140	118.5142	118.5231	-0.0075	-0.0075
30.0000	20.0140	112.0164	112.0232	-0.0061	-0.0059
40.0000	20.0140	107.1666	107.1718	-0.0049	-0.0047
50.0000	20.0140	103.6148	103.6189	-0.0039	-0.0038
75.0000	20.0140	98.3762	98.3789	-0.0027	-0.0024

Table 9 (Continued)

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	32.8100	89.8188	89.8188	0.0	0.0000
1.0000	32.8100	102.7377	102.7377	0.0	0.0000
2.0000	32.8100	107.5017	107.5017	0.0	0.0000
5.0000	32.8100	110.9302	110.9302	0.0	0.0000
10.0000	32.8100	110.4778	110.4778	0.0	0.0000
20.0000	32.8100	106.7469	106.7469	0.0	0.0000
30.0000	32.8100	103.2156	103.2156	0.0	0.0000
40.0000	32.8100	100.4397	100.4397	0.0	0.0000
50.0000	32.8100	98.3443	98.3443	0.0	0.0000
75.0000	32.8100	95.1593	95.1593	0.0	0.0000
0.1000	42.9810	89.6092	89.6092	0.0	0.0000
1.0000	42.9810	96.3070	96.3070	0.0	0.0000
2.0000	42.9810	100.3595	100.3595	0.0	0.0000
5.0000	42.9810	103.9458	103.9458	0.0	0.0000
10.0000	42.9810	104.3998	104.3998	0.0	0.0000
20.0000	42.9810	102.2328	102.2328	0.0	0.0000
30.0000	42.9810	99.8277	99.8277	0.0	0.0000
40.0000	42.9810	97.8426	97.8426	0.0	0.0000
50.0000	42.9810	96.3075	96.3075	0.0	0.0000
75.0000	42.9810	93.9153	93.9153	0.0	0.0000
0.1000	49.2150	89.6010	89.6010	0.0	0.0000
1.0000	49.2150	94.0338	94.0338	0.0	0.0000
2.0000	49.2150	97.5860	97.5860	0.0	0.0000
5.0000	49.2150	101.1786	101.1786	0.0	0.0000
10.0000	49.2150	101.9261	101.9261	0.0	-0.0000
20.0000	49.2150	100.3911	100.3911	0.0	0.0000
30.0000	49.2150	98.4340	98.4340	0.0	0.0000
40.0000	49.2150	96.7740	96.7740	0.0	0.0000
50.0000	49.2150	95.4692	95.4692	0.0	0.0000
75.0000	49.2150	93.4040	93.4040	0.0	0.0000
0.1000	65.6199	89.6000	89.6000	0.0	0.0000
1.0000	65.6199	91.0348	91.0348	0.0	0.0000
2.0000	65.6199	93.3127	93.3127	0.0	0.0000
5.0000	65.6199	96.4657	96.4657	0.0	0.0000
10.0000	65.6199	97.6987	97.6987	0.0	0.0000
20.0000	65.6199	97.1767	97.1767	0.0	0.0000
30.0000	65.6199	96.0051	96.0051	0.0	0.0000
40.0000	65.6199	94.9081	94.9081	0.0	0.0000
50.0000	65.6199	94.0048	94.0048	0.0	0.0000
75.0000	65.6199	92.5121	92.5121	0.0	0.0000
0.1000	164.0500	89.6000	89.6000	0.0	0.0000
1.0000	164.0500	89.6001	89.6001	0.0	0.0000
2.0000	164.0500	89.6155	89.6155	0.0	0.0000
5.0000	164.0500	89.9506	89.9506	0.0	0.0000
10.0000	164.0500	90.6389	90.6389	0.0	0.0000
20.0000	164.0500	91.2832	91.2832	0.0	0.0000
30.0000	164.0500	91.3935	91.3935	0.0	0.0000
40.0000	164.0500	91.3078	91.3078	0.0	0.0000
50.0000	164.0500	91.1584	91.1584	0.0	0.0000
75.0000	164.0500	90.7826	90.7826	0.0	0.0000

Table 9 (Continued)

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	328.1001	89.6000	89.6000	0.0	0.0
1.0000	328.1001	89.6000	89.6000	0.0	0.0000
2.0000	328.1001	89.6000	89.6000	0.0	0.0000
5.0000	328.1001	89.6004	89.6004	0.0	0.0000
10.0000	328.1001	89.6205	89.6205	0.0	0.0000
20.0000	328.1001	89.7544	89.7544	0.0	0.0000
30.0000	328.1001	89.8911	89.8911	0.0	0.0000
40.0000	328.1001	89.9802	89.9802	0.0	0.0000
50.0000	328.1001	90.0266	90.0266	0.0	0.0000
75.0000	328.1001	90.0381	90.0381	0.0	0.0000
0.1000	492.1499	89.6000	89.6000	0.0	0.0
1.0000	492.1499	89.6000	89.6000	0.0	-0.0000
2.0000	492.1499	89.6000	89.6000	0.0	0.0000
5.0000	492.1499	89.6000	89.6000	0.0	0.0000
10.0000	492.1499	89.6001	89.6001	0.0	0.0000
20.0000	492.1499	89.6078	89.6078	0.0	0.0000
30.0000	492.1499	89.6339	89.6339	0.0	0.0000
40.0000	492.1499	89.6687	89.6687	0.0	0.0000
50.0000	492.1499	89.7019	89.7019	0.0	0.0000
75.0000	492.1499	89.7559	89.7559	0.0	0.0000
0.1000	656.2000	89.6000	89.6000	0.0	0.0
1.0000	656.2000	89.6000	89.6000	0.0	-0.0000
2.0000	656.2000	89.6000	89.6000	0.0	0.0000
5.0000	656.2000	89.6000	89.6000	0.0	0.0000
10.0000	656.2000	89.6000	89.6000	0.0	0.0000
20.0000	656.2000	89.6002	89.6002	0.0	0.0000
30.0000	656.2000	89.6024	89.6024	0.0	0.0000
40.0000	656.2000	89.6087	89.6087	0.0	0.0000
50.0000	656.2000	89.6186	89.6186	0.0	0.0000
75.0000	656.2000	89.6469	89.6469	0.0	0.0000
0.1000	820.2500	89.6000	89.6000	0.0	0.0
1.0000	820.2500	89.6000	89.6000	0.0	0.0
2.0000	820.2500	89.6000	89.6000	0.0	0.0000
5.0000	820.2500	89.6000	89.6000	0.0	0.0000
10.0000	820.2500	89.6000	89.6000	0.0	0.0000
20.0000	820.2500	89.6000	89.6000	0.0	0.0000
30.0000	820.2500	89.6001	89.6001	0.0	0.0000
40.0000	820.2500	89.6008	89.6008	0.0	0.0000
50.0000	820.2500	89.6025	89.6025	0.0	0.0000
75.0000	820.2500	89.6115	89.6115	0.0	0.0000

Table 10. Sensitivity of Temperature to Source Decay Time Before Burial for Benchmark 3

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	1.4600	502.4185	504.7993	-0.4716	-0.4776
1.0000	1.4600	575.8779	578.4497	-0.4446	-0.4487
2.0000	1.4600	565.8777	568.1526	-0.4004	-0.4032
5.0000	1.4600	518.5020	520.2839	-0.3425	-0.3437
10.0000	1.4600	446.3330	447.7085	-0.3072	-0.3080
20.0000	1.4600	340.2073	341.0781	-0.2553	-0.2556
30.0000	1.4600	271.1650	271.7324	-0.2088	-0.2092
40.0000	1.4600	223.5511	223.9227	-0.1659	-0.1663
50.0000	1.4600	192.9234	193.1769	-0.1312	-0.1313
75.0000	1.4600	151.4606	151.5654	-0.0691	-0.0691
0.1000	3.2810	296.2642	297.3396	-0.3617	-0.3662
1.0000	3.2810	357.9990	359.2905	-0.3595	-0.3630
2.0000	3.2810	356.6208	357.7861	-0.3257	-0.3280
5.0000	3.2810	335.1982	336.1367	-0.2792	-0.2800
10.0000	3.2810	298.1724	298.9185	-0.2496	-0.2503
20.0000	3.2810	240.2907	240.7848	-0.2052	-0.2056
30.0000	3.2810	200.8599	201.1926	-0.1654	-0.1658
40.0000	3.2810	173.9299	174.1580	-0.1310	-0.1312
50.0000	3.2810	155.3186	155.4772	-0.1020	-0.1022
75.0000	3.2810	129.4875	129.5553	-0.0523	-0.0526
0.1000	6.5620	176.5452	176.9653	-0.2374	-0.2403
1.0000	6.5620	228.1698	228.7927	-0.2723	-0.2748
2.0000	6.5620	231.0290	231.6078	-0.2499	-0.2514
5.0000	6.5620	223.3107	223.7904	-0.2144	-0.2152
10.0000	6.5620	205.6153	206.0081	-0.1907	-0.1911
20.0000	6.5620	175.5808	175.8511	-0.1537	-0.1541
30.0000	6.5620	154.1325	154.3201	-0.1216	-0.1216
40.0000	6.5620	139.0702	139.2010	-0.0940	-0.0943
50.0000	6.5620	128.4655	128.5579	-0.0719	-0.0721
75.0000	6.5620	113.4528	113.4935	-0.0359	-0.0360
0.1000	16.4050	100.6648	100.7170	-0.0518	-0.0522
1.0000	16.4050	133.7918	133.9812	-0.1414	-0.1429
2.0000	16.4050	138.9001	139.0932	-0.1388	-0.1400
5.0000	16.4050	139.9885	140.1616	-0.1235	-0.1239
10.0000	16.4050	135.3659	135.5139	-0.1092	-0.1097
20.0000	16.4050	125.0227	125.1309	-0.0865	-0.0865
30.0000	16.4050	116.8685	116.9465	-0.0667	-0.0666
40.0000	16.4050	110.8693	110.9252	-0.0504	-0.0505
50.0000	16.4050	106.5147	106.5552	-0.0380	-0.0380
75.0000	16.4050	100.1501	100.1687	-0.0186	-0.0187
0.1000	20.0140	94.6741	94.6978	-0.0250	-0.0254
1.0000	20.0140	122.1822	122.3215	-0.1139	-0.1152
2.0000	20.0140	127.3776	127.5260	-0.1164	-0.1170
5.0000	20.0140	129.4291	129.5654	-0.1052	-0.1057
10.0000	20.0140	126.3588	126.4779	-0.0942	-0.0940
20.0000	20.0140	118.4357	118.5231	-0.0737	-0.0741
30.0000	20.0140	111.9595	112.0232	-0.0569	-0.0570
40.0000	20.0140	107.1254	107.1718	-0.0433	-0.0432
50.0000	20.0140	103.5855	103.6189	-0.0322	-0.0325
75.0000	20.0140	98.3634	98.3789	-0.0158	-0.0160

Table 10 (Continued)

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	32.8100	89.8177	89.8188	-0.0012	-0.0011
1.0000	32.8100	102.6812	102.7377	-0.0550	-0.0555
2.0000	32.8100	107.4311	107.5017	-0.0657	-0.0662
5.0000	32.8100	110.8572	110.9302	-0.0658	-0.0662
10.0000	32.8100	110.4111	110.4778	-0.0604	-0.0607
20.0000	32.8100	106.6953	106.7469	-0.0483	-0.0487
30.0000	32.8100	103.1766	103.2156	-0.0378	-0.0377
40.0000	32.8100	100.4108	100.4397	-0.0288	-0.0287
50.0000	32.8100	98.3228	98.3443	-0.0219	-0.0218
75.0000	32.8100	95.1485	95.1593	-0.0114	-0.0110
0.1000	42.9810	89.6092	89.6092	0.0	-0.0000
1.0000	42.9810	96.2777	96.3070	-0.0304	-0.0307
2.0000	42.9810	100.3168	100.3595	-0.0425	-0.0434
5.0000	42.9810	103.8964	103.9458	-0.0475	-0.0480
10.0000	42.9810	104.3523	104.3998	-0.0455	-0.0457
20.0000	42.9810	102.1945	102.2328	-0.0375	-0.0376
30.0000	42.9810	99.7983	99.8277	-0.0295	-0.0295
40.0000	42.9810	97.8206	97.8426	-0.0225	-0.0227
50.0000	42.9810	96.2911	96.3075	-0.0170	-0.0173
75.0000	42.9810	93.9070	93.9153	-0.0088	-0.0090
0.1000	49.2150	89.6010	89.6010	0.0	-0.0000
1.0000	49.2150	94.0145	94.0338	-0.0205	-0.0209
2.0000	49.2150	97.5537	97.5860	-0.0331	-0.0334
5.0000	49.2150	101.1382	101.1786	-0.0399	-0.0402
10.0000	49.2150	101.8866	101.9261	-0.0388	-0.0391
20.0000	49.2150	100.3579	100.3911	-0.0331	-0.0328
30.0000	49.2150	98.4086	98.4340	-0.0258	-0.0259
40.0000	49.2150	96.7543	96.7740	-0.0204	-0.0201
50.0000	49.2150	95.4541	95.4692	-0.0158	-0.0154
75.0000	49.2150	93.3963	93.4040	-0.0082	-0.0081
0.1000	65.6199	89.6000	89.6000	0.0	-0.0000
1.0000	65.6199	91.0285	91.0348	-0.0069	-0.0071
2.0000	65.6199	93.2973	93.3127	-0.0165	-0.0166
5.0000	65.6199	96.4412	96.4657	-0.0254	-0.0255
10.0000	65.6199	97.6724	97.6987	-0.0269	-0.0271
20.0000	65.6199	97.1535	97.1767	-0.0239	-0.0240
30.0000	65.6199	95.9864	96.0051	-0.0195	-0.0195
40.0000	65.6199	94.8938	94.9081	-0.0151	-0.0154
50.0000	65.6199	93.9938	94.0048	-0.0117	-0.0120
75.0000	65.6199	92.5063	92.5121	-0.0063	-0.0065
0.1000	164.0500	89.6000	89.6000	0.0	-0.0000
1.0000	164.0500	89.6001	89.6001	0.0	-0.0000
2.0000	164.0500	89.6154	89.6155	-0.0001	-0.0001
5.0000	164.0500	89.9492	89.9506	-0.0016	-0.0015
10.0000	164.0500	90.6353	90.6389	-0.0040	-0.0040
20.0000	164.0500	91.2778	91.2832	-0.0059	-0.0059
30.0000	164.0500	91.3880	91.3935	-0.0060	-0.0060
40.0000	164.0500	91.3028	91.3078	-0.0055	-0.0055
50.0000	164.0500	91.1541	91.1584	-0.0047	-0.0048
75.0000	164.0500	90.7797	90.7826	-0.0032	-0.0032

Table 10 (Continued)

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	328.1001	89.6000	89.6000	0.0	0.0
1.0000	328.1001	89.6000	89.6000	0.0	-0.0000
2.0000	328.1001	89.6000	89.6000	0.0	-0.0000
5.0000	328.1001	89.6004	89.6004	0.0	-0.0000
10.0000	328.1001	89.6204	89.6205	-0.0001	-0.0001
20.0000	328.1001	89.7539	89.7544	-0.0005	-0.0006
30.0000	328.1001	89.8902	89.8911	-0.0010	-0.0011
40.0000	328.1001	89.9790	89.9802	-0.0013	-0.0013
50.0000	328.1001	90.0253	90.0266	-0.0014	-0.0014
75.0000	328.1001	90.0368	90.0381	-0.0014	-0.0014
0.1000	492.1499	89.6000	89.6000	0.0	0.0
1.0000	492.1499	89.6000	89.6000	0.0	0.0000
2.0000	492.1499	89.6000	89.6000	0.0	-0.0000
5.0000	492.1499	89.6000	89.6000	0.0	-0.0000
10.0000	492.1499	89.6001	89.6001	0.0	-0.0000
20.0000	492.1499	89.6077	89.6078	-0.0001	-0.0000
30.0000	492.1499	89.6337	89.6339	-0.0002	-0.0001
40.0000	492.1499	89.6685	89.6687	-0.0002	-0.0003
50.0000	492.1499	89.7016	89.7019	-0.0003	-0.0004
75.0000	492.1499	89.7554	89.7559	-0.0006	-0.0005
0.1000	656.2000	89.6000	89.6000	0.0	0.0
1.0000	656.2000	89.6000	89.6000	0.0	-0.0000
2.0000	656.2000	89.6000	89.6000	0.0	-0.0000
5.0000	656.2000	89.6000	89.6000	0.0	-0.0000
10.0000	656.2000	89.6000	89.6000	0.0	-0.0000
20.0000	656.2000	89.6002	89.6002	0.0	-0.0000
30.0000	656.2000	89.6024	89.6024	0.0	-0.0000
40.0000	656.2000	89.6087	89.6087	0.0	-0.0000
50.0000	656.2000	89.6185	89.6186	-0.0001	-0.0001
75.0000	656.2000	89.6468	89.6469	-0.0001	-0.0002
0.1000	820.2500	89.6000	89.6000	0.0	0.0
1.0000	820.2500	89.6000	89.6000	0.0	0.0
2.0000	820.2500	89.6000	89.6000	0.0	-0.0000
5.0000	820.2500	89.6000	89.6000	0.0	-0.0000
10.0000	820.2500	89.6000	89.6000	0.0	-0.0000
20.0000	820.2500	89.6000	89.6000	0.0	-0.0000
30.0000	820.2500	89.6001	89.6001	0.0	-0.0000
40.0000	820.2500	89.6008	89.6008	0.0	-0.0000
50.0000	820.2500	89.6025	89.6025	0.0	-0.0000
75.0000	820.2500	89.6115	89.6115	0.0	-0.0000

Table 11. Sensitivity of Temperature to Value of TBUR, Source Burial Time for Benchmark 3

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	1.4600	505.4270	504.7993	0.1243	0.1252
1.0000	1.4600	578.4290	578.4497	-0.0036	-0.0033
2.0000	1.4600	567.8625	568.1526	-0.0510	-0.0509
5.0000	1.4600	519.4919	520.2839	-0.1522	-0.1523
10.0000	1.4600	446.3987	447.7085	-0.2926	-0.2932
20.0000	1.4600	339.3821	341.0781	-0.4973	-0.4993
30.0000	1.4600	270.0671	271.7324	-0.6128	-0.6165
40.0000	1.4600	222.4518	223.9227	-0.6569	-0.6621
50.0000	1.4600	191.9247	193.1769	-0.6482	-0.6542
75.0000	1.4600	150.7915	151.5654	-0.5106	-0.5170
0.1000	3.2810	297.8113	297.3396	0.1586	0.1597
1.0000	3.2810	359.3442	359.2905	0.0149	0.0152
2.0000	3.2810	357.6824	357.7861	-0.0290	-0.0289
5.0000	3.2810	335.7471	336.1367	-0.1159	-0.1159
10.0000	3.2810	298.2261	298.9185	-0.2316	-0.2321
20.0000	3.2810	239.8334	240.7848	-0.3951	-0.3966
30.0000	3.2810	200.2248	201.1926	-0.4810	-0.4840
40.0000	3.2810	173.2722	174.1580	-0.5086	-0.5122
50.0000	3.2810	154.7086	155.4772	-0.4943	-0.4988
75.0000	3.2810	129.0654	129.5553	-0.3781	-0.3828
0.1000	6.5620	177.3141	176.9653	0.1971	0.1985
1.0000	6.5620	228.8792	228.7927	0.0378	0.0381
2.0000	6.5620	231.5989	231.6078	-0.0038	-0.0036
5.0000	6.5620	223.6174	223.7904	-0.0773	-0.0772
10.0000	6.5620	205.6620	206.0081	-0.1680	-0.1683
20.0000	6.5620	175.3425	175.8511	-0.2892	-0.2903
30.0000	6.5620	153.7845	154.3201	-0.3471	-0.3489
40.0000	6.5620	138.7005	139.2010	-0.3596	-0.3622
50.0000	6.5620	128.1164	128.5579	-0.3434	-0.3465
75.0000	6.5620	113.2050	113.4935	-0.2542	-0.2572
0.1000	16.4050	100.8605	100.7170	0.1425	0.1432
1.0000	16.4050	134.0776	133.9812	0.0720	0.0728
2.0000	16.4050	139.1414	139.0932	0.0347	0.0351
5.0000	16.4050	140.1321	140.1616	-0.0211	-0.0209
10.0000	16.4050	135.4060	135.5139	-0.0796	-0.0796
20.0000	16.4050	124.9433	125.1309	-0.1499	-0.1502
30.0000	16.4050	116.7367	116.9465	-0.1794	-0.1801
40.0000	16.4050	110.7219	110.9252	-0.1833	-0.1843
50.0000	16.4050	106.3716	106.5552	-0.1723	-0.1738
75.0000	16.4050	100.0438	100.1687	-0.1247	-0.1260
0.1000	20.0140	94.7882	94.6978	0.0955	0.0958
1.0000	20.0140	122.4156	122.3215	0.0769	0.0775
2.0000	20.0140	127.5794	127.5260	0.0419	0.0424
5.0000	20.0140	129.5523	129.5654	-0.0101	-0.0097
10.0000	20.0140	126.3984	126.4779	-0.0629	-0.0625
20.0000	20.0140	118.3757	118.5231	-0.1244	-0.1246
30.0000	20.0140	111.8551	112.0232	-0.1500	-0.1507
40.0000	20.0140	107.0067	107.1718	-0.1541	-0.1545
50.0000	20.0140	103.4692	103.6189	-0.1445	-0.1458
75.0000	20.0140	98.2759	98.3789	-0.1047	-0.1060

Table 11 (Continued)

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	32.8100	89.8279	89.8188	0.0101	0.0101
1.0000	32.8100	102.8147	102.7377	0.0749	0.0755
2.0000	32.8100	107.5587	107.5017	0.0530	0.0535
5.0000	32.8100	110.9447	110.9302	0.0131	0.0132
10.0000	32.8100	110.4484	110.4778	-0.0266	-0.0266
20.0000	32.8100	106.6699	106.7469	-0.0721	-0.0722
30.0000	32.8100	103.1212	103.2156	-0.0915	-0.0918
40.0000	32.8100	100.3438	100.4397	-0.0955	-0.0961
50.0000	32.8100	98.2546	98.3443	-0.0912	-0.0917
75.0000	32.8100	95.0953	95.1593	-0.0673	-0.0680
0.1000	42.9810	89.6098	89.6092	0.0007	0.0007
1.0000	42.9810	96.3670	96.3070	0.0623	0.0628
2.0000	42.9810	100.4128	100.3595	0.0531	0.0532
5.0000	42.9810	103.9686	103.9458	0.0219	0.0221
10.0000	42.9810	104.3883	104.3998	-0.0110	-0.0110
20.0000	42.9810	102.1821	102.2328	-0.0496	-0.0494
30.0000	42.9810	99.7614	99.8277	-0.0664	-0.0668
40.0000	42.9810	97.7729	97.8426	-0.0712	-0.0715
50.0000	42.9810	96.2412	96.3075	-0.0688	-0.0693
75.0000	42.9810	93.8667	93.9153	-0.0517	-0.0526
0.1000	49.2150	89.6011	89.6010	0.0001	0.0001
1.0000	49.2150	94.0835	94.0338	0.0529	0.0530
2.0000	49.2150	97.6350	97.5860	0.0502	0.0507
5.0000	49.2150	101.2038	101.1786	0.0249	0.0252
10.0000	49.2150	101.9214	101.9261	-0.0046	-0.0044
20.0000	49.2150	100.3511	100.3911	-0.0398	-0.0398
30.0000	49.2150	98.3793	98.4340	-0.0556	-0.0560
40.0000	49.2150	96.7151	96.7740	-0.0609	-0.0611
50.0000	49.2150	95.4125	95.4692	-0.0594	-0.0598
75.0000	49.2150	93.3610	93.4040	-0.0461	-0.0461
0.1000	65.6199	89.6000	89.6000	0.0	0.0000
1.0000	65.6199	91.0609	91.0348	0.0287	0.0287
2.0000	65.6199	93.3495	93.3127	0.0394	0.0397
5.0000	65.6199	96.4929	96.4657	0.0282	0.0286
10.0000	65.6199	97.7045	97.6987	0.0059	0.0065
20.0000	65.6199	97.1550	97.1767	-0.0223	-0.0223
30.0000	65.6199	95.9697	96.0051	-0.0369	-0.0367
40.0000	65.6199	94.8683	94.9081	-0.0419	-0.0423
50.0000	65.6199	93.9650	94.0048	-0.0423	-0.0428
75.0000	65.6199	92.4805	92.5121	-0.0342	-0.0345
0.1000	164.0500	89.6000	89.6000	0.0	0.0000
1.0000	164.0500	89.6001	89.6001	0.0	0.0000
2.0000	164.0500	89.6163	89.6155	0.0009	0.0009
5.0000	164.0500	89.9581	89.9506	0.0083	0.0084
10.0000	164.0500	90.6500	90.6389	0.0122	0.0123
20.0000	164.0500	91.2890	91.2832	0.0064	0.0064
30.0000	164.0500	91.3928	91.3935	-0.0008	-0.0007
40.0000	164.0500	91.3026	91.3078	-0.0057	-0.0057
50.0000	164.0500	91.1505	91.1584	-0.0087	-0.0088
75.0000	164.0500	90.7729	90.7826	-0.0107	-0.0108

Table 11 (Continued)

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	328.1001	89.6000	89.6000	0.0	0.0
1.0000	328.1001	89.6000	89.6000	0.0	0.0000
2.0000	328.1001	89.6000	89.6000	0.0	0.0000
5.0000	328.1001	89.6004	89.6004	0.0	0.0000
10.0000	328.1001	89.6213	89.6205	0.0009	0.0009
20.0000	328.1001	89.7574	89.7544	0.0033	0.0034
30.0000	328.1001	89.8945	89.8911	0.0038	0.0038
40.0000	328.1001	89.9827	89.9802	0.0028	0.0029
50.0000	328.1001	90.0281	90.0266	0.0017	0.0016
75.0000	328.1001	90.0372	90.0381	-0.0010	-0.0010
0.1000	492.1499	89.6000	89.6000	0.0	0.0
1.0000	492.1499	89.6000	89.6000	0.0	-0.0000
2.0000	492.1499	89.6000	89.6000	0.0	0.0000
5.0000	492.1499	89.6000	89.6000	0.0	0.0000
10.0000	492.1499	89.6001	89.6001	0.0	0.0000
20.0000	492.1499	89.6081	89.6078	0.0003	0.0004
30.0000	492.1499	89.6348	89.6339	0.0010	0.0011
40.0000	492.1499	89.6701	89.6687	0.0016	0.0016
50.0000	492.1499	89.7034	89.7019	0.0017	0.0017
75.0000	492.1499	89.7569	89.7559	0.0011	0.0011
0.1000	656.2000	89.6000	89.6000	0.0	0.0
1.0000	656.2000	89.6000	89.6000	0.0	-0.0000
2.0000	656.2000	89.6000	89.6000	0.0	0.0000
5.0000	656.2000	89.6000	89.6000	0.0	0.0000
10.0000	656.2000	89.6000	89.6000	0.0	0.0000
20.0000	656.2000	89.6002	89.6002	0.0	0.0000
30.0000	656.2000	89.6025	89.6024	0.0001	0.0001
40.0000	656.2000	89.6091	89.6087	0.0004	0.0004
50.0000	656.2000	89.6191	89.6186	0.0005	0.0006
75.0000	656.2000	89.6477	89.6469	0.0009	0.0009
0.1000	820.2500	89.6000	89.6000	0.0	0.0
1.0000	820.2500	89.6000	89.6000	0.0	0.0
2.0000	820.2500	89.6000	89.6000	0.0	0.0000
5.0000	820.2500	89.6000	89.6000	0.0	0.0000
10.0000	820.2500	89.6000	89.6000	0.0	0.0000
20.0000	820.2500	89.6000	89.6000	0.0	0.0000
30.0000	820.2500	89.6001	89.6001	0.0	0.0000
40.0000	820.2500	89.6008	89.6008	0.0	0.0001
50.0000	820.2500	89.6026	89.6025	0.0001	0.0001
75.0000	820.2500	89.6119	89.6115	0.0004	0.0004

Table 12. Reference Value of Input Parameters for Benchmark 4

ACOND	1243.89	Thermal conductivity correlation parameter
BCOND	0.126	Thermal conductivity correlation parameter
RHO	134.8	Density of geological medium, lb/ft^3
CP	0.215	Specific heat of geological medium, Btu/lbm- F
TINIT	89.6	Initial temperature of geological medium, F
MTHM	9.576	Number of metric tons of heavy metal per cannister
SLEN	12.074	Source length, ft
TCOOL	10.0	Source decay time before burial, yrs
PITCH X	85.962	Source pitch in X direction, ft
PITCH Y	40.028	Source pitch in Y direction, ft

TXCORD (X-coordinate of calculated calculated temperature, ft)	TBUR (Time after burial, yrs)
41.687	0.1
39.7	1.0
36.419	2.0
26.576	3.5
22.967	5.0
10.171	7.5
0.0	10.0

Table 13. Sensitivity of Temperature to Parameter A in Conductivity Equation for Benchmark 4

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	41.6870	536.9106	541.5610	-0.8587	-0.8673
1.0000	41.6870	635.8643	642.0884	-0.9694	-0.9801
2.0000	41.6870	651.0156	657.2993	-0.9560	-0.9667
3.5000	41.6870	657.7566	663.9316	-0.9301	-0.9402
5.0000	41.6870	657.0789	663.0972	-0.9076	-0.9174
7.5000	41.6870	647.6621	653.3730	-0.8741	-0.8837
10.0000	41.6870	632.6965	638.0876	-0.8449	-0.8537
0.1000	39.7000	295.6360	297.3374	-0.5722	-0.5860
1.0000	39.7000	378.2036	381.0093	-0.7364	-0.7438
2.0000	39.7000	399.6543	402.5913	-0.7295	-0.7371
3.5000	39.7000	417.6262	420.6204	-0.7118	-0.7190
5.0000	39.7000	428.2124	431.2195	-0.6973	-0.7043
7.5000	39.7000	437.1775	440.1509	-0.6755	-0.6821
10.0000	39.7000	439.5867	442.4956	-0.6574	-0.6634
0.1000	36.4190	176.4730	176.9946	-0.2947	-0.2965
1.0000	36.4190	247.1528	248.4332	-0.5154	-0.5203
2.0000	36.4190	270.7200	272.1423	-0.5227	-0.5275
3.5000	36.4190	293.1379	294.6687	-0.5195	-0.5240
5.0000	36.4190	308.4856	310.0852	-0.5159	-0.5205
7.5000	36.4190	325.4685	327.1360	-0.5097	-0.5143
10.0000	36.4190	335.8965	337.5950	-0.5031	-0.5076
0.1000	26.5760	100.7467	100.7168	0.0297	0.0303
1.0000	26.5760	150.2433	150.5252	-0.1873	-0.1886
2.0000	26.5760	174.6670	175.0777	-0.2346	-0.2361
3.5000	26.5760	199.6655	200.1798	-0.2569	-0.2711
5.0000	26.5760	217.9349	218.5707	-0.2909	-0.2928
7.5000	26.5760	240.2191	240.9724	-0.3126	-0.3143
10.0000	26.5760	255.9764	256.8152	-0.3266	-0.3292
0.1000	22.9670	94.7345	94.6977	0.0389	0.0396
1.0000	22.9670	137.8233	137.9881	-0.1194	-0.1201
2.0000	22.9670	162.2643	162.5527	-0.1774	-0.1785
3.5000	22.9670	187.5457	187.9640	-0.2225	-0.2233
5.0000	22.9670	206.1278	206.6457	-0.2506	-0.2518
7.5000	22.9670	229.0570	229.6968	-0.2785	-0.2799
10.0000	22.9670	245.4865	246.2177	-0.2970	-0.2989
0.1000	10.1710	89.8253	89.8188	0.0072	0.0072
1.0000	10.1710	117.0616	117.0418	0.0169	0.0177
2.0000	10.1710	141.4426	141.5304	-0.0620	-0.0620
3.5000	10.1710	167.1859	167.4043	-0.1305	-0.1307
5.0000	10.1710	186.3912	186.7093	-0.1704	-0.1713
7.5000	10.1710	210.2296	210.6815	-0.2145	-0.2155
10.0000	10.1710	227.7952	228.3456	-0.2410	-0.2424
0.1000	0.0	89.6000	89.6000	0.0	0.0
1.0000	0.0	112.9924	112.9378	0.0483	0.0493
2.0000	0.0	137.3541	137.4023	-0.0351	-0.0345
3.5000	0.0	163.1177	163.2984	-0.1107	-0.1108
5.0000	0.0	182.4868	182.7658	-0.1526	-0.1534
7.5000	0.0	206.4809	206.8996	-0.2024	-0.2017
10.0000	0.0	224.2458	224.7614	-0.2294	-0.2308

Table 14. Sensitivity of Temperature to Parameter B in Conductivity Equation for Benchmark 4

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	41.6870	541.2004	541.5610	-0.0666	-0.0665
1.0000	41.6870	641.5825	642.0884	-0.0788	-0.0792
2.0000	41.6870	656.7825	657.2993	-0.0786	-0.0788
3.5000	41.6870	663.4202	663.9316	-0.0770	-0.0770
5.0000	41.6870	662.6001	663.0972	-0.0750	-0.0752
7.5000	41.6870	652.9011	653.3730	-0.0722	-0.0722
10.0000	41.6870	637.6458	638.0876	-0.0693	-0.0692
0.1000	39.7000	297.2227	297.3374	-0.0386	-0.0385
1.0000	39.7000	380.8118	381.0093	-0.0518	-0.0517
2.0000	39.7000	402.3816	402.5913	-0.0521	-0.0520
3.5000	39.7000	420.4038	420.6204	-0.0515	-0.0514
5.0000	39.7000	431.0015	431.2195	-0.0506	-0.0507
7.5000	39.7000	439.9348	440.1509	-0.0491	-0.0493
10.0000	39.7000	442.2825	442.4956	-0.0482	-0.0481
0.1000	36.4190	176.9633	176.9946	-0.0177	-0.0178
1.0000	36.4190	248.3514	248.4332	-0.0329	-0.0330
2.0000	36.4190	272.0503	272.1423	-0.0338	-0.0341
3.5000	36.4190	294.5676	294.6687	-0.0343	-0.0344
5.0000	36.4190	309.9785	310.0852	-0.0344	-0.0345
7.5000	36.4190	327.0232	327.1360	-0.0345	-0.0345
10.0000	36.4190	337.4800	337.5950	-0.0341	-0.0343
0.1000	26.5760	100.7185	100.7168	0.0017	0.0016
1.0000	26.5760	150.5088	150.5252	-0.0109	-0.0111
2.0000	26.5760	175.0532	175.0777	-0.0140	-0.0141
3.5000	26.5760	200.1469	200.1798	-0.0164	-0.0165
5.0000	26.5760	218.5311	218.5707	-0.0181	-0.0181
7.5000	26.5760	240.9247	240.9724	-0.0198	-0.0197
10.0000	26.5760	256.7622	256.8152	-0.0206	-0.0209
0.1000	22.9670	94.6998	94.6977	0.0022	0.0022
1.0000	22.9670	137.9786	137.9881	-0.0069	-0.0070
2.0000	22.9670	162.5357	162.5527	-0.0105	-0.0105
3.5000	22.9670	187.9388	187.9640	-0.0134	-0.0135
5.0000	22.9670	206.6137	206.6457	-0.0155	-0.0154
7.5000	22.9670	229.6585	229.6968	-0.0167	-0.0174
10.0000	22.9670	246.1715	246.2177	-0.0188	-0.0188
0.1000	10.1710	89.8191	89.8188	0.0003	0.0004
1.0000	10.1710	117.0430	117.0418	0.0010	0.0010
2.0000	10.1710	141.5255	141.5304	-0.0035	-0.0036
3.5000	10.1710	167.3910	167.4043	-0.0079	-0.0077
5.0000	10.1710	186.6902	186.7093	-0.0102	-0.0103
7.5000	10.1710	210.6543	210.6815	-0.0129	-0.0132
10.0000	10.1710	228.3120	228.3456	-0.0147	-0.0150
0.1000	0.0	89.6000	89.6000	0.0	0.0
1.0000	0.0	112.9411	112.9378	0.0029	0.0028
2.0000	0.0	137.3991	137.4023	-0.0023	-0.0020
3.5000	0.0	163.2878	163.2984	-0.0065	-0.0065
5.0000	0.0	182.7494	182.7658	-0.0090	-0.0092
7.5000	0.0	206.8743	206.8996	-0.0122	-0.0123
10.0000	0.0	224.7288	224.7614	-0.0145	-0.0142

Table 15. Sensitivity of Temperature to Density of Geological Medium for Benchmark 4

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	41.6870	540.8835	541.5610	-0.1251	-0.1256
1.0000	41.6870	641.5562	642.0884	-0.0829	-0.0836
2.0000	41.6870	656.6250	657.2993	-0.1026	-0.1033
3.5000	41.6870	663.0759	663.9316	-0.1289	-0.1298
5.0000	41.6870	662.1140	663.0972	-0.1483	-0.1494
7.5000	41.6870	652.2444	653.3730	-0.1727	-0.1739
10.0000	41.6870	636.8708	638.0876	-0.1907	-0.1923
0.1000	39.7000	296.8560	297.3374	-0.1619	-0.1624
1.0000	39.7000	380.5857	381.0093	-0.1112	-0.1119
2.0000	39.7000	402.0388	402.5913	-0.1372	-0.1382
3.5000	39.7000	419.8818	420.6204	-0.1756	-0.1702
5.0000	39.7000	430.3982	431.2195	-0.1905	-0.1922
7.5000	39.7000	439.1648	440.1509	-0.2240	-0.2191
10.0000	39.7000	441.4214	442.4956	-0.2428	-0.2376
0.1000	36.4190	176.6401	176.9946	-0.2003	-0.2011
1.0000	36.4190	248.0657	248.4332	-0.1479	-0.1489
2.0000	36.4190	271.6282	272.1423	-0.1889	-0.1811
3.5000	36.4190	294.0356	294.6687	-0.2148	-0.2166
5.0000	36.4190	309.3467	310.0852	-0.2382	-0.2397
7.5000	36.4190	326.2739	327.1360	-0.2635	-0.2656
10.0000	36.4190	336.6479	337.5950	-0.2805	-0.2832
0.1000	26.5760	100.5737	100.7168	-0.1421	-0.1434
1.0000	26.5760	150.1834	150.5252	-0.2271	-0.2149
2.0000	26.5760	174.6348	175.0777	-0.2530	-0.2548
3.5000	26.5760	199.6052	200.1798	-0.2870	-0.2892
5.0000	26.5760	217.8747	218.5707	-0.3184	-0.3094
7.5000	26.5760	240.1783	240.9724	-0.3295	-0.3317
10.0000	26.5760	255.9391	256.8152	-0.3411	-0.3440
0.1000	22.9670	94.6078	94.6977	-0.0949	-0.0958
1.0000	22.9670	137.6550	137.9881	-0.2414	-0.2285
2.0000	22.9670	162.1158	162.5527	-0.2688	-0.2707
3.5000	22.9670	187.3957	187.9640	-0.3023	-0.3047
5.0000	22.9670	205.9830	206.6457	-0.3207	-0.3231
7.5000	22.9670	228.9137	229.6968	-0.3409	-0.3440
10.0000	22.9670	245.3248	246.2177	-0.3626	-0.3553
0.1000	10.1710	89.8099	89.8188	-0.0099	-0.0101
1.0000	10.1710	116.7486	117.0418	-0.2505	-0.2526
2.0000	10.1710	141.1035	141.5304	-0.3016	-0.3039
3.5000	10.1710	166.8488	167.4043	-0.3318	-0.3348
5.0000	10.1710	186.0569	186.7093	-0.3494	-0.3521
7.5000	10.1710	209.9145	210.6815	-0.3641	-0.3671
10.0000	10.1710	227.4921	228.3456	-0.3738	-0.3771
0.1000	0.0	89.6000	89.6000	0.0	0.0
1.0000	0.0	112.6494	112.9378	-0.2554	-0.2576
2.0000	0.0	136.9756	137.4023	-0.3105	-0.3126
3.5000	0.0	162.7462	163.2984	-0.3382	-0.3407
5.0000	0.0	182.1148	182.7658	-0.3562	-0.3589
7.5000	0.0	206.1356	206.8996	-0.3693	-0.3721
10.0000	0.0	223.9133	224.7614	-0.3773	-0.3813

Table 16. Sensitivity of Temperature to Specific Heat of Geological Medium for Benchmark 4

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	41.6870	540.8835	541.5610	-0.1251	-0.1256
1.0000	41.6870	641.5562	642.0884	-0.0829	-0.0836
2.0000	41.6870	656.6250	657.2993	-0.1026	-0.1033
3.5000	41.6870	663.0759	663.9316	-0.1289	-0.1298
5.0000	41.6870	662.1140	663.0972	-0.1483	-0.1494
7.5000	41.6870	652.2444	653.3730	-0.1727	-0.1739
10.0000	41.6870	636.8708	638.0876	-0.1907	-0.1923
0.1000	39.7000	296.8560	297.3374	-0.1619	-0.1624
1.0000	39.7000	380.5857	381.0093	-0.1112	-0.1119
2.0000	39.7000	402.0388	402.5913	-0.1372	-0.1382
3.5000	39.7000	419.8818	420.6204	-0.1756	-0.1702
5.0000	39.7000	430.3982	431.2195	-0.1905	-0.1922
7.5000	39.7000	439.1648	440.1509	-0.2240	-0.2191
10.0000	39.7000	441.4214	442.4956	-0.2428	-0.2376
0.1000	36.4190	176.6401	176.9946	-0.2003	-0.2011
1.0000	36.4190	248.0657	248.4332	-0.1479	-0.1489
2.0000	36.4190	271.6282	272.1423	-0.1889	-0.1811
3.5000	36.4190	294.0356	294.6687	-0.2148	-0.2166
5.0000	36.4190	309.3467	310.0852	-0.2382	-0.2397
7.5000	36.4190	326.2739	327.1360	-0.2635	-0.2656
10.0000	36.4190	336.6479	337.5950	-0.2805	-0.2833
0.1000	26.5760	100.5737	100.7168	-0.1421	-0.1434
1.0000	26.5760	150.1834	150.5252	-0.2271	-0.2149
2.0000	26.5760	174.6348	175.0777	-0.2530	-0.2548
3.5000	26.5760	199.6052	200.1798	-0.2870	-0.2892
5.0000	26.5760	217.8747	218.5707	-0.3184	-0.3094
7.5000	26.5760	240.1783	240.9724	-0.3295	-0.3317
10.0000	26.5760	255.9391	256.8152	-0.3411	-0.3440
0.1000	22.9670	94.6078	94.6977	-0.0949	-0.0958
1.0000	22.9670	137.6550	137.9881	-0.2414	-0.2285
2.0000	22.9670	162.1158	162.5527	-0.2688	-0.2707
3.5000	22.9670	187.3957	187.9640	-0.3023	-0.3047
5.0000	22.9670	205.9830	206.6457	-0.3207	-0.3231
7.5000	22.9670	228.9137	229.6968	-0.3409	-0.3440
10.0000	22.9670	245.3248	246.2177	-0.3626	-0.3553
0.1000	10.1710	89.8099	89.8188	-0.0099	-0.0101
1.0000	10.1710	116.7486	117.0418	-0.2505	-0.2526
2.0000	10.1710	141.1035	141.5304	-0.3016	-0.3039
3.5000	10.1710	166.8488	167.4043	-0.3318	-0.3348
5.0000	10.1710	186.0569	186.7093	-0.3494	-0.3521
7.5000	10.1710	209.9145	210.6815	-0.3641	-0.3671
10.0000	10.1710	227.4921	228.3456	-0.3738	-0.3771
0.1000	0.0	89.6000	89.6000	0.0	0.0
1.0000	0.0	112.6494	112.9378	-0.2554	-0.2576
2.0000	0.0	136.9756	137.4023	-0.3105	-0.3126
3.5000	0.0	162.7462	163.2984	-0.3382	-0.3407
5.0000	0.0	182.1148	182.7658	-0.3562	-0.3589
7.5000	0.0	206.1356	206.8996	-0.3693	-0.3721
10.0000	0.0	223.9133	224.7614	-0.3773	-0.3813

Table 17. Sensitivity of Temperature to Initial Temperature of Geological Medium for Benchmark 4

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	41.6870	543.0244	541.5610	0.2702	0.2702
1.0000	41.6870	643.7153	642.0884	0.2534	0.2534
2.0000	41.6870	658.9241	657.2993	0.2472	0.2475
3.5000	41.6870	665.5405	663.9316	0.2423	0.2423
5.0000	41.6870	664.6846	663.0972	0.2394	0.2396
7.5000	41.6870	654.9270	653.3730	0.2378	0.2377
10.0000	41.6870	639.6057	638.0876	0.2379	0.2380
0.1000	39.7000	298.4746	297.3374	0.3825	0.3825
1.0000	39.7000	382.2783	381.0093	0.3331	0.3332
2.0000	39.7000	403.8723	402.5913	0.3182	0.3183
3.5000	39.7000	421.9048	420.6204	0.3054	0.3053
5.0000	39.7000	432.5020	431.2195	0.2974	0.2974
7.5000	39.7000	441.4258	440.1509	0.2897	0.2897
10.0000	39.7000	443.7595	442.4956	0.2856	0.2860
0.1000	36.4190	177.9700	176.9946	0.5511	0.5511
1.0000	36.4190	249.5145	248.4332	0.4352	0.4353
2.0000	36.4190	273.2415	272.1423	0.4039	0.4036
3.5000	36.4190	295.7788	294.6687	0.3767	0.3766
5.0000	36.4190	311.2024	310.0852	0.3603	0.3602
7.5000	36.4190	328.2593	327.1360	0.3434	0.3434
10.0000	36.4190	338.7212	337.5950	0.3336	0.3334
0.1000	26.5760	101.6078	100.7168	0.8847	0.8845
1.0000	26.5760	151.4431	150.5252	0.6098	0.6244
2.0000	26.5760	176.0362	175.0777	0.5475	0.5475
3.5000	26.5760	201.1564	200.1798	0.4879	0.4878
5.0000	26.5760	219.5358	218.5707	0.4416	0.4528
7.5000	26.5760	241.9767	240.9724	0.4168	0.4170
10.0000	26.5760	257.8315	256.8152	0.3958	0.3956
0.1000	22.9670	95.5874	94.6977	0.9395	0.9397
1.0000	22.9670	138.8885	137.9881	0.6525	0.6681
2.0000	22.9670	163.4932	162.5527	0.5786	0.5785
3.5000	22.9670	188.9225	187.9640	0.5099	0.5102
5.0000	22.9670	207.6185	206.6457	0.4708	0.4708
7.5000	22.9670	230.6872	229.6968	0.4312	0.4306
10.0000	22.9670	247.2187	246.2177	0.4066	0.4066
0.1000	10.1710	90.7137	89.8188	0.9963	0.9964
1.0000	10.1710	117.9349	117.0418	0.7631	0.7627
2.0000	10.1710	142.4402	141.5304	0.6428	0.6428
3.5000	10.1710	168.3332	167.4043	0.5549	0.5552
5.0000	10.1710	187.6531	186.7093	0.5055	0.5056
7.5000	10.1710	211.6447	210.6815	0.4572	0.4570
10.0000	10.1710	229.3221	228.3456	0.4276	0.4275
0.1000	0.0	90.4960	89.6000	1.0000	1.0000
1.0000	0.0	113.8249	112.9378	0.7855	0.7855
2.0000	0.0	138.3057	137.4023	0.6575	0.6575
3.5000	0.0	164.2222	163.2984	0.5657	0.5657
5.0000	0.0	183.7042	182.7658	0.5134	0.5134
7.5000	0.0	207.8572	206.8996	0.4628	0.4628
10.0000	0.0	225.7355	224.7614	0.4334	0.4322

Table 18. Sensitivity of Temperature to Value of TXCORD, Location in Medium for Benchmark 4

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	41.6870	670.3599	541.5610	23.7829	18.4936
1.0000	41.6870	778.0872	642.0884	21.1807	16.5256
2.0000	41.6870	789.0510	657.2993	20.0444	15.6761
3.5000	41.6870	788.7627	663.9316	18.8018	14.7388
5.0000	41.6870	781.1624	663.0972	17.8051	13.9902
7.5000	41.6870	760.6982	653.3730	16.4263	12.9564
10.0000	41.6870	735.5649	638.0876	15.2765	12.0828
0.1000	39.7000	325.7268	297.3374	9.5479	8.6703
1.0000	39.7000	411.6824	381.0093	8.0505	7.3263
2.0000	39.7000	432.6501	402.5913	7.4663	6.7994
3.5000	39.7000	449.4714	420.6204	6.8592	6.2585
5.0000	39.7000	458.8835	431.2195	6.4153	5.8517
7.5000	39.7000	465.7598	440.1509	5.8182	5.3179
10.0000	39.7000	466.1387	442.4956	5.3431	4.8894
0.1000	36.4190	184.8095	176.9946	4.4153	4.1874
1.0000	36.4190	257.2859	248.4332	3.5634	3.3923
2.0000	36.4190	280.8831	272.1423	3.2118	3.0582
3.5000	36.4190	303.1416	294.6687	2.8754	2.7387
5.0000	36.4190	318.2649	310.0852	2.6379	2.5133
7.5000	36.4190	334.8040	327.1360	2.3440	2.2341
10.0000	36.4190	344.7493	337.5950	2.1192	2.0205
0.1000	26.5760	101.3574	100.7168	0.6361	0.6192
1.0000	26.5760	151.6658	150.5252	0.7577	0.7456
2.0000	26.5760	176.2149	175.0777	0.6495	0.6395
3.5000	26.5760	201.2910	200.1798	0.5551	0.5464
5.0000	26.5760	219.6502	218.5707	0.4939	0.4864
7.5000	26.5760	241.9933	240.9724	0.4237	0.4176
10.0000	26.5760	257.7788	256.8152	0.3752	0.3690
0.1000	22.9670	94.9636	94.6977	0.2808	0.2742
1.0000	22.9670	138.6503	137.9881	0.4799	0.4742
2.0000	22.9670	163.2155	162.5527	0.4077	0.4031
3.5000	22.9670	188.6119	187.9640	0.3447	0.3408
5.0000	22.9670	207.2757	206.6457	0.3049	0.3016
7.5000	22.9670	230.2949	229.6968	0.2604	0.2572
10.0000	22.9670	246.7810	246.2177	0.2288	0.2262
0.1000	10.1710	89.8251	89.8188	0.0070	0.0070
1.0000	10.1710	117.1280	117.0418	0.0737	0.0729
2.0000	10.1710	141.6172	141.5304	0.0613	0.0610
3.5000	10.1710	167.4893	167.4043	0.0508	0.0506
5.0000	10.1710	186.7924	186.7093	0.0445	0.0442
7.5000	10.1710	210.7605	210.6815	0.0375	0.0372
10.0000	10.1710	228.4208	228.3456	0.0329	0.0324
0.1000	0.0	89.6000	89.6000	0.0	0.0
1.0000	0.0	112.9378	112.9378	0.0	0.0
2.0000	0.0	137.4023	137.4023	0.0	0.0
3.5000	0.0	163.2984	163.2984	0.0	0.0
5.0000	0.0	182.7658	182.7658	0.0	0.0
7.5000	0.0	206.8996	206.8996	0.0	0.0
10.0000	0.0	224.7614	224.7614	0.0	0.0

Table 19. Sensitivity of Temperature to Source Pitch in X-Direction for Benchmark 4

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	41.6870	456.6516	541.5610	-15.6786	-19.0675
1.0000	41.6870	551.8403	642.0884	-14.0554	-17.0493
2.0000	41.6870	569.2361	657.2993	-13.3977	-16.2206
3.5000	41.6870	579.7278	663.9316	-12.6826	-15.3167
5.0000	41.6870	582.8103	663.0972	-12.1079	-14.5914
7.5000	41.6870	579.4795	653.3730	-11.3096	-13.5849
10.0000	41.6870	570.2715	638.0876	-10.6280	-12.7297
0.1000	39.7000	271.9768	297.3374	-8.5292	-9.3869
1.0000	39.7000	353.3848	381.0093	-7.2504	-7.9513
2.0000	39.7000	375.2180	402.5913	-6.7993	-7.4476
3.5000	39.7000	393.9250	420.6204	-6.3467	-6.9413
5.0000	39.7000	405.3342	431.2195	-6.0028	-6.5571
7.5000	39.7000	415.7000	440.1509	-5.5551	-6.0486
10.0000	39.7000	419.5876	442.4956	-5.1770	-5.6346
0.1000	36.4190	168.7554	176.9946	-4.6551	-4.9419
1.0000	36.4190	238.9369	248.4332	-3.8225	-4.0384
2.0000	36.4190	262.5164	272.1423	-3.5371	-3.7329
3.5000	36.4190	285.0132	294.6687	-3.2767	-3.4529
5.0000	36.4190	300.5076	310.0852	-3.0887	-3.2508
7.5000	36.4190	317.8064	327.1360	-2.8519	-2.9969
10.0000	36.4190	328.5984	337.5950	-2.6649	-2.7972
0.1000	26.5760	99.7506	100.7168	-0.9593	-1.0014
1.0000	26.5760	148.6183	150.5252	-1.2668	-1.2976
2.0000	26.5760	172.9308	175.0777	-1.2263	-1.2536
3.5000	26.5760	197.7967	200.1798	-1.1905	-1.2157
5.0000	26.5760	216.0032	218.5707	-1.1747	-1.1873
7.5000	26.5760	238.2481	240.9724	-1.1305	-1.1521
10.0000	26.5760	253.9891	256.8152	-1.1004	-1.1214
0.1000	22.9670	94.2326	94.6977	-0.4911	-0.5131
1.0000	22.9670	136.6227	137.9881	-0.9895	-1.0091
2.0000	22.9670	160.9387	162.5527	-0.9929	-1.0107
3.5000	22.9670	186.1036	187.9640	-0.9898	-1.0066
5.0000	22.9670	204.6122	206.6457	-0.9841	-1.0000
7.5000	22.9670	227.4580	229.6968	-0.9747	-0.9902
10.0000	22.9670	243.8205	246.2177	-0.9736	-0.9783
0.1000	10.1710	89.7936	89.8188	-0.0281	-0.0296
1.0000	10.1710	116.3504	117.0418	-0.5907	-0.5985
2.0000	10.1710	140.5707	141.5304	-0.6781	-0.6861
3.5000	10.1710	166.1902	167.4043	-0.7252	-0.7338
5.0000	10.1710	185.3035	186.7093	-0.7529	-0.7614
7.5000	10.1710	209.0474	210.6815	-0.7756	-0.7847
10.0000	10.1710	226.5410	228.3456	-0.7903	-0.7996
0.1000	0.0	89.6000	89.6000	0.0	0.0
1.0000	0.0	112.3513	112.9378	-0.5193	-0.5256
2.0000	0.0	136.5417	137.4023	-0.6263	-0.6330
3.5000	0.0	162.1879	163.2984	-0.6800	-0.6880
5.0000	0.0	181.4554	182.7658	-0.7170	-0.7247
7.5000	0.0	205.3597	206.8996	-0.7443	-0.7518
10.0000	0.0	223.0492	224.7614	-0.7618	-0.7714

Table 20. Sensitivity of Temperature to Source Pitch in X-Direction for Benchmark 4

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	CRESS
0.1000	41.6870	541.5613	541.5610	0.0000	0.0000
1.0000	41.6870	641.3191	642.0884	-0.1198	-0.1218
2.0000	41.6870	656.1292	657.2993	-0.1780	-0.1805
3.5000	41.6870	662.3838	663.9316	-0.2331	-0.2362
5.0000	41.6870	661.2832	663.0972	-0.2736	-0.2771
7.5000	41.6870	651.2568	653.3730	-0.3239	-0.3280
10.0000	41.6870	635.7751	638.0876	-0.3624	-0.3668
0.1000	39.7000	297.3376	297.3374	0.0001	0.0001
1.0000	39.7000	380.3784	381.0093	-0.1656	-0.1682
2.0000	39.7000	401.6309	402.5913	-0.2386	-0.2417
3.5000	39.7000	419.3093	420.6204	-0.3117	-0.3094
5.0000	39.7000	429.7031	431.2195	-0.3516	-0.3561
7.5000	39.7000	438.2949	440.1509	-0.4217	-0.4127
10.0000	39.7000	440.4829	442.4956	-0.4549	-0.4535
0.1000	36.4190	176.9906	176.9946	-0.0023	-0.0023
1.0000	36.4190	247.8893	248.4332	-0.2189	-0.2225
2.0000	36.4190	271.2832	272.1423	-0.3157	-0.3116
3.5000	36.4190	293.5408	294.6687	-0.3828	-0.3878
5.0000	36.4190	308.7153	310.0852	-0.4418	-0.4391
7.5000	36.4190	325.5325	327.1360	-0.4902	-0.4959
10.0000	36.4190	335.7773	337.5950	-0.5384	-0.5365
0.1000	26.5760	100.7168	100.7168	0.0	0.0
1.0000	26.5760	150.0996	150.5252	-0.2828	-0.2737
2.0000	26.5760	174.4131	175.0777	-0.3796	-0.3844
3.5000	26.5760	199.2460	200.1798	-0.4665	-0.4720
5.0000	26.5760	217.4092	218.5707	-0.5314	-0.5259
7.5000	26.5760	239.5798	240.9724	-0.5779	-0.5841
10.0000	26.5760	255.2408	256.8152	-0.6130	-0.6202
0.1000	22.9670	94.6977	94.6977	0.0	0.0
1.0000	22.9670	137.6061	137.9881	-0.2768	-0.2665
2.0000	22.9670	161.9357	162.5527	-0.3796	-0.3840
3.5000	22.9670	187.0551	187.9640	-0.4836	-0.4767
5.0000	22.9670	205.5608	206.6457	-0.5250	-0.5308
7.5000	22.9670	228.3582	229.6968	-0.5828	-0.5899
10.0000	22.9670	244.6926	246.2177	-0.6194	-0.6260
0.1000	10.1710	89.8188	89.8188	0.0	0.0
1.0000	10.1710	116.7946	117.0418	-0.2112	-0.2136
2.0000	10.1710	141.0374	141.5304	-0.3483	-0.3522
3.5000	10.1710	166.6434	167.4043	-0.4545	-0.4595
5.0000	10.1710	185.7472	186.7093	-0.5153	-0.5208
7.5000	10.1710	209.4675	210.6815	-0.5762	-0.5826
10.0000	10.1710	226.9430	228.3456	-0.6142	-0.6214
0.1000	0.0	89.6000	89.6000	0.0	0.0
1.0000	0.0	112.7194	112.9378	-0.1934	-0.1951
2.0000	0.0	136.9382	137.4023	-0.3378	-0.3414
3.5000	0.0	162.5693	163.2984	-0.4465	-0.4513
5.0000	0.0	181.8350	182.7658	-0.5093	-0.5145
7.5000	0.0	205.7174	206.8996	-0.5714	-0.5783
10.0000	0.0	223.3898	224.7614	-0.6102	-0.6174

Table 21. Sensitivity of Temperature to Metric Tons of Heavy Metal Per Canister for Benchmark 4

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	41.6870	547.3110	541.5610	1.0617	1.0594
1.0000	41.6870	649.4485	642.0884	1.1463	1.1429
2.0000	41.6870	664.8708	657.2993	1.1519	1.1488
3.5000	41.6870	671.5686	663.9316	1.1503	1.1471
5.0000	41.6870	670.6909	663.0972	1.1452	1.1420
7.5000	41.6870	660.7756	653.3730	1.1330	1.1298
10.0000	41.6870	645.2217	638.0876	1.1180	1.1152
0.1000	39.7000	299.6797	297.3374	0.7878	0.7869
1.0000	39.7000	384.4727	381.0093	0.9090	0.9074
2.0000	39.7000	406.3306	402.5913	0.9288	0.9273
3.5000	39.7000	424.5840	420.6204	0.9423	0.9406
5.0000	39.7000	435.3120	431.2195	0.9491	0.9471
7.5000	39.7000	444.3416	440.1509	0.9521	0.9506
10.0000	39.7000	446.7012	442.4956	0.9504	0.9491
0.1000	36.4190	177.9073	176.9946	0.5157	0.5153
1.0000	36.4190	250.1798	248.4332	0.7030	0.7022
2.0000	36.4190	274.1665	272.1423	0.7438	0.7427
3.5000	36.4190	296.9558	294.6687	0.7762	0.7750
5.0000	36.4190	312.5518	310.0852	0.7954	0.7947
7.5000	36.4190	329.8030	327.1360	0.8153	0.8144
10.0000	36.4190	340.3848	337.5950	0.8264	0.8251
0.1000	26.5760	100.8291	100.7168	0.1115	0.1114
1.0000	26.5760	151.1495	150.5252	0.4147	0.4146
2.0000	26.5760	175.9622	175.0777	0.5052	0.5051
3.5000	26.5760	201.3351	200.1798	0.5771	0.5769
5.0000	26.5760	219.9272	218.5707	0.6206	0.6204
7.5000	26.5760	242.5768	240.9724	0.6658	0.6658
10.0000	26.5760	258.5991	256.8152	0.6946	0.6941
0.1000	22.9670	94.7489	94.6977	0.0541	0.0541
1.0000	22.9670	138.4793	137.9881	0.3560	0.3556
2.0000	22.9670	163.3002	162.5527	0.4598	0.4598
3.5000	22.9670	188.9819	187.9640	0.5415	0.5414
5.0000	22.9670	207.8651	206.6457	0.5901	0.5903
7.5000	22.9670	231.1705	229.6968	0.6416	0.6412
10.0000	22.9670	247.8758	246.2177	0.6734	0.6730
0.1000	10.1710	89.8210	89.8188	0.0024	0.0024
1.0000	10.1710	117.3157	117.0418	0.2340	0.2339
2.0000	10.1710	142.0534	141.5304	0.3695	0.3695
3.5000	10.1710	168.1962	167.4043	0.4730	0.4732
5.0000	10.1710	187.7062	186.7093	0.5339	0.5337
7.5000	10.1710	211.9375	210.6815	0.5962	0.5958
10.0000	10.1710	229.7957	228.3456	0.6350	0.6345
0.1000	0.0	89.6000	89.6000	0.0	0.0
1.0000	0.0	113.1698	112.9378	0.2054	0.2055
2.0000	0.0	137.8817	137.4023	0.3489	0.3491
3.5000	0.0	164.0466	163.2984	0.4582	0.4580
5.0000	0.0	183.7191	182.7658	0.5216	0.5215
7.5000	0.0	208.1113	206.8996	0.5856	0.5861
10.0000	0.0	226.1699	224.7614	0.6267	0.6263

Table 22. Sensitivity of Temperature to Source Length for Benchmark 4

TBUR	TXCORD	PERT CASE	BASE CASE	DIFECT	CRESS
0.1000	41.6870	537.6055	541.5610	-0.7304	-0.7365
1.0000	41.6870	637.8577	642.0884	-0.6589	-0.6644
2.0000	41.6870	653.1873	657.2993	-0.6256	-0.6304
3.5000	41.6870	660.0273	663.9316	-0.5881	-0.5928
5.0000	41.6870	659.3962	663.0972	-0.5581	-0.5627
7.5000	41.6870	649.9944	653.3730	-0.5171	-0.5211
10.0000	41.6870	635.0103	638.0876	-0.4823	-0.4859
0.1000	39.7000	296.1663	297.3374	-0.3939	-0.3953
1.0000	39.7000	379.7268	381.0093	-0.3366	-0.3379
2.0000	39.7000	401.3323	402.5913	-0.3127	-0.3137
3.5000	39.7000	419.4099	420.6204	-0.2878	-0.2888
5.0000	39.7000	430.0610	431.2195	-0.2686	-0.2701
7.5000	39.7000	439.0752	440.1509	-0.2444	-0.2454
10.0000	39.7000	441.5002	442.4956	-0.2249	-0.2257
0.1000	36.4190	176.7104	176.9946	-0.1606	-0.1606
1.0000	36.4190	248.1067	248.4332	-0.1314	-0.1314
2.0000	36.4190	271.8193	272.1423	-0.1187	-0.1186
3.5000	36.4190	294.3557	294.6687	-0.1062	-0.1063
5.0000	36.4190	309.7834	310.0852	-0.0973	-0.0975
7.5000	36.4190	326.8521	327.1360	-0.0868	-0.0867
10.0000	36.4190	337.3308	337.5950	-0.0782	-0.0784
0.1000	26.5760	100.7005	100.7168	-0.0162	-0.0160
1.0000	26.5760	150.4976	150.5252	-0.0183	-0.0187
2.0000	26.5760	175.0495	175.0777	-0.0161	-0.0162
3.5000	26.5760	200.1523	200.1798	-0.0137	-0.0139
5.0000	26.5760	218.5437	218.5707	-0.0123	-0.0124
7.5000	26.5760	240.9465	240.9724	-0.0107	-0.0107
10.0000	26.5760	256.7915	256.8152	-0.0092	-0.0094
0.1000	22.9670	94.6912	94.6977	-0.0069	-0.0068
1.0000	22.9670	137.9728	137.9881	-0.0111	-0.0112
2.0000	22.9670	162.5367	162.5527	-0.0098	-0.0097
3.5000	22.9670	187.9483	187.9640	-0.0084	-0.0083
5.0000	22.9670	206.6304	206.6457	-0.0074	-0.0074
7.5000	22.9670	229.6826	229.6968	-0.0062	-0.0063
10.0000	22.9670	246.2039	246.2177	-0.0056	-0.0055
0.1000	10.1710	89.8188	89.8188	0.0	0.0000
1.0000	10.1710	117.0418	117.0418	0.0	0.0000
2.0000	10.1710	141.5307	141.5304	0.0002	0.0000
3.5000	10.1710	167.4042	167.4043	-0.0001	0.0000
5.0000	10.1710	186.7092	186.7093	-0.0001	0.0000
7.5000	10.1710	210.6816	210.6815	0.0000	0.0000
10.0000	10.1710	228.3458	228.3456	0.0001	0.0000
0.1000	0.0	89.6000	89.6000	0.0	0.0
1.0000	0.0	112.9378	112.9378	0.0	0.0000
2.0000	0.0	137.4023	137.4023	0.0	0.0000
3.5000	0.0	163.2984	163.2984	0.0	0.0000
5.0000	0.0	182.7659	182.7658	0.0001	0.0000
7.5000	0.0	206.8997	206.8996	0.0001	0.0000
10.0000	0.0	224.7614	224.7614	0.0	0.0000

Table 23. Sensitivity of Temperature to Source Decay Time Before Burial for Benchmark 4

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	GRESS
0.1000	41.6870	538.9302	541.5610	-0.4858	-0.4921
1.0000	41.6870	639.1345	642.0884	-0.4600	-0.4647
2.0000	41.6870	654.5312	657.2993	-0.4211	-0.4241
3.5000	41.6870	661.3433	663.9316	-0.3899	-0.3916
5.0000	41.6870	660.6147	663.0972	-0.3744	-0.3757
7.5000	41.6870	651.0193	653.3730	-0.3602	-0.3614
10.0000	41.6870	635.8528	638.0876	-0.3502	-0.3515
0.1000	39.7000	296.2617	297.3374	-0.3618	-0.3662
1.0000	39.7000	379.6069	381.0093	-0.3681	-0.3716
2.0000	39.7000	401.2078	402.5913	-0.3437	-0.3459
3.5000	39.7000	419.2590	420.6204	-0.3236	-0.3252
5.0000	39.7000	429.8657	431.2195	-0.3139	-0.3155
7.5000	39.7000	438.8010	440.1509	-0.3067	-0.3076
10.0000	39.7000	441.1626	442.4956	-0.3012	-0.3023
0.1000	36.4190	176.5745	176.9946	-0.2374	-0.2403
1.0000	36.4190	247.7181	248.4332	-0.2878	-0.2906
2.0000	36.4190	271.3823	272.1423	-0.2793	-0.2814
3.5000	36.4190	293.8701	294.6687	-0.2710	-0.2727
5.0000	36.4190	309.2537	310.0852	-0.2682	-0.2692
7.5000	36.4190	326.2639	327.1360	-0.2666	-0.2672
10.0000	36.4190	336.7002	337.5950	-0.2650	-0.2660
0.1000	26.5760	100.6651	100.7168	-0.0513	-0.0522
1.0000	26.5760	150.2626	150.5252	-0.1745	-0.1764
2.0000	26.5760	174.7331	175.0777	-0.1968	-0.1986
3.5000	26.5760	199.7608	200.1798	-0.2093	-0.2106
5.0000	26.5760	218.0747	218.5707	-0.2269	-0.2169
7.5000	26.5760	240.4346	240.9724	-0.2232	-0.2238
10.0000	26.5760	256.2314	256.8152	-0.2273	-0.2281
0.1000	22.9670	94.6740	94.6977	-0.0250	-0.0254
1.0000	22.9670	137.7800	137.9881	-0.1508	-0.1525
2.0000	22.9670	162.2584	162.5527	-0.1810	-0.1826
3.5000	22.9670	187.5914	187.9640	-0.1982	-0.1995
5.0000	22.9670	206.2180	206.6457	-0.2070	-0.2080
7.5000	22.9670	229.2008	229.6968	-0.2159	-0.2167
10.0000	22.9670	245.6729	246.2177	-0.2213	-0.2221
0.1000	10.1710	89.8177	89.8188	-0.0012	-0.0011
1.0000	10.1710	116.9232	117.0418	-0.1013	-0.1026
2.0000	10.1710	141.3194	141.5304	-0.1491	-0.1505
3.5000	10.1710	167.1077	167.4043	-0.1772	-0.1781
5.0000	10.1710	186.3543	186.7093	-0.1901	-0.1911
7.5000	10.1710	210.2546	210.6815	-0.2026	-0.2035
10.0000	10.1710	227.8658	228.3456	-0.2101	-0.2111
0.1000	0.0	89.6000	89.6000	0.0	0.0
1.0000	0.0	112.8364	112.9378	-0.0898	-0.0907
2.0000	0.0	137.2073	137.4023	-0.1419	-0.1431
3.5000	0.0	163.0176	163.2984	-0.1720	-0.1733
5.0000	0.0	182.4249	182.7658	-0.1865	-0.1875
7.5000	0.0	206.4858	206.8996	-0.2000	-0.2007
10.0000	0.0	224.2965	224.7614	-0.2068	-0.2087

Table 24. Sensitivity of Temperature to Value of TBUR, Source Burial Time for Benchmark 4

TBUR	TXCORD	PERT CASE	BASE CASE	DIRECT	CRFSS
0.1000	41.6870	542.2144	541.5610	0.1206	0.1215
1.0000	41.6870	642.3506	642.0884	0.0408	0.0410
2.0000	41.6870	657.4658	657.2993	0.0253	0.0259
3.5000	41.6870	663.9734	663.9316	0.0063	0.0066
5.0000	41.6870	662.9785	663.0972	-0.0179	-0.0172
7.5000	41.6870	652.9653	653.3730	-0.0624	-0.0619
10.0000	41.6870	637.3931	638.0876	-0.1089	-0.1082
0.1000	39.7000	297.8362	297.3374	0.1677	0.1597
1.0000	39.7000	381.3113	381.0093	0.0793	0.0797
2.0000	39.7000	402.9060	402.5913	0.0782	0.0786
3.5000	39.7000	420.9307	420.6204	0.0738	0.0742
5.0000	39.7000	431.4822	431.2195	0.0609	0.0615
7.5000	39.7000	440.2905	440.1509	0.0317	0.0326
10.0000	39.7000	442.4844	442.4956	-0.0025	-0.0018
0.1000	36.4190	177.3457	176.9946	0.1984	0.1996
1.0000	36.4190	248.7449	248.4332	0.1255	0.1259
2.0000	36.4190	272.5134	272.1423	0.1364	0.1368
3.5000	36.4190	295.0884	294.6687	0.1424	0.1434
5.0000	36.4190	310.5107	310.0852	0.1372	0.1384
7.5000	36.4190	327.5205	327.1360	0.1175	0.1184
10.0000	36.4190	337.9026	337.5950	0.0911	0.0918
0.1000	26.5760	100.8608	100.7168	0.1430	0.1432
1.0000	26.5760	150.8323	150.5252	0.2040	0.2042
2.0000	26.5760	175.4797	175.0777	0.2296	0.2302
3.5000	26.5760	200.6903	200.1798	0.2550	0.2437
5.0000	26.5760	219.1005	218.5707	0.2424	0.2427
7.5000	26.5760	241.5206	240.9724	0.2275	0.2291
10.0000	26.5760	257.3394	256.8152	0.2041	0.2054
0.1000	22.9670	94.7882	94.6977	0.0956	0.0958
1.0000	22.9670	138.2913	137.9881	0.2197	0.2201
2.0000	22.9670	162.9575	162.5527	0.2490	0.2497
3.5000	22.9670	188.4577	187.9640	0.2627	0.2640
5.0000	22.9670	207.2089	206.6457	0.2725	0.2623
7.5000	22.9670	230.2645	229.6968	0.2472	0.2487
10.0000	22.9670	246.7679	246.2177	0.2235	0.2253
0.1000	10.1710	89.8279	89.8188	0.0101	0.0101
1.0000	10.1710	117.3316	117.0418	0.2476	0.2484
2.0000	10.1710	141.9392	141.5304	0.2888	0.2897
3.5000	10.1710	167.9100	167.4043	0.3021	0.3034
5.0000	10.1710	187.2719	186.7093	0.3013	0.3024
7.5000	10.1710	211.2795	210.6815	0.2838	0.2855
10.0000	10.1710	228.9422	228.3456	0.2613	0.2627
0.1000	0.0	89.6000	89.6000	0.0	0.0
1.0000	0.0	113.2242	112.9378	0.2536	0.2542
2.0000	0.0	137.8132	137.4023	0.2991	0.2999
3.5000	0.0	163.8273	163.2984	0.3239	0.3112
5.0000	0.0	183.3333	182.7658	0.3105	0.3115
7.5000	0.0	207.5005	206.8996	0.2904	0.2933
10.0000	0.0	225.3659	224.7614	0.2690	0.2702

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