Evaluation of Potential Severe Accidents During Low Power and Shutdown Operations at Surry, Unit 1

Evaluation of Severe Accident Risk During Mid-Loop Operations

Appendices

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ABSTRACT

Traditionally, probabilistic risk assessments (PRA) of severe accidents in nuclear power plants have considered initiating events potentially occurring only during full power operation. Some previous screening analysis that were performed for other modes of operation suggested that risks during those modes were small relative to full power operation. However, more recent studies and operational experience have implied that accidents during low power and shutdown could be significant contributors to risk.

During 1989, the Nuclear Regulatory Commission (NRC) initiated an extensive program to carefully examine the potential risks during low power and shutdown operations. The program includes two parallel projects being performed by Brookhaven National Laboratory (BNL) and Sandia National Laboratories (SNL). Two plants, Surry (pressurized water reactor) and Grand Gulf (boiling water reactor), were selected as the plants to be studied.

The objectives of the program are to assess the risks of severe accidents initiated during plant operational states other than full power operation and to compare the estimated core damage frequencies, important accident sequences and other qualitative and quantitative results with those accidents initiated during full power operation as assessed in NUREG-1150. The scope of the program includes that of a level-3 PRA.

A phased approach was used in the level-1 program. In phase 1 which was completed in Fall 1991, a coarse screening analysis including internal fire and flood was performed for all plant operational states (POs). The objective of the phase 1 study was to identify potential vulnerable plant configurations, to characterize (on a high, medium, or low basis) the potential core damage accident scenarios, and to provide a foundation for a detailed phase 2 analysis.

In phase 2, mid-loop operation was selected as the plant configuration to be analyzed based on the results of the phase 1 study. The objective of the phase 2 study is to perform a detailed analysis of the potential accident scenarios that may occur during mid-loop operation, and compare the results with those of NUREG-1150. Volume 1 summarizes the results of the study. The scope of the level-1 study includes plant damage state analyses, and uncertainty analysis. The internal event analysis is documented in Volume 2. The internal fire and internal flood analysis are documented in Volumes 3 and 4, respectively. A separate study on seismic analysis, documented in Volume 5, was performed for the NRC by Future Resources Associated, Inc.

A phased approach was also used in the level 2/3 program however both phases addressed the risk from only mid-loop operation. The first phase of the level 2/3 PRA was initiated in late 1991 and consisted of an Abridged Risk Study. This study was completed in May 1992 and was focused on accident progression and consequences, conditional on core damage. Phase 2 is a more detailed study in which an evaluation of risk during mid-loop operation was performed. The results of the phase 2 level 2/3 study are the subject of this volume of NUREG/CR-6144, Volume 6.

The offsite risk estimates for latent health effects of accidents during mid-loop operation were similar to the risk estimates for full power operation. The early health consequences are much lower than the full power results primarily due to the long time after shutdown when the accidents occur in mid-loop operation (i.e., because of the natural decay of the short-lived isotopes of iodine and tellurium, which are primarily associated with early health effects). The uncertainties in risk for accidents during mid-loop operating are largely due to uncertainties associated with isolating the containment and achieving a pressure retaining capability.

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APPENDIX A

SUPPORTING INFORMATION FOR THE PDS ANALYSIS

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APPENDIX A

SUPPORTING INFORMATION FOR THE PDS ANALYSIS

Introduction

Appendix A presents additional information on how the 2186 core damage frequency cutsets were grouped together into a smaller number of plant damage states. The process is described in Sections 5.2 and 5.3 of Part 1 of this volume and that material will not be repeated here.

Initially seven characteristics were defined that largely determine the progression of the accident. These seven characteristics (refer to Table A.1) were then used to allocate each of the 2186 cutsets to a PDS. The PDS designators of the 82 highest frequency cutsets are given in Table A.2. Only cutsets with frequencies higher than 10^{-8} per year are included in the table. These 82 cutsets comprise about 70% of the core damage frequency. However, the remaining 2104 cutsets with frequencies lower than 10^{-8} per year were all allocated to PDS designators and included in the subsequent accident progression analysis.

Many of the cutsets in Table A.2 have similar PDS designators. When all of the cutsets with the same PDS designators were combined, 48 individual plant damage states resulted. The 48 PDSs are listed in Table A.3. An uncertainty analysis described in Chapter 12 of Volume 2 of this report was performed for the 48 PDSs. Four statistical measures of the distribution obtained for each PDS are also included in Table A.3.

The 48 PDSs listed in Table A.3 were regrouped into four PDS groups to be processed by the accident progression event tree (refer to Appendix B). Table A.4 indicates how the 48 PDSs were placed into four more general PDS groups.

An uncertainty analysis was performed for the four PDS groups using 100 samples. The PDS group frequencies for each of the 100 samples are given in Table A.5, which also provides the frequencies for the four time windows. The information in Table A.5 was used to obtain the uncertainty in the PDS and Time Window frequencies. Four statistical measures of the PDS and Time Window frequency distributions are presented in Table 5.5 of Part 1 of this volume.

Table A.1 PDS Definition

1. Time of Accident Initiation
 - 1: Window 1
 - 2: Window 2
 - 3: Window 3
 - 4: Window 4
2. AC Power
 - Y: Available
 - U: Unrecoverable blackout
 - B: Blackout (recoverable by recovery of off-site power)
 - F: Loss of 4 kV Bus
3. Human Error
 - N: No human error or non-recoverable human error
 - D: Diagnosis error
 - A: Action error
4. RCS Status at Onset of Core Damage
 - L: Low pressure
 - G: Intermediate pressure
5. ECCS Status
 - U: Unrecoverable hardware failure
 - R: Recoverable if human error, LOSP, or 4 kV is recovered
 - C: Failure of recirculation
6. Recirculation Spray Status
 - R: Recoverable
 - U: Unrecoverable
7. RWST Status
 - Y: Injected
 - R: Not injected but recoverable
 - N: Not injected and not recoverable

Appendix A Supporting Information for the PDS Analysis

Table A.2 Plant Damage State Assignment of the Dominant Cutsets

Cutset Number*	PDS Designator	Frequency per Reactor Year
1	2YDLRRR	2.20E-07
2	3YDLRRR	2.07E-07
3	2YDLRRR	1.70E-07
4	1YNGCUY	1.46E-07
5	3YDLRRR	1.46E-07
6	1YDGRRR	1.24E-07
7	2YDLRRR	1.22E-07
8	1YNGCUY	1.08E-07
9	3YDLRRR	9.52E-08
10	2YDLRRR	9.37E-08
11	1YDGRRR	9.04E-08
12	1YDGRRR	8.73E-08
13	2YDLRRR	7.74E-08
14	1BNGRRR	7.38E-08
15	3YDLRRR	6.70E-08
16	1YDGRRR	5.82E-08
17	1FNRRY	5.41E-08
18	2YDLRRR	5.38E-08
19	3YDLRRR	5.29E-08
20	3YDLRRR	5.07E-08
21	3YDLRRR	4.86E-08
22	2BNLRRR	4.75E-08
23	1YNGCYY	4.39E-08
24	2YDLRRR	4.27E-08
25	4BNLRRR	4.07E-08
26	4YDLRRR	3.91E-08
27	1BNGRRR	3.63E-08

Appendix A Supporting Information for the PDS Analysis

Table A.2 (continued)

Cutset Number*	PDS Designator	Frequency per Reactor Year
28	2YDLRRR	3.39E-08
29	2UDLRUR	3.38E-08
30	2YDLRRR	3.36E-08
31	2YDLRRR	3.30E-08
32	1BNGRRR	3.27E-08
33	1YNGCYY	3.23E-08
34	2YDLRRR	2.97E-08
35	1YNGCUY	2.95E-08
36	3YDLRRR	2.92E-08
37	2YDLRRR	2.91E-08
38	3UDLRUR	2.91E-08
39	3YDLRRR	2.89E-08
40	2BNLRRR	2.62E-08
41	1FNGRRY	2.52E-08
42	1YNGCUY	2.47E-08
43	3YDLRRR	2.33E-08
44	3YDLRRR	2.23E-08
45	1YNGCUY	2.17E-08
46	3BNLRRR	2.13E-08
47	2YALRUY	2.11E-08
48	2YDLRRR	2.01E-08
49	2YDLRRR	1.89E-08
50	2YDLRRR	1.87E-08
51	2UDLRUR	1.87E-08
52	2YDLRRR	1.86E-08
53	1YNGCUY	1.83E-08
54	3YDLRRR	1.83E-08
55	1YDGRRR	1.79E-08

Appendix A Supporting Information for the PDS Analysis

Table A.2 (continued)

Cutset Number*	PDS Designator	Frequency per Reactor Year
56	1YDGRRR	1.75E-08
57	1YDGRRR	1.73E-08
58	3YDLRRR	1.73E-08
59	1BNGRRR	1.68E-08
60	4YDLRRR	1.68E-08
61	2YDLRRR	1.61E-08
62	1YDGRRR	1.60E-08
63	1YNGCYY	1.53E-08
64	1YAGCRY	1.46E-08
65	1YNGCUY	1.35E-08
66	3YDLRRR	1.34E-08
67	3UDLRUR	1.34E-08
68	3YDLRRR	1.33E-08
69	2YDLRRR	1.29E-08
70	2FALRRY	1.26E-08
71	1YNGCYY	1.19E-08
72	1YNGCYY	1.19E-08
73	3YDLRRR	1.19E-08
74	1FNRRY	1.15E-08
75	1YNGCUY	1.13E-08
76	2YDLRRR	1.11E-08
77	1FNRRY	1.09E-08
78	1YAGCRY	1.08E-08
79	3YDLRRR	1.07E-08
80	4YDLRRR	1.07E-08
81	3YDLRRR	1.06E-08
82	2YDLRRR	1.04E-08

*Defined in Table 10.50 of Volume 2 of this report.

Table A.3 Results of Plant Damage State Uncertainty Analysis
(per reactor year)

PDS	MEAN	5th Percentile	50th Percentile	95th Percentile
1BNGCRY	2.95E-09	5.90E-11	7.48E-10	1.11E-08
1BNGRRR	1.71E-07	4.07E-09	4.40E-08	6.35E-07
1BNLCRY	1.43E-10	3.93E-13	1.40E-11	4.70E-10
1FAGRRY	9.07E-09	1.39E-10	2.12E-09	3.31E-08
1FNRRR	4.78E-10	6.02E-12	9.57E-11	1.73E-09
1FNRRY	1.25E-07	2.69E-09	3.43E-08	4.62E-07
1UAGCUY	1.89E-10	1.27E-12	2.92E-11	7.31E-10
1UDGUUR	8.29E-09	7.73E-12	4.40E-10	2.51E-08
1UDLCUY	6.08E-10	8.79E-13	4.23E-11	1.86E-09
1YAGCRY	8.11E-08	4.12E-09	2.84E-08	2.76E-07
1YAGCUY	2.12E-08	5.18E-10	5.48E-09	7.93E-08
1YAGRRR	2.75E-09	1.46E-10	1.04E-09	9.32E-09
1YDGRRR	4.64E-07	1.22E-08	1.19E-07	1.68E-06
1YNGCUY	5.41E-07	1.29E-08	1.28E-07	1.96E-06
1YNGCYY	3.15E-07	1.90E-08	1.08E-07	1.01E-06
1YNGUUR	1.49E-09	2.67E-11	3.54E-10	5.50E-09
1YNGUYR	8.84E-09	6.17E-10	3.93E-09	3.03E-08
1YNLCUY	2.22E-09	2.91E-12	1.30E-10	6.00E-09
1YNLCYY	7.02E-10	2.15E-12	7.03E-11	2.45E-09
2BNLCRY	3.34E-08	9.03E-10	9.76E-09	1.18E-07
2BNLCUY	2.99E-09	1.12E-11	4.46E-10	1.09E-08
2BNLRRR	1.05E-07	4.01E-09	3.57E-08	3.75E-07
2FALRRR	1.46E-08	2.44E-10	3.57E-09	5.48E-08
2FALRRY	4.31E-08	1.17E-09	1.41E-08	1.62E-07
2FNLRRR	2.75E-08	7.12E-10	8.11E-09	9.97E-08
2UALRUY	1.17E-10	1.26E-12	2.40E-11	4.19E-10
2UDLRUR	5.12E-08	1.08E-10	4.21E-09	1.68E-07

Appendix A Supporting Information for the PDS Analysis

Table A.3 (continued)

PDS	MEAN	5th Percentile	50th Percentile	95th Percentile
2YALRRR	7.30E-09	4.48E-10	3.08E-09	2.58E-08
2YALRRY	8.72E-09	5.40E-10	3.78E-09	3.02E-08
2YALRUR	1.50E-08	8.43E-10	5.81E-09	5.20E-08
2YALRUY	4.93E-08	2.05E-09	1.61E-08	1.85E-07
2YALRYR	7.06E-08	1.14E-08	4.11E-08	2.06E-07
2YDLRRR	1.08E-06	3.10E-08	2.80E-07	3.62E-06
2YNLCUY	4.84E-08	1.12E-09	1.28E-08	1.59E-07
2YNLCYY	1.94E-08	1.39E-09	8.11E-09	6.61E-08
3BDLRRR	2.39E-10	2.31E-13	1.30E-11	6.68E-10
3BNLRRR	4.18E-08	1.65E-09	1.38E-08	1.40E-07
3UDLRUR	4.24E-08	9.48E-11	3.49E-09	1.34E-07
3YALRRR	5.31E-09	4.18E-10	2.41E-09	1.80E-08
3YALRUR	2.55E-08	1.53E-09	1.05E-08	8.64E-08
3YALRYR	4.38E-08	6.96E-09	2.57E-08	1.30E-07
3YDLRRR	9.15E-07	2.51E-08	2.42E-07	3.19E-06
4BNLRRR	5.81E-08	7.00E-10	8.98E-09	1.96E-07
4UDLRUR	1.16E-08	1.47E-11	6.35E-10	3.37E-08
4YALRRR	2.75E-09	1.37E-11	3.86E-10	9.32E-09
4YALRUR	2.28E-08	3.76E-10	4.85E-09	7.55E-08
4YALRYR	8.06E-08	3.34E-09	2.95E-08	2.54E-07
4YDLRRR	1.28E-07	1.42E-09	1.81E-08	3.85E-07

Appendix A Supporting Information for the PDS Analysis

Table A.4 Grouping of 48 PDSs into Four PDS Groups

PDS Group Number	Group Description	PDS
1	Station Blackout	1BNGRRR
		2BNLRRR
		3BDLRRR
		3BNLRRR
		4BNLRRR
2	Human Error	1YAGRRR
		1YDGRRR
		2UALRUY
		2UDLRUR
		2YALRRR
		2YALRRY
		2YALRUR
		2YALRUY
		2YALRYR
		2YDLRRR
		3UDLRUR
		3YALRRR
		3YALRUR
		3YALRYR
		3YDLRRR
		4UDLRUR
		4YALRRR
		4YALRUR
		4YALRYR
		4YDLRRR
3	Recirculation Failure	1BNGCRY
		1BNLCRY
		1UAGCUY

Appendix A Supporting Information for the PDS Analysis

Table A.4 (continued)

PDS Group Number	Group Description	PDS
		1UDGUUR
		1UDLCUY
		1YAGCRY
		1YAGCUY
		1YNGCUY
		1YNGCYY
		1YNGUUR
		1YNGUYR
		1YNLCUY
		1YNLCYY
		2BNLCRY
		2BNLCUY
		2YNLCUY
		2YNLCYY
4	Loss of 4 kV Bus	1FAGRRY
		1FNGRRR
		1FNGRRY
		2FALRRR
		2FALRRY
		2FNLRRR

Table A.5 Frequencies of PDS Groups for Each Time Window for the 100 Observations

OBS	1	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1		0.35938E-07	0.76949E-08	0.31299E-07	0.72024E-08	0.82134E-07	25.85
Window 2		0.12034E-07	0.12130E-06	0.60941E-08	0.10525E-07	0.14995E-06	47.19
Window 3		0.18983E-08	0.74006E-07	0.00000E+00	0.00000E+00	0.75904E-07	23.89
Window 4		0.61907E-10	0.96789E-08	0.00000E+00	0.00000E+00	0.97408E-08	3.07
PDS Tot		0.49933E-07	0.21268E-06	0.37393E-07	0.17728E-07	0.31773E-06	
%		15.72	66.94	11.77	5.58		
OBS	2	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1		0.21056E-06	0.93224E-06	0.32112E-05	0.38126E-07	0.43921E-05	65.36
Window 2		0.28091E-07	0.99648E-06	0.57716E-07	0.50233E-07	0.11325E-05	16.85
Window 3		0.78191E-08	0.90320E-06	0.00000E+00	0.00000E+00	0.91102E-06	13.56
Window 4		0.25194E-08	0.28164E-06	0.00000E+00	0.00000E+00	0.28416E-06	4.23
PDS Tot		0.24899E-06	0.31136E-05	0.32689E-05	0.88359E-07	0.67198E-05	
%		3.71	46.33	48.65	1.31		
OBS	3	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1		0.50705E-06	0.31922E-05	0.71610E-06	0.54813E-07	0.44702E-05	79.14
Window 2		0.28312E-06	0.33085E-06	0.35390E-07	0.68466E-07	0.71783E-06	12.71
Window 3		0.15038E-06	0.26066E-06	0.00000E+00	0.00000E+00	0.41105E-06	7.28
Window 4		0.12308E-07	0.37336E-07	0.00000E+00	0.00000E+00	0.49645E-07	0.88
PDS Tot		0.95286E-06	0.38210E-05	0.75149E-06	0.12328E-06	0.56487E-05	
%		16.87	67.64	13.30	2.18		
OBS	4	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1		0.79522E-07	0.10539E-06	0.45254E-06	0.35306E-06	0.99052E-06	49.19
Window 2		0.15084E-06	0.28002E-06	0.83831E-07	0.20553E-06	0.72022E-06	35.77
Window 3		0.37971E-07	0.21401E-06	0.00000E+00	0.00000E+00	0.25198E-06	12.51
Window 4		0.43635E-08	0.46370E-07	0.00000E+00	0.00000E+00	0.5733E-07	2.52
PDS Tot		0.27270E-06	0.64579E-06	0.53637E-06	0.55860E-06	0.20135E-05	
%		13.54	32.07	26.64	27.74		
OBS	5	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1		0.63809E-07	0.31048E-07	0.33797E-06	0.63118E-07	0.49594E-06	15.09
Window 2		0.29902E-07	0.67669E-06	0.29259E-07	0.45196E-07	0.78104E-06	23.77
Window 3		0.25323E-07	0.82070E-06	0.00000E+00	0.00000E+00	0.84602E-06	25.75
Window 4		0.32023E-06	0.84242E-06	0.00000E+00	0.00000E+00	0.11626E-05	35.39
PDS Tot		0.43926E-06	0.23708E-05	0.36723E-06	0.10831E-06	0.32856E-05	
%		13.37	72.16	11.18	3.30		
OBS	6	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1		0.11972E-07	0.17025E-07	0.71249E-07	0.28420E-08	0.10309E-06	49.82
Window 2		0.13055E-07	0.37166E-07	0.41381E-08	0.10939E-07	0.65299E-07	31.56
Window 3		0.32327E-08	0.29396E-07	0.00000E+00	0.00000E+00	0.32628E-07	15.77
Window 4		0.11984E-08	0.47143E-08	0.00000E+00	0.00000E+00	0.59126E-08	2.86
PDS Tot		0.29458E-07	0.88301E-07	0.75387E-07	0.13781E-07	0.20693E-06	
%		14.24	42.67	36.43	6.66		
OBS	7	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1		0.25172E-07	0.31924E-06	0.21624E-06	0.21064E-06	0.77128E-06	65.49
Window 2		0.81922E-08	0.25981E-06	0.77212E-08	0.12843E-07	0.28856E-06	24.50
Window 3		0.90263E-08	0.81781E-07	0.00000E+00	0.00000E+00	0.90808E-07	7.71
Window 4		0.88940E-09	0.26203E-07	0.00000E+00	0.00000E+00	0.27093E-07	2.30
PDS Tot		0.43280E-07	0.68703E-06	0.22396E-06	0.22348E-06	0.11777E-05	
%		3.67	58.33	19.02	18.98		
OBS	8	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1		0.21966E-07	0.81915E-07	0.55854E-07	0.54081E-09	0.16028E-06	26.27
Window 2		0.63433E-08	0.14400E-06	0.99062E-08	0.15010E-08	0.16175E-06	26.51
Window 3		0.23911E-08	0.20266E-06	0.00000E+00	0.00000E+00	0.20505E-06	33.60
Window 4		0.32022E-07	0.51110E-07	0.00000E+00	0.00000E+00	0.83132E-07	13.62
PDS Tot		0.62722E-07	0.47968E-06	0.65760E-07	0.20418E-08	0.61020E-06	
%		10.28	78.61	10.78	0.33		

Appendix A Supporting Information for the PDS Analysis

Table A.5 (continued)

OBS 9	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.83072E-07	0.12362E-06	0.15289E-05	0.28536E-07	0.17642E-05	37.03
Window 2	0.16202E-06	0.14201E-05	0.15041E-06	0.24041E-07	0.17566E-05	36.87
Window 3	0.49724E-07	0.11195E-05	0.00000E+00	0.00000E+00	0.11692E-05	24.54
Window 4	0.20709E-07	0.54141E-07	0.00000E+00	0.00000E+00	0.74849E-07	1.57
PDS Tot	0.31552E-06	0.27174E-05	0.16794E-05	0.52577E-07	0.47648E-05	
%	6.62	57.03	35.24	1.10		
OBS 10	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.46735E-07	0.22160E-06	0.99369E-06	0.21884E-06	0.14809E-05	58.50
Window 2	0.42169E-07	0.26825E-06	0.53158E-07	0.21655E-06	0.58013E-06	22.92
Window 3	0.68925E-08	0.40504E-06	0.00000E+00	0.00000E+00	0.41194E-06	16.27
Window 4	0.25548E-07	0.33062E-07	0.00000E+00	0.00000E+00	0.58609E-07	2.32
PDS Tot	0.12134E-06	0.92796E-06	0.10469E-05	0.43539E-06	0.25315E-05	
%	4.79	36.66	41.35	17.20		
OBS 11	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.37537E-07	0.14091E-07	0.41051E-06	0.82066E-08	0.47034E-06	23.97
Window 2	0.33626E-06	0.40611E-06	0.77910E-07	0.10314E-06	0.92342E-06	47.06
Window 3	0.37749E-07	0.31835E-06	0.00000E+00	0.00000E+00	0.35610E-06	18.15
Window 4	0.64349E-07	0.14786E-06	0.00000E+00	0.00000E+00	0.21221E-06	10.82
PDS Tot	0.47590E-06	0.88641E-06	0.48842E-06	0.11135E-06	0.19621E-05	
%	24.25	45.18	24.89	5.67		
OBS 12	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.36364E-07	0.13442E-07	0.29476E-06	0.57167E-07	0.40173E-06	30.62
Window 2	0.50758E-07	0.37000E-06	0.74044E-07	0.36845E-07	0.53165E-06	40.52
Window 3	0.26202E-07	0.30857E-06	0.00000E+00	0.00000E+00	0.33477E-06	25.52
Window 4	0.62415E-08	0.37592E-07	0.00000E+00	0.00000E+00	0.43833E-07	3.34
PDS Tot	0.11956E-06	0.72961E-06	0.36880E-06	0.94012E-07	0.13120E-05	
%	9.11	55.61	28.11	7.17		
OBS 13	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.47102E-07	0.63613E-07	0.15245E-06	0.18551E-06	0.44868E-06	45.28
Window 2	0.10588E-07	0.12628E-06	0.81105E-07	0.59365E-07	0.27734E-06	27.99
Window 3	0.23891E-07	0.78852E-07	0.00000E+00	0.00000E+00	0.10274E-06	10.37
Window 4	0.14112E-07	0.14802E-06	0.00000E+00	0.00000E+00	0.16213E-06	16.36
PDS Tot	0.95693E-07	0.41677E-06	0.23356E-06	0.24487E-06	0.99089E-06	
%	9.66	42.06	23.57	24.71		
OBS 14	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.10893E-06	0.90293E-07	0.39536E-06	0.44081E-07	0.63866E-06	46.82
Window 2	0.26616E-07	0.16602E-06	0.12849E-06	0.45216E-07	0.36634E-06	26.86
Window 3	0.14086E-07	0.14014E-06	0.00000E+00	0.00000E+00	0.15423E-06	11.31
Window 4	0.15300E-07	0.18941E-06	0.00000E+00	0.00000E+00	0.20471E-06	15.01
PDS Tot	0.16493E-06	0.58587E-06	0.52384E-06	0.89297E-07	0.13639E-05	
%	12.09	42.95	38.41	6.55		
OBS 15	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.13345E-07	0.74152E-08	0.54946E-06	0.38349E-07	0.60856E-06	59.03
Window 2	0.78420E-08	0.20428E-06	0.71637E-07	0.11974E-07	0.29573E-06	28.69
Window 3	0.50995E-08	0.11308E-06	0.00000E+00	0.00000E+00	0.11818E-06	11.46
Window 4	0.59663E-09	0.77934E-08	0.00000E+00	0.00000E+00	0.83901E-08	0.81
PDS Tot	0.26883E-07	0.33256E-06	0.62109E-06	0.50323E-07	0.10309E-05	
%	2.61	32.26	60.25	4.88		
OBS 16	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.42251E-05	0.16963E-05	0.32839E-05	0.14038E-05	0.10609E-04	53.91
Window 2	0.11232E-05	0.38026E-05	0.20560E-05	0.55104E-06	0.75329E-05	38.27
Window 3	0.13018E-06	0.12824E-05	0.00000E+00	0.00000E+00	0.14126E-05	7.18
Window 4	0.39241E-07	0.87204E-07	0.00000E+00	0.00000E+00	0.12644E-06	0.64
PDS Tot	0.55177E-05	0.68685E-05	0.53399E-05	0.19548E-05	0.19681E-04	
%	28.04	34.90	27.13	9.93		

Appendix A Supporting Information for the PDS Analysis

Table A.5 (continued)

OBS 17	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.33350E-07	0.55349E-07	0.46075E-07	0.79535E-08	0.14273E-06	42.57
Window 2	0.17503E-07	0.62886E-07	0.96159E-08	0.29756E-08	0.92980E-07	27.73
Window 3	0.46633E-08	0.47898E-07	0.00000E+00	0.00000E+00	0.52562E-07	15.68
Window 4	0.60529E-08	0.40924E-07	0.00000E+00	0.00000E+00	0.46977E-07	14.01
PDS Tot	0.61569E-07	0.20706E-06	0.55691E-07	0.10929E-07	0.33525E-06	
%	18.37	61.76	16.61	3.26		
OBS 18	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.24249E-08	0.80289E-08	0.73129E-07	0.17586E-07	0.10117E-06	22.35
Window 2	0.44791E-08	0.17859E-06	0.51859E-07	0.26759E-07	0.26169E-06	57.82
Window 3	0.26321E-08	0.75559E-07	0.00000E+00	0.00000E+00	0.78191E-07	17.28
Window 4	0.13179E-08	0.10196E-07	0.00000E+00	0.00000E+00	0.11513E-07	2.54
PDS Tot	0.10854E-07	0.27238E-06	0.12499E-06	0.44344E-07	0.45256E-06	
%	2.40	60.19	27.62	9.80		
OBS 19	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.82271E-07	0.14032E-05	0.16582E-05	0.10652E-05	0.42089E-05	33.76
Window 2	0.18008E-06	0.34601E-05	0.62249E-07	0.27486E-06	0.39772E-05	31.90
Window 3	0.30052E-07	0.41418E-05	0.00000E+00	0.00000E+00	0.41718E-05	33.46
Window 4	0.34287E-08	0.10630E-06	0.00000E+00	0.00000E+00	0.10973E-06	0.88
PDS Tot	0.29583E-06	0.91114E-05	0.17204E-05	0.13401E-05	0.12468E-04	
%	2.37	73.08	13.80	10.75		
OBS 20	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.32259E-07	0.54201E-06	0.61333E-06	0.10323E-06	0.12908E-05	46.94
Window 2	0.14641E-07	0.29599E-06	0.87619E-07	0.21570E-07	0.41982E-06	15.27
Window 3	0.11395E-07	0.34336E-06	0.00000E+00	0.00000E+00	0.35476E-06	12.90
Window 4	0.14688E-06	0.53761E-06	0.00000E+00	0.00000E+00	0.68448E-06	24.89
PDS Tot	0.20517E-06	0.17190E-05	0.70095E-06	0.12479E-06	0.27499E-05	
%	7.46	62.51	25.49	4.54		
OBS 21	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.77878E-08	0.10114E-06	0.15887E-06	0.67902E-07	0.33570E-06	35.43
Window 2	0.17497E-07	0.11154E-06	0.38468E-07	0.70508E-07	0.23802E-06	25.12
Window 3	0.76891E-08	0.89199E-07	0.00000E+00	0.00000E+00	0.96888E-07	10.22
Window 4	0.27799E-07	0.24919E-06	0.00000E+00	0.00000E+00	0.27699E-06	29.23
PDS Tot	0.60774E-07	0.55108E-06	0.19734E-06	0.13841E-06	0.94760E-06	
%	6.41	58.15	20.83	14.61		
OBS 22	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.34908E-07	0.51489E-06	0.80669E-06	0.13216E-06	0.14887E-05	22.87
Window 2	0.14466E-07	0.20647E-05	0.90815E-06	0.45105E-07	0.30324E-05	46.59
Window 3	0.45689E-08	0.19552E-05	0.00000E+00	0.00000E+00	0.19597E-05	30.11
Window 4	0.13385E-08	0.26343E-07	0.00000E+00	0.00000E+00	0.27682E-07	0.43
PDS Tot	0.55282E-07	0.45611E-05	0.17148E-05	0.17727E-06	0.65085E-05	
%	0.85	70.08	26.35	2.72		
OBS 23	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.11154E-05	0.51635E-06	0.10823E-05	0.24442E-06	0.29585E-05	33.75
Window 2	0.10560E-05	0.25170E-05	0.23429E-06	0.77115E-07	0.38844E-05	44.31
Window 3	0.14815E-06	0.16792E-05	0.00000E+00	0.00000E+00	0.18273E-05	20.84
Window 4	0.60064E-07	0.36527E-07	0.00000E+00	0.00000E+00	0.96591E-07	1.10
PDS Tot	0.23796E-05	0.47491E-05	0.13166E-05	0.32154E-06	0.87669E-05	
%	27.14	54.17	15.02	3.67		
OBS 24	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.46696E-07	0.18501E-06	0.23757E-06	0.86890E-07	0.55616E-06	42.08
Window 2	0.16853E-07	0.35502E-06	0.15536E-07	0.14312E-07	0.40172E-06	30.40
Window 3	0.11106E-07	0.27640E-06	0.00000E+00	0.00000E+00	0.28750E-06	21.76
Window 4	0.68140E-08	0.69350E-07	0.00000E+00	0.00000E+00	0.76164E-07	5.76
PDS Tot	0.81468E-07	0.88578E-06	0.25310E-06	0.10120E-06	0.13216E-05	
%	6.16	67.03	19.15	7.66		

Appendix A Supporting Information for the PDS Analysis

Table A.5 (continued)

OBS 25	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.14866E-07	0.57564E-07	0.91206E-07	0.88289E-08	0.17246E-06	26.46
Window 2	0.13227E-07	0.22690E-06	0.24158E-07	0.89934E-08	0.27328E-06	41.93
Window 3	0.19867E-08	0.19837E-06	0.00000E+00	0.00000E+00	0.20035E-06	30.74
Window 4	0.14140E-08	0.42417E-08	0.00000E+00	0.00000E+00	0.56557E-08	0.87
PDS Tot	0.31494E-07	0.48707E-06	0.11536E-06	0.17822E-07	0.65175E-06	
%	4.83	74.73	17.70	2.73		
OBS 26	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.16144E-08	0.14942E-07	0.96896E-07	0.21278E-08	0.11558E-06	10.62
Window 2	0.52671E-08	0.55696E-06	0.10490E-07	0.66981E-08	0.57942E-06	53.24
Window 3	0.11524E-08	0.31763E-06	0.00000E+00	0.00000E+00	0.31878E-06	29.29
Window 4	0.72645E-08	0.67367E-07	0.00000E+00	0.00000E+00	0.74631E-07	6.86
PDS Tot	0.15298E-07	0.95690E-06	0.10739E-06	0.88259E-08	0.10884E-05	
%	1.41	87.92	9.87	0.81		
OBS 27	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.25138E-07	0.52702E-07	0.19857E-06	0.16185E-07	0.29259E-06	25.64
Window 2	0.57331E-07	0.37851E-06	0.73091E-07	0.45340E-07	0.55427E-06	48.57
Window 3	0.18226E-07	0.21518E-06	0.00000E+00	0.00000E+00	0.23341E-06	20.45
Window 4	0.30602E-07	0.30281E-07	0.00000E+00	0.00000E+00	0.60883E-07	5.34
PDS Tot	0.13130E-06	0.67668E-06	0.27166E-06	0.61526E-07	0.11412E-05	
%	11.51	59.30	23.81	5.39		
OBS 28	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.10236E-06	0.21537E-05	0.10008E-05	0.17265E-06	0.34296E-05	53.36
Window 2	0.27397E-07	0.15281E-05	0.64212E-07	0.14064E-07	0.16338E-05	25.42
Window 3	0.70735E-08	0.12454E-05	0.00000E+00	0.00000E+00	0.12525E-05	19.49
Window 4	0.47035E-07	0.64730E-07	0.00000E+00	0.00000E+00	0.11177E-06	1.74
PDS Tot	0.18387E-06	0.49920E-05	0.10650E-05	0.18672E-06	0.64276E-05	
%	2.86	77.66	16.57	2.90		
OBS 29	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.25486E-07	0.41389E-07	0.13592E-06	0.18062E-07	0.22086E-06	27.72
Window 2	0.30897E-07	0.22824E-06	0.35102E-07	0.36370E-08	0.29788E-06	37.39
Window 3	0.53659E-08	0.16423E-06	0.00000E+00	0.00000E+00	0.16959E-06	21.28
Window 4	0.20382E-07	0.88057E-07	0.00000E+00	0.00000E+00	0.10844E-06	13.61
PDS Tot	0.82131E-07	0.52192E-06	0.17102E-06	0.21699E-07	0.79677E-06	
%	10.31	65.50	21.46	2.72		
OBS 30	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.30604E-06	0.27878E-06	0.38808E-05	0.53605E-06	0.50017E-05	16.22
Window 2	0.78809E-07	0.13723E-04	0.20206E-07	0.34636E-07	0.13857E-04	44.93
Window 3	0.35369E-07	0.11800E-04	0.00000E+00	0.00000E+00	0.11836E-04	38.38
Window 4	0.27092E-07	0.12084E-06	0.00000E+00	0.00000E+00	0.14793E-06	0.48
PDS Tot	0.44731E-06	0.25923E-04	0.39010E-05	0.57068E-06	0.30842E-04	
%	1.45	84.05	12.65	1.85		
OBS 31	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.26224E-06	0.61781E-06	0.25586E-05	0.10504E-06	0.35437E-05	36.80
Window 2	0.52281E-07	0.19727E-05	0.14627E-06	0.18506E-06	0.23563E-05	24.47
Window 3	0.39184E-07	0.36200E-05	0.00000E+00	0.00000E+00	0.36592E-05	38.00
Window 4	0.51364E-08	0.65540E-07	0.00000E+00	0.00000E+00	0.70677E-07	0.73
PDS Tot	0.35884E-06	0.62761E-05	0.27049E-05	0.29011E-06	0.96299E-05	
%	3.73	65.17	28.09	3.01		
OBS 32	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.78507E-08	0.23845E-07	0.27573E-07	0.11404E-08	0.60409E-07	13.87
Window 2	0.34414E-07	0.13923E-06	0.25689E-07	0.10566E-07	0.20990E-06	48.19
Window 3	0.68439E-08	0.12210E-06	0.00000E+00	0.00000E+00	0.12894E-06	29.60
Window 4	0.47913E-08	0.31546E-07	0.00000E+00	0.00000E+00	0.36337E-07	8.34
PDS Tot	0.53900E-07	0.31672E-06	0.53263E-07	0.11706E-07	0.43558E-06	
%	12.37	72.71	12.23	2.69		

Appendix A Supporting Information for the PDS Analysis

Table A.5 (continued)

OBS 33	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.19401E-05	0.15312E-05	0.37487E-05	0.19180E-06	0.74118E-05	26.02
Window 2	0.77805E-06	0.17574E-04	0.44049E-06	0.12604E-05	0.20053E-04	70.40
Window 3	0.12626E-06	0.67061E-06	0.00000E+00	0.00000E+00	0.79687E-06	2.80
Window 4	0.56244E-07	0.16564E-06	0.00000E+00	0.00000E+00	0.22188E-06	0.78
PDS Tot	0.29006E-05	0.19941E-04	0.41892E-05	0.14522E-05	0.28483E-04	
%	10.18	70.01	14.71	5.10		
OBS 34	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.25391E-06	0.43575E-06	0.87454E-06	0.31713E-06	0.18813E-05	24.07
Window 2	0.12713E-06	0.16870E-05	0.74579E-07	0.14190E-06	0.20306E-05	25.98
Window 3	0.11929E-06	0.36592E-05	0.00000E+00	0.00000E+00	0.37785E-05	48.35
Window 4	0.13973E-07	0.11106E-06	0.00000E+00	0.00000E+00	0.12503E-06	1.60
PDS Tot	0.51430E-06	0.58930E-05	0.94912E-06	0.45903E-06	0.78154E-05	
%	6.58	75.40	12.14	5.87		
OBS 35	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.12899E-07	0.16241E-06	0.12518E-06	0.19135E-07	0.31963E-06	33.89
Window 2	0.26843E-07	0.18572E-06	0.13226E-06	0.84921E-08	0.35332E-06	37.46
Window 3	0.14604E-07	0.70245E-07	0.00000E+00	0.00000E+00	0.84849E-07	9.00
Window 4	0.43283E-07	0.14210E-06	0.00000E+00	0.00000E+00	0.18539E-06	19.66
PDS Tot	0.97629E-07	0.56049E-06	0.25744E-06	0.27627E-07	0.94319E-06	
%	10.35	59.42	27.30	2.93		
OBS 36	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.93856E-06	0.36185E-06	0.16123E-05	0.38026E-06	0.32930E-05	45.76
Window 2	0.40865E-06	0.13970E-05	0.48794E-06	0.23517E-06	0.25288E-05	35.14
Window 3	0.15098E-06	0.11021E-05	0.00000E+00	0.00000E+00	0.12531E-05	17.42
Window 4	0.30663E-07	0.89998E-07	0.00000E+00	0.00000E+00	0.12066E-06	1.68
PDS Tot	0.15289E-05	0.29510E-05	0.21002E-05	0.61542E-06	0.71955E-05	
%	21.25	41.01	29.19	8.55		
OBS 37	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.11861E-06	0.65170E-06	0.31487E-06	0.72920E-07	0.11581E-05	53.64
Window 2	0.10718E-06	0.27052E-06	0.25563E-07	0.18220E-07	0.42148E-06	19.52
Window 3	0.20599E-06	0.28324E-06	0.00000E+00	0.00000E+00	0.48923E-06	22.66
Window 4	0.10203E-07	0.79904E-07	0.00000E+00	0.00000E+00	0.90107E-07	4.17
PDS Tot	0.44199E-06	0.12854E-05	0.34044E-06	0.91140E-07	0.21589E-05	
%	20.47	59.54	15.77	4.22		
OBS 38	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.74179E-07	0.14189E-06	0.42023E-06	0.49810E-08	0.64128E-06	19.64
Window 2	0.77507E-07	0.11006E-05	0.47376E-07	0.11992E-07	0.12375E-05	37.89
Window 3	0.15305E-07	0.10112E-05	0.00000E+00	0.00000E+00	0.10265E-05	31.43
Window 4	0.14399E-07	0.34603E-06	0.00000E+00	0.00000E+00	0.36043E-06	11.04
PDS Tot	0.18139E-06	0.25998E-05	0.46761E-06	0.16973E-07	0.32657E-05	
%	5.55	79.61	14.32	0.52		
OBS 39	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.21384E-07	0.28264E-07	0.25109E-06	0.13638E-07	0.31438E-06	14.08
Window 2	0.61960E-07	0.98408E-06	0.12448E-06	0.34987E-07	0.12055E-05	53.99
Window 3	0.73769E-08	0.66571E-06	0.00000E+00	0.00000E+00	0.67309E-06	30.14
Window 4	0.51139E-08	0.34946E-07	0.00000E+00	0.00000E+00	0.40060E-07	1.79
PDS Tot	0.95835E-07	0.17130E-05	0.37557E-06	0.48624E-07	0.22330E-05	
%	4.29	76.71	16.82	2.18		
OBS 40	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.32237E-08	0.18701E-07	0.59516E-07	0.14406E-07	0.95847E-07	14.72
Window 2	0.11946E-07	0.26851E-06	0.11577E-07	0.22890E-07	0.31492E-06	48.36
Window 3	0.59082E-08	0.19637E-06	0.00000E+00	0.00000E+00	0.20228E-06	31.06
Window 4	0.14975E-08	0.36617E-07	0.00000E+00	0.00000E+00	0.38114E-07	5.85
PDS Tot	0.22576E-07	0.52020E-06	0.71093E-07	0.37296E-07	0.65116E-06	
%	3.47	79.89	10.92	5.73		

Appendix A Supporting Information for the PDS Analysis

Table A.5 (continued)

OBS 41	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.58141E-07	0.61548E-07	0.12868E-06	0.24739E-07	0.27311E-06	45.35
Window 2	0.26049E-07	0.10154E-06	0.46036E-07	0.17861E-07	0.19149E-06	31.80
Window 3	0.52189E-08	0.77478E-07	0.00000E+00	0.00000E+00	0.82697E-07	13.73
Window 4	0.46007E-08	0.50274E-07	0.00000E+00	0.00000E+00	0.54875E-07	9.11
PDS Tot	0.94010E-07	0.29084E-06	0.17472E-06	0.42600E-07	0.60217E-06	
%	15.61	48.30	29.01	7.07		
OBS 42	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.15083E-07	0.95170E-07	0.15610E-06	0.12427E-07	0.27878E-06	30.25
Window 2	0.15098E-07	0.25858E-06	0.89119E-07	0.29653E-07	0.39245E-06	42.59
Window 3	0.62891E-08	0.15304E-06	0.00000E+00	0.00000E+00	0.15933E-06	17.29
Window 4	0.26731E-07	0.64229E-07	0.00000E+00	0.00000E+00	0.90961E-07	9.87
PDS Tot	0.63202E-07	0.57102E-06	0.24522E-06	0.42081E-07	0.92152E-06	
%	6.86	61.96	26.61	4.57		
OBS 43	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.41934E-08	0.33763E-07	0.34780E-06	0.16917E-07	0.40267E-06	7.22
Window 2	0.10930E-07	0.21486E-05	0.61672E-07	0.13541E-07	0.22348E-05	40.06
Window 3	0.11913E-07	0.16576E-05	0.00000E+00	0.00000E+00	0.16696E-05	29.92
Window 4	0.41914E-07	0.12303E-05	0.00000E+00	0.00000E+00	0.12722E-05	22.80
PDS Tot	0.68951E-07	0.50703E-05	0.40947E-06	0.30459E-07	0.55792E-05	
%	1.24	90.88	7.34	0.55		
OBS 44	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.14481E-06	0.21372E-06	0.24253E-06	0.11590E-06	0.71695E-06	52.52
Window 2	0.18705E-07	0.24634E-06	0.49173E-07	0.70813E-08	0.32129E-06	23.53
Window 3	0.15829E-07	0.29390E-06	0.00000E+00	0.00000E+00	0.30972E-06	22.69
Window 4	0.36783E-08	0.13559E-07	0.00000E+00	0.00000E+00	0.17237E-07	1.26
PDS Tot	0.18302E-06	0.76751E-06	0.29170E-06	0.12298E-06	0.13652E-05	
%	13.41	56.22	21.37	9.01		
OBS 45	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.93795E-06	0.16155E-06	0.30532E-06	0.41719E-07	0.14465E-05	57.30
Window 2	0.12886E-06	0.32266E-06	0.16283E-06	0.50692E-07	0.66504E-06	26.34
Window 3	0.10038E-06	0.24228E-06	0.00000E+00	0.00000E+00	0.34266E-06	13.57
Window 4	0.12931E-07	0.57250E-07	0.00000E+00	0.00000E+00	0.70182E-07	2.78
PDS Tot	0.11801E-05	0.78374E-06	0.46814E-06	0.92411E-07	0.25244E-05	
%	46.75	31.05	18.54	3.66		
OBS 46	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.58814E-07	0.69448E-06	0.62466E-06	0.79770E-06	0.21757E-05	22.80
Window 2	0.27648E-06	0.29718E-05	0.24096E-06	0.11709E-05	0.46602E-05	48.84
Window 3	0.65370E-07	0.24768E-05	0.00000E+00	0.00000E+00	0.25422E-05	26.64
Window 4	0.30451E-07	0.13324E-06	0.00000E+00	0.00000E+00	0.16369E-06	1.72
PDS Tot	0.43112E-06	0.62764E-05	0.86563E-06	0.19686E-05	0.95417E-05	
%	4.52	65.78	9.07	20.63		
OBS 47	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.15554E-07	0.13802E-06	0.12609E-06	0.37916E-07	0.31758E-06	38.22
Window 2	0.24935E-08	0.27703E-06	0.58859E-08	0.83436E-08	0.29375E-06	35.35
Window 3	0.90438E-09	0.20914E-06	0.00000E+00	0.00000E+00	0.21005E-06	25.28
Window 4	0.50584E-09	0.90858E-08	0.00000E+00	0.00000E+00	0.95916E-08	1.15
PDS Tot	0.19458E-07	0.63328E-06	0.13198E-06	0.46260E-07	0.83097E-06	
%	2.34	76.21	15.88	5.57		
OBS 48	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.16865E-07	0.76815E-07	0.18108E-06	0.38658E-08	0.27863E-06	16.34
Window 2	0.44769E-08	0.11555E-06	0.24122E-07	0.84533E-08	0.15261E-06	8.95
Window 3	0.13447E-07	0.87637E-07	0.00000E+00	0.00000E+00	0.10108E-06	5.93
Window 4	0.18435E-06	0.98825E-06	0.00000E+00	0.00000E+00	0.11726E-05	68.78
PDS Tot	0.21914E-06	0.12683E-05	0.20520E-06	0.12319E-07	0.17049E-05	
%	12.85	74.39	12.04	0.72		

Table A.5 (continued)

OBS 49	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.76929E-08	0.28022E-07	0.79731E-07	0.57275E-08	0.12117E-06	11.44
Window 2	0.16730E-08	0.38054E-07	0.10420E-07	0.89391E-08	0.59086E-07	5.58
Window 3	0.26159E-08	0.46905E-07	0.00000E+00	0.00000E+00	0.49521E-07	4.67
Window 4	0.84576E-07	0.74512E-06	0.00000E+00	0.00000E+00	0.82970E-06	78.31
PDS Tot	0.96558E-07	0.85810E-06	0.90151E-07	0.14667E-07	0.10595E-05	
%	9.11	80.99	8.51	1.38		
OBS 50	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.63547E-07	0.28974E-07	0.21947E-06	0.21673E-07	0.33367E-06	41.76
Window 2	0.38289E-07	0.20731E-06	0.88753E-08	0.13671E-07	0.26814E-06	33.56
Window 3	0.10276E-07	0.16490E-06	0.00000E+00	0.00000E+00	0.17518E-06	21.92
Window 4	0.38599E-08	0.18172E-07	0.00000E+00	0.00000E+00	0.22032E-07	2.76
PDS Tot	0.11597E-06	0.41935E-06	0.22835E-06	0.35344E-07	0.79902E-06	
%	14.51	52.48	28.58	4.42		
OBS 51	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.12539E-06	0.48745E-07	0.24002E-06	0.28015E-07	0.44217E-06	13.23
Window 2	0.56009E-07	0.12033E-05	0.21601E-07	0.99594E-08	0.12909E-05	38.62
Window 3	0.22133E-07	0.15024E-05	0.00000E+00	0.00000E+00	0.15246E-05	45.61
Window 4	0.46039E-08	0.80266E-07	0.00000E+00	0.00000E+00	0.84870E-07	2.54
PDS Tot	0.20813E-06	0.28348E-05	0.26162E-06	0.37974E-07	0.33425E-05	
%	6.23	84.81	7.83	1.14		
OBS 52	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.14761E-07	0.15837E-07	0.11946E-06	0.23745E-07	0.17380E-06	26.49
Window 2	0.30749E-07	0.17133E-06	0.42234E-07	0.30507E-07	0.27482E-06	41.88
Window 3	0.96681E-08	0.11686E-06	0.00000E+00	0.00000E+00	0.12652E-06	19.28
Window 4	0.32757E-07	0.48284E-07	0.00000E+00	0.00000E+00	0.81041E-07	12.35
PDS Tot	0.87935E-07	0.35230E-06	0.16169E-06	0.54252E-07	0.65618E-06	
%	13.40	53.69	24.64	8.27		
OBS 53	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.17478E-07	0.19359E-06	0.55767E-06	0.45395E-07	0.81413E-06	21.68
Window 2	0.34511E-07	0.15485E-05	0.58945E-07	0.51193E-07	0.16931E-05	45.09
Window 3	0.83719E-08	0.10665E-05	0.00000E+00	0.00000E+00	0.10749E-05	28.63
Window 4	0.12033E-08	0.17157E-06	0.00000E+00	0.00000E+00	0.17277E-06	4.60
PDS Tot	0.61564E-07	0.29801E-05	0.61662E-06	0.96588E-07	0.37549E-05	
%	1.64	79.37	16.42	2.57		
OBS 54	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.60314E-07	0.91655E-07	0.62512E-06	0.41118E-07	0.81821E-06	20.47
Window 2	0.94891E-07	0.15896E-05	0.10250E-06	0.11519E-06	0.19021E-05	47.58
Window 3	0.32138E-07	0.12219E-05	0.00000E+00	0.00000E+00	0.12541E-05	31.37
Window 4	0.72031E-08	0.16457E-07	0.00000E+00	0.00000E+00	0.23660E-07	0.59
PDS Tot	0.19455E-06	0.29196E-05	0.72762E-06	0.15631E-06	0.39981E-05	
%	4.87	73.02	18.20	3.91		
OBS 55	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.41413E-06	0.23124E-05	0.96024E-06	0.54511E-06	0.42319E-05	73.34
Window 2	0.26056E-06	0.35535E-06	0.86437E-07	0.12894E-06	0.83129E-06	14.41
Window 3	0.16033E-06	0.27444E-06	0.00000E+00	0.00000E+00	0.43477E-06	7.53
Window 4	0.69169E-07	0.20339E-06	0.00000E+00	0.00000E+00	0.27256E-06	4.72
PDS Tot	0.90419E-06	0.31456E-05	0.10467E-05	0.67405E-06	0.57705E-05	
%	15.67	54.51	18.14	11.68		
OBS 56	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.72928E-08	0.16151E-07	0.87974E-07	0.16956E-07	0.12837E-06	15.16
Window 2	0.95997E-08	0.30526E-06	0.18945E-07	0.15689E-07	0.34949E-06	41.27
Window 3	0.29723E-08	0.28319E-06	0.00000E+00	0.00000E+00	0.28616E-06	33.79
Window 4	0.14344E-07	0.68554E-07	0.00000E+00	0.00000E+00	0.82897E-07	9.79
PDS Tot	0.34209E-07	0.67315E-06	0.10692E-06	0.32646E-07	0.84692E-06	
%	4.04	79.48	12.62	3.85		

Appendix A Supporting Information for the PDS Analysis

Table A.5 (continued)

OBS	57	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1		0.23469E-07	0.63326E-08	0.11031E-06	0.10218E-07	0.15033E-06	46.51
Window 2		0.48986E-08	0.60541E-07	0.18432E-07	0.38819E-08	0.87753E-07	27.15
Window 3		0.15825E-08	0.50037E-07	0.00000E+00	0.00000E+00	0.51619E-07	15.97
Window 4		0.14789E-08	0.32056E-07	0.00000E+00	0.00000E+00	0.33535E-07	10.37
PDS Tot		0.31429E-07	0.14897E-06	0.12874E-06	0.14100E-07	0.32323E-06	
%		9.72	46.09	39.83	4.36		
OBS	58	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1		0.12735E-05	0.83973E-05	0.15441E-05	0.22111E-05	0.13426E-04	67.46
Window 2		0.17221E-05	0.21541E-05	0.15878E-06	0.39329E-07	0.40743E-05	20.47
Window 3		0.84233E-07	0.20102E-05	0.00000E+00	0.00000E+00	0.20944E-05	10.52
Window 4		0.16775E-07	0.29060E-06	0.00000E+00	0.00000E+00	0.30738E-06	1.54
PDS Tot		0.30966E-05	0.12852E-04	0.17028E-05	0.22505E-05	0.19902E-04	
%		15.56	64.58	8.56	11.31		
OBS	59	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1		0.29626E-07	0.18118E-06	0.36889E-06	0.29453E-07	0.60914E-06	51.53
Window 2		0.66405E-07	0.21055E-06	0.36993E-07	0.93745E-08	0.32332E-06	27.35
Window 3		0.31837E-08	0.22064E-06	0.00000E+00	0.00000E+00	0.22383E-06	18.94
Window 4		0.48332E-08	0.20947E-07	0.00000E+00	0.00000E+00	0.25780E-07	2.18
PDS Tot		0.10405E-06	0.63332E-06	0.40588E-06	0.38827E-07	0.11821E-05	
%		8.80	53.58	34.34	3.28		
OBS	60	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1		0.91393E-07	0.37484E-06	0.13631E-06	0.16246E-07	0.61879E-06	44.55
Window 2		0.38049E-07	0.27913E-06	0.36746E-07	0.11688E-07	0.36561E-06	26.32
Window 3		0.23407E-07	0.20379E-06	0.00000E+00	0.00000E+00	0.22719E-06	16.36
Window 4		0.54646E-08	0.17195E-06	0.00000E+00	0.00000E+00	0.17742E-06	12.77
PDS Tot		0.15831E-06	0.10297E-05	0.17305E-06	0.27935E-07	0.13890E-05	
%		11.40	74.13	12.46	2.01		
OBS	61	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1		0.25778E-07	0.15020E-06	0.53609E-07	0.57093E-07	0.28668E-06	20.77
Window 2		0.54616E-07	0.44837E-06	0.43292E-07	0.11423E-06	0.66051E-06	47.85
Window 3		0.14462E-07	0.35532E-06	0.00000E+00	0.00000E+00	0.36979E-06	26.79
Window 4		0.96452E-08	0.53835E-07	0.00000E+00	0.00000E+00	0.63480E-07	4.60
PDS Tot		0.10450E-06	0.10077E-05	0.96900E-07	0.17132E-06	0.13804E-05	
%		7.57	73.00	7.02	12.41		
OBS	62	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1		0.34340E-08	0.49196E-07	0.91266E-07	0.15536E-07	0.15943E-06	20.80
Window 2		0.17813E-08	0.23976E-06	0.73553E-08	0.91610E-08	0.25806E-06	33.67
Window 3		0.10466E-08	0.27030E-06	0.00000E+00	0.00000E+00	0.27134E-06	35.41
Window 4		0.41908E-08	0.73316E-07	0.00000E+00	0.00000E+00	0.77507E-07	10.11
PDS Tot		0.10453E-07	0.63257E-06	0.98622E-07	0.24697E-07	0.76634E-06	
%		1.36	82.54	12.87	3.22		
OBS	63	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1		0.13869E-06	0.64465E-06	0.47450E-06	0.23176E-06	0.14896E-05	34.14
Window 2		0.60832E-06	0.11052E-05	0.81815E-07	0.20980E-07	0.18163E-05	41.63
Window 3		0.10900E-06	0.92734E-06	0.00000E+00	0.00000E+00	0.10363E-05	23.75
Window 4		0.10476E-07	0.10479E-07	0.00000E+00	0.00000E+00	0.20955E-07	0.48
PDS Tot		0.86648E-06	0.26876E-05	0.55632E-06	0.25274E-06	0.43632E-05	
%		19.86	61.60	12.75	5.79		
OBS	64	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1		0.30405E-07	0.53977E-07	0.50448E-07	0.10630E-07	0.14546E-06	18.10
Window 2		0.32524E-07	0.24804E-06	0.43441E-07	0.42697E-09	0.32443E-06	40.36
Window 3		0.12239E-07	0.20909E-06	0.00000E+00	0.00000E+00	0.22133E-06	27.53
Window 4		0.30397E-07	0.82221E-07	0.00000E+00	0.00000E+00	0.11262E-06	14.01
PDS Tot		0.10557E-06	0.59333E-06	0.93889E-07	0.11057E-07	0.80384E-06	
%		13.13	73.81	11.68	1.38		

Appendix A Supporting Information for the PDS Analysis

Table A.5 (continued)

OBS 65	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.55681E-08	0.94198E-07	0.28449E-06	0.17233E-07	0.40149E-06	19.71
Window 2	0.90457E-08	0.77170E-06	0.85981E-08	0.54350E-07	0.84370E-06	41.42
Window 3	0.24745E-08	0.78120E-06	0.00000E+00	0.00000E+00	0.78368E-06	38.47
Window 4	0.15251E-08	0.67634E-08	0.00000E+00	0.00000E+00	0.82885E-08	0.41
PDS Tot	0.18613E-07	0.16539E-05	0.29309E-06	0.71583E-07	0.20372E-05	
%	0.91	81.19	14.39	3.51		
OBS 66	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.10183E-07	0.16570E-07	0.14319E-06	0.12818E-07	0.18276E-06	28.80
Window 2	0.13742E-07	0.19404E-06	0.12826E-07	0.67652E-08	0.22737E-06	35.83
Window 3	0.90819E-08	0.13573E-06	0.00000E+00	0.00000E+00	0.14481E-06	22.82
Window 4	0.51716E-08	0.74533E-07	0.00000E+00	0.00000E+00	0.79704E-07	12.56
PDS Tot	0.38179E-07	0.42087E-06	0.15601E-06	0.19583E-07	0.63465E-06	
%	6.02	66.32	24.58	3.09		
OBS 67	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.62776E-08	0.30465E-07	0.13110E-07	0.13356E-08	0.51189E-07	20.69
Window 2	0.30364E-08	0.98555E-07	0.80035E-08	0.13503E-08	0.11095E-06	44.83
Window 3	0.30182E-09	0.69959E-07	0.00000E+00	0.00000E+00	0.70261E-07	28.39
Window 4	0.29393E-08	0.12121E-07	0.00000E+00	0.00000E+00	0.15061E-07	6.09
PDS Tot	0.12555E-07	0.21110E-06	0.21114E-07	0.26858E-08	0.24746E-06	
%	5.07	85.31	8.53	1.09		
OBS 68	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.52499E-07	0.13354E-06	0.42533E-06	0.33938E-07	0.64530E-06	40.34
Window 2	0.13503E-06	0.17300E-06	0.37197E-07	0.11866E-07	0.35709E-06	22.32
Window 3	0.11327E-07	0.37293E-06	0.00000E+00	0.00000E+00	0.38426E-06	24.02
Window 4	0.93679E-07	0.11930E-06	0.00000E+00	0.00000E+00	0.21298E-06	13.31
PDS Tot	0.29253E-06	0.79877E-06	0.46252E-06	0.45804E-07	0.15996E-05	
%	18.29	49.93	28.91	2.86		
OBS 69	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.72885E-07	0.14164E-06	0.75266E-06	0.55938E-07	0.10231E-05	48.95
Window 2	0.50696E-07	0.47515E-06	0.15503E-07	0.91195E-08	0.55047E-06	26.34
Window 3	0.21768E-07	0.45087E-06	0.00000E+00	0.00000E+00	0.47264E-06	22.61
Window 4	0.61882E-08	0.37683E-07	0.00000E+00	0.00000E+00	0.43871E-07	2.10
PDS Tot	0.15154E-06	0.11053E-05	0.76817E-06	0.65057E-07	0.20901E-05	
%	7.25	52.88	36.75	3.11		
OBS 70	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.11033E-07	0.11215E-07	0.22889E-06	0.86305E-09	0.25200E-06	18.87
Window 2	0.10109E-07	0.39810E-06	0.40611E-07	0.12634E-08	0.45009E-06	33.70
Window 3	0.60063E-08	0.24491E-06	0.00000E+00	0.00000E+00	0.25092E-06	18.79
Window 4	0.24814E-07	0.35791E-06	0.00000E+00	0.00000E+00	0.38272E-06	28.65
PDS Tot	0.51963E-07	0.10121E-05	0.26950E-06	0.21264E-08	0.13357E-05	
%	3.89	75.77	20.18	0.16		
OBS 71	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.22206E-06	0.74781E-07	0.70380E-06	0.73215E-07	0.10739E-05	35.71
Window 2	0.15917E-06	0.40150E-06	0.25370E-06	0.12002E-06	0.93440E-06	31.08
Window 3	0.18641E-06	0.54071E-06	0.00000E+00	0.00000E+00	0.72712E-06	24.18
Window 4	0.12955E-07	0.25851E-06	0.00000E+00	0.00000E+00	0.27147E-06	9.03
PDS Tot	0.58059E-06	0.12755E-05	0.95751E-06	0.19323E-06	0.30068E-05	
%	19.31	42.42	31.84	6.43		
OBS 72	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.15533E-06	0.35136E-05	0.59382E-06	0.65710E-07	0.43285E-05	64.33
Window 2	0.18610E-06	0.12715E-05	0.23267E-07	0.19074E-07	0.14999E-05	22.29
Window 3	0.37826E-07	0.83411E-06	0.00000E+00	0.00000E+00	0.87194E-06	12.96
Window 4	0.11300E-07	0.17070E-07	0.00000E+00	0.00000E+00	0.28370E-07	0.42
PDS Tot	0.39055E-06	0.56363E-05	0.61708E-06	0.84783E-07	0.67287E-05	
%	5.80	83.76	9.17	1.26		

Appendix A Supporting Information for the PDS Analysis

Table A.5 (continued)

OBS 73	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.62543E-06	0.14577E-05	0.29281E-05	0.13862E-06	0.51498E-05	38.63
Window 2	0.34170E-06	0.10427E-05	0.81971E-07	0.78150E-07	0.15446E-05	11.59
Window 3	0.18949E-06	0.91578E-06	0.00000E+00	0.00000E+00	0.11053E-05	8.29
Window 4	0.40077E-07	0.54911E-05	0.00000E+00	0.00000E+00	0.55312E-05	41.49
PDS Tot	0.11967E-05	0.89073E-05	0.30101E-05	0.21677E-06	0.13331E-04	
%	8.98	66.82	22.58	1.63		
OBS 74	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.51235E-07	0.90600E-07	0.25250E-07	0.33269E-08	0.17041E-06	57.96
Window 2	0.10931E-07	0.51893E-07	0.14477E-07	0.21960E-08	0.79497E-07	27.04
Window 3	0.23571E-08	0.34379E-07	0.00000E+00	0.00000E+00	0.36736E-07	12.49
Window 4	0.69209E-09	0.66797E-08	0.00000E+00	0.00000E+00	0.73718E-08	2.51
PDS Tot	0.65215E-07	0.18355E-06	0.39728E-07	0.55228E-08	0.29402E-06	
%	22.18	62.43	13.51	1.88		
OBS 75	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.64968E-07	0.57830E-06	0.12629E-05	0.10575E-06	0.20119E-05	18.47
Window 2	0.26932E-07	0.48284E-05	0.23726E-06	0.16900E-06	0.52616E-05	48.31
Window 3	0.25384E-07	0.35604E-05	0.00000E+00	0.00000E+00	0.35858E-05	32.92
Window 4	0.49639E-08	0.27937E-07	0.00000E+00	0.00000E+00	0.32901E-07	0.30
PDS Tot	0.12225E-06	0.89951E-05	0.15002E-05	0.27475E-06	0.10892E-04	
%	1.12	82.58	13.77	2.52		
OBS 76	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.84614E-07	0.51575E-07	0.62421E-06	0.77025E-07	0.83742E-06	22.27
Window 2	0.60877E-07	0.10540E-05	0.14611E-06	0.35698E-06	0.16179E-05	43.02
Window 3	0.26175E-07	0.80670E-06	0.00000E+00	0.00000E+00	0.83288E-06	22.15
Window 4	0.36514E-08	0.46877E-06	0.00000E+00	0.00000E+00	0.47243E-06	12.56
PDS Tot	0.17532E-06	0.23810E-05	0.77032E-06	0.43400E-06	0.37606E-05	
%	4.66	63.31	20.48	11.54		
OBS 77	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.15036E-06	0.26844E-06	0.33068E-06	0.69341E-07	0.81882E-06	53.85
Window 2	0.17404E-06	0.16091E-06	0.14094E-06	0.31758E-07	0.50764E-06	33.39
Window 3	0.40077E-07	0.12088E-06	0.00000E+00	0.00000E+00	0.16095E-06	10.59
Window 4	0.13014E-07	0.20136E-07	0.00000E+00	0.00000E+00	0.33149E-07	2.18
PDS Tot	0.37749E-06	0.57036E-06	0.47161E-06	0.10110E-06	0.15206E-05	
%	24.83	37.51	31.02	6.65		
OBS 78	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.90264E-07	0.16212E-06	0.11842E-05	0.30755E-07	0.14673E-05	9.81
Window 2	0.61020E-07	0.73810E-05	0.11686E-06	0.21408E-07	0.75803E-05	50.70
Window 3	0.26578E-07	0.58066E-05	0.00000E+00	0.00000E+00	0.58332E-05	39.01
Window 4	0.44657E-08	0.67027E-07	0.00000E+00	0.00000E+00	0.71492E-07	0.48
PDS Tot	0.18233E-06	0.13417E-04	0.13010E-05	0.52163E-07	0.14952E-04	
%	1.22	89.73	8.70	0.35		
OBS 79	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.82739E-07	0.55237E-06	0.21718E-05	0.43239E-06	0.32393E-05	16.14
Window 2	0.21596E-07	0.90277E-05	0.45098E-07	0.34314E-07	0.91287E-05	45.49
Window 3	0.13704E-07	0.76259E-05	0.00000E+00	0.00000E+00	0.76396E-05	38.07
Window 4	0.11180E-08	0.57830E-07	0.00000E+00	0.00000E+00	0.58949E-07	0.29
PDS Tot	0.11916E-06	0.17264E-04	0.22169E-05	0.46671E-06	0.20067E-04	
%	0.59	86.03	11.05	2.33		
OBS 80	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.69809E-07	0.67363E-07	0.70820E-06	0.18601E-06	0.10314E-05	29.67
Window 2	0.64455E-07	0.91717E-06	0.11100E-06	0.47643E-07	0.11403E-05	32.80
Window 3	0.15446E-07	0.12421E-05	0.00000E+00	0.00000E+00	0.12576E-05	36.18
Window 4	0.32608E-08	0.43407E-07	0.00000E+00	0.00000E+00	0.46668E-07	1.34
PDS Tot	0.15297E-06	0.22701E-05	0.81920E-06	0.23365E-06	0.34759E-05	
%	4.40	65.31	23.57	6.72		

Appendix A Supporting Information for the PDS Analysis

Table A.5 (continued)

OBS 81	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.43633E-07	0.36242E-07	0.43530E-06	0.77243E-08	0.52290E-06	50.24
Window 2	0.46900E-07	0.23190E-06	0.15489E-07	0.24745E-07	0.31903E-06	30.66
Window 3	0.14107E-07	0.16257E-06	0.00000E+00	0.00000E+00	0.17667E-06	16.98
Window 4	0.68063E-08	0.15299E-07	0.00000E+00	0.00000E+00	0.22105E-07	2.12
PDS Tot	0.11145E-06	0.44600E-06	0.45079E-06	0.32469E-07	0.10407E-05	
%	10.71	42.86	43.32	3.12		
OBS 82	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.54438E-06	0.28379E-06	0.18070E-05	0.21789E-06	0.28530E-05	39.39
Window 2	0.22426E-06	0.23692E-05	0.84734E-07	0.45994E-07	0.27241E-05	37.61
Window 3	0.20015E-06	0.13217E-05	0.00000E+00	0.00000E+00	0.15219E-05	21.01
Window 4	0.24860E-07	0.11889E-06	0.00000E+00	0.00000E+00	0.14375E-06	1.98
PDS Tot	0.99365E-06	0.40936E-05	0.18917E-05	0.26388E-06	0.72428E-05	
%	13.72	56.52	26.12	3.64		
OBS 83	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.80377E-08	0.78094E-06	0.30604E-07	0.56060E-08	0.82519E-06	29.69
Window 2	0.80940E-08	0.10496E-05	0.34420E-07	0.98912E-07	0.11910E-05	42.85
Window 3	0.18458E-08	0.74273E-06	0.00000E+00	0.00000E+00	0.74457E-06	26.79
Window 4	0.14334E-08	0.17290E-07	0.00000E+00	0.00000E+00	0.18723E-07	0.67
PDS Tot	0.19411E-07	0.25906E-05	0.65024E-07	0.10452E-06	0.27795E-05	
%	0.70	93.20	2.34	3.76		
OBS 84	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.75585E-08	0.49385E-06	0.12416E-06	0.65013E-07	0.69057E-06	36.71
Window 2	0.28588E-07	0.51749E-06	0.33993E-07	0.69116E-07	0.64919E-06	34.51
Window 3	0.10019E-07	0.52259E-06	0.00000E+00	0.00000E+00	0.53261E-06	28.31
Window 4	0.15288E-08	0.74786E-08	0.00000E+00	0.00000E+00	0.90074E-08	0.48
PDS Tot	0.47693E-07	0.15414E-05	0.15815E-06	0.13413E-06	0.18814E-05	
%	2.54	81.93	8.41	7.13		
OBS 85	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.22045E-07	0.70328E-07	0.17291E-06	0.43878E-07	0.30916E-06	26.76
Window 2	0.28284E-07	0.49845E-06	0.10147E-07	0.30852E-08	0.53997E-06	46.73
Window 3	0.80781E-08	0.25912E-06	0.00000E+00	0.00000E+00	0.26720E-06	23.13
Window 4	0.10066E-07	0.29011E-07	0.00000E+00	0.00000E+00	0.39077E-07	3.38
PDS Tot	0.68473E-07	0.85691E-06	0.18306E-06	0.46963E-07	0.11554E-05	
%	5.93	74.17	15.84	4.06		
OBS 86	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.18292E-06	0.21635E-06	0.59112E-06	0.72247E-07	0.10626E-05	48.44
Window 2	0.53354E-07	0.33909E-06	0.20017E-06	0.41007E-07	0.63362E-06	28.88
Window 3	0.76944E-07	0.24734E-06	0.00000E+00	0.00000E+00	0.32428E-06	14.78
Window 4	0.37848E-07	0.13528E-06	0.00000E+00	0.00000E+00	0.17313E-06	7.89
PDS Tot	0.35106E-06	0.93805E-06	0.79129E-06	0.11325E-06	0.21937E-05	
%	16.00	42.76	36.07	5.16		
OBS 87	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.79965E-08	0.23201E-05	0.84755E-06	0.22672E-07	0.31983E-05	87.00
Window 2	0.93829E-08	0.13161E-06	0.27806E-07	0.32056E-07	0.20085E-06	5.46
Window 3	0.34871E-08	0.73856E-07	0.00000E+00	0.00000E+00	0.77343E-07	2.10
Window 4	0.22886E-07	0.17697E-06	0.00000E+00	0.00000E+00	0.19986E-06	5.44
PDS Tot	0.43753E-07	0.27025E-05	0.87536E-06	0.54728E-07	0.36764E-05	
%	1.19	73.51	23.81	1.49		
OBS 88	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.90728E-08	0.14437E-07	0.10373E-06	0.25153E-07	0.15239E-06	20.16
Window 2	0.24435E-07	0.27771E-06	0.30815E-07	0.26642E-08	0.33562E-06	44.41
Window 3	0.79787E-08	0.19206E-06	0.00000E+00	0.00000E+00	0.2004E-06	26.47
Window 4	0.14371E-07	0.53342E-07	0.00000E+00	0.00000E+00	0.67713E-07	8.96
PDS Tot	0.55857E-07	0.53754E-06	0.13454E-06	0.27817E-07	0.75576E-06	
%	7.39	71.13	17.80	3.68		

Appendix A Supporting Information for the PDS Analysis

Table A.5 (continued)

OBS 89	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.60471E-06	0.26523E-05	0.14790E-06	0.52810E-07	0.34578E-05	69.52
Window 2	0.16228E-06	0.39619E-06	0.76690E-07	0.42465E-06	0.10598E-05	21.31
Window 3	0.37468E-07	0.27508E-06	0.00000E+00	0.00000E+00	0.31255E-06	6.28
Window 4	0.10836E-07	0.13291E-06	0.00000E+00	0.00000E+00	0.14375E-06	2.89
PDS Tot	0.81529E-06	0.34565E-05	0.22459E-06	0.47746E-06	0.49739E-05	
%	16.39	69.49	4.52	9.60		
OBS 90	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.52302E-06	0.10148E-05	0.14635E-05	0.16188E-06	0.31631E-05	32.68
Window 2	0.78096E-06	0.27277E-05	0.40089E-07	0.82071E-07	0.36308E-05	37.52
Window 3	0.32763E-06	0.24902E-05	0.00000E+00	0.00000E+00	0.28179E-05	29.12
Window 4	0.17598E-07	0.48744E-07	0.00000E+00	0.00000E+00	0.66342E-07	0.69
PDS Tot	0.16492E-05	0.62815E-05	0.15036E-05	0.24395E-06	0.96782E-05	
%	17.04	64.90	15.54	2.52		
OBS 91	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.36988E-07	0.11059E-06	0.17646E-05	0.93936E-07	0.20061E-05	54.42
Window 2	0.15049E-06	0.75491E-06	0.13649E-06	0.49630E-07	0.10915E-05	29.61
Window 3	0.27207E-07	0.45563E-06	0.00000E+00	0.00000E+00	0.48284E-06	13.10
Window 4	0.10390E-07	0.95197E-07	0.00000E+00	0.00000E+00	0.10559E-06	2.86
PDS Tot	0.22507E-06	0.14163E-05	0.19011E-05	0.14357E-06	0.36861E-05	
%	6.11	38.42	51.58	3.89		
OBS 92	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.40497E-07	0.70165E-06	0.10256E-05	0.28733E-07	0.17965E-05	63.41
Window 2	0.20574E-07	0.23511E-06	0.33443E-06	0.63874E-07	0.65399E-06	23.08
Window 3	0.16998E-07	0.33085E-06	0.00000E+00	0.00000E+00	0.34785E-06	12.28
Window 4	0.31661E-08	0.31796E-07	0.00000E+00	0.00000E+00	0.34962E-07	1.23
PDS Tot	0.81235E-07	0.12994E-05	0.13600E-05	0.92607E-07	0.28333E-05	
%	2.87	45.86	48.00	3.27		
OBS 93	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.16905E-06	0.12956E-06	0.52774E-06	0.38803E-07	0.86515E-06	60.49
Window 2	0.57265E-07	0.15367E-06	0.28422E-07	0.12486E-07	0.25184E-06	17.61
Window 3	0.20805E-07	0.16568E-06	0.00000E+00	0.00000E+00	0.18649E-06	13.04
Window 4	0.17991E-07	0.10873E-06	0.00000E+00	0.00000E+00	0.12673E-06	8.86
PDS Tot	0.26511E-06	0.55765E-06	0.55616E-06	0.51289E-07	0.14302E-05	
%	18.54	38.99	38.89	3.59		
OBS 94	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.12508E-06	0.37938E-06	0.41910E-06	0.31583E-07	0.95514E-06	46.32
Window 2	0.41346E-07	0.40101E-06	0.46777E-07	0.20724E-06	0.69637E-06	33.77
Window 3	0.10495E-07	0.27475E-06	0.00000E+00	0.00000E+00	0.28524E-06	13.83
Window 4	0.32798E-08	0.12221E-06	0.00000E+00	0.00000E+00	0.12549E-06	6.09
PDS Tot	0.18020E-06	0.11773E-05	0.46587E-06	0.23882E-06	0.20622E-05	
%	8.74	57.09	22.59	11.58		
OBS 95	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.33419E-07	0.11146E-06	0.28315E-06	0.22544E-07	0.45057E-06	23.34
Window 2	0.11732E-07	0.74892E-06	0.34095E-07	0.17881E-07	0.81263E-06	42.10
Window 3	0.61220E-08	0.60094E-06	0.00000E+00	0.00000E+00	0.60706E-06	31.45
Window 4	0.85457E-09	0.59202E-07	0.00000E+00	0.00000E+00	0.60056E-07	3.11
PDS Tot	0.52127E-07	0.15205E-05	0.31724E-06	0.40425E-07	0.19303E-05	
%	2.70	78.77	16.43	2.09		
OBS 96	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.91322E-06	0.12728E-05	0.33461E-05	0.45621E-07	0.55778E-05	74.10
Window 2	0.61304E-07	0.52757E-06	0.39511E-06	0.50319E-07	0.10343E-05	13.74
Window 3	0.20782E-06	0.46883E-06	0.00000E+00	0.00000E+00	0.67665E-06	8.99
Window 4	0.12334E-07	0.22637E-06	0.00000E+00	0.00000E+00	0.23871E-06	3.17
PDS Tot	0.11947E-05	0.24956E-05	0.37412E-05	0.95940E-07	0.75274E-05	
%	15.87	33.15	49.70	1.27		

Appendix A Supporting Information for the PDS Analysis

Table A.5 (continued)

OBS 97	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.33112E-08	0.26705E-08	0.92293E-08	0.21753E-08	0.17386E-07	7.10
Window 2	0.14972E-07	0.36432E-07	0.28933E-08	0.74878E-08	0.61785E-07	25.24
Window 3	0.28184E-08	0.22234E-07	0.00000E+00	0.00000E+00	0.25053E-07	10.24
Window 4	0.57910E-07	0.82642E-07	0.00000E+00	0.00000E+00	0.14055E-06	57.42
PDS Tot	0.79012E-07	0.14398E-06	0.12123E-07	0.96631E-08	0.24478E-06	
%	32.28	58.82	4.95	3.95		
OBS 98	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.13051E-06	0.18870E-06	0.47275E-06	0.35666E-06	0.11486E-05	7.93
Window 2	0.12056E-05	0.61325E-05	0.37643E-06	0.66732E-06	0.83818E-05	57.89
Window 3	0.20899E-06	0.46179E-05	0.00000E+00	0.00000E+00	0.48269E-05	33.34
Window 4	0.88871E-07	0.33032E-07	0.00000E+00	0.00000E+00	0.12190E-06	0.84
PDS Tot	0.16340E-05	0.10972E-04	0.84918E-06	0.10240E-05	0.14479E-04	
%	11.28	75.78	5.86	7.07		
OBS 99	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.11782E-08	0.51819E-07	0.14185E-06	0.32448E-07	0.22730E-06	17.12
Window 2	0.24906E-08	0.15408E-06	0.40274E-07	0.21677E-07	0.21852E-06	16.46
Window 3	0.91693E-08	0.11616E-06	0.00000E+00	0.00000E+00	0.12533E-06	9.44
Window 4	0.57074E-07	0.69969E-06	0.00000E+00	0.00000E+00	0.75676E-06	56.99
PDS Tot	0.69912E-07	0.10217E-05	0.18213E-06	0.54125E-07	0.13279E-05	
%	5.26	76.94	13.72	4.08		
OBS 100	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.32671E-07	0.53852E-07	0.16999E-06	0.18437E-07	0.27495E-06	34.37
Window 2	0.16401E-07	0.21093E-06	0.57429E-07	0.79370E-08	0.29269E-06	36.59
Window 3	0.72367E-08	0.13707E-06	0.00000E+00	0.00000E+00	0.14431E-06	18.04
Window 4	0.12722E-07	0.75196E-07	0.00000E+00	0.00000E+00	0.87918E-07	10.99
PDS Tot	0.69032E-07	0.47705E-06	0.22742E-06	0.26374E-07	0.79987E-06	
%	8.63	59.64	28.43	3.30		
Mean	PDS Group 1	PDS Group 2	PDS Group 3	PDS Group 4	Window Total	%
Window 1	0.19791E-06	0.49014E-06	0.66870E-06	0.13326E-06	0.14900E-05	35.31
Window 2	0.13327E-06	0.12362E-05	0.10835E-06	0.88147E-07	0.15660E-05	37.11
Window 3	0.40498E-07	0.91445E-06	0.00000E+00	0.00000E+00	0.95495E-06	22.63
Window 4	0.23813E-07	0.18529E-06	0.00000E+00	0.00000E+00	0.20911E-06	4.96
PDS Tot	0.39548E-06	0.28261E-05	0.77705E-06	0.22140E-06	0.42201E-05	
%	9.37	66.97	18.41	5.25		

APPENDIX B

SUPPORTING INFORMATION FOR THE ACCIDENT PROGRESSION ANALYSIS

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APPENDIX B

SUPPORTING INFORMATION FOR THE ACCIDENT PROGRESSION ANALYSIS

Introduction

Appendix B contains a detailed description and listing of the Accident Progression Event Tree (APET) and the binner that groups the outcomes of evaluating the APET.

A brief description of the Surry Low Power APET is given in Section 6.1, and the binner is treated in Section 6.4. The material in these sections is not repeated here. The 40 questions in the APET are listed concisely in Table 6.1. This appendix consists of four subsections. Subsection B.1 contains a discussion of each question in the APET. The event tree itself is too large to be depicted graphically and exists only in computer input format, which appears in subsection B.2. Subsection B.3 is a detailed discussion of the binner, and subsection B.4 contains a listing of the binner.

B.1 Description of the Accident Progression Event Tree

Question 1. Time Window

4 Branches, Type 1, 1 Case

The Branches for this question are:

1. Win-1 The core damage accident was initiated at Time Window 1.
2. Win-2 The core damage accident was initiated at Time Window 2.
3. Win-3 The core damage accident was initiated at Time Window 3.
4. Win-4 The core damage accident was initiated at Time Window 4.

The branch taken in this question depends solely upon the first PDS characteristic. For each PDS group, fractions of frequencies of PDSs belonging to each time window are assigned into each time window branch of this question.

Question 2. Size of the RCS Break when the Core Uncovers?

2 Branches, Type 2

The branches for this question are:

1. Large Sufficient break area is available to maintain the RCS pressure below 500 psia.

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2. Small The break area is too small to maintain the RCS pressure below 500 psia.

The branch taken in this question depends on the time window of the first question and the fourth PDS characteristic. The Level 1 analysis on success criteria indicates that the RCS pressure will remain below 500 psi for all time windows except Time Window 1 if at least one PORV is open. For Time Window 1, the RCS pressure will continue to rise if only one PORV is open until it reaches 650 psi, the rupture pressure of the RHR vent valve. Once the RHR vent valve is ruptured, the RCS pressure will drop below 500 psia.

Case 1: For Time Window 1, only one PORV is available. The RCS pressure may not reach the rupture pressure of RHR vent valve before vessel failure. This branch probability was determined internally by BNL staff.

Branch 1: 0.95

Branch 2: 0.05

Case 2: For all other time windows, 1 PORV is always open and the pressure does not rise above 500 psi.

Branch 1: 1.00

Branch 2: 0.00

Question 3. Is the RCS depressurized before Breach by Opening the Pressurizer PORVs?

2 Branches, Type 2, 2 Cases

The branches for this question are:

1. VDep The pressurizer PORVs are already open or the operators open the pressurizer PORVs and depressurize the RCS successfully before vessel breach.
2. noVDep The operators do not open sufficient number of pressurizer PORVs.

This question was quantified internally. The branch taken at this question depends upon the branch previously taken at Questions 1 and 2.

The pressure in the RCS may be reduced directly if the operators open more than one PORVs on the pressurizer in Time Window 1. In all other time windows, the RCS is already at low pressure and depressurization is not necessary.

Case 1: At Time Window 1, only one PORV was open at core damage.

Branch 1: VDep - 0.80

Branch 2: noVDep - 0.20

Case 2: Other time windows or more than PORV is already available.

Branch 1: VDep - 1.0

Branch 2: noVDep - 0.0

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Question 4. Status of AC Power?

3 Branches, Type 1

The branches for this question are:

1. AC AC electrical power is available from offsite or from the DGs throughout the accident.
2. No-AC AC electrical power is not available due to loss of offsite power and DGs (SBO), but may be recovered.
3. No4KV AC electrical power is not available to the injection pumps because of loss of a 4 kV bus.

The branch taken depends upon the second PDS characteristic.

Loss of offsite power and failure of the diesel generators to start (SBO) leads to the second branch since offsite power may always be restored. AC power available when the ECCS and sprays are failed means that an ignition source is likely to be present in the containment when a significant amount of hydrogen has accumulated after VB.

Question 5. Is the core damage accident due to human errors?

3 Branches, Type 2

The branches for this question are:

1. No-HX Accident is not due to human errors.
2. HXA Operators fail to take correct actions after loss of RHR cooling. AC electrical power is available throughout.
3. HXD Operators fail to diagnose loss of core cooling. AC electrical power is available throughout.

The branch taken depends upon the third PDS characteristic.

For internal initiators, accidents begin with loss of RHR cooling during shutdown. Operators either fail to recognize the accident, make a wrong diagnosis, or take a wrong action. Consequently, the core cooling is not restored and the accident progresses to core damage. AC power is available throughout the accident; recovery of core cooling and termination of the accident depends solely on the recovery from the human error.

Question 6. Status of ECCS?

5 Branches, Type 1

The branches for this question are:

1. ECCSf4KV The ECCS are available and can operate when the 4 kV bus to the injection pumps is restored.
2. ECCSfAC The ECCS are available and can operate when offsite electric power is restored.
3. ECCSfHX The ECCS are available and can operate when human errors are corrected.
4. ECCSfHW The ECCS is failed, and is not recoverable.

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5. ECCSfREC The ECCS have worked in the injection mode from RWST, but is failed in the recirculation mode.

The branch taken depends upon the fifth PDS characteristic.

The first branch is chosen in situations where the ECCS are available, but not operating because of the loss of the 4 kV bus; if or when the 4 kV bus is restored, the ECCS will function. The second branch is chosen in blackout situations with no ECCS failures; if or when power is recovered, the ECCS will function. The third branch is chosen when core damage occurs because of human errors but ECCS is available; if or when the human error is corrected, the ECCS will function. The fourth branch is selected when the failures are in the ECCS themselves, and there is no recovery within the time frame of this analysis. Since the period in which the ECCS operate in the injection mode occurs before the uncovering of the core, this branch is chosen for those PDS's in which the ECCS never operate. For those PDS's in which the ECCS operate in the injection mode and fail in the recirculation mode, the fifth branch is chosen.

Question 7. Status of Sprays?

6 Branches, Type 2, 2 Cases.

The branches for this question are:

1. SP The containment sprays are operating or are operable in the recirculation mode prior to vessel failure.
2. SPfAC The containment sprays are available and can operate when offsite electric power is restored.
3. SPfHX The containment sprays are available and can operate when human error is corrected.
4. SPfHW The sprays themselves are not operable, and not recoverable.
5. SPfREC The containment sprays are failed in the recirculation mode and are not recoverable.
6. SPf4KV The containment sprays are available and can operate when the 4 kV bus is restored.

The branch taken depends upon the sixth PDS characteristic, and upon the branches taken at Question 1.

This question concerns the sprays during the period of core degradation, and has impact on the source term calculations. The second or sixth branches are chosen in situations where the sprays are available, but not operating because of SBO or the loss of the 4 kV bus respectively; if or when power is recovered, or the 4 kV bus is restored, the spray will function. The third branch is chosen when core damage occurs because of human errors but spray is available; if or when the human error is corrected, the spray will function. The fourth branch is selected when the failures are in the sprays themselves, and there is no recovery within the time frame of this analysis. For those PDS's in which the ECCS operate in the injection mode and fail in the recirculation mode, the fifth branch is chosen.

Question 8. RWST Injected into Containment?

4 Branches, Type 2, 2 Cases.

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The branches for this question are:

1. RWST-In The contents of the refueling water storage tank have been injected into the containment.
2. RWSTfAC The contents of the RWST have not been injected into the containment, but can be injected if offsite power is recovered or the 4 kV bus is restored.
3. RWSTfHX The contents of the RWST have not been injected into the containment, but can be injected if human error is corrected.
4. RWSTfIn The contents of the RWST have not been injected into the containment, and cannot be injected even if power is recovered or human error is corrected.

The branch taken depends upon the seventh PDS characteristic and upon the branch taken at Questions 6 and 7.

The branch taken in this question is used to determine whether the reactor cavity is full of water.

Question 9. Initial Containment Isolation Failure?

2 Branches, Type 1

The branches for this questions are:

1. ClsdCI Prior to the accident, the containment is isolated.
2. noCldCI At the time of accident initiation, the containment is open.

This question addresses whether the containment is closed at the time of accident initiation. This question was included in this APET because the Surry personnel indicated in a discussion that they may consider to close containment before entering the Mid-loop operation. However, since subsequent discussions did not provide any further information on this subject, the second branch is taken for all PDS's in this phase of analysis.

Question 10. Is containment closed before core damage?

2 Branches, Type 2, 6 Cases.

The branches for this questions are:

1. ClsdCD The containment is successfully isolated before core damage.
2. noCldCD The containment is not isolated before core damage.

This question addresses whether the containment is successfully closed before core damage; it does not determine whether the containment leaks even if it is closed. The branch taken in this question depends on the first, fifth and ninth questions. The split fractions in this questions were sampled and their distributions are determined internally by BNL staff.

Case 1: The containment is closed at the initiation of accident. The split fraction of the first branch is 1.0.

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Case 2: The core damage accident occurs because operators fail to recognize the accident or fail to make correct diagnosis. Under this circumstance, it is not very likely for operators to close the containment in time. The split fraction of the second branch is 1.0.

Case 3 through 6: Operators recognize a potential core damage accident and attempt to close the containment. The success probability of containment closure depends on the available time before onset of core damage; it increases with increasing time window. Since Surry has prepared a detailed procedure to perform this closure, the probability that the containment is successfully isolated is considered high. The mean split fractions for the first branch are 0.8, 0.9, 0.95 and 1.0 for time windows 1, 2, 3 and 4, respectively.

Question 11. Containment Pressure Capability.

3 Branches, Type 2, 3 Cases

The branches for this question are:

1. CP126p The mean containment failure pressure is 126 psig.
2. CP45p The mean containment failure pressure is 45 psig.
3. CP2p The mean containment failure pressure is 2 psig.

This question determines the mean containment failure pressure. The Surry containment closure procedure during POS 6 would provide a barrier capable of withstanding 45 psig, which is the design pressure of the containment during the full power operation. The mean failure pressure was estimated to be 126 psig in the NUREG-1150 study. However, it is not clear whether the containment during POS 6 can also provide 126 psig of failure pressure. Therefore, it was assumed in the base case analysis that the mean failure pressure is 45 psig when the containment is successfully isolated. A sensitivity analysis also performed where the failure pressure is 126 psig. The third branch is taken when the containment is not successfully isolated or leaks even after isolated. This question does not provide the distribution of the failure pressure itself; it is addressed in Question 23.

Case 1: The containment is closed when the mid-loop operation begins. The probability that the containment is successfully isolated and does not leak is very high. The probability of containment leak after isolation was 0.0002 in the NUREG-1150. This value is increased to 0.01 in this study. The rest (0.99) is assigned to Branch 2 (CP45p) for the base case and to Branch 1 (CP126p) for the sensitivity case, respectively.

Case 2: The containment is open when the mid-loop operation begins, but successfully closed before core damage. The probability that the containment may leak is higher than Case 1. This value is increased to 0.1. The rest (0.9) is assigned to Branch 2 (CP45p) for the base case and to Branch 1 (CP126p) for the sensitivity case, respectively.

Case 3: The containment fails to close. The split fraction for Branch 3 is 1.00.

Question 12. Is AC Power Available Early?

2 Branches, Type 2, 9 Cases

The branches for this question are:

1. ERAC AC power is available in this time period.
2. NoERAC AC power is not available in this time period.

This question addresses the recovery of electric power to the injection pumps before the vessel breach for the cases where either off-site power or 4 kV bus was not available. Cases 1 through 8 of this question are sampled; the distributions were obtained from an analysis of data on offsite power recovery and restoration of the 4 kV bus for the Surry plant. These data are available in Vol. 1 of this report. The branching at this question depends upon the branches taken at Questions 1 and 4.

Probability of power recovery means the probability that offsite electrical power is recovered, or the 4 kV bus is restored in a specified period given that power was not recovered prior to the start of the period. These time periods available to recover power before vessel breach vary depending on the time window. The time periods used in Cases 1 through 8 are listed in Section 6.1 of this report. These time periods are derived from the results of MELCOR calculations which are presented in Appendix F of this report.

Case 1 through 4: Offsite power was not available at the start of the accident which occurred in Time Windows 1, 2, 3 and 4, respectively. The probability of power recovery before vessel breach is calculated based on the recovery distribution and is assigned to the first branch.

Case 5 through 8: Injection pumps were not operating because of loss of 4 kV bus to the available injection pumps at the start of the accident which occurred in Time Windows 1, 2, 3 and 4, respectively. The probability of restoring the 4 kV bus before vessel breach is assigned to the first branch.

Case 9: Power was available at the start of the accident and remains available. The quantification for this case is:

Branch 1: ERAC - 1.0

Branch 2: NoERAC - 0.0

Question 13. Recovered from human errors early?

2 Branches, Type 2, 9 Cases

The branches for this question are:

1. ERHX Operators recover from previous error.
2. NoERHX Operators do not recover from the previous error.

This question addresses the recovery from operator errors for the accidents where the core damage occurred because of inadequate operator actions following the loss of RHR cooling. Cases 1 through 8 of this question are sampled; the distributions were obtained from "Handbook of HRA," (Reference 6.6 of this report). The branching at this question depends upon the branches taken at Questions 1 and 5.

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The meaning of probability of recovery in this question is similar to that of Question 12, except that it concerns recovery from erroneous operator decisions in this question. The time periods in this question are identical to those of Question 12.

Question 14. Is Core Damage Arrested? No Vessel Breach?

2 Branches, Type 2, 4 Cases

The branches for this question are:

1. noVB The process of core degradation is arrested and a safe stable state is reached with the vessel intact.
2. VB Core degradation continues, resulting in core melt and vessel breach.

The branching at this question depends upon the branches previously taken at Questions 6, 12 and 13.

Case 1: ECCS were not available because of hardware error of injection pumps, or they failed during recirculation. In both cases, the ECCS are not recoverable and accident progress to vessel breach. The quantification for this case is:

Branch 1: 0.0

Branch 2: 1.0

Case 2: ECCS were not available due to loss of either offsite power or 4 kV bus. They are not recovered during this time period. The quantification for this case is:

Branch 1: 0.0

Branch 2: 1.0

Case 3: ECCS were not available due to operator errors. They are not recovered during this time period. The quantification for this case is:

Branch 1: 0.0

Branch 2: 1.0

Case 4: ECCS are recovered either due to recovery of power or recovery from operator errors during this time period. The quantification for this case is:

Branch 1: 1.0

Branch 2: 0.0

Question 15. Vessel Pressure just before Breach?

2 Branches, Type 2, 2 Cases

The branches for this question are:

1. I-ImPr The vessel is at intermediate pressure before breach, about 500 to 1000 psia.
2. I-LoPr The vessel is at low pressure before breach, about 500 psia or less.

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During mid-loop operation, at least one PORV is kept open. One PORV is sufficient to keep the RCS pressure below 500 psia at all time windows except Time Window 1. For Time Window 1, the RCS pressure can increase to 650 psia, which is the vent pressure of the RHR system. In any time windows, the RCS pressure would not increase to "high Pressure" range which is above 1000 psia.

Case 1: Accidents occur either in Windows 2, 3 or 4; more than 1 PORV is open; or operator successfully depressurize by opening additional PORV's.

Branch 1: ImPr - 0.00

Branch 2: LoPr - 1.00

Case 2: Accidents occur in Window 1, only one PORV is open and operator fails to open additional PORVs.

Branch 1: ImPr - 1.00

Branch 2: LoPr - 0.00

Question 16. Does an Alpha Mode Event Fail both the Vessel and the Containment?

2 Branches, Type 2, 2 Cases

The branches for this question are:

1. Alpha A very energetic molten fuel-coolant interaction (steam explosion) in the vessel fails the vessel and generates a missile which fails the containment as well.
2. noAlpha The vessel does not fail in this manner.

This question is sampled; the distribution used was taken from NUREG-1150, which was developed from opinions expressed by the Steam Explosion Review Group (SERG) and can be found in Volume 2, Part 6 of NUREG/CR-4551. The branch taken at this question depends upon the branches previously taken at Questions 14 and 15.

Case 1: There is vessel breach and the RCS was at low pressure. Steam explosions are more likely when the RCS is at low pressure than when the RCS is at some higher pressure. The aggregate distribution developed from distribution in the SERG was used for this case. This distribution covers many orders of magnitude. Based on the mean value of the distribution, the quantification for this case is:

Branch 1: Alpha - 0.008

Branch 2: noAlpha - 0.992

Case 2: This case includes two different groups of accidents. In the first group, the core degradation process has been arrested and there is no vessel breach. In the second group, there is vessel breach and the RCS was not at low pressure. In the latter group, steam explosions are possible but less likely when the RCS is not at low pressure. In NUREG-1150, this probability was set at 1/10 of the low pressure case, i.e., 0.0008. Since the fractions of accidents at intermediate pressure or higher is very small in this study, this probability is ignored. In both groups, the quantification is:

Branch 1: Alpha - 0.0

Branch 2: noAlpha - 1.0

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Question 17. Type of Vessel Breach?

5 Branches, Type 2, 4 Cases

The branches for this question are:

1. PrEj The molten core material is ejected under considerable pressure from a hole in the bottom of the vessel.
2. Pour The molten core material pours slowly from the vessel, primarily driven by gravity.
3. BtmHd A large portion of the bottom head fails, perhaps due to a circumferential failure.
4. noVB There is no failure of the reactor pressure vessel.
5. Alpha An alpha mode failure has occurred.

The branch taken at this question depends upon the branches previously taken at Questions 14, 15 and 16. The type of vessel breach was taken from NUREG-1150 which was determined by the In-Vessel Expert Panel. The conclusions of the Experts and their aggregate distributions are presented in Volume 2, Part 1, of NUREG/CR-4551. Case 3 is sampled.

The pressurized ejection failure mode requires that the RCS be at intermediate to high pressure when the vessel fails. The pour failure mode is considered to occur only with the RCS at low pressure. Since there could be a small driving force due to the gas pressure in the RCS, the Pour failure mode is distinguished by the fact that gravity is the primary force causing the molten core debris to leave the vessel. The bottom head failure mode can occur at any RCS pressure; the failure could be a circumferential failure in which the whole bottom head falls into the cavity or some other failure in which a substantial portion of the bottom head fails. The fourth branch is used when there is no vessel breach. The fifth branch is specified when the vessel failed in the Alpha mode.

Case 1: The core degradation process has been arrested and there is no vessel breach. The quantification for this case is:

Branch 1: PrEj	- 0.0
Branch 2: Pour	- 0.0
Branch 3: BtmHd	- 0.0
Branch 4: noVB	- 1.0
Branch 5: Alpha	- 0.0

Case 2: An alpha mode failure of both the vessel and the containment has occurred. The quantification for this case is:

Branch 1: PrEj	- 0.0
Branch 2: Pour	- 0.0
Branch 3: BtmHd	- 0.0
Branch 4: noVB	- 0.0
Branch 5: Alpha	- 1.0

Case 3: The vessel fails when the RCS is at intermediate pressure. The most likely failure mode is penetration failure leading to HPME. Based on the mean value of the distribution provided by the Experts, the quantification is:

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Branch 1: PrEj - 0.60
Branch 2: Pour - 0.27
Branch 3: BtmHd - 0.13
Branch 4: noVB - 0.0
Branch 5: Alpha - 0.0

Case 4: The vessel fails when the RCS is at low pressure. The failure mode is gravity pour. The quantification for this case is:

Branch 1: PrEj - 0.0
Branch 2: Pour - 1.0
Branch 3: BtmHd - 0.0
Branch 4: noVB - 0.0
Branch 5: Alpha - 0.0

Question 18. Early Sprays?

4 Branches, Type 2, 5 Cases

The branches for this question are:

1. E-Sp The containment sprays are operating.
2. ESPfAC The containment sprays are available to operate if power is recovered.
3. ESPfHX The containment sprays are available to operate if operators recover from previous error.
4. ESPf The containment sprays are failed and cannot be recovered.

This question is not sampled; the branch chosen depends directly upon the branches taken at previous questions. The branch chosen for this question depends upon the branches taken at Questions 7, 12 and 13.

If the sprays were initially in the "available" state, the sprays will operate in this period, when power has been recovered, the 4 kV bus has been restored, or operators have recovered from previous errors, depending on what led to the core damage. If power is recovered and the sprays operate, the contents of the RWST will be transferred to the containment and the cavity will fill up with water.

Case 1: The sprays were available at the start of the accident. The quantification for this case is:

Branch 1: E-Sp - 1.0
Branch 2: ESPfAC - 0.0
Branch 3: ESPfHX - 0.0
Branch 4: ESPf - 0.0

Case 2: The sprays were failed at the start of the accident, and no recovery is possible, so the sprays remain failed. The quantification for this case is:

Branch 1: E-Sp - 0.0
Branch 2: ESPfAC - 0.0
Branch 3: ESPfHX - 0.0
Branch 4: ESPf - 1.0

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Case 3: The sprays were available to operate at the start of the accident, but power or the 4 kV bus has not been recovered so the sprays remain available to operate in the future when power or 4 kV bus is recovered. The quantification for this case is:

Branch 1: E-Sp - 0.0
Branch 2: ESPfAC - 1.0
Branch 3: ESPfHX - 0.0
Branch 4: ESPf - 0.0

Case 4: The sprays were available to operate at the start of the accident, but operators have not recovered from previous errors so the sprays remain available to operate in the future when the operator error is corrected. The quantification for this case is:

Branch 1: E-Sp - 0.0
Branch 2: ESPfAC - 0.0
Branch 3: ESPfHX - 1.0
Branch 4: ESPf - 0.0

Case 5: The sprays were available to operate at the start of the accident. The sprays now operate because power has been recovered, the 4 kV bus has been restored, or operators have recovered from previous errors, depending on what led to the core damage. The quantification for this case is:

Branch 1: E-Sp - 1.0
Branch 2: ESPfAC - 0.0
Branch 3: ESPfHX - 0.0
Branch 4: ESPf - 0.0

Question 19. Amount of Water in the Reactor Cavity at Vessel Breach?

2 Branches, Type 2, 4 Cases

The branches for this question are:

1. RC-Wet The reactor cavity is full or nearly full of water.
2. RC-Dry The reactor cavity contains little or no water.

This question is not sampled; the amount of water in the reactor cavity may be reliably deduced from the information available about the injection of the RWST water into the containment and the operation of the sprays. The branch taken at this question depends upon the branches previously taken at Questions 8, 12 and 13.

What is of interest here is the presence of water for the direct containment heating (DCH) and ex-vessel steam explosion (EVSE) events. The magnitude of the pressure rise due to DCH depends upon whether there is water in the cavity. Whether an EVSE occurs also depends upon whether there is water in the cavity.

Case 1: The RWST was injected into the containment before breach or the sprays operated before breach; the reactor cavity is full of water at breach. The quantification for this case is:

Branch 1: RC-Wet - 1.0
Branch 2: RC-Dry - 0.0

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Case 2: The RWST was not injected into the containment before breach, but the sprays operate before breach because of power recovery; the reactor cavity full of water at breach. The quantification for this case is:

Branch 1: RC-Wet - 1.0

Branch 2: RC-Dry - 0.0

Case 3: The RWST was not injected into the containment before breach, but the sprays operate before breach because of recovery from operator errors; the reactor cavity full of water at breach. The quantification for this case is:

Branch 1: RC-Wet - 1.0

Branch 2: RC-Dry - 0.0

Case 4: The RWST was not injected into the containment before breach, and the sprays never operate before breach; the reactor cavity contains little or no water at breach. The quantification for this case is:

Branch 1: RC-Wet - 0.0

Branch 2: RC-Dry - 1.0

Question 20. Baseline Containment Pressure just before Vessel Breach?

1 Branch, Type 4, 3 Cases

The single branch has the same name as the parameter read in at this question:

P1. IPBase The baseline pressure in the containment is read in as Parameter 1.

This question is not sampled; the baseline pressure before VB is a direct function of whether there is blowdown to the containment, whether there is containment heat removal, and whether the containment is successfully isolated. The available codes are in reasonable agreement about the value of the pressure in the containment before vessel breach for the full power cases, and it is believed that they similarly provide reasonable value of pressure for the lower power cases. Several calculations have been performed using the MELCOR codes to obtain the containment pressure. Results of these calculations are reported in Appendix F of this volume. The cases for this question depend upon the branches taken at Questions 11 and 17.

Case 1: The containment is not successfully isolated and does not have pressure retaining capability. The containment is near normal operating pressure. The value of IPBase is 17 psia.

Case 2: The containment is successfully isolated. There is no blowdown to containment, or the core damage has been arrested. The containment is near normal operating pressure. The value of IPBase is 17 psia.

Case 3: The containment is successfully isolated. There is no containment heat removal, and there is blowdown to the containment from PORV's and/or SRV's. The MELCOR results show containment pressures at about 19 psia.

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Question 21. Pressure Rise at Vessel Breach?

1 Branch, Type 4, 5 Cases

A parameter is read in at this question:

P4. DP-VB The total containment pressure rise due to all the events that occur at vessel breach is read in as Parameter 4.

Cases 3 through 5 are sampled. Distributions for the pressure rise at vessel breach are taken from the results of MELCOR calculations for low RCS pressure cases. Distributions for intermediate RCS pressure cases are taken from NUREG-1150. The branch taken at this question depends upon the branches previously taken at Questions 15, 17 and 19.

- Case 1: There is no vessel breach, or alpha mode failure of the containment. The pressure rise is set to zero.
- Case 2: There is an Alpha mode failure of the vessel and the containment. The pressure rise at vessel breach is set to an arbitrary high value to ensure that containment failure occurs in Question 24.
- Case 3: At breach, the RCS is at low pressure, or the molten core debris pours out of the vessel under the influence primarily of gravity alone. The mean value of the aggregate distribution of the pressure rise for this case is 5.0 psi.
- Case 4: The vessel fails with intermediate pressure in the RCS and there is water in the reactor cavity. The fraction of the core ejected is medium. The mean value of the aggregate distribution of the pressure rise for this case is 57.7 psi.
- Case 5: The vessel fails with intermediate pressure in the RCS and there is little or no water in the reactor cavity. The mean value of the aggregate distribution of the pressure rise for this case is 64.7 psi.

Question 22. Does a Significant Ex-Vessel Steam Explosion occur?

2 Branches, Type 2, 2 Cases

The branches for this question are:

- 1. EVSE An energetic molten fuel-coolant interaction occurs in the reactor cavity upon vessel breach.
- 2. noEVSE No energetic molten fuel-coolant interaction occurs in the reactor cavity upon vessel breach.

This question is not sampled. The branch fractions were taken from NUREG-1150 which were quantified internally. The branch taken at this question depends upon the branches previously taken at Questions 17 and 19.

The dropping of hot metal into water has been observed to cause energetic and violent reactions which are commonly known as steam explosions. They appear to be more likely when the water is considerably below the saturation temperature. In a severe reactor accident, a steam explosion may occur when the core slumps into the lower head of the vessel, known as an in-vessel steam explosion (IVSE), or when the lower head of

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the vessel fails and the core falls or is expelled into water in the reactor cavity beneath the vessel. This latter event is known as an ex-vessel steam explosion (EVSE). While IVSEs were explicitly considered for the BWR APETs, the probability of a PWR vessel failure by an IVSE was judged to be negligible. Thus IVSEs are not considered in this analysis for Surry.

The effects of EVSEs are considered in two places in this APET. If the RCS is at intermediate pressure at VB, the effects of an EVSE at VB are considered in Question 21. The experts who considered pressure rise at VB included the pressure rise due to EVSEs in their distributions for total pressure rise. The other effects of an EVSE are considered to be small compared with the effects of HPME. This question considers the effects of EVSEs when the vessel fails at low pressure or the molten debris pours from the vessel due to gravity alone. Whether an EVSE occurs following a low pressure VB also determines whether the debris bed in the reactor cavity after VB is in a coolable configuration and the amount of core involved in CCI.

Case 1: The vessel failure resulted in the melt pouring out, driven primarily by gravity, and there was water in the cavity when this occurred. This is the only situation in which an ex-vessel steam explosion is of interest. Not all steam explosions are "significant" in context used here. The fraction of the time that a pour of hot metal into water results in a significant EVSE is thought to be between 0.1 and 0.9. The state of knowledge in this area is such that, at this time, it is not possible to do a great deal better than assigning a probability of 0.50 to the probability for a significant EVSE. Thus, the quantification for this case is:

Branch 1: EVSE - 0.50

Branch 2: noEVSE - 0.50

Case 2: There was no vessel breach, or the cavity was dry at breach, or the vessel failed by an alpha mode event or by pressurized ejection of the melt. An ex-vessel steam explosion is not of interest or is not credible. The quantification for this case is:

Branch 1: EVSE - 0.0

Branch 2: noEVSE - 1.0

Question 23. Containment Failure Pressure?

1 Branch, Type 4, 3 Cases

A parameter is read in at this question:

P6. CF-Pr The containment failure pressure is read in as Parameter 6.

This question reads in the failure pressure of the containment. The comparison of the failure pressure with the load pressure, and the determination of the mode of failure, take place in the next question. Two distributions of the failure pressure are read in this question, depending on the nominal containment pressure which was discussed in Question 11. The distribution when the mean value is 126 psig is taken from NUREG-1150 (which was provided by the Structural Expert Panel). The distribution when the mean value is 45 psig is obtained by scaling the above distribution proportionally.

Question 24. Containment Failure at VB?

2 Branches, Type 5, 1 Case

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The branches for this question are:

1. ICF-Rupt The containment fails by rupture.
2. no-ICF The containment does not fail at vessel breach.

The result in this question depends upon the branches previously taken at Questions 20, 21 and 23.

This question adds the pressure rise at vessel breach (Parameter 4, DP-VB) to the base pressure in the containment before breach (Parameter 1, IPBase) to obtain the load pressure. This is then compared to the aggregate distribution of containment failure pressure (Parameter 6, CF-Pr) to determine whether the containment will fail or not.

Case 1: The containment is failed by an alpha mode event or a rocket event. Dummy values are used with the comparison capability of EVNTRE so that rupture, Branch 2, is selected.

Question 25. Containment Status at VB?

3 Branches, Type 2, 5 Case

The branches for this question are:

1. ICF-Rupt The containment is not successfully isolated at core damage, or fails at VB either by Alpha mode or rupture.
2. ICF-Leak The containment is isolated, but leaks.
3. no-ICF The containment is successfully isolated and does not fail at vessel breach.

This question summarizes the containment status based on the results of previous questions (Questions 10, 11, 17 and 24).

Question 26. Is AC Power Available Late?

2 Branches, Type 2, 9 Cases

The branches for this question are:

1. LRAC AC power is available during the initial portion of CCI.
2. noLRAC AC power is not available for this time period, but may be recovered in the future.

The time period of interest here is between vessel breach and the initial portion of CCI. This time period for each time window is given Section 6.1. This question addresses the recovery of electric power to the injection pumps during this time period for the cases where either off-site power or 4 kV bus was not available. The meaning of recovery probability and their distributions are the same as discussed in Question 12. The branching at this question depends upon the branches taken at Questions 1, 4 and 12. Cases 1 through 8 of this question are sampled.

Case 1 through 4: Offsite power was not available at the VB. The probability of power recovery during this period is calculated based on the recovery distribution and is assigned to the first branch.

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Case 5 through 8: Injection pumps were not operating because of loss of 4 kV bus to the available injection pumps at VB. The probability of restoring the 4 kV bus during this period is assigned to the first branch.

Case 9: Power was available at VB and remains available. The quantification for this case is:

Branch 1: ERAC - 1.0

Branch 2: NoERAC - 0.0

Question 27. Recovered from human errors late?

2 Branches, Type 2, 5 Cases

The branches for this question are:

1. LRHX Operators recover from previous error.
2. NoLRHX Operators do not recover from the previous error.

This question addresses the recovery from operator errors for the accidents where the VB occurred because of inadequate operator actions following the core damage. The time period of interest is the same as Question 26. Cases 1 through 4 of this question are sampled. The meaning of recovery probability and their distributions are the same as discussed in Question 13. The branching at this question depends upon the branches taken at Questions 1 and 13.

Question 28. Late Sprays?

4 Branches, Type 2, 5 Cases

The branches for this question are:

1. L-Sp The containment sprays are operating during this period.
2. LSPfAC The containment sprays are available to operate and will operate when power is recovered.
3. LSPfHX The containment sprays are available to operate if operators recover from previous error.
4. LSPf The containment sprays are failed and cannot be recovered.

This question is not sampled. The branch chosen for this question depends directly upon the branches taken at Questions 18, 26 and 27. The time period of interest is the same as in the preceding question. If sprays are recovered during this period, the release from CCI will be considerably reduced. If the debris bed is coolable and water was present, but was not being replenished, spray recovery will prevent dryout and the start of CCI. If the sprays were in the "available" state before, the sprays will operate in this period, when power has been recovered, the 4 kV bus has been restored, or operators have recovered from previous errors, depending on what led to the core damage. If power is recovered and the sprays operate, the contents of the RWST will be transferred to the containment and the cavity will fill up with water.

Case 1: The sprays were available at the start of the accident. The quantification for this case is:

Branch 1: L-Sp - 1.0

Branch 2: LSPfAC - 0.0

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Branch 3: LSPfHX - 0.0

Branch 4: LSPf - 0.0

Case 2: The sprays were failed at the start of the accident, and no recovery is possible, so the sprays remain failed. The quantification for this case is:

Branch 1: L-Sp - 0.0

Branch 2: LSPfAC - 0.0

Branch 3: LSPfHX - 0.0

Branch 4: LSPf - 1.0

Case 3: The sprays are available to operate during this time period, but power or the 4 kV bus has not been recovered so the sprays remain available to operate in the future when power or 4 kV bus is recovered. The quantification for this case is:

Branch 1: L-Sp - 0.0

Branch 2: LSPfAC - 1.0

Branch 3: LSPfHX - 0.0

Branch 4: LSPf - 0.0

Case 4: The sprays are available to operate at the start of the accident, but operators have not recovered from previous errors so the sprays remain available to operate in the future when the operator error is corrected. The quantification for this case is:

Branch 1: L-Sp - 0.0

Branch 2: LSPfAC - 0.0

Branch 3: LSPfHX - 1.0

Branch 4: LSPf - 0.0

Case 5: The sprays were available to operate during the previous time period. The sprays now operate because power has been recovered, the 4 kV bus has been restored, or operators have recovered from previous errors, depending on what led to the core damage. The quantification for this case is:

Branch 1: L-Sp - 1.0

Branch 2: LSPfAC - 0.0

Branch 3: LSPfHX - 0.0

Branch 4: LSPf - 0.0

Question 29. Late Ignition

2 Branches, Type 2, 3 Cases

The branches for this question are:

1. L-Ign Ignition of the hydrogen in the containment will occur during this period if the concentration is flammable.
2. noL-Ign Ignition of the hydrogen in the containment will not occur during this period even if the concentration is flammable.

This question determines whether conditions exist to ignite the hydrogen in the containment between VB and early part of CCI. The conditions that make hydrogen combustion capable of threatening the Surry containment in the late period are no prior failure, little or no combustion at VB, and absence of continuous electrical power and sprays. If the sprays do not operate in this period, the containment will be steam inert through this period and combustion is not possible. If power is recovered during this period and the sprays operate, then ignition is very likely.

Case 1: The containment is already failed. Ignition and burn at this time is irrelevant. The quantification for this case is:

Branch 1: L-Ign - 0.0

Branch 2: noL-Ign - 1.0

Case 2: Electrical power and spray operation were recovered during this period. Ignition is highly likely. The quantification for this case is:

Branch 1: L-Ign - 0.99

Branch 2: noL2-Ign - 0.01

Case 3: Electric power is not recovered during this time period. The sprays do not operate, so the containment will remain inerted by the high steam concentration. The quantification for this case is:

Branch 1: L-Ign - 0.00

Branch 2: noL-Ign - 1.00

Question 30. Number of Holes in vessel?

2 Branches, Type 1, 1 Case

The branches for this question are:

1. 1-Hole There is only one large hole in the RCS following VB.
2. 2-Hole There are two large holes in the RCS.

This question was intended to provide the information on the number of holes in the RCS to the source term code. However, source term analysis showed that this parameter does not make a significant contribution to the source term release fractions. Therefore, the this question is dummied out and take the first branch always.

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Question 31. Late Containment Failure due to hydrogen burning?

3 Branches, Type 2, 6 Cases

The branches for this question are:

1. LCF-Rupt The containment already failed, or ruptures due to hydrogen burning during this period.
2. LCF-Leak The containment already leaks. No hydrogen burning is possible, since all hydrogen escaped the containment.
3. no-LCF The containment does not fail during this period.

The time period of interest of this question is same as the previous question. This question determines the status of the containment at the end of this time period, including rupture by hydrogen burning during this period. This question is not sampled. The branch chosen for this question depends directly upon the branches taken at Questions 11, 17, 18, 25, and 29.

The pressure generated by hydrogen burning when ignited is not calculated in this analysis. Calculations show that the pressure generated by hydrogen burning is generally much higher than 45 psig, but substantially below 126 psig. The probability of the containment failure by hydrogen burning is relatively small in this analysis since the dominating containment failure mode is initial isolation failure. Therefore, it has been assumed in this analysis that the containment would fail by hydrogen burning, when ignition occurred, if the containment pressure capability is 45 psig, but would not if it is 126 psig.

Case 1: The containment already failed. The quantification for this case is:

Branch 1: LCF-Rupt - 1.0
Branch 2: LCF-Leak - 0.0
Branch 3: no-LCF - 0.0

Case 2: The containment already leaked. The quantification for this case is:

Branch 1: LCF-Rupt - 0.0
Branch 2: LCF-Leak - 1.0
Branch 3: no-LCF - 0.0

Case 3: Conditions do not exist for hydrogen ignition. The containment does not fail. The quantification for this case is:

Branch 1: LCF-Rupt - 0.0
Branch 2: LCF-Leak - 0.0
Branch 3: no-LCF - 1.0

Case 4: The containment failure pressure is 45 psig. Conditions exist for hydrogen ignition. HPME occurred at VB, and most of hydrogen released at VB did not burn. The quantification for this case is:

Branch 1: LCF-Rupt - 1.0
Branch 2: LCF-Leak - 0.0
Branch 3: no-LCF - 0.0

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Case 5: The containment failure pressure is 45 psig. Conditions exist for hydrogen ignition. The core debris poured out of the vessel at VB. None of hydrogen released at VB burned. The quantification for this case is:

Branch 1: LCF-Rupt - 1.0

Branch 2: LCF-Leak - 0.0

Branch 3: no-LCF - 0.0

Case 6: The containment does not fail either because the containment failure pressure is 126 psig, or sufficient amount of hydrogen does not exist in the containment. The quantification for this case is:

Branch 1: LCF-Rupt - 0.0

Branch 2: LCF-Leak - 0.0

Branch 3: no-LCF - 1.0

Question 32. Is the Debris Bed in a Coolable Configuration?

2 Branches, Type 2, 5 Cases

The branches for this question are:

1. CDB The debris bed is coolable; no CCI takes place as long as the debris remains covered with water.
2. noCDB The debris bed is not coolable. CCI will begin as soon as the melt reheats whether water is present or not.

This question is not sampled and was quantified as for the NUREG-1150 analysis. The branch taken at this question depends upon the branches previously taken at Questions 17 and 22.

Core-concrete interactions will not occur if the debris bed is in a coolable configuration, and if there is water present to cool it. This question determines whether the debris bed is coolable assuming that water is present when the core debris enters the cavity and is continuously replenished thereafter. Whether water is present is determined in the next question. The portion of the molten core that participates in DCH is unavailable for CCI. Thus the core debris considered in this question is the debris expelled at VB that remains in the cavity and the debris that leaves the vessel some time after VB. More discussion of debris coolability topic may be found in Volume 2, Part 6, of NUREG/CR-4551.

An Alpha event is likely to scatter at least some corium around the containment. If this corium comes to rest in a thin uniform layer, air cooling will suffice. However, it is possible that drifts of corium particles might accumulate in corners, in the wall-floor angle, and so on, that would be large enough to reheat and start CCI. Debris coolability is very uncertain in scenarios such as these.

Case 1: The vessel has failed by an Alpha mode event which also fails the containment. These events are so energetic that a substantial portion of the core debris is likely to be widely scattered throughout the containment. However, very little is known about these events or the expected corium distribution. Since the Alpha mode failure of the containment also fail the sprays, there is no supply of water to the cavity and CCI will occur eventually even if the debris bed is initially coolable and some water is present. Thus the quantification for this case is largely irrelevant. The quantification for this case is:

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Branch 1: CDB - 0.85

Branch 2: noCDB - 0.15

Case 2: There was no vessel failure; CCI does not occur. The quantification of this case is:

Branch 1: CDB - 1.0

Branch 2: noCDB - 0.0

Case 3: The vessel failure resulted in HPME or gross bottom head failure at high pressure. The core debris involved in HPME but which does not participate in DCH is likely to be widely distributed throughout the containment. The state of the debris ejected at vessel failure which remains in the cavity is not well known. The debris that pours out of the vessel some time after vessel blowdown may assume a coolable form if it fragments into pieces that are neither too small nor too large. The quantification for this case is:

Branch 1: CDB - 0.80

Branch 2: noCDB - 0.20

Case 4: A gravity pour of the core debris resulted at vessel breach, and an EVSE occurred. The EVSE may spread a portion of the debris throughout the containment where it would be coolable. On the other hand, the EVSE may create fine particles that remain in the cavity and make the bulk of the core debris in the cavity noncoolable. The quantification for this case is:

Branch 1: CDB - 0.80

Branch 2: noCDB - 0.20

Case 5: The vessel has failed with a gravity pour resulting. No EVSE occurred. All of the core which exits the vessel should remain on the cavity floor. To form a coolable debris bed, the debris must fragment when it hits the water, the resulting particles must quench while falling through the water, and the size of the bulk of the particles must fall within a certain size range. Further, if a portion of the debris bed is noncoolable, the available evidence is that this portion of the bed will grow in size until essentially the entire bed has become noncoolable. The quantification for this case is:

Branch 1: CDB - 0.35

Branch 2: noCDB - 0.65

Question 33. Does Prompt CCI Occur?

2 Branches, Type 2, 3 Cases

The branches for this question are:

1. PrmptCCI CCI occurs promptly following vessel breach.
2. noPrmCCI CCI does not occur promptly after vessel breach.

This question is not sampled; whether prompt CCI occurs follows logically from the information available about the coolability of the core debris and the presence of water in the reactor cavity. The branch taken at this question depends upon the branches previously taken at Questions 17, 19, and 32.

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Case 1: Vessel did not fail and there is no corium in the cavity floor. No CCI occurs. The quantification for this case is:

Branch 1: PrmptCCI - 0.0

Branch 2: noPrmCCI - 1.0

Case 2: The debris is coolable and there is water in the cavity. CCI does not begin promptly. The situation where the containment sprays operate only in the late period is not considered a sufficient water supply to prevent CCI from starting. Electrical power may be recovered any time in the period, so the sprays may not start until several hours after VB. Water must be continuously present from VB to prevent prompt CCI. The quantification for this case is:

Branch 1: PrmptCCI - 1.0

Branch 2: noPrmCCI - 0.0

Case 3: There is no water in the cavity, or the debris is not coolable. In either case, CCI begins promptly, either at once, if the debris is hot when it leaves the vessel, or as soon as the debris has reheated.

The quantification for this case is:

Branch 1: PrmptCCI - 1.0

Branch 2: noPrmCCI - 0.0

Question 34. Is AC Power Available Very Late?

2 Branches, Type 2, 9 Cases

The branches for this question are:

1. L2RAC AC power is available Very Late?
2. noL2RAC AC power is not available for this time period, but may be recovered in the future.

The time period of interest here is from the initial portion of CCI to 24 hours. This time period for each time window is given Section 6.1. This question addresses the recovery of electric power to the injection pumps during this time period for the cases where either off-site power or 4 kV bus was not available. The meaning of recovery probability and their distributions are the same as discussed in Question 12. The branching at this question depends upon the branches taken at Questions 1, 4 and 26. Cases 1 through 8 of this question are sampled.

Case 1 through 4: Offsite power was not available at the end of the previous period. The probability of power recovery during this period is calculated based on the recovery distribution and is assigned to the first branch.

Case 5 through 8: Injection pumps were not operating because of loss of 4 kV bus to the available injection pumps at the end of the previous period. The probability of restoring the 4 kV bus during this period is assigned to the first branch.

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Case 9: Power was available at the end of the previous period and remains available. The quantification for this case is:

Branch 1: ERAC - 1.0

Branch 2: NoERAC - 0.0

Question 35. Recovered from human errors very late?

2 Branches, Type 2, 5 Cases

The branches for this question are:

1. L2RHX Operators recover from previous error during this time period.
2. NoL2RHX Operators do not recover from the previous error during this time period.

This question addresses the recovery from operator errors for the accidents where the VB occurred because of inadequate operator actions following the core damage. The time period of interest is the same as Question 34. Cases 1 through 4 of this question are sampled. The meaning of recovery probability and their distributions are the same as discussed in Question 27. The branching at this question depends upon the branches taken at Questions 1 and 27.

Question 36. Very Late Sprays?

2 Branches, Type 2, 5 Cases

The branches for this question are:

1. L2-Sp The containment sprays are operating during this period.
2. L2SPf The containment sprays are not recovered.

This question is not sampled. The branch chosen for this question depends directly upon the branches taken at Questions 28, 34 and 35. The time period of interest is the same as in the preceding question. If sprays are recovered during this time period, steam condensation will de-inert the containment, making a hydrogen burn possible. If the debris bed is coolable, spray operation during this period is required to prevent dryout and concrete attack.

Case 1: The sprays were available in the previous period. The quantification for this case is:

Branch 1: L2-Sp - 1.0

Branch 2: L2SPf - 0.0

Case 2: The sprays were failed at the start of the accident, and no recovery is possible, so the sprays remain failed. The quantification for this case is:

Branch 1: L2-Sp - 0.0

Branch 2: L2Spf - 1.0

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Case 3: The sprays are available to operate during this time period, but power or the 4 kV bus has not been recovered so the sprays remain available to operate in the future when power or 4 kV bus is recovered. The quantification for this case is:

Branch 1: L2-Sp - 0.0

Branch 2: L2SPf - 1.0

Case 4: The sprays are available to operate at the start of the accident, but operators have not recovered from previous errors so the sprays remain available to operate in the future when the operator error is corrected. The quantification for this case is:

Branch 1: L2-Sp - 0.0

Branch 2: L2SPf - 1.0

Case 5: The sprays were available to operate during the previous time period. The sprays now operate because power has been recovered, the 4 kV bus has been restored, or operators have recovered from previous errors, depending on what led to the core damage. The quantification for this case is:

Branch 1: L2-Sp - 1.0

Branch 2: L2Spf - 0.0

Question 37. Does Delayed CCI Occur?

2 Branches, Type 2, 4 Cases

The branches for this question are:

1. DidCCI CCI occurs after a delay to boil off the water in the cavity.
2. noDidCCI CCI does not occur after a delay to boil off the water in the cavity.

This question is not sampled; whether delayed CCI occurs follows logically from the information available about the coolability of the core debris, whether prompt CCI has occurred, and whether the sprays are operating. The branch taken at this question depends upon the branches previously taken at Questions 17, 33, and 36.

Case 1: Vessel did not fail and there is no corium in the cavity floor. No CCI occurs. The quantification for this case is:

Branch 1: DidCCI - 0.0

Branch 2: noDidCCI - 1.0

Case 2: Prompt CCI occurred. Delayed CCI is not possible. The quantification for this case is:

Branch 1: DidCCI - 0.0

Branch 2: noDidCCI - 1.0

Case 3: Prompt CCI did not occur and the sprays are now operating. Prompt CCI must not have occurred since the debris bed have been coolable with water available. Since the sprays are now operating,

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the water cooling the debris bed is being replenished and delayed CCI will not take place. The quantification for this case is:

Branch 1: DldCCI - 0.0

Branch 2: noDldCCI - 1.0

Case 4: Prompt CCI did not occur, and the sprays are not operating. The debris bed must have been coolable, and there must have been some water present, or prompt CCI would have resulted. As the water being boiled off is not being replenished, delayed CCI will begin when the water is all boiled off. The quantification for this case is:

Branch 1: DldCCI - 1.0

Branch 2: noDldCCI - 0.0

Question 38. Does Very Late Ignition Occur?

2 Branches, Type 2, 5 Cases

The branches for this question are:

1. L2-Ign Ignition of the hydrogen in the containment will occur during this period if the concentration is flammable.
2. noL2-Ign Ignition of the hydrogen in the containment will not occur during this period even if the concentration is flammable.

This question is not sampled and was quantified as for the NUREG-1150 analysis. The applicable case depends upon the branches taken at Questions 26, 29, 31, 34 and 36.

This question determines whether conditions exist to ignite the hydrogen in the containment during the latter part of CCI. In the very late period, if no burns, containment failures, or bypasses have occurred, the hydrogen available is that produced in-vessel or at VB, the hydrogen produced by oxidizing all the remaining unoxidized Zr during the initial part of CCI, and the hydrogen produced in CCI in addition to that from oxidizing the rest of the zirconium. Significant combustion events during this period are negligible if electric power and containment sprays have been continuously available since the start of the accident. They may occur in this period when electric power and the sprays are recovered.

Case 1: The containment is already failed. Ignition and burn at this time is irrelevant. The quantification for this case is:

Branch 1: L2-Ign - 0.0

Branch 2: noL2-Ign - 1.0

Case 2: Ignition occurred in the previous time period, and most of hydrogen already burned. The quantification for this case is:

Branch 1: L2-Ign - 0.0

Branch 2: noL2-Ign - 1.0

Case 3: Electrical power and spray operation were recovered during this period. Ignition is highly likely. The quantification for this case is:

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Branch 1: L2-Ign - 0.99

Branch 2: noL2-Ign - 0.01

Case 4: Electric power is not recovered during the time frame of interest for this analysis. The sprays do not operate, so the containment will remain inerted by the high steam concentration for some time. Eventually the steam concentration in the containment may drop to about 55%, and then ignition is possible if enough hydrogen is present. When no electrical power is available ignition appears to be a stochastic phenomenon. A similar case was considered by the experts considering hydrogen combustion events at Grand Gulf. They gave distributions for ignition probability which depended on the hydrogen concentration. This issue is summarized in Volume 2, Part 2, of NUREG/CR-4551. The mean values of their ignition probability distributions for concentrations of interest are about 0.30. This value (0.30) for the ignition probability also includes implicitly the probability that heat loss through the containment wall alone eventually causes enough wall condensation to reduce the steam concentration to about 55%. The quantification for this case is:

Branch 1: L2-Ign - 0.30

Branch 2: noL2-Ign - 0.70

Case 5: The concentration is not flammable or is steam-inert. Very late ignition cannot take place. The quantification for this case is:

Branch 1: L2-Ign - 0.0

Branch 2: noL2-Ign - 1.0

Question 39. Very Late Containment Failure due to hydrogen burning?

3 Branches, Type 2, 5 Cases

The branches for this question are:

1. L2CF-Rupt The containment already failed, or ruptures due to hydrogen burning during this period.
2. L2CF-Leak The containment already leaks. No hydrogen burning is possible, since all hydrogen escaped the containment.
3. no-L2CF The containment does not fail during this period.

The time period of interest of this question is same as the previous question. This question determines the status of the containment at the end of this time period, including rupture by hydrogen burning during this period. This question is not sampled. The branch chosen for this question depends directly upon the branches taken at Questions 11, 31, 33, 37, and 38.

As in Question 31, the pressure generated by hydrogen burning when ignited is not calculated in this question and it is assumed that the containment would fail by hydrogen burning if the containment pressure capability is 45 psig, but would not if it is 126 psig.

Case 1: The containment already failed. The quantification for this case is:

Branch 1: L2CF-Rupt - 1.0

Branch 2: L2CF-Leak - 0.0

Branch 3: no-L2CF - 0.0

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Case 2: The containment already leaked. The quantification for this case is:

Branch 1: L2CF-Rupt - 0.0
Branch 2: L2CF-Leak - 1.0
Branch 3: no-L2CF - 0.0

Case 3: Conditions do not exist for hydrogen ignition. The containment does not fail. The quantification for this case is:

Branch 1: L2CF-Rupt - 0.0
Branch 2: L2CF-Leak - 0.0
Branch 3: no-L2CF - 1.0

Case 4: The containment failure pressure is 45 psig. Conditions exist for hydrogen ignition. Prompt or delayed CCI occurred. The quantification for this case is:

Branch 1: L2CF-Rupt - 1.0
Branch 2: L2CF-Leak - 0.0
Branch 3: no-L2CF - 0.0

Case 5: The containment does not fail either because the containment failure pressure is 126 psig, or sufficient amount of hydrogen does not exist in the containment. The quantification for this case is:

Branch 1: L2CF-Rupt - 0.0
Branch 2: L2CF-Leak - 0.0
Branch 3: no-L2CF - 1.0

Question 40. Final Containment Condition and Failure Time?

6 Branches, Type 2, 7 Cases

The branches for this question are:

1. Leak-I The containment was initially isolated, but leaks.
2. Rupt-I The containment was not successfully isolated before the core damage.
3. Rupt-VB The containment failed at VB either because of Alpha mode failure, DCH or EVSE.
4. Rupt-L The containment failed late due to hydrogen burning.
5. Rupt-L2 The containment failed very late due to hydrogen burning.
6. No-CF The containment remains intact in 24 hours.

This question is not sampled. This question utilizes the results of many previous questions to summarize the state of the containment at the end of this event tree analysis. Only the most important condition in determining the releases is considered. The branches in this question depend upon the branches previously taken at Questions 11, 25, 31, and 39.

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6 Status of ECCS at CD?						\$ PDS 5
5	ECCSf4KV	ECCSfAC	ECCSfHX	ECCSfHW	ECCSfREC	
1	1	2	3	4	5	
	0.000	0.000	0.000	0.000	1.000	\$ Level 1
7 Spray at CD?						\$ PDS 6
6	SP	SPfAC	SPfHX	SPfHW	SPfREC	SPf4KV
2	1	2	3	4	5	6
2 Cases						
1	1					
1						
	W1					
	0.000	0.000	0.000	0.000	0.000	1.000
	Otherwise					
	0.000	0.000	0.000	0.000	0.000	1.000
8 RWST at CD						\$ PDS 8
4	RWST-In	RWSTfAC	RWSTfHX	RWSTfIn		
2	1	2	3	4		
2 Cases						
2	6	7				
	4 *	4				
	ECCSfHW &	SPfHW				
	0.000	0.000	0.000	1.000		
	Otherwise					
	1.000	0.000	0.000	0.000		
9 Is containment closed at beginning of accident?						\$ PDS0
2	ClsdCI	No-ClsdCI				
1	1	2				
	0.000	1.000				
10 Is containment closed before core damage?						
2	ClsdCD	No-ClsdCD				
2	1	2				
6 Cases						
1	9					
	1					
	ClsdCI					
	1.000	0.000				
1	5					
	3					
	HXD					
	0.000	1.000				
1	1					
	1					
	W1					
	0.800	0.200				
1	1					
	2					
	W2					
	0.900	0.100				
1	1					
	3					
	W3					
	0.950	0.050				
	Otherwise					
	1.000	0.000				\$ W4

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11 Containment Pressure Capability

3	CP125p	CP45p	CP2p
2	1	2	3
3 Cases			
1	9		
	1		
	ClsdCI		
	0.99	0.000	0.01
2	9	10	
	2 *	1	
	No-ClsdCI & ClsdCD		
	0.900	0.000	0.100
	Otherwise		
	0.000	0.000	1.000

12 AC recovered before VB?

\$ Conditional...Power/4KV Recovery Curve

2	ERAC	No-ERAC
2	1	2
9 Cases		
2	1	4
	1 *	2
	W1 &	No-AC
	0.800	0.200
2	1	4
	2 *	2
	W2 &	No-AC
	0.850	0.150
2	1	4
	3 *	2
	W3 &	No-AC
	0.900	0.100
2	1	4
	4 *	2
	W4 &	No-AC
	0.950	0.050
2	1	4
	1 *	3
	W1 &	No-4KV
	0.800	0.200
2	1	4
	2 *	3
	W2 &	No-4KV
	0.850	0.150
2	1	4
	3 *	3
	W3 &	No-4KV
	0.900	0.100
2	1	4
	4 *	3
	W4 &	No-4KV
	0.950	0.050
	Otherwise	
	1.000	0.000

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13 Recovered from HX before VB?

2	ERHX	No-ERHX
2	1	2
9 Cases		
2	1	5
	1 *	2
	W1 &	HXA
	0.500	0.500
2	1	5
	1 *	3
	W1 &	HXD
	0.850	0.150
2	1	5
	2 *	2
	W2 &	HXA
	0.600	0.400
2	1	5
	2 *	3
	W2 &	HXD
	0.900	0.100
2	1	5
	3 *	2
	W3 &	HXA
	0.700	0.300
2	1	5
	3 *	3
	W3 &	HXD
	0.930	0.070
2	1	5
	4 *	2
	W4 &	HXA
	0.800	0.200
2	1	5
	4 *	3
	W4 &	HXD
	0.950	0.050
	Otherwise	
	1.000	0.000

14 VB?

2	No-VB	VB
2	1	2
4 Cases		
2	6	6
	4 +	5
	ECCSfHW or Recf	
	0.000	1.000
3	6	6
	(1 + 2)	12
	(ECCSf4KV or ECCSfAC)	* 2
	0.000	1.000
2	6	13
	3 *	2*
	ECCSfHX &	No-ERHX
	0.000	1.000
	Otherwise	
	1.000	0.000

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15 Vessel Pressure just before Breach?

2 I-ImPr I-LoPr
 2 1 2
 2 Cases
 1 3
 1
 VDEP
 0.000 1.000
 Otherwise
 1.000 0.000

16 ALPHA Mode Failure?

2 Alpha noAlpha
 2 1 2
 2 Cases
 2 14 15
 2 2 * 2
 VB & I-Lopr
 0.0080 0.9920
 Otherwise
 0.0000 1.0000

17 Type of Vessel Breach? \$ Summary .. Cumulative.

	PrEj	Pour	BtmHd	noVB	ALPHA
2	1	2	3	4	5
4 Cases					
1	14				
	1				
	noVB				
	0.000	0.000	0.000	1.000	0.000
1	16				
	1				
	ALPHA				
	0.000	0.000	0.000	0.000	1.000
2	14	15			
	2	*	1		
	VB &	I-ImPr			
	1.0000	0.0000	0.0000	0.0000	0.000
	Otherwise - I-LoPr				
	0.0000	1.0000	0.0000	0.0000	0.000

18 Early Sprays before vb? \$ Cumulative

	E-Sp	ESPfAC	ESPfHX	ESPf
4	1	2	3	4
2				
5 Cases				
1	7			
	1			
	Sp			
	1.000	0.000	0.000	0.000
2	7	7		
	4	+	5	
	SPfHW	or	Recf	
	0.000	0.000	0.000	1.000
3	7	7	12	
	(2	+	6)	*
	(SPfAC	or	SPf4KV)	& No-ERAC
	0.000	1.000	0.000	0.000
2	7	13		
	3	*	2	

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	SPfHX	& No-ERHX		
	0.000	0.000	1.000	0.000
	Otherwise			
	1.000	0.000	0.000	0.000
19	Amount of Water in the Reactor Cavity at Vessel Breach? \$\$X			
2	RC-Wet	RC-Dry		
2	1	2		
4	Cases			
1	8			
	1			
	RWSTIn			
	1.000	0.000		
2	8	12		
	2 *	1		
	RWSTfAC &	ERAC		
	1.000	0.000		
2	8	13		
	3 *	1		
	RWSTfHX &	ERHX		
	1.000	0.000		
	Otherwise			
	0.000	1.000		
20	Baseline Containment Pressure just before VB? \$\$X			
1	IPBase			
4	1			
3	Cases			
1	11			
	3			
	CP2p			
	1.000			
1				
1	17.00			
1	17			
	4			
	noVB			
	1.000			
1				
1	17.00			
	Otherwise			
	1.000			
1				
1	19.00			
21	Pressure Rise at Vessel Breach?		Large Hole Cases	\$\$X
1	DP-VB			
4	1			
5	Cases			
1	17			
	4			
	noVB			
	1.000			
1				
4	0.00			
1	17			
	5			
	Alpha			
	1.000			

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```

1
4 777.00
2 15 17
2 2 + 2
I-LoPr or Pour
1.000

1
4 5.00
2 15 19
2 1 * 1
I-ImPr & RC-Wet
1.000

1
4 57.70
Otherwise
1.000

1
4 64.70
22 Does a Significant Ex-Vessel Steam Explosion Occur? $$X
2 EVSE noEVSE
2 1 2
2 Cases
2 19 17
2 1 * 2
RC-Wet & Pour
0.500 0.500
Otherwise -- No EVSE
0.000 1.000

23 Containment Failure Pressure? $$X
1 CF-Pr
4 1
3 Cases
1 11
1 1
CP125p
1.000

1
6 140
1 11
2
CP45p
1.000

1
6 59.70
Otherwise
1.000

1
6 16.70
24 Containment Rupture at VB?
2 ICF-Rupt no-ICF
5 1 2
3 1 4 -6
IPBase DP-VB CF-Pr
AND
GETHRESH 1 0
ICF rupture if IPBase + (DP-VB) > CF-Pr

```

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25 Containment Status at VB?

3	ICF-Rupt	ICF-Leak	no-ICF
2	1	2	3
5	Cases		
2	10	11	
	1 *	3	
	ClsdCD &	CP2p	
	0.000	1.000	0.000
2	10	11	
	2 *	3	
	NoClsdCD &	CP2p	
	1.000	0.000	0.000
1	17		
	5		
	Alpha		
	1.000	0.000	0.000
1	24		
	1		
	ICF-R		
	1.000	0.000	0.000
	Otherwise		
	0.000	0.000	1.000

26 AC recovered after VB but before major CCI? \$ Conditional

2	LRAC	No-LRAC	
2	1	2	
9	Cases		
3	12	1	4
	2 *	1 *	2
	NO-ERAC &	W1 &	No-AC
	0.800	0.200	
3	12	1	4
	2 *	2 *	2
	NO-ERAC &	W2 &	No-AC
	0.850	0.150	
3	12	1	4
	2 *	3 *	2
	NO-ERAC &	W3 &	No-AC
	0.900	0.100	
3	12	1	4
	2 *	4 *	2
	NO-ERAC &	W4 &	No-AC
	0.950	0.050	
3	12	1	4
	2 *	1 *	3
	NO-ERAC &	W1 &	No-4KV
	0.800	0.200	
3	12	1	4
	2 *	2 *	3
	NO-ERAC &	W2 &	No-4KV
	0.850	0.150	
3	12	1	4
	2 *	3 *	3
	NO-ERAC &	W3 &	No-4KV
	0.900	0.100	
3	12	1	4
	2 *	4 *	3

Appendix B Supporting Information for the Accident Progression Analysis

	NO-ERAC & 0.950 Otherwise 1.000	W4 & 0.050 \$ 12/1 0.000	No-4KV	
27 Recovered from HX after VB but before major CCI?	\$Conditional			
2	LRHX	No-LRHX		
2	1	2		
5 Cases				
2	13	1		
	2 *	1		
	NO-ERHX &	W1		
	0.800	0.200		
2	13	1		
	2 *	2		
	NO-ERHX &	W2		
	0.850	0.150		
2	13	1		
	2 *	3		
	NO-ERHX &	W3		
	0.900	0.100		
2	13	1		
	2 *	4		
	NO-ERHX &	W4		
	0.950	0.050		
	Otherwise 1.000	0.000		
28 Late Sprays (After VB but before major CCI)?	\$ Cumulative			
4	L-Sp	LSPfAC	LSPfHX	LSPf
2	1	2	3	4
5 Cases				
1	18			
	1			
	E-Sp			
	1.000	0.000	0.000	0.000
1	18			
	4			
	ESPf			
	0.000	0.000	0.000	1.000
2	18	26		
	2 *	2		
	ESPfAC & No-LRAC			
	0.000	1.000	0.000	0.000
2	18	27		
	3 *	2		
	ESPfHX & No-LRHX			
	0.000	0.000	1.000	0.000
	Otherwise 1.000	0.000	0.000	0.000
29 Does Late Ignition Occur?				
2	L-Ign	noL-Ign		
2	1	2		
3 Cases				
2	25	25		
	1 +	2		
	C-Rupt or C-Leak			
	0.000	1.000		

Appendix B Supporting Information for the Accident Progression Analysis

3	12	26	28
	2 *	1 *	1
	noE-RAC &	L-RAC &	L-SP
	0.990	0.010	
	Otherwise		
	0.000	1.000	
30 DUMMY			
2	Dummy1	Dummy2	
1	1	2	
	1.000	0.000	
31 Late Containment Failure due to H2 Burning? \$(After VB but before CCI)			
3	LCF-Rupt	LCF-Leak	no-LCF
2	1	2	3
6 Cases			
1	25		
	1		
	ICF-Rupt		
	1.000	0.000	0.000
1	25		
	2		
	ICF-Leak		
	0.000	1.000	0.000
1	29		
	2		
	NoL-Ign		
	0.000	0.000	1.000
4	11	18	17
	2 *	-1 *	(1 + 3)
	C60p &	NoE-Sp &	PrEj BtmHd
	1.000	0.000	0.000
2	11	17	
	2 *	2	
	C60p &	Pour	
	1.000	0.000	0.000
	Otherwise		
	0.000	0.000	1.000
32 Is the Debris Bed in a Coolable Configuration?			
2	CDB	noCDB	
2	1	2	
5 Cases			
1	17		
	5		
	Alpha		
	0.850	0.150	
1	17		
	4		
	noVB		
	1.000	0.000	
2	17	17	
	1 +	3	
	PrEj or	BtmHd	
	0.800	0.200	
1	22		
	1		
	EVSE		
	0.800	0.200	

Appendix B Supporting Information for the Accident Progression Analysis

	Otherwise - Pour & noEVSE			
	0.350	0.650		
33 Does Prompt CCI Occur?				
2 PrmptCCI	noPrmCCI			
2	1	2		
3 Cases				
1	17			
	4			
	noVB			
	0.000	1.000		
2	32	19		
	1 *	1		
	CDB &	RC-Wet		
	0.000	1.000		
	Otherwise -- Not coolable or no water			
	1.000	0.000		
34 AC rec before 24 hours?	\$ Conditional			
2 L2RAC	No-L2RAC			
2	1	2		
9 Cases				
3	26	1	4	
	2 *	1 *	2	
	NO-LRAC &	W1 &	No-AC	
	0.800	0.200		
3	26	1	4	
	2 *	2 *	2	
	NO-LRAC &	W2 &	No-AC	
	0.850	0.150		
3	26	1	4	
	2 *	3 *	2	
	NO-LRAC &	W3 &	No-AC	
	0.900	0.100		
3	26	1	4	
	2 *	4 *	2	
	NO-LRAC &	W4 &	No-AC	
	0.950	0.050		
3	26	1	4	
	2 *	1 *	3	
	NO-LRAC &	W1 &	No-4KV	
	0.800	0.200		
3	26	1	4	
	2 *	2 *	3	
	NO-LRAC &	W2 &	No-4KV	
	0.850	0.150		
3	26	1	4	
	2 *	3 *	3	
	NO-LRAC &	W3 &	No-4KV	
	0.900	0.100		
3	26	1	4	
	2 *	4 *	3	
	NO-LRAC &	W4 &	No-4KV	
	0.950	0.050		
	Otherwise	\$ 12/1		
	1.000	0.000		

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35 Recovered from HX before 24 HOURS? \$Conditional

2	L2RHX	No-L2RHX
2	1	2

5 Cases

2	27	1
---	----	---

2	*	1
---	---	---

NO-LRHX	&	W1
---------	---	----

0.800		0.200
-------	--	-------

2	27	1
---	----	---

2	*	2
---	---	---

NO-LRHX	&	W2
---------	---	----

0.850		0.150
-------	--	-------

2	27	1
---	----	---

2	*	3
---	---	---

NO-LRHX	&	W3
---------	---	----

0.900		0.100
-------	--	-------

2	27	1
---	----	---

2	*	4
---	---	---

NO-LRHX	&	W4
---------	---	----

0.950		0.050
-------	--	-------

Otherwise

1.000		0.000
-------	--	-------

36 Very Late Sprays (BEFORE 24 hours)? \$Cumulative

2	L2-Sp	L2SPf
---	-------	-------

2	1	2
---	---	---

5 Cases

1	28
---	----

1

L-SP

1.000		0.000
-------	--	-------

1	28
---	----

4

LSPf

0.000		1.000
-------	--	-------

2	28	34
---	----	----

2	*	2
---	---	---

LSPfAC	&	No-L2RAC
--------	---	----------

0.000		1.000
-------	--	-------

2	28	35
---	----	----

3	*	2
---	---	---

LSPfHX	&	No-L2RHX
--------	---	----------

0.000		1.000
-------	--	-------

Otherwise

1.000		0.000
-------	--	-------

37 Does Delayed CCI Occur?

2	DldCCI	noDldCCI
---	--------	----------

2	1	2
---	---	---

4 Cases

1	17
---	----

4

noVB

0.000		1.000
-------	--	-------

1	33
---	----

1

PrmptCCI

0.000		1.000
-------	--	-------

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2	33	36				
	2	1				
	noPrmCCI	LSp				
	0.000	1.000				
	Otherwise					
	1.000	0.000				
38	Does Very Late Ignition Occur (BEFORE 24 HRS)?					
2	L2-Ign	noL2-Ign				
2	1	2				
5	Cases					
2	31	31				
	1	+	2			
	LCF-Rupt	or LCF-Leak				
	0.000	1.000				
1	29					
	1					
	L-Ign					
	0.000	1.000				
3	26	34	36			
	2	*	1	*	1	
	noL-RAC	& L2RAC	& L2-SP			
	0.990	0.010				
2	34	36				
	2	*	2			
	noL2RAC	& NoL2-SP				
	0.300	0.700				
	Otherwise					
	0.000	1.000				
39	Very Late Containment Failure due to H2 Burning (Before 24Hrs)?					
3	L2CF-Rupt	L2CF-Leak	no-L2CF			
2	1	2	3			
5	Cases					
1	31					
	1					
	LCF-Rupt					
	1.000	0.000	0.000			
1	31					
	2					
	LCF-Leak					
	0.000	1.000	0.000			
1	38					
	2					
	NoL2-Ign					
	0.000	0.000	1.000			
3	11	33	37			
	2	*	(1 + 1)			
	C60p &	(P-CCI or D-CCI)				
	1.000	0.000	0.000			
	Otherwise					
	0.000	0.000	1.000			
40	Final Containment Sondition and Failure Time?					
6	Leak-I	Rupt-I	Rupt-VB	Rupt-L	Rupt-L2	No-CF
2	1	2	3	4	5	6
7	Cases					
1	39					
	3					

Appendix B Supporting Information for the Accident Progression Analysis

1	No-L2CF					
	0.000	0.000	0.000	0.000	0.000	1.000
2	ICF-Leak					
	1.000	0.000	0.000	0.000	0.000	0.000
2	CP2p					
	0.000	1.000	0.000	0.000	0.000	0.000
2	NoCP2p					
	0.000	0.000	1.000	0.000	0.000	0.000
2	No-ICF					
	0.000	0.000	0.000	1.000	0.000	0.000
2	No-LCF					
	0.000	0.000	0.000	0.000	1.000	0.000
2	Otherwise					
	0.000	0.000	0.000	0.000	0.000	1.000

B.3 Characteristics of the Surry Binner

The binner is the computer input which instructs EVNTRE how to group the outcomes from evaluating the APET.

These outcomes constitute the interface with the subsequent source term analysis. There are too many outcomes for them all to be saved for analysis afterwards, so as each unique path through the event tree is evaluated, the probability of that path is added to the probability for the appropriate accident progression bin. The term "binner" refers to the set of computer input that defines these bins.

Section 6.4 of this volume gives a general description of the accident progression bins and defines each attribute of each characteristic. That material is not repeated here. The binner itself, a computer input file read by EVNTRE, defines the accident progression bins and is listed in Section B.4. This section of Appendix B contains a case-by-case description of the binner. Since the format of this binner is designed to match the format requirement of the SRSOR code, some characteristics and attributes which are not specifically applicable to this study are included in the binning. The twelfth characteristic, "Time Window," is not required by the SRSOR code, but added to be passed to the consequence analysis.

Characteristic 1. CF-Time (Time of Containment Failure)
7 Attributes, 7 Cases

The attributes for this characteristic are:

- A. V-Dry Check valve failures resulted in a pipe break in an interfacing low pressure system. The break location was not underwater at the start of core degradation.
- B. V-Wet Check valve failures resulted in a pipe break in an interfacing low pressure system. The break location was underwater at the start of core degradation.
- C. Early-CF The containment failed before vessel breach. This characteristic represents isolation failures at the beginning of the accident.
- D. CF-at-VB The containment failed at the time of vessel breach.
- E. L/VL-CF The containment failed in the late or very late period, including CCI.
- F. Final-CF The containment failed during the final period.
- G. No-CF The containment did not fail.

This characteristic primarily concerns the time of containment failure. In addition to four time periods in which the containment may fail, there is an attribute for no containment failure.

Case 1: This case defines the conditions for Attribute G, No-CF. For this characteristic, no containment failure is interpreted to mean successful isolation of containment initially, no failure of the containment pressure boundary later and no bypass by Event V. The size or type of containment failure is treated in Characteristic 10.

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- Case 2: This case defines the conditions for Attribute A, V-Dry. This attribute is not applicable to this analysis.
- Case 3: This case defines the conditions for Attribute B, V-Wet. This attribute is not applicable to this analysis.
- Case 4: This case defines the conditions for Attribute C, Early-CF. Early containment failure here means failure before vessel breach, which includes failure of initial isolation of the containment.
- Case 5: This case defines the conditions for Attribute D, CF-at-VB. This is containment failure within a few minutes of vessel breach due to the events accompanying vessel failure.
- Case 6: This case defines the conditions for Attribute E, Late or Very Late CF. This is containment failure which occurs after VB. It could occur anywhere from a few tens of minutes after VB to several hours after VB. The major cause of this failure is hydrogen burning.
- Case 7: This case defines the conditions for Attribute F, Final-CF. Basemat melt-through (BMT) and eventual overpressure failure due to the inability to restore containment heat removal in the days following the accident were the failures that occurred in the Final period in the full power study. These failure modes were determined to be not credible for accidents during mid-loop operation and therefore this attribute was not used in this analysis.

Characteristic 2. Sprays (Operation of Containment Sprays) 8 Attributes, 8 Cases

The attributes for this characteristic are:

- A. Sp-Early The sprays operate only in the Early period, that is, before vessel breach.
- B. Sp-E+I The sprays operate only in the Early and Intermediate periods, that is, before vessel breach and immediately after vessel breach.
- C. Sp-E+I+L The sprays operate only in the Early, Intermediate, and Late periods, that is, from UTAF through the initial part of CCI.
- D. SpAlways The sprays Always operate during the periods of interest for fission product removal, that is, for at least 24 hours starting at UTAF.
- E. Sp-Late The sprays operate only in the Late period, that is, during the initial part of CCI.
- F. Sp-L+VL The sprays operate only in the Late and Very Late periods, that is, from the start of CCI through the release of almost all the fission products from CCI.
- G. Sp-VL The sprays operate only in the Very Late period, that is, during the latter part of CCI.
- H. Sp-Never The sprays Never operate during the accident.

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This characteristic concerns the operation of the containment sprays. Spray operation implies containment heat removal and radionuclide scrubbing. The division into the eight attributes is a straightforward sorting out of the various combinations of time periods. The final time period is of little consequence for the fission product release, but it must be included because there are cases where sprays operate only in this period and, for each characteristic, the binner must have a location in which to place every outcome.

- Case 1: This case defines the conditions for Attribute A, Sp-Early. In this case, the sprays operate only in the period before vessel breach.
- Case 2: This case defines the conditions for Attribute B, Sp-E+I. In this case, the sprays operate only before and at vessel breach.
- Case 3: This case defines the conditions for Attribute C, Sp-E+I+L. In this case, the sprays operate only from the start of the accident through the initial part of CCI.
- Case 4: This case defines the conditions for Attribute D, SpAlways. In this case, the sprays operate continuously from UTAF for at least 24 hours.
- Case 5: This case defines the conditions for Attribute E, Sp-Late. In this case, the sprays operate only during the initial part of CCI.
- Case 6: This case defines the conditions for Attribute F, Sp-L+VL. In this case, the sprays operate only in the Late and Very Late periods, that is, from the start of CCI through the release of almost all the fission products from CCI.
- Case 7: This case defines the conditions for Attribute G, Sp-VL. In this case, the sprays operate only in during the latter part of CCI, which follows a hydrogen burn (if any).
- Case 8: This case defines the conditions for Attribute H, Sp-Never. In this case, the containment sprays do not operate at all when they could contribute to fission product removal.

Characteristic 3. CCI (Core-Concrete Interactions) 6 Attributes, 6 Cases

The attributes for this characteristic are:

- A. Prom-Dry CCI takes place promptly following vessel breach in a dry cavity. There is no overlying water pool to scrub the releases.
- B. PromShlw CCI takes place promptly following vessel breach. The accumulators dump at vessel breach, so when CCI starts there is about 4.5 feet of water in the cavity.
- C. No-CCI CCI does not take place.
- D. PromDeep CCI takes place promptly following vessel breach. The cavity is full of water at this time; the pool is about 14 feet deep.

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- E. SDlyd-Dry CCI takes place after a short delay, in a dry cavity. The debris bed is coolable, but the water in the cavity is not replenished.
- F. LDlyd-Dry CCI takes place after a long delay, in a dry cavity. The debris bed is coolable, but the water in the cavity is not replenished. The delay is the time needed to boil off the water in a full cavity.

This characteristic concerns the core-concrete interaction; if it takes place, when it takes place, and whether there is overlying pool of water to scrub the fission products released from the CCI.

- Case 1: This case defines the conditions for Attribute A, Prom-Dry. CCI takes place promptly following vessel breach in a dry cavity. As there is no water in the cavity after VB, whether the debris bed is coolable is not relevant.
- Case 2: This case defines the conditions for Attribute B, PromShlw. CCI takes place promptly following vessel breach. The cavity was dry just before vessel failure, but the accumulators discharge at vessel breach. Since accumulators are not operational during shutdown period, there is no accumulator discharge at vessel breach and this case is not applicable.
- Case 3: This case defines the conditions for Attribute C, No-CCI. If neither prompt CCI nor delayed CCI takes place, there is no CCI. Either there was no vessel breach, or the debris is coolable, water was present at VB, and the water supply is continuously replenished by the containment sprays.
- Case 4: This case defines the conditions for Attribute D, PromDeep. CCI takes place promptly following vessel breach, and the cavity is full of water when CCI commences.
- Case 5: This case defines the conditions for Attribute E, SDlyd-Dry. CCI takes place after a short delay. The debris bed is initially coolable, and the cavity contains the accumulator water (only). This case is not applicable to this analysis.
- Case 6: This case defines the conditions for Attribute F, LDlyd-Dry. CCI takes place after a long delay. The debris bed is initially coolable, and the cavity is full of water at vessel breach. After all the water is boiled away, CCI commences in a dry cavity.

Characteristic 4. RCS-Pres (RCS Pressure before Vessel Breach)
4 Attributes, 4 Cases

The attributes for this characteristic are:

- A. SSPr Just before vessel breach, the RCS is at system setpoint pressure, about 2500 psia. This pressure is determined by the setpoint of the PORVs.
- B. HiPr Just before vessel breach, the RCS is in the range denoted high pressure. The hole in the RCS pressure boundary is small enough that the pressure spike that follows core slump decays away relatively slowly. The pressure at vessel breach can range from 1000 to 2000 psia.

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C. ImPr Just before vessel breach, the RCS is in the range denoted intermediate pressure. The hole in the RCS is larger than for Attribute B, so the pressure at breach is within the range of 500 to 1000 psia.

D. LoPr Just before vessel breach, the RCS is at low pressure, less than 500 psia.

This characteristic determines the pressure in the reactor coolant system just before the failure of the vessel. This pressure, together with the mode of vessel breach, Characteristic 5, largely determines the events that take place in the containment immediately following vessel breach. The RCS pressure during most of the core degradation period for accidents in mid-loop were in the intermediate to low pressure range. Attributes A and B are therefore not used.

Case 1: This case defines the conditions for Attribute A, SSPr. The RCS is at system setpoint pressure, about 2500 psia, when the vessel fails. This attribute is not applicable to this analysis.

Case 2: This case defines the conditions for Attribute B, HiPr. The RCS is in the range denoted high pressure, 1000 to 2000 psia, when the vessel fails. This attribute is not applicable to this analysis.

Case 3: This case defines the conditions for Attribute C, ImPr. The RCS is in the range denoted intermediate pressure, 500 to 1000 psia, when the vessel fails.

Case 4: This case defines the conditions for Attribute D, LoPr. The RCS is at low pressure, less than 500 psia, when the vessel fails.

Characteristic 5. VB-Mode (Mode of Vessel Breach)
6 Attributes, 6 Cases

The attributes for this characteristic are:

A. VB-HPME Vessel breach occurs when one or more penetration(s) fails and the vessel is above 500 psia. These conditions ensure High Pressure Melt Ejection.

B. VB-Pour Molten core material Pours out of the vessel at breach, driven primarily by the effects of gravity.

C. VB-BtmHd Either there is a circumferential failure of the Bottom Head, or a large portion of the Bottom Head of the vessel fails.

D. Alpha An Alpha mode failure occurs - resulting in containment failure as well as vessel failure.

E. Rocket A Rocket mode failure occurs - resulting in containment failure as well as vessel failure.

F. No-VB No Vessel Breach occurs.

This characteristic determines the mode of vessel failure. The mode of vessel failure and the pressure in the reactor coolant system just before the failure of the vessel, Characteristic 4, largely determine the events that

Appendix B Supporting Information for the Accident Progression Analysis

take place in the containment immediately following vessel breach. In two of the failure modes, the failure of the vessel directly causes the failure of the containment as well.

- Case 1: This case defines the conditions for Attribute A, VB-HPME. High Pressure Melt Ejection results when one or more penetration(s) fails and the vessel is in the intermediate to high pressure range.
- Case 2: This case defines the conditions for Attribute B, VB-Pour. The molten core Pours out of the vessel, driven primarily by the effects of gravity. This mode of vessel failure always occurs if the vessel is at low pressure when it fails. It can also occur when the vessel is at higher pressures if the gases in the vessel escape before an appreciable amount of molten core material leaves the vessel.
- Case 3: This case defines the conditions for Attribute C, VB-BtmHd. The vessel failure involves a substantial part of the Bottom Head.
- Case 4: This case defines the conditions for Attribute D, Alpha. Alpha mode failure is defined to be a steam explosion in the vessel that fails the vessel and also results in containment failure.
- Case 5: This case defines the conditions for Attribute E, Rocket. If the bottom head of the vessel fails and the vessel is at very high pressure, it is conceivable that the entire vessel could be propelled upward and somehow fail the containment. This mode of failure is not applicable in this analysis since it requires a high vessel pressure which is not possible for accidents during mid-loop operation.
- Case 6: This case defines the conditions for Attribute F, No-VB. Core damage was arrested before vessel breach.

Characteristic 6. SGTR (Steam Generator Tube Rupture)
3 Attributes, 3 Cases

Steam generator tube ruptures are not identified in the Level 1 analysis so that the attribute for this characteristic is always "No-SGTR." This characteristic is included only to match the SRS code requirement.

Characteristic 7. Amt-CCI (Amount of Core not in HPME available for CCI)
4 Attributes, 4 Cases

The attributes for this characteristic are:

- A. Lrg-CCI A Large amount of the Core (70-100%) not in HPME participates in the Core-Concrete Interaction.
- B. Med-CCI A Medium amount of the Core (30-70%) not in HPME participates in the Core-Concrete Interaction.

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C. Sml-CCI	A Small amount of the Core (0-30%) not in HPME participates in the Core-Concrete Interaction.
D. No-CCI	There is no Core-Concrete Interaction.

This characteristic determines how much of the core that is not in HPME participates in the core-concrete interaction. Whether the CCI occurs at all, and the timing and the conditions of the CCI, are determined in Characteristic3. The selection of one of the first three attributes in this characteristic implies that CCI occurs. This characteristic was used in determining the amount of hydrogen produced during CCI and the likelihood of basemat melt-through. The primary use of this binning characteristic is to pass information on to SURSOR for the source term analysis.

- Case 1: This case defines the conditions for Attribute C, Sml-CCI. A Small amount of the Core (0-30%) was determined to be available for CCI in the APET.
- Case 2: This case defines the conditions for Attribute D, No-CCI. If there is no VB, or there is no prompt CCI and no delayed CCI, there is no Core-Concrete Interaction.
- Case 3: This case defines the conditions for Attribute B, Med-CCI. A Medium amount of the Core (30-70%) was determined to be available for CCI in the APET.
- Case 4: This case defines the conditions for Attribute A, Lrg-CCI. Either a Large amount of the Core (70-100%) was determined to be available for CCI in the APET, or HPME occurred. Setting Characteristic 7 to Large here ensures that a large fraction of the core not involved in HPME is available for CCI. HPME is meant to include all the events in which core material leaves the vessel first under high gas pressure, followed by blowdown of the gas. The PrEj case in the APET includes only those cases where the hole in the vessel involves only a small fraction of the area of the bottom head. Thus the situation where the bottom head fails at any pressure above a few hundred psia has to be specifically included.

Characteristic 8. Zr-Ox (Zr Oxidation in-vessel)
2 Attributes, 2 Cases

The attribute for this characteristics are:

A. Lo-ZrOx	A low amount of the core Zirconium was oxidized in the vessel before VB. This implies a range from 0 to 40% oxidizes, with a nominal value of 25%.
B. Hi-ZrOx	A high amount of the core Zirconium was oxidized in the vessel before VB. This implies that more than 40% of Zr oxidized, with a nominal value of 25%.

This characteristic is considered to be not important for this analysis and is included only to match the SURSOR code requirement. Attribute B (Hi-ZrOx) is taken for all cases.

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Characteristic 9. HPME (High Pressure Melt Ejection) 4 Attributes, 4 Cases

The attributes for this characteristic are:

- A. Hi-HPME A High fraction ($> 40\%$) of the core was ejected under pressure from the vessel at failure.
- B. Md-HPME A Moderate fraction (20 to 40%) of the core was ejected under pressure from the vessel at failure.
- C. Lo-HPME A High fraction ($< 20\%$) of the core was ejected under pressure from the vessel at failure.
- D. No-HPME There was no HPME at vessel failure.

This characteristic determines how much of the core participated in high pressure melt ejection.

- Case 1: This case defines the conditions for attribute A, Hi-HPME. Since this case requires a high vessel pressure at vessel failure, it is not applicable to this study.
- Case 2: This case defines the conditions for attribute B, Md-HPME. This case occurs when vessel fails at intermediate pressure with moderate amount of core melt ejection.
- Case 3: This case defines the conditions for attribute C, Lo-HPME. This case occurs when vessel fails at intermediate pressure with low amount of core melt ejection.
- Case 4: This case defines the conditions for attribute D, No-HPME. There was no HPME at vessel failure. This case includes the Pour mode of vessel failure, bottom head failure at low pressure, Alpha mode failures.

Characteristic 10. CF-Size (Containment Failure Size or Type) 4 Attributes, 4 Cases

The attributes for this characteristic are:

- A. Cat-Rupt The containment failed by catastrophic rupture, resulting in a very large hole and gross structural failure.
- B. Rupture The containment failed by the development of a large hole or rupture; nominal hole size is 7 square feet.
- C. Leak The containment failed by the development of a small hole or a leak; nominal hole size is 0.10 square foot.
- D. No-CF The containment did not fail.

Appendix B Supporting Information for the Accident Progression Analysis

This characteristic determines how the containment failed. The first three attributes define the hole size if the containment pressure boundary failed above ground. The fourth attribute indicates that the pressure boundary did not fail.

- Case 1: This case defines the conditions for Attribute A, Cat-Rupt. The containment failed by catastrophic rupture or major structural failure. This can occur at vessel breach or due to a hydrogen burn after VB.
- Case 2: This case defines the conditions for Attribute B, Rupture. The containment failed by the development of a large hole. This case includes the failure to isolate the containment initially at the beginning of the accident.
- Case 3: This case defines the conditions for Attribute C, Leak. The containment failed by the development of a small hole, denoted a leak in this analysis. This case includes situations where operators successfully isolated the containment at the beginning of the accident, but the some temporary barrier failed.
- Case 4: This case defines the conditions for Attribute D, No-CF. The containment did not fail above ground or below ground, and it was not bypassed.

Characteristic 11. RCS-Hole (Number of large holes in the RCS) 2 Attributes, 2 Cases

The attributes for this characteristic are:

- A. 1-Hole There is only One large Hole in the RCS following VB, so there is no effective natural circulation through the vessel after breach.
- B. 2-Hole There are two large Holes in the RCS following VB, so there will be effective natural circulation through the vessel after breach.

This characteristic is considered to be not important for this analysis and is included only to match the SURSOR code requirement. Attribute A (1-Hole) is taken for all cases.

Characteristic 12. Time Window 4 Attribute, 4 Cases

The attributes for this characteristic are:

- A. Win-1 The core damage accident was initiated in Time Window 1.
- B. Win-2 The core damage accident was initiated in Time Window 2.
- C. Win-3 The core damage accident was initiated in Time Window 3.
- D. Win-4 The core damage accident was initiated in Time Window 4.

This characteristic is solely determined by the first characteristic of PDS.

B.4 Listing of the Binner for the Surry Shutdown Risk Study

Surry LP Binning - Rev. 1 - Sep 23, 93 - 11 Characteristics - PDSG-?

12 CF-Time Sprays CCI RCS-Pres VB-Mode SGTR Amt-CCI		Zr-Ox HPME CF-Size RCS-Hole WINDOW				
7	7	V-Dry	V-Wet	Early-CF	CF-at-VB	L/VLate-CF Final-CF No-CF
1	7	40				
		6				
		noCF				
1	1	30				
		2				
		zero				
1	2	30				
		2				
		zero				
2	3	40		40		
		1 +		2		
		Leak-I or		Rupt-I		
1	4	40				
		3				
		Rupt-VB				
2	5	40		40		
		4 +		5		
		Rupt-L		Rupt-VL		
1	6	30				
		2				
		zero				
8	8	Sp-Early	Sp-E+I	Sp-E+I+L	SpAlways	Sp-Late Sp-L+VL
		Sp-VL	Sp-Never			
3	1	18		28		36
		1	*	-1 *		-1
		E-Sp	&	noLSP &		noL2Sp
1	2	30				
		2				
		zero				
3	3	18		28		36
		1	*	1 *		-1
		E-Sp	&	LSp &		noL2Sp
3	4	18		28		36
		1	*	1 *		1
		E-Sp	&	LSp &		L2SP
3	5	18		28		36
		-1	*	1 *		-1
		noE-Sp	&	LSp &		noL2SP
3	6	18		28		36
		-1	*	1 *		1
		noE-SP	&	LSP &		L2SP
3	7	18		28		36
		-1	*	-1 *		1
		noE-SP	&	noL-SP	&	L2-SP
1	8	36				
		2				
		No-L2SP				
6	6	Prompt-Dry	PromptShlw	No-CCI	PromptDeep	SDlyd-Dry LDlyd-Dry
2	1	33	19			

Appendix B Supporting Information for the Accident Progression Analysis

		1	*	2					
		PrmptCCI		RC-Dry					
1	2	30							
		2							
		zero							
2	3	33		37					
		2	*	2					
		noPrmCCI	&	noDldCCI					
2	4	33		19					
		1	*	1					
		PrmptCCI	&	RC-Wet					
1	6	30							
		2							
		zero							
1	5	37							
		1							
		DelydCCI							
4	4	SSPr	HiPr	ImPr	LoPr				
1	1	30							
		2							
		zero/I-SSPr							
1	2	30							
		2							
		zero/I-HiPr							
1	3	15							
		1							
		I-ImPr							
1	4	15							
		2							
		I-LoPr							
6	6	VB-HPME	VB-Pour	VB-BtmHd	Alpha	Rocket	No-VB		
1	1	17							
		1							
		PrEj							
1	2	17							
		2							
		Pour							
1	3	17							
		3							
		BtmHd							
1	4	17							
		5							
		Alpha							
1	5	30							
		2							
		zero/Rocket							
1	6	17							
		4							
		noVB							
3	3	SGTR	SGTR-SRVO	No-SGTR					
1	1	30							
		2							
		zero/B-SGTR							
1	2	30							
		2							
		zero/B-SGTR							

Appendix B Supporting Information for the Accident Progression Analysis

1	3	30			
		1			
		one/noB-SGTR			
4	4	Lrg-CCI	Med-CCI	Sml-CCI	No-CCI
1	3	30			
		2			
		zero			
3	4	17		33	37
		4	+	(2	* 2)
		NO-VB	or	(NoPrmCCI	& noDldCCI)
3	2	17		17	17
		5	+	1	+
		ALPHA	or	PrEj	or BtmHd
1	1	17			
		2			
		pour			
2	2	Lo-ZrOx	Hi-ZrOx		
1	1	30			
		2			
		zero			
1	2	30			
		1			
		one			
4	4	Hi-HPME	Md-HPME	Lo-HPME	No-HPME
1	1	30			
		2			
		zero			
2	2	17		17	
		1	+	3	
		PrEj	or	BtmHd	
1	3	30			
		2			
		zero			
3	4	17		17	17
		2	+	4	+
		Pour	or	noVB	or ALPHA
4	4	Cat-Rupt	Rupture	Leak	No-CF
3	1	40		40	40
		3	+	4	+
		Rupt-VB	or	Rupt-L	or Rupt-L2
1	2	40			
		2			
		Rupt-I			
1	3	40			
		1			
		Leak-I			
1	4	40			
		6			
		noCF			
2	2	1-Hole	2-Holes		
1	1	30			
		1			
		one			
1	2	30			
		2			
		zero			

Appendix B Supporting Information for the Accident Progression Analysis

		WIN1	WIN2	WIN3	WIN4
4	4	WIN1			
1	1	1			
		1			
		WIN-1			
1	2	1			
		2			
		WIN-2			
1	3	1			
		3			
		WIN-3			
1	4	1			
		4			
		WIN-4			

APPENDIX C

SUPPORTING INFORMATION FOR THE SOURCE TERM ANALYSIS

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APPENDIX C SOURCE TERM ANALYSIS

C.1 Introduction

Source term estimation for mid-loop operation at Surry was first investigated in the abridged study ^{C1,C2}. It was decided in the abridged study that the source terms should address uncertainty and, wherever possible, the NUREG-1150 approach would be used to calculate the source terms from an accident during mid-loop operation. The parametric code, SURSOR^{C3}, that was developed in NUREG-1150^{C4} for Surry, was used to define the source terms in the abridged study. Two measures were taken to assure the adequacy of the source terms: The first involved comparing the calculations from MELCOR with the data used in and the results obtained from SURSOR. Second, the Source Term Advisory Group was established to provide guidance, and any additional information on modifying the SURSOR code for the study of mid-loop operation.

Based on the results of the previous abridged study, the SURSOR code was used in the present study to predict the source terms for the accident progression bins obtained in the accident progression (Level 2) analysis. Since it is not practical to perform consequence calculations for all the source terms obtained in the present analysis (about 15,000), the source terms were partitioned (grouped according to their potential health effects). This partitioning process reduces the number of consequence code calculations required for calculating risk. The methods used for source term definition and partitioning are described in the following sections. Some of the source term calculational results are also provided in this Appendix for information.

C.2 Source Term Definition

C.2.1 Description of Parametric Model

The SURSOR code, along with its associated distributions from the NUREG-1150 study, was selected as the basis for source term estimation. This section provides a brief discussion of the SURSOR code, its evaluation (or modification, if required), and the final parametric model used.

SURSOR is a parametric computer code used in NUREG-1150 to predict source terms for full power operation. Table C.1 lists the parameters used in the SURSOR code, whose values were obtained in NUREG-1150 by expert elicitation. A distribution, instead of a single value, was assigned to each parameter to address uncertainty. It was assumed that the distributions for the parameters developed in the NUREG-1150 study could, in most cases, also be used in this study.¹ This assumption was based on guidance provided by an internal Source Term Advisory Group to provide guidance on the use of existing methods and data, to review the source term issues being treated and to identify any new issues that may be important to shutdown accidents. Guidance provided by this group was factored into this study. Guidance provided by the review

¹ Here we are discussing the parameters that are used to determine the fraction of the inventory at the start of the accident that is released to the environment. By using the same parameters it is implied that for a similar accident, the release fractions for a full power accident and a shutdown accident will be the same. While the release fractions may be the same, the amount of radioactive material released to the environment will not be the same because of the differences in the radioactive inventories at the start of the accident.

Appendix C Source Term Analysis

group did not indicate that there was anything fundamentally different with these shutdown accidents, as compared to full power accidents, that would make the parametric approach unacceptable for its intended use. Based on a review of the expected accidents and their associated phenomena as well as results from MELCOR calculations performed for these shutdown accidents, the review group guidance also suggested that it would be acceptable to use the source term parameters developed in the NUREG-1150 as a starting point for this study considering the large uncertainties already reflected by the distributions and the objectives of the study. This guidance is supported by a comparison of selected results from a series of MELCOR calculations of shutdown accidents with the NUREG-1150 full power source term distributions which suggested that the two sets of information were in qualitative agreement. In most cases, the results from the MELCOR calculations fell within the large uncertainty bands of the NUREG-1150 source term distributions. While it was suggested that the NUREG-1150 distributions could be used as a starting point, the guidance also warned that the distributions should be modified or new distributions should be added when the plant configuration or other characteristics of the accident were sufficiently different from the full power conditions that different initial conditions or phenomena would be introduced. The release fractions and source terms predicted by MELCOR were generally not used directly in this analysis because the models and data used in MELCOR present one view of a severe accident; alternative and conflicting views also exist. The distributions from NUREG-1150 are based on results from formal expert judgement elicitations that consider and account for these alternative views.

A review by the project staff of the POS 6 and POS 10 accidents indicated that the plant configuration and accident conditions associated with these accidents were sufficiently similar to the full power accidents that modifications to the NUREG-1150 distributions would not be necessary. Many of the source term parameters defined in the NUREG-1150 study depended on conditions in the containment and/or core and were not necessarily tied to specific accident sequences (e.g., FCOR depends on the amount of zirconium oxidized in the core).

C.2.2 Source Term Results

In the present study, the SURSOR code was used to predict the source terms for all the APBs in each of the 100 observations. There are about 150 APBs in each observation. Although the total number of APBs (for the 100 observations) and thus the total number of source terms is 15,443, the number of APBs with different characteristics is only 360. Since the same APBs (i.e., APBs with the same characteristics) occur in different observations, the release fractions associated with the APBs in different observations are different because the LHS values vary from observation to observation. Table C.3 lists the 360 unique APBs, their characteristics (represented by their attribute strings), the frequency weighted mean release fractions (of the 100 observations) for the nine radionuclide groups, and their mean frequencies. The exceedance frequencies for the release fractions of the iodine, cesium, tellurium, and lanthanum radionuclide groups are presented in Figures C.1(a), C.1(b), C.1(c), and C.1(d), respectively.

C.3 Source Term Partition

The accident progression and source term analyses resulted in a total of 15,443 source terms for internally initiated accidents during mid-loop operation. It is computationally impractical to carry out a consequence calculation for each source term to obtain the integrated risk for the selected consequence measures. To create an interface between the source term analysis and the consequence calculation, the total number of

source terms are grouped into a much smaller number of source term groups. The groups are created such that the source terms within each group have similar properties with respect to consequences, i.e., their potential for causing early fatalities and latent cancer fatalities is similar. A frequency weighted mean source term is determined for each group and the consequence calculations are performed for the mean source term in four time windows.

The four core radionuclide inventories which were used in the partitioning consequence calculations for each of the four time windows are shown in Table C.4. These inventories were obtained by interpolation from the data published in Reference C5 on the core inventories at Surry as a function of time after reactor shutdown.

The partitioning procedures described below consist of defining an early health effect weight, EH, and a latent health effect weight, LH, for each source term and grouping the source terms based on these weights.

C.3.1 Calculation of Early Fatality Health Weight, EH

The early health effect weight was calculated by converting the radionuclide releases associated with the range of source terms into equivalent I-131 releases. Surry site-specific consequence calculations of the early health effects were performed in each of the time windows used in the analysis and the results were presented as a function of equivalent I-131 release. This correlation of the estimated number of early health effects is the EH weight which was used in partitioning of all source terms.

The relationship between the early health effect weight and the equivalent I-131 release is shown in Figure C.2. This relationship was produced by following the methodology used in the PARTITION code, References C.6 and C.7. Table C.5 shows the equivalent I-131 inventories in four time windows for a range of source terms used to predict the EH weight.

Using the data displayed in Figure C.2 for the early health effects, 213 source terms with $EH > 0$ and $LH > 0$ were identified and grouped into four cells as discussed in section C.3.3 below.

C.3.2 Calculation of Latent Cancer Fatality Health Weight, LH

The latent health effect weight, LH, was calculated by assuming a linear relationship between the number of latent cancer fatalities due to a particular radionuclide and the amount of release of that radionuclide.

The average release fractions for the nine radionuclide groups (averaged over all 15,433 source terms generated by SURSOR) were used in the LH weight calculations. Thirty six consequence calculations were performed, nine for each of the four time windows. Each of the nine calculations was run with only one of the nine radionuclide groups present in the source term while the release fractions of the remaining eight groups were set to zero. The results of the thirty six calculations for number of latent health effects are presented in Table C.6 ($LH_{i,w}$ where $i = 1,9$ is the number of radionuclide groups and $w = 1,4$ is the number of time windows). The last column in Table C.6 contains the release fractions of the nine radionuclide groups averaged over all 15,433 source terms, RF_i^a .

The four corresponding values of latent health effects (LH) predicted by using the complete source terms ("complete" in the present context means that all radionuclide groups are non-zero) for four windows are

Appendix C Source Term Analysis

(LH_w^s): 6.79E+02, 6.56E+02, 6.36E+02, and 6.25E+02, respectively. Summation of $LH_{i,w}$ over nine groups for four windows in Table C.6 produces LH_w^s for four windows (superscript "s" stands for "separate", i.e., calculation with only one non-zero radionuclide group): 9.61E+02, 9.19E+02, 8.78E+02, and 8.17E+02, respectively. An adjustment factor AF_w is calculated as LH_w^s/LH_w^e (7.07E-01, 7.14E-01, 7.24E-01, and 7.65E-01) to be used in the final steps of the partitioning procedure.

The adjustment factor AF_w is needed to take into account the effects of the counter-measures: population is relocated based on the projected individual dose level. These dose projections are made using the combined effect of all radionuclide groups. Therefore, the collective dose (and latent health effects) predicted for a "complete" source term will be lower than a sum of doses predicted in "separate" radionuclide group calculations because of a more extensive relocation of the population.

In addition, in order to account for the dependency of the health consequences on the decay of the core inventory, a window factor, WF_w , defined as a ratio of the inventory of a particular radionuclide group in any window to its corresponding inventory in window 1, was also calculated. It is shown in Table C.7.

Using the information presented in Tables C.6 and C.7, the number of latent health effects for all 15,443 source terms (i.e., $LH_{j,w}$, where $j = 1$ to 15,443) can be estimated using the following correlation:

$$LH_{j,w} = \sum_i^9 \left[\frac{LH_{i1}}{RF_i^a} \right] \times RF_i \times WF_{i,w} \times AF_w$$

where RF_i is the release fraction of the radionuclide group i and LH_{i1} is the corresponding latent health effect corresponding to the average source term RF_i^a for the same radionuclide group i . Use of the window factor, $WF_{i,w}$ is based on the assumption that the number of latent health effects is proportional to the magnitude of release.

Finally, 15,230 source terms with $LH > 0$ and $EH = 0$ were grouped into twenty one cells assuming a Max/Min ratio of 1.5 for each cell as discussed in section C.3.3 below.

C.3.3 Results of Source Terms Partitioning

Using the data displayed in Figure C.2 for early fatalities and the correlation of section C.3.2 between the release fractions and time windows and the number of latent health effects, values of EHs and LHs for all 15,443 source terms were calculated and the source terms subdivided into three groups with the following population:

- a) $EH > 0$ and $LH > 0$ (213 source terms or 1.3% of the total number),
- b) $EH = 0$ and $LH > 0$ (15,230 source terms, 98.7% of the total number), and
- c) $EH = 0$, $LH = 0$ (no source terms).

Each of the above categories was treated separately for partitioning.

The logarithms of minimum and maximum predictions for the early and latent fatalities for group (a) are as follows:

$$\text{Log}_{10}(\text{Min EH}) = -2.0; \text{Log}_{10}(\text{Max EH}) = 0.6,$$

$$\text{Log}_{10}(\text{Min LH}) = 3.6; \text{Log}_{10}(\text{Max LH}) = 4.3.$$

The logarithms of minimum and maximum predictions for the latent fatalities for group (b) are as follows:

$$\text{Log}_{10}(\text{Min LH}) = -0.9; \text{Log}_{10}(\text{Max LH}) = 3.5.$$

Group (a) In the process of partitioning for the latent fatalities, all source terms in group (a) were placed into four groups defined such that the ratio of the maximum LH to minimum LH within the same group was 1.5. Similar ratio for the four groups used to partition source terms based on the number of the early health effects was 10. Partitioning of the source terms was performed in two steps. First, the source terms were assigned to the corresponding cells according to the health effect weights. Results of this preliminary partitioning for group (a) are shown in Table C.8.

Secondly, based on the number of source terms in each cell, the source terms were combined with adjacent cells carrying the higher number of source terms. Results of this final partitioning for group (a) are shown in Table C.9.

Group (b) The one dimensional partitioning of the source terms in group (b) which contains source terms with zero early health effects and non-zero latent health effects is shown in Table C.10.

As a result of partitioning, 25 source term groups were formed for further consequence calculations. A frequency weighted mean source term was then calculated by frequency averaging the source terms in each of these 25 partition groups. The resulting 25 mean source terms are shown in Table C.11.

C.4 References

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- C4. "Severe Accident Risks: An Assessment for Five U. S. Nuclear Power Plants, Final Summary Report" NUREG-1150, U. S. Nuclear Regulatory Commission (USNRC), December 1990.
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- C7. R. L. Iman, et al., "PARTITION: A Program for Defining the Source Term/Consequence Analysis Interface in the NUREG-1150 Probabilistic Risk Assessments, User's Guide," Sandia National Laboratories, NUREG/CR-5253, May 1990.

C.1(a) Exceedance Frequencies for Release Fractions of Iodine Group

C.1(b) Exceedance Frequencies for Release Fractions of Cesium Group

C.1(c) Exceedance Frequencies for Release Fractions of Tellurium Group

C.1(d) Exceedance Frequencies for Release Fractions of Lanthanum Group

Figure C.2 Prediction of Early Fatalities vs. Equivalent I-131 Release

Table C.1 Parameters Used in the SRSOR Code

FCOR	Fraction of the radionuclide in the core released to the vessel before or at vessel breach (VB)
FVES	Fraction of the radionuclide released from the vessel to the containment before or at VB
VDF	Decontamination factor for pool scrubbing for Event V (not used)
FCONV	Fraction of the radionuclide in the containment from RCS release that is released from the containment in the absence of any mitigating effects
FCCI	Fraction release of radionuclide from corium during CCI
FCONC	Containment transport fraction for ex-vessel release
SPRDF	Decontamination factor for containment sprays
LATEI	Fraction of the iodine deposited in the containment which is revolatalized and released to the environment late in the accident
FLATE	Fractional release of material deposited in the RCS due to revaporization
DST	Fraction of core radionuclide released to the containment due to DCH at VB
FISGFOSG	Fraction of radionuclide released from the RCS to the steam generator, and from the steam generator to the environment (not used)
POOL-DF	Decontamination factor for a pool of water overlying the core debris during CCI

Table C.2 APB Characteristics

Characteristic 1 — Containment Failure Time

A	V-Dry	Event V, Not used for mid-loop
B	V-Wet	Event V, Not used for mid-loop
C	Early-CF	Containment Failure before VB
D	CF-at-VB	Containment Failure at VB
E	VLate-CF	Late or Very Late Containment Failure (used for hydrogen combustion failure in mid-loop study)
F	Final-CF	Containment Failure in the Final Period (not used)
G	No-CF	No Containment Failure

Characteristic — Sprays

A	Sp-Early	The sprays operate only in the Early period
B	Sp-E+I	The sprays operate only in the Early and Intermediate periods
C	Sp-E+I+L	The sprays operate only in the Early, Intermediate, and Late periods
D	Sp-Always	The sprays Always operate during the periods of interest for fission product removal.
E	Sp-Late	The sprays operate only in the Late period.
F	Sp-L+VL	The sprays operate only in the Late and Very Late periods.
G	Sp-VL	The sprays operate only in the Very Late period.
H	Sp-NonOp	The sprays Never operate during the accident, or operate only during the Final period, which is not of interest for fission product removal.

Characteristic 3 — Core-Concrete Interactions

A	Prmpt-Dry	CCI takes place promptly following VB. There is no overlying water pool to scrub the releases.
B	PrmptShlw	CCI takes place promptly following VB. There is a shallow (about 4.5 ft) overlying water pool to scrub the releases.
C	No-CCI	CCI does not take place.
D	PrmptDeep	CCI takes place promptly following VB. There is a deep (about 14 ft) overlying water pool to scrub the releases.
E	Sdlyd-Dry	CCI takes place after a short delay. The debris bed is coolable, but the water in the cavity is not replenished. The delay is the time needed to boil off the accumulator water.
F	LDlyd-Dry	CCI takes place after a long delay. The debris bed is coolable, but the water in the cavity is not replenished. The delay is the time needed to boil off the water in a full cavity.

Characteristic 4 — RCS Pressure Before Vessel Breach

A	SSPr	System Setpoint Pressure (2500 psia) - Not used.
B	HiPr	High Pressure (1000 to 2000 psia) - Not used.
C	ImPr	Intermediate Pressure (200 to 1000 psia)
D	LoPr	Low Pressure (less than 200 psia)

Table C.2 (continued)

Characteristic 5 — Mode of Vessel Breach

A	VB-HPME	HPME occurs - direct heating always occurs to some extent.
B	VB-Pour	The molten core Pours out of the vessel, driven primarily by the effects of gravity.
C	VB-BtmHd	Gross failure of a large portion of the Bottom Head of the vessel occurs, perhaps as a result of a circumferential failure.
D	Alpha	An Alpha mode failure occurs resulting in containment failure as well as vessel failure.
E	Rocket	A Rocket mode failure occurs resulting in containment failure as well as vessel failure (not used).
F	No-VB	No Vessel Breach occurs

Characteristic 6 — Steam Generator Tube Rupture (the attribute of this characteristic was always C)

A	SGTR	A SGTR occurs. The SRVs on the secondary system are not stuck open - not used.
B	SGTR-SRVO	A SGTR occurs. The SRVs on the secondary system are stuck open - not used.
C	No-SGRT	A SGTR does not occur.

Characteristic 7 — Amount of Core not in HPME available for CCI (Rebinned)

A	Lrg-CCI	A CCI occurs and involves a Large Amount of the Core (70-100%).
B	Med-CCI	A CCI occurs and involves a Medium Amount of the Core (30-70%).
C	Sml-CCI	A CCI occurs and involves a Small Amount of the Core (0-30%).
D	No-CCI	No CCI occurs.

Characteristic 8 — Zirconium Oxidation

A	Lo-ZrOx	A Low amount of the core Zirconium was Oxidized in the vessel prior to vessel breach. This implies a range from 0 to 40% oxidized, with a nominal value of 25%.
B	Hi-ZrOx	A High amount of the core Zirconium was Oxidized in the vessel before VB. This implies that more than 40% of the zirconium was oxidized, with a nominal value of 65%.

Characteristic 9 — High Pressure Melt Ejection (HPME)

A	Hi-HPME	A High fraction (> 40%) of the core was ejected under pressure from the vessel at failure.
B	Md-HPME	A Moderate fraction (10 to 40%) of the core was ejected under pressure from the vessel at failure.
C	Lo-HPME	A Low fraction (< 10%) of the core was ejected under pressure from the vessel at failure.
D	No-HPME	There was no HPME at vessel failure.

Characteristic 10 — Containment Failure Size

A	Cat-Rupt	The containment failed by catastrophic rupture, resulting in a very large hole and gross structural failure.
B	Rupture	The containment failed by the development of a large hole or rupture; nominal hole size is 7 ft ² .
C	Leak	The containment failed by the development of a leak (nominal size 0.1 ft ²).
D	No-CF	The containment did not fail. It may have been bypassed.

Table C.2 (continued)

Characteristic 11 — Holes in the RCS

A	1-Hole	There is only One large Hole in the RCS following vessel breach, so there is no effective natural circulation through the RCS after breach.
B	2-Holes	There are Two large Holes in the RCS following vessel breach, so there will be effective natural circulation through the RCS after breach.

Characteristic 12 — Time Window

A	Win-1	Accident occurs in Time Window 1
B	Win-2	Accident occurs in Time Window 2
C	Win-3	Accident occurs in Time Window 3
D	Win-4	Accident occurs in Time Window 4

A typical bin might be GHEDBCABDDAA (the leading bin contributing to Window 1) which, using the information given above, is:

G	No-CF	No Containment Failure
H	Sp-NonOp	Sprays do not operate
E	SDlyd-Dry	CCI occurs. Water is not replenished
D	LoPr	Primary system is at low pressure
B	VB-Poor	Core material pours out of vessel
C	No-SGTR	A SGTR does not occur
A	Lrg-CCI	Large amount of core involved in CCI
B	Hi-ZrOx	Large zirconium oxidation in vessel
D	No-HPME	No high pressure melt ejection at vessel failure
D	No-CF	Containment did not fail
A	1-Hole	One hole in vessel following vessel breach by core debris
A	Win-1	Accident occurs in time Window 1

Table C.3 Frequency-Weighted Release Fractions and Frequencies

1	CHADBCABDBAB	1.000E+00	4.310E-01	3.884E-01	2.167E-01	6.362E-02	6.039E-03	7.747E-03	1.149E-02	5.585E-02	4.174E-07
2	CHADBCABDBAC	1.000E+00	4.128E-01	3.649E-01	2.232E-01	7.863E-02	6.400E-03	9.742E-03	1.348E-02	6.780E-02	2.994E-07
3	CDCDFCDBDBAB	8.433E-01	1.407E-01	1.136E-01	5.439E-02	1.392E-02	2.890E-03	8.251E-04	3.671E-03	1.484E-02	2.785E-07
4	CHCDFCDBDBAB	8.352E-01	1.334E-01	1.091E-01	4.728E-02	7.374E-03	1.965E-03	4.435E-04	2.038E-03	8.273E-03	2.280E-07
5	CDCDFCDBDBAC	8.122E-01	1.186E-01	8.812E-02	4.487E-02	1.519E-02	2.874E-03	8.964E-04	3.953E-03	1.600E-02	2.165E-07
6	GHEDBCABDDAA	5.000E-03	1.330E-04	6.603E-07	3.889E-07	1.400E-07	1.050E-08	1.562E-08	2.077E-08	1.175E-07	1.959E-07
7	CHCDFCDBDBAC	8.099E-01	1.144E-01	8.780E-02	3.851E-02	7.339E-03	1.790E-03	4.282E-04	1.888E-03	8.150E-03	1.741E-07
8	CHADBCABDBAA	1.000E+00	5.015E-01	4.621E-01	2.631E-01	6.994E-02	7.239E-03	8.911E-03	1.245E-02	6.410E-02	1.595E-07
9	CGADBCABDBAB	1.000E+00	4.319E-01	3.849E-01	2.072E-01	7.240E-02	6.794E-03	8.520E-03	1.391E-02	6.372E-02	1.580E-07
10	GDCDBCDBDDAA	5.000E-03	9.194E-05	2.754E-09	1.472E-09	4.288E-10	8.350E-11	1.826E-11	7.210E-11	4.550E-10	1.484E-07
11	GHDDBCABDDAA	5.000E-03	1.327E-04	3.668E-07	2.067E-07	4.025E-08	9.186E-09	2.334E-09	7.632E-09	4.386E-08	1.448E-07
12	CDCDFCDBDBAA	8.244E-01	1.514E-01	1.281E-01	6.185E-02	1.093E-02	2.871E-03	5.880E-04	2.593E-03	1.228E-02	1.240E-07
13	GDDDBCABDDAA	5.000E-03	1.589E-04	3.685E-09	2.085E-09	6.088E-10	8.499E-11	4.091E-11	9.523E-11	5.813E-10	1.097E-07
14	CGADBCABDBAC	1.000E+00	4.157E-01	3.645E-01	2.078E-01	8.569E-02	6.916E-03	1.016E-02	1.574E-02	7.392E-02	1.090E-07
15	CHCDFCDBDBAA	8.543E-01	1.556E-01	1.380E-01	6.381E-02	9.515E-03	2.657E-03	5.294E-04	2.443E-03	1.081E-02	1.069E-07
16	CFADBCABDBAB	1.000E+00	4.335E-01	3.866E-01	2.099E-01	7.333E-02	6.926E-03	8.636E-03	1.414E-02	6.461E-02	1.058E-07
17	CFADBCABDBAC	1.000E+00	4.178E-01	3.657E-01	2.115E-01	8.768E-02	7.140E-03	1.040E-02	1.622E-02	7.576E-02	6.643E-08
18	GDCDFCDBDDAA	4.122E-03	4.994E-05	1.249E-09	6.411E-10	1.802E-10	3.583E-11	7.617E-12	2.963E-11	1.925E-10	6.250E-08
19	CGADBCABDBAA	1.000E+00	5.024E-01	4.626E-01	2.584E-01	7.959E-02	6.887E-03	9.255E-03	1.302E-02	6.948E-02	5.947E-08
20	GDCDFCDBDDAB	4.106E-03	4.407E-05	9.361E-10	4.273E-10	5.702E-11	1.650E-11	2.495E-12	9.185E-12	6.519E-11	5.818E-08
21	GHCDFCDBDDAA	4.075E-03	6.148E-05	2.292E-07	9.753E-08	9.855E-09	3.339E-09	4.605E-10	1.654E-09	1.190E-08	5.234E-08
22	CFADBCABDBAA	1.000E+00	5.069E-01	4.690E-01	2.647E-01	8.139E-02	7.085E-03	9.495E-03	1.328E-02	7.110E-02	5.118E-08
23	GHCDFCDBDDAB	3.972E-03	5.410E-05	1.977E-07	8.265E-08	8.523E-09	2.859E-09	4.253E-10	1.652E-09	1.028E-08	5.063E-08
24	CHADBCABDBAD	1.000E+00	5.149E-01	4.855E-01	2.020E-01	5.555E-02	6.260E-03	5.606E-03	1.483E-02	4.965E-02	5.026E-08
25	GHADBCABDDAB	5.000E-03	2.019E-04	7.505E-07	4.117E-07	7.400E-08	7.269E-09	6.816E-09	1.056E-08	6.303E-08	4.666E-08
26	GDCDBCDBDDAB	5.000E-03	6.374E-05	2.128E-09	1.217E-09	4.166E-10	7.851E-11	1.850E-11	7.662E-11	4.391E-10	4.191E-08
27	CDCDFCDBDDAD	7.881E-01	1.223E-01	8.641E-02	3.634E-02	1.100E-02	2.246E-03	8.266E-04	4.491E-03	1.168E-02	3.792E-08
28	GHADBCABDDAA	5.000E-03	1.535E-04	8.205E-07	3.689E-07	5.473E-08	6.945E-09	4.858E-09	7.129E-09	4.865E-08	3.695E-08
29	GDDDBCABDDAB	5.000E-03	1.460E-04	2.755E-09	1.580E-09	5.167E-10	7.929E-11	3.219E-11	9.052E-11	5.112E-10	3.096E-08
30	GHADBCABDDAD	5.000E-03	1.541E-04	6.680E-07	4.291E-07	1.264E-07	9.041E-09	1.348E-08	2.235E-08	1.046E-07	2.205E-08
31	GHEDBCABDDAB	5.000E-03	1.580E-04	6.771E-07	3.987E-07	1.016E-07	8.457E-09	1.172E-08	1.610E-08	8.779E-08	2.194E-08
32	CHCDFCDBDDAD	8.242E-01	1.474E-01	1.181E-01	5.610E-02	1.670E-02	3.682E-03	1.366E-03	7.948E-03	1.771E-02	2.138E-08
33	EFADBCABDAAA	1.000E+00	2.723E-02	9.914E-04	6.034E-04	2.375E-04	1.074E-05	3.227E-05	3.671E-05	1.811E-04	2.005E-08
34	CHEDBCABDCAA	1.000E+00	2.662E-01	2.292E-01	1.157E-01	3.909E-02	5.046E-03	4.340E-03	6.879E-03	3.739E-02	1.975E-08
35	GHADBCABDDAC	5.000E-03	1.567E-04	7.054E-07	4.003E-07	8.568E-08	8.461E-09	7.645E-09	1.217E-08	7.313E-08	1.941E-08
36	CGADBCABDBAD	1.000E+00	5.164E-01	4.905E-01	1.504E-01	4.385E-02	4.374E-03	4.590E-03	1.080E-02	3.902E-02	1.900E-08
37	GDCDFCDBDDAC	4.152E-03	4.318E-05	1.405E-09	7.582E-10	2.264E-10	4.498E-11	9.630E-12	3.754E-11	2.416E-10	1.774E-08
38	CDCDBCDBDCAA	1.000E+00	3.017E-02	1.137E-02	6.805E-03	2.638E-03	4.737E-04	1.116E-04	4.438E-04	2.765E-03	1.695E-08
39	GHDDBCABDDAB	5.000E-03	1.577E-04	3.604E-07	1.981E-07	3.065E-08	6.619E-09	2.581E-09	6.946E-09	3.244E-08	1.622E-08
40	GDCDFCDBDDAD	4.398E-03	4.556E-05	1.280E-09	6.287E-10	1.605E-10	3.295E-11	6.879E-12	2.706E-11	1.718E-10	1.548E-08
41	CHDDBCABDCAA	1.000E+00	1.921E-01	1.392E-01	7.758E-02	1.951E-02	4.053E-03	1.158E-03	3.726E-03	2.092E-02	1.460E-08
42	EGADBCABDAAA	1.000E+00	9.420E-02	7.201E-02	4.092E-02	5.399E-03	7.792E-04	4.693E-04	8.176E-04	5.009E-03	1.437E-08
43	GHCDFCDBDDAC	4.078E-03	4.091E-05	1.694E-07	8.107E-08	1.361E-08	3.762E-09	6.857E-10	2.703E-09	1.575E-08	1.418E-08
44	GDCDFCDBDDAD	3.982E-03	3.677E-05	1.339E-07	5.869E-08	1.408E-08	3.012E-09	8.546E-10	4.024E-09	1.527E-08	1.388E-08
45	CHDDBCABDCAA	1.000E+00	4.722E-02	1.441E-02	8.087E-03	3.269E-03	4.843E-04	2.102E-04	5.421E-04	3.210E-03	1.253E-08
46	EFADBCABDAAB	1.000E+00	3.493E-02	9.017E-04	6.967E-04	1.509E-04	7.240E-06	1.814E-05	1.876E-05	1.105E-04	9.497E-09
47	CFADBCABDBAD	1.000E+00	5.201E-01	4.957E-01	1.531E-01	4.557E-02	4.616E-03	4.794E-03	1.149E-02	4.071E-02	9.474E-09

Table C.3 (continued)

48	GGADBCABDDAB	5.000E-03	1.596E-04	3.639E-09	1.983E-09	5.274E-10	5.553E-11	4.938E-11	7.484E-11	4.612E-10	8.610E-09
49	CDCDFCDBDCAA	7.922E-01	1.450E-02	4.516E-03	2.662E-03	9.703E-04	1.792E-04	4.099E-05	1.612E-04	1.022E-03	7.703E-09
50	CDCDBCDBDBAB	1.000E+00	3.418E-01	2.736E-01	1.389E-01	4.756E-02	8.514E-03	2.724E-03	1.193E-02	4.952E-02	7.536E-09
51	CDCDFCDBDCAB	7.979E-01	1.163E-02	2.452E-03	1.153E-03	2.664E-04	5.680E-05	1.136E-05	4.405E-05	2.884E-04	7.102E-09
52	GGCDBCDBDDAA	5.000E-03	7.050E-05	1.879E-09	8.524E-10	1.284E-10	3.096E-11	5.530E-12	2.059E-11	1.441E-10	6.684E-09
53	EGADBCABDAAB	1.000E+00	7.786E-02	4.262E-02	2.859E-02	3.651E-03	3.816E-04	3.507E-04	4.863E-04	3.094E-03	6.622E-09
54	CDCFCDBDBBAA	8.193E-01	1.320E-01	1.137E-01	5.658E-02	1.127E-02	2.798E-03	6.793E-04	3.323E-03	1.240E-02	6.481E-09
55	CHACACBBBBAA	1.000E+00	3.938E-01	3.563E-01	1.647E-01	3.329E-02	7.338E-03	5.373E-03	5.979E-03	3.235E-02	6.393E-09
56	CHCDFCDBDCAA	7.602E-01	9.325E-02	7.160E-02	2.960E-02	4.206E-03	1.248E-03	2.005E-04	7.359E-04	4.997E-03	6.109E-09
57	CDCDBCDBDBAC	1.000E+00	3.090E-01	2.316E-01	1.254E-01	5.163E-02	8.680E-03	2.966E-03	1.301E-02	5.331E-02	6.085E-09
58	CHCDFCDBDCAB	7.534E-01	7.972E-02	5.865E-02	2.399E-02	3.356E-03	9.984E-04	1.713E-04	6.734E-04	3.993E-03	6.047E-09
59	CHCCFCDBDBAA	8.668E-01	1.496E-01	1.374E-01	6.302E-02	9.936E-03	2.638E-03	6.403E-04	3.335E-03	1.102E-02	5.752E-09
60	CHADBCABDCAB	1.000E+00	2.740E-01	2.278E-01	1.034E-01	1.950E-02	2.771E-03	1.855E-03	3.324E-03	1.817E-02	5.744E-09
61	CDCDBCDBDCAB	1.000E+00	2.035E-02	8.124E-03	5.165E-03	2.152E-03	3.854E-04	9.350E-05	3.821E-04	2.250E-03	5.673E-09
62	GFADBCABDDAB	5.000E-03	1.607E-04	3.656E-09	2.009E-09	5.377E-10	5.582E-11	5.083E-11	7.618E-11	4.690E-10	5.611E-09
63	DHECACBBBBAA	1.000E+00	4.018E-01	3.881E-01	1.686E-01	3.645E-02	1.822E-02	4.869E-03	7.092E-03	3.960E-02	5.572E-09
64	CDDDBCABDCAB	1.000E+00	3.621E-01	2.858E-01	1.508E-01	4.947E-02	8.599E-03	3.028E-03	1.224E-02	5.099E-02	5.566E-09
65	GGADBCABDDAD	5.000E-03	1.401E-04	4.051E-09	2.693E-09	9.892E-10	8.741E-11	8.136E-11	1.358E-10	8.398E-10	5.219E-09
66	EGDDBCABDAAA	1.000E+00	4.534E-02	1.508E-02	1.005E-02	1.633E-03	3.012E-04	9.543E-05	2.570E-04	1.681E-03	4.891E-09
67	CHADBCABDCAA	1.000E+00	3.763E-01	3.596E-01	1.157E-01	1.436E-02	2.640E-03	1.174E-03	2.182E-03	1.462E-02	4.873E-09
68	GGADBCABDDAC	5.000E-03	1.443E-04	3.976E-09	2.265E-09	6.089E-10	6.475E-11	5.224E-11	8.386E-11	5.305E-10	4.483E-09
69	CDDDBCABDBAC	1.000E+00	3.317E-01	2.462E-01	1.385E-01	5.421E-02	8.800E-03	3.325E-03	1.343E-02	5.529E-02	4.470E-09
70	GGCDBCDBDDAB	5.000E-03	3.995E-05	1.456E-09	7.294E-10	1.621E-10	3.430E-11	6.898E-12	2.661E-11	1.745E-10	4.341E-09
71	DDCCACDBBAAA	1.000E+00	1.061E-01	8.857E-02	3.200E-02	5.481E-03	1.003E-02	2.195E-03	2.232E-03	7.930E-03	4.308E-09
72	CDDDBCABDCAB	1.000E+00	4.066E-02	9.763E-03	5.975E-03	2.552E-03	3.896E-04	1.520E-04	4.412E-04	2.517E-03	4.182E-09
73	EFADBCABDAAC	1.000E+00	3.231E-02	1.364E-03	8.969E-04	2.948E-04	1.378E-05	3.911E-05	4.416E-05	2.226E-04	3.617E-09
74	CDCDBCDBDBAA	1.000E+00	3.393E-01	2.854E-01	1.282E-01	1.923E-02	5.015E-03	9.914E-04	4.153E-03	2.159E-02	3.532E-09
75	CHEDBCABDBAA	1.000E+00	4.889E-01	4.501E-01	3.005E-01	9.791E-02	8.326E-03	1.103E-02	1.562E-02	8.456E-02	3.514E-09
76	EFCDBCDBDAAA	1.000E+00	2.172E-02	7.518E-05	3.996E-05	2.836E-06	7.853E-07	1.288E-07	4.704E-07	3.246E-06	3.327E-09
77	CHADDCBDBBAB	1.000E+00	3.898E-01	3.174E-01	2.420E-01	1.406E-01	1.549E-02	1.239E-02	3.173E-02	1.295E-01	3.229E-09
78	EGDDBCABDAAB	1.000E+00	3.010E-02	1.104E-02	6.830E-03	1.345E-03	2.615E-04	6.819E-05	2.186E-04	1.409E-03	3.179E-09
79	GDCCFCDBDDAA	4.117E-03	4.568E-05	1.051E-09	5.478E-10	1.500E-10	2.965E-11	6.345E-12	2.474E-11	1.599E-10	3.165E-09
80	CHEDBCABDCAB	1.000E+00	2.391E-01	1.975E-01	1.050E-01	2.709E-02	3.544E-03	3.278E-03	4.879E-03	2.565E-02	2.926E-09
81	GHCCFCDBDDAA	4.155E-03	6.595E-05	1.986E-07	8.246E-08	7.450E-09	2.483E-09	3.480E-10	1.301E-09	8.850E-09	2.923E-09
82	GFADBCABDDAC	5.000E-03	1.433E-04	3.987E-09	2.294E-09	6.273E-10	6.571E-11	5.428E-11	8.642E-11	5.455E-10	2.684E-09
83	CFADBCABDCAA	1.000E+00	2.579E-01	2.034E-01	9.584E-02	1.229E-02	3.863E-03	6.227E-04	2.057E-03	1.426E-02	2.630E-09
84	CDDDBCABDBAA	1.000E+00	3.658E-01	3.015E-01	1.536E-01	2.495E-02	5.259E-03	1.884E-03	5.061E-03	2.619E-02	2.602E-09
85	CHDDBCABDBAA	1.000E+00	3.177E-01	2.503E-01	1.514E-01	2.642E-02	6.038E-03	1.815E-03	6.346E-03	2.823E-02	2.595E-09
86	CHADDCBDBBAC	1.000E+00	3.958E-01	3.214E-01	2.462E-01	1.480E-01	1.667E-02	1.304E-02	3.376E-02	1.372E-01	2.560E-09
87	GHECACBBBBDA	5.000E-03	4.836E-05	3.977E-07	2.385E-07	9.937E-08	1.046E-08	1.156E-08	1.663E-08	9.097E-08	2.559E-09
88	GFADBCABDDAD	5.000E-03	1.369E-04	3.986E-09	2.668E-09	9.878E-10	8.638E-11	8.184E-11	1.357E-10	8.377E-10	2.520E-09
89	CHADBCABDCAD	1.000E+00	2.645E-01	2.121E-01	1.316E-01	3.432E-02	3.294E-03	3.004E-03	6.856E-03	2.964E-02	2.486E-09
90	EFDDBCABDAAA	1.000E+00	3.426E-02	4.274E-04	7.600E-04	1.693E-04	7.215E-06	2.411E-05	2.466E-05	1.263E-04	2.458E-09
91	GDCCACDBBDA	5.000E-03	5.277E-05	5.402E-09	3.537E-09	1.463E-09	2.568E-10	6.141E-11	2.432E-10	1.526E-09	2.259E-09
92	EGADBCABDAAC	1.000E+00	8.071E-02	4.865E-02	3.108E-02	6.696E-03	8.038E-04	5.839E-04	1.020E-03	6.027E-03	2.202E-09
93	CHADBCABDCAC	1.000E+00	2.519E-01	2.056E-01	1.073E-01	2.333E-02	3.647E-03	1.975E-03	3.985E-03	2.239E-02	2.185E-09

Table C.3 (continued)

94	GHECBCABDDAA	5.000E-03	1.387E-04	7.097E-07	3.690E-07	8.469E-08	7.257E-09	7.472E-09	1.010E-08	7.088E-08	2.176E-09
95	CHDDBCABDCAB	1.000E+00	1.786E-01	1.232E-01	6.187E-02	1.021E-02	2.573E-03	6.784E-04	2.282E-03	1.128E-02	2.157E-09
96	CDCDFCDBDCAC	8.115E-01	1.537E-02	5.446E-03	3.239E-03	1.252E-03	2.253E-04	5.274E-05	2.081E-04	1.314E-03	2.132E-09
97	CGCDBCDBDBAA	1.000E+00	2.495E-01	2.042E-01	9.985E-02	1.595E-02	4.413E-03	8.931E-04	3.949E-03	1.851E-02	2.007E-09
98	CGADBCABDCAB	1.000E+00	2.583E-01	2.094E-01	9.191E-02	1.904E-02	2.958E-03	1.927E-03	3.670E-03	1.831E-02	1.932E-09
99	CFADBCABDCAB	1.000E+00	1.845E-01	1.249E-01	5.643E-02	9.303E-03	2.486E-03	5.506E-04	2.037E-03	1.055E-02	1.901E-09
100	CGADBCABDCAA	1.000E+00	3.886E-01	3.661E-01	1.360E-01	1.918E-02	3.694E-03	1.557E-03	2.982E-03	1.925E-02	1.879E-09
101	GDCCBCDBDDAA	5.000E-03	4.602E-05	8.853E-10	3.599E-10	2.181E-11	7.959E-12	9.557E-13	3.161E-12	2.778E-11	1.837E-09
102	CHACBCABDBAA	1.000E+00	5.385E-01	5.294E-01	2.654E-01	5.045E-02	9.368E-03	3.256E-03	7.045E-03	5.068E-02	1.831E-09
103	CGACACBBBBAA	1.000E+00	3.666E-01	3.291E-01	1.538E-01	4.383E-02	1.099E-02	6.671E-03	7.964E-03	4.194E-02	1.809E-09
104	CHEDBCABDBAB	1.000E+00	4.300E-01	3.966E-01	2.339E-01	6.810E-02	5.036E-03	7.204E-03	1.086E-02	5.686E-02	1.770E-09
105	EFCDFCDBDCAAB	1.000E+00	1.451E-02	5.924E-05	2.924E-05	9.029E-07	5.883E-07	5.080E-08	1.486E-07	1.314E-06	1.759E-09
106	CDCDFCDBDCAD	8.777E-01	1.384E-02	4.560E-03	2.510E-03	8.674E-04	1.610E-04	3.703E-05	1.472E-04	9.142E-04	1.678E-09
107	CGADDCBDBBAB	1.000E+00	4.015E-01	3.110E-01	2.438E-01	1.752E-01	2.339E-02	1.541E-02	4.466E-02	1.707E-01	1.636E-09
108	CHCDFCDBDCAD	7.686E-01	7.074E-02	4.800E-02	2.000E-02	5.311E-03	1.076E-03	3.400E-04	1.615E-03	5.746E-03	1.636E-09
109	GDCCBCABDDAA	5.000E-03	1.384E-04	3.086E-07	1.739E-07	2.484E-08	7.133E-09	1.348E-09	3.925E-09	2.885E-08	1.759E-09
110	EHADBCABDAAA	1.000E+00	8.855E-02	6.007E-02	3.377E-02	4.323E-03	5.344E-04	3.752E-04	6.472E-04	3.931E-03	1.595E-09
111	CFACACBBBBAA	1.000E+00	3.679E-01	3.305E-01	1.550E-01	4.383E-02	1.104E-02	6.704E-03	7.966E-03	4.190E-02	1.577E-09
112	EHADBCABDAAAB	1.000E+00	8.326E-02	3.499E-02	2.628E-02	2.810E-03	2.322E-04	2.492E-04	3.351E-04	2.272E-03	1.576E-09
113	CHCDFCDBDCAC	7.908E-01	1.159E-02	6.237E-02	3.155E-02	6.305E-03	1.638E-03	3.169E-04	1.254E-03	7.202E-03	1.551E-09
114	CGDDBCABDBAA	1.000E+00	2.954E-01	2.291E-01	1.281E-01	2.130E-02	4.442E-03	1.548E-03	4.623E-03	2.223E-02	1.482E-09
115	CGCDBCDBDBAB	1.000E+00	1.826E-01	1.303E-01	5.596E-02	8.207E-03	2.360E-03	5.060E-04	2.391E-03	9.456E-03	1.402E-09
116	DHDCACBBBBAA	1.000E+00	3.146E-01	2.809E-01	1.375E-01	2.761E-02	1.821E-02	4.010E-03	6.228E-03	3.344E-02	1.392E-09
117	CHCDFCDBDDAA	5.000E-03	1.233E-04	1.729E-09	1.084E-09	2.278E-10	8.350E-12	2.396E-11	2.690E-11	1.668E-10	1.356E-09
118	CHDDBCABDBAB	1.000E+00	2.617E-01	1.947E-01	1.065E-01	1.862E-02	3.991E-03	1.418E-03	5.024E-03	1.942E-02	1.306E-09
119	EFDDBCABDAAAB	1.000E+00	2.720E-02	2.366E-04	3.584E-04	3.112E-05	1.405E-06	3.336E-06	3.530E-06	2.141E-05	1.300E-09
120	EHEDBCABDAAAB	1.000E+00	4.280E-02	2.479E-02	2.183E-02	3.403E-03	2.236E-04	2.794E-04	4.087E-04	2.785E-03	1.264E-09
121	CGADDCBDBBAC	1.000E+00	4.072E-01	3.155E-01	2.489E-01	1.815E-01	2.419E-02	1.598E-02	4.632E-02	1.768E-01	1.217E-09
122	DHEDDCBDDAAA	1.000E+00	4.530E-01	3.669E-01	2.775E-01	1.716E-01	1.928E-02	1.719E-02	4.031E-02	1.591E-01	1.205E-09
123	EHEDBCABDAAA	1.000E+00	6.515E-02	3.501E-02	3.325E-02	6.351E-03	2.855E-04	5.711E-04	7.270E-04	4.979E-03	1.176E-09
124	CFADDCBDBBAB	1.000E+00	4.057E-01	3.141E-01	2.471E-01	1.778E-01	2.378E-02	1.560E-02	4.539E-02	1.732E-01	1.085E-09
125	DDDCACBBBBAA	1.000E+00	1.155E-01	9.277E-02	3.381E-02	6.012E-03	1.004E-02	2.245E-03	2.285E-03	8.263E-03	1.074E-09
126	DDCDDCDBDAAA	1.000E+00	2.422E-02	3.969E-03	1.977E-03	4.676E-04	9.798E-05	2.550E-05	1.086E-04	5.077E-04	1.040E-09
127	CGDDBCABDBAB	1.000E+00	2.256E-01	1.570E-01	8.602E-02	1.354E-02	2.383E-03	1.275E-03	3.172E-03	1.337E-02	1.035E-09
128	CFCDBCDBDBAA	1.000E+00	3.216E-01	2.735E-01	1.671E-01	3.551E-02	9.843E-03	2.117E-03	9.758E-03	4.066E-02	1.007E-09
129	CHDCBCABDDAA	1.000E+00	5.043E-01	4.874E-01	2.310E-01	3.643E-02	6.776E-03	2.493E-03	4.871E-03	3.592E-02	9.853E-09
130	EHDDBCABDAAAB	1.000E+00	3.137E-02	1.076E-02	6.964E-03	1.183E-03	2.203E-04	5.833E-05	1.862E-04	1.237E-03	9.324E-10
131	GDCCCCDBDDAA	5.000E-03	4.457E-05	2.295E-10	1.693E-10	9.476E-11	1.485E-11	4.328E-12	1.807E-11	9.649E-11	9.106E-10
132	EHDDBCABDAAA	1.000E+00	4.851E-02	1.553E-02	1.033E-02	1.527E-03	2.714E-04	8.415E-05	2.350E-04	1.575E-03	8.680E-10
133	GHACACBBBBAA	1.000E+00	5.054E-01	4.858E-01	1.963E-01	1.127E-02	7.695E-03	1.589E-03	1.956E-03	1.298E-02	8.489E-10
134	EGADBCABDAAAD	1.000E+00	5.900E-02	2.997E-02	3.576E-02	8.874E-03	4.880E-04	9.788E-04	1.206E-03	6.779E-03	8.324E-10
135	CFACBCABDBAA	1.000E+00	5.174E-01	5.044E-01	2.423E-01	3.856E-02	7.286E-03	2.625E-03	5.198E-03	3.820E-02	8.251E-10
136	CFCDBCDBDBAB	1.000E+00	2.208E-01	1.703E-01	7.435E-02	1.123E-02	3.369E-03	7.375E-04	3.684E-03	1.290E-02	8.246E-10
137	CHECACBBBBAA	1.000E+00	1.843E-01	1.590E-01	8.108E-02	3.037E-02	9.238E-03	4.132E-03	5.948E-03	3.110E-02	8.208E-10
138	GHECCCBDDAA	5.000E-03	7.330E-05	3.000E-07	2.320E-07	1.721E-07	2.053E-08	1.893E-08	4.411E-08	1.626E-07	8.155E-10
139	EFADBCABDAAAD	1.000E+00	2.774E-02	1.020E-03	1.878E-03	5.024E-04	1.382E-05	5.069E-05	5.190E-05	3.449E-04	7.917E-10

Table C.3 (continued)

140	GHACBCABDDAA	5.000E-03	4.254E-05	8.175E-07	2.742E-07	2.800E-08	5.603E-09	1.701E-09	3.395E-09	2.804E-08	7.742E-10
141	CGADBCABDCAC	1.000E+00	2.462E-01	1.966E-01	9.486E-02	2.157E-02	3.514E-03	1.817E-03	3.897E-03	2.097E-02	7.628E-10
142	CFDDBCABDBAA	1.000E+00	3.553E-01	2.937E-01	1.904E-01	4.165E-02	1.003E-02	3.050E-03	1.070E-02	4.541E-02	7.434E-10
143	CFADBCABDBAC	1.000E+00	4.139E-01	3.209E-01	2.536E-01	1.859E-01	2.482E-02	1.634E-02	4.757E-02	1.812E-01	7.401E-10
144	CFADBCABDCAC	1.000E+00	2.044E-01	1.483E-01	7.616E-02	1.493E-02	3.692E-03	8.091E-04	2.940E-03	1.654E-02	7.119E-10
145	CGCDBCDBDCAA	1.000E+00	1.454E-01	1.111E-01	5.372E-02	8.951E-03	2.399E-03	4.109E-04	1.507E-03	1.035E-02	6.906E-10
146	CDCCACDBBCAA	1.000E+00	3.102E-02	1.317E-02	8.642E-03	3.488E-03	6.196E-04	1.467E-04	5.799E-04	3.646E-03	6.600E-10
147	DDCCCBDBBAAA	1.000E+00	1.096E-01	9.759E-02	3.582E-02	3.850E-03	7.845E-03	1.769E-03	2.126E-03	5.234E-03	6.397E-10
148	GHDCACBBBDAA	5.000E-03	4.822E-05	3.083E-07	1.664E-07	4.681E-08	8.348E-09	2.516E-09	7.747E-09	4.868E-08	6.388E-10
149	CFDDBCABDBAB	1.000E+00	2.565E-01	1.947E-01	1.065E-01	1.684E-02	3.429E-03	1.624E-03	4.583E-03	1.720E-02	6.082E-10
150	CDCCBCDBDBAD	1.000E+00	2.753E-01	1.950E-01	8.087E-02	1.590E-02	3.538E-03	1.233E-03	6.742E-03	1.715E-02	6.060E-10
151	CGADBCABDCAD	1.000E+00	2.347E-01	1.702E-01	1.086E-01	3.955E-02	4.574E-03	3.574E-03	9.396E-03	3.595E-02	5.885E-10
152	GDDCABBBBDAA	5.000E-03	6.992E-05	5.617E-09	3.729E-09	1.540E-09	2.606E-10	7.337E-11	2.557E-10	1.586E-09	5.628E-10
153	EHADBCABDAAC	1.000E+00	7.919E-02	4.248E-02	2.868E-02	5.292E-03	5.819E-04	4.505E-04	7.759E-04	4.673E-03	5.617E-10
154	CGCDBCDBDCAB	1.000E+00	1.159E-01	8.293E-02	4.106E-02	6.233E-03	1.844E-03	2.901E-04	1.051E-03	7.259E-03	5.507E-10
155	GDCDBCDBDDAC	5.000E-03	8.655E-05	2.848E-09	1.552E-09	4.193E-10	8.160E-11	1.770E-11	6.898E-11	4.460E-10	5.339E-10
156	CGDDBCABDCAA	1.000E+00	1.618E-01	1.151E-01	5.797E-02	9.715E-03	2.425E-03	5.164E-04	1.599E-03	1.090E-02	5.088E-10
157	CHACCCBBBBBAA	1.000E+00	3.990E-01	3.548E-01	2.386E-01	1.578E-01	3.292E-02	1.767E-02	8.514E-02	1.565E-01	4.531E-10
158	DHECCBBDDBAAA	1.000E+00	4.881E-01	4.281E-01	2.502E-01	1.241E-01	2.542E-02	1.765E-02	5.049E-02	1.211E-01	4.495E-10
159	CDDDBCABDBAD	1.000E+00	3.013E-01	2.055E-01	8.628E-02	1.809E-02	3.409E-03	1.542E-03	7.239E-03	1.847E-02	4.249E-10
160	CGDDBCABDCAB	1.000E+00	1.263E-01	8.651E-02	4.310E-02	6.541E-03	1.846E-03	3.278E-04	1.091E-03	7.466E-03	4.053E-10
161	GDCDBCDBDDAD	5.000E-03	9.119E-05	3.423E-09	1.567E-09	2.458E-10	5.918E-11	1.038E-11	3.949E-11	2.696E-10	4.047E-10
162	EHADBCABDAAD	1.000E+00	6.395E-02	3.408E-02	3.929E-02	6.943E-03	5.376E-04	7.210E-04	9.021E-04	5.246E-03	3.985E-10
163	EFACBCABDAAA	1.000E+00	8.582E-03	1.605E-04	1.617E-04	2.585E-05	1.015E-07	2.397E-06	2.434E-06	1.788E-05	3.823E-10
164	CDCCFCDBDCAA	7.874E-01	1.217E-02	3.670E-03	2.263E-03	8.225E-04	1.508E-04	3.477E-05	1.370E-04	8.647E-04	3.794E-10
165	GDDDBCABDDAC	5.000E-03	1.503E-04	4.038E-09	2.263E-09	6.027E-10	8.512E-11	3.287E-11	8.680E-11	5.642E-10	3.790E-10
166	CHADDCBBDCAA	1.000E+00	3.193E-01	2.590E-01	1.958E-01	8.169E-02	8.711E-03	7.140E-03	1.717E-02	7.338E-02	3.619E-10
167	CFCDBCDBDCAA	1.000E+00	1.716E-01	1.287E-01	5.384E-02	8.653E-03	2.438E-03	4.434E-04	1.696E-03	1.019E-02	3.526E-10
168	CFADBCABDCAD	1.000E+00	1.610E-01	1.086E-01	5.901E-02	2.327E-02	3.997E-03	1.633E-03	7.065E-03	2.392E-02	3.127E-10
169	CHCCFCDBDCAA	7.678E-01	7.683E-02	5.932E-02	2.484E-02	3.560E-03	1.008E-03	1.706E-04	6.413E-04	4.152E-03	2.966E-10
170	GDDDBCABDDAD	5.000E-03	1.455E-04	4.110E-09	2.812E-09	6.343E-10	5.731E-11	4.897E-11	7.728E-11	5.075E-10	2.907E-10
171	EGACBCABDAAA	1.000E+00	9.355E-02	9.642E-02	4.576E-02	9.123E-04	9.819E-05	7.536E-05	8.276E-05	8.112E-04	2.856E-10
172	CGACCCBBBBBAA	1.000E+00	3.511E-01	2.891E-01	1.912E-01	1.110E-01	2.217E-02	1.176E-02	5.012E-02	1.096E-01	2.793E-10
173	DFACACBBBBBAA	1.000E+00	3.184E-01	2.901E-01	1.005E-01	1.311E-02	1.218E-02	2.730E-03	3.373E-03	1.649E-02	2.742E-10
174	CFDDBCABDCAA	1.000E+00	1.852E-01	1.307E-01	5.479E-02	3.369E-03	2.468E-03	5.688E-04	1.822E-03	1.076E-02	2.595E-10
175	CHECBCABDCAA	1.000E+00	2.948E-01	2.754E-01	1.127E-01	1.592E-02	3.205E-03	9.723E-04	2.194E-03	1.642E-02	2.554E-10
176	CDCCBCDBDCAA	1.000E+00	1.165E-02	2.306E-03	1.009E-03	8.826E-05	2.750E-05	3.889E-06	1.330E-05	1.080E-04	2.501E-10
177	EFACACBBBBBAA	1.000E+00	2.634E-02	6.347E-04	5.910E-04	4.294E-04	3.350E-05	5.599E-05	7.234E-05	3.510E-04	2.492E-10
178	CFACCCBBBBBAA	1.000E+00	3.537E-01	2.918E-01	1.937E-01	1.133E-01	2.253E-02	1.217E-02	5.054E-02	1.119E-01	2.389E-10
179	GDDCCCBBDDBAA	5.000E-03	6.634E-05	3.317E-10	2.294E-10	1.045E-10	1.488E-11	5.576E-12	1.927E-11	1.023E-10	2.273E-10
180	CDCDDCDBDBAB	1.000E+00	4.368E-01	3.392E-01	2.616E-01	1.817E-01	2.751E-02	1.051E-02	4.647E-02	1.840E-01	2.078E-10
181	DHDDDCBBDAAA	1.000E+00	4.111E-01	3.123E-01	2.225E-01	1.266E-01	1.945E-02	7.496E-03	3.180E-02	1.281E-01	2.064E-10
182	GHACACBBBDAA	5.000E-03	5.751E-05	4.700E-07	2.796E-07	9.451E-08	1.206E-08	9.326E-09	1.542E-08	8.764E-08	2.062E-10
183	GHDDCCBBBDAA	5.000E-03	7.329E-05	2.661E-07	2.097E-07	1.353E-07	2.036E-08	7.964E-09	3.451E-08	1.366E-07	2.038E-10
184	CFCDBCDBDCAB	1.000E+00	1.723E-01	1.315E-01	5.039E-02	3.708E-03	1.612E-03	1.850E-04	6.221E-04	4.894E-03	2.010E-10
185	CHDCACBBBDCAA	1.000E+00	1.563E-01	1.238E-01	6.738E-02	1.935E-02	8.648E-03	2.146E-03	4.016E-03	2.162E-02	2.010E-10

Table C.3 (continued)

186	GFADBCABDDAA	5.000E-03	1.307E-04	4.002E-09	2.275E-09	9.200E-10	1.102E-10	7.447E-11	1.450E-10	8.544E-10	2.009E-10
187	CGADDCBBDBAA	1.000E+00	2.947E-01	2.312E-01	1.898E-01	1.021E-01	1.172E-02	9.248E-03	2.235E-02	9.513E-02	2.007E-10
188	DGACACBBBAAA	1.000E+00	4.465E-01	4.221E-01	1.478E-01	1.907E-02	1.146E-02	3.159E-03	3.823E-03	2.026E-02	1.967E-10
189	CHDCBCABDCAA	1.000E+00	1.741E-01	1.312E-01	7.020E-02	1.100E-02	3.208E-03	5.389E-04	1.773E-03	1.303E-02	1.883E-10
190	CDCDDCDBDBAC	1.000E+00	4.384E-01	3.406E-01	2.628E-01	1.827E-01	2.766E-02	1.057E-02	4.673E-02	1.850E-01	1.881E-10
191	CDCCCCDBBCAA	1.000E+00	1.608E-02	2.916E-03	1.550E-03	7.128E-04	1.214E-04	3.894E-05	1.928E-04	7.319E-04	1.880E-10
192	DHADDCBBDAAB	1.000E+00	4.237E-01	3.717E-01	2.512E-01	7.497E-02	1.305E-03	6.525E-03	7.347E-03	5.331E-02	1.843E-10
193	CFADDCBBDBAA	1.000E+00	2.917E-01	2.283E-01	1.864E-01	9.862E-02	1.133E-02	8.921E-03	2.153E-02	9.183E-02	1.804E-10
194	DDDDDCBBDDAA	1.000E+00	2.910E-02	5.161E-03	2.915E-03	8.379E-04	9.481E-05	7.168E-05	1.552E-04	7.450E-04	1.780E-10
195	CDDCBCABDCAA	1.000E+00	2.549E-02	4.580E-03	2.067E-03	3.099E-04	2.871E-05	2.755E-05	3.828E-05	2.582E-04	1.778E-10
196	GGCCBCBDDDA	5.000E-03	2.470E-05	7.491E-10	3.020E-10	1.359E-11	5.678E-12	6.089E-13	1.935E-12	1.795E-11	1.695E-10
197	DHEDDCBBDAAB	1.000E+00	4.429E-01	3.922E-01	2.485E-01	8.863E-02	3.499E-03	8.421E-03	1.278E-02	6.826E-02	1.656E-10
198	CDCCACDBBBAA	1.000E+00	3.051E-01	2.740E-01	1.029E-01	8.714E-03	7.904E-03	1.504E-03	2.074E-03	1.109E-02	1.621E-10
199	CDDCBCABDCAA	1.000E+00	3.885E-01	1.473E-02	9.356E-03	6.041E-03	6.495E-04	2.309E-04	6.761E-04	4.084E-03	1.602E-10
200	EGACACBBBAAA	1.000E+00	1.062E-01	7.803E-02	5.503E-02	1.332E-02	2.543E-03	1.001E-03	2.207E-03	1.330E-02	1.598E-10
201	DDCCCCBBBAAA	1.000E+00	1.174E-01	1.002E-01	3.803E-02	4.927E-03	7.857E-03	1.947E-03	2.305E-03	6.074E-03	1.596E-10
202	CHECCCCBBBCAA	1.000E+00	1.927E-01	1.467E-01	9.258E-02	5.305E-02	9.881E-03	5.439E-03	1.597E-02	5.282E-02	1.552E-10
203	CFDDCBCABDCAB	1.000E+00	1.893E-01	1.339E-01	5.079E-02	3.611E-03	1.585E-03	1.886E-04	5.779E-04	4.760E-03	1.474E-10
204	CHEDDCBBDDCAA	1.000E+00	2.019E-01	1.511E-01	1.144E-01	6.464E-02	8.239E-03	4.645E-03	1.486E-02	6.174E-02	1.445E-10
205	GGADBCABDDAA	5.000E-03	1.276E-04	4.076E-09	2.364E-09	9.660E-10	1.171E-10	7.696E-11	1.524E-10	8.985E-10	1.431E-10
206	CDCDDCDBDCAA	1.000E+00	2.142E-02	1.007E-03	4.761E-04	1.377E-04	2.633E-05	7.674E-06	3.270E-05	1.457E-04	1.378E-10
207	CHACBCABDCAA	1.000E+00	4.591E-01	4.825E-01	1.178E-01	6.053E-03	1.596E-03	3.495E-04	8.354E-04	7.063E-03	1.330E-10
208	EGDCBCABDAAA	1.000E+00	2.538E-02	6.978E-03	5.502E-03	4.797E-04	4.553E-05	4.519E-05	5.895E-05	4.023E-04	1.244E-10
209	CHADDCBBDBAD	1.000E+00	3.959E-01	3.574E-01	2.492E-01	8.797E-02	3.169E-03	8.180E-03	1.549E-02	6.539E-02	1.154E-10
210	DDCDDCDBDAAB	1.000E+00	2.949E-02	7.836E-03	5.074E-03	1.035E-03	2.415E-04	6.006E-05	2.863E-04	1.138E-03	1.151E-10
211	DHCCCCBBBAAA	1.000E+00	4.091E-01	3.412E-01	1.696E-01	6.982E-02	2.180E-02	8.536E-03	4.143E-02	7.307E-02	1.121E-10
212	DGCCACDBBAAA	1.000E+00	3.778E-01	3.632E-01	1.826E-01	4.108E-02	1.694E-02	3.585E-03	7.972E-03	4.683E-02	1.091E-10
213	DFCCACDBBAAA	1.000E+00	4.084E-01	4.015E-01	1.459E-01	6.450E-03	6.517E-03	1.114E-03	1.372E-03	8.682E-03	9.156E-11
214	CHECBCABDBAA	1.000E+00	4.921E-01	4.805E-01	2.997E-01	8.440E-02	7.969E-03	6.678E-03	1.038E-02	7.294E-02	8.772E-11
215	DHADDCBBDDAA	1.000E+00	3.213E-01	2.577E-01	1.824E-01	6.705E-02	6.964E-03	6.161E-03	1.337E-02	5.953E-02	7.537E-11
216	CHACACBBBCAA	1.000E+00	2.165E-01	1.732E-01	8.910E-02	1.928E-02	5.499E-03	2.111E-03	3.468E-03	1.977E-02	7.406E-11
217	DHADDCBBDAAC	1.000E+00	4.814E-01	4.379E-01	2.873E-01	9.628E-02	1.146E-03	8.592E-03	9.754E-03	6.816E-02	7.385E-11
218	CHECACBBBBA	1.000E+00	3.348E-01	2.935E-01	1.488E-01	3.024E-02	9.088E-03	5.111E-03	5.355E-03	2.767E-02	7.363E-11
219	GHACCCBBBDAA	5.000E-03	4.989E-05	2.495E-07	7.072E-09	1.638E-11	4.282E-14	1.326E-13	1.567E-13	3.679E-11	6.633E-11
220	CHDCBCABDBAA	1.000E+00	2.839E-01	2.338E-01	1.521E-01	3.368E-02	7.818E-03	1.785E-03	5.408E-03	3.719E-02	6.385E-11
221	CGCCBCBDBBAA	1.000E+00	1.695E-01	1.415E-01	8.234E-02	1.761E-02	4.596E-03	8.115E-04	2.906E-03	2.040E-02	6.274E-11
222	EFCCBCBDDAAA	1.000E+00	4.301E-03	3.453E-05	1.770E-05	1.473E-07	6.021E-08	6.465E-09	2.109E-08	1.851E-07	6.113E-11
223	DHACCCBBBAAA	1.000E+00	4.371E-01	3.786E-01	2.072E-01	7.719E-02	1.733E-02	9.746E-03	1.991E-02	7.320E-02	5.877E-11
224	DHADDCBBDAAD	1.000E+00	5.108E-01	4.530E-01	3.082E-01	9.995E-02	9.042E-04	8.839E-03	9.448E-03	7.026E-02	5.788E-11
225	CFACBCABDCAA	1.000E+00	1.512E-01	1.096E-01	3.600E-02	4.011E-03	1.369E-03	1.906E-04	6.373E-04	5.172E-03	5.590E-11
226	CFACACBBBCAA	1.000E+00	3.088E-01	2.691E-01	1.453E-01	1.927E-02	8.165E-03	1.421E-03	3.534E-03	2.224E-02	5.584E-11
227	DFADDCBBDDAA	1.000E+00	3.345E-01	2.545E-01	1.534E-01	4.465E-02	9.472E-03	2.588E-03	1.099E-02	4.724E-02	5.395E-11
228	CGCCACDBBBAA	1.000E+00	2.352E-01	1.977E-01	7.868E-02	5.750E-03	1.070E-02	2.114E-03	2.565E-03	8.486E-03	4.692E-11
229	CDDCCCBBCAA	1.000E+00	2.187E-02	3.810E-03	1.988E-03	8.207E-04	1.243E-04	5.351E-05	2.081E-04	8.154E-04	4.678E-11
230	CGDCBCABDBAA	1.000E+00	2.332E-01	1.776E-01	1.066E-01	2.149E-02	4.608E-03	1.242E-03	3.359E-03	2.304E-02	4.623E-11
231	EFDCBCABDAAA	1.000E+00	1.383E-02	4.684E-04	7.934E-04	1.589E-04	1.638E-07	1.759E-05	1.820E-05	1.065E-04	4.501E-11

Table C.3 (continued)

232	GGDDBCABDDAA	5.000E-03	1.269E-04	3.719E-09	2.360E-09	6.868E-10	3.281E-11	6.940E-11	8.737E-11	5.234E-10	4.369E-11
233	DGADDCBBDAAB	1.000E+00	3.472E-01	2.731E-01	2.094E-01	6.793E-02	9.647E-03	6.257E-03	1.520E-02	6.426E-02	4.116E-11
234	CGACBCABDCAA	1.000E+00	4.531E-01	4.757E-01	1.126E-01	5.045E-03	1.305E-03	2.969E-04	6.864E-04	5.905E-03	4.072E-11
235	CDCDBCDBDCAC	1.000E+00	3.422E-02	1.224E-02	7.491E-03	3.114E-03	5.463E-04	1.308E-04	5.170E-04	3.259E-03	3.924E-11
236	CDCCBCDBDBAA	1.000E+00	3.960E-01	3.481E-01	1.701E-01	2.147E-02	7.073E-03	9.986E-04	3.453E-03	2.576E-02	3.907E-11
237	CHDCCCBBBCAA	1.000E+00	1.680E-01	1.213E-01	7.783E-02	4.352E-02	9.193E-03	3.324E-03	1.429E-02	4.431E-02	3.744E-11
238	CDDDDCBBDBAB	1.000E+00	4.387E-01	3.415E-01	2.638E-01	1.841E-01	2.781E-02	1.076E-02	4.713E-02	1.863E-01	3.621E-11
239	DFACCCBBBAAA	1.000E+00	4.238E-01	3.411E-01	1.718E-01	7.268E-02	2.554E-02	8.240E-03	1.969E-02	7.770E-02	3.592E-11
240	DFADDCBBDAAB	1.000E+00	2.214E-01	1.427E-01	7.593E-02	1.923E-02	4.336E-03	1.074E-03	4.395E-03	2.072E-02	3.522E-11
241	DGADDCBBDAAB	1.000E+00	2.820E-01	1.990E-01	1.454E-01	2.870E-02	3.984E-03	2.139E-03	4.965E-03	2.631E-02	3.522E-11
242	CHEDDCBBDBAA	1.000E+00	3.239E-01	2.611E-01	1.642E-01	3.628E-02	2.168E-03	3.001E-03	4.368E-03	2.787E-02	3.463E-11
243	CHADDCBBDCAB	1.000E+00	1.668E-01	1.298E-01	1.041E-01	3.450E-02	4.320E-04	3.043E-03	3.272E-03	2.402E-02	3.427E-11
244	CDDDDCBBDBAC	1.000E+00	4.391E-01	3.419E-01	2.641E-01	1.844E-01	2.785E-02	1.078E-02	4.719E-02	1.865E-01	3.293E-11
245	CFCCBCDBDBAA	1.000E+00	2.651E-01	2.366E-01	1.571E-01	3.786E-02	9.678E-03	1.749E-03	6.290E-03	4.358E-02	3.189E-11
246	CFCCACDBBBAA	1.000E+00	3.097E-01	2.673E-01	1.243E-01	8.608E-03	1.495E-02	2.703E-03	3.307E-03	1.330E-02	3.072E-11
247	DFCCCCBBBAAA	1.000E+00	4.445E-01	3.766E-01	1.798E-01	2.920E-02	1.692E-02	3.541E-03	7.851E-03	3.690E-02	3.070E-11
248	EHECBCABDAAA	1.000E+00	4.835E-02	2.654E-02	3.059E-02	5.538E-03	4.101E-05	5.412E-04	5.564E-04	3.959E-03	3.054E-11
249	GFCDDBCDBDDAA	5.000E-03	1.120E-04	2.312E-09	9.876E-10	7.100E-11	2.811E-11	3.272E-12	1.063E-11	9.144E-11	2.937E-11
250	EHACBCABDAAA	1.000E+00	9.711E-02	1.024E-01	4.782E-02	6.114E-04	9.904E-05	4.683E-05	5.489E-05	6.098E-04	2.898E-11
251	CGACACBBBCAA	1.000E+00	3.437E-01	3.055E-01	1.717E-01	3.422E-02	9.548E-03	3.172E-03	6.052E-03	3.550E-02	2.831E-11
252	DHDDCBBDAAB	1.000E+00	2.913E-01	2.019E-01	1.044E-01	2.552E-02	3.016E-03	1.818E-03	5.437E-03	2.417E-02	2.704E-11
253	DGDCACBBBAAA	1.000E+00	3.986E-01	3.757E-01	1.888E-01	4.192E-02	1.701E-02	3.623E-03	8.088E-03	4.765E-02	2.677E-11
254	CHEDDCBBDCAB	1.000E+00	1.598E-01	1.259E-01	9.839E-02	3.324E-02	1.845E-04	2.959E-03	3.037E-03	2.281E-02	2.676E-11
255	CDDDBCABDCAC	1.000E+00	5.424E-02	1.564E-02	8.764E-03	3.948E-03	6.106E-04	2.297E-04	6.596E-04	3.954E-03	2.584E-11
256	CHEDDCBBDBAB	1.000E+00	3.262E-01	2.883E-01	1.905E-01	6.448E-02	2.104E-04	5.959E-03	6.072E-03	4.472E-02	2.552E-11
257	DGACCCBBBAAA	1.000E+00	4.671E-01	3.945E-01	2.549E-01	1.407E-01	2.612E-02	1.914E-02	3.193E-02	1.322E-01	2.551E-11
258	GGDDBCABDDAB	5.000E-03	6.899E-05	2.773E-09	1.463E-09	4.042E-10	3.886E-11	2.937E-11	5.423E-11	3.427E-10	2.519E-11
259	CDCDBCDBDCAD	1.000E+00	2.824E-02	8.698E-03	3.308E-03	1.458E-04	7.523E-05	5.903E-06	1.808E-05	1.930E-04	2.449E-11
260	DGCCCCBBBAAA	1.000E+00	4.970E-01	4.246E-01	2.200E-01	3.581E-02	1.848E-02	3.632E-03	8.429E-03	4.527E-02	2.449E-11
261	CHDDCBBDDCAA	1.000E+00	1.862E-01	1.278E-01	9.414E-02	5.662E-02	8.636E-03	3.317E-03	1.431E-02	5.717E-02	2.370E-11
262	CFDCBCABDBAA	1.000E+00	3.208E-01	2.681E-01	1.693E-01	3.925E-02	9.708E-03	1.893E-03	6.455E-03	4.457E-02	2.350E-11
263	CDDCBCABDBAA	1.000E+00	4.539E-01	4.131E-01	2.141E-01	2.699E-02	8.896E-03	1.257E-03	4.344E-03	3.223E-02	2.296E-11
264	EFCCACDBBAAA	1.000E+00	1.392E-02	7.406E-05	4.014E-05	1.434E-05	2.579E-06	6.041E-07	2.386E-06	1.500E-05	2.276E-11
265	CDDDDCBBDDCAA	1.000E+00	2.673E-02	1.352E-03	8.449E-04	2.937E-04	2.193E-05	2.475E-05	4.877E-05	2.378E-04	2.266E-11
266	EHDCBCABDAAA	1.000E+00	3.138E-02	7.382E-03	5.785E-03	3.942E-04	3.184E-05	3.816E-05	4.598E-05	3.221E-04	2.209E-11
267	DFDCACBBBAAA	1.000E+00	4.240E-01	4.125E-01	1.497E-01	6.391E-03	6.045E-03	1.013E-03	1.251E-03	8.437E-03	2.198E-11
268	CDDCACBBBAAA	1.000E+00	3.950E-01	3.687E-01	1.409E-01	3.921E-03	3.839E-03	5.749E-04	6.063E-04	5.212E-03	2.027E-11
269	GFDDBCABDDAA	5.000E-03	1.734E-04	3.409E-09	1.895E-09	4.176E-10	3.184E-11	5.538E-11	6.258E-11	3.449E-10	1.914E-11
270	CGCCBCDBDCAA	1.000E+00	8.685E-02	6.661E-02	3.159E-02	4.070E-03	1.385E-03	1.955E-04	6.623E-04	5.034E-03	1.891E-11
271	DDDDCBBDAAB	1.000E+00	3.413E-02	8.573E-03	5.582E-03	1.192E-03	2.464E-04	7.388E-05	3.160E-04	1.254E-03	1.854E-11
272	CHDCACBBBAAA	1.000E+00	2.900E-01	2.416E-01	1.099E-01	6.477E-03	8.170E-03	1.832E-03	2.003E-03	8.330E-03	1.747E-11
273	CDDDBCABDCAD	1.000E+00	3.748E-02	1.161E-02	8.513E-03	2.600E-03	8.404E-05	2.377E-04	2.598E-04	1.730E-03	1.571E-11
274	GGCCACDBDDAA	5.000E-03	4.329E-05	8.486E-09	5.711E-09	2.389E-09	4.198E-10	1.004E-10	3.975E-10	2.491E-09	1.482E-11
275	DFCDDCDBDAAA	1.000E+00	4.733E-01	3.774E-01	2.696E-01	1.467E-01	2.453E-02	8.415E-03	3.662E-02	1.510E-01	1.432E-11
276	CGDCBCABDCAA	1.000E+00	8.700E-02	6.100E-02	2.843E-02	3.696E-03	1.004E-03	2.089E-04	5.705E-04	4.201E-03	1.330E-11
277	CDCDDCDBDCAB	1.000E+00	2.264E-02	2.114E-03	1.124E-03	1.452E-04	4.477E-05	6.735E-06	2.375E-05	1.709E-04	1.305E-11

Table C.3 (continued)

278	CHADDCBBDCAA	1.000E+00	1.532E-01	1.007E-01	6.982E-02	2.121E-02	2.623E-03	1.566E-03	3.873E-03	1.906E-02	1.290E-11
279	CHADDCBBDCA	1.000E+00	1.834E-01	1.525E-01	1.302E-01	4.753E-02	2.030E-04	4.232E-03	4.540E-03	3.274E-02	1.289E-11
280	CGCCACBDBCAA	1.000E+00	1.691E-01	1.463E-01	7.789E-02	2.169E-02	8.534E-03	1.859E-03	4.320E-03	2.429E-02	1.257E-11
281	CGDCACBDBBAA	1.000E+00	2.511E-01	2.024E-01	8.469E-02	6.269E-03	1.043E-02	2.270E-03	2.626E-03	8.513E-03	1.104E-11
282	EFCCCCBDBAAA	1.000E+00	1.275E-02	8.967E-06	8.382E-06	5.433E-07	8.223E-08	3.143E-08	1.390E-07	5.500E-07	1.053E-11
283	CDCCCCBDBBAA	1.000E+00	3.517E-01	2.887E-01	1.574E-01	3.598E-02	1.070E-02	2.738E-03	1.207E-02	4.018E-02	1.036E-11
284	CHADDCBBDCA	1.000E+00	1.829E-01	1.523E-01	1.302E-01	4.693E-02	2.832E-05	4.203E-03	4.286E-03	3.195E-02	1.030E-11
285	CHACCCBDBCAA	1.000E+00	1.649E-01	1.464E-01	5.462E-02	1.634E-02	6.079E-03	1.874E-03	4.183E-03	1.652E-02	1.013E-11
286	GFCDBCDBDDAB	5.000E-03	8.537E-05	2.093E-09	8.975E-10	3.384E-11	2.466E-11	1.633E-12	4.340E-12	5.013E-11	9.997E-12
287	DGCDDCDBDAAA	1.000E+00	4.526E-01	3.935E-01	1.875E-01	3.248E-02	8.438E-03	1.717E-03	6.640E-03	3.743E-02	9.910E-12
288	CFADDCBBDCAA	1.000E+00	2.167E-01	1.585E-01	8.988E-02	1.417E-02	4.286E-03	8.367E-04	3.394E-03	1.588E-02	9.738E-12
289	CGCDDCDBDBAB	1.000E+00	1.065E-01	6.064E-02	1.014E-02	2.068E-04	1.260E-04	5.653E-06	1.095E-05	3.632E-04	9.717E-12
290	CFCCACBDBCAA	1.000E+00	1.451E-01	1.178E-01	4.569E-02	2.388E-03	3.960E-03	7.306E-04	8.350E-04	3.613E-03	9.704E-12
291	CHECCCBDBBAA	1.000E+00	5.092E-01	4.933E-01	4.098E-01	3.604E-01	6.751E-02	4.998E-02	1.830E-01	3.582E-01	9.342E-12
292	CGADDCBBDAB	1.000E+00	2.529E-01	1.694E-01	1.084E-01	4.184E-02	1.794E-03	5.048E-03	5.900E-03	3.520E-02	9.197E-12
293	EHACACBDBAAA	1.000E+00	1.059E-01	8.057E-02	5.878E-02	2.094E-02	3.445E-03	1.536E-03	3.517E-03	2.059E-02	8.228E-12
294	EFACCCBDBAAA	1.000E+00	9.740E-03	3.473E-05	1.484E-05	1.106E-08	1.043E-11	6.109E-09	4.663E-09	1.102E-08	7.549E-12
295	CFCCBDBDCAA	1.000E+00	1.440E-01	1.073E-01	3.816E-02	7.614E-03	1.907E-03	3.461E-04	1.246E-03	8.992E-03	9.910E-12
296	CGCDDCDBDBAA	1.000E+00	1.757E-01	1.219E-01	4.083E-02	9.176E-04	5.995E-04	2.393E-05	4.413E-05	1.420E-03	7.298E-12
297	DFDCCBDBBAAA	1.000E+00	4.576E-01	3.874E-01	1.969E-01	3.544E-02	1.779E-02	4.432E-03	8.814E-03	4.241E-02	7.083E-12
298	CGADDCBBDCAA	1.000E+00	1.491E-01	9.274E-02	6.002E-02	1.753E-02	3.203E-03	1.159E-03	4.033E-03	1.766E-02	6.911E-12
299	CFCCCBDBBAA	1.000E+00	3.544E-01	3.162E-01	2.059E-01	1.547E-01	3.600E-02	1.717E-02	1.034E-01	1.563E-01	6.840E-12
300	GFDDCBABDDAB	5.000E-03	1.392E-04	2.884E-09	1.233E-09	6.712E-11	2.570E-11	4.431E-12	7.465E-12	7.199E-11	6.829E-12
301	DFADDCBBDAA	1.000E+00	2.744E-01	1.876E-01	1.211E-01	5.490E-02	9.733E-03	3.110E-03	1.335E-02	5.698E-02	6.705E-12
302	CFDCACBDBBAA	1.000E+00	3.096E-01	2.616E-01	1.403E-01	1.451E-02	1.687E-02	3.918E-03	4.577E-03	1.875E-02	6.554E-12
303	CFADDCBBDCA	1.000E+00	1.288E-01	7.262E-02	3.577E-02	5.399E-03	1.751E-03	3.177E-04	1.256E-03	6.198E-03	6.328E-12
304	EGACCCBDBAAA	1.000E+00	2.356E-02	1.464E-02	1.003E-03	1.479E-06	7.500E-09	1.350E-07	1.156E-07	3.025E-06	6.207E-12
305	DGCDCBDBBAAA	1.000E+00	5.054E-01	4.311E-01	2.279E-01	3.792E-02	1.800E-02	4.019E-03	7.033E-03	4.620E-02	5.936E-12
306	DGADDCBBDAA	1.000E+00	3.674E-01	2.478E-01	1.984E-01	6.929E-02	9.674E-03	6.104E-03	1.555E-02	6.667E-02	5.568E-12
307	DGCDDCDBDAA	1.000E+00	2.301E-01	1.780E-01	5.091E-02	1.337E-03	3.990E-04	3.197E-05	8.194E-05	1.969E-03	5.491E-12
308	CHDDCBDBDBAA	1.000E+00	2.479E-01	1.630E-01	8.515E-02	4.338E-03	1.059E-03	3.131E-04	3.636E-04	4.008E-03	5.393E-12
309	CDCCDCBDBBAA	1.000E+00	1.352E-01	9.284E-02	5.451E-02	3.193E-02	4.841E-03	1.840E-03	8.127E-03	3.243E-02	5.390E-12
310	CFDCBDBDCAA	1.000E+00	1.462E-01	1.061E-01	3.802E-02	7.715E-03	1.935E-03	3.511E-04	1.264E-03	9.101E-03	5.315E-12
311	CGADDCBBDCA	1.000E+00	1.334E-01	7.993E-02	4.643E-02	7.238E-03	1.715E-03	4.467E-04	1.392E-03	7.394E-03	5.152E-12
312	EFDCACBDBAAA	1.000E+00	1.826E-02	1.198E-04	2.977E-04	4.495E-04	5.988E-05	9.855E-05	9.854E-05	4.156E-04	5.017E-12
313	CFCCDCBDBBAB	1.000E+00	1.170E-01	6.703E-02	9.288E-03	2.094E-04	2.032E-04	8.894E-06	1.898E-05	3.795E-04	4.722E-12
314	CFADDCBBDAB	1.000E+00	2.516E-01	1.687E-01	1.115E-01	4.416E-02	1.793E-03	5.349E-03	6.197E-03	3.696E-02	4.505E-12
315	CHDDCBBDCA	1.000E+00	9.674E-02	4.548E-02	2.859E-02	3.252E-02	2.008E-05	3.126E-04	3.263E-04	2.283E-02	4.161E-12
316	CFACCCBDBCAA	1.000E+00	1.655E-01	1.142E-01	5.995E-02	2.668E-02	8.488E-03	2.526E-03	6.963E-03	2.838E-02	3.792E-12
317	DGADDCBBDAA	1.000E+00	5.438E-01	3.272E-01	2.890E-01	6.197E-02	6.532E-03	4.773E-03	8.314E-03	5.596E-02	3.599E-12
318	CHDDCBBDAB	1.000E+00	2.009E-01	1.252E-01	6.217E-02	6.704E-03	2.811E-05	6.452E-04	6.717E-04	4.895E-03	3.593E-12
319	EGDCACBDBAAA	1.000E+00	6.357E-02	4.396E-02	2.955E-02	1.122E-02	2.114E-03	5.576E-04	1.892E-03	1.170E-02	3.371E-12
320	CFCCCBDBBAA	1.000E+00	1.653E-01	1.178E-01	6.757E-02	2.587E-02	7.214E-03	2.031E-03	6.534E-03	2.765E-02	3.367E-12
321	CGCCCBDBBAA	1.000E+00	4.612E-01	4.217E-01	3.181E-01	2.523E-01	5.677E-02	2.747E-02	1.680E-01	2.550E-01	2.868E-12
322	CFCCDCBDBBAA	1.000E+00	1.369E-01	8.080E-02	3.115E-02	1.005E-02	2.526E-03	1.007E-03	6.362E-03	1.060E-02	2.813E-12
323	DFCCDCBBDAA	1.000E+00	2.931E-01	2.200E-01	1.311E-01	5.823E-02	1.013E-02	3.360E-03	1.466E-02	5.996E-02	2.796E-12

Table C.3 (continued)

324	EHACCCBBBAAA	1.000E+00	2.332E-02	1.462E-02	7.223E-04	1.253E-06	9.336E-10	1.908E-09	4.764E-10	2.865E-06	2.595E-12
325	CGDCACBBBCAA	1.000E+00	1.925E-01	1.559E-01	8.373E-02	2.500E-02	9.275E-03	2.141E-03	4.893E-03	2.773E-02	2.592E-12
326	EFDCCCBBBAAA	1.000E+00	1.405E-02	1.065E-05	8.741E-06	1.447E-06	8.596E-08	3.490E-07	4.225E-07	1.171E-06	2.571E-12
327	CGACCCBBBCAA	1.000E+00	1.856E-01	1.299E-01	7.715E-02	4.148E-02	9.345E-03	4.064E-03	1.017E-02	4.179E-02	2.314E-12
328	CHDCCCB BBBAA	1.000E+00	4.157E-01	3.824E-01	3.003E-01	2.656E-01	5.922E-02	2.907E-02	1.761E-01	2.666E-01	2.093E-12
329	CDDDDCBBD CAB	1.000E+00	2.417E-02	1.780E-03	7.662E-04	9.895E-05	1.460E-05	8.581E-06	1.057E-05	8.050E-05	2.068E-12
330	DFDDDCBBDA AA	1.000E+00	5.298E-01	4.289E-01	3.145E-01	1.801E-01	2.951E-02	1.035E-02	4.498E-02	1.847E-01	2.033E-12
331	DFADDCBBDA AD	1.000E+00	2.946E-01	1.807E-01	1.354E-01	3.841E-02	8.545E-03	1.745E-03	6.371E-03	4.261E-02	1.580E-12
332	GGCCCCBBDAA	5.000E-03	3.510E-05	8.834E-11	7.473E-11	1.935E-11	2.926E-12	1.119E-12	4.951E-12	1.960E-11	1.553E-12
333	CGDDDCBBD BAB	1.000E+00	1.329E-01	8.145E-02	3.547E-02	4.782E-03	1.795E-04	7.239E-04	7.377E-04	3.870E-03	1.427E-12
334	CFDCCCBBB BAA	1.000E+00	3.569E-01	3.199E-01	2.215E-01	1.815E-01	3.995E-02	2.004E-02	1.234E-01	1.820E-01	1.421E-12
335	CGCCCCBBDCAA	1.000E+00	2.104E-01	1.582E-01	7.730E-02	1.155E-02	6.882E-03	1.320E-03	2.284E-03	1.499E-02	1.336E-12
336	CDDCCCB BBBBAA	1.000E+00	4.745E-01	4.052E-01	2.402E-01	3.489E-02	1.234E-02	1.795E-03	5.685E-03	4.295E-02	1.118E-12
337	EHECACBBBAAA	1.000E+00	7.944E-02	6.096E-02	4.612E-02	2.349E-02	3.298E-03	1.519E-03	3.873E-03	2.281E-02	1.061E-12
338	CFDCCDCBDCAA	1.000E+00	2.386E-01	1.787E-01	1.378E-01	9.622E-02	1.456E-02	5.565E-03	2.461E-02	9.738E-02	1.056E-12
339	CFDCACBBBCAA	1.000E+00	1.380E-01	1.113E-01	5.136E-02	4.402E-03	6.350E-03	1.542E-03	1.615E-03	6.152E-03	9.184E-13
340	DGDDDCBBDAAA	1.000E+00	4.332E-01	3.684E-01	2.149E-01	3.237E-02	1.107E-02	1.723E-03	5.204E-03	3.938E-02	8.275E-13
341	CFDDDCBBD BAB	1.000E+00	1.293E-01	7.713E-02	4.005E-02	6.317E-03	1.590E-04	1.007E-03	1.022E-03	5.016E-03	8.170E-13
342	CGDDDCBBD BAA	1.000E+00	1.887E-01	1.218E-01	5.509E-02	2.245E-03	7.899E-04	1.657E-04	1.970E-04	2.360E-03	7.984E-13
343	DDCDDCBBD AAC	1.000E+00	2.043E-02	1.520E-03	8.613E-04	5.092E-04	7.743E-05	2.933E-05	1.296E-04	5.165E-04	6.573E-13
344	CGCDDCBBD CAB	1.000E+00	6.826E-02	3.783E-02	9.678E-03	2.037E-04	1.081E-04	4.898E-06	9.255E-06	3.254E-04	5.895E-13
345	DGDDDCBBD AAB	1.000E+00	1.691E-01	1.052E-01	3.593E-02	3.370E-03	9.769E-05	3.675E-04	3.790E-04	2.709E-03	5.582E-13
346	CFDCCCBBB CAA	1.000E+00	1.254E-01	7.911E-02	2.801E-02	4.220E-03	4.517E-03	1.133E-03	1.135E-03	5.568E-03	3.970E-13
347	EHECCCBBBAAA	1.000E+00	6.520E-02	4.328E-02	5.347E-02	3.567E-03	3.926E-08	1.710E-04	1.838E-04	2.225E-03	3.948E-13
348	CGCDDCBBDCAA	1.000E+00	6.748E-02	3.820E-02	8.975E-03	1.716E-04	4.700E-05	2.215E-06	2.982E-06	2.701E-04	3.511E-13
349	DDCDDCBBD AAD	1.000E+00	1.050E-01	5.475E-02	4.773E-02	9.739E-03	2.183E-03	4.366E-04	1.622E-03	1.083E-02	3.224E-13
350	EHDCACBBBAAA	1.000E+00	8.544E-02	6.572E-02	4.622E-02	2.089E-02	3.591E-03	8.774E-04	3.482E-03	2.173E-02	2.426E-13
351	CGDCCCBBB BAA	1.000E+00	8.349E-01	8.329E-01	8.284E-01	8.224E-01	1.698E-01	8.838E-02	5.605E-01	8.224E-01	2.124E-13
352	CFADDCBBD CAC	1.000E+00	2.190E-01	1.624E-01	1.227E-01	8.496E-02	1.286E-02	4.914E-03	2.173E-02	8.598E-02	1.957E-13
353	CFDCCDCBDCAB	1.000E+00	6.807E-02	3.705E-02	1.223E-02	3.266E-04	3.191E-04	1.419E-05	3.052E-05	5.108E-04	1.603E-13
354	CGADDCBBD CAC	1.000E+00	2.386E-01	1.787E-01	1.396E-01	1.008E-01	1.458E-02	6.972E-03	2.585E-02	1.006E-01	1.304E-13
355	DFDDDCBBD AAB	1.000E+00	1.156E-01	6.479E-02	2.142E-02	5.729E-04	5.577E-04	2.489E-05	5.344E-05	8.940E-04	1.106E-13
356	EHDCCCB BBBAAA	1.000E+00	4.377E-02	1.583E-02	2.311E-02	6.845E-04	5.077E-09	2.971E-05	3.325E-05	4.073E-04	9.869E-14
357	CGDDDCBBD CAB	1.000E+00	7.405E-02	4.046E-02	9.144E-03	1.821E-04	5.307E-05	2.496E-06	3.362E-06	2.721E-04	6.606E-14
358	CDCDDCBBD BAD	1.000E+00	8.056E-02	4.654E-02	1.191E-02	2.405E-04	5.101E-05	3.137E-06	4.061E-06	3.740E-04	6.564E-14
359	CGDDDCBBD CAA	1.000E+00	7.405E-02	4.046E-02	9.144E-03	1.821E-04	5.307E-05	2.496E-06	3.362E-06	2.721E-04	5.074E-14
360	EGDCCCB BBBAAA	1.000E+00	3.595E-02	1.560E-02	1.543E-02	2.629E-06	3.522E-07	2.556E-07	9.770E-07	2.566E-06	3.691E-14

Table C.4 Isotope Inventories for Four Time Windows (Bq)

Radionuclide	Window 1 48 hr	Window 2 120 hr	Window 3 288 hr	Window 4 768 hr	MACCS Group
KR-88	1.6E+13	3.75E+05	0.00E+00	0.00E+00	1
KR-87	6.2E+06	0.00E+00	0.00E+00	0.00E+00	1
XE-133	4.8E+18	3.36E+18	1.76E+18	9.68E+16	1
XE-135	2.9E+17	1.48E+15	0.00E+00	0.00E+00	1
KR-85	1.8E+16	1.73E+16	1.73E+16	1.72E+16	1
KR-85M	4.4E+14	6.41E+09	0.00E+00	0.00E+00	1
I-132	2.5E+18	1.33E+18	4.60E+17	4.27E+15	2
I-131	2.3E+18	1.76E+18	1.14E+18	1.72E+17	2
I-133	1.1E+18	1.02E+17	1.86E+15	4.26E+07	2
I-134	7.7E+02	0.00E+00	0.00E+00	0.00E+00	2
I-135	3.3E+16	1.73E+13	0.00E+00	0.00E+00	2
CS-136	8.1E+16	6.90E+16	5.29E+16	1.65E+16	3
CS-137	1.8E+17	1.81E+17	1.81E+17	1.80E+17	3
CS-134	2.1E+17	2.12E+17	2.11E+17	2.07E+17	3
RB-86	3.1E+15	2.82E+15	2.34E+15	1.03E+15	3
TE-127	2.2E+17	1.42E+17	7.86E+16	2.78E+16	4
TE-127M	3.2E+16	3.21E+16	3.14E+16	2.75E+16	4
SB-127	2.0E+17	1.14E+17	4.63E+16	8.81E+14	4
SB-129	3.8E+14	3.68E+09	0.00E+00	0.00E+00	4
TE-131M	1.3E+17	2.37E+16	1.48E+15	7.47E+09	4
TE-132	2.4E+18	1.29E+18	4.47E+17	4.14E+15	4
TE-129	7.7E+16	7.23E+16	6.52E+16	4.14E+16	4
TE-129M	1.2E+17	1.11E+17	1.00E+17	6.36E+16	4
SR-90	1.3E+17	1.34E+17	1.34E+17	1.34E+17	5
SR-91	1.0E+17	5.26E+14	0.00E+00	0.00E+00	5
SR-92	1.7E+13	1.68E+05	0.00E+00	0.00E+00	5
SR-89	2.6E+18	2.54E+18	2.37E+18	1.75E+18	5

Table C.4 (Continued)

Radionuclide	Window 1 48 hr	Window 2 120 hr	Window 3 288 hr	Window 4 768 hr	MACCS Group
CO-58	2.26E+16	2.19E+16	2.06E+16	1.69E+16	6
CO-60	1.76E+16	1.76E+16	1.75E+16	1.74E+16	6
RU-103	3.8E+18	3.57E+18	3.27E+18	2.22E+18	6
TC-99M	2.8E+18	1.32E+18	3.74E+17	1.46E+15	6
MO-99	2.9E+18	1.37E+18	3.88E+17	1.52E+15	6
RU-105	1.5E+15	1.94E+10	0.00E+00	0.00E+00	6
RH-105	1.1E+18	2.60E+17	2.48E+16	7.92E+11	6
RU-106	9.2E+17	9.13E+17	9.04E+17	8.68E+17	6
LA-140	4.6E+18	4.03E+18	3.12E+18	9.53E+17	7
AM-241	2.90E+14	2.90E+14	2.90E+14	2.90E+14	7
CM-242	3.14E+16	3.11E+16	3.01E+16	2.77E+16	7
CM-244	1.86E+15	1.86E+15	1.85E+15	1.85E+15	7
ND-147	1.6E+18	1.29E+18	9.44E+17	2.38E+17	7
LA-141	1.0E+15	3.11E+09	0.00E+00	0.00E+00	7
LA-142	2.2E+09	0.00E+00	0.00E+00	0.00E+00	7
PR-143	4.0E+18	3.50E+18	2.74E+18	8.94E+17	7
Y-93	1.5E+17	1.11E+15	0.00E+00	0.00E+00	7
Y-92	1.2E+15	9.48E+08	0.00E+00	0.00E+00	7
ZR-95	4.4E+18	4.25E+18	4.02E+18	3.17E+18	7
NB-95	4.4E+18	4.36E+18	4.33E+18	4.06E+18	7
ZR-97	6.2E+17	3.26E+16	2.37E+14	9.34E+04	7
Y-91	3.4E+18	3.27E+18	3.08E+18	2.37E+18	7
Y-90	1.4E+17	1.36E+17	1.35E+17	1.34E+17	7
PU-239	7.1E+14	7.11E+14	7.14E+14	7.15E+14	8
PU-241	2.0E+17	2.04E+17	2.04E+17	2.04E+17	8
PU-240	8.9E+14	8.94E+14	8.94E+14	8.94E+14	8
PU-238	2.8E+15	2.77E+15	2.78E+15	2.81E+15	8
CE-144	2.6E+18	2.56E+18	2.53E+18	2.39E+18	8

Table C.4 (Continued)

Radionuclide	Window 1 48 hr	Window 2 120 hr	Window 3 288 hr	Window 4 768 hr	MACCS Group
CE-143	1.5E+18	3.36E+17	2.70E+16	4.13E+11	8
NP-239	2.9E+19	1.20E+19	2.76E+18	4.27E+15	8
CE-141	4.3E+18	4.07E+18	3.66E+18	2.29E+18	8
BA-140	4.2E+18	3.58E+18	2.73E+18	8.28E+17	9
BA-139	1.8E+08	0.00E+00	0.00E+00	0.00E+00	9

Table C.5 Equivalent I-131 Inventory for Four Time Windows (Bq)

Window 1	Window 2	Window 3	Window 4
3.55E+15	1.85E+15	9.50E+14	6.59E+13
1.85E+15	1.02E+17	5.27E+16	3.48E+15
9.50E+14	5.27E+16	5.85E+16	4.19E+15
6.59E+13	3.48E+15	4.19E+15	4.96E+15
2.59E+17	1.35E+17	6.90E+16	5.94E+15
3.08E+17	1.61E+17	8.23E+16	8.24E+15
2.90E+17	1.53E+17	7.86E+16	9.51E+15
5.08E+17	2.66E+17	1.34E+17	1.53E+16
4.36E+17	2.33E+17	1.21E+17	1.96E+16
2.64E+17	1.46E+17	8.06E+16	2.15E+16
3.59E+17	1.99E+17	1.11E+17	3.04E+16
5.27E+17	2.97E+17	1.68E+17	5.27E+16
6.23E+17	3.55E+17	2.03E+17	6.84E+16
9.92E+17	5.73E+17	3.26E+17	1.15E+17
1.22E+18	7.07E+17	4.06E+17	1.50E+17
1.75E+18	1.02E+18	5.94E+17	2.33E+17
2.88E+18	1.71E+18	9.87E+17	3.98E+17
3.69E+18	2.32E+18	1.46E+18	6.68E+17
5.62E+18	3.44E+18	2.08E+18	9.05E+17
7.34E+18	4.48E+18	2.72E+18	1.25E+18
1.17E+19	7.53E+18	4.82E+18	2.31E+18
1.76E+19	1.21E+19	8.25E+18	4.14E+18
2.62E+19	1.88E+19	1.35E+19	7.03E+18
2.91E+19	2.09E+19	1.49E+19	7.80E+18
4.53E+19	3.04E+19	2.05E+19	1.04E+19

Table C.6 Numbers of Latent Health Effects Predicted in the LH Weight Calculations

MACCS Radionuclide Group	Window 1	Window 2	Window 3	Window 4	Average Source Term
Xe	3.98E-01	2.23E-01	1.17E-01	6.53E-03	0.77
I	3.99E+01	2.97E+01	2.02E+01	3.74E+00	0.165
Cs	6.04E+02	6.03E+02	6.02E+02	6.02E+02	0.133
Te	4.37E+01	2.44E+01	9.84E+00	1.34E+00	0.075
Sr	3.57E+01	3.53E+01	3.46E+01	3.30E+01	0.02
Ru	2.96E+01	2.88E+01	2.79E+01	2.53E+01	0.004
La	3.01E+01	2.92E+01	2.78E+01	2.31E+01	0.002
Ce	1.21E+02	1.19E+02	1.17E+02	1.14E+02	0.006
Ba	5.64E+01	4.91E+01	3.89E+01	1.46E+01	0.02

Table C.7 Windows Inventories Relative to Inventory of Window 1

	Window 1	Window 2	Window 3	Window 4
Xe	1	0.664	0.349	0.022
I	1	0.538	0.271	0.030
Cs	1	0.973	0.936	0.848
Te	1	0.556	0.239	0.051
Sr	1	0.928	0.870	0.655
Ru	1	0.648	0.432	0.269
La	1	0.901	0.794	0.510
Ce	1	0.509	0.243	0.130
Ba	1	0.851	0.648	0.197

Appendix C Source Term Analysis

Table C.8 Preliminary Partitioning of Source Terms With Non-Zero Early Fatalities and Non-Zero Latent Fatalities

Number of Source Terms					Log EH (mid-point)
				33	0.34
	24	27	24	18	-0.72
	60	17	4	6	-1.25

Table C.9 Final Partitioning of Source Terms with Non-Zero Early Fatalities and Non-Zero Latent Fatalities

Number of Source Terms					Log EH (mid-point)
				57	0.34
		44	28		-0.72
	84				-1.25
Log LH (mid-point)	3.64	3.82	4.00	4.17	
ST Group	22	23	24	25	

Table C.10 Partitioning of Source Terms with Zero Early Fatalities and Non-Zero Latent Fatalities

4047	121	163	177	225	265	310	322	315	276	393	439	547	735	826	1036	946	1187	1109	1001	800	# of STs
-30	0.10	0.27	0.45	0.63	0.81	0.98	1.16	1.34	1.52	1.69	1.87	2.05	2.22	2.40	2.58	2.76	2.93	3.11	3.29	3.47	Log LH
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	ST

Table C.11 Release Fractions for 25 Mean Source Term Partition Groups

Group	Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba
1	1.57E-02	1.36E-04	6.58E-07	3.20E-07	6.28E-08	6.77E-09	5.80E-09	1.26E-08	5.74E-08
2	9.91E-01	4.29E-03	8.92E-05	2.48E-05	1.86E-06	2.82E-07	1.54E-07	4.89E-07	1.99E-06
3	9.83E-01	7.77E-03	1.51E-04	4.45E-05	2.11E-06	3.55E-07	1.67E-07	4.21E-07	2.28E-06
4	9.49E-01	1.07E-02	2.98E-04	1.15E-04	9.12E-06	2.07E-06	7.48E-07	2.23E-06	9.91E-06
5	9.29E-01	1.46E-02	4.50E-04	1.98E-04	1.62E-05	3.76E-06	8.78E-07	2.57E-06	1.80E-05
6	9.62E-01	2.03E-02	8.04E-04	4.01E-04	7.87E-05	1.03E-05	8.06E-06	1.42E-05	7.33E-05
7	8.45E-01	2.03E-02	1.86E-03	5.11E-04	3.87E-05	9.81E-06	2.49E-06	4.71E-06	4.26E-05
8	9.82E-01	4.76E-02	1.47E-03	9.09E-04	2.01E-04	1.66E-05	2.01E-05	2.76E-05	1.68E-04
9	9.61E-01	3.42E-02	4.04E-03	2.54E-03	3.91E-04	3.69E-05	4.67E-05	6.00E-05	3.30E-04
10	4.28E-01	2.35E-02	8.49E-03	9.90E-04	8.05E-05	1.14E-05	6.12E-06	1.04E-05	9.77E-05
11	6.48E-01	2.90E-02	1.21E-02	2.17E-03	1.21E-04	4.14E-05	1.29E-05	1.67E-05	1.37E-04
12	7.61E-01	4.41E-02	2.22E-02	4.47E-03	2.22E-04	3.54E-05	1.30E-05	3.36E-05	2.70E-04
13	7.67E-01	5.20E-02	2.90E-02	6.79E-03	4.04E-04	1.23E-04	2.67E-05	4.90E-05	4.67E-04
14	9.22E-01	7.50E-02	4.44E-02	1.97E-02	1.61E-03	7.80E-04	8.72E-05	2.56E-04	2.20E-03
15	8.38E-01	1.08E-01	6.51E-02	1.91E-02	1.00E-03	1.82E-04	4.69E-05	6.20E-05	1.01E-03
16	8.57E-01	1.47E-01	1.00E-01	3.49E-02	2.13E-03	4.96E-04	1.36E-04	2.59E-04	2.33E-03
17	9.91E-01	1.95E-01	1.49E-01	9.38E-02	9.79E-03	1.96E-03	5.58E-04	1.00E-03	9.01E-03
18	9.78E-01	2.11E-01	1.82E-01	1.06E-01	3.34E-02	2.41E-03	3.67E-03	4.70E-03	2.68E-02
19	9.96E-01	3.74E-01	2.93E-01	1.63E-01	3.51E-02	4.67E-03	2.41E-03	6.14E-03	3.24E-02
20	1.00E+00	5.27E-01	5.07E-01	2.05E-01	2.46E-02	3.67E-03	1.91E-03	4.24E-03	2.24E-02
21	1.00E+00	6.16E-01	5.82E-01	3.48E-01	1.28E-01	1.31E-02	1.24E-02	2.41E-02	1.14E-01
22	1.00E+00	5.97E-01	5.58E-01	4.95E-01	3.22E-01	3.96E-02	3.98E-02	5.71E-02	2.98E-01
23	1.00E+00	5.82E-01	5.92E-01	6.66E-01	5.61E-01	4.40E-02	1.01E-01	1.10E-01	5.24E-01
24	1.00E+00	6.29E-01	6.44E-01	6.65E-01	6.05E-01	7.52E-02	1.10E-01	1.66E-01	5.92E-01
25	1.00E+00	8.87E-01	8.86E-01	8.81E-01	8.86E-01	1.70E-01	9.25E-02	6.03E-01	8.86E-01

APPENDIX D

SUPPORTING INFORMATION FOR THE CONSEQUENCE ANALYSIS

 

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Appendix D

This appendix contains the input data files used in the MACCS calculations. The original files taken from the NUREG-1150 Surry study were modified where needed to reflect the specifics of the LP/SD study.

D.1 ATMOS Input File

```
* GENERAL DESCRIPTIVE TITLE DESCRIBING THIS "ATMOS" INPUT
RIATNAM1001 'SURRY ATMOS INPUT FOR FINAL NUREG-1150 CALCULATIONS'
* FLAG TO INDICATE THAT THIS IS THE LAST PROGRAM IN THE SERIES TO BE RUN
*
OCENDAT1001 .FALSE. (SET THIS VALUE TO .TRUE. TO SKIP EARLY AND CHRONC)
*****
* GEOMETRY DATA BLOCK, LOADED BY INPGEO, STORED IN /GEOM/
*
* NUMBER OF RADIAL SPATIAL ELEMENTS
*
GENUMRAD001 26
*
* SPATIAL ENDPOINT DISTANCES IN MILES
*
*   END001      0.25      0.5      0.75      1.0      1.5
*   END002      2.0      2.5      3.0      3.5      5.0
*   END003      7.0      10      13      16      20
*   END004      25      30      40      50      70
*   END005     100     150     200     350     500
*   END006    1000
*
GESPAEND001      .16      .52      1.21      1.61      2.13
GESPAEND002      3.22      4.02      4.83      5.63      8.05
GESPAEND003     11.27     16.09     20.92     25.75     32.19
GESPAEND004     40.23     48.28     64.37     80.47    112.65
GESPAEND005    160.93    241.14    321.87    563.27    804.67
GESPAEND006   1609.34
*****
* NUCLIDE DATA BLOCK, LOADED BY INPISO, STORED IN /ISOGRP/, /ISONAM/
*
* NUMBER OF NUCLIDES
*
ISNUMISO001 60
*
* NUMBER OF NUCLIDE GROUPS
*
ISMAXGRP001 9
*
* WET AND DRY DEPOSITION FLAGS FOR EACH NUCLIDE GROUP
*
*           WETDEP      DRYDEP
*
ISDEPFLA001  .FALSE.   .FALSE.
ISDEPFLA002  .TRUE.    .TRUE.
ISDEPFLA003  .TRUE.    .TRUE.
```


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ISDEPFLA004 .TRUE. .TRUE.
 ISDEPFLA005 .TRUE. .TRUE.
 ISDEPFLA006 .TRUE. .TRUE.
 ISDEPFLA007 .TRUE. .TRUE.
 ISDEPFLA008 .TRUE. .TRUE.
 ISDEPFLA009 .TRUE. .TRUE.

*

* NUCLIDE GROUP DATA FOR 9 NUCLIDE GROUPS

*

	NUCNAM	PARENT	IGROUP	HAFLIF
ISOTPGRP001	CO-58	NONE	6	6.160E+06
ISOTPGRP002	CO-60	NONE	6	1.660E+08
ISOTPGRP003	KR-85	NONE	1	3.386E+08
ISOTPGRP004	KR-85M	NONE	1	1.613E+04
ISOTPGRP005	KR-87	NONE	1	4.560E+03
ISOTPGRP006	KR-88	NONE	1	1.008E+04
ISOTPGRP007	RB-86	NONE	3	1.611E+06
ISOTPGRP008	SR-89	NONE	5	4.493E+06
ISOTPGRP009	SR-90	NONE	5	8.865E+08
ISOTPGRP010	SR-91	NONE	5	3.413E+04
ISOTPGRP011	SR-92	NONE	5	9.756E+03
ISOTPGRP012	Y-90	SR-90	7	2.307E+05
ISOTPGRP013	Y-91	SR-91	7	5.080E+06
ISOTPGRP014	Y-92	SR-92	7	1.274E+04
ISOTPGRP015	Y-93	NONE	7	3.636E+04
ISOTPGRP016	ZR-95	NONE	7	5.659E+06
ISOTPGRP017	ZR-97	NONE	7	6.048E+04
ISOTPGRP018	NB-95	ZR-95	7	3.033E+06
ISOTPGRP019	MO-99	NONE	6	2.377E+05
ISOTPGRP020	TC-99M	MO-99	6	2.167E+04
ISOTPGRP021	RU-103	NONE	6	3.421E+06
ISOTPGRP022	RU-105	NONE	6	1.598E+04
ISOTPGRP023	RU-106	NONE	6	3.188E+07
ISOTPGRP024	RH-105	RU-105	6	1.278E+05
ISOTPGRP025	SB-127	NONE	4	3.283E+05
ISOTPGRP026	SB-129	NONE	4	1.562E+04
ISOTPGRP027	TE-127	SB-127	4	3.366E+04
ISOTPGRP028	TE-127M	NONE	4	9.418E+06
ISOTPGRP029	TE-129	SB-129	4	4.200E+03
ISOTPGRP030	TE-129M	NONE	4	2.886E+06
ISOTPGRP031	TE-131M	NONE	4	1.080E+05
ISOTPGRP032	TE-132	NONE	4	2.808E+05
ISOTPGRP033	I-131	TE-131M	2	6.947E+05
ISOTPGRP034	I-132	TE-132	2	8.226E+03
ISOTPGRP035	I-133	NONE	2	7.488E+04
ISOTPGRP036	I-134	NONE	2	3.156E+03
ISOTPGRP037	I-135	NONE	2	2.371E+04
ISOTPGRP038	XE-133	I-133	1	4.571E+05
ISOTPGRP039	XE-135	I-135	1	3.301E+04
ISOTPGRP040	CS-134	NONE	3	6.501E+07
ISOTPGRP041	CS-136	NONE	3	1.123E+06
ISOTPGRP042	CS-137	NONE	3	9.495E+08
ISOTPGRP043	BA-139	NONE	9	4.986E+03
ISOTPGRP044	BA-140	NONE	9	1.105E+06
ISOTPGRP045	LA-140	BA-140	7	1.448E+05

NEW

NEW

NEW

NEW

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ISOTPGRP046	LA-141	NONE	7	1.418E+04	NEW
ISOTPGRP047	LA-142	NONE	7	5.724E+03	NEW
ISOTPGRP048	CE-141	LA-141	8	2.811E+06	PARENT ADDED
ISOTPGRP049	CE-143	NONE	8	1.188E+05	
ISOTPGRP050	CE-144	NONE	8	2.457E+07	
ISOTPGRP051	PR-143	CE-143	7	1.173E+06	
ISOTPGRP052	ND-147	NONE	7	9.495E+05	
ISOTPGRP053	NP-239	NONE	8	2.030E+05	
ISOTPGRP054	PU-238	CM-242	8	2.809E+09	
ISOTPGRP055	PU-239	NP-239	8	7.700E+11	
ISOTPGRP056	PU-240	CM-244	8	2.133E+11	
ISOTPGRP057	PU-241	NONE	8	4.608E+08	
ISOTPGRP058	AM-241	PU-241	7	1.366E+10	
ISOTPGRP059	CM-242	NONE	7	1.408E+07	
ISOTPGRP060	CM-244	NONE	7	5.712E+08	

* WET DEPOSITION DATA BLOCK, LOADED BY INPWET, STORED IN /WETCON/

*

* WASHOUT COEFFICIENT NUMBER ONE, LINEAR FACTOR

*

WDCWASH1001 9.5E-5 (HELTON AFTER JONES, 1986)

*

* WASHOUT COEFFICIENT NUMBER TWO, EXPONENTIAL FACTOR

*

WDCWASH2001 0.8 (HELTON AFTER JONES, 1986)

* DRY DEPOSITION DATA BLOCK, LOADED BY INPDY, STORED IN /DRYCON/

*

* NUMBER OF PARTICLE SIZE GROUPS

*

DDNPSGRP001 1

*

* DEPOSITION VELOCITY OF EACH PARTICLE SIZE GROUP (M/S)

*

DDVDEPOS001 0.01 (VALUE SELECTED BY S. ACHARYA, NRC)

* DISPERSION PARAMETER DATA BLOCK, LOADED BY INPDIS, STORED IN /DISPY/, /DISPZ/

*

* SIGMA = A X ** B WHERE A AND B VALUES ARE FROM TADMOR AND GUR (1969)

*

* LINEAR TERM OF THE EXPRESSION FOR SIGMA-Y, 6 STABILITY CLASSES

*

* STABILITY CLASS: A B C D E F

*

DPCYSIGA001 0.3658 0.2751 0.2089 0.1474 0.1046 0.0722

*

* EXPONENTIAL TERM OF THE EXPRESSION FOR SIGMA-Y, 6 STABILITY CLASSES

*

* STABILITY CLASS: A B C D E F

*

DPCYSIGB001 .9031 .9031 .9031 .9031 .9031 .9031

*

* LINEAR TERM OF THE EXPRESSION FOR SIGMA-Z, 6 STABILITY CLASSES

*

* STABILITY CLASS: A B C D E F

*

Appendix D Supporting Information for the Consequence Analysis

```

DPCZSIGA001  2.5E-4  1.9E-3      .2      .3      .4      .2
*
* EXPONENTIAL TERM OF THE EXPRESSION FOR SIGMA-Z, 6 STABILITY CLASSES
*
* STABILITY CLASS; A      B      C      D      E      F
*
DPCZSIGB001  2.125  1.6021  .8543  .6532  .6021  .6020
*
* LINEAR SCALING FACTOR FOR SIGMA-Y FUNCTION, NORMALLY 1
*
DPYSCALE001  1.
*
* LINEAR SCALING FACTOR FOR SIGMA-Z FUNCTION,
* NORMALLY USED FOR SURFACE ROUGHNESS LENGTH CORRECTION.
* (Z1 / Z0) ** 0.2, FROM CRAC2 WE HAVE (10 CM / 3 CM) ** 0.2 = 1.27
*
DPZSCALE001  1.27
*****
*
* EXPANSION FACTOR DATA BLOCK, LOADED BY INPEXP, STORED IN /EXPAND/
*
* TIME BASE FOR EXPANSION FACTOR (SECONDS)
*
PMTIMBAS001  600.  (10 MINUTES)
*
* BREAK POINT FOR FORMULA CHANGE (SECONDS)
*
PMBRKPNT001  3600.  (1 hour)
*
* EXPONENTIAL EXPANSION FACTOR NUMBER 1
*
PMXPFAC1001  0.2
*
* EXPONENTIAL EXPANSION FACTOR NUMBER 2
*
PMXPFAC2001  0.25
*****
*
* PLUME RISE DATA BLOCK, LOADED BY INPLRS, STORED IN /PLUMRS/
*
* SCALING FACTOR FOR THE CRITICAL WIND SPEED FOR ENTRAINMENT OF A BOUYANT PLUME
* (USED BY FUNCTION CAUGHT)
*
PRSCLCRW001  1.
*
* SCALING FACTOR FOR THE A-D STABILITY PLUME RISE FORMULA
* (USED BY FUNCTION PLMRIS)
*
PRSCLDAP001  1.
*
* SCALING FACTOR FOR THE E-F STABILITY PLUME RISE FORMULA
* (USED BY FUNCTION PLMRIS)
*
PRSCLEFP001  1.
*****
*
* WAKE EFFECTS DATA BLOCK, LOADED BY INPWAK, STORED IN /BILWAK/
*

```

Appendix D Supporting Information for the Consequence Analysis

```

*      SITE      GG  PB  SEQ  SUR
*      WIDTH  (M) 40  50  40  40
*      HEIGHT (M) 60  50  40  50
*
* BUILDING WIDTH (METERS)
*
WEBUILDW001  40.  *  SURRY
*
* BUILDING HEIGHT (METERS)
*
WEBUILDH001  50.  *  SURRY
*
* 3412 MWTH PWR CORE INVENTORY, END-OF-CYCLE
*      SUPPLIED BY D.E. BENNETT, 5/14/86
*      replaced by SURRY LP/SD specific data
*      LPSD Window 1 inventory (48 hours) 12/7/93
*
*
*      NUCNAM      CORINV(BQ)
*
RDCORINV001  CO-58      2.260E+16
RDCORINV002  CO-60      1.760E+16
RDCORINV003  KR-85      1.762E+16
RDCORINV004  KR-85M     4.410E+14
RDCORINV005  KR-87      6.194E+06
RDCORINV006  KR-88      1.618E+13
RDCORINV007  RB-86      3.148E+15
RDCORINV008  SR-89      2.647E+18
RDCORINV009  SR-90      1.343E+17
RDCORINV010  SR-91      1.006E+17
RDCORINV011  SR-92      1.669E+13
RDCORINV012  Y-90       1.383E+17
RDCORINV013  Y-91       3.383E+18
RDCORINV014  Y-92       1.211E+15
RDCORINV015  Y-93       1.548E+17
RDCORINV016  ZR-95      4.385E+18
RDCORINV017  ZR-97      6.246E+17
RDCORINV018  NB-95      4.362E+18
RDCORINV019  MO-99      2.916E+18
RDCORINV020  TC-99M     2.807E+18
RDCORINV021  RU-103     3.770E+18
RDCORINV022  RU-105     1.480E+15
RDCORINV023  RU-106     9.183E+17
RDCORINV024  RH-105     1.067E+18
RDCORINV025  SB-127     1.955E+17
RDCORINV026  SB-129     3.818E+14
RDCORINV027  TE-127     2.179E+17
RDCORINV028  TE-127M    3.229E+16
RDCORINV029  TE-129     7.733E+16
RDCORINV030  TE-129M    1.181E+17
RDCORINV031  TE-131M    1.252E+17
RDCORINV032  TE-132     2.449E+18
RDCORINV033  I-131      2.258E+18
RDCORINV034  I-132      2.525E+18
RDCORINV035  I-133      1.118E+18
RDCORINV036  I-134      7.748E+02

```

Appendix D Supporting Information for the Consequence Analysis

RDCORINV037	I-135	3.292E+16
RDCORINV038	XE-133	4.784E+18
RDCORINV039	XE-135	2.885E+17
RDCORINV040	CS-134	2.130E+17
RDCORINV041	CS-136	8.081E+16
RDCORINV042	CS-137	1.807E+17
RDCORINV043	BA-139	1.805E+08
RDCORINV044	BA-140	4.207E+18
RDCORINV045	LA-140	4.581E+18
RDCORINV046	LA-141	1.015E+15
RDCORINV047	LA-142	2.155E+09
RDCORINV048	CE-141	4.336E+18
RDCORINV049	CE-143	1.525E+18
RDCORINV050	CE-144	2.577E+18
RDCORINV051	PR-143	3.966E+18
RDCORINV052	ND-147	1.558E+18
RDCORINV053	NP-239	2.905E+19
RDCORINV054	PU-238	2.758E+15
RDCORINV055	PU-239	7.071E+14
RDCORINV056	PU-240	8.936E+14
RDCORINV057	PU-241	2.042E+17
RDCORINV058	AM-241	2.900E+14
RDCORINV059	CM-242	3.140E+16
RDCORINV060	CM-244	1.860E+15

*

RDCORSCA001 1.0

*

* PARTICLE SIZE DISTRIBUTION OF EACH NUCLIDE GROUP

* YOU MUST SPECIFY A COLUMN OF DATA FOR EACH OF THE PARTICLE SIZE GROUPS

*

RDPSDIST001	1.
RDPSDIST002	1.
RDPSDIST003	1.
RDPSDIST004	1.
RDPSDIST005	1.
RDPSDIST006	1.
RDPSDIST007	1.
RDPSDIST008	1.
RDPSDIST009	1.

* OUTPUT CONTROL DATA BLOCK, LOADED BY INPOPT, STORED IN /ATMOPT/

*

OCIDEBUG001 0

*

* NAME OF THE NUCLIDE TO BE LISTED ON THE DISPERSION LISTINGS

*

OCNUCOUT001 CS-137

* METEOROLOGICAL SAMPLING DATA BLOCK

*

* METEOROLOGICAL SAMPLING OPTION CODE:

*

* METCOD = 1, USER SPECIFIED DAY AND HOUR IN THE YEAR (FROM MET FILE),

*

2, WEATHER CATEGORY BIN SAMPLING,

*

3, 120 HOURS OF WEATHER SPECIFIED ON THE ATMOS USER INPUT FILE,

*

4, CONSTANT MET (BOUNDARY WEATHER USED FROM THE START),

Appendix D Supporting Information for the Consequence Analysis

* 5, STRATIFIED RANDOM SAMPLES FOR EACH DAY OF THE YEAR.
*
M1METCOD001 2
M3ISTRDY001 1
M3ISTRHR001 1
*
* LAST SPATIAL INTERVAL FOR MEASURED WEATHER
*
M2LIMSPA001 25
*
* BOUNDARY WEATHER, NO RAIN, WIND SPEED = 0.5 M/S, A-STABILITY,
* MIXING HEIGHT = 1000 M, APPLIES TO THE LAST SPATIAL INTERVAL
* (500 - 1000 MILES)
*
* BOUNDARY WEATHER MIXING LAYER HEIGHT
*
M2BNDMXH001 1000. (METERS)
*
* BOUNDARY WEATHER STABILITY CLASS INDEX
*
M2IBDSTB001 1 (A-STABILITY)
*
* BOUNDARY WEATHER RAIN RATE
*
M2BNDRAN001 0. (0 MM / HOUR = NO RAIN)
*
* BOUNDARY WEATHER WIND SPEED
*
M2BNDWND001 0.5 (M / S)
*
* NUMBER OF SAMPLES PER BIN
*
M4NSMPLS001 4 (THIS NUMBER SHOULD BE SET TO 4 FOR RISK ASSESSMENT)
*
* NUMBER OF RAIN DISTANCE INTERVALS FOR BINNING
*
M4NRNINT001 6
*
* ENDPOINTS OF THE RAIN DISTANCE INTERVALS (KILOMETERS)
*
* NOTE: THESE MUST BE CHOSEN TO MATCH THE SPATIAL ENDPOINT DISTANCES
* SPECIFIED FOR THE ARRAY SPAEND (10 % ERROR IS ALLOWED).
*
* 2.0 3.5 7.0 13.0 25.0 50.0 MILES
*
M4RNDSTS001 3.22 5.63 11.27 20.92 40.23 80.47 KM
*
* NUMBER OF RAIN INTENSITIY BREAKPOINTS
*
M4NRINTN001 3
*
* RAIN INTENSITY BREAKPOINTS FOR WEATHER BINNING (MILLIMETERS PER HOUR)
*
M4RRNRATE001 1. 2. 3.
*
* INITIAL SEED FOR RANDOM NUMBER GENERATOR

Appendix D Supporting Information for the Consequence Analysis

*

M4IRSEED001 1

***** RELEASE DATA BLOCK *****

*

* WARNING TIME

*

* 1 hr based on similarity to V-sequence in 1150

RDOALARM001 3.6E+3

*

* SELECTION OF RISK DOMINANT PLUME

*

RDMAXRIS001 1

*

* REFERENCE TIME FOR DISPERSION AND RADIOACTIVE DECAY

*

RDREFTIM001 0. .5

*

* NUMBER OF PLUME SEGMENTS THAT ARE RELEASED

*

RDNUMREL001 1

*

* HEAT CONTENT OF THE RELEASE SEGMENTS (W)

* A VALUE SPECIFIED FOR EACH OF THE RELEASE SEGMENTS

*

RDPLHEAT001 0.0

*

* HEIGHT OF THE PLUME SEGMENTS AT RELEASE (M)

* A VALUE SPECIFIED FOR EACH OF THE RELEASE SEGMENTS

*

* 12/7/93 hatch elevation: 27'5" approx. 8.4 m

RDPLHITE001 8.4

*

* DURATION OF THE PLUME SEGMENTS (S)

* A VALUE SPECIFIED FOR EACH OF THE RELEASE SEGMENTS

*

RDPLUDUR001 21600.

*

* TIME OF RELEASE FOR EACH PLUME (S AFTER SCRAM)

* A VALUE SPECIFIED FOR EACH OF THE RELEASE SEGMENTS

*

* start of release 2hr based on MELCOR calculations

RDPDELAY001 7.2E+3

*

* RELEASE FRACTIONS FOR ISOTOPE GROUPS IN RELEASE

* 25 Source Term Groups from Partitioning

*

RDATNAM2001 'Group 1'

*

	Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba
RDRELFR001	1.6E-2	1.4E-4	6.6E-7	3.2E-7	6.3E-8	6.8E-9	5.8E-9	1.3E-8	5.7E-8

RDATNAM2001 'Group 2'

*

	Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba
RDRELFR001	9.9E-1	4.3E-3	8.9E-5	2.5E-5	1.9E-6	2.8E-7	1.5E-7	4.9E-7	2.0E-6

RDATNAM2001 'Group 3'

Appendix D Supporting Information for the Consequence Analysis

* Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba	
RDRELFRC001	9.8E-1	7.8E-3	1.5E-4	4.4E-5	2.1E-6	3.5E-7	1.7E-7	4.2E-7	2.3E-6
RDATNAM2001	'Group 4'								
* Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba	
RDRELFRC001	9.5E-1	1.1E-2	3.0E-4	1.2E-4	9.1E-6	2.1E-6	7.5E-7	2.2E-6	9.9E-6
RDATNAM2001	'Group 5'								
* Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba	
RDRELFRC001	9.3E-1	1.5E-2	4.5E-4	2.0E-4	1.6E-5	3.8E-6	8.8E-7	2.6E-6	1.8E-5
RDATNAM2001	'Group 6'								
* Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba	
RDRELFRC001	9.6E-1	2.0E-2	8.0E-4	4.0E-4	7.9E-5	1.0E-5	8.1E-6	1.4E-5	7.3E-5
RDATNAM2001	'Group 7'								
* Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba	
RDRELFRC001	8.4E-1	2.0E-2	1.9E-3	5.1E-4	3.9E-5	9.8E-6	2.5E-6	4.7E-6	4.3E-5
RDATNAM2001	'Group 8'								
* Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba	
RDRELFRC001	9.8E-1	4.8E-2	1.5E-3	9.1E-4	2.0E-4	1.7E-5	2.0E-5	2.8E-5	1.7E-4
RDATNAM2001	'Group 9'								
* Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba	
RDRELFRC001	9.6E-1	3.4E-2	4.0E-3	2.5E-3	3.9E-4	3.7E-5	4.7E-5	6.0E-5	3.3E-4
RDATNAM2001	'Group 10'								
* Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba	
RDRELFRC001	4.3E-1	2.3E-2	8.5E-3	9.9E-4	8.1E-5	1.1E-5	6.1E-6	1.0E-5	9.8E-5
RDATNAM2001	'Group 11'								
* Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba	
RDRELFRC001	6.5E-1	2.9E-2	1.2E-2	2.2E-3	1.2E-4	4.1E-5	1.3E-5	1.7E-5	1.4E-4
RDATNAM2001	'Group 12'								
* Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba	
RDRELFRC001	7.6E-1	4.4E-2	2.2E-2	4.5E-3	2.2E-4	3.5E-5	1.3E-5	3.4E-5	2.7E-4
RDATNAM2001	'Group 13'								
* Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba	
RDRELFRC001	7.7E-1	5.2E-2	2.9E-2	6.8E-3	4.0E-4	1.2E-4	2.7E-5	4.9E-5	4.7E-4
RDATNAM2001	'Group 14'								
* Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba	
RDRELFRC001	9.2E-1	7.5E-2	4.4E-2	2.0E-2	1.6E-3	7.8E-4	8.7E-5	2.6E-4	2.2E-3
RDATNAM2001	'Group 15'								
* Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba	
RDRELFRC001	8.4E-1	1.1E-1	6.5E-2	1.9E-2	1.0E-3	1.8E-4	4.7E-5	6.2E-5	1.0E-3
RDATNAM2001	'Group 16'								
* Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba	
RDRELFRC001	8.6E-1	1.5E-1	1.0E-1	3.5E-2	2.1E-3	5.0E-4	1.4E-4	2.6E-4	2.3E-3
RDATNAM2001	'Group 17'								

Appendix D Supporting Information for the Consequence Analysis

*	Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba
RDRELFRC001	9.9E-1	1.9E-1	1.5E-1	9.4E-2	9.8E-3	2.0E-3	5.6E-4	1.0E-3	9.0E-3
.									
RDATNAM2001	'Group 18'								
*	Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba
RDRELFRC001	9.8E-1	2.1E-1	1.8E-1	1.1E-1	3.3E-2	2.4E-3	3.7E-3	4.7E-3	2.7E-2
.									
RDATNAM2001	'Group 19'								
*	Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba
RDRELFRC001	1.0E+00	3.7E-1	2.9E-1	1.6E-1	3.5E-2	4.7E-3	2.4E-3	6.1E-3	3.2E-2
.									
RDATNAM2001	'Group 20'								
*	Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba
RDRELFRC001	1.0E+00	5.3E-1	5.1E-1	2.1E-1	2.5E-2	3.7E-3	1.9E-3	4.2E-3	2.2E-2
.									
RDATNAM2001	'Group 21'								
*	Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba
RDRELFRC001	1.0E+00	6.2E-1	5.8E-1	3.5E-1	1.3E-1	1.3E-2	1.2E-2	2.4E-2	1.1E-1
.									
RDATNAM2001	'Group 22'								
*	Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba
RDRELFRC001	1.0E+00	6.0E-1	5.6E-1	4.9E-1	3.2E-1	4.0E-2	4.0E-2	5.7E-2	3.0E-1
.									
RDATNAM2001	'Group 23'								
*	Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba
RDRELFRC001	1.0E+00	5.8E-1	5.9E-1	6.7E-1	5.6E-1	4.4E-2	1.0E-1	1.1E-1	5.2E-1
.									
RDATNAM2001	'Group 24'								
*	Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba
RDRELFRC001	1.0E+00	6.3E-1	6.4E-1	6.7E-1	6.0E-1	7.5E-2	1.1E-1	1.7E-1	5.9E-1
.									
RDATNAM2001	'Group 25'								
*	Xe	I	Cs	Te	Sr	Ru	La	Ce	Ba
RDRELFRC001	1.0E+00	8.9E-1	8.9E-1	8.8E-1	8.9E-1	1.7E-1	9.3E-2	6.0E-1	8.9E-1

D.2 EARLY Input File

```

* GENERAL DESCRIPTIVE TITLE DESCRIBING THIS "EARLY" INPUT FILE
* Modified for MACCS Version 1.5.11.1
MIEANAM1001 'SURRY EARLY INPUT FOR FINAL NUREG-1150 CALCULATIONS'
*
* FLAG TO INDICATE THAT THIS IS THE LAST PROGRAM IN THE SERIES TO BE RUN
*
MIENDAT2001 .FALSE.      (SET THIS VALUE TO .TRUE. TO SKIP CHRONC)
*
* DISPERSION MODEL OPTION CODE:  1 * STRAIGHT LINE
*                                2 * WIND-SHIFT WITH ROTATION
*                                3 * WIND-SHIFT WITHOUT ROTATION
*
MIIPLUME001  2
*
* NUMBER OF FINE GRID SUBDIVISIONS USED BY THE MODEL
*
MINUMFIN001  7      (3, 5 OR 7 ALLOWED)
*
* LEVEL OF DEBUG OUTPUT REQUIRED, NORMAL RUNS SHOULD SPECIFY ZERO
*
MIIPRINT001  0
*
* FLAG INDICATING IF WIND-ROSES FROM ATMOS ARE TO BE OVERRIDDEN
*
MIOVRRID001 .FALSE.  (USE THE WIND ROSE CALCULATED FOR EACH WEATHER BIN)
*
* LOGICAL FLAG SIGNIFYING THAT THE BREAKDOWN OF RISK BY WEATHER CATEGORY
* BIN ARE TO BE PRESENTED TO SHOW THEIR RELATIVE CONTRIBUTION TO THE MEAN
*
*           RISBIN
*
MIRISCAT001 .FALSE.
*****
* POPULATION DISTRIBUTION DATA BLOCK, LOADED BY INOPU, STORED IN /POPDAT/
*
PDPOPFLG001 FILE
*
*****
* ORGAN DEFINITION DATA BLOCK, LOADED BY INORGA, STORED IN /EARDIM/ AND /ORGNAM/
*
* NUMBER OF ORGANS DEFINED FOR HEALTH EFFECTS
*
*****
* SHIELDING AND EXPOSURE FACTORS, LOADED BY INDFAC, STORED IN /EADFAC/
*
* THREE VALUES OF EACH PROTECTION FACTOR ARE SUPPLIED,
* ONE FOR EACH TYPE OF ACTIVITY:
*
* ACTIVITY TYPE:
*   1 - EVACUEES WHILE MOVING
*   2 - NORMAL ACTIVITY IN SHELTERING AND EVACUATION ZONE
*   3 - SHELTERED ACTIVITY
*

```

Appendix D Supporting Information for the Consequence Analysis

* CLOUD SHIELDING FACTOR

*
 * SITE GG PB SEQ SUR ZION
 * SHELTERING 0.7 0.5 0.65 0.6 0.5
 *

* EVACUEES NORMAL SHELTER
 *

SECSFACT001 1. 0.75 0.6 * SURRY SHELTERING VALUE
 *

* PROTECTION FACTOR FOR INHALATION

*
 * SEPROTIN001 1. 0.41 0.33 * VALUES FOR NORMAL ACTIVITY AND
 * SHELTERING SELECTED BY S. ACHARYA, NRC
 *

* BREATHING RATE (CUBIC METERS PER SECOND)

*
 * SEBRRATE001 2.66E-4 2.66E-4 2.66E-4
 *

* SKIN PROTECTION FACTOR

*
 * SESKPFAC001 1.0 0.41 0.33 * VALUES FOR NORMAL ACTIVITY AND
 * SHELTERING SELECTED BY S. ACHARYA, NRC
 *

* GROUND SHIELDING FACTOR

*
 * SITE GG PB SEQ SUR ZION
 * SHELTERING 0.25 0.1 0.2 0.2 0.1
 *

SEGSHFAC001 0.5 0.33 0.2 * VALUE FOR NORMAL ACTIVITY SELECTED BY
 * S. ACHARYA, NRC; SURRY SHELTERING VALUE
 *

* RESUSPENSION INHALATION MODEL CONCENTRATION COEFFICIENT (/METER)

*
 * RESCON = 1.E-4 IS APPROPRIATE FOR MECHANICAL RESUSPENSION BY VEHICLES.
 * RESHAF = 2.11 DAYS CAUSES 1.E-4 TO DECAY IN ONE WEEK TO 1.E-5, THE VALUE
 * OF RESCON USED IN THE FIRST TERM OF THE LONG-TERM RESUSPENSION EQUATION
 * USED IN CHRONC.
 *

SERESCON001 1.E-4 (RESUSPENSION IS TURNED ON)
 *

* RESUSPENSION CONCENTRATION COEFFICIENT HALF-LIFE (SEC)

*
 * SERESHAF001 1.82E5 (2.11 DAYS)
 *

* EVACUATION ZONE DATA BLOCK, LOADED BY EVNETW, STORED IN /NETWORK/, /EOPTIO/
 *

* THE TYPE OF WEIGHTING TO BE APPLIED TO THE EMERGENCY RESPONSE SCENARIOS
 * YOU MUST SUPPLY A VALUE OF 'TIME' OR 'PEOPLE'
 *

EZWTNAME001 'TIME'
 *

*
 * SITE GG PB SEQ SUR
 * CLDELAY (HR) 0.75 1.0 1.8 1.5
 * ESPEED (M/S) 3.7 4.8 1.4 1.8
 *

* EDELAY = CLDELAY + 0.5 HR

Appendix D Supporting Information for the Consequence Analysis

```

*
*      CLDELAY = DELAY BETWEEN WARNING OF PUBLIC TO BEGIN EVACUATION AND
*                TIME EVACUATION ACTUALLY BEGINS; VALUES USED ARE DEVELOPED
*                FROM SITE-SPECIFIC CLEAR TIME STUDIES
*
*      0.5 HR = MEAN (EXPECTED) TIME FROM GENERAL EMERGENCY
*                CONDITIONS TO WARNING OF PUBLIC (SIRENS, BROADCAST)
*
*      RADIAL EVACUATION SPEED (M/S)
*
EZESPEED001      1.8      *   SURRY
*
*      DURATION OF THE EMERGENCY PHASE (SECONDS FROM PLUME ARRIVAL)
*
SRENDEMP001      604800.  (ONE WEEK)
*
*      CRITICAL ORGAN FOR RELOCATION DECISIONS
*
SRCRIORG001      'EDEWBODY'
*
*      HOT SPOT RELOCATION TIME (SECONDS FROM PLUME ARRIVAL)
*
SRTIMHOT001      43200.   (ONE-HALF DAY)
*
*      NORMAL RELOCATION TIME (SECONDS FROM PLUME ARRIVAL)
*
SRTIMNRM001      86400.   (ONE DAY)
*
*      HOT SPOT RELOCATION DOSE CRITERION THRESHOLD (SIEVERTS)
*
SRDOSHOT001      0.5      (50 REM DOSE TO WHOLE BODY IN 1 WEEK TRIGGERS RELOCATION)
*
*      NORMAL RELOCATION DOSE CRITERION THRESHOLD (SIEVERTS)
*
SRDOSNRM001      0.25     (25 REM DOSE TO WHOLE BODY IN 1 WEEK TRIGGERS RELOCATION)
*****
*****
*      RESULT 1 OPTIONS BLOCK, LOADED BY INOUT1, STORED IN /INOUT1/
*      TOTAL NUMBER OF A GIVEN EFFECT (LATENT CANCER, EARLY DEATH, EARLY INJURY)
*
*      NUMBER OF DESIRED RESULTS OF THIS TYPE
*
TYPE1NUMBER      2
*
TYPE1OUT001      'ERL FAT/TOTAL'          1  19 (50 MILES)
TYPE1OUT002      'CAN FAT/TOTAL'          1  19 CCDF
*****
*      RESULT 2 OPTIONS BLOCK, LOADED BY INOUT2, STORED IN /INOUT2/
*      FURTHEST DISTANCE AT WHICH A GIVEN RISK OF EARLY DEATH IS EXCEEDED.
*
*      NUMBER OF DESIRED RESULTS OF THIS TYPE
*
TYPE2NUMBER      0
*****
*      RESULT 3 OPTIONS BLOCK, LOADED BY INOUT3, STORED IN /INOUT3/

```

Appendix D Supporting Information for the Consequence Analysis

* NUMBER OF PEOPLE WHOSE ACUTE DOSE TO A GIVEN ORGAN EXCEEDS A GIVEN THRESHOLD.
*
* NUMBER OF DESIRED RESULTS OF THIS TYPE
*

TYPE3NUMBER 0

* RESULT 4 OPTIONS BLOCK, LOADED BY INOUT4, STORED IN /INOUT4/
* 360 DEGREE AVERAGE RISK OF A GIVEN EFFECT AT A GIVEN DISTANCE.
* NUMBER OF DESIRED RESULTS OF THIS TYPE
*

TYPE4NUMBER 0

* RESULT 5 OPTIONS BLOCK, LOADED BY INOUT5, STORED IN /INOUT5/
*
* TOTAL POPULATION DOSE TO A GIVEN ORGAN BETWEEN TWO DISTANCES.
*
* NUMBER OF DESIRED RESULTS OF THIS TYPE
*

TYPE5NUMBER 1

TYPE5OUT001 'EDEWBODY' 1 19 CCDF (0-50 MILES)

* RESULT 6 OPTIONS BLOCK, LOADED BY INOUT6, STORED IN /INOUT6/
*
* CENTERLINE DOSE TO AN ORGAN VS DIST BY PATHWAY, PATHWAY NAMES ARE AS FOLLOWS:
* NUMBER OF DESIRED RESULTS OF THIS TYPE
*

TYPE6NUMBER 0

* RESULT 7 OPTIONS BLOCK, LOADED BY INOUT7, STORED IN /INOUT7/
*
* CENTERLINE RISK OF A GIVEN EFFECT VS DISTANCE
*
* NUMBER OF DESIRED RESULTS OF THIS TYPE
*

TYPE7NUMBER 0

* RESULT 8 OPTIONS BLOCK, LOADED BY INOUT8, STORED IN /INOUT8/
*
* POPULATION WEIGHTED FATALITY RISK BETWEEN 2 DISTANCES
*
* NUMBER OF DESIRED RESULTS OF THIS TYPE
*

TYPE8NUMBER 0

* copied from in2a.inp for MACCS Version 1.5.11.1
* EARLY FATALITY MODEL PARAMETERS, LOADED BY INEFAT, STORED IN /EFATAL/
*
* NUMBER OF EARLY FATALITY EFFECTS
*

EFNUMEFA001 3

*

	ORGNAM	EFFACA	EFFACB	EFFTHR
--	--------	--------	--------	--------

*

EFATAGRP001	'RED MARR'	3.8	5.0	1.5
EFATAGRP002	'LUNGS'	10.0	7.0	5.0

Appendix D Supporting Information for the Consequence Analysis

```

EFATAGRP003 'LOWER LI'      15.0      10.0      8.0
*****
* EARLY INJURY MODEL PARAMETERS, LOADED BY INEINJ, STORED IN /EINJUR/
*
* NUMBER OF EARLY INJURY EFFECTS
*
EINUM EIN001 7
*
*          EINAME          ORGNAM   EISUSC EITHRE EIFACA EIFACB
*
EINJUGRP001 'PRODROMAL VOMIT' 'STOMACH' 1.      .5      2.      3.
EINJUGRP002 'DIARRHEA'      'STOMACH' 1.      1.      3.      2.5
EINJUGRP003 'PNEUMONITIS'   'LUNGS'  1.      5.     10.      7.
EINJUGRP004 'SKIN ERYTHEMA'  'SKIN'   1.      3.      6.      5.
EINJUGRP005 'TRANSEPIDERMAL' 'SKIN'   1.     10.     20.      5.
EINJUGRP006 'THYROIDITIS'   'THYROIDH' 1.    40.    240.      2.
EINJUGRP007 'HYPOTHYROIDISM' 'THYROIDH' 1.      2.     60.     1.3
*****
* ACUTE EXPOSURE CANCER PARAMETERS, LOADED BY INACAN STORED IN /ACANCR/.
*
* NUMBER OF ACUTE EXPOSURE CANCER EFFECTS
*
LCNUM ACA001 7
*
* THRESHOLD DOSE FOR APPLYING THE DOSE DEPENDENT REDUCTION FACTOR
*
LCDDTHRE001 0.2 (LOWEST DOSE FOR WHICH DDREFA WILL BE APPLIED)
*
* DOSE THRESHOLD FOR LINEAR DOSE RESPONSE (SV)
*
LCACTHRE001 0.0 (LINEAR-QUADRATIC MODEL IS NOT BEING USED)
*
*          ACNAME          ORGNAM   ACSUSC DOSEFA DOSEFB CFRISK      CIRISK  DDREFA
*
LCANCERS001 'LEUKEMIA'      'RED MARR' 1.0    1.0    0.0    9.70E-3  9.70E-3  2.0
LCANCERS002 'BONE'          'BONE SUR' 1.0    1.0    0.0    9.00E-4  9.00E-4  2.0
LCANCERS003 'BREAST'        'BREAST'   1.0    1.0    0.0    5.40E-3  1.59E-2  1.0
LCANCERS004 'LUNG'          'LUNGS'    1.0    1.0    0.0    1.55E-2  1.73E-2  2.0
LCANCERS005 'THYROID'      'THYROIDH' 1.0    1.0    0.0    7.20E-4  7.20E-3  1.0
LCANCERS006 'GI'           'LOWER LI' 1.0    1.0    0.0    3.36E-2  5.75E-2  2.0
LCANCERS007 'OTHER'        'BLAD WAL' 1.0    1.0    0.0    2.76E-2  5.52E-2  2.0
ODNUM ORG001 10
*
* NAMES OF THE ORGANS DEFINED FOR HEALTH EFFECTS
*
ODORGNAM001 'SKIN', 'EDEWBODY', 'LUNGS', 'RED MARR', 'LOWER LI', 'STOMACH',
ODORGNAM002 'THYROIDH', 'BONE SUR', 'BREAST', 'BLAD WAL'
*****
*          EMERGENCY RESPONSE SCENARIO
*
EZEANAM2001 'EVACUATION WITHIN 10 MILES'
*
* FRACTION OF THE TIME THIS SCENARIO AFFECTS
*
EZWTFRAC001 .995
*

```

Appendix D Supporting Information for the Consequence Analysis

```
* LAST RING IN THE MOVEMENT ZONE
*
EZLASMOV001      15
*
* FIRST SPATIAL INTERVAL IN THE EVACUATION ZONE
*
EZINIEVA001      1  (NO INNER SHELTER ZONE)
*
* DISTANCE INTERVALS OF THE THREE EVACUATION ZONES
*
EZLASEVA001      0   0   12
*
* EVAC DELAY TIMES FOR THE THREE EVAC DELAY RINGS:
* TIME FOR PEOPLE TO GET MOVING AFTER BEING WARNED
*
EZEDELAY001      0.  0.   7200.
*****
*              SHELTER RESPONSE DEFINITION
*
* TIME TO TAKE SHELTER (INNER SHELTER ZONE) (S)
*
SRTTOSH1001      0.
*
* SHELTER DURATION (INNER SHELTER ZONE) (S)
*
SRSHELT1001      0.
*
* LAST RING (OUTER SHELTER ZONE)
*
SRLASHE2001      0
*
* TIME TO TAKE SHELTER (OUTER SHELTER ZONE) (S)
*
SRTTOSH2001      0.
*
* SHELTER DURATION (OUTER SHELTER ZONE) (S)
*
SRSHELT2001      0.
*
*****
*              EMERGENCY RESPONSE SCENARIO
*
EZEANAM2001      'NO EVACUATION'
*
* FRACTION OF THE TIME THIS SCENARIO AFFECTS
*
EZWTFRAC001      0.005
*
* LAST RING IN THE MOVEMENT ZONE
*
EZLASMOV001      0
*
* FIRST SPATIAL INTERVAL IN THE EVACUATION ZONE
*
EZINIEVA001      1  (NO INNER SHELTER ZONE)
*
```

Appendix D Supporting Information for the Consequence Analysis

* DISTANCE INTERVALS OF THE THREE EVACUATION ZONES

*

EZLASEVA001 0 0 0

*

* EVAC DELAY TIMES FOR THE THREE EVAC DELAY RINGS:

* TIME FOR PEOPLE TO GET MOVING AFTER BEING WARNED

*

EZEDELAY001 0. 0. 0.

*

SHELTER RESPONSE DEFINITION

*

* TIME TO TAKE SHELTER (INNER SHELTER ZONE) (S)

*

SRTTOSH1001 0.

*

* SHELTER DURATION (INNER SHELTER ZONE) (S)

*

SRSHELT1001 0.

*

* LAST RING (OUTER SHELTER ZONE)

*

SRLASHE2001 0

*

* TIME TO TAKE SHELTER (OUTER SHELTER ZONE) (S)

*

SRTTOSH2001 0.

*

* SHELTER DURATION (OUTER SHELTER ZONE) (S)

*

SRSHELT2001 0.

.

Appendix D Supporting Information for the Consequence Analysis

D.3 CHRONC Input File

```
* GENERAL DESCRIPTIVE TITLE DESCRIBING THIS "CHRONC" INPUT FILE
* Foodchain related data are copied from file IN3A.INP, MACCS Version 1.5.11.1
CHCHNAME001 'SURRY CHRONC INPUT FOR FINAL NUREG-1150 CALCULATIONS'
*****
* EMERGENCY RESPONSE COST DATA BLOCK
*
* EVACUATION COST (DOLLARS/PERSON-DAY)
*
CHEVACST001 27.00
*
* RELOCATION DOST (DOLLARS/PERSON-DAY)
*
CHRELCST001 27.00
*****
* LONG TERM PROTECTIVE ACTION DATA BLOCK
*
* END OF THE INTERMEDIATE PHASE PERIOD (SECONDS FROM ACCIDENT INITIATION)
*
CHTMIPND001 604800. (7 DAYS, NO INTERMEDIATE PHASE)
*
* ACTION PERIOD (PROJECTION PERIOD) FROM THE START OF THE LONG TERM PHASE,
* THE POINT AT WHICH THE LONG TERM DOSE CRITERION IS EVALUATED (SECONDS)
*
CHTMPACT001 1.58E8 (5 YEARS)
*
* DOSE CRITERION FOR INTERMEDIATE PHASE RELOCATION (SV)
*
CHDSCRTI001 1.0E5 (NO INTERMEDIATE PHASE RELOCATION)
*
* DOSE CRITERION FOR LONG TERM PHASE RELOCATION (SV)
*
CHDSCRLT001 0.04 (2 REM IN FIRST YEAR, 0.5 REM PER YEAR FOR YRS 2 - 5)
*
* CRITICAL ORGAN NAME FOR LONG-TERM ACTIONS
*
CHCRTOCR001 'EDEWBODY'
*
*****
* DECONTAMINATION PLAN DATA BLOCK
*
* NUMBER OF LEVELS OF DECONTAMINATION
*
CHLVLDEC001 2
*
* DECONTAMINATION TIMES CORRESPONDING TO THE LVLDEC LEVELS OF DECONTAMINATION
* (SECONDS)
*
CHTIMDEC001 5.184E6 1.0368E7 (60, 120 DAYS)
*
* DOSE REDUCTION FACTORS CORRESPONDING TO THE LVLDEC LEVELS OF DECONTAMINATION
*
CHDSRFCT001 3. 15.
*
```

Appendix D Supporting Information for the Consequence Analysis

* COST OF FARM DECONTAMINATION PER UNIT AREA (DOLLARS/HECTARE)
* FOR THE VARIOUS LEVELS OF DECONTAMINATION

CHCDFRM0001 562.5 1250.

* COST OF NONFARM DECONTAMINATION PER PERSON
* FOR THE VARIOUS LEVELS OF DECONTAMINATION (DOLLARS/PERSON)

CHCDNFRM001 3000. 8000.

* FRACTION OF FARMLAND DECONTAMINATION COST DUE TO LABOR
* FOR THE VARIOUS DECONTAMINATION LEVELS

CHFRFDL0001 .3 .35

* FRACTION OF NON-FARM DECONTAMINATION COST DUE TO LABOR
* FOR THE VARIOUS DECONTAMINATION LEVELS

CHFRNFDL001 .7 .5

* FRACTION OF TIME WORKERS IN FARM AREAS SPEND IN DECONTAMINATION WORK
* FOR THE VARIOUS DECONTAMINATION LEVELS

CHTFWKFO001 .10 .33

* FRACTION OF TIME WORKERS IN NON-FARM AREAS SPEND IN DECONTAMINATION WORK
* FOR THE VARIOUS DECONTAMINATION LEVELS

CHTFWKNF001 .33 .33

* AVERAGE COST OF DECONTAMINATION LABOR (DOLLARS/MAN-YEAR)

CHDLBCST001 35000.

* INTERDICTION COST DATA BLOCK

* DEPRECIATION RATE DURING INTERDICTION PERIOD (PER YEAR)

CHDPRATE001 .20

* SOCIETAL DISCOUNT RATE DURING INTERDICTION PERIOD (PER YEAR)

CHDSRATE001 .12

* URBAN POPULATION REMOVAL COST (DOLLARS/PERSON)

CHPOPCST001 5000.

* GROUNDSHINE WEATHERING DEFINITION DATA BLOCK

* NUMBER OF TERMS IN THE GROUNDSHINE WEATHERING RELATIONSHIP (EITHER 1 OR 2)

CHNGWTRM001 2

* GROUNDSHINE WEATHERING COEFFICIENTS

Appendix D Supporting Information for the Consequence Analysis

```

CHGWCOEF001  0.5    0.5                (GAYLE'S EQUATION)
*
* HALF LIVES CORRESPONDING TO THE GROUND SHINE WEATHERING COEFFICIENTS (S)
*
CHTGWHLF001  1.6E7  2.8E9                (GAYLE'S EQUATION)
*****
* RESUSPENSION WEATHERING DEFINITION DATA BLOCK
*
* NUMBER OF TERMS IN THE RESUSPENSION WEATHERING RELATIONSHIP
*
CHNRWTRM001    3
*
* RESUSPENSION CONCENTRATION COEFFICIENTS (/ METER)
* RELATIONSHIP BETWEEN GROUND CONCENTRATION AND INSTANTANEOUS AIR CONC.
*
CHRWCOEF001  1.0E-5  1.0E-7  1.0E-9
*
* HALF-LIVES CORRESPONDING TO THE RESUSPENSION CONCENTRATION COEFFICIENTS (S)
*
CHTRWHLF001  1.6E7  1.6E8  1.6E9 (6 MONTHS, 5 YEARS, 50 YEARS)
*****
* SITE REGION DESCRIPTION DATA BLOCK
*
* FRACTION OF AREA THAT IS LAND IN THE REGION
*
CHFRACLD001  1.0E-35 (VALUE NOT USED SINCE SITE FILE PROVIDED)
*
* FRACTION OF LAND DEVOTED TO FARMING IN THE REGION
*
CHFRCFRM001  1.0E-35 (VALUE NOT USED SINCE SITE FILE PROVIDED)
*
* AVERAGE VALUE OF ANNUAL FARM PRODUCTION IN THE REGION (DOLLARS/HECTARE)
* (CASH RECEIPTS FROM FARMING PLUS VALUE OF HOME CONSUMPTION)/(LAND IN FARMS)
*
CHFRMPRD001  0.      (VALUE NOT USED SINCE SITE FILE PROVIDED)
*
* FRACTION OF FARM PRODUCTION RESULTING FROM DAIRY PRODUCTION IN THE REGION
* (VALUE OF MILK PRODUCED)/(CASH RECEIPTS FROM FARMING PLUS VALUE OF HOME...)
*
CHDPFRCT001  0.      (VALUE NOT USED SINCE SITE FILE PROVIDED)
*
* VALUE OF FARM WEALTH (DOLLARS/HECTARE)
* (AVERAGE VALUE PER HECTARE OF FARM LAND AND BUILDINGS TO 100 MILES)
*
* SITE          GG    LS    PB    SEQ    SUR    ZION
* VALWF ($/HECTARE) 2561 3305 3421 1855 2613 2897
*
CHVALWF0001  3975. * SURRY
*
* FRACTION OF FARM WEALTH IN IMPROVEMENTS FOR THE REGION
*
* SITE  GG    LS    PB    SEQ    SUR    ZION
* FRFIM 0.3   0.19 0.25 0.27 0.25 0.49
*
CHFRFIM0001  0.25 * SURRY
*

```

Appendix D Supporting Information for the Consequence Analysis

```

* NON-FARM WEALTH, PROPERTY AND IMPROVEMENTS FOR THE REGION (DOLLARS/PERSON)
* THE VALUE OF ALL RESIDENTIAL, BUSINESS, AND PUBLIC ASSETS WHICH WOULD BE
* LOST IN THE EVENT OF PERMANENT INTERDICTION OF THE AREA
*
* SITE          GG    PB    SUR  SEQ  ZION
* VALWNF ($K)  53    78    84   66   76
*
CHVALWNF001  123000.  *  SURRY  AGT  BNL  8-26-93
*
* FRACTION OF NON-FARM WEALTH IN IMPROVEMENTS FOR THE REGION
*
CHFRNFIM001   0.8
*****
* SPECIAL OPTIONS DATA BLOCK
*
* DETAILED PRINT OPTION CONTROL SWITCHES, LOOK AT THE CODE BEFORE TURNING ON!!
*   (KCEPNT, KDPEPNT, KDTPEPNT, KGCPNT, KLTPNT, KWTPNT, KSWRSK, KSWDSC)
*
CHKSWTCH001   0 0 0 0 0 0 0 0 0 0 0 0
*****
* WATER PATHWAY NUCLIDE DEFINITIONS FOR CHRONC
*
* NUMBER OF NUCLIDES IN THE WATER INGESTION PATHWAY MODEL
*
CHNUMWPI001    4
*
* TABLE OF NUCLIDE DEFINITIONS IN THE WATER INGESTION PATHWAY MODEL
* WATER PATHWAY NUCLIDES MUST BE A SUBSET OF THE INGESTION MODEL NUCLIDES
*
* IF A SITE DATA FILE IS DEFINED, THE DATA DEFINING THE WATERSHED INGESTION
* FACTOR IS SUPERSEDED BY THE CORRESPONDING DATA IN THE SITE DATA FILE
*
*   WINGF VALUES BY DRAINAGE SYSTEM
*   NUCLIDE      SR-89    SR-90    CS-134    CS-137
*   RIVER        5.0E-6    5.0E-6    5.0E-6    5.0E-6
*   GREAT LAKE   2.0E-7    2.0E-7    2.0E-6    4.0E-6
*   OCEAN        0.0      0.0      0.0      0.0
*
* ALL NUREG-1150 SITES HAVE RIVER DRAINAGE SYSTEMS EXCEPT LASALLE AND ZION
*
*
*           WATER          INITIAL    ANNUAL    INGESTION FACTOR
*           NUCLIDE        WASHOFF    WASHOFF    ((BQ INGESTED)/
*           (BQ IN WATER))
*
*           NAMWPI        WSHFRI        WSHRTA        WINGF
CHWTRIS0001  SR-89        0.01        0.004        5.0E-6
CHWTRIS0002  SR-90        0.01        0.004        5.0E-6
CHWTRIS0003  CS-134       0.005       0.001        5.0E-6
CHWTRIS0004  CS-137       0.005       0.001        5.0E-6
*****
* CROP PATHWAY DEFINITIONS FOR CHRONC
*
* MODIFIED 14 OCT 88, BY JLS, VALUES CHANGED TO THOSE DEVELOPED BY J. ROLLSTIN
*
* NUMBER OF DEFINED CROPS IN THE CHRONC FOOD INGESTION MODEL
*

```

Appendix D Supporting Information for the Consequence Analysis

CHNFICRP001 7 (UP TO 10 ALLOWED)

*
* NOTE TO USER: THE CODE MAKES SPECIAL TREATMENT OF CROP NAMES BEGINNING WITH
* 'PASTURE' DUE TO THE CONTINUOUS NATURE OF THE HARVESTING PROCESS.
*

* IF THE USER WISHES TO DEFINE A NEW CROP CATEGORY FOR RANGELAND PASTURE,
* IT SHOULD BE CALLED 'PASTURE-RANGE' OR 'PASTURE-DRY'
*

* TABLE OF CROP DEFINITIONS FOR THE CHRONC FOOD INGESTION MODEL
*

* FRACTION OF CROP CONSUMED BY
*

CROP NAME	MAN	DAIRY ANIMALS	MEAT ANIMALS
NAMCRP	FRCTCH	FRCTCM	FRCTCB
CHCRPTBL001 'PASTURE	' 0.0	0.1	0.9
CHCRPTBL002 'STORED FORAGE	' 0.0	0.13	0.87
CHCRPTBL003 'GRAINS	' 0.35	0.040	0.61
CHCRPTBL004 'GRN LEAFY VEGETABLES'	1.0	0.0	0.0
CHCRPTBL005 'OTHER FOOD CROPS	' 1.0	0.0	0.0
CHCRPTBL006 'LEGUMES AND SEEDS	' 0.24	0.046	0.714
CHCRPTBL007 'ROOTS AND TUBERS	' 1.0	0.0	0.0

* CHRONC INGESTION PATHWAY NUCLIDE DEFINITIONS
*

* NUMBER OF NUCLIDES IN THE CHRONC FOOD INGESTION MODEL
*

CHNFIIS0001 6 (UP TO 10 ALLOWED, BEWARE THAT DAUGHTER BUILDUP IS NOT TREATED)

* TABLE OF NUCLIDE DEFINITIONS IN THE CHRONC INGESTION PATHWAY MODEL
*

* NUCLIDES THAT WERE DEFINED IN THE WATER PATHWAY DATA ABOVE MUST BE
* A SUBSET OF THE CHRONC INGESTION FOOD PATHWAY NUCLIDES. THE WATER
* PATHWAY NUCLIDES MUST BE LISTED FIRST IN THIS DATA BLOCK AND IN THE
* SAME ORDER AS THEY WERE LISTED IN THE WATER PATHWAY DATA BLOCK
*

INGESTION NUCLIDE	RETENTION FACTORS PROCESSING AND DECAY		TRANSFER FACTORS [(BQ TRANSFERED)/ (BQ INGESTED)]	
	MILK/MAN	MEAT/MAN	MILK	MEAT
NAMIPI	DCYPMH	DCYPBH	TFMLK	TFBF
CHISODEF001 SR-89	0.66	0.77	0.022	0.00022
CHISODEF002 SR-90	1.0	1.0	0.022	0.00022
CHISODEF003 CS-134	1.0	1.0	0.11	0.023
CHISODEF004 CS-137	1.0	1.0	0.11	0.024
CHISODEF005 I-131	0.28	0.18	0.13	0.0024
CHISODEF006 I-133	0.002	0.0	0.062	0.0011

* TRANSFER FACTOR FROM SOIL TO PLANT BY ROOT-UP TAKE (AND BY SOIL INGESTION FOR
* GRAZING ON PASTURE) INTEGRATED OVER ALL TIME [(BQ TRANSFERED)/(BQ DEPOSITED)]
*

NUCLIDE	PASTURE	STORED FORAGE	GRAINS	GREEN	OTHER	LEGUMES	ROOTS
				LEAFY VEG	FOOD CROPS	AND SEEDS	AND TUBERS

Appendix D Supporting Information for the Consequence Analysis

* *	NAMISO	TCROOT	TCROOT	TCROOT	TCROOT	TCROOT	TCROOT	TCROOT
CHTCROOT001	SR-89	4.1E-4	1.3E-3	4.3E-5	1.7E-4	8.6E-6	3.7E-4	1.1E-4
CHTCROOT002	SR-90	2.6E-2	9.0E-2	3.3E-3	1.3E-2	6.6E-4	2.8E-2	8.4E-3
CHTCROOT003	CS-134	1.3E-3	7.1E-4	3.5E-5	1.4E-5	1.1E-4	9.3E-5	5.6E-5
CHTCROOT004	CS-137	6.9E-3	1.5E-3	7.6E-5	3.0E-5	2.3E-4	2.0E-4	1.2E-4
CHTCROOT005	I-131	1.6E-4	0.0	0.0	0.0	0.0	0.0	0.0
CHTCROOT006	I-133	1.7E-6	0.0	0.0	0.0	0.0	0.0	0.0

* RADIOACTIVE DECAY RETENTION FACTORS (I.E., 1 - F WHERE F = FRACTION OF
* RADIOACTIVITY LOST BY DECAY) FOR NUCLIDES IN CROPS FROM TIME OF HARVEST
* TO TIME OF CONSUMPTION BY HUMANS (FRACTION RETAINED)

* * *	NUCLIDE	PASTURE	STORED FORAGE	GRAINS	GREEN LEAFY VEG	OTHER FOOD CROPS	LEGUMES AND SEEDS	ROOTS AND TUBERS
* *	NAMISO	DCYPCH	DCYPCH	DCYPCH	DCYPCH	DCYPCH	DCYPCH	DCYPCH
CHDCYPCH001	SR-89	0.0	0.0	0.18	0.67	0.21	0.18	0.18
CHDCYPCH002	SR-90	0.0	0.0	0.99	1.0	0.99	0.99	0.99
CHDCYPCH003	CS-134	0.0	0.0	0.84	0.96	0.85	0.84	0.84
CHDCYPCH004	CS-137	0.0	0.0	0.99	1.0	0.99	0.99	0.99
CHDCYPCH005	I-131	0.0	0.0	0.0099	0.21	0.024	0.0099	0.0099
CHDCYPCH006	I-133	0.0	0.0	0.0	0.0	0.0	0.0	0.0

* CROP PROCESSING AND PREPARATION RETENTION FACTORS FOR NUCLIDES IN FOOD
* CROPS CONSUMED BY HUMANS (FRACTION RETAINED). FACTORS REFLECT LOSS OF
* NUCLIDES FROM FOODS DUE TO PROCESSING (E.G., WASHING OF FRUIT, PEELING
* OF POTATOES, LOSSES DURING CANNING) AND FOOD PREPARATION (COOKING) FROM
* THE TIME OF PROCESSING OF THE HARVESTED CROP TO THE TIME OF CONSUMPTION
* BY HUMANS. FACTORS DO NOT REFLECT LOSSES DUE TO RADIOACTIVE DECAY.

* * *	NUCLIDE	PASTURE	STORED FORAGE	GRAINS	GREEN LEAFY VEG	OTHER FOOD CROPS	LEGUMES AND SEEDS	ROOTS AND TUBERS
* *	NAMISO	FPLSCH	FPLSCH	FPLSCH	FPLSCH	FPLSCH	FPLSCH	FPLSCH
CHFPLSCH001	SR-89	0.0	0.0	0.25	0.5	0.71	0.8	0.8
CHFPLSCH002	SR-90	0.0	0.0	0.25	0.5	0.71	0.8	0.8
CHFPLSCH003	CS-134	0.0	0.0	0.25	0.5	0.71	0.8	0.8
CHFPLSCH004	CS-137	0.0	0.0	0.25	0.5	0.71	0.8	0.8
CHFPLSCH005	I-131	0.0	0.0	0.33	0.5	0.71	0.8	0.8
CHFPLSCH006	I-133	0.0	0.0	0.33	0.5	0.71	0.8	0.8

* RETENTION FACTORS FOR NUCLIDES IN CROPS FROM TIME OF HARVEST TO TIME OF
* CONSUMPTION BY MILK-PRODUCING ANIMALS (FRACTION RETAINED). FACTOR REFLECTS
* LOSSES DUE TO RADIOACTIVE DECAY.

* * *	NUCLIDE	PASTURE	STORED FORAGE	GRAINS	GREEN LEAFY VEG	OTHER FOOD CROPS	LEGUMES AND SEEDS	ROOTS AND TUBERS
* *	NAMISO	DCYPCM	DCYPCM	DCYPCM	DCYPCM	DCYPCM	DCYPCM	DCYPCM
CHDCYPCM001	SR-89	1.0	0.37	0.20	0.0	0.0	0.20	0.0
CHDCYPCM002	SR-90	1.0	0.99	0.99	0.0	0.0	0.99	0.0
CHDCYPCM003	CS-134	1.0	0.92	0.85	0.0	0.0	0.85	0.0

Appendix D Supporting Information for the Consequence Analysis

CHDCYPCM004	CS-137	1.0	0.99	0.99	0.0	0.0	0.99	0.0
CHDCYPCM005	I-131	1.0	0.063	0.032	0.0	0.0	0.032	0.0
CHDCYPCM006	I-133	1.0	0.0068	0.0034	0.0	0.0	0.0034	0.0

* RETENTION FACTORS FOR NUCLIDES IN CROPS FROM TIME OF HARVEST TO TIME OF
* CONSUMPTION BY MEAT-PRODUCING ANIMALS (FRACTION RETAINED). FACTOR REFLECTS
* LOSSES DUE TO RADIOACTIVE DECAY.

*

	NUCLIDE	PASTURE	STORED FORAGE	GRAINS	GREEN LEAFY VEG	OTHER FOOD CROPS	LEGUMES AND SEEDS	ROOTS AND TUBERS
--	---------	---------	------------------	--------	-----------------------	------------------------	-------------------------	------------------------

*

	NAMISO	DCYPCB	DCYPCB	DCYPCB	DCYPCB	DCYPCB	DCYPCB	DCYPCB
CHDCYPCB001	SR-89	1.0	0.37	0.20	0.0	0.0	0.20	0.0
CHDCYPCB002	SR-90	1.0	0.99	0.99	0.0	0.0	0.99	0.0
CHDCYPCB003	CS-134	1.0	0.92	0.85	0.0	0.0	0.85	0.0
CHDCYPCB004	CS-137	1.0	0.99	0.99	0.0	0.0	0.99	0.0
CHDCYPCB005	I-131	1.0	0.063	0.032	0.0	0.0	0.032	0.0
CHDCYPCB006	I-133	1.0	0.0068	0.0034	0.0	0.0	0.0034	0.0

* DEFINE THE DIRECT DEPOSITION TO CROPS TRANSFER FUNCTION

*

* NUMBER OF TERMS IN THE DIRECT DEPOSITION TO CROPS TRANSFER FUNCTION

*

CHNTRTRM001 2

*

* LOSSES DUE TO WEATHERING FROM PLANT SURFACES AND DURING TRANSLOCATION
* FROM PLANT SURFACES TO INTERIOR EDIBLE PORTIONS OF PLANTS ARE MODELLED
* USING THE FOLLOWING EQUATION:

*

* FRACTION RETAINED = CTCOE1*EXP(-LN2/CTHALF1) + CTCOE2*EXP(-LN2/CTHALF2)

*

* FOR PASTURE, STORED FORAGE, GREEN LEAFY VEGETABLES, AND OTHER FOOD CROPS,
* THIS EQUATION IS USED AS A TWO TERM WEATHERING EQUATION. FOR GRAINS,
* LEGUMES AND SEEDS, AND ROOTS AND TUBERS WHERE RADIOACTIVITY IS CONSUMED
* ONLY IF TRANSLOCATED TO EDIBLE PORTIONS OF THE PLANT, THIS EQUATION IS
* REDUCED TO A TRANSLOCATION TRANSFER FACTOR BY SETTING CTCOE2 TO ZERO,
* CTHALF2 TO ONE SECOND, AND CTHALF1 TO ABOUT ONE MILLION YEARS (1E13
* SECONDS). WHEN USED TO MODEL TRANSLOCATION, THE VALUE OF THE TRANSLOCATION
* TRANSFER FACTOR IS DEVELOPED FROM FALLOUT DATA AND IS INPUT AS THE VALUE
* OF CTCOE1.

*

* TWO TIME PERIODS ARE USED FOR WEATHERING, THE FIRST IS 14 DAYS LONG (1.21E6
* SECONDS) AND THE SECOND IS 50 DAYS LONG (4.32E6 SECONDS).

*

* DIRECT DEPOSITION TRANSFER COEFFICIENTS BY CHRONC INGESTION MODEL NUCLIDE
* ((BQ TRANSFERED)/(BQ DEPOSITED))

*

	TERM 1	NUCLIDE	PASTURE	STORED FORAGE	GRAINS	GREEN LEAFY VEG	OTHER FOOD CROPS	LEGUMES AND SEEDS	ROOTS AND TUBERS
CHCTCOEF101		SR-89	0.3	0.2	0.01	0.24	0.2	0.005	0.0006
CHCTCOEF102		SR-90	0.3	0.2	0.01	0.24	0.2	0.005	0.0006
CHCTCOEF103		CS-134	0.3	0.2	0.05	0.24	0.2	0.01	0.025
CHCTCOEF104		CS-137	0.3	0.2	0.05	0.24	0.2	0.01	0.025
CHCTCOEF105		I-131	0.3	0.2	0.0	0.24	0.2	0.0	0.0
CHCTCOEF106		I-133	0.3	0.2	0.0	0.24	0.2	0.0	0.0

Appendix D Supporting Information for the Consequence Analysis

* TERM 2

CHCTCOEF201	SR-89	0.076	0.05	0.0	0.06	0.05	0.0	0.0
CHCTCOEF202	SR-90	0.076	0.05	0.0	0.06	0.05	0.0	0.0
CHCTCOEF203	CS-134	0.076	0.05	0.0	0.06	0.05	0.0	0.0
CHCTCOEF204	CS-137	0.076	0.05	0.0	0.06	0.05	0.0	0.0
CHCTCOEF205	I-131	0.076	0.05	0.0	0.06	0.05	0.0	0.0
CHCTCOEF206	I-133	0.076	0.05	0.0	0.06	0.05	0.0	0.0

*

* CROP TRANSFER HALF-LIVES BY CHRONC INGESTION MODEL NUCLIDE (SECONDS)

*

* TERM 1	NUCLIDE	PASTURE	STORED FORAGE	GRAINS	GREEN	OTHER	LEGUMES	ROOTS
					LEAFY VEG	FOOD CROPS	AND SEEDS	AND TUBERS
CHCTHALF101	SR-89	1.21E6	1.21E6	1E13	1.21E6	1.21E6	1E13	1E13
CHCTHALF102	SR-90	1.21E6	1.21E6	1E13	1.21E6	1.21E6	1E13	1E13
CHCTHALF103	CS-134	1.21E6	1.21E6	1E13	1.21E6	1.21E6	1E13	1E13
CHCTHALF104	CS-137	1.21E6	1.21E6	1E13	1.21E6	1.21E6	1E13	1E13
CHCTHALF105	I-131	1.21E6	1.21E6	1.0	1.21E6	1.21E6	1.0	1.0
CHCTHALF106	I-133	1.21E6	1.21E6	1.0	1.21E6	1.21E6	1.0	1.0

* TERM2

CHCTHALF201	SR-89	4.32E6	4.32E6	1.0	4.32E6	4.32E6	1.0	1.0
CHCTHALF202	SR-90	4.32E6	4.32E6	1.0	4.32E6	4.32E6	1.0	1.0
CHCTHALF203	CS-134	4.32E6	4.32E6	1.0	4.32E6	4.32E6	1.0	1.0
CHCTHALF204	CS-137	4.32E6	4.32E6	1.0	4.32E6	4.32E6	1.0	1.0
CHCTHALF205	I-131	4.32E6	4.32E6	1.0	4.32E6	4.32E6	1.0	1.0
CHCTHALF206	I-133	4.32E6	4.32E6	1.0	4.32E6	4.32E6	1.0	1.0

* TABLE OF CROP DATA (GROWING SEASON AND FARMLAND SHARE) IN THE REGION.

*

* IF A SITE DATA FILE IS BEING USED (AS SPECIFIED ON THE EARLY USER INPUT FILE),
* THEN DATA FROM THE SITE FILE (AND NOT THE DATA BELOW) IS USED FOR THE
* CALCULATION OF DOSES AND COSTS FROM THE AGRICULTURE MODEL AND THE NUMBERS
* BELOW ARE IGNORED.

*

* IF A SITE DATA FILE IS NOT BEING USED, THE DATA BELOW IS USED IN ITS STEAD.

*

* FARMLAND SHARE VALUES (FRCTFL) BY SITE AND CROP CATEGORY

*

SITE	GG	LS	PB	SEQ	SUR	ZION
PASTURE	0.70	0.47	0.38	0.69	0.41	0.45
STORED FORAGE	0.05	0.10	0.13	0.006	0.13	0.11
GRAINS	0.18	0.26	0.23	0.16	0.21	0.26
GRN LEAFY VEGETABLES	0.0005	0.0003	0.002	0.0007	0.002	0.0004
OTHER FOOD CROPS	0.004	0.001	0.004	0.005	0.004	0.001
LEGUMES AND SEEDS	0.13	0.13	0.16	0.15	0.15	0.13
ROOTS AND TUBERS	0.0008	0.002	0.004	0.001	0.003	0.002

*

* CROP NAME	GROWING SEASON (DAYS)			FARMLAND SHARE
	START	END		
NAMCRP	TGSBEG	TGSEND	FRCTFL	
CHCRPRGN001 'PASTURE	' 90.	270.	0.41	
CHCRPRGN002 'STORED FORAGE	' 150.	240.	0.13	
CHCRPRGN003 'GRAINS	' 150.	240.	0.21	

Appendix D Supporting Information for the Consequence Analysis

```

CHCRPRGN004 'GRN LEAFY VEGETABLES' 150. 240. 0.002
CHCRPRGN005 'OTHER FOOD CROPS      ' 150. 240. 0.004
CHCRPRGN006 'LEGUMES AND SEEDS     ' 150. 240. 0.15
CHCRPRGN007 'ROOTS AND TUBERS      ' 150. 240. 0.003

```

```

* PROTECTIVE ACTION GUIDES FOR THE DIRECT DEPOSITION PATHWAY TO
* MILK AND ITS PRODUCTS AND TO OTHER CROPS AND THEIR PRODUCTS
* BY FOOD INGESTION MODEL NUCLIDE (PERMISSIBLE SURFACE
* CONCENTRATION IN BECQUERELS PER SQUARE METER)

```

```

* PERMISSIBLE SURFACE CONCENTRATIONS WERE DERIVED BY INVERTING
* THE FOOD PATHWAY MODEL THEREBY MAKING THE DOSE TO AN ORGAN THE
* INDEPENDENT VARIABLE AND GROUND CONCENTRATION THE DEPENDENT
* VARIABLE. PERMISSIBLE GROUND CONCENTRATIONS WERE CALCULATED
* ASSUMING (1) ALLOWABLE FIRST YEAR (I.E., DIRECT DEPOSITION)
* ORGAN DOSES OF 15 REM PER YEAR TO THYROID AND 5 REM PER YEAR
* TO ANY OTHER ORGAN; AND (2) ALLOWABLE DOSES IN SUBSEQUENT YEARS
* (I.E., ROOT UPTAKE PATH) OF 1.5 REM TO THYROID AND 0.5 REM TO
* ANY OTHER ORGAN.

```

```

*
*
*          MILK AND   OTHER CROPS
*          NUCLIDE    PRODUCTS  AND PRODUCTS

```

```

*          NAMIPI      PSCMLK      PSCOTH

```

```

* PROTECTIVE ACTION GUIDES FOR LONG-TERM TRANSFER TO FARM CROPS
* FROM ROOT AND OTHER SOIL UPTAKE FROM SURFACE CONTAMINATION
* BY CHRONC INGESTION MODEL NUCLIDE (PERMISSIBLE SURFACE
* CONCENTRATION IN BEQUERELS PER SQUARE METER) AND THE ASSOCIATED
* ANNUAL DEPLETION RATE FOR THE NUCLIDE IN THE SOIL.

```

```

*
*          PERMISSIBLE   ANNUAL
*          SURFACE        DEPLETION
*          NUCLIDE        CONCENTRATION  RATE

```

```

*          NAMIPI      GCMAXR      QROOT

```

```

* DEFINE THE TYPE 9 RESULTS

```

```

* LONG-TERM POPULATION DOSE IN A GIVEN REGION BROKEN DOWN BY THE 12 PATHWAYS

```

```

* NUMBER OF RESULTS OF THIS TYPE THAT ARE BEING REQUESTED
* FOR EACH RESULT YOU REQUEST, THE CODE WILL PRODUCE A SET OF 12

```

```

TYPE9NUMBER      1
*TYPE9OUT001     'EDEWBODY'  1  26  (0-1000 MILES)
TYPE9OUT001     'EDEWBODY'  1  19  (0-50 MILES)

```

```

* ECONOMIC COST RESULTS IN A REGION BROKEN DOWN BY 12 TYPES OF COSTS

```

```

* NUMBER OF RESULTS OF THIS TYPE THAT ARE BEING REQUESTED
* FOR EACH RESULT YOU REQUEST, THE CODE WILL PRODUCE A SET OF 12

```

```

TYP10NUMBER      0          (UP TO 10 ALLOWED)

```

```

*
*          INNER      OUTER

```

Appendix D Supporting Information for the Consequence Analysis

```

*
*TYP100OUT001      1      26      (0-1000 MILES)
*TYP100OUT002      1      21      (0-100 MILES)
*TYP100OUT003      1      19      (0-50 MILES)
*TYP100OUT004      1      12      (0-10 MILES)
*****
* DEFINE A FLAG THAT CONTROLS THE PRODUCTION OF THE ACTION DISTANCE RESULTS
*
* SPECIFYING A VALUE OF .TRUE. TURNS ON ALL 8 OF THE ACTION DISTANCE RESULTS,
* A VALUE OF .FALSE. WILL ELIMINATE THE ACTION DISTANCE RESULTS FROM THE OUTPUT.
*
TYP11FLAG11      .FALSE.
*****
* IMPACTED AREA/POPULATION RESULTS IN A REGION BROKEN DOWN BY 6 TYPES OF IMPACTS
*
* NUMBER OF RESULTS OF THIS TYPE THAT ARE BEING REQUESTED
* FOR EACH RESULT YOU REQUEST, THE CODE WILL PRODUCE A SET OF 8
*
TYP12NUMBER      0      (UP TO 10 ALLOWED)
*****
* Data below are copied from file IN3A.INP, MACCS version 1.5.11.1
CHCOUPLD001      .FALSE.
*
*      NAMIPI      PSCMLK      PSC0TH
CHPAGMCP001      SR-89      2.2E07      2.2E07
CHPAGMCP002      SR-90      2.4E05      2.4E05
CHPAGMCP003      CS-134      2.2E05      2.2E05
CHPAGMCP004      CS-137      2.7E05      2.7E05
CHPAGMCP005      I-131      1.3E06      8.0E06
CHPAGMCP006      I-133      1.1E10      1.0E20
*****
*      NAMIPI      GCMAXR      QROOT
CHPAGLTS001      SR-89      1.8E8      4.9
CHPAGLTS002      SR-90      3.7E4      0.065
CHPAGLTS003      CS-134      4.1E6      0.59
CHPAGLTS004      CS-137      1.8E6      0.28
CHPAGLTS005      I-131      1.E20      32.0
CHPAGLTS006      I-133      1.E20      290.0
*

```

Appendix D Supporting Information for the Consequence Analysis

D.4 SITE Input File

(Note: NUREG-1150 input)

MACCS SITE DATA FILE FOR SURRY (JLS, 11/10/88)

SECPop POP DISTRIBUTION FROM 1980 CENSUS DATA ALTERED USING 0-10 MI NRC DATA

26 SPATIAL INTERVALS

16 WIND DIRECTIONS

7 CROP CATEGORIES

4 WATER PATHWAY ISOTOPES

2 WATERSHEDS

59 ECONOMIC REGIONS

SPATIAL DISTANCES

0.16	0.52	1.21	1.61	2.13	3.22	4.02	4.83
5.63	8.05	11.27	16.09	20.92	25.75	32.19	40.23
48.28	64.37	80.47	112.65	160.93	241.14	321.87	563.27
804.67	1609.34						

POPULATION

0.	0.	0.	0.	0.	0.	4.	5.
6.	25.	3341.	7107.	2173.	0.	1305.	474.
2252.	2945.	5403.	20169.	112004.	3431358.	1355700.	2742710.
2487346.	104331.						
0.	0.	0.	0.	1.	2.	9.	13.
15.	63.	1667.	3550.	1330.	1072.	3198.	2425.
515.	9469.	5317.	7120.	13586.	198785.	1058744.	20508438.
3290082.	830354.						
0.	0.	0.	0.	0.	0.	5.	6.
8.	31.	822.	1752.	4543.	1713.	1597.	2296.
6535.	1775.	0.	8555.	48596.	119411.	233382.	3003954.
7620063.	1169436.						
0.	0.	0.	0.	0.	0.	1.	1.
2.	11.	543.	1157.	3820.	1621.	3364.	0.
0.	129.	6679.	11858.	0.	0.	0.	0.
0.	0.						
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	4798.	10202.	10348.	10480.	9570.	0.
0.	2317.	1756.	0.	0.	0.	0.	0.
0.	0.						
0.	0.	0.	0.	0.	0.	1.	1.
1.	7.	8316.	17684.	16340.	30419.	39474.	74998.
24195.	80412.	57477.	0.	0.	0.	0.	0.
0.	0.						
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	1722.	6433.	36763.	20632.
126203.	372471.	68327.	8599.	6339.	1057.	0.	0.
0.	0.						
0.	0.	0.	0.	0.	0.	2.	2.
3.	13.	127.	273.	1649.	4571.	3441.	7838.
11747.	19019.	3360.	36387.	10447.	12402.	0.	0.
0.	0.						
0.	0.	5.	4.	8.	23.	14.	20.
23.	93.	301.	650.	0.	0.	1264.	4065.
1106.	14665.	4071.	18006.	37417.	89072.	81626.	0.
0.	0.						
0.	0.	0.	0.	0.	0.	19.	25.
29.	117.	45.	105.	0.	510.	951.	1521.

Appendix D Supporting Information for the Consequence Analysis

1223.	17636.	4926.	30765.	53265.	289674.	216165.	479431.
280809.	8801784.						
0.	0.	0.	0.	1.	2.	14.	20.
23.	93.	155.	338.	125.	1079.	0.	1355.
2765.	154.	5296.	21409.	62228.	523803.	479588.	1538059.
1526840.	3099458.						
0.	0.	0.	0.	1.	2.	14.	20.
23.	93.	110.	240.	1056.	0.	50.	1396.
915.	3153.	4132.	16295.	35596.	239712.	709522.	2845970.
3957581.	10560254.						
0.	0.	0.	0.	0.	0.	25.	33.
38.	154.	30.	70.	450.	0.	980.	517.
155.	66531.	40902.	9557.	44818.	194801.	376828.	1492286.
2250273.	12145932.						
0.	0.	0.	0.	0.	0.	7.	9.
12.	47.	31.	69.	0.	380.	281.	445.
1986.	32459.	183133.	193630.	30369.	203275.	94113.	1328987.
5086913.	19537940.						
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	223.	477.	0.	1026.	609.	2575.
2794.	6593.	96857.	107328.	47585.	156826.	101785.	4175263.
7535605.	9667977.						
0.	0.	0.	0.	0.	0.	15.	20.
23.	92.	2503.	5326.	3508.	1826.	1884.	275.
3965.	2084.	6270.	10765.	103787.	970659.	472558.	1396088.
1969210.	73968.						

LAND FRACTION

1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80	1.00	1.00	0.95	0.75	0.70	0.85
1.00	0.85	0.70	0.75	0.55	0.70	0.60	1.00	1.00	0.95						
1.00	1.00	1.00	1.00	0.90	0.70	0.40	0.00	0.00	0.45	1.00	0.95	0.40	0.60	1.00	1.00
0.90	0.45	0.60	0.20	0.50	0.50	0.30	0.25	0.50	0.60						
1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.05	1.00	1.00	0.20	1.00	0.70	0.30
0.85	0.20	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00						
1.00	1.00	1.00	1.00	1.00	0.80	0.10	0.00	0.00	0.00	1.00	1.00	0.75	0.30	0.40	0.00
0.15	0.00	0.45	0.30	0.00	0.00	0.00	0.00	0.00	0.00						
1.00	1.00	1.00	1.00	1.00	0.60	0.00	0.00	0.00	0.00	0.95	1.00	1.00	0.70	0.40	0.10
0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
1.00	1.00	1.00	1.00	1.00	0.70	0.00	0.00	0.00	0.80	0.90	0.75	0.85	1.00	1.00	0.70
0.15	0.25	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
1.00	1.00	1.00	1.00	1.00	1.00	0.55	0.50	0.25	0.15	0.00	0.10	0.00	0.10	0.50	0.60
0.85	1.00	1.00	0.40	0.40	0.05	0.00	0.00	0.00	0.00						
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.35	0.40	0.80	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	0.95	0.20	0.00	0.00	0.00						
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	0.80	0.40	0.00	0.00	0.20						
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.50	0.40						
1.00	1.00	0.70	0.40	0.20	0.75	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	0.95	1.00	1.00	1.00	1.00	0.80						
1.00	1.00	0.00	0.00	0.00	0.00	0.05	0.70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	0.95	0.90	1.00	1.00	1.00	1.00						
1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.15	0.70	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00						
1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.50	0.40	0.30	0.25	0.75	0.80	0.85
0.85	0.95	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.85						
1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.15	0.80	0.75	0.80	0.85	0.95	1.00	1.00	1.00

1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.45						
1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	0.95	0.80	0.85	1.00	1.00	0.55	0.95						

[illegible][illegible]

1 PASTURE	90.	270.	0.41
2 STORED FORAGE	150.	240.	0.13
3 GRAINS	150.	240.	0.21
4 GRN LEAFY VEGETABLES	150.	240.	0.002
5 OTHER FOOD CROPS	150.	240.	0.004
6 LEGUMES AND SEEDS	150.	240.	0.15
7 ROOTS AND TUBERS	150.	240.	0.003

1	SR-89	5.0E-6	0.0
2	SR-90	5.0E-6	0.0
3	CS-134	5.0E-6	0.0
4	CS-137	5.0E-6	0.0

1	AL	.308	.027	676.	2302.	93617.
2	AZ	.495	.127	128.	879.	99909.
3	AR	.480	.026	657.	2082.	88486.
4	CA	.311	.139	1502.	4438.	129140.
5	CO	.497	.047	315.	1114.	117723.

Appendix D Supporting Information for the Consequence Analysis

6	CT	.129	.173	2754.	11140.	158515.
7	DE	.480	.031	2651.	5809.	125432.
8	FL	.318	.070	1281.	5380.	115720.
9	GA	.351	.060	730.	2729.	106394.
10	ID	.264	.128	517.	1862.	95190.
11	IL	.815	.045	676.	3660.	127604.
12	IN	.697	.062	761.	3302.	105620.
13	IA	.951	.054	749.	2951.	107992.
14	KS	.917	.022	360.	1371.	113004.
15	KY	.551	.095	546.	2653.	93579.
16	LA	.323	.072	527.	2490.	90683.
17	ME	.071	.207	811.	2746.	107255.
18	MD	.352	.150	1510.	6207.	136430.
19	MA	.140	.181	1474.	9524.	140787.
20	MI	.303	.226	714.	2712.	114715.
21	MN	.589	.181	577.	2218.	116918.
22	MS	.433	.044	462.	2028.	80084.
23	MO	.680	.098	324.	1907.	109103.
24	MT	.655	.027	65.	817.	95527.
25	NE	.955	.018	464.	1588.	109172.
26	NV	.128	.131	91.	709.	118903.
27	NH	.087	.349	662.	5755.	129664.
28	NJ	.168	.079	1997.	11676.	155306.
29	NM	.579	.177	83.	714.	88973.
30	NY	.265	.518	928.	2635.	138128.
31	NC	.321	.045	1202.	3349.	101532.
32	ND	.929	.048	152.	1069.	95845.
33	OH	.610	.151	644.	3203.	109659.
34	OK	.751	.047	266.	1457.	96444.
35	OR	.293	.099	317.	1640.	107249.
36	PA	.279	.398	1163.	4693.	116593.
37	RI	.150	.066	1753.	12649.	117405.
38	SC	.259	.051	580.	2475.	94509.
39	SD	.906	.063	188.	1040.	99185.
40	TN	.455	.150	419.	2690.	99047.
41	TX	.787	.064	224.	1452.	104347.
42	UT	.209	.229	169.	1190.	87294.
43	VT	.237	.777	788.	3169.	109272.
44	VA	.355	.139	581.	3974.	122973.
45	WA	.375	.170	589.	2154.	117205.
46	WV	.259	.110	208.	1744.	85789.
47	WI	.518	.556	783.	2213.	109796.
48	WY	.563	.017	54.	598.	101638.
49	BRIT COL	.377	.154	476.	1948.	60000.
50	OCEAN	.0	.0	0.	0.	0.
51	SASKAT	.657	.030	61.	563.	60000.
52	MANITOBA	.924	.048	164.	948.	60000.
53	ONTARIO	.597	.223	516.	2111.	60000.
54	QUEBEC	.310	.589	711.	1378.	60000.
55	NOVA SCOT	.079	.260	662.	1133.	60000.
56	BAJA CAL	.330	.144	1022.	4394.	10000.
57	SONORA	.516	.104	110.	682.	10000.
58	CHIHUAHUA	.590	.144	53.	473.	10000.
59	COAHUILA	.816	.064	164.	1492.	10000.

END

APPENDIX E

**SUPPORTING INFORMATION FOR
THE MELCOR ANALYSIS**

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APPENDIX E

MELCOR CODE CALCULATIONS

E.1 Plant Model

The MELCOR nodalization scheme for the Surry plant is shown in Figure E.1. The reactor vessel is divided into six nodes representing the downcomer, lower plenum, core, core bypass, upper plenum and the upper head regions. In the core and lower plenum regions, fuel and structures are represented by 39 cells. There are three radial rings and 13 axial sections in each ring. Among the 13 axial sections, 10 are fuel elements and 3 are lower core plate and lower plenum nodes. Penetration tubes located on the lower head wall are modeled for each radial ring. The failure of the penetration tube indicates vessel breach.

Surry is a 3-loop PWR plant. Each loop is represented by a hot-leg and a cold-leg. The pressurizer, pressurizer surge tank, RHR and RWST are modeled as separate volumes in the MELCOR nodalization. The RHR was used to establish the steady-state condition for the MELCOR analysis.

The Surry containment is divided into seven nodes representing the basement, cavity, cubicles of the three steam generators, pressurizer room and the dome area. Environment is modeled as an additional node.

The 24 nodes are inter-connected by 52 flow paths. The descriptions of the control volumes and flow paths are given in Tables E.1 and E.2, respectively. It is believed that the MELCOR nodalization provides a reasonable representation of the Surry plant.

E.2 Sequence Description

A total of 6 calculations were performed in support of this study as summarized in Table E.3. The 'time window' approach was based on a set of representative decay heat levels. The first three MELCOR sequences assumed decay power levels of 13.2, 7 and 5 MW, respectively. These power levels correspond to that defined in windows 1, 3 and 4, respectively, as described in the main report. In these sequences, it was assumed that the ECCS is not available and the containment is closed during the entire transient.

Sensitivity studies were performed to evaluate the effects of containment leakage, actuation of containment sprays and the restoration ECCS. The sensitivity studies were performed using the decay power level corresponding to that defined in window 1.

E.3 MELCOR Analysis

The analysis was based on mid-loop operation with the primary system open to the atmosphere. All six loop isolation valves were closed to minimize the primary system inventory and to preclude the use of reflux cooling

Appendix E MELCOR Code Calculations

as a recovery procedure. A Tygon tube connects the upper head vent to the pressurizer relief tank, and at least one pressurizer SRV is assumed to have been removed which provides a vent path to the containment.

All calculations commenced with a period of 5000 seconds running in quasi-steady state conditions with the actuation of RHR. This method was sufficient for the MELCOR model to approach a close approximation to a steady state condition prior to initiating the transient. The initial conditions in each control volume including the atmospheric pressure, temperature, composition and water pool mass and temperature are included in Table E.1.

The transient was initiated by closing off the RHR flow paths to simulate a loss of RHR. All timings referred to in this discussion are measured relative to this time in the calculation. Transient analyses were focused on the occurrence of major events, such as the timing of core uncover, gap release, failure of the core support plate and vessel breach. Core uncover is defined as the depletion of water in the upper plenum of the reactor vessel. The gap release occurs when the clad reaches 1173 K, at which temperature all inventories of fission products in the gap region are released instantaneously to the core channel control volume. The failure of core support plate and penetration tubes attached to the lower head wall are determined by the user specified failure temperatures (default values are 1273 K). The failure of penetration tubes indicates the breach of the reactor vessel.

The standard ANS decay power curve, as programmed into MELCOR, was used throughout these calculations to provide a best-estimate heat generation rate. The selection of the initial decay power levels was determined by the 'time window' approach described in the main volume of this report.

The latest release of MELCOR, version 1.8.2, was used throughout this analysis. This version includes several major improvements and corrections, particularly in the areas of core melting, relocation and interaction in the lower plenum.

E.4 Results

Case 1

This is the case with the highest decay power level (13.2 MW) corresponding to that defined in window 1. The failure of ECCS was assumed and the containment was closed. The loss of RHR leads to core uncover at about 5280 seconds. The boil-off of water causes an increase of pressure and temperature in the RCS as shown in Figures E.2 to E.3. The fuel clad temperatures reach the criterion of gap release between about 5600 to 7500 seconds for fuels in the three radial rings. Continued loss of coolant and core heating eventually cause the failure of core support plate at about 12900 to 13900 seconds. The relocation of corium into the lower plenum and the rapid heating of the penetration tubes (Figure E.4) result the failure of the reactor vessel.

Large quantities of water and corium are discharged into the cavity following the vessel breach. The corium/water interaction in the cavity gradually vaporizes all the water remained in the cavity as shown in Figure E.5. This interaction has two effects on containment performance: containment pressurization due to steam addition and reduction of corium/concrete interaction due to the cooling of core debris. A limestone/common sand concrete was assumed for the analysis. Figure E.6 shows the radial and axial concrete erosion in the cavity. The axial erosion distance is about 0.75 meters at the end of 120,000 seconds. This is

about 25% of the concrete floor thickness. It appears that thermal attack of the cavity concrete floor is not a severe challenge to the Surry containment for accidents during mid-loop operation.

The MELCOR predicted containment pressures and temperatures are illustrated in Figures E.7 and E.8, respectively. There is a continuous pressure increase in the containment. The two pressure spikes at about 40,000 and 80,000 seconds are caused by hydrogen burn in the containment dome and basement area. Within the time period of 120,000 seconds, the pressure does not threaten the containment integrity. However, high temperatures occur in the cavity region over a very long period of time. This severe thermal condition could cause damage in that area.

The in-vessel hydrogen generation and hydrogen distribution in containment are shown in Figures E.9 to E.10. The sudden reduction of hydrogen mass at about 40,000 seconds in the dome and basement region, and at about 80,000 seconds in the dome area indicates deflagrations in the containment. They are reflected as pressure and temperature spikes in Figures E.7 and E.8.

MELCOR calculates radionuclides in two forms: vapor and aerosol. The distributions of active aerosols and vapor in various containment regions are given in Figures E.11 and E.12. Most of the active aerosols and vapor are accumulated in the dome and basement regions. The distributions of Cs and I elements at the end of 24 hours are summarized in Table E.5. Because the containment is assumed to be closed, there is no environmental release.

Case 2

This case is similar to Case 1, but with the decay power level reduced to 7 MW corresponding to that defined in window 2. With a lower decay power the occurrence of major events are delayed by 2 to 3 hours as shown in Table E.4. The results of the transient calculation are given in Figures E.13 to E.23. Similar to Case 1, hydrogen generation, hydrogen burn, concrete erosion and containment pressurization do not threaten the containment integrity within a time period of 24 hours after the initiation of accident. The high temperatures in the cavity still present a severe challenge to the containment integrity. The distributions of Cs and I elements are about the same as in Case 1 as shown in Table E.5.

Case 3

The decay power level is further reduced to 5 MW in this case. The transient behavior shown in Figures E.24 to E.34 are similar to that of Cases 1 and 2. However, at such a low level of decay power, the occurrence of major events are delayed considerably in comparison with that of Case 1 as summarized in Table E.4.

Case 4

This case is similar to Case 1 but with the assumption of containment leakage initiated at the beginning of the accident. The leak area is assumed to be 1 square ft and is located in the dome area. The MELCOR predicted transient behavior and results are given in Figures E.35 to E.45, and in Tables E.4 and E.5.

Appendix E MELCOR Code Calculations

The leakage in containment does not have any major impact on transient behavior in the reactor vessel. Only the in-vessel hydrogen production is reduced by about 10% in comparison with Case 1. In the containment, the pressure is generally at atmospheric level. The gas temperature in the cavity region is still at an elevated level of about 1700 K (Figure E.41). It is noted that both the radial and axial concrete erosion in the cavity region (Figure E.39) are much stronger than that in the base case (i.e. Case 1). This strong erosion of concrete would release more gases from the concrete, which could become a driving force to discharge gases and aerosols into the environment. Figures E.44 and E.45 show that large quantities of active vapor and aerosols are released into the environment. The distributions of Cs, I elements and other species, summarized in Table E.5 indicate that about 20%, 87% and 53% of the total releases of Cs, I and all species are released to the environment, respectively.

Case 5

This case is similar to Case 4 but with the actuation of the containment sprays after vessel failure. The flow rate of the sprays is about 0.19 Kg/s as illustrated in Figure E.46. The spray heads are located in the dome area. Actuation of sprays after vessel failure has no effect on transient behavior in the reactor vessel as shown in Figures E.47 to E.49 and in Table E.4.

Figure E.50 shows that spray water is collected in the cavity and basement area. The cavity is completely filled with water in about 9.5 hours after the actuation of sprays. The presence of such a large water pool in the cavity reduced the concrete erosion rate as shown in Figures E.51. According to the MELCOR model, core debris in the cavity never reached a coolable configuration which could terminate the concrete erosion. As one expected, sprays eliminated high temperatures in containment (Figure E.53) and greatly reduced the releases of active aerosols and vapor to the environment (Figures E.56 and E.57). Table E.5 indicates that releases of radioactive species to the environment at the end of 73,515 seconds are negligible.

Figure E.1 MELCOR Nodalization

Figure E.2 RCS Pressure For Case 1

Figure E.3 RCS Temperature For Case 1

Figure E.4 Lower Head Penetration Temperature For Case 1

Figure E.5 Liquid Levels In Cavity And Basement For Case 1

Figure E.6 Cavity Concrete Erosion For Case 1

Figure E.7 Containment Pressure For Case 1

Figure E.8 Containment Gas Temperature For Case 1

Figure E.9 In-vessel Hydrogen Generation For Case 1

Figure E.10 Hydrogen Distribution In Containment For Case 1

Figure E.11 Total Mass Of Active Vapor For Case 1

Figure E.12 Total Mass Of Active Aerosols For Case 1

Figure E.13 RCS Pressure For Case 2

Figure E.14 RCS Temperature For Case 2

Figure E.15 Lower Head Penetration Temperature For Case 2

Figure E.16 Liquid Levels In Cavity And Basement For Case 2

Figure E.17 Cavity Concrete Erosion For Case 2

Figure E.18 Containment Pressure For Case 2

Figure E.19 Containment Gas Temperature For Case 2

Figure E.20 In-vessel Hydrogen Generation For Case 2

Figure E.21 Hydrogen Distribution In Containment For Case 2

Figure E.22 Total Mass Of Active Vapor For Case 2

Figure E.23 Total Mass Of Active Aerosols For Case 2

Figure E.24 RCS Pressure For Case 3

Figure E.25 RCS Temperature For Case 3

Figure E.26 Lower Head Penetration Temperature For Case 3

Figure E.27 Liquid Levels In Cavity And Basement For Case 3

Figure E.28 Cavity Concrete Erosion For Case 3

Figure E.29 Containment Pressure For Case 3

Figure E.30 Containment Gas Temperature For Case 3

Figure E.31 In-vessel Hydrogen Generation For Case 3

Figure E.32 Hydrogen Distribution In Containment For Case 3

Figure E.33 Total Mass Of Active Vapor For Case 3

Figure E.34 Total Mass Of Active Aerosols For Case 3

Figure E.35 RCS Pressure For Case 4

Figure E.36 RCS Temperature For Case 4

Figure E.37 Lower Head Penetration Temperature For Case 4

Figure E.38 Liquid Levels In Cavity And Basement For Case 4

Figure E.39 Cavity Concrete Erosion For Case 4

Figure E.40 Containment Pressure For Case 4

Figure E.41 Containment Gas Temperature For Case 4

Figure E.42 In-vessel Hydrogen Generation For Case 4

Figure E.43 Hydrogen Distribution In Containment For Case 4

Figure E.44 Total Mass Of Active Vapor For Case 4

Figure E.45 Total Mass Of Active Aerosols For Case 4

Figure E.46 Containment Spray For Case 5

Figure E.47 RCS Pressure For Case 5

Figure E.48 RCS Temperature For Case 5

Figure E.49 Lower Head Penetration Temperature For Case 5

Figure E.50 Liquid Levels In Cavity And Basement For Case 5

Figure E.51 Cavity Concrete Erosion For Case 5

Figure E.52 Containment Pressure For Case 5

Figure E.53 Containment Gas Temperature For Case 5

Figure E.54 In-vessel Hydrogen Generation For Case 5

Figure E.55 Hydrogen Distribution In Containment For Case 5

Figure E.56 Total Mass Of Active Aerosols For Case 5

Figure E.57 Total Mass Of Active Vapor For Case 5

Figure E.58 RCS Pressure For Case 6

Figure E.59 RCS Temperature For Case 6

Figure E.60 Lower Head Penetration Temperature For Case 6

Figure E.61 Liquid Levels In Cavity And Basement For Case 6

Figure E.62 Cavity Concrete Erosion For Case 6

Figure E.63 Containment Pressure For Case 6

Figure E.64 Containment Gas Temperature For Case 6

Figure E.65 In-vessel Hydrogen Generation For Case 6

Figure E.66 Hydrogen Distribution In Containment For Case 6

Figure E.67 Total Mass Of Active Vapor For Case 6

Figure E.68 Total Mass Of Active Aerosols For Case 6

Table E-1 MELCOR 24-Node Compartment Description

Volume No.	Name	Volume (m ³)
1	Environment	1.0E10
5	Basement	1.52E4
10	Cavity	157.1
20	Steam Generator A Cubicle	1268.1
30	Steam Generator B Cubicle	1118.1
40	Steam Generator C Cubicle	1118.1
41	Pressurizer Cubicle	823.7
50	Upper Dome	29513.0
100	Downcomer	17.78
110	Lower Plenum	20.90
120	Core	14.56
130	Core Bypass	5.39
140	Upper Plenum	29.12
150	Upper Head	14.16
200	Hot Leg A	3.07
240	Cold Leg A	4.37
300	Hot Leg B	3.07
340	Cold Leg B	4.37
400	Hot Leg C	3.07
410	Pressurizer	37.84
440	Cold Leg C	4.37
450	Pressurizer Surge Tank	36.82
500	RHR	1.0E5
600	RWST	1465.5

Table E-2 MELCOR 52 Inter-Compartment Flow Paths Description

*** NAME AND CONNECTION DATA ***					
* PATH	FLNAME	KCVFM	KCVTO	ZFM	ZTO
FL10300	'DCOMER TOP'	100	150	10.18307	10.18307
FL10500	'DCOMER BOT'	100	110	1.74550	1.74550
FL10700	'NOZZLE LEAK'	100	140	8.08917	8.08917
FL11300	'BYPASS INLET'	110	130	3.06437	3.06437
FL11500	'CORE INLET'	110	120	3.06437	3.06437
FL12500	'CORE OUTLET A'	120	140	6.72197	6.72197
FL13500	'BYPASS OUTLET'	130	140	6.72197	6.72197
FL15300	'CRD HOUSINGS A'	150	140	10.18307	8.0892
FL15500	'UPPER HEAD LEAK'	150	450	12.02379	6.2
FL15600	'UH LEAK BURST'	150	50	12.02379	13.02379
FL16000	'UP PLEN BLEED'	140	150	10.18307	12.02379
FL16500	'DWNCMR BLEED'	100	150	10.18307	12.02379
FL17000	'CORE BLEED'	120	150	6.72197	12.02379
FL20100	'UP TO HL A'	140	200	8.0892	8.0892
FL20300	'HL A BLEED LINE'	200	150	8.4575	12.0
FL24200	'CL A TO VESSEL'	240	100	8.0892	8.0892
FL24400	'CL A BLEED LINE'	240	150	8.4386	12.0
FL30100	'UP TO HL B'	140	300	8.0892	8.0892
FL30300	'HL B BLEED'	300	150	8.4575	12.0
FL34200	'CL B TO VESSEL'	340	100	8.0892	8.0892
FL34400	'CL B BLEED'	340	150	8.4386	12.0
FL40100	'UP TO HL C'	140	400	8.0892	8.0892
FL40300	'HL C BLEED'	400	150	8.4575	12.0
FL41100	'PZR TO HL C'	410	400	8.0892	8.0892
FL41200	'PRIMARY PORV'	410	450	23.2600	6.2
FL41300	'PRIMARY SRV'	410	41	23.2600	23.2600
FL44200	'CL C TO VESSEL'	440	100	8.0892	8.0892
FL44400	'CL C BLEED'	440	150	8.4386	12.0
FL45000	'SURGE TANK'	450	1	7.725	7.7971
FL45100	'BURST DISC'	450	41	7.725	7.735
FL50100	'UPPR PLEN TO RHR'	140	500	7.7971	7.7971
FL51100	'RHR TO DOWNCOMER'	500	100	7.7971	7.7971
FL52100	'RHR TO DOWNCOMER'	500	100	7.7971	7.7971
FL52200	'RHR TO ENVIRONS'	500	1	7.7971	7.7971
FL60100	'RWST - LOOP A CL'	600	240	12.57	8.0892
FL60200	'RWST - LOOP B CL'	600	340	12.57	8.0892
FL60300	'RWST - LOOP C CL'	600	440	12.57	8.0892
FL61100	'RWST - ENVIRON'	600	1	26.44	36.44
FL00100	'DOME-ENVIRONS'	050	001	19.08	19.08
FL00500	'BASEMENT-DOME'	005	050	19.08	19.08
FL01100	'CAVITY-BASEMENT'	010	005	-0.14	-0.14
FL01200	'CAVITY-DOME'	010	050	7.21	7.21
FL02100	'SGA-BASEMENT'	020	005	10.0	10.0
FL02200	'SGA-DOME'	020	050	19.08	19.08
FL03100	'SGB-BASEMENT'	030	005	10.0	10.0
FL03200	'SGA-DOME'	030	050	19.08	19.08
FL04100	'SGC-BASEMENT'	040	005	10.0	10.0
FL04200	'SGA-DOME'	040	050	19.08	19.08
FL04300	'PRESS-BASEMENT'	041	005	9.02	9.02
FL04400	'PRESS-SGC'	041	040	14.4	14.4
FL04500	'PRESS-SGB'	041	030	17.9	17.9
FL04600	'PRESS-DOME'	041	050	19.08	19.08

Table E-3 Summary of Accident Sequences Analyzed by MELCOR

Sequence No.	Decay Heat (MW)	Containment	ECCS	Vessel Failure
1	13.2	Closed	None	Yes
2	7.0	Closed	None	Yes
3	5.0	Closed	None	Yes
4	13.2	Leak*	None	Yes
5	13.2	Leak	Spray after VB	Yes

* Leak area = 1.0 ft², Leak location = dome

Table E-4 Sequence of Events

Sequence No.	Core Uncovery* (s)	Gap Release			Core Support Plate Failure (s)			Vessel Breach (s)		
		Ring 1	Ring 2	Ring 3	Ring 1	Ring 2	Ring 3	Ring 1	Ring 2	Ring 3
1	5280	5598	6142	7504	12900	13018	13941	12949	13358	14129
2	10210	13769	14330	15734	22978	23153	25330	23030	23458	24905
3	14220	19803	20506	22276	31495	31588	31724	31550	31860	32056
4	5470	5424	5922	7285	11971	12215	12479	12016	12479	13362
5	5470	5424	5922	7285	11971	12215	12479	12016	12479	13362

* Defined as Dry-out of Upper Plenum

Table E-5 Distribution of Radioactive Species at 24 Hours

Case Number	Total Releases (Kg)			Containment (Kg)			Environment (Kg)		
	CS	I	All Species	CS	I	All Species	CS	I	All Species
1	138.2	9.14	493.4	121.1	9.12	462.2	0.0	0.0	0.0
2	138.9	8.47	445.0	126.3	8.45	427.9	0.0	0.0	0.0
3	138.9	8.47	449.6	124.7	8.45	430.2	0.0	0.0	0.0
4	138.9	8.48	491.1	95.0	1.09	204.9	28.6	7.39	261.0
5*	138.8	8.53	457.4	122.4	4.20	287.0	0.65	4.3	143.7

* Results at 73515 s.

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10. SUPPLEMENTARY NOTES

11. ABSTRACT (200 words or less)

This document contains the accident progression analysis of internally initiated events for Surry, Unit 1 as it operates in mid-loop operation during drained maintenance or a refueling outage. The report documents the methodology used during the analysis, describes the results from the application of the methodology, and compares the results with the results from a full power analysis performed on Surry as a part of the Nureg-1150 study.

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