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December 3, 2013

U. S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555
ATTN: David B. Matthews, Director
Division of New Reactor Licensing

SUBJECT: COMANCHE PEAK NUCLEAR POWER PLANT, UNITS 3 AND 4
DOCKET NUMBERS 52-034 AND 52-035
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION 276 (7116)
(SECTION 19.2)

Dear Sir:

Luminant Generation Company LLC (Luminant) submits herein the response to Request for Additional Information (RAI) 276 (7116) for the Comanche Peak Nuclear Power Plant Units 3 and 4 Combined License Application. The RAI response addresses averted costs.

The enclosed CD contains native files of MACCS2 input/output data that do not meet the requirements of Guidance for Electronic Submissions to the NRC, Revision 6.1. Should you have any questions regarding the response, please contact Don Woodlan (254-897-6887, Donald.Woodlan@luminant.com) or me.

There are no commitments in this letter.

I state under penalty of perjury that the foregoing is true and correct.

Executed on December 3, 2013.

Sincerely,

Luminant Generation Company LLC

Donald R. Woodlan for

Rafael Flores

Attachment: Response to Request for Additional Information 276 (7116)

D090
NRO

cc: Stephen Monarque w/attachment and CD

Electronic distribution w/attachment but w/o CD:

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RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak, Units 3 and 4

Luminant Generation Company LLC

Docket Nos. 52-034 and 52-035

RAI 276 (7116)

SRP SECTION: 19.2 - Review of Risk Information Used to Support Permanent Plant-Specific Changes to the Licensing Basis: General Guidance

DATE OF RAI ISSUE: 6/27/2013

QUESTION NO.: 19-27

In the Request for Additional Information 267-6907, Question 19-23, the staff requested that the applicant address the discrepancy in maximum averted cost-risk stated in COL FSAR Section 19.2.6.6 ("Cost-Benefit Comparison") and COL Environmental Report Section 7.3.3 ("Monetization of the Base Case"). In response to Question 19-23, dated December 18, 2012, the applicant provided a mark-up of relevant pages in the COL FSAR and the Environmental Report. The staff found these mark-ups acceptable. However, the applicant should also update Table 19.2-9R, "SAMA Cost Evaluation Results," of the COL FSAR accordingly.

ANSWER:

FSAR Table 19.2-9R has been updated with the requested information from the latest calculation performed for Question 19-28 below.

Impact on R-COLA

See attached marked-up FSAR Revision 4 pages 19.2-3, 19.2-4, and 19.2-6.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak, Units 3 and 4

Luminant Generation Company LLC

Docket Nos. 52-034 and 52-035

RAI 276 (7116)

SRP SECTION: 19.2 - Review of Risk Information Used to Support Permanent Plant-Specific Changes to the Licensing Basis: General Guidance

DATE OF RAI ISSUE: 6/27/2013

QUESTION NO.: 19-28

In the US-APWR design certification's (DC) severe accident mitigation design alternatives (SAMDA) analysis and the combined license's (COL) severe accident mitigation alternatives (SAMA) analysis, it is assumed that the population dose risk from internal events at power is applicable to internal fire at power, internal flooding at power, and low-power/shutdown (LPSD) events. A core damage frequency (CDF) scaling factor was applied to adjust the population dose risk from internal events to the other event categories. The same assumption is applied to the offsite property damage risk. However, if the population dose risk and offsite property damage risk were based on the actual release category source terms from the Level 3 PRA analysis for internal events, internal fire, internal flooding, and LPSD events (i.e., Tables 2.2-3 (Internal), 3.1-4 (Flood), 3.2-3 (Fire), and 3.3-5 (LPSD) of the updated Level 3 PRA document, MUAP-08004-P, discussed in COL FSAR Section 19.2.6.2), then the total maximum averted cost would likely be greater than that calculated by the CDF scaling factor method. As an example, for the US-APWR DC that assumed a generic site, the population dose risk and offsite property damage risk increased by a factor of about 3 when considering the actual release category source terms for internal events, internal fire, internal flooding, and LPSD events.

The staff requests that the applicant substantiate the conclusions of the SAMA taking into consideration averted costs based on site-specific parameters and actual release category source terms for internal events at power, internal fire at power, internal flooding at power, and LPSD events. Also, please provide the following from the updated Level 3 PRA analysis discussed in COL FSAR Section 19.2.6.2 for internal events at power, internal fire at power, internal flooding at power, and LPSD events:

(1) site-specific population doses (person-rem) and site-specific offsite property damage costs ($) from each release category.
(2) MACCS2 input and output files in electronic format for all of the consequence runs.

ANSWER:

A reanalysis of the severe accident was performed utilizing site-specific parameters and actual release category source terms for internal events at-power, internal fire at-power, internal flooding at-power, and LPSD events. The reanalysis included new CDF values for each event type and release category. Based on the results of the reanalysis, the maximum averted cost-risk for all four event types is $383,220.

This value is less than the maximum averted cost-risk of $400,073 previously stated in Environmental Report (ER) Subsection 7.3.3. The reduction is due in large part to the reduced CDF values. Since the new maximum averted cost-risk is slightly less than the previously determined maximum averted cost-risk, the conclusions of the SAMA are substantiated.

The site specific population doses (person-rem) and site-specific offsite property damage costs ($) from each release category are provided in the table below for the worst case meteorological year evaluated (2006) assuming 90% evacuation.

The release categories listed in the table below are defined as:

RC1: Containment bypass, which includes both core damage after steam generator tube rupture (SGTR) and temperature-induced SGTR after core damage

RC2: Containment isolation failure

RC3: Containment overpressure failure before core damage due to loss of heat removal

RC4: Early containment failure due to dynamic loads, which includes hydrogen combustion before or just after reactor vessel failure, in-vessel and ex-vessel steam explosion, rocket-mode reactor vessel failure, and direct containment heating

RC5: Late containment failure, which includes containment overpressure failure after core damage, hydrogen combustion long after reactor vessel failure, and basemat meltthrough

RC6: Intact containment in which fission products are released at the design leak rate

FRS: Filled RCS state where the equipment hatch is expected to be closed because RCS temperature is still high or inspection cannot be carried out during the period

MOS: Mid-loop operation state where the equipment hatch is anticipated to be open

Event Type	Release Category	Release Frequency	Site-Specific Population Dose Consequences		Site-Specific Offsite Property Damage Costs	
		per RY	person-rem	person-rem/RY	$	$/RY
Internal Event	RC1	1.7E-08	6.26E+06	1.06E-01	1.38E+10	2.35E+02
	RC2	3.4E-09	4.72E+06	1.60E-02	7.09E+09	2.41E+01
	RC3	2.2E-08	9.10E+06	2.00E-01	1.81E+10	3.98E+02
	RC4	1.8E-08	3.47E+06	6.25E-02	5.59E+09	1.01E+02
	RC5	4.7E-08	2.75E+06	1.29E-01	2.18E+09	1.02E+02
	RC6	9.2E-07	9.32E+02	8.57E-04	6.95E+03	6.39E-03
Internal Flood Event	RC1	4.0E-09	4.35E+05	1.74E-03	3.11E+08	1.24E+00
	RC2	4.0E-09	9.35E+05	3.74E-03	1.12E+09	4.48E+00
	RC3	1.0E-07	7.15E+06	7.15E-01	1.52E+10	1.52E+03
	RC4	1.6E-08	4.36E+06	6.98E-02	5.20E+09	8.32E+01
	RC5	3.2E-08	4.60E+05	1.47E-02	1.50E+08	4.80E+00
	RC6	7.4E-07	1.28E+03	9.47E-04	1.51E+04	1.12E-02
Internal Fire Event	RC1	2.7E-08	4.35E+05	1.17E-02	3.11E+08	8.40E+00
	RC2	6.2E-09	4.72E+06	2.93E-02	7.09E+09	4.40E+01
	RC3	9.2E-08	9.09E+06	8.36E-01	1.84E+10	1.69E+03
	RC4	3.6E-08	4.36E+06	1.57E-01	5.20E+09	1.87E+02
	RC5	2.5E-08	2.75E+06	6.88E-02	2.18E+09	5.45E+01
	RC6	6.7E-07	1.28E+03	8.58E-04	1.51E+04	1.01E-02
LPSD	FRS	3.5E-08	1.21E+05	4.24E-03	1.03E+07	3.61E-01
	MOS	1.4E-07	3.79E+06	5.31E-01	5.53E+09	7.74E+02
TOTAL				**2.96E+00**		**5.24E+03**

The MACCS2 input and output files associated with these consequence runs for the worst case meteorological data year (2006) are included on the attached CD.

Attachment

CD with MACCS2 input and output (native) files

Impact on R-COLA

See marked-up FSAR Revision 4 pages 19.2-3, 19.2-4, and 19.2-6 provided in the response to Question 19-27 above and the following attached marked-up Environmental Report Revision 4 pages:

7-xiii	7.2-13	7.2-23	7.2-33	7.2-43	7.3-5
7-xviii	7.2-14	7.2-24	7.2-34	7.2-44	7.3-6
7.2-1	7.2-15	7.2-25	7.2-35	7.2-45	7.5-3
7.2-3	7.2-16	7.2-26	7.2-36	7.2-46	7.5-4
7.2-4	7.2-17	7.2-27	7.2-37	7.2-47	7.5-7
7.2-5	7.2-18	7.2-28	7.2-38	7.2-48	7.5-8
7.2-6	7.2-19	7.2-29	7.2-39	7.2-49	7.5-9
7.2-7	7.2-20	7.2-30	7.2-40	7.2-50	7.5-11
7.2-8	7.2-21	7.2-31	7.2-41	7.3-3	7.5-12
7.2-12	7.2-22	7.2-32	7.2-42	7.3-4	7.5-13

Impact on DCD

None.

In the absence of a completed plant with established procedural controls, the current analysis is limited to demonstrating that a US-APWR located at the site is bounded by the DCD analysis, and determining what magnitude of plant-specific design or procedural modifications would be cost-effective. Determining the magnitude of cost effective design or procedural modifications is the same as step 1, "Define base case," for operating nuclear plants. The base case benefit value is calculated by assuming that the current dose risk of the unit could be reduced to zero, then assigning a defined dollar value for this change in risk. Any design or procedural change cost that exceeds the benefit value would not be considered cost-effective.

The dose-risk and cost-risk results (Section 7.2 of the Environmental Report) are monetized in accordance with methods established in NUREG/BR-0184. NUREG/BR-0184 presents methods for determination of the value of decreases in risk by using four types of attributes: public health, occupational health, off-site property, and on-site property. Any SAMAs in which the conservatively low implementation cost exceeds the base case monetization would not be expected to pass the screening in step 2. If the baseline analysis produces a value that is below that expected for implementation of any reasonable SAMA, no matter how inexpensive, then the remaining steps of the SAMA analysis are not necessary.

(Note: Hereafter where the word "SAMDA" appears in the DCD, it is replaced with "SAMA" in the Final Safety Analysis Report (FSAR) without any further notification.)

19.2.6.2 Estimate of Risk for Design

STD COL 19.3(4) Replace the last sentence of the first paragraph and all of the second paragraph in DCD Subsection 19.2.6.2 with the following. RCOL2_19-28

The second analysis is a Level 3 PRA analysis that integrates the Level 2 source term to quantify the consequences based on the site-specific parameters.

The CDF and LRF are summarized in FSAR Section 19.1.8. RCOL2_19-28

CP COL 19.3(4) Replace the third through the last sentences of the third paragraph and all of the fourth paragraph in DCD Subsection 19.2.6.2 with the following.

In the offsite dose risk quantification, three years of site-specific meteorological data are used. The 50-mile population distribution data are based on the projected population for calendar year 2056.

The total population dose risk ~~is 3.0E-01 person-rem/reactor-year, and the largest contributor is from RC5 - containment failure condition including overpressure failure after core damage, hydrogen combustion failure after core damage, hydrogen combustion long after reactor vessel failure and basemat melt-through (49 percent).~~for at power internal events, internal fire, internal flood and LPSD is 2.96E+00 person-rem/RY. The total dollar consequences for at power internal events, internal fire, internal flood and LPSD is 5.24E+03 $/RY. RCOL2_19-28

19.2.6.4 Risk Reduction Potential of Design Improvements

CP COL 19.3(4) Replace the last sentence in DCD Subsection 19.2.6.4 with the following.

The maximum averted cost is ~~$305k~~approximately $~~400~~383k. RCOL2_19-23 RCOL2_19-28

19.2.6.5 Cost Impacts of Candidate Design Improvements

STD COL 19.3(4) Replace the first sentence in the last paragraph in DCD Subsection 19.2.6.5 with the following.

SAMA cost evaluation results are described in Table 19.2-9R.

19.2.6.6 Cost-Benefit Comparison

CP COL 19.3(4) Replace the content of DCD Subsection 19.2.6.6 with the following.

The maximum averted cost-risk of ~~less than $305k~~approximately $~~400~~383k for a single US-APWR unit at the CPNPP Unit 3 and 4 is so low that there are no design changes over those already incorporated into the US-APWR design that could be determined to be cost-effective. ~~Even with a conservative 3-percent discount rate, the valuation of the averted risk is less than $787kapproximately $1,055k.~~A sensitivity evaluation was performed with a conservative 3% discount rate and the valuation of the maximum averted cost is approximately $~~1,055~~925K. The benefit of each SAMA at 3% and 7% discount rates was calculated and is presented in Table 19.2-9R. The cost of each SAMA exceeds the corresponding benefit. RCOL2_19-23 RCOL2_19-28 RCOL2_19-23 CTS-01528 RCOL2_19-28

Accordingly, further evaluation of design-related SAMAs is not warranted. Evaluation of administrative SAMAs would not be appropriate until the plant design is finalized, and plant administrative processes and procedures are developed. At that time, appropriate administrative controls on plant operations

CP COL 19.3(4)

Table 19.2-9R

SAMA Cost Evaluation Results

CTS-01528

RCOL2_19-28

	Design Alternative	Cost Impact	Maximum Averted Cost	Sensitivity of each SAMA benefit: 7% Discount rate (baseline)	Sensitivity of each SAMA benefit: 3% Discount rate (Sensitivity)
1	Provide additional dc battery capacity.	$2,000k		$1~~2260~~53k	$~~315422~~370k
2	Provide an additional gas turbine generator.	$10,000k		$1~~2260~~53k	$~~315422~~370k
3	Install an additional, buried off-site power source.	$10,000k		$1~~2564~~57k	$~~323433~~379k
4	Provide an additional high-pressure injection pump with independent diesel.	$1,000k		$~~159208~~199k	$~~409549~~481k
5	Add a service water pump.	$5,900k		$~~76100~~96k	$~~197264~~231k
6	Install an independent reactor coolant pump seal injection system with dedicated diesel.	$3,800k	$~~305400~~383k (Baseline) $~~1,055~~925k (Sensitivity)	$1~~4388~~80k	$~~370~~4~~96~~35k
7	Install an additional component cooling water pump.	$1,500k		$~~76100~~96k	$~~197264~~231k
8	Add a motor-driven feed-water pump.	$2,000k		$1~~407~~34k	$~~275369~~324k
9	Install a filtered containment vent to remove decay heat.	$3,000k		$~~183~~2~~4~~30k	$~~471632~~554k
10	Install a redundant containment spray system.	$870k		$1~~49~~8k	$~~3750~~43k

ACRONYMS AND ABBREVIATIONS

ESW	essential service cooling water
ESWS	essential service water system
F&N	Freese & Nicholas, Inc.
FAA	U.S. Federal Aviation Administration
FAC	flow-accelerated corrosion
FBC	fluidized bed combustion
FCT	Fuel Cell Today
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FFCA	Federal Facilities Compliance Act
FLMNH	Florida Museum of Natural History
FM	farm-to-market
FP	fire protection
FPL	Florida Power and Light
FPS	fire protection system
FPSC	Florida Public Service Commission
FR	Federal Register
FRS	filled RCS state
FSAR	Final Safety Analysis Report
FSL	Forecast Systems Laboratory
ft	feet
FWAT	flow weighted average temperature
FWCOC	Fort Worth Chamber of Commerce
FWS	U.S. Fish and Wildlife Service
gal	gallon

RCOL2_19-28

ACRONYMS AND ABBREVIATIONS

MIT	Massachusetts Institute of Technology
MMbbl	million barrels
MMBtu	million Btu
MNES	Mitsubishi Nuclear Energy Systems Inc.
MOS	mid-loop operation state RCOL2_19-28
MOU	municipally-owned utility
MOV	motor operated valve
MOX	mixed oxide fuel
mph	miles per hour
MSDS	Materials Safety Data Sheets
msl	mean sea level
MSR	maximum steaming rate
MSW	municipal solid waste
MT	Main Transformer
MTU	metric tons of uranium
MW	megawatts
MW	monitoring wells
MWd	megawatt-days
MWd/MTU	megawatt–days per metric ton uranium
MWe	megawatts electrical
MWh	megawatt hour
MWS	makeup water system
MWt	megawatts thermal
NAAQS	National Ambient Air Quality Standards
NAPA	Natural Areas Preserve Association

7.2 SEVERE ACCIDENTS

This section discusses the probabilities and consequences of accidents of greater severity than the design basis accidents (DBAs), which are discussed in Section 7.1.

7.2.1 INTRODUCTION

Severe accidents, as a class, are considered less likely to occur, but because their consequences could be more severe, they are considered important both in terms of impact to the environment and off-site costs. These severe accidents can be distinguished from DBAs in two primary respects: (1) they involve substantial physical deterioration of the fuel in the reactor core, including overheating to the point of melting, and (2) they involve deterioration of the capability of the containment system to perform its intended function of limiting the release of radioactive materials to the environment.

7.2.2 EVALUATION OF POTENTIAL SEVERE ACCIDENT RELEASES

The severe accident consequence analysis was performed using the Level 3 probabilistic risk assessment (PRA) Melcor Accident Consequence Code System (MACCS2) code.

The analysis was performed with the MACCS2 version designated as Oak Ridge National Laboratory RSICC Computer Code Collection MACCS2 V.1.13.1, CCC-652 Code Package (Chanin and Young 1997). MACCS2, Version 1.13.1, released in January 2004, simulates the impact of severe accidents at nuclear power plants on the surrounding environment. The principal phenomena considered in MACCS2 are atmospheric transport, mitigating actions based on dose projections, dose accumulation by a number of pathways including food and water ingestion, early and latent health effects, and economic costs. The MACCS2 program was chosen for this analysis because it is U.S. Nuclear Regulatory Commission (NRC)-endorsed, as stated in the MACCS2 User's Guide. The model for the proposed project, Comanche Peak Nuclear Power Plant (CPNPP) Units 3 and 4, had no important deviations from the default code input values, except for site-specific values and reactor design information. The code values modified for the U.S. Advanced Pressurized Water Reactor (US-APWR) were primarily the source term data ~~(MHI 2007)~~(MHI1 2011 & MHI2 2011). These data include the release fractions, plume release height, delay, and duration. Values for the ATMOS input data file, one of the five input files used by MACCS2, were modified as necessary to use data appropriate for the US-APWR source terms and probability frequencies. The remaining four MACCS2 input files were reviewed and modified as necessary. RCOL2_19-28

Three years of site-specific hourly meteorological data were used in the analysis. Stability class was calculated using the CPNPP site meteorological data and the methodology of Regulatory Guide (RG) 1.23, Table 1. In accordance with U.S. Environmental Protection Agency (EPA) recommendations, short periods of missing data were replaced by interpolating from the values immediately before the data gap to the values immediately after the data gap, while longer periods of missing data were replaced with data from nearby days that had similar meteorological conditions as before and after the data gaps (EPA 1992). Meteorology is further discussed in Section 2.7 and in Final Safety Analysis Report (FSAR) Section 2.3.

The emergency evacuation model has been modeled as a single evacuation zone extending out 10 mi from the site. For the purposes of this analysis, an average evacuation speed of 4.0 mi per hour (mph) is used with a 7200-second delay between the alarm and start of evacuation, with no sheltering. Once evacuees are more than 50 mi from the site, they no longer receive dose and are not included in the analysis. The evacuation scenario is modeled so that 90 percent of the population is evacuated.

The ATMOS input data file calculates the dispersion and deposition of material-released "source terms" to the atmosphere as a function of downwind distance. Source term release fractions (RELFRC) are shown in ~~Table 7.2-3~~Tables 7.2-3a through 7.2-3d, and plume characterizations are shown in ~~Table 7.2-4~~Tables 7.2-4a through 7.2-4d. These data include the RELFRC, plume start time, plume release height, delay, and duration. RCOL2_19-28

The data in ~~Tables 7.2-3 and 7.2-4~~Tables 7.2-3a through 7.2-3d and 7.2-4a through 7.2-4d are from References MHI1 2011 and MHI2 2011.~~the US-APWR DC Applicant's Environmental Report (ER) (MHI 2007). The four plumes in Table 8 of the DC Applicant's ER (MHI 2007) were collapsed into two plumes using the following steps:~~ RCOL2_19-28

1. ~~The release fractions for the first two plumes in the DC Applicant's ER Table 8 (MHI 2007) were added together to produce a release fraction for the first plume in Table 7.2-3. Similarly, the third and fourth plumes in the DC Applicant's ER (MHI 2007) Table 8 were combined for the second plume in Table 7.2-3. This process assures that the total release is the same.~~

2. ~~The first plume duration in Table 7.2-4 is the maximum of the first two plume durations in the DC Applicant's ER (MHI 2007) Table 8. Similarly, the second plume duration in Table 7.2-4 is the maximum of the third and fourth plume durations in the DC Applicant's ER (MHI 2007) Table 8.~~

3. ~~The plume delays in Table 7.2-4 were taken as the first and second plume start times in the DC Applicant's ER (MHI 2007) Table 8. The inventory is released faster in this approach than in the four-plume approach.~~

4. ~~The Ref Time term in Table 7.2-4, which calculates the plume position according to its leading edge (0) or midpoint (0.5), is equal to the plume position in the DC Applicant's ER (MHI 2007) Table 8 for the first and second plumes, respectively, to be consistent with the plume delay approach.~~

The plume release height was conservatively set to zero, as specified in Appendix A.3 of the DC Applicant's ER ~~(MHI 2007)~~(MHI1 2011 & MHI2 2011), which corresponds to a ground level release. Parameters are assigned to each source term according to release category. Each released plume is assumed to have two segments. RCOL2_19-28

The results of the dose and dollar risk assessments for all internal events (i.e., internal events, internal flooding events, internal fire events, and LPSD events), including the water ingestion pathway, are provided in Table 7.2-5. Risk is defined in these results as the product of release category frequency and the dose or cost associated with the release category. The total risk is assumed to be the sum of all scenarios. RCOL2_19-28

The sum of the values for affected land areas for all release scenarios, as given in ~~Tables 7.2-9, 7.2-10, and 7.2-11~~Tables 7.2-9a through 7.2-9d, 7.2-10a through 7.2-10d, and 7.2-11a through 7.2-11d, is also shown in Table 7.2-5. Each of these values has also been multiplied by their release category frequency. RCOL2_19-28

The values for total early and latent fatalities per reactor-year (RY) were conservatively calculated as the sum of all release scenarios. Tables 7.2-6 and 7.2-7 support the calculated dose per RY and dollars per RY risks presented in Table 7.2-5 for ~~internal~~all events. The release frequency data come from Tables 3.2-6, 4.1-1, 4.2-1, and Subsection 4.3.2 of US-APWR Risk Evaluation of Level 2 PRA Final Design Output (MHI 2013)~~Table 7 of the DC Applicant's ER (MHI 2007)~~. RCOL2_19-28

External events were considered in Subsection 19.1.5 of the US-APWR design control document (DCD) and in FSAR Subsection 19.1.5. FSAR Subsection 19.1.5 provides discussion of high winds and tornadoes, external flooding, transportation and nearby facility accidents, and aircraft crashes. The FSAR concludes that all of these external events make an insignificant contribution to the total core damage frequency (CDF). Seismic events are discussed in Subsection 19.1.5 of the US-APWR DCD and are not incorporated into the total CDF. Therefore, external events were determined to be negligible compared to internal events and were not incorporated into the release frequencies.

Due to the extremely low frequency of severe accidents, the severe accident population dose for the CPNPP site is also low. The weighted total dose risk from internal events for the year 2006, which had the most conservative met data, is ~~3.00~~5.15 × 10^{-1} person-rem/RY, as shown in ~~Table 7.2-11~~Table 7.2-11a. This dose is based on the calendar year 2056 projected population distribution. To obtain the average individual dose, this value is divided by the calendar year 2056 population of 2,760,243 people within 50 mi of the CPNPP site, as given in Tables 2.5-1 and 2.5-2, resulting in a dose of 1.~~09~~87 × 10^{-7}rem/RY. This value is lower than the background radiation. Idaho State University indicates that the average individual dose caused by all other sources in the United States is 3.6 × 10^{-1} rem/yr (ISU 2008). Because the weighted total dose risk from severe accidents is lower than the background radiation, it can also be concluded that the impact on the local biota would be negligible. Additionally, biota tend to be less sensitive to radiation than humans, and the primary concern regarding biota is survival of the species, not individual fatalities. RCOL2_19-28 RCOL2_19-28

The liquid pathways dose is not expected to be significant. The MACCS2 analysis resulted in a water ingestion dose risk of 1.~~63~~99 × 10^{-2} person-rem/RY for the year 2006, which provided the most conservative water ingestion dose risk, as shown in ~~Table 7.2-5~~Table 7.2-11a for internal events. This dose accounts for airborne deposition directly onto surface water bodies and deposition onto land that is washed off into surface water bodies, which is eventually consumed in drinking water. NUREG-1437 Table 5.17 indicates that, for a freshwater site such as CPNPP, drinking water is the dominant liquid pathway compared to fish ingestion and shoreline exposure. Furthermore, the water ingestion dose risk of 1.~~63~~99 × 10^{-2} person-rem/RY is small compared to the total dose risk of ~~3.00~~5.15 × 10^{-1} person-rem/RY for internal events. Aquifers in the vicinity of the site are provided in Section 2.3, and a list of public surface water users is provided in Tables 2.3-34 and 2.3-36. In addition to surface water, groundwater must be considered in the liquid pathways dose. As discussed in Subsection 2.3.1.5.6 and FSAR Subsection 2.4.12.3.1, the RCOL2_19-28 RCOL2_19-28 estimated travel time for groundwater from CPNPP Unit 3 to Squaw Creek Reservoir (SCR) through ~~undifferentiated fill/regolith~~engineered fill, which represents the ~~most~~fastest conservative pathway, is ~~720.9~~62 days, ~~or approximately 2 years,~~ which would allow ample time for interdiction and other prevention activities. RCOL2_02.04.12-9 S04

The results of severe accidents for current generation reactors are compared to the severe accident risk calculated in the MACCS2 analysis in Table 7.2-8, where the data for the current generation reactors were taken from System Energy Resources Inc. (SERI 2004). The conclusion is that the low frequency of releases associated with the US-APWR design makes the severe accident risk of a future unit at this site extremely low. Additional severe accident analysis results are reported in ~~Tables 7.2-9, 7.2-10, and 7.2-11~~Tables 7.2-9a through 7.2-9d, 7.2-10a through 7.2-10d, and 7.2-11a through 7.2-11d. The CDF in these tables comes from ~~Table 7 of the DC Applicant's ER (MHI 2007)~~Tables 3.2-6, 4.1-1, 4.2-1, and Subsection 4.3.2 of US-APWR Risk Evaluation of Level 2 PRA Final Design Output (MHI 2013). RCOL2_19-28

The significance of the impacts associated with each severe accident issue has been identified as either SMALL, MODERATE, or LARGE, consistent with the criteria that the NRC established in 10 Code of Federal Regulations (CFR) 51, Appendix B, Table B-1, Footnote 3 as follows:

> SMALL – Environmental effects are not detectable or are so minor that they are not expected to destabilize nor noticeably alter any important attribute of the resource. For purposes of assessing radiological impacts, the NRC has concluded that those impacts that do not exceed permissible levels in the NRC's regulations are considered small.
>
> MODERATE – Environmental effects are sufficient to alter noticeably, but not to destabilize, any important attribute of the resource.
>
> LARGE – Environmental effects are clearly noticeable and are sufficient to destabilize any important attributes of the resource.

In accordance with National Environmental Policy Act (NEPA) practice, ongoing and potential additional mitigation is considered in proportion to the significance of the impact to be addressed (i.e., impacts that are SMALL receive less mitigative consideration than impacts that are LARGE).

As discussed previously, the frequency of releases is extremely low. Also, the average individual dose risk for internal events of 1.~~09~~87 $\times 10^{-7}$ rem/RY, as calculated above, is lower than the average individual dose caused by all other sources in the United States of 3.6×10^{-1} rem/yr; therefore, the CPNPP site risks would be acceptable. RCOL2_19-28

The MACCS2 analysis also considers potential economic impacts as a result of postulated severe accidents at a nuclear reactor on the CPNPP site. MACCS2 calculated severe accident costs based on the following:

- Evacuation costs.
- Value of crops contaminated and condemned.

- Value of milk contaminated and condemned.
- Costs of decontamination of property.
- Indirect costs resulting from the loss of use of property and incomes derived as a result of the accident.

The total cost of severe accidents at the CPNPP site was determined to be $~~714~~5,240/RY given the 2006 meteorological data, which was the most conservative of the three years considered, as shown in Table 7.2-5. This low cost is mostly due to the extremely low accident frequencies expected for accidents of this magnitude. RCOL2_19-28

7.2.3 CONSIDERATION OF COMMISSION SEVERE ACCIDENT POLICY

In 1985, the NRC adopted a Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants. This policy statement indicated that the NRC fully expects that vendors engaged in designing new standard (or custom) plants are to achieve a higher standard of severe accident safety performance than their prior designs. This expectation is based on:

- The growing volume of information from industry and government-sponsored research and operating reactor experience has improved our knowledge of specific severe accident vulnerabilities and of low-cost methods for their mitigation. Further learning on safety vulnerabilities and innovative methods is to be expected.
- The inherent flexibility of this policy statement (that permits risk-risk tradeoffs in systems and subsystems design) encourages thereby innovative ways of achieving an improved overall systems reliability at a reasonable cost.
- Public acceptance, and hence investor acceptance, of nuclear technology is dependent on demonstrable progress in safety performance, including the reduction in frequency of accident precursor events as well as a diminished controversy among experts as to the adequacy of nuclear safety technology.

Thus, implementation of the NRC's Severe Accident Policy can be expected to show that the environmental impact of any additional reactor or reactors on the CPNPP site would be within the range of risk previously determined to be SMALL.

A significant factor in the risk associated with the plant design is the frequency of the considered release modes. The various accident frequencies for a US-APWR are extremely low, resulting in the low-impact consequences discussed previously.

7.2.4 CONCLUSION

The following are directly applicable conclusions from NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), Volume 1, and conclusions drawn based on the foregoing analysis:

- The conclusion of the GEIS, based on the generic evaluations presented, is that the probability-weighted consequences of severe accidents are SMALL for all plants.

- As described above, the results of the GEIS are applicable to the consideration of new plants. Evaluation of site-specific factors for purposes of this application has shown that the CPNPP site is within the range of sites considered in the GEIS. Thus, it is concluded that the GEIS conclusion is applicable to the CPNPP site.

The environmental impacts of a postulated severe accident at the CPNPP site could be severe but, due to the low likelihood of such an accident, the impacts are determined to be SMALL. ~~The total dose risk value of 3.00 × 10^{-1} person-rem/RY is not bounded by the dose risk of 2.7 × 10^{-1} person-rem/RY calculated in Table 10a of the DC Applicant's ER (MHI 2007). However, the calculation in the DC Applicant's ER (MHI 2007) does not account for Release Category RC5 because there is no release within 24 hr after the onset of core damage. If the dose risk value for RC5 is subtracted from the total dose risk value in Table 7.2-6 for the year 2006, the resulting total dose risk value is 1.52 x 10^{-1} person-rem/RY, which is bounded by 2.7 × 10^{-1} person-rem/RY. Other notable differences between the DC Applicant's analysis and the site-specific analysis are that the DC Applicant's analysis did not credit evacuation and sheltering and only considered the first 24 hours (hr) of the event. Radiological dose consequences and health effects associated with normal and anticipated operational releases are discussed in Subsection 5.4.3.~~ RCOL2_19-28

The CDF for internal events is 1.~~2~~0 × 10^{-6}. This value is used in conjunction with the Applicant's ER (MHI 2007) to determine the total severe accident health effects, which include internal events, internal fire, internal flood, and low-power and shutdown (LPSD) events, as shown in Tables 7.2-12, 7.2-13, and 7.2-14. The health effects resulting from internal fire, internal flood, and LPSD events were determined using ~~the ratio of the CDF values for these events and the CDF value for the internal events~~the MACCS2 computer code. The maximum dose risk from the three years of meteorological data is ~~1.15~~2.96 person-rem/RY. The maximum numbers of early and latent fatalities per RY from the three years of meteorological data are ~~2.87~~5.48 × 10^{-7} and ~~9.17~~1.82 × 10^{-43}, respectively. Finally, the maximum dose for the water ingestion pathway from the three years of meteorological data is ~~6.25~~1.28 × 10^{-21} person-rem/RY. RCOL2_19-28

Additionally, the NRC's Safety Goal Policy Statement, issued in 1986, states that "the risk to an average individual in the vicinity of a nuclear power plant of prompt fatalities that might result from reactor accidents should not exceed one-tenth of one percent (0.1 percent) of the sum of prompt fatality risks resulting from other accidents to which members of the U.S. population are generally exposed" and that "the risk to the population in the area near a nuclear power plant of cancer fatalities that might result from nuclear power plant operation should not exceed one-tenth of one percent (0.1 percent) of the sum of cancer fatality risks resulting from all other causes." According to the Centers for Disease Control and Prevention (CDC), there were 39.7 deaths caused by accidents per 100,000 people in the year 2005. Also, there were 188.7 deaths caused by cancer per 100,000 people in the year 2005 (CDC 2008). These statistics mean that the cancer fatality risk from "all other causes" is 1.89 × 10^{-3}, and the prompt fatality risk from "other accidents" is 3.97 × 10^{-4}. One-tenth of one percent of each of these risks results in a value of 1.89 × 10^{-6} for cancer fatalities and 3.97 × 10^{-7} for prompt fatalities. As stated above, the maximum number of latent fatalities per RY from the three years of meteorological data is ~~9.17~~1.82 × ~~10^{-4}~~ 10^{-3}. In order to obtain the appropriate risk number, the number of latent fatalities is divided by the calendar year 2056 population within 50 mi of the CPNPP site of 2,760,243. This results in a cancer fatality risk of ~~3.32~~6.59 × 10^{-10}, which is well below the cancer fatality safety goal of 1.89 × 10^{-6}. Also as stated above, the maximum number of early fatalities per RY from the three years of meteorological data is ~~2.87~~5.48 × 10^{-7}. In order to obtain the appropriate risk number, the number of early fatalities is divided by the calendar year 2056 population within two kilometers of the CPNPP site of 182, as provided in Table 2.5-1. The Safety Goal Policy Statement indicates that the population within one mile of the plant should be used, but here the population within two kilometers is considered to be a reasonable estimate, particularly because the risk of prompt fatalities is bounded by the safety goal regardless of the population size used. This results in a prompt fatality risk of ~~1.58~~3.01 × 10^{-9}, which is well below the prompt fatality safety goal of 3.97 × 10^{-7}. Therefore, the early and latent fatality risks from a severe accident at the CPNPP site are found to be acceptable. RCOL2_19-28 RCOL2_19-28 RCOL2_19-28 RCOL2_19-28

7.2.5 REFERENCES

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TABLE 7.2-3a (Sheet 1 of 2)
US-APWR SOURCE TERM RELEASE FRACTIONS – INTERNAL EVENTS[a]

RCOL2_19-28

Release Category[b]	Plume No.	Kr/Xe	I	Cs	Te/Sb	Sr	Ru	La	Ce	Ba
~~RC1[c],[d]~~	~~1~~	~~9.4E-1~~	~~2.8E-1~~	~~2.0E-1~~	~~1.3E-1~~	~~4.9E-3~~	~~1.8E-2~~	~~2.4E-4~~	~~2.8E-4~~	~~1.2E-2~~
~~RC1[e]~~	~~2~~	~~7.6E-3~~	~~6.3E-3~~	~~1.1E-2~~	~~8.5E-3~~	~~3.9E-3~~	~~4.3E-3~~	~~2.7E-3~~	~~1.9E-3~~	~~3.6E-3~~
~~RC2[f]~~	~~1~~	~~9.7E-1~~	~~6.8E-2~~	~~2.6E-2~~	~~4.3E-2~~	~~5.4E-3~~	~~1.6E-2~~	~~4.0E-3~~	~~2.3E-3~~	~~8.6E-3~~
~~RC2~~	~~2~~	~~2.7E-2~~	~~2.1E-1~~	~~1.7E-2~~	~~3.5E-2~~	~~2.3E-3~~	~~1.0E-4~~	~~1.1E-4~~	~~4.1E-4~~	~~2.6E-3~~
~~RC3[g]~~	~~1~~	~~9.9E-1~~	~~4.8E-1~~	~~4.7E-1~~	~~4.3E-1~~	~~4.4E-2~~	~~2.8E-1~~	~~1.6E-3~~	~~6.4E-3~~	~~1.1E-1~~
~~RC3~~	~~2~~	~~2.0E-3~~	~~1.3E-3~~	~~1.1E-3~~	~~4.3E-3~~	~~4.9E-4~~	~~1.8E-4~~	~~6.6E-6~~	~~6.3E-5~~	~~2.5E-4~~
~~RC4[h]~~	~~1~~	~~1.0E+0~~	~~5.5E-2~~	~~4.2E-2~~	~~5.3E-2~~	~~4.8E-3~~	~~2.7E-2~~	~~1.2E-4~~	~~3.7E-4~~	~~2.4E-2~~
~~RC4~~	~~2~~	~~3.8E-4~~	~~1.4E-2~~	~~4.5E-3~~	~~1.1E-2~~	~~1.3E-3~~	~~1.1E-5~~	~~1.5E-5~~	~~4.7E-4~~	~~4.7E-4~~
~~RC5[i]~~	~~1~~	~~9.6E-1~~	~~2.5E-2~~	~~5.3E-3~~	~~9.0E-3~~	~~8.2E-5~~	~~1.0E-4~~	~~3.0E-5~~	~~1.9E-5~~	~~6.8E-5~~
~~RC5~~	~~2~~	~~2.5E-2~~	~~1.2E-1~~	~~1.5E-2~~	~~7.7E-3~~	~~2.2E-6~~	~~2.6E-6~~	~~5.9E-8~~	~~5.9E-8~~	~~5.0E-6~~
~~RC6[j]~~	~~1~~	~~7.8E-4~~	~~1.7E-6~~	~~1.7E-6~~	~~1.3E-6~~	~~1.7E-7~~	~~6.4E-7~~	~~3.5E-9~~	~~5.6E-9~~	~~2.7E-7~~
~~RC6~~	~~2~~	~~1.3E-3~~	~~1.9E-9~~	~~0.0E+0~~	~~6.0E-10~~	~~6.5E-11~~	~~4.4E-11~~	~~4.6E-13~~	~~1.2E-12~~	~~6.4E-11~~
RC1[c]	1	6.9E-1	2.0E-1	1.6E-1	8.6E-2	3.5E-4	1.5E-2	1.5E-5	4.3E-5	2.9E-3
	2	2.5E-1	8.7E-2	3.9E-2	3.9E-2	4.6E-3	3.9E-3	2.3E-4	2.4E-4	8.8E-3
	3	2.7E-3	4.0E-3	8.5E-3	7.9E-3	3.7E-3	4.2E-3	2.1E-3	1.4E-3	3.5E-3
	4	4.9E-3	2.3E-3	2.7E-3	6.1E-4	1.9E-4	7.6E-5	6.2E-4	5.3E-4	9.7E-5
RC2[d]	1	7.3E-1	3.6E-2	2.1E-2	3.6E-2	5.1E-3	1.5E-2	3.6E-3	2.0E-3	8.1E-3
	2	2.4E-1	3.2E-2	4.2E-3	7.2E-3	2.6E-4	7.1E-4	4.0E-4	3.7E-4	4.4E-4
	3	2.2E-2	1.7E-1	1.2E-2	2.9E-2	1.2E-3	4.0E-5	5.2E-5	1.6E-4	1.5E-3
	4	5.4E-3	4.7E-2	5.5E-3	5.9E-3	1.1E-3	6.1E-5	5.6E-5	2.5E-4	1.1E-3
RC3[e]	1	9.4E-1	4.7E-1	4.6E-1	4.2E-1	4.2E-2	2.7E-1	1.5E-3	6.3E-3	1.0E-1
	2	4.7E-2	8.4E-3	6.5E-3	6.4E-3	1.8E-3	4.9E-3	6.6E-5	8.7E-5	3.5E-3
	3	1.5E-3	1.0E-3	1.1E-3	2.8E-3	4.4E-4	1.8E-4	6.4E-6	6.0E-5	2.2E-4
	4	5.5E-4	2.5E-4	1.8E-5	1.5E-3	5.4E-5	0.0E+0	2.3E-7	2.8E-6	2.4E-5
RC4[f]	1	1.0E+0	3.8E-2	3.3E-2	4.9E-2	4.5E-3	2.4E-2	1.2E-4	3.7E-4	2.3E-2
	2	1.6E-3	1.7E-2	8.6E-3	3.8E-3	3.1E-4	2.8E-3	6.8E-7	3.5E-6	5.6E-4
	3	2.7E-4	7.5E-3	3.4E-3	7.8E-3	1.3E-3	1.1E-5	1.5E-5	4.7E-4	4.7E-4
	4	1.0E-4	6.3E-3	1.1E-3	2.8E-3	1.5E-6	0.0E+0	3.1E-8	9.6E-7	1.0E-6

TABLE 7.2-3a (Sheet 2 of 2)
US-APWR SOURCE TERM RELEASE FRACTIONS – INTERNAL EVENTS[(a)] RCOL2_19-28

Release Category[(b)]	Plume No.	Kr/Xe	I	Cs	Te/Sb	Sr	Ru	La	Ce	Ba
RC5[(g)]	1	9.3E-1	2.7E-3	1.1E-3	6.4E-3	8.1E-5	1.0E-4	3.0E-5	1.9E-5	6.6E-5
	2	3.5E-2	2.2E-2	4.2E-3	2.5E-3	1.5E-6	1.9E-6	5.3E-7	3.4E-7	1.6E-6
	3	1.8E-2	6.0E-2	8.0E-3	3.1E-3	5.2E-7	1.7E-6	5.7E-8	4.6E-8	1.3E-6
	4	6.5E-3	5.7E-2	6.4E-3	4.6E-3	1.6E-6	9.2E-7	2.1E-9	1.3E-8	3.7E-6
RC6[(h)]	1	1.2E-4	1.7E-6	1.7E-6	1.3E-6	1.6E-7	6.3E-7	3.2E-9	5.3E-9	2.4E-7
	2	6.5E-4	1.5E-9	0.0E+0	7.0E-9	1.8E-8	6.5E-9	2.9E-10	2.8E-10	2.5E-8
	3	6.9E-4	1.9E-9	0.0E+0	5.1E-10	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0
	4	6.5E-4	0.0E+0	0.0E+0	8.9E-11	6.5E-11	4.4E-11	4.6E-13	1.2E-12	6.4E-11

a) Some release fraction values contain negligible errors due to rounding.

b) Two lines of data are provided for each release category because the four plumes in the DC Applicant's Environmental Report, Table 8 (MHI 2007) were collapsed into two plumes.Release Fraction data provided in Table 1 of CP34 COLA Conceptual Engineering, Information on Severe Accident – MACCS2 (MHI1 2011). RCOL2_19-28

c) Containment bypass, which includes core damage after steam generator tube rupture (SGTR) and thermally induced SGTR after core damage.

d) The release fractions for the first two plumes in the DC Applicant's Environmental Report, Table 8 (MHI 2007) were added together to produce a release fraction for the first plume for each release category.Containment isolation failure. RCOL2_19-28

e) The release fractions for the third and fourth plumes in the DC Applicant's Environmental Report, Table 8 (MHI 2007) were added together to produce a release fraction for the second plume for each release category.Overpressure failure before core damage due to loss of heat removal.

f) Containment isolation failure.Containment failure condition due to dynamic loads, which includes hydrogen combustion before or just after reactor vessel failure, in-vessel or ex-vessel steam explosion, and containment direct heating.

g) Overpressure failure before core damage due to loss of heat removal.Containment failure condition, including overpressure failure after core damage, hydrogen combustion failure after core damage, hydrogen combustion long after reactor vessel failure, and basemat melt-through.

h) Containment failure condition due to dynamic loads, which includes hydrogen combustion before or just after reactor vessel failure, in vessel or ex vessel steam explosion, and containment direct heating.Condition which assumes intact containment throughout the sequence and fission products released at the design leak rate.

j) Condition which assumes intact containment throughout the sequence and fission products released at the design leak rate.

TABLE 7.2-3b
US-APWR SOURCE TERM RELEASE FRACTIONS – INTERNAL FLOODING EVENTS(a)

RCOL2_19-28

Release Category(b)	Plume No.	Kr/Xe	I	Cs	Te/Sb	Sr	Ru	La	Ce	Ba
RC1(c)	1	1.7E-1	5.3E-3	1.1E-3	7.7E-3	1.0E-4	4.7E-3	2.0E-5	3.4E-5	2.7E-3
	2	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0
	3	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0
	4	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0
RC2(d)	1	2.1E-1	5.9E-3	3.7E-3	2.7E-3	1.5E-3	1.7E-3	1.5E-3	7.8E-4	1.5E-3
	2	6.5E-1	3.0E-6	2.1E-6	3.0E-6	5.5E-6	2.7E-6	5.6E-6	3.0E-6	4.9E-6
	3	1.3E-1	5.9E-6	1.1E-6	3.4E-6	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0
	4	3.9E-3	8.5E-7	4.0E-7	4.0E-7	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0
RC3(e)	1	9.6E-1	3.3E-1	3.2E-1	3.0E-1	1.6E-2	1.4E-1	3.0E-4	9.8E-4	4.5E-2
	2	4.2E-2	2.0E-2	6.1E-3	1.1E-2	1.3E-2	8.3E-3	4.8E-4	2.7E-4	1.7E-2
	3	1.1E-3	1.1E-2	1.0E-3	3.1E-4	7.0E-4	2.7E-4	2.1E-4	1.2E-4	6.2E-4
	4	0.0E+0	2.2E-3	5.5E-4	3.7E-3	1.4E-4	0.0E+0	1.0E-5	3.1E-5	6.2E-5
RC4(f)	1	8.4E-1	1.0E-2	5.1E-3	9.9E-3	2.6E-2	1.0E-2	2.6E-2	1.4E-2	2.1E-2
	2	1.3E-1	4.6E-8	7.9E-9	1.3E-7	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0
	3	2.0E-2	1.1E-6	1.7E-7	1.9E-7	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0
	4	5.0E-3	0.0E+0	1.8E-9	5.4E-6	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0
RC5(g)	1	9.8E-1	4.0E-5	4.0E-5	1.1E-4	5.9E-5	1.2E-4	2.6E-6	1.7E-6	1.1E-4
	2	1.3E-2	5.7E-5	5.0E-5	1.5E-4	4.5E-7	9.2E-7	2.0E-8	1.1E-8	7.5E-7
	3	0.0E+0	1.2E-3	5.1E-4	3.1E-4	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0
	4	0.0E+0	3.0E-3	1.0E-3	3.2E-4	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0
RC6(h)	1	4.2E-5	2.6E-6	2.2E-6	3.5E-6	3.3E-8	1.8E-6	7.6E-10	1.4E-9	3.0E-7
	2	2.3E-4	8.1E-9	7.8E-9	2.5E-8	5.8E-9	4.8E-8	1.0E-10	2.2E-10	2.2E-8
	3	7.3E-4	0.0E+0	0.0E+0	0.0E+0	9.3E-12	0.0E+0	1.4E-12	1.6E-12	2.7E-12
	4	1.1E-3	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0

a) Some release fraction values contain negligible errors due to rounding.

b) Release Fraction data provided in Table 3 of US-APWR Standard Design, Information on Severe Accident of Internal Flood and Fire Events at Power, and LPSD Conditions – MACCS2 (MHI2 2011).

c) Containment bypass, which includes core damage after steam generator tube rupture (SGTR) and thermally induced SGTR after core damage.

d) Containment isolation failure. RCOL2_19-28

e) Overpressure failure before core damage due to loss of heat removal.

f) Containment failure condition due to dynamic loads, which includes hydrogen combustion before or just after reactor vessel failure, in-vessel or ex-vessel steam explosion, and containment direct heating.

g) Containment failure condition, including overpressure failure after core damage, hydrogen combustion failure after core damage, hydrogen combustion long after reactor vessel failure, and basemat melt-through.

h) Condition which assumes intact containment throughout the sequence and fission products released at the design leak rate.

TABLE 7.2-3c

US-APWR SOURCE TERM RELEASE FRACTIONS – INTERNAL FIRE EVENTS[(a)]

RCOL2_19-28

Release Category[(b)]	Plume No.	Kr/Xe	I	Cs	Te/Sb	Sr	Ru	La	Ce	Ba
RC1[(c)]	1	1.7E-1	5.3E-3	1.1E-3	7.7E-3	1.0E-4	4.7E-3	2.0E-5	3.4E-5	2.7E-3
	2	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0
	3	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0
	4	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0
RC2[(d)]	1	7.3E-1	3.6E-2	2.1E-2	3.6E-2	5.1E-3	1.5E-2	3.6E-3	2.0E-3	8.1E-3
	2	2.4E-1	3.2E-2	4.2E-3	7.2E-3	2.6E-4	7.1E-4	4.0E-4	3.7E-4	4.4E-4
	3	2.2E-2	1.7E-1	1.2E-2	2.9E-2	1.2E-3	4.0E-5	5.2E-5	1.6E-4	1.5E-3
	4	5.4E-3	4.7E-2	5.5E-3	5.9E-3	1.1E-3	6.1E-5	5.6E-5	2.5E-4	1.1E-3
RC3[(e)]	1	9.4E-1	4.7E-1	4.6E-1	4.2E-1	4.2E-2	2.7E-1	1.5E-3	6.3E-3	1.0E-1
	2	4.7E-2	8.4E-3	6.5E-3	6.4E-3	1.8E-3	4.9E-3	6.6E-5	8.7E-5	3.5E-3
	3	1.5E-3	1.0E-3	1.1E-3	2.8E-3	4.4E-4	1.8E-4	6.4E-6	6.0E-5	2.2E-4
	4	5.5E-4	2.5E-4	1.8E-5	1.5E-3	5.4E-5	0.0E+0	2.3E-7	2.8E-6	2.4E-5
RC4[(f)]	1	8.4E-1	1.0E-2	5.1E-3	9.9E-3	2.6E-2	1.0E-2	2.6E-2	1.4E-2	2.1E-2
	2	1.3E-1	4.6E-8	7.9E-9	1.3E-7	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0
	3	2.0E-2	1.1E-6	1.7E-7	1.9E-7	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0
	4	5.0E-3	0.0E+0	1.8E-9	5.4E-6	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0
RC5[(g)]	1	9.3E-1	2.7E-3	1.1E-3	6.4E-3	8.1E-5	1.0E-4	3.0E-5	1.9E-5	6.6E-5
	2	3.5E-2	2.2E-2	4.2E-3	2.5E-3	1.5E-6	1.9E-6	5.3E-7	3.4E-7	1.6E-6
	3	1.8E-2	6.0E-2	8.0E-3	3.1E-3	5.2E-7	1.7E-6	5.7E-8	4.6E-8	1.3E-6
	4	6.5E-3	5.7E-2	6.4E-3	4.6E-3	1.6E-6	9.2E-7	2.1E-9	1.3E-8	3.7E-6
RC6[(h)]	1	4.2E-5	2.6E-6	2.2E-6	3.5E-6	3.3E-8	1.8E-6	7.6E-10	1.4E-9	3.0E-7
	2	2.3E-4	8.1E-9	7.8E-9	2.5E-8	5.8E-9	4.8E-8	1.0E-10	2.2E-10	2.2E-8
	3	7.3E-4	0.0E+0	0.0E+0	0.0E+0	9.3E-12	0.0E+0	1.4E-12	1.6E-12	2.7E-12
	4	1.1E-3	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0

a) Some release fraction values contain negligible errors due to rounding.

b) Release Fraction data provided in Table 1 of US-APWR Standard Design, Information on Severe Accident of Internal Flood and Fire Events at Power, and LPSD Conditions – MACCS2 (MHI2 2011).

c) Containment bypass, which includes core damage after steam generator tube rupture (SGTR) and thermally induced SGTR after core damage.

d) Containment isolation failure. RCOL2_19-28

e) Overpressure failure before core damage due to loss of heat removal.

f) Containment failure condition due to dynamic loads, which includes hydrogen combustion before or just after reactor vessel failure, in-vessel or ex-vessel steam explosion, and containment direct heating.

g) Containment failure condition, including overpressure failure after core damage, hydrogen combustion failure after core damage, hydrogen combustion long after reactor vessel failure, and basemat melt-through.

h) Condition which assumes intact containment throughout the sequence and fission products released at the design leak rate.

TABLE 7.2-3d
US-APWR SOURCE TERM RELEASE FRACTIONS – LPSD CONDITIONS[(a)]

RCOL2_19-28

Release Category[(b)]	Plume No.	Kr/Xe	I	Cs	Te/Sb	Sr	Ru	La	Ce	Ba
FRS[(c)]	1	1.0E+0	4.3E-6	8.5E-6	5.9E-4	2.8E-8	8.2E-8	1.2E-9	3.9E-9	7.4E-7
	2	2.9E-3	6.3E-6	8.2E-6	4.3E-4	4.1E-9	1.3E-8	1.9E-10	5.1E-10	1.2E-7
	3	2.1E-4	1.0E-4	6.2E-5	1.0E-3	7.3E-9	2.4E-8	3.6E-10	1.0E-9	2.1E-7
	4	0.0E+0	4.5E-4	1.9E-4	9.8E-4	5.9E-9	2.0E-8	3.0E-10	8.1E-10	1.7E-7
MOS[(d)]	1	1.8E-1	2.6E-2	2.5E-2	2.7E-2	2.1E-3	6.2E-3	2.7E-5	2.1E-4	2.8E-3
	2	3.1E-1	2.3E-3	1.4E-3	4.1E-3	6.3E-3	2.3E-3	3.6E-4	1.2E-3	6.8E-3
	3	3.3E-1	6.0E-3	2.0E-3	1.3E-3	2.5E-3	4.4E-4	8.9E-4	8.3E-4	2.3E-3
	4	1.2E-1	4.6E-3	5.2E-3	1.1E-3	2.0E-4	8.7E-5	5.3E-4	5.0E-4	1.7E-4

a) Some release fraction values contain negligible errors due to rounding.

b) Release Fraction data provided in Table 5 of US-APWR Standard Design, Information on Severe Accident of Internal Flood and Fire Events at Power, and LPSD Conditions – MACCS2 (MHI2 2011).

c) Filled RCS State, the equipment hatch is expected closed because RCS temperature is still high or inspection cannot be carried out during the period.

d) Mid-loop Operation State, the equipment hatch is anticipated opened.

TABLE 7.2-4a (Sheet 1 of 2)
US-APWR PLUME CHARACTERIZATION DATA – INTERNAL EVENTS

RCOL2_19-28

Release Category ~~(a)~~	Plume No.	Number of Plumes ~~Releases~~	Risk-Dominant Plume	Ref Time ~~(b)~~ (a)	Plume Heat (W)	Plume Release Height (m)	Plume Duration (s) ~~(c)~~(b)	Plume Delay (s) ~~(d)~~(c)
~~RC1~~	~~1~~	~~2~~	~~1~~	~~0.0~~	~~0~~	~~0~~	~~3.6E+4~~	~~1.0E+5~~
~~RC1~~	~~2~~	~~2~~	~~1~~	~~0.5~~	~~0~~	~~0~~	~~8.6E+4~~	~~1.2E+5~~
~~RC2~~	~~1~~	~~2~~	~~1~~	~~0.0~~	~~0~~	~~0~~	~~5.3E+4~~	~~9.0E+3~~
~~RC2~~	~~2~~	~~2~~	~~1~~	~~0.5~~	~~0~~	~~0~~	~~8.6E+4~~	~~4.2E+4~~
~~RC3~~	~~1~~	~~2~~	~~1~~	~~0.0~~	~~0~~	~~0~~	~~4.4E+4~~	~~1.7E+5~~
~~RC3~~	~~2~~	~~2~~	~~1~~	~~0.0~~	~~0~~	~~0~~	~~8.6E+4~~	~~2.1E+5~~
~~RC4~~	~~1~~	~~2~~	~~1~~	~~0.0~~	~~0~~	~~0~~	~~3.2E+4~~	~~7.8E+4~~
~~RC4~~	~~2~~	~~2~~	~~1~~	~~0.5~~	~~0~~	~~0~~	~~8.6E+4~~	~~9.4E+4~~
~~RC5~~	~~1~~	~~2~~	~~1~~	~~0.0~~	~~0~~	~~0~~	~~6.0E+4~~	~~1.9E+5~~
~~RC5~~	~~2~~	~~2~~	~~1~~	~~0.5~~	~~0~~	~~0~~	~~8.6E+4~~	~~2.0E+5~~
~~RC6~~	~~1~~	~~2~~	~~1~~	~~0.0~~	~~0~~	~~0~~	~~7.3E+4~~	~~1.3E+3~~
~~RC6~~	~~2~~	~~2~~	~~1~~	~~0.5~~	~~0~~	~~0~~	~~8.6E+4~~	~~1.5E+4~~
RC1	1	4	1	0.0	0	0	1.5E+4	1.0E+5
	2			0.5	0	0	3.6E+4	1.2E+5
	3			0.5	0	0	8.6E+4	1.5E+5
	4			0.5	0	0	8.6E+4	2.4E+5
RC2	1	4	1	0.0	0	0	3.3E+4	9.0E+3
	2			0.5	0	0	5.3E+4	4.2E+4
	3			0.5	0	0	6.8E+4	9.5E+4
	4			0.5	0	0	8.6E+4	1.6E+5
RC3	1	4	1	0.0	0	0	4.1E+4	1.7E+5
	2			0.5	0	0	4.4E+4	2.1E+5
	3			0.5	0	0	8.3E+4	2.6E+5
	4			0.5	0	0	8.6E+4	3.4E+5
RC4	1	4	1	0.0	0	0	1.6E+4	7.8E+4
	2			0.5	0	0	3.2E+4	9.4E+4
	3			0.5	0	0	8.6E+4	1.3E+5
	4			0.5	0	0	8.6E+4	2.1E+5

TABLE 7.2-4a (Sheet 2 of 2)
US-APWR PLUME CHARACTERIZATION DATA – INTERNAL EVENTS

RCOL2_19-28

Release Category (a)	Plume No.	Number of Plumes Releases	Risk-Dominant Plume	Ref Time(b) (a)	Plume Heat (W)	Plume Release Height (m)	Plume Duration (s)(c)(b)	Plume Delay (s)(d)(c)
RC5	1	4	1	0.0	0	0	1.0E+4	1.9E+5
	2			0.5	0	0	6.0E+4	2.0E+5
	3			0.5	0	0	8.3E+4	2.6E+5
	4			0.5	0	0	8.6E+4	3.4E+5
RC6	1	4	1	0.0	0	0	1.4E+4	1.3E+3
	2			0.5	0	0	7.3E+4	1.5E+4
	3			0.5	0	0	8.6E+4	8.8E+4
	4			0.5	0	0	8.6E+4	1.7E+5

a) Two lines of data are provided for each release category because the four plumes in the DC Applicant's Environmental Report Table 8 (MHI 2007) were collapsed into two plumes. The Ref Time values for each release category, which calculate the plume position according to its leading edge (0.0) or midpoint (0.5), are equal to the plume position in Table 1 of CP34 COLA Conceptual Engineering, Information on Severe Accident – MACCS2 (MHI1 2011).

b) The Ref Time values for each release category, which calculate the plume position according to its leading edge (0) or midpoint (0.5), are equal to the plume position in the DC Applicant's Environmental Report Table 8 (MHI 2007) for the first and second plumes, respectively, to be consistent with the plume delay approach. The plume duration for each release category is provided in Table 2 of CP34 COLA Conceptual Engineering, Information on Severe Accident – MACCS2 (MHI1 2011).

c) The first plume duration for each release category is the maximum of the first two plume durations in the DC Applicant's Environmental Report, Table 8 (MHI 2007). The second plume duration for each release category is the maximum of the third and fourth plume durations in the DC Applicant's Environmental Report, Table 8 (MHI 2007). The plume delay for each release category is provided in Table 2 of CP34 COLA Conceptual Engineering, Information on Severe Accident – MACCS2 (MHI1 2011).

d) The plume delays for each release category were taken as the first and second plume start times in the DC Applicant's Environmental Report Table 8 (MHI 2007).

TABLE 7.2-4b
US-APWR PLUME CHARACTERIZATION DATA – INTERNAL FLOODING EVENTS

RCOL2_19-28

Release Category	Plume No.	Number of Plumes	Risk Dominant Plume	Ref Time(a)	Plume Heat (W)	Plume Release Height (m)	Plume Duration (s)(b)	Plume Delay (s)(c)
RC1	1	4	1	0.0	0	0	3.3E+3	1.6E+4
	2			0.0	0	0	7.5E+4	1.9E+4
	3			0.0	0	0	8.6E+4	9.4E+4
	4			0.0	0	0	8.6E+4	1.8E+5
RC2	1	4	1	0.0	0	0	1.1E+4	1.0E+4
	2			0.0	0	0	3.8E+4	2.1E+4
	3			0.0	0	0	8.6E+4	5.8E+4
	4			0.0	0	0	8.6E+4	1.5E+5
RC3	1	4	1	0.0	0	0	6.2E+4	1.6E+5
	2			0.0	0	0	2.0E+4	2.2E+5
	3			0.5	0	0	5.8E+4	2.4E+5
	4			0.5	0	0	8.6E+4	3.0E+5
RC4	1	4	1	0.0	0	0	7.8E+3	2.0E+4
	2			0.5	0	0	4.0E+4	2.8E+4
	3			0.0	0	0	5.6E+4	6.7E+4
	4			0.5	0	0	8.6E+4	1.2E+5
RC5	1	4	1	0.0	0	0	1.1E+4	3.0E+5
	2			0.5	0	0	5.8E+4	3.1E+5
	3			0.5	0	0	8.3E+4	3.6E+5(d)
	4			0.5	0	0	8.6E+4	4.5E+5(d)
RC6	1	4	1	0.0	0	0	6.9E+3	1.0E+4
	2			0.0	0	0	2.8E+4	1.7E+4
	3			0.5	0	0	8.6E+4	4.5E+4
	4			0.5	0	0	8.6E+4	1.3E+5

a) The Ref Time values for each release category, which calculate the plume position according to its leading edge (0.0) or midpoint (0.5), are equal to the plume position in Table 3 of US-APWR Standard Design, Information on Severe Accident of Internal Flood and Fire Events at Power, and LPSD Conditions – MACCS2 (MHI2 2011).

b) The plume duration for each release category is provided in Table 4 of US-APWR Standard Design, Information on Severe Accident of Internal Flood and Fire Events at Power, and LPSD Conditions – MACCS2 (MHI2 2011). RCOL2_19-28

c) The plume delay for each release category is provided in Table 4 of US-APWR Standard Design, Information on Severe Accident of Internal Flood and Fire Events at Power, and LPSD Conditions – MACCS2 (MHI2 2011).

d) The plume delays for these plumes were reduced to 3.456×10^5 seconds when modeling in MACCS2 due to code limitations.

TABLE 7.2-4c
US-APWR PLUME CHARACTERIZATION DATA – INTERNAL FIRE EVENTS

RCOL2_19-28

Release Category	Plume No.	Number of Plumes	Risk Dominant Plume	Ref Time[(a)]	Plume Heat (W)	Plume Release Height (m)	Plume Duration (s)[(b)]	Plume Delay (s)[(c)]
RC1	1	4	1	0.0	0	0	3.3E+3	1.6E+4
	2			0.0	0	0	7.5E+4	1.9E+4
	3			0.0	0	0	8.6E+4	9.4E+4
	4			0.0	0	0	8.6E+4	1.8E+5
RC2	1	4	1	0.0	0	0	3.3E+4	9.0E+3
	2			0.5	0	0	5.3E+4	4.2E+4
	3			0.5	0	0	6.8E+4	9.5E+4
	4			0.5	0	0	8.6E+4	1.6E+5
RC3	1	4	1	0.0	0	0	4.1E+4	1.7E+5
	2			0.0	0	0	4.4E+4	2.1E+5
	3			0.5	0	0	8.3E+4	2.6E+5
	4			0.5	0	0	8.6E+4	3.4E+5
RC4	1	4	1	0.0	0	0	7.8E+3	2.0E+4
	2			0.5	0	0	4.0E+4	2.8E+4
	3			0.0	0	0	5.6E+4	6.7E+4
	4			0.5	0	0	8.6E+4	1.2E+5
RC5	1	4	1	0.0	0	0	1.0E+4	1.9E+5
	2			0.5	0	0	6.0E+4	2.0E+5
	3			0.5	0	0	8.3E+4	2.6E+5
	4			0.5	0	0	8.6E+4	3.4E+5
RC6	1	4	1	0.0	0	0	6.9E+3	1.0E+4
	2			0.0	0	0	2.8E+4	1.7E+4
	3			0.5	0	0	8.6E+4	4.5E+4
	4			0.5	0	0	8.6E+4	1.3E+5

a) The Ref Time values for each release category, which calculate the plume position according to its leading edge (0.0) or midpoint (0.5), are equal to the plume position in Table 1 of US-APWR Standard Design, Information on Severe Accident of Internal Flood and Fire Events at Power, and LPSD Conditions – MACCS2 (MHI2 2011).

b) The plume duration for each release category is provided in Table 2 of US-APWR Standard Design, Information on Severe Accident of Internal Flood and Fire Events at Power, and LPSD Conditions – MACCS2 (MHI2 2011). RCOL2_19-28

c) The plume delay for each release category is provided in Table 2 of US-APWR Standard Design, Information on Severe Accident of Internal Flood and Fire Events at Power, and LPSD Conditions – MACCS2 (MHI2 2011).

RCOL2_19-28

TABLE 7.2-4d

US-APWR PLUME CHARACTERIZATION DATA – LPSD EVENTS

Release Category	Plume No.	Number of Plumes	Risk Dominant Plume	Ref Time[a]	Plume Heat (W)	Plume Release Height (m)	Plume Duration (s)[b]	Plume Delay (s)[c]
FRS	1	4	1	0.0	0	0	1.8E+4	6.0E+5[d]
	2			0.0	0	0	3.3E+4	6.2E+5[d]
	3			0.5	0	0	8.3E+4	6.5E+5[d]
	4			0.5	0	0	8.6E+4	7.3E+5[d]
MOS	1	4	1	0.0	0	0	2.4E+4	1.1E+4
	2			0.0	0	0	4.0E+4	3.5E+4
	3			0.0	0	0	8.6E+4	7.5E+4
	4			0.5	0	0	8.6E+4	1.6E+5

a) The Ref Time values for each release category, which calculate the plume position according to its leading edge (0.0) or midpoint (0.5), are equal to the plume position in Table 5 of US-APWR Standard Design, Information on Severe Accident of Internal Flood and Fire Events at Power, and LPSD Conditions – MACCS2 (MHI2 2011).

b) The plume duration for each release category is provided in Table 6 of US-APWR Standard Design, Information on Severe Accident of Internal Flood and Fire Events at Power, and LPSD Conditions – MACCS2 (MHI2 2011).

c) The plume delay for each release category is provided in Table 6 of US-APWR Standard Design, Information on Severe Accident of Internal Flood and Fire Events at Power, and LPSD Conditions – MACCS2 (MHI2 2011).

d) The plume delays for these plumes were reduced to 3.456 x 105 seconds when modeling in MACCS2 due to code limitations.

TABLE 7.2-5
SEVERE ACCIDENT ANALYSIS RESULTS SUMMARY WITHIN 50 MI OF CPNPP SITE[(a)]

Met Data Year	Dose Risk (person-rem/ RY)	DollarEconomic Risk ($/RY)	Affected Land (hectares/RY) (b)	Early Fatalities (per RY)	Latent Fatalities (per RY)	Water Ingestion Dose Risk (person-rem/ RY)
2001	2.21E-01 2.55E+00	5.78E+02 4.52E+03	2.66E-02 1.48E-01	7.49E-08 5.44E-07	1.85E-04 1.56E-03	1.62E-02 1.27E-01
2003	2.71E-01 2.88E+oo	6.62E+02 5.18E+03	2.76E-02 1.54E-01	7.43E-08 5.48E-07	2.15E-04 1.73E-03	1.52E-02 1.19E-01
2006	3.00E-01 2.96E+00	7.06E+02 5.24E+03	2.70E-02 1.47E-01	6.73E-08 4.91E-07	2.39E-04 1.82E-03	1.63E-02 1.28E-01

RCOL2_19-28

RCOL2_19-28

a) All data are compiled from Tables 7.2-9, 7.2-10, and 7.2-11Tables 7.2-9a through 7.2-9d, Tables 7.2-10a through 7.2-10d, and Tables 7.2-11a through 7.2-11d.

b) This value reflects the sum of affected land areas that have been multiplied by their release category frequency, whereas the affected land areas shown in the MACCS2 analysis are neither multiplied by release category frequency or summed. However, the same MACCS2 data were used as the basis for both values.

TABLE 7.2-6a
INTERNAL EVENTS MEAN VALUE FOR ~~TOTAL~~ DOSE RISK ASSESSMENT IN PERSON-REM/RY

RCOL2_19-28

Release Category	Frequency (per RY)	Dose Risk - 2001	Dose Risk - 2003	Dose Risk - 2006
RC1	~~7.5E-09~~1.7E-08	~~2.39E-02~~9.88E-02	~~2.90E-02~~1.14E-01	~~2.93E-02~~1.06E-01
RC2	~~2.1E-09~~3.4E-09	~~4.62E-03~~1.43E-02	~~5.61E-03~~1.65E-02	~~6.09E-03~~1.60E-02
RC3	~~2.0E-08~~2.2E-08	~~7.56E-02~~1.70E-01	~~8.10E-02~~1.89E-01	~~8.96E-02~~2.00E-01
RC4	~~1.1E-08~~1.8E-08	~~2.24E-02~~5.40E-02	~~2.66E-02~~6.70E-02	~~2.67E-02~~6.25E-02
RC5	~~6.5E-08~~4.7E-08	~~9.36E-02~~1.33E-01	~~1.27E-01~~1.35E-01	~~1.48E-01~~1.29E-01
RC6	~~1.1E-06~~9.2E-07	~~9.97E-04~~8.45E-04	~~1.18E-03~~9.75E-04	~~1.01E-03~~8.57E-04
Total	~~1.2E-06~~1.0E-06	~~2.21E-01~~4.71E-01	~~2.71E-01~~5.22E-01	~~3.00E-01~~5.15E-01

RCOL2_19-28

TABLE 7.2-6b

INTERNAL FLOODING EVENTS MEAN VALUE FOR DOSE RISK ASSESSMENT IN PERSON-REM/RY

RCOL2_19-28

Release Category	Frequency (per RY)	Dose Risk - 2001	Dose Risk - 2003	Dose Risk - 2006
RC1	4.0E-09	1.44E-03	1.53E-03	1.74E-03
RC2	4.0E-09	3.20E-03	3.49E-03	3.74E-03
RC3	1.0E-07	5.80E-01	6.99E-01	7.15E-01
RC4	1.6E-08	5.92E-02	6.14E-02	6.98E-02
RC5	3.2E-08	1.28E-02	1.64E-02	1.47E-02
RC6	7.4E-07	9.32E-04	1.07E-03	9.47E-04
Total	9.0E-07	6.58E-01	7.83E-01	8.06E-01

TABLE 7.2-6c
INTERNAL FIRE EVENTS MEAN VALUE FOR DOSE RISK ASSESSMENT IN PERSON-REM/RY

RCOL2_19-28

Release Category	Frequency (per RY)	Dose Risk - 2001	Dose Risk - 2003	Dose Risk - 2006
RC1	2.7E-08	9.69E-03	1.03E-02	1.17E-02
RC2	6.2E-09	2.61E-02	3.01E-02	2.93E-02
RC3	9.2E-08	7.07E-01	7.76E-01	8.36E-01
RC4	3.6E-08	1.33E-01	1.38E-01	1.57E-01
RC5	2.5E-08	7.08E-02	7.18E-02	6.88E-02
RC6	6.7E-07	8.44E-04	9.65E-04	8.58E-04
Total	8.6E-07	9.48E-01	1.03E+00	1.10E+00

TABLE 7.2-6d
LPSD EVENTS MEAN VALUE FOR DOSE RISK ASSESSMENT IN PERSON-REM/RY

RCOL2_19-28

Release Category	Frequency (per RY)	Dose Risk - 2001	Dose Risk - 2003	Dose Risk - 2006
FRS	3.5E-08	3.96E-03	4.13E-03	4.24E-03
MOS	1.4E-07	4.73E-01	5.40E-01	5.31E-01
Total	1.8E-07	4.77E-01	5.45E-01	5.35E-01

TABLE 7.2-7a
~~DOLLAR~~INTERNAL EVENTS ECONOMIC RISK ASSESSMENT IN DOLLARS/RY RCOL2_19-28

Release Category	Frequency (per RY)	~~Dollar~~Economic Risk - 2001[a]	~~Dollar~~Economic Risk - 2003[a]	~~Dollar~~Economic Risk - 2006[a]
RC1	~~7.5E-09~~1.7E-08	~~8.10E+01~~1.92E+02	~~9.08E+01~~2.35E+02	~~9.90E+01~~2.35E+02
RC2	~~2.1E-09~~3.4E-09	~~1.12E+01~~2.22E-01	~~1.47E+01~~2.41E+01	~~1.65E+01~~2.41E+01
RC3	~~2.0E-08~~2.2E-08	~~2.96E+02~~3.43E+02	~~3.18E+02~~3.78E+02	~~3.38E+02~~3.98E+02
RC4	~~1.1E-08~~1.8E-08	~~4.64E+01~~8.46E+01	~~5.23E+01~~9.95E+01	~~5.73E+01~~1.01E+02
RC5	~~6.5E-08~~4.7E-08	~~1.43E+02~~1.18E+02	~~1.87E+02~~1.24E+02	~~1.95E+02~~1.02E+02
RC6	~~1.1E-06~~9.2E-07	~~4.96E-03~~6.92E-03	~~7.46E-03~~8.26E-03	~~6.84E-03~~6.39E-03
Total	~~1.2E-06~~1.0E-06	~~5.78E+02~~7.60E+02	~~6.62E+02~~8.61E+02	~~7.06E+02~~8.60E+02

RCOL2_19-28

RCOL2_19-28

a) The ~~dollar~~economic risk accounts for the costs of evacuation, crops contaminated and condemned, milk contaminated and condemned, decontamination of property, and indirect costs resulting from the loss of use of property and incomes. The 2001, 2003, and 2006 refer to the year of meteorological data used in the calculation.

TABLE 7.2-7b
INTERNAL FLOODING EVENTS ECONOMIC RISK ASSESSMENT IN DOLLARS/RY

RCOL2_19-28

Release Category	Frequency (per RY)	Economic Risk - 2001[(a)]	Economic Risk - 2003[(a)]	Economic Risk - 2006[(a)]
RC1	4.0E-09	1.26E+00	1.39E+00	1.24E+00
RC2	4.0E-09	3.56E+00	3.88E+00	4.48E+00
RC3	1.0E-07	1.35E+03	1.55E+03	1.52E+03
RC4	1.6E-08	6.98E+01	8.03E+01	8.32E+01
RC5	3.2E-08	4.16E+00	4.10E+00	4.80E+00
RC6	7.4E-07	1.26E-02	1.36E-02	1.12E-02
Total	9.0E-07	1.43E+03	1.64E+03	1.61E+03

a) The economic risk accounts for the costs of evacuation, crops contaminated and condemned, milk contaminated and condemned, decontamination of property, and indirect costs resulting from the loss of use of property and incomes. The 2001, 2003, and 2006 refer to the year of meteorological data used in the calculation.

TABLE 7.2-7c
INTERNAL FIRE EVENTS ECONOMIC RISK ASSESSMENT IN DOLLARS/RY

RCOL2_19-28

Release Category	Frequency (per RY)	Economic Risk - 2001[(a)]	Economic Risk - 2003[(a)]	Economic Risk - 2006[(a)]
RC1	2.7E-08	8.53E+00	9.37E+00	8.40E+00
RC2	6.2E-09	4.04E+01	4.40E+01	4.40E+01
RC3	9.2E-08	1.44E+03	1.52E+03	1.69E+03
RC4	3.6E-08	1.57E+02	1.81E+02	1.87E+02
RC5	2.5E-08	6.28E+01	6.60E+01	5.45E+01
RC6	6.7E-07	1.14E-02	1.23E-02	1.01E-02
Total	8.6E-07	1.70E+03	1.82E+03	1.99E+03

a) The economic risk accounts for the costs of evacuation, crops contaminated and condemned, milk contaminated and condemned, decontamination of property, and indirect costs resulting from the loss of use of property and incomes. The 2001, 2003, and 2006 refer to the year of meteorological data used in the calculation.

TABLE 7.2-7d
LPSD EVENTS ECONOMIC RISK ASSESSMENT IN DOLLARS/RY

RCOL2_19-28

Release Category	Frequency (per RY)	Economic Risk - 2001[a]	Economic Risk - 2003[a]	Economic Risk - 2006[a]
FRS	3.5E-08	3.82E-01	4.83E-01	3.61E-01
MOS	1.4E-07	6.24E+02	8.61E+02	7.74E+02
Total	1.8E-07	6.25E+02	8.61E+02	7.75E+02

a) The economic risk accounts for the costs of evacuation, crops contaminated and condemned, milk contaminated and condemned, decontamination of property, and indirect costs resulting from the loss of use of property and incomes. The 2001, 2003, and 2006 refer to the year of meteorological data used in the calculation.

TABLE 7.2-8
INTERNAL EVENT POPULATION DOSE COMPARISON AMONG PLANTS RCOL2_19-28

Plant	Population Dose within 50 mi (person-rem/RY)[a]
Zion	5.00E+1
Grand Gulf	5.00E-1
Surry	6.00E+0
North Anna	2.51E+1
CPNPP US-APWR	~~3.00~~5.15E-1[b]

RCOL2_19-28

a) Data for the current generation reactors were taken from System Energy Resources, Inc. (SERI 2004).

b) Value based on 2006 meteorological data.

TABLE 7.2-9a

INTERNAL EVENTS SEVERE ACCIDENT IMPACTS TO THE POPULATION AND LAND USING 2001 METEOROLOGICAL DATA RCOL2_19-28

RCOL2_19-28

Release Category	~~Core-Damage-~~ Frequency (per RY)	Dose~~-~~ Risk (person-rem/ RY)	~~Number of~~ Early Fatalities (per RY)	~~Number of~~ Latent Fatalities (per RY)	Affected Land ~~Area~~ (hectares)(a)	~~Cost~~ Economic Risk (~~dollars~~$/ RY)(b)	Water Ingestion ~~Pathway~~ Dose Risk (person-rem/RY)
RC1	~~7.5E-09~~ 1.7E-08	~~2.30E-02~~ 9.88E-02	~~2.19E-09~~ 8.43E-09	~~1.59E-05~~ 4.74E-05	~~2.13E-03~~ 6.10E-03	~~8.10E+01~~ 1.92E+02	~~1.00E-03~~ 4.11E-03
RC2	~~2.1E-09~~ 3.4E-09	~~4.62E-03~~ 1.43E-02	~~3.07E-10~~ 5.07E-10	~~3.36E-06~~ 6.97E-06	~~6.95E-04~~ 1.49E-03	~~1.12E+01~~ 2.22E+01	~~1.28E-04~~ 1.91E-04
RC3	~~2.0E-08~~ 2.2E-08	~~7.56E-02~~ 1.70E-01	~~7.16E-08~~ 8.27E-08	~~1.06E-04~~ 1.24E-04	~~5.30E-03~~ 6.69E-03	~~2.96E+02~~ 3.43E+02	~~1.21E-02~~ 1.33E-02
RC4	~~1.1E-08~~ 1.8E-08	~~2.24E-02~~ 5.40E-02	~~8.26E-10~~ 1.59E-09	~~1.38E-05~~ 2.63E-05	~~2.51E-03~~ 4.72E-03	~~4.64E+01~~ 8.46E+01	~~6.89E-04~~ 1.08E-03
RC5	~~6.5E-08~~ 4.7E-08	~~9.36E-02~~ 1.33E-01	~~0.00E+00~~ 5.03E-14	~~4.52E-05~~ 5.83E-05	~~1.59E-02~~ 1.66E-02	~~1.43E+02~~ 1.18E+02	~~1.43E-02~~ 8.65E-04
RC6	~~1.1E-06~~ 9.2E-07	~~9.07E-04~~ 8.45E-04	~~0.00E+00~~ 0.00E+00	~~5.28E-07~~ 3.86E-07	~~5.40E-06~~ 7.66E-06	~~4.96E-03~~ 6.92E-03	~~2.39E-6~~ 2.01E-06
Total	~~1.2E-06~~ 1.0E-06	~~2.21E-01~~ 4.71E-01	~~7.49E-08~~ 9.33E-08	~~1.86E-04~~ 2.64E-04	~~2.66E-02~~ 3.56E-02	~~5.78E+02~~ 7.60E+02	~~1.62E-02~~ 1.95E-02

a) These values reflect affected land areas that have been multiplied by their release category frequency; whereas, the affected land areas shown in the MACCS2 analysis are not multiplied by release category frequency. However, the same MACCS2 data were used as the basis for both values.

b) The ~~cost~~ economic risk accounts for the costs of evacuation, crops contaminated and condemned, milk contaminated and condemned, decontamination of property, and indirect costs resulting from the loss of use of property and incomes. RCOL2_19-28

TABLE 7.2-9b

INTERNAL FLOODING EVENTS SEVERE ACCIDENT IMPACTS TO THE POPULATION AND LAND USING 2001 METEOROLOGICAL DATA

RCOL2_19-28

Release Category	Frequency (per RY)	Dose Risk (person-rem/RY)	Early Fatalities (per RY)	Latent Fatalities (per RY)	Affected Land (hectares)[a]	Economic Risk ($/ RY)[b]	Water Ingestion Dose Risk (person-rem/RY)
RC1	4.0E-09	1.44E-03	6.88E-11	9.24E-07	1.99E-04	1.26E+00	5.76E-06
RC2	4.0E-09	3.20E-03	5.28E-11	1.75E-06	2.20E-04	3.56E+00	2.54E-05
RC3	1.0E-07	5.80E-01	7.51E-08	3.48E-04	3.36E-02	1.35E+03	4.16E-02
RC4	1.6E-08	5.92E-02	8.61E-09	4.42E-05	1.11E-03	6.98E+01	6.67E-04
RC5	3.2E-08	1.28E-02	0.00E+00	5.66E-06	1.11E-03	4.16E+00	5.47E-05
RC6	7.4E-07	9.32E-04	0.00E+00	4.40E-07	9.92E-06	1.26E-02	1.92E-06
Total	9.0E-07	6.58E-01	8.38E-08	4.01E-04	3.62E-02	1.43E+03	4.24E-02

a) These values reflect affected land areas that have been multiplied by their release category frequency; whereas, the affected land areas shown in the MACCS2 analysis are not multiplied by release category frequency. However, the same MACCS2 data were used as the basis for both values.

b) The economic risk accounts for the costs of evacuation, crops contaminated and condemned, milk contaminated and condemned, decontamination of property, and indirect costs resulting from the loss of use of property and incomes.

TABLE 7.2-9c

INTERNAL FIRE EVENTS SEVERE ACCIDENT IMPACTS TO THE POPULATION AND LAND USING 2001 METEOROLOGICAL DATA

RCOL2_19-28

Release Category	Frequency (per RY)	Dose Risk (person-rem/RY)	Early Fatalities (per RY)	Latent Fatalities (per RY)	Affected Land (hectares)[(a)]	Economic Risk ($/ RY)[(b)]	Water Ingestion Dose Risk (person-rem/RY)
RC1	2.7E-08	9.69E-03	4.64E-10	6.24E-06	1.34E-03	8.53E+00	3.89E-05
RC2	6.2E-09	2.61E-02	9.24E-10	1.27E-05	2.72E-03	4.04E+01	3.48E-04
RC3	9.2E-08	7.07E-01	3.46E-07	5.18E-04	2.82E-02	1.44E+03	5.54E-02
RC4	3.6E-08	1.33E-01	1.94E-08	9.94E-05	2.49E-03	1.57E+02	1.50E-03
RC5	2.5E-08	7.08E-02	2.68E-14	3.10E-05	8.83E-03	6.28E+01	4.60E-04
RC6	6.7E-07	8.44E-04	0.00E+00	3.98E-07	8.98E-06	1.14E-02	1.74E-06
Total	8.6E-07	9.48E-01	3.67E-07	6.68E-04	4.35E-02	1.70E+03	5.77E-02

a) These values reflect affected land areas that have been multiplied by their release category frequency; whereas, the affected land areas shown in the MACCS2 analysis are not multiplied by release category frequency. However, the same MACCS2 data were used as the basis for both values.

b) The economic risk accounts for the costs of evacuation, crops contaminated and condemned, milk contaminated and condemned, decontamination of property, and indirect costs resulting from the loss of use of property and incomes.

TABLE 7.2-9d
LPSD EVENTS SEVERE ACCIDENT IMPACTS TO THE POPULATION AND LAND USING 2001 METEOROLOGICAL DATA

RCOL2_19-28

Release Category	Frequency (per RY)	Dose Risk (person-rem/RY)	Early Fatalities (per RY)	Latent Fatalities (per RY)	Affected Land (hectares)[a]	Economic Risk ($/ RY)[b]	Water Ingestion Dose Risk (person-rem/RY)
FRS	3.5E-08	3.96E-03	0.00E+00	1.81E-06	1.57E-04	3.82E-01	9.24E-06
MOS	1.4E-07	4.73E-01	4.03E-10	2.24E-04	3.28E-02	6.24E+02	7.28E-03
Total	1.8E-07	4.77E-01	4.03E-10	2.26E-04	3.29E-02	6.25E+02	7.29E-03

a) These values reflect affected land areas that have been multiplied by their release category frequency; whereas, the affected land areas shown in the MACCS2 analysis are not multiplied by release category frequency. However, the same MACCS2 data were used as the basis for both values.

b) The economic risk accounts for the costs of evacuation, crops contaminated and condemned, milk contaminated and condemned, decontamination of property, and indirect costs resulting from the loss of use of property and incomes.

TABLE 7.2-10a
INTERNAL EVENTS SEVERE ACCIDENT IMPACTS TO THE POPULATION AND LAND USING 2003 METEOROLOGICAL DATA

RCOL2_19-28

Release Category	~~Core Damage~~ Frequency (per RY)	Dose~~-~~ Risk (person-rem/RY)	~~Number of~~ Early Fatalities (per RY)	~~Number of~~ Latent Fatalities (per RY)	Affected Land ~~Area~~ (hectares)(a)	~~Cost~~ Economic Risk (~~dollars~~$/ RY)(b)	Water Ingestion ~~Pathway~~ Dose Risk (person-rem/RY)
RC1	~~7.5E-09~~ 1.7E-08	~~2.90E-02~~ 1.14E-01	~~2.20E-09~~ 8.47E-09	~~1.89E-05~~ 5.46E-05	~~2.24E-03~~ 6.34E-03	~~9.08E+01~~ 2.35E+02	~~1.76E-03~~ 4.03E-03
RC2	~~2.1E-09~~ 3.4E-09	~~5.61E-03~~ 1.65E-02	~~2.96E-10~~ 4.79E-10	~~3.99E-06~~ 7.89E-06	~~7.56E-04~~ 1.62E-03	~~1.47E+01~~ 2.41E+01	~~1.16E-04~~ 1.95E-04
RC3	~~2.0E-08~~ 2.2E-08	~~8.10E-02~~ 1.89E-01	~~7.10E-08~~ 8.23E-08	~~1.14E-04~~ 1.36E-04	~~5.64E-03~~ 7.15E-03	~~3.18E+02~~ 3.78E+02	~~1.12E-02~~ 1.23E-02
RC4	~~1.1E-08~~ 1.8E-08	~~2.66E-02~~ 6.70E-02	~~7.84E-10~~ 1.51E-09	~~1.61E-05~~ 3.22E-05	~~2.53E-03~~ 4.84E-03	~~5.23E+01~~ 9.95E+01	~~6.41E-04~~ 1.04E-03
RC5	~~6.5E-08~~ 4.7E-08	~~1.27E-01~~ 1.35E-01	~~0.00E+00~~ 5.22E-14	~~6.11E-05~~ 5.88E-05	~~1.64E-02~~ 1.59E-02	~~1.87E+02~~ 1.24E+02	~~1.49E-03~~ 1.03E-03
RC6	~~1.1E-06~~ 9.2E-07	~~1.18E-03~~ 9.75E-04	~~0.00E+00~~ 0.00E+00	~~6.12E-07~~ 4.49E-07	~~9.78E-06~~ 1.00E-05	~~7.46E-03~~ 8.26E-03	~~2.24E-06~~ 1.86E-06
Total	~~1.2E-06~~ 1.0E-06	~~2.71E-01~~ 5.22E-01	~~7.43E-08~~ 9.27E-08	~~2.15E-04~~ 2.90E-04	~~2.76E-02~~ 3.59E-02	~~6.62E+02~~ 8.61E+02	~~1.52E-02~~ 1.85E-02

RCOL2_19-28

a) These values reflect affected land areas that have been multiplied by their release category frequency; whereas, the affected land areas shown in the MACCS2 analysis are not multiplied by release category frequency. However, the same MACCS2 data were used as the basis for both values.

b) The ~~cost~~ economic risk accounts for the costs of evacuation, crops contaminated and condemned, milk contaminated and condemned, decontamination of property, and indirect costs resulting from the loss of use of property and incomes. RCOL2_19-28

TABLE 7.2-10b
INTERNAL FLOODING EVENTS SEVERE ACCIDENT IMPACTS TO THE POPULATION AND LAND USING 2003 METEOROLOGICAL DATA

RCOL2_19-28

Release Category	Frequency (per RY)	Dose Risk (person-rem/RY)	Early Fatalities (per RY)	Latent Fatalities (per RY)	Affected Land (hectares)[a]	Economic Risk ($/ RY)[b]	Water Ingestion Dose Risk (person-rem/RY)
RC1	4.0E-09	1.53E-03	5.52E-11	9.56E-07	2.06E-04	1.39E+00	5.28E-06
RC2	4.0E-09	3.49E-03	4.20E-11	1.87E-06	2.31E-04	3.88E+00	2.36E-05
RC3	1.0E-07	6.99E-01	7.78E-08	4.12E-04	3.57E-02	1.55E+03	3.89E-02
RC4	1.6E-08	6.14E-02	9.66E-09	4.54E-05	1.13E-03	8.03E+01	6.34E-04
RC5	3.2E-08	1.64E-02	0.00E+00	7.33E-06	1.24E-03	4.10E+00	5.66E-05
RC6	7.4E-07	1.07E-03	0.00E+00	5.11E-07	1.21E-05	1.36E-02	1.77E-06
Total	9.0E-07	7.83E-01	8.76E-08	4.68E-04	3.85E-02	1.64E+03	3.96E-02

a) These values reflect affected land areas that have been multiplied by their release category frequency; whereas, the affected land areas shown in the MACCS2 analysis are not multiplied by release category frequency. However, the same MACCS2 data were used as the basis for both values.

b) The economic risk accounts for the costs of evacuation, crops contaminated and condemned, milk contaminated and condemned, decontamination of property, and indirect costs resulting from the loss of use of property and incomes.

TABLE 7.2-10c

INTERNAL FIRE EVENTS SEVERE ACCIDENT IMPACTS TO THE POPULATION AND LAND USING 2003 METEOROLOGICAL DATA

RCOL2_19-28

Release Category	Frequency (per RY)	Dose Risk (person-rem/RY)	Early Fatalities (per RY)	Latent Fatalities (per RY)	Affected Land (hectares)[a]	Economic Risk ($/ RY)[b]	Water Ingestion Dose Risk (person-rem/RY)
RC1	2.7E-08	1.03E-02	3.73E-10	6.45E-06	1.39E-03	9.37E+00	3.56E-05
RC2	6.2E-09	3.01E-02	8.74E-10	1.44E-05	2.96E-03	4.40E+01	3.56E-04
RC3	9.2E-08	7.76E-01	3.44E-07	5.61E-04	2.99E-02	1.52E+03	5.12E-02
RC4	3.6E-08	1.38E-01	2.17E-08	1.02E-04	2.55E-03	1.81E+02	1.43E-03
RC5	2.5E-08	7.18E-02	2.78E-14	3.13E-05	8.48E-03	6.60E+01	5.48E-04
RC6	6.7E-07	9.65E-04	0.00E+00	4.63E-07	1.09E-05	1.23E-02	1.60E-06
Total	8.6E-07	1.03E+00	3.67E-07	7.16E-04	4.53E-02	1.82E+03	5.36E-02

a) These values reflect affected land areas that have been multiplied by their release category frequency; whereas, the affected land areas shown in the MACCS2 analysis are not multiplied by release category frequency. However, the same MACCS2 data were used as the basis for both values.

b) The economic risk accounts for the costs of evacuation, crops contaminated and condemned, milk contaminated and condemned, decontamination of property, and indirect costs resulting from the loss of use of property and incomes.

TABLE 7.2-10d

LPSD EVENTS SEVERE ACCIDENT IMPACTS TO THE POPULATION AND LAND USING 2003 METEOROLOGICAL DATA

RCOL2_19-28

Release Category	Frequency (per RY)	Dose Risk (person-rem/RY)	Early Fatalities (per RY)	Latent Fatalities (per RY)	Affected Land (hectares)[a]	Economic Risk ($/ RY)[b]	Water Ingestion Dose Risk (person-rem/RY)
FRS	3.5E-08	4.13E-03	0.00E+00	1.89E-06	2.26E-04	4.83E-01	1.13E-05
MOS	1.4E-07	5.40E-01	3.44E-10	2.56E-04	3.44E-02	8.61E+02	7.04E-03
Total	1.8E-07	5.45E-01	3.44E-10	2.58E-04	3.47E-02	8.61E+02	7.05E-03

a) These values reflect affected land areas that have been multiplied by their release category frequency; whereas, the affected land areas shown in the MACCS2 analysis are not multiplied by release category frequency. However, the same MACCS2 data were used as the basis for both values.

b) The economic risk accounts for the costs of evacuation, crops contaminated and condemned, milk contaminated and condemned, decontamination of property, and indirect costs resulting from the loss of use of property and incomes.

TABLE 7.2-11a
INTERNAL EVENTS SEVERE ACCIDENT IMPACTS TO THE POPULATION AND LAND USING 2006 METEOROLOGICAL DATA RCOL2_19-28

RCOL2_19-28

Release Category	~~Core Damage~~ Frequency (per RY)	Dose ~~-~~ Risk (person-rem/RY)	~~Number of~~ Early Fatalities (per RY)	~~Number of~~ Latent Fatalities (per RY)	Affected Land ~~Area~~ (hectares)[(a)]	~~Cost~~ Economic Risk (~~dollars~~ $/ RY)[(b)]	Water Ingestion ~~Pathway~~ Dose Risk (person-rem/RY)
RC1	~~7.5E-09~~ 1.7E-08	~~2.93E-02~~ 1.06E-01	~~1.90E-09~~ 6.19E-09	~~1.97E-05~~ 5.12E-05	~~2.05E-03~~ 5.92E-03	~~9.90E+01~~ 2.35E+02	~~1.91E-03~~ 4.28E-03
RC2	~~2.1E-09~~ 3.4E-09	~~6.09E-03~~ 1.60E-02	~~2.46E-10~~ 3.81E-10	~~4.39E-06~~ 7.82E-06	~~7.01E-04~~ 1.57E-03	~~1.65E+01~~ 2.41E+01	~~1.27E-04~~ 1.90E-04
RC3	~~2.0E-08~~ 2.2E-08	~~8.96E-02~~ 2.00E-01	~~6.46E-08~~ 7.50E-08	~~1.27E-04~~ 1.47E-04	~~5.28E-03~~ 6.64E-03	~~3.38E+02~~ 3.98E+02	~~1.21E-02~~ 1.34E-02
RC4	~~1.1E-08~~ 1.8E-08	~~2.67E-02~~ 6.25E-02	~~4.70E-10~~ 1.09E-09	~~1.65E-05~~ 3.04E-05	~~2.44E-03~~ 4.81E-03	~~5.73E+01~~ 1.01E+02	~~6.90E-04~~ 1.13E-03
RC5	~~6.5E-08~~ 4.7E-08	~~1.48E-01~~ 1.29E-01	~~0.00E+00~~ 1.16E-13	~~7.09E-05~~ 5.64E-05	~~1.65E-02~~ 1.59E-02	~~1.05E+02~~ 1.02E+02	~~1.45E-03~~ 8.93E-04
RC6	~~1.1E-06~~ 9.2E-07	~~1.01E-03~~ 8.57E-04	~~0.00E+00~~ 0.00E+00	~~5.26E-07~~ 3.89E-07	~~7.69E-06~~ 6.87E-06	~~6.84E-03~~ 6.39E-03	~~2.41E-06~~ 2.02E-06
Total	~~1.2E-06~~ 1.0E-06	~~3.00E-01~~ 5.15E-01	~~6.73E-08~~ 8.27E-08	~~2.39E-04~~ 2.94E-04	~~2.70E-02~~ 3.49E-02	~~7.06E+02~~ 8.60E+02	~~1.63E-02~~ 1.99E-02

a) These values reflect affected land areas that have been multiplied by their release category frequency; whereas, the affected land areas shown in the MACCS2 analysis are not multiplied by release category frequency. However, the same MACCS2 data were used as the basis for both values.

b) The ~~cost~~ economic risk accounts for the costs of evacuation, crops contaminated and condemned, milk contaminated and condemned, decontamination of property, and indirect costs resulting from the loss of use of property and incomes. RCOL2_19-28

TABLE 7.2-11b
INTERNAL FLOODING EVENTS SEVERE ACCIDENT IMPACTS TO THE POPULATION AND LAND USING 2006 METEOROLOGICAL DATA

RCOL2_19-28

Release Category	Frequency (per RY)	Dose Risk (person-rem/ RY)	Early Fatalities (per RY)	Latent Fatalities (per RY)	Affected Land (hectares)[(a)]	Economic Risk ($/ RY)[(b)]	Water Ingestion Dose Risk (person-rem/RY)
RC1	4.0E-09	1.74E-03	6.20E-11	1.09E-06	1.92E-04	1.24E+00	5.76E-06
RC2	4.0E-09	3.74E-03	4.52E-11	2.01E-06	2.24E-04	4.48E+00	2.57E-05
RC3	1.0E-07	7.15E-01	6.36E-08	4.25E-04	3.40E-02	1.52E+03	4.21E-02
RC4	1.6E-08	6.98E-02	9.09E-09	5.25E-05	1.20E-03	8.32E+01	6.77E-04
RC5	3.2E-08	1.47E-02	0.00E+00	6.53E-06	9.79E-04	4.80E+00	7.33E-05
RC6	7.4E-07	9.47E-04	0.00E+00	4.41E-07	1.01E-05	1.12E-02	1.93E-06
Total	9.0E-07	8.06E-01	7.28E-08	4.88E-04	3.66E-02	1.61E+03	4.29E-02

a) These values reflect affected land areas that have been multiplied by their release category frequency; whereas, the affected land areas shown in the MACCS2 analysis are not multiplied by release category frequency. However, the same MACCS2 data were used as the basis for both values.

b) The economic risk accounts for the costs of evacuation, crops contaminated and condemned, milk contaminated and condemned, decontamination of property, and indirect costs resulting from the loss of use of property and incomes.

TABLE 7.2-11c

INTERNAL FIRE EVENTS SEVERE ACCIDENT IMPACTS TO THE POPULATION AND LAND USING 2006 METEOROLOGICAL DATA

RCOL2_19-28

Release Category	Frequency (per RY)	Dose Risk (person-rem/ RY)	Early Fatalities (per RY)	Latent Fatalities (per RY)	Affected Land (hectares)[a]	Economic Risk ($/ RY)[b]	Water Ingestion Dose Risk (person-rem/RY)
RC1	2.7E-08	1.17E-02	4.19E-10	7.37E-06	1.29E-03	8.40E+00	3.89E-05
RC2	6.2E-09	2.93E-02	6.94E-10	1.43E-05	2.86E-03	4.40E+01	3.46E-04
RC3	9.2E-08	8.36E-01	3.14E-07	6.16E-04	2.77E-02	1.69E+03	5.56E-02
RC4	3.6E-08	1.57E-01	2.04E-08	1.18E-04	2.71E-03	1.87E+02	1.52E-03
RC5	2.5E-08	6.88E-02	6.15E-14	3.00E-05	8.48E-03	5.45E+01	4.75E-04
RC6	6.7E-07	8.58E-04	0.00E+00	3.99E-07	9.18E-06	1.01E-02	1.75E-06
Total	8.6E-07	1.10E+00	3.35E-07	7.87E-04	4.30E-02	1.99E+03	5.80E-02

a) These values reflect affected land areas that have been multiplied by their release category frequency; whereas, the affected land areas shown in the MACCS2 analysis are not multiplied by release category frequency. However, the same MACCS2 data were used as the basis for both values.

b) The economic risk accounts for the costs of evacuation, crops contaminated and condemned, milk contaminated and condemned, decontamination of property, and indirect costs resulting from the loss of use of property and incomes.

TABLE 7.2-11d
LPSD EVENTS SEVERE ACCIDENT IMPACTS TO THE POPULATION AND LAND USING 2006 METEOROLOGICAL DATA

RCOL2_19-28

Release Category	Frequency (per RY)	Dose Risk (person-rem/ RY)	Early Fatalities (per RY)	Latent Fatalities (per RY)	Affected Land (hectares)[(a)]	Economic Risk ($/ RY)[(b)]	Water Ingestion Dose Risk (person-rem/RY)
FRS	3.5E-08	4.24E-03	0.00E+00	1.93E-06	1.47E-04	3.61E-01	9.14E-06
MOS	1.4E-07	5.31E-01	2.56E-10	2.51E-04	3.22E-02	7.74E+02	7.48E-03
Total	1.8E-07	5.35E-01	2.56E-10	2.53E-04	3.23E-02	7.75E+02	7.49E-03

a) These values reflect affected land areas that have been multiplied by their release category frequency; whereas, the affected land areas shown in the MACCS2 analysis are not multiplied by release category frequency. However, the same MACCS2 data were used as the basis for both values.

b) The economic risk accounts for the costs of evacuation, crops contaminated and condemned, milk contaminated and condemned, decontamination of property, and indirect costs resulting from the loss of use of property and incomes.

TABLE 7.2-12
TOTAL SEVERE ACCIDENT HEALTH EFFECTS USING 2001 METEOROLOGICAL DATA(b) RCOL2_19-28

RCOL2_19-28

Accident Type	Core Damage Frequency (per RY)(a)	Scaling Factor	Dose- Risk (person-rem/RY)	Number of Early Fatalities (per RY)	Number of Latent Fatalities (per RY)	Water Ingestion Pathway Dose Risk (person-rem/RY)
Internal Events	1.2E-6 1.0E-06	1	2.21E-01 4.71E-01	7.49E-08 9.33E-08	1.85E-04 2.64E-04	1.62E-02 1.95E-02
Internal Fire Flooding Events	1.8E-6 9.0E-07	1.60	3.32E-01 6.58E-01	1.12E-07 8.38E-08	2.78E-04 4.01E-04	2.43E-02 4.24E-02
Internal Flood Fire Events	1.4E-6 8.6E-07	1.17	2.59E-01 9.48E-01	8.76E-08 3.67E-07	2.16E-04 6.68E-04	1.90E-02 5.77E-02
LPSD Events	2.0E-7 1.8E-07	0.167	3.69E-02 4.77E-01	1.25E-08 4.03E-10	3.09E-05 2.26E-04	2.71E-03 7.29E-03
Total	4.6E-6 2.94E-06	-	8.48E-01 2.55E+00	2.87E-07 5.44E-07	7.10E-04 1.56E-03	6.22E-02 1.27E-01

a) Core damage frequency values are taken from Table 5 of the DC Applicant's Environmental Report (MHI 2007). Reference MHI 2013

b) The values for internal fire, internal flood, and LPSD are calculated as described on page 7.2-7.

TABLE 7.2-13
TOTAL SEVERE ACCIDENT HEALTH EFFECTS USING 2003 METEOROLOGICAL DATA~~(b)~~ RCOL2_19-28

RCOL2_19-28

Accident Type	~~Core Damage~~ Frequency (per RY)(a)	~~Scaling Factor~~	Dose~~-~~ Risk (person-rem/RY)	~~Number of~~ Early Fatalities (per RY)	~~Number of~~ Latent Fatalities (per RY)	Water Ingestion ~~Pathway~~Dose Risk (person-rem/ RY)
Internal Events	~~1.2E-6~~1.0E-06	~~1~~	~~2.71E-01~~5.22E-01	~~7.43E-08~~9.27E-08	~~2.15E-04~~2.90E-04	~~1.52E-02~~1.85E-02
Internal ~~Fire~~Flooding Events	~~1.8E-6~~9.0E-07	~~1.50~~	~~4.07E-01~~7.83E-01	~~1.11E-07~~8.76E-08	~~3.23E-04~~4.68E-04	~~2.28E-02~~3.96E-02
Internal ~~Flood~~Fire Events	~~1.4E-6~~8.6E-07	~~1.17~~	~~3.17E-01~~1.03E+00	~~8.60E-08~~3.67E-07	~~2.52E-04~~7.16E-04	~~1.78E-02~~5.36E-02
LPSD Events	~~2.0E-7~~1.8E-07	~~0.167~~	~~4.53E-02~~5.45E-01	~~1.24E-08~~3.44E-10	~~3.59E-05~~2.58E-04	~~2.54E-03~~7.05E-03
Total	~~4.6E-6~~2.94E-06	-	~~1.04E-00~~2.88E+00	~~2.85E-07~~5.48E-07	~~8.25E-04~~1.73E-03	~~5.83E-02~~1.19E-01

a) Core damage frequency values are taken from ~~Table 5 of the DC Applicant's Environmental Report (MHI 2007).~~ Reference MHI 2013

~~b) The values for internal fire, internal flood, and LPSD are calculated as described on page 7.2-7.~~

TABLE 7.2-14
TOTAL SEVERE ACCIDENT HEALTH EFFECTS USING 2006 METEOROLOGICAL DATA~~(b)~~ RCOL2_19-28

RCOL2_19-28

Accident Type	~~Core Damage~~ Frequency (per RY)[a]	~~Scaling Factor~~	Dose- Risk (person-rem/RY)	~~Number of~~ Early Fatalities (per RY)	~~Number of~~ Latent Fatalities (per RY)	Water Ingestion ~~Pathway~~Dose Risk (person-rem/RY)
Internal Events	~~1.2E-6~~1.0E-06	~~1~~	~~3.00E-01~~ 5.15E-01	~~6.73E-08~~ 8.27E-08	~~2.30E-04~~ 2.94E-04	~~1.63E-02~~ 1.99E-02
Internal ~~Fire~~Flooding Events	~~1.8E-6~~9.0E-07	~~1.50~~	~~4.50E-01~~ 8.06E-01	~~1.01E-07~~ 7.28E-08	~~3.59E-04~~ 4.88E-04	~~2.45E-02~~ 4.29E-02
Internal ~~Flood~~Fire Events	~~1.4E-6~~8.6E-07	~~1.17~~	~~3.51E-01~~ 1.10E+00	~~7.87E-08~~ 3.35E-07	~~2.80E-04~~ 7.87E-04	~~1.91E-02~~ 5.80E-02
LPSD Events	~~2.0E-7~~1.8E-07	~~0.167~~	~~5.01E-02~~ 5.35E-01	~~1.12E-08~~ 2.56E-10	~~3.09E-05~~ 2.53E-04	~~2.72E-03~~ 7.49E-03
Total	~~4.6E-6~~2.94E-06	-	~~1.15E-00~~2.96E+00	~~2.58E-07~~ 4.91E-07	~~9.17E-04~~ 1.82E-03	~~6.25E-02~~ 1.28E-01

a) Core damage frequency values are taken from ~~Table 5 of the DC Applicant's Environmental Report (MHI 2007).~~Reference MHI 2013

~~b) The values for internal fire, internal flood, and LPSD are calculated as described on page 7.2-7.~~

3. Install an additional, buried off-site power source.

4. Provide an additional high-pressure injection pump with an independent AC power source. (Include a dedicated pump cooling system.)

5. Add a service water pump. (Add an independent train.)

6. Install an independent reactor coolant pump (RCP) seal injection system with a dedicated diesel power source. (With dedicated pump cooling.)

7. Install an additional component cooling water pump. (Add an independent train.)

8. Add a motor-driven feedwater pump. (With independent room cooling.)

9. Install a filtered containment vent to remove decay heat.

10. Install a redundant containment spray system. (Add an independent train.)

These remaining SAMDAs were quantified by the PRA model to determine the reduction in risk for implementing the SAMDA. Each SAMDA was assumed to reduce the risk of the accident sequences that they address to zero, which is a conservative assumption. Using the cost-benefit methodology of NUREG/BR-0184, the maximum averted cost risk was calculated for each SAMDA. The maximum averted cost risk calculation used the dose-risks and cost-risks calculated for the severe accidents described in Section 7.2 for internal events.

The evaluation of averted costs considered the following five principal cost considerations:

- Off-site exposure cost.
- On-site exposure cost.
- Off-site property damage.
- Cleanup and decontamination cost.
- Replacement power cost.

The risk assessment considered four categories of events: (1) internal events; (2) internal fire; (3) internal flood; and (4) low-power and shutdown (LPSD). The analysis assumed that the population dose risk from internal events at power is applicable to internal fire events at power, internal flooding events at power, and shutdown events. A core damage frequency (CDF) scaling factor was applied to adjust from the population dose risk from internal events to the other event categories. The same argument is also applied to the property damage risk from internal events at power and scaling property damage risk for internal fire events at power, internal flooding events at power, and shutdown events.

The total base case maximum averted cost risk was determined to be $~~289,300~~383,220 using a 7 percent discount rate. The maximum averted cost benefit for internal events accounted for RCOL2_19-28

~~$75,500~~105,277 of this total. The MNES SAMDA analysis next compared the implementation costs for each SAMDA to the ~~$289,300~~383,220 value and found that none of the SAMDAs would be cost-effective. The least costly SAMDA, installation of a redundant containment spray system, had an implementation cost of approximately $870,000, with the others having higher costs. This potential SAMDA was evaluated but was not found to be cost-effective. Using a discount rate of 7 percent, the maximum benefit of this potential SAMDA was $148,000. Another calculation of the maximum attainable benefit for this SAMDA was made with the discount rate of 3 percent. The resulting maximum benefit was $43~~6~~,000, which is an insufficient benefit to justify implementation of this SAMDA. Due to the low public risk reduction, a value impact ratio is not estimated. RCOL2_19-28 RCOL2_19-28 RCOL2_19-28

7.3.3 MONETIZATION OF THE BASE CASE

The principal inputs to the site-specific calculations are the CDF (Section 7.2), dose-risk and dollar-risk (Table 7.2-5), dollars per person-rem ($2000 as provided by the U.S. Nuclear Regulatory Commission [NRC] in NUREG/BR-0184), licensing period (60 years assuming a 40-year initial operating license and one 20-year license renewal), and economic discount rate (7 percent and 3 percent are NRC precedents). With these inputs, the monetized value of reducing the base case CDF to zero for internal events is presented in Table 7.3-1. This evaluation uses meteorological data from 2006, which was limiting. The monetized value presented in Table 7.3-1 is based on November 2009 dollars. The monetized value, known as the maximum averted cost-risk, is conservative because no SAMA can reduce the CDF to zero.

~~The maximum averted cost-risk for internal events is $104,267 for a 7 percent discount rate and $274,852 for a 3 percent discount rate. These values were then used in conjunction with the Applicant's ER (MHI 2007) to determine a total value of risk avoided, which includes internal events, internal fire, internal flood, and LPSD events, as shown inTable 7.3-1 and Table 7.3-2. The risk avoided from internal fire, internal flood, and LPSD events were determined using the ratio of the CDF values for these events and the CDF value for internal events.~~ The maximum averted cost-risk of ~~$400,073~~383,220 is so low that there are no design changes over those already incorporated into the US-APWR design that could be determined to be cost-effective. The valuation of the averted risk is less than the cost of implementing the cheapest SAMDA, $870,000, as described above. RCOL2_19-28

Accordingly, further evaluation of design-related SAMAs is not warranted. Evaluation of administrative SAMAs would not be appropriate until the plant design is finalized, and plant administrative processes and procedures are developed. At that time, appropriate administrative controls on plant operations would be incorporated into the plant's management systems as part of its baseline.

7.3.4 REFERENCES

(MHI 2007) US-APWR Applicant's Environmental Report – Standard Design Certification. MUAP-DC021. Revision 0. December 2007.

(MHI 2013) US-APWR Risk Evaluation of Level 2 PRA Final Design Output. N0-EB40013. Revision 2. July 2013. RCOL2_19-28

TABLE 7.3-1
MONETIZATION OF CPNPP UNITS 3 AND 4 US-APWR BASE CASE
INTERNAL EVENTS ONLY

Cost Component	Internal Events		Internal Fire		Internal Flood		LPSD		Totals for All Events	
	7% Discount	3% Discount	7% Discount	3% Discount	7% Discount	3% Discount	7% Discount	3% Discount	7% Discount	3% Discount
Off-~~s~~Site ~~e~~Exposure ~~c~~Cost	$~~4306~~ 14,500	$~~8,514~~ 28,671	$~~6459~~ 31,066	$~~12,771~~ 61,426	$~~5038~~ 22,681	$~~9,961~~ 44,846	$~~719~~ 15,052	$~~1,422~~ 29,762	$~~16,522~~ 83,299	$~~32,668~~ 164,705
Off-~~s~~Site ~~property damage~~Economic ~~c~~Cost	$~~7303~~ 12,101	$~~14,440~~ 23,928	$~~10,955~~ 27,958	$~~21,660~~ 55,281	$~~8545~~ 22,708	$~~16,895~~ 44,900	$~~1220~~ 10,899	$~~2,411~~ 21,551	$~~28,022~~ 73,666	$~~55,406~~ 145,660
On-~~s~~Site ~~e~~Exposure ~~c~~Cost	$~~602~~511	$~~1,386~~ 1,177	$~~903~~426	$~~2,079~~ 980	$~~704~~446	$~~1,622~~ 1,026	$~~101~~87	$~~231~~200	$~~2311~~ 1,470	$~~5,318~~ 3,383
~~Cleanup and decontamination cost~~On-Site Cleanup Cost	$~~18,367~~ 15,595	$~~43,628~~ 37,045	$~~27,551~~ 12,997	$~~65,442~~ 30,872	$~~21,489~~ 13,601	$~~51,045~~ 32,307	$~~3067~~ 2,656	$~~7,286~~ 6,310	$~~70,475~~ 44,850	$~~167,401~~ 106,533
Replacement ~~p~~Power ~~c~~Cost	$~~73,689~~ 62,568	$~~206,884~~ 175,663	$~~110,534~~ 52,142	$~~310,326~~ 146,392	$~~86,216~~ 54,566	$~~242,054~~ 153,196	$~~12,306~~ 10,657	$~~34,550~~ 29,921	$~~282,744~~ 179,935	$~~793,814~~ 505,172
Total (maximum averted cost)	$~~104,267~~ 105,277	$~~274,852~~ 266,483	$~~156,401~~ 124,589	$~~412,278~~ 294,951	$~~121,992~~ 114,001	$~~321,577~~ 276,275	$~~17,413~~ 39,352	$~~45,900~~ 87,744	$~~400,073~~ 383,220	$~~1,054,607~~ 925,453

RCOL2_19-23

RCOL2_19-28

Base ~~c~~Case is 7% discount rate.

TABLE 7.3-2
TOTAL VALUE OF RISK AVOIDED

Value	Internal Events	Internal Fire	Internal Flood	LPSD	Total
CDF (per RY)[a]	~~1.2E-06~~ 1.0E-06	~~1.8E-06~~ 8.6E-07	~~1.4E-06~~ 9.0E-07	~~2.0E-07~~ 1.8E-07	~~4.6E-06~~ 2.94E-06
CPNPP, 7% Discount Rate	$~~104,267~~ 105,277	$~~156,401~~ 124,589	$~~121,992~~ 114,001	$~~17,413~~ 39,352	$~~400,073~~ 383,220
CPNPP, 3% Discount Rate	$~~274,852~~ 266,483	$~~412,278~~ 294,951	$~~321,577~~ 276,275	$~~45,900~~ 87,744	$~~1,054,607~~ 925,453

RCOL2_19-28

a) Core damage frequency values are taken from ~~Table 5 of the DC Applicant's Environmental Report (MHI 2007).~~ Reference MHI 2013

Release Category	Description
RC1	Containment bypass which includes both core damage after a Steam Generator Tube Rupture (SGTR) and thermal induced SGTR after core damage
RC2	Containment isolation failure
RC3	Containment overpressure failure before core damage due to loss of heat removal
RC4	Early containment failure due to dynamic loads which includes hydrogen combustion before or just after reactor vessel failure, in-vessel and ex-vessel steam explosion, and containment direct heating
RC5	Late containment failure which includes containment overpressure failure after core damage, hydrogen combustion long after reactor vessel failure, and basemat melt through
RC6	Intact containment in which fission products are released at design leak rate

The following table presents the release frequencies for the above release categories.

CPNPP Units 3 and 4 Release Category	CPNPP Units 3 and 4 Release Frequency per reactor-year (Table 7.2-6)
RC1	~~7.5E-09~~1.7E-08
RC2	~~2.1E-09~~3.4E-09
RC3	~~2.0E-08~~2.2E-08
RC4	~~1.1E-08~~1.8E-08
RC5	~~6.5E-08~~4.7E-08
RC6	~~1.1E-06~~9.2E-07

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Under NEPA, events with a probability of less than 1.0 E-6 per reactor-year are considered remote and speculative and need not be evaluated further. Release categories RC1 through RC5 are eliminated from further consideration because of their low probability; those events are remote and speculative. Release category RC6 is for an intact containment, which means that the radionuclide release rate would be similar to the design basis accident. As demonstrated in FSAR Chapter 15, design basis accident releases do not have a significant impact on the affected unit and the impact at the unaffected units would be less due to the additional atmospheric dispersion of the release. As such, RC6 would not have an adverse impact on the safe shutdown of the unaffected units and also need not be considered further.

The above release scenarios do not consider internal fire, internal flood, or low power and shutdown events. The release frequencies for other events that result in large radiological releases are ~~2.3E-07~~8.6E-07 per reactor-year for internal fire, ~~2.8E-07~~9.0E-07 per reactor-year for internal flood, and ~~2.0E-07~~1.8E-07 for low power and shutdown events. The release frequency for external events, including seismic, are negligible compared to internal events (Section 7.2). These frequencies are too low to warrant further consideration (these events are remote and speculative). RCOL2_19-28

The accident sequences and accident progressions at the existing Westinghouse PWR units at CPNPP Units 1 and 2 are similar to the US-APWR units. The accident sequences and accident progressions for Units 1 and 2 are classified into 14 release categories as given below.

CPNPP Units 1 & 2 Release Category	Description	CPNPP Units 1 & 2 Core Damage Frequency per reactor-year
I	Early containment rupture failure without sprays	4.21E-08
II	Early containment leakage without sprays	8.00E-09
III	Early containment rupture failure with sprays	4.60E-08
IV	Early containment leakage with sprays	1.88E-08
V	Late containment rupture failure due to core concrete interaction (CCI)-induced non-condensible gas overpressure without sprays	2.29E-08
VI	Late leakage-type containment failure due to CCI-induced non-condensible gas overpressure without sprays	4.55E-06

Radiological protection of the control room operators needed during shutdown activities following a severe accident would be provided by the control room habitability systems of the adjacent units and available post-accident mitigating measures. For a severe accident, the control room habitability system would be placed in the emergency mode to minimize the introduction of radionuclides released from the damaged unit into the control room envelope. The control room operator dose could be further minimized by the use of self-contained breathing apparatus which would essentially eliminate the inhalation dose component of the total dose.

The main control room habitability systems provide filters and iodine adsorbers for the outside air intake and the control room recirculation air flow. The initial post-accident operating mode for the control room habitability systems is the isolation mode with only recirculation air flow. The emergency ventilation mode of operation which introduces fresh air into the control room is under administrative control so that the dose to the control room occupants is minimized, and the need for air change is satisfied.

Once a plant is shutdown, stable, and in long term decay heat removal, operator action is not continuously necessary to maintain the plant in a safe shutdown condition. Therefore, at that time, the operators could be evacuated or replaced by other operators as necessary. Additional mitigating measures which could be used to limit control room operator doses following the severe accident include:

- Control room access control to minimize introduction of radioactive materials into the control room envelope
- Limitation of exposure times
- Individual thyroid protection

Implementation of any of these protective measures would be in accordance with the Site Emergency Plan.

7.5.3.2 Evaluation of Potential Impacts of Severe Accidents on Equipment Operability

Nuclear power plant equipment can inherently perform its safety functions given the radiation doses expected from a design basis accident at that unit. Additionally, plant design features, such as shielding, provide protection by reducing the post-accident radiation dose from another unit at the site. For example, the concrete of the unaffected units containment structure provides substantial shielding and the containment is sealed which prevents the introduction of post-accident airborne radioactivity releases into the containment. The structural concrete in other buildings would also provide equipment shielding and protection from external radiation.

The potential impact of a severe accident on equipment operability at an adjacent unit is due to the post-accident radiation exposure of the equipment. A dose analysis, which bounds the Unit 1 and 2 release category VI, determined that the 30 day ground level gamma radiation dose resulting from the radionuclides released to the atmosphere is less than ~~1.3E+03~~2.1E-03 rad at Unit 3 or 4. The MELCOR Accident Consequence Code System (MACCS2) software, Version 1.13.1 (Chanin and Young 1997) was used to determine the external gamma dose. Doses inside the adjacent units would be reduced due to shielding by structural materials. The doses would be RCOL2_19-28 reduced to approximately ~~11.6~~18.1 rad by 1 foot of concrete. The exterior walls and roof of the US-APWR Auxiliary Building, Reactor Building, and Power Source Building have a thickness of greater than or equal to 1 foot of concrete. As a result, doses internal to these buildings due to ground level external gamma radiation is expected to be less than or equal to the radiation level calculated based on 1 foot of concrete shielding. With the additional shielding of the internal walls and the self shielding of critical components by the equipment itself, the actual doses to needed equipment and components will actually be less. RCOL2_19-28

Doses in buildings outside the containment could be somewhat higher than the ~~11.6~~18.1 rad dose due to external radiation, because of the possibility of additional equipment radiation dose due to the intake or infiltration of contaminated air into areas where the equipment is located. Contaminated air could be introduced into the Auxiliary Building by the Auxiliary Building HVAC system. During normal plant operation, two air handling units and two exhaust fans are in operation. The exhaust airflow is continuously and automatically controlled at a predetermined value to maintain a slightly negative pressure in the controlled areas. Maintaining this negative pressure inside the building could result in the potential for infiltration of contaminated air from outside the building. Airborne radioactivity is monitored inside the exhaust air duct from the fuel handling area, penetration and safeguard component area, Reactor Building controlled area, Auxiliary Building controlled area, and sampling/laboratory area. An alarm is actuated in the main control room when the radiation levels exceed a predetermined value. If high airborne radioactivity is detected, the supply and exhaust duct isolation dampers are manually closed. Following a severe accident, if contaminated air is introduced into the building atmosphere, the exhaust air flow would be terminated upon reaching the setpoint established to keep the building releases within the 10 CFR 20.1301 limits. Securing the exhaust air flow at this point would terminate the intake of contaminated air before the concentration inside the building reaches a level which would be detrimental to the equipment. RCOL2_19-28

For the power source buildings, radiation monitors are not provided and the HVAC system is not isolated on high radiation. As a result, there would be a continuous flow of potentially contaminated air into the building and contaminated air and exhaust out of the building. However, the total integrated radiation dose to equipment in the power source building would be no more than the unshielded external gamma dose (~~1.3E+03~~2.1E-03 rad). Radiation doses at this level are not detrimental to equipment operation and would be reduced by equipment self shielding to a lower dose. RCOL2_19-28

From the standpoint of equipment survivability, the radiation levels inside the adjacent units would be at a level considered to be a mild radiation environment (i.e., < 1.0E+04 rad). Plant equipment is not considered to be adversely impacted by radiation if in a mild radiation environment (Unit 1 and 2 FSAR Subsection 3.11B-1 and DCD Subsection 3.11.5.2). Based on the discussion above, the necessary equipment in the adjacent US-APWR units would be able to perform its design function following the severe accident involving release category VI at CPNPP Units 1 and 2. This equipment would be capable of promptly shutting down the reactor, maintaining the unit in a safe condition during hot shutdown, and subsequently placing and maintaining the unit in cold shutdown. The radiation exposure to equipment at an adjacent unit, due to the radiation released from the damaged unit, would not be detrimental to equipment operation.

7.5.3.3 Evaluation of Potential Overall Operational Impacts of Severe Accidents on the Unaffected Units

Severe accidents that have a very low probability are remote and speculative and do not need to be evaluated under NEPA. With respect to the remaining severe accidents, the required equipment and operator oversight will be available to safely shutdown each of the unaffected units during a postulated severe accident scenario on any of the four units on site. There will be no adverse impact on the unaffected units' operations that would result in additional environmental impacts due to the unaffected units. Therefore, the consequences of a severe accident on the unaffected units would be limited to general site contamination and prolonged outages while the original accident cause is investigated.

7.5.4 ECONOMIC IMPACTS OF A TEMPORARY SHUTDOWN OF THE UNAFFECTED UNITS

The economic impacts of the postulated event are assessed based upon the cost-risk of the event (Section 7.2 and 7.3). The risk and cost are addressed below.

7.5.4.1 Severe Accident Risk

Severe accidents, as discussed in Section 7.2, have a very low probability of occurrence. The sum of the frequencies of occurrence for each of the six US-APWR release categories, which are shown in Table 7.2-6, is the core damage frequency (CDF) for internal events. The total US-APWR CDF for internal events, internal fire, internal flooding, and low-power and shutdown (LPSD) events is ~~4.6E-06~~2.94E-06 per reactor-year as shown in Table 7.2-12, 7.2-13 and 7.2-14. RCOL2_19-28 The CDF contribution due to external events such as seismic, tornados, external flooding, transportation accidents, and nearby facility accidents is considered in FSAR Subsection 19.1.5. The CDF resulting from a tornado strike is 7.0E-08 events per reactor-year, which is almost two orders of magnitude lower than the total CDF for internal events, internal flood, internal fire, and LPSD events. As discussed in FSAR Subsection 19.1.5, the contribution of external flooding, transportation accidents, and nearby facility accidents to the total CDF is considered insignificant. Seismic events are also discussed in Subsection 19.1.5 of the US-APWR DCD and are not significant contributors to the total CDF. Therefore, external events were determined to be negligible compared to internal events and were not incorporated into the release frequencies.

The CDF for CPNPP Unit 1 due to internal events, including internal fire and flood, as derived from the PRA for Units 1 and 2, is 3.09E-05 events per reactor-year. The corresponding internal CDF for Unit 2 is 3.06E-05 events per reactor-year. Including the CDF contribution due to tornadoes increases the Unit 1 CDF to 3.46E-05 events per reactor-year and the Unit 2 CDF to 3.43E-05 events per reactor-year. Because Comanche Peak is in a low seismicity region, the seismic CDF contribution is 5.0E-07 per reactor-year. The CDF for low power and shutdown events is 3.0E-06 per reactor-year.

7.5.4.2 Cost-Risk Impacts

A severe accident at any of the CPNPP units would result in contamination and possible prolonged outages at the other units. The economic risk at an affected US-APWR unit has been evaluated and quantified in sections 7.2 and 7.3. As discussed below, this economic risk of the units to reduce the economic impact to the utility and the local community. This would reduce the overall cost impact.

As noted in Table 7.3-1, the maximum averted cost-risk for internal events including internal fire, internal flood, and LPSD events [external events are not included in the US-APWR CDF because they are not a significant contributor to total risk, (Subsection 7.5.4.1)] results in a maximum averted cost-risk of $~~400,073~~383,220 as shown in Table 7.3-1. Inclusion of the cost of the protracted shutdown of the unaffected units, given in Table 7.5-1, increases the maximum averted cost-risk to $~~692,576~~569,364 based on a seven percent discount rate. The averted cost-risk increase would be even smaller if more realistic shutdown times (on the order of weeks) for the unaffected units are considered. RCOL2_19-28 RCOL2_19-28

Based on Table 7.5-1, the severe accident cost-risks do not impact the severe accident mitigation alternatives (SAMA) evaluation given in Section 7.3. The valuation of the averted risk of $~~692,576~~569,364 is less than the cost of implementing the cheapest SAMA, $870,000, as described in Section 7.3. RCOL2_19-28

The analysis of a postulated severe accident at one of the existing units conservatively assumed that the affected W-PWR unit is Unit 2 because this unit has a longer remaining life which would maximize the replacement power costs. The monetization of the Unit 2 severe accident was based on the assumption that the off-site dose and property damage would be similar to those for a severe accident at one of the US-APWRs. This assumption is reasonable because Units 1 and 2 are also pressurized water reactors with similar design and safety features such that the accident sequences and release characteristics would be similar. In addition, the power level of the older W-PWR units is bounded by the US-APWR power level, which would make the post-accident radiological consequences smaller. As before, the unaffected units are assumed to be out of service for six years following the accident. The Unit 2 severe accident economic impact is given in Table 7.5-2. The higher economic risk for a severe accident at Unit 2 is not unexpected because the CDF for Unit 2 is a factor of approximately ~~18~~28 higher than the CDF for the US-APWR units. (~~4.6E-06~~2.94E-06 per reactor-year for the US-APWR units for all internal events, internal fire, internal flood and LPSD events vs. 8.5E-05 events per reactor-year for Unit 2 internal and external events). RCOL2_19-28

The data provided in Table 7.5-2 is provided for completeness only. These costs are not relevant to the SAMA analysis for Units 3 and 4 because there are no SAMAs which could be implemented at Units 3 and 4 which could reduce the CDF at Units 1 or 2.

7.5.5 CONCLUSIONS

Under NEPA, it is not necessary to consider those severe accidents that have a very low probability of occurrence (less than 1E-6 per reactor-year) because such accidents are remote and speculative. As demonstrated above, severe accidents with a probability of greater than 1E-6 per reactor-year at the affected unit would not prevent the unaffected units from safely shutting down. All equipment necessary to complete a safe shutdown of the unaffected units would be able to operate as designed without any degradation to its functional capabilities for the exposure levels associated with the airborne release from the accidents evaluated. The radiation dose to equipment is below the level normally considered as a harsh environment which ensures proper equipment function. The control room habitability systems are capable of maintaining habitability of the control rooms during shutdown of the unaffected units. Operators at the unaffected units would be able to achieve and maintain safe shutdown of the units prior to a large release from the affected unit.

In summary, the consequences of a severe radiological accident at any one unit on the operation of the other units at the Comanche Peak site are of SMALL significance. The accident scenarios would not result in any incremental severe accident environmental impacts attributable to the unaffected units beyond those evaluated in Section 7.2. The environmental impact from a severe accident would remain SMALL.

Furthermore, even if it is arbitrarily postulated that severe accidents were to occur in all four units simultaneously, the cumulative environmental impacts would still be SMALL. In such a scenario, the releases of radioactivity from all four units would be approximately four times the release from an individual unit. However, even if the risk-based environmental impacts discussed in Section 7.2 for an accident originating in one of the US-APWR units were to be multiplied by a factor of four, the environmental risks would still be SMALL. For example, the cumulative dose risk from all four units would be about ~~1.2~~11.76 person-rem/year (i.e., 4 x ~~0.3~~2.96 person-rem per reactor-year), which is less than the cumulative population dose risk from normal operation (1.64 person-rem TEDE per reactor-year). Furthermore, the cancer fatality risk would be ~~1.2~~2.6E-09 per reactor-year (i.e., four times ~~3.22~~6.59E-10 per reactor-year from Subsection 7.2.4), which is well below the NRC's safety goal of 1.89E-06 per reactor-year. This value is well below the 0.1 percent value specified in the NRC's Safety Goal Policy Statement. As discussed in Section 7.5.4, the CDF for Units 1 and 2 is approximately ~~18~~28 times the CDF for Units 3 and 4. However, even if these risk-based values were to be multiplied by a factor of ~~18~~28, the resulting cancer fatality risk would remain well below the NRC's Safety Goal. Therefore, the environmental impact from such an arbitrary scenario would remain SMALL.

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7.5.6 REFERENCES

(Chanin and Young 1997) Chanin, D.I. and M.L. Young. Code Manual for MACCS2: Volume 1, User's Guide. NUREG/CR-6613. SAND97-0594. Sandia National Laboratories. Albuquerque, New Mexico. May 1998.

TABLE 7.5-1
IMPACT OF ASSUMED SIX-YEAR OUTAGES AT UNDAMAGED UNITS ON SEVERE ACCIDENT COSTS* SEVERE ACCIDENT AT UNIT 3 OR 4

	7 Percent Discount Rate Single Unit	7 Percent Discount Rate Four Units
Off-site Exposure Cost	$~~16,522~~83,299	$~~16,522~~83,299
Off-site Property Damage Cost	$~~28,022~~73,666	$~~28,022~~73,666
On-site Exposure Cost	$~~2,311~~1,470	$~~9,242~~5,880
On-site Cleanup Cost	$~~70,475~~44,850	$~~70,475~~44,850
Replacement Power Cost	$~~282,744~~179,935	$~~568,315~~361,669
Total	$~~400,073~~383,220	$~~692,576~~569,364

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*values are expressed in terms of risk (i.e., cost times likelihood in $/yr)