Enclosure 1

To

RBG-46222

Information copy of revised River Bend Alternate Source Term LOCA Off-Site and Control Room Dose Analysis Calculation

ENTERGY

CALCULATION COVER PAGE ENGINEERING DEPARTMENT RIVER BEND STATION

CALC. NO. - REV. ADDENDUM G13.18.9.5*061-01
ATTACHMENT NO.: (as required)
JBI NO.: G13.18.9.5
PAGE: 1 OF 71

TITLE: Alternate Source Term LOCA Off-Site and Control Room Dose Analysis

CALCULATION STATUS: ☐ APPROVED ☒ PENDING ON IMPLEMENTATION OF ER-RB-2002-0223 ☐ CANCELED
☐ PENDING ON CONFIRMATIONS

SYSTEM NO.: N/A | **MARK NO.:** N/A

CLASSIFICATION: ☒ SAFETY RELATED **NON-SAFETY RELATED:** ☐ QAPA ☐ NON-QAPA

PURPOSE / SCOPE / OBJECTIVE:

The purpose of this analysis is to determine the off-site and Main Control Room dose consequences due to a DBA-LOCA utilizing the Alternate Source Term dose methodology prescribed in NUREG-1465 and Regulatory Guide 1.183. The original analysis assumed a number of relaxations from the current Technical Specification requirements. This revision will assume the elimination of the Annulus Mixing System and the increase in the assumed MSIV leakage.

CONCLUSION:

This analysis demonstrates that the dose consequences due to a DBA-LOCA will not exceed the criteria set forth in 10CFR50.67. Specifically, the off-site dose consequences (EAB and LPZ) will be less than 25 REM TEDE, and the doses to main control room operators will not exceed 5 REM TEDE.

SOFTWARE USED FOR CALCULATION: ☒ YES ☐ NO

SDDF #	Manufacturer	Name	Version/Release No
VA-6244.400-912-001B	USNRC	RADTRAD	3.02

KEYWORDS:

LOCA; Dose; Alternate Source Term; AST; Dose Consequences; USAR Chapter 15

Licensing/Design Basis Impact

☒ Addressed in DCA No. ER-RB-2002-0223
☐ Licensing/Design Basis Impact Checklist included
☐ None – Reason:

REVIEW & APPROVAL

[signature] 10/1/03	[signature] 10/1/03	[signature] 10/13/03
(Signature/Date) Preparer (Printed Name, KCN, or SSN) Thomas W. Oliphant, 0032	(Signature/Date) ☐ Reviewer (Non-Safety) ☒ Design Verification Reviewer Virgel T. Furr, 0252	(Signature/Date) Supervisor (Printed Name, KCN, or SSN) Harry A. Goodman, 1024

TABLE OF CONTENTS

REVISION HISTORY

Revision No.	Paragraph No.	Description of Change
0	All	Initial Issue
1	All	This revision incorporates addenda A and B to the previous revision, and revises the calculation to reflect deletion of the Annulus Mixing System, and increasing the single MSIV leakage limit from 50 CFH to 150 CFH.

REFERENCE DOCUMENTATION

I. REFERENCES: List RBS Calculations, Procedures, Drawings, etc related to this calculation. Identify how the documents are affected by only selecting one Relationship Code and one Relationship Status. Note: Ers are always listed as Related/References.

	Document Number	Rev.	Relationship (Related, Supercedes, Voids)	Relationship Status (Reference, Pending, As-Built, Supplements, Other)
I.1	G13.18.9.5*051	2	Related	Supplements
I.2	PR-C-539 (Note)	4	Related	Reference
I.3	PB-211	0	Related	Reference
I.4	PN-213	1	Related	Reference
I.5	PN-228_ADDA	3A	Related	Reference
I.6	PN-330_ADDA	1A	Related	Reference
I.7	G13.18.14.0*196	0	Related	Reference
I.8	G13.18.2.7*023_ADDA	2A	Related	Reference
I.9	R-SA-00-003	0	Related	Reference
I.10	R-SA-00-004	0	Related	Reference
I.11	ES-151_ADDA	0A	Related	Reference
I.12	ES-155_ADDA	0	Related	Reference
I.13	G13.18.7.7*011	0	Related	Reference
I.14	G13.18.7.7*012_ADDC	00C	Related	Reference
I.15	RBC-47866	-	Related	Reference
I.16	RBC-49376	-	Related	Reference
I.17	RBC-49387	-	Related	Reference
I.18	EM-002D	7	Related	Reference
I.19	7222.250-000-009	A	Related	Reference
I.20	PID-22-01D	14	Related	Reference
I.21	PID-27-15A	14	Related	Reference
I.22	~~6244.400-912-001B~~ See I.25 TWD 11/11/03	00	Related	Reference
I.23	7222.250-000-029	A	Related	Reference
I.24	ES-194_ADDA	4A	Related	Reference
I.25	VA-6244.400-912-001B	00	Related	Reference
I.26	316759	00	Related	Reference
I.27	PID-27-21A	5	Related	Reference
I.28	ADM-0050	10	Related	Reference
I.29	RBC-49932	-	Related	Reference
I.30	RBC-49975	-	Related	Reference
I.31	SDC-257	01	Related	Reference

I. REFERENCES: List RBS Calculations, Procedures, Drawings, etc related to this calculation. Identify how the documents are affected by only selecting one Relationship Code and one Relationship Status. Note: Ers are always listed as Related/References.

Document Number	Rev.	Relationship (Related, Supercedes, Voids)	Relationship Status (Reference, Pending, As-Built, Supplements, Other)
I.32 SDC-402/410	02	Related	Reference
I.33 G13.18.14.0*196_ADDA	0A	Related	Reference
I.34 SDC-403/404/409	04	Related	Reference
I.35 ~~ER-RB-2002-0223~~ Deleted TJW 11/11/03	00	Related	Reference
I.36 EB-015C	7	Related	Reference
I.37 EB-015D	7	Related	Reference
I.38 EB-015E	8	Related	Reference
I.39 EB-015F	8	Related	Reference
I.40 EB-015G	11	Related	Reference
I.41 EB-015H	12	Related	Reference
I.42 EB-015J	11	Related	Reference
I.43 EB-015K	10	Related	Reference
I.44 EB-015L	7	Related	Reference
I.45 EB-015M	7	Related	Reference
I.46 EB-015Q	9	Related	Reference
I.47 G13.18.9.5*061	0	Supercedes	Pending
I.48 G13.18.9.5*061_ADDA	00A	Supercedes	Pending
I.49 G13.18.9.5*061_ADDB	00B	Supercedes	Pending

II. CROSS REFERENCES: Applicable codes, standards, & references (may be non-RBS documents).

Document No.	Rev.	Description/Title
II.1. Regulatory Guide 1.3	2	Assumptions Used for Evaluating the Potential Radiological Consequences on a Loss of Coolant Accident for Boiling Water Reactors
II.2. Regulatory Guide 1.49	0	Power Levels of Nuclear Power Plants
II.3. Regulatory Guide 1.183	0	Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors
II.4. SRP 6.4	-	USNRC Standard Review Plan for Control Rooms
II.5. NCR Letter GNRI-99/00074	-	SER for application of GE Report DFR A12-00117 - approves a 121 sec. delay in the release of fission products following a DBA-LOCA
II.6. Murphy & Campe	-	Nuclear Power Plant Control Room Ventilation System Design for Meeting General Design Criterion 19

II. CROSS REFERENCES: Applicable codes, standards, & references (may be non-RBS documents).

Document No.	Rev.	Description/Title
II.7. USNRC License NPF-47	-	
II.8. 10CFR50.67	135	River Bend Station, Unit 1 Operating License
II.9. 10CFR50, Appendix K	-	
II.10. NUREG/CR-6604	-	RADTRAD User's Manual (Including Supplement 1)
II.11. GGNS Letter: GNRO-2000/00080	-	Grand Gulf LAR for Full Scope Implementation of AST
II.12. Thermodynamics	(c) 1989	Cengel and Boles, McGraw Hill Publishing
II.13. TID-14844	-	
II.14. RBS USAR	Sept., 2001	Updated Safety Analysis Report for River Bend Station
II.15. LAR 2001-21	-	RBS LAR adding IFTS drain line and FB airlock to SCB summation (TRM Change Only)
II.16. NUREG-1465	0	Accident Source Terms for Light Water Nuclear Power Plants
II.17. NUREG/CR-0009	-	
II.18. NUREG-0989	-	River Bend Station Safety Evaluation Report (Including Supplements 1 – 5)
II.19. Regulatory Guide 1.52		
II.20. CNRO99-00026	-	Letter from EOI to USNRC, "Proposed Amendment to Technical Specifications Laboratory Testing of Activated Charcoal".

CALCULATION CHECKLIST

YES	NO	N/A	FORMAT	EDP-AA-20 SECTION
X			Cover Page completed.	6.4.1
X			Table of Contents completed (as required).	6.4.2
X			Revision History Sheet completed (as required).	6.4.3
	X		Revisions are identified with revision lines in right margin.	6.4.3
X			Reference Documentation Page completed.	6.4.4
X			Definitions established (as required).	6.4.5
X			Calculation/revision/addendum/page numbers are identified correctly.	6.4.9
			CONTENTS	
X			Previous calculation for the required analysis exists.	6.3
X			Calculation is appropriately titled for the intended scope.	6.4.1-2
X			Purpose and scope are clearly and adequately established.	6.4.1-7, 7.1
X			Safety classification is correct for the identified scope.	6.4.1-6
X			Topics/documents/equipment for cross-reference/retrieval are identified.	6.4.1-11
X			Calculation is clear and comprehensible.	6.1
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X			RBS references are identified.	6.4.4-2
X			Affected documents are identified	6.4.4-3
X			Inputs and sources are identified, appropriate, and correct.	7.2.2-1
X			Assumptions are identified and appropriate.	7.2.2-2
		X	Inputs derived from field walkdown have been witnessed/verified	7.2.2-5
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X			Conclusion is appropriate and is justified by calculation.	7.3
		X	Confirmations are identified and indicated as required on Cover Page.	7.5.7
		X	Directions for Confirmations are included.	7.5.7-3
X			Calculation data is appropriately included, attached, or referenced.	7.4
X			Programs and software are identified and have been verified and validated.	8.0
X			Methods/calculations use to check results are identified and included.	
X			Results are accurate and in accordance with the established methodology.	
	X		Certification by Professional Engineer is required.	11.7
			VENDOR CALCULATIONS	
		X	Calculation is performed in accordance with EDP-AA-20.	10.2
		X	Calculation content and format are acceptable.	10.2
		X	Vendor, preparer, reviewer, and approver are clearly identified.	10.3
		X	Design verification review has been completed (as applicable).	

DESIGN VERIFICATION RECORD

METHOD

Verification methods to be used:

☐ Design Review

☐ Qualification Testing

☐ Alternative Calculations

DOCUMENT(S) REVIEWED: (Attach Additional Sheet(s), if needed)

Document Number	Revision	Document Title
G13.18.9.5*061	0	Alternate Source Term LOCA Off-Site And Control Room Dose Analysis

SUMMARY OF REVIEW: (Attach Additional Sheet(s), if needed)

Inputs were review and the conclusion reached is correct.

Design Verification Completed By: [signature] Date: 10-1-03

Comment Resolutions Accepted By: [signature] Date: 10-1-03

Engineering Supervisor: [signature] Date: 10/13/03

DESIGN VERIFICATION RECORD (cont.)

Comment Number	Comment	Resolution	Accept Y/N	Initial / Date
1.	Multiple typographical errors.	Corrected	Y	[illegible] / 01-03
2.	Include definition for LOP in Section 2, "Definitions".	Corrected	Y	
3.	Subsection 3.5, "Air Volume Mixing", second paragraph, first sentence states the 50% mixing assumption was used for the Auxiliary Building. While this is true, the subject paragraph is discussing the annulus. Change Auxiliary Building to Annulus.	Corrected	Y	
4.	The elemental iodine removal inputs described in 7.1.1.1 and 7.2.1.1 terminate deposition after 24 hours. What is the basis for this value?	See assumption 3.22, "Natural Depostion – Elemental Iodine", and revisions to the text in 7.1.1.1 and 7.2.1.1.	Y	

1 PURPOSE

The NRC has recently developed regulatory guidance utilizing the Alternate Source Term (AST) dose methodology. AST uses more realistic assumptions in determining the potential dose consequences from design basis accidents. In support of this effort the NRC has recently issued Regulatory Guide 1.183 which provides assumptions and guidance in analyzing accidents with AST. The purpose of this evaluation is to determine Design Basis – Loss of Coolant Accident doses using the AST dose methodology and demonstrate that all Regulatory Limits will be met.

2 DEFINITIONS

AST	-	Alternate Source Term (synonymous with "Revised Source Term" or RST)
CEDE	-	Committed Effective Dose Equivalent
CRFAS	-	Main Control Room Fresh Air System, System #402
DBA	-	Design Basis Accident
DDE	-	Deep Dose Equivalent
ECCS	-	Emergency Core Cooling Systems
EDG	-	Emergency Diesel Generator
EIV	-	Early In-Vessel Phase of AST
ESF	-	Engineered Safety Features
GAP	-	Gap Phase of AST
HVF	-	Fuel Building Ventilation System, System #406
L_a	-	Containment Design Leakage Rate (currently 0.26% per day at P_a)
LOCA	-	Loss of Coolant Accident
MCR	-	Main Control Room
P_a	-	Containment Maximum Pressure Due to a DBA (= 7.6 psig)
PPP	-	Positive Pressure Period
RCPB	-	Reactor Coolant Pressure Boundary
RG	-	Regulatory Guide
SCB	-	Secondary Containment Bypass (most valves formerly served by the PVLCS system)
SGTS	-	Standby Gas Treatment System, System #257
ST	-	Source Term
TEDE	-	Total Effective Dose Equivalent
TID	-	NRC Technical Information Document (In this calculation "TID" specifically references TID-14844 [unless otherwise noted] which previously was the basis for accident off-site dose calculations)
X/Q	-	Atmospheric Dispersion Factors (Chi/Q, or χ/Q)
LOP	-	Loss of Off-Site Power
SA	-	Severe Accident

3 ASSUMPTIONS

3.1 Single Failure Assumption

This analysis will assume a single active failure of an Emergency Diesel Generator and a complete Loss of Off-site Power (LOP).

3.2 Fuel Damage

This analysis assumes a 121 second delay prior to fuel damage commencing based on Reference II.5. Note that this short decay time will not be directly credited. However, the time may be used to off-set the timing of some elements in the AST analysis.

3.3 Containment Purge

Regulatory Guide 1.183, Appendix A, Section 3.8 states that if the containment is routinely purged during power operations then releases prior to containment isolation should be analyzed and the resulting doses summed with the postulated doses from the other release paths. RBS does routinely vent containment during normal operations, however, a rigorous analysis is not warranted due to several factors. First, containment purges are filtered by either HVR-FLT6 (non-safety related) for normal purge and by the SGTS filter train for high volume purges. Also, control logic closes the containment and drywell purge isolation valves on a containment isolation signal, and the purge system remains locked out for 10 hours following the isolation signal. Finally, Reference I.9 performed an analysis of a "puff release" of the reactor coolant to the atmosphere. If it is conservatively assumed that the purge remains in affect for 1 minute (valve stroke time is 3 seconds), only ~1% of the containment volume would be released by a high volume purge and the resulting doses are estimated to be <10 mrem TEDE which is clearly bounded by the conservative assumptions used in this analysis (such as assuming two single active failures rather than the one required per regulations).

3.4 Main Control Room Fresh Air System Initiation

This analysis assumes that the MCRFA system is manually initiated, thus, there is a 20 minute delay in crediting filtration. Currently the system would actually be initiated via either a LOCA signal (RPV Level 2 or high drywell pressure) or a HI-HI radiation signal from the MCR main air intake radiation monitors. Also, it should be noted that the system will auto-initiate in emergency mode following a LOP.

3.5 Air Volume Mixing

This analysis will credit 50% of the auxiliary building volume consistent with SRP 6.5.3 and Regulatory Guide 1.183, Appendix A, Section 4.4. The auxiliary building has a number of unit coolers which provide a flow which would mix different room volumes. Also, SGTS is balanced such that it takes suction from a number of different points in the auxiliary building. If a leak was somewhat localized then mixing would occur in the SGTS itself as only a fraction of the total SGTS flow would come from the localized area. This 50% mixing assumption is consistent with the methodology which was previously approved by the NRC (this assumption was inherent in the original licensing basis analysis and the analyses developed to support Amendments 98, 110, 113, and 114).

Previous to this revision, the RBS design included the Annulus Mixing System which provided mixing of the shield building annulus and the 50% mixing assumption allowed by Regulatory Guide 1.183, Appendix A, Section 4.4 was used for the annulus. In this design, suction from the annulus to SGTS was from the annulus mixing system. The annulus mixing system will be ~~was~~ removed from the RBS design via ~~Reference I.35,~~ ER-RB-2003-… thus there is no forced mixing of the annulus. Regulatory Guide 1.183, Appendix A, Section 4.4 states that when there is no mixing, the leakage should be assumed to be transported directly to the exhaust system without mixing. However, the annulus mixing system ductwork will not be removed, thus the SGTS suction will be through the annulus mixing system suction and discharge ducts. A review of the duct drawings (References I.36, I.37, I.38, I.39, I.40, I.41, I.42, I.43, I.44, I.45, and I.46) indicates that with the annulus mixing fans not powered, the suction for SGTS will be distributed about the annulus suggesting some mixing will take place. Therefore, minimal credit will be taken for mixing in the annulus by setting the annulus volume to 1.0 ft^3. An informal sensitivity study indicates the calculated doses do not change for annulus volumes in the range of 1.0 to 10^{-9} ft^3. Below this range numerical instabilities are observed in RADTRAD.

3.6 Containment Leakage Rate (L_a)

The containment leakage rate (L_a) is assumed to be 0.325% per day. This has been accepted by the NRC (Reference I.30).

3.7 Secondary Containment Bypass (SCB) Leakage Rate

This analysis will assume a SCB leakage rate of 580,000 cc/hr at Pa. Note that since containment pressure is the driving force for this leakage, it will be reduced at 24 hours consistent with the containment leakage. This has been accepted by the NRC (Reference I.30).

3.8 Annulus Bypass Leakage Rate

Annulus bypass leakage was a subset of L_a which is not released to the annulus. Originally, 13,500 cc/hr (at P_a) was allowed per Technical Specification 3.6.1.3.12. However, sensitivity studies (Reference I.9) indicate that off-site and main control room dose is insensitive to this contributor when it is filtered. For example, increasing the annulus bypass from 13,500 cc/hr to ~65,000 cc/hr yielded an increase of <1%. Therefore, annulus bypass will not be modeled in this analysis. This has been accepted by the NRC (Reference I.30).

3.9 MSIV Leakage

A RELAP model was developed for the previous LOCA dose evaluation (Reference I.1) and it demonstrated that the pressure in the volume between the valves after they close remains significantly greater than RPV and drywell pressure for more than 2 hours. This model was not updated for power uprate conditions, however, it easily supports the assumption that the volume will remain above P_a for at least 25 minutes. Therefore no leakage will be assumed for lines in which both isolation valves close.

Failure of one MSIV will be assumed resulting in MSIV leakage prior to the MS-PLCS system becoming fully operational. Note that this constitutes a second "single active failure" since failure of a EDG is already assumed. This is assumed since for some doses the EDG failure is bounding and others the MSIV failure may be bounding. Assuming both conservatively bounds both scenarios and exceeds regulatory requirements. The single leaking MSIV will be assumed to leak at the 150 scfh value specified for all valves specified in Technical Specification Surveillance Requirement 3.6.1.3.10.

3.10 Engineering Safety Feature Leakage

Regulatory Guide 1.183 states that "The [Engineered Safety Features (ESF)] leakage should be taken as two times the sum of all of the simultaneous leakage from all components in the ESF recirculation systems above which ... would require declaring such systems INOPERABLE." RBS has historically assumed 60 gph leakage based on NUREG-0989 which states that 60 gph "represents the largest flow that could plausibly exist over the duration of the accident without discovery and isolation of the source." This analysis will assume 60 gph for ESF leakage. This has been accepted by the NRC (Reference I.30).

3.11 Suppression Pool Scrubbing

Regulatory Guide 1.183, Appendix A, Section 3.5 states that suppression pool scrubbing generally should not be credited. Therefore, this analysis will not credit SP scrubbing.

3.12 Suppression Pool pH

The chemical fractions used in this analysis inherently assume no iodine re-evolution from the suppression pool. Calculation G13.18.14.0*196-0 demonstrates that injection via the SLCS tank will buffer the suppression pool to ensure that the pH remains above 7, which is the limit for iodine re-evolution per Regulatory Guide 1.183 (Reference II.3).

3.13 SGTS Initiation

Per the current design SGTS will auto-start on a LOCA signal. However, this analysis will assume manual initiation of the SGTS system at 20 minutes into the event.

3.14 SGTS Flows

This analysis will assume that SGTS is balanced such that there is no recirculation. This maximizes the flow from the auxiliary building and the annulus and subsequently to the environs. In reality the system is currently balanced such that there is recirculation. Specifically, MAI #316759 (Reference I.26) documents measured flow rates of 6,591 cfm for the auxiliary building and 753 cfm for the annulus as compared to the design flow rates of 10,000 cfm and 2,500 cfm (Reference I.31) assumed for the auxiliary building and annulus, respectively.

3.15 Main Steam Positive Leakage Control System Initiation

MS-PLCS is assumed to be initiated 20 minutes into the event. An additional 5 minutes is credited for the system to become fully operational. Note that this is consistent with the original and current design/licensing basis of the plant.

3.16 Secondary Containment Positive Pressure Period (PPP)

The current design of the SGTS is to initiate on a LOCA signal or a high annulus radiation signal (Reference I.31). This analysis will assume manual initiation of the SGTS system at 20 minutes into the event. Assuming an additional 10 minutes for the drawdown of secondary containment, the resulting PPP is 30 minutes. Note that the 30 minute PPP was confirmed in References I.8 and I.24 which calculated PPP of <1300 seconds for the Shield Building Annulus and the Auxiliary Building. This has been accepted by the NRC (Reference I.30).

3.17 Main Control Room HVAC Volume

The Control Room volume used in this analysis will conservatively neglect the volume of the HVAC handling area.

3.18 Main Control Room Fresh Air System Initiation

River Bend Station has dual air intakes which may be manually selected in the Main Control Room. SRP 6.4 allows the more favorable X/Q to be reduced by a factor of 4 to account for the fact that the operators would select the most favorable air intake. Previous analyses conservatively assumed an "operator action" to initiate the change to the more favorable intake. Therefore, no credit was taken in the LOCA dose analysis until 20 minutes into the event. However, further review indicates that this was an overly conservative assumption, therefore, this analysis will credit SRP 6.4 from the onset of the event. This has been accepted by the NRC (Reference I.30).

3.19 Main Control Room Fresh Air System Emergency Charcoal Filter Initiation

This analysis will assume manual initiation of the main control room fresh air system (MCRFA) emergency charcoal filters at 20 minutes.

3.20 Main Control Room Inleakage and System Flow Rates

This analysis will assume the following flow rates:

- Unfiltered Leakage Flow Rate: 300 cfm
- Filtered Suction Flow Rate: 1,700 cfm
- Discharge Flow Rate: 2,000 cfm
- Recirculation Flow Rate: 2,000 cfm

Note that filtered suction flow is less than the design flow rate of 2,000 cfm (Reference I.32). This is necessary to ensure that the assumed inlet and outlet flows are balanced (i.e., the sum of the unfiltered leakage and filtered suction flow equals the discharge flow). These assumptions are more conservative than assuming that the intake remains 2000 cfm with an additional 300 cfm inleakage due to the fact that assuming an additional 300 cfm inleakage warrants the addition of 300 cfm to the discharge flow. Under those assumptions (2000 cfm filtered intake, 300 cfm unfiltered, and 2300 cfm discharge) the additional discharge purges the MCR at a faster rate which results in lower calculated MCR doses. This has been accepted by the NRC (Reference I.30).

3.21 HEPA Filtration Efficiencies

Consistent with previous analysis the HEPA filters will be assumed to have an efficiency of 99%.

3.22 **Natural Deposition – Elemental Iodine**

This calculation credits that natural deposition of elemental iodine in the drywell for the first 24 hours into the event. This has been accepted by the NRC (Reference I.30).

4 METHODOLOGY

This analysis will utilize the computer code RADTRAD v. 3.02 which was developed by Sandia National Labs for the Nuclear Regulatory Commission. This code was developed to support AST. The code allows for up to 10 nodes and 25 flow paths. Reference I.9 developed and benchmarked a RBS specific LOCA model consistent with the model which was approved via Technical Specification Amendment 98. AST assumptions were then applied to the model and a number of sensitivity studies were performed in an effort to determine the potential applications of AST.

Three separate models are used in this calculation. The first model is intended to determine the dose consequences from leakage from primary and secondary containment. The second model will determine the dose consequences due to secondary containment bypass and MSIV leakage. Finally, the third file will determine the dose consequences from liquid leakage from ECCS equipment (ESF leakage).

4.1 Acceptance Criteria

The radiological acceptance criteria are set forth in 10CFR50.67 and are as follows:

- EAB Dose $\leq$25 rem (0.25 Sv) TEDE for any 2-hour period
- LPZ Dose $\leq$25 rem (0.25 Sv) TEDE for the duration of the event
- MCR Dose $\leq$5 rem (0.05 Sv) TEDE for the duration of the event

5 SYSTEM DESCRIPTIONS

5.1 Pressure Suppression Containment

The RBS containment building is designed to limit fission product leakage during and following a postulated design basis accident to values less than the leakage rates which would result in offsite doses greater than the exposure limits set forth in 10 CFR 100. The design containment leak rate was established during initial plant licensing. The primary considerations were reactor power level, site characteristics and meteorology, iodine removal capability, and offsite dose assessment.

The Mark III pressure suppression containment system consists of a drywell, a vapor suppression pool, and a primary containment building. The reinforced concrete cylindrical drywell structure houses the reactor system. The primary containment structure encloses the drywell and the suppression pool which fills the bottom 20 ft of the annular volume outside the drywell. The basic design concept of the pressure suppression containment is to direct any primary system leakage through the drywell vent system into the suppression pool where the steam is condensed. This design limits pressurization of the containment.

Drywell

The RBS drywell is designed to maintain its structural integrity during and following any postulated LOCA including the worst single failure in conjunction with a loss of offsite power and a safe shutdown earthquake. The drywell is designed to limit the energy and fission product transfer to the containment by directing the flow from postulated pipe ruptures through the suppression pool. The drywell design pressure is 25 psid and the design temperature is 330°F. During a DBA-LOCA, primary system leakage is directed through the horizontal vent system into the suppression pool. The allowable drywell bypass leakage is based on the amount of steam bypass which can be allowed without exceeding the containment design pressure of 15 psig. The allowable leakage is expressed in terms of the flow parameter $A/\sqrt{K}$ where A is the flow area of the leakage path and K is the geometric and friction loss coefficient (unitless).

Containment Building

The primary containment structure is a free-standing steel cylinder with a torispherical dome. It serves both as a suppression chamber and as a leak-tight vapor barrier to protect against release of fission products in the unlikely event of a LOCA.

Penetrations through the containment building are protected by either primary containment isolation valves (PCIV) or primary containment isolation dampers (PCID). Typically the penetrations have redundant isolation valves. The penetrations are tested in accordance with industry standards to demonstrate that that the containment building's overall leakage rate meets the design values.

Note that several subsets of the PCIVs are not considered to be contributors to L_a. Specifically, the Main Steam Lines (MSL) are currently protected by a Main Steam – Positive Valve Leakage Control System (MSPLCS). This system eliminates leakage to the environment through the MSL by pressurizing the volume between isolation valves to greater than P_a, and thus, MSIV leakage need not be considered as part of L_a. The second set of valves which are not considered in L_a are the secondary containment bypass valves. These valves serve primary containment penetrations which completely bypass secondary containment, thus, any releases through these lines would be directly to the environment rather than to the secondary containment buildings. Previously any potential releases through these valves would have been eliminated by the Penetration Valve Leakage Control System (PVLCS) which operated similar to MSPLCS, thus, it was initially not considered as a contributor to L_a. The secondary containment bypass leakage is limited to 580,000 cc/hr per Technical Specification Surveillance Requirement 3.6.1.3.9 (Reference II.7).

Suppression Pool

The suppression pool is designed as a passive means of removing blowdown energy resulting from a postulated design basis LOCA. The main portion of the suppression pool volume is in the bottom of the containment between the outer surface of the drywell wall and the inner surface of the steel containment structure. As discussed previously, following a DBA-LOCA the primary system leakage is directed through the horizontal vent system into the suppression pool. The horizontal vents consist of 129 vent pipes directed radially through the lower portion of the drywell wall. The vents are spaced uniformly around the drywell circumference at three elevations. There are 43 vents in each of 3 rows for a total of 129 vents. A pressure of 3.1 psid will lower the water level such that flow through the suppression pool vents occurs.

The pool functions both as a heat sink for operational transients and postulated accidents and as a reservoir for emergency core cooling systems (ECCS). Redundant systems are available to ensure that the suppression pool will not exceed its design temperature of 185°F under LOCA conditions.

5.2 Main Steam Isolation Valves and MSIV Leakage Control System

The Main Steam Isolation Valves (MSIV) isolate the Main Steam Lines following a LOCA. These valves are tested to ensure that the allowable leakage rate for the inboard (Division 2) and outboard (Division 1) MSIV and Main Steam Line Drains is ≤150 scfh when tested at ≥ P_a.

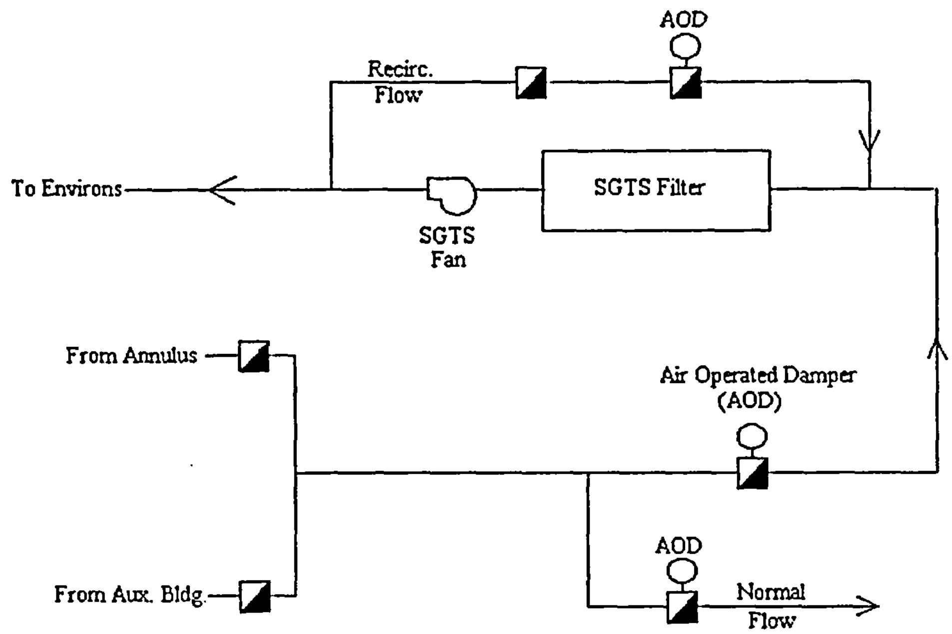
Leakage past these valves results in bypassing the secondary containment. The MSIV Leakage Control System is designed to control and minimize this secondary containment bypass leakage and the release of fission products after a LOCA. This objective is accomplished by pressurizing the volume between the inboard and outboard valves with the Main Steam Positive Leakage Control System (MS-PLCS). The second division pressurizes the volume between the outboard MSIV and the NSSS valve (B21-MOVF098A/B/C/D) for redundancy, however, the *098 valves must be manually closed. This system is designed to be manually actuated at approximately 20 minutes post-LOCA and it takes up to 5 minutes for the system to reach its operating pressure. Since the steam line pressure is above the RPV and drywell pressure when the MS-PLCS is fully operational, any potential leakage through the main steam lines would be terminated.

5.3 Standby Gas Treatment System (SGTS)

The Standby Gas Treatment System (SGTS) limits release of radioisotopes which may leak from the primary containment, Emergency Core Cooling Systems (ECCS), and other potentially radioactive sources to the secondary containment under accident conditions. Currently the SGTS units are automatically started in the event of a LOCA signal (high pressure in the drywell or reactor vessel low water level), however, this analysis will assume manual initiation of the system to support potential future modifications to the system.

The SGTS is designed to maintain a pressure of less than -0.50 inches of water gauge in the annulus and a pressure of less than 0.25 inches of water gauge in the auxiliary building (Reference I.31). With the annulus at a negative pressure, any leakage is directed inward and primary containment leakage is collected and passed through a filter train of the SGTS before being released to the environs.

The SGTS consists of two identical, parallel charcoal filter trains with associated ductwork, dampers, controls, and exhaust fans. Each train is capable of passing 100% of the design flow. Both trains of SGTS are safety related, thus, they would be powered by the Emergency Diesel Generators (EDG) should a Loss of Off-Site Power occur. The discharge from the two fans is connected to a common exhaust duct. Air flow through the SGTS filter train is taken from 1) the annulus via the annulus mixing system ductwork, 2) the Auxiliary Building, and 3) recirculation flow from the discharge of the SGTS fans. A portion of SGTS fan discharge flow is available for release to the environment via the plant exhaust stack, the remainder is recirculated through the SGTS filters. Balancing dampers are available to balance the system as necessary to achieve the desired building pressures and system flows. Each filter train consists of a demister (moisture separator), an electric heating coil, prefilters upstream of the first bank of high efficiency particulate air (HEPA) filters, a bank of HEPA filters (to remove virtually all fine airborne particulates from the airstream), a 4" minimum depth bank of charcoal adsorber filters, and a second bank of filters to capture charcoal particles which may escape from the charcoal filters.



Standby Gas Treatment Schematic

5.4 Main Control Room Fresh Air System

The functions of the control building ventilation system are to provide cooling, heating, ventilation, pressurization, and smoke removal for the several areas within the control building (Reference I.32). The control building ventilation system is completely independent of all other plant heating, ventilating, and air conditioning systems, and consists of the following subsystems: Main Control Room Air Conditioning Subsystem, Standby Switchgear Rooms Air Conditioning Subsystem, and the Chiller Equipment Room Air Conditioning Subsystem.

The main control room air conditioning subsystem is designed in accordance with the following criteria:

- Maintain ambient condition within the design limits and control the air circulation for optimum personnel comfort and equipment performance requirements.
- Maintain a positive pressure above atmospheric pressure to prevent outside air and air from other control building areas from leaking into the main control room.
- Reduce the airborne radioactivity in the outside air to the main control room by diverting the intake airflow through a special filter train containing charcoal filters during an accident.
- Perform its design function during normal, shutdown, loss of offsite power, and DBA conditions without loss of function.
- Operate under DBA conditions assuming the single failure of any one active component.
- Detect and limit the introduction of smoke into the main control room.

Two outside air charcoal filter trains are provided to filter the main control room outside air supply during and after a LOCA. One serves as a full capacity spare.

The main control room pressure envelope is maintained at a positive pressure relative to the adjoining areas to prevent air infiltration. Two separate outside air intakes are furnished to provide alternate sources of outdoor air for the main control room. The local air intake is located on the roof of the control building, and the remote air intake is located inside the standby cooling tower. The air intakes are located so that under a variety of wind conditions one of the air intakes continually ensures air free of contamination for main control room pressurization (Reference I.32), thus minimizing the potential for exposure to airborne radioactivity to persons in the main control room. Manual control switches are provided in the main control room for manual control of the air handling units. Local and remote outside air intake radioactivity levels are monitored, and a high radiation level condition activates an alarm in the main control room.

Following a DBA or high outdoor radioactivity, the main control room outside air supply is automatically diverted through one of the emergency charcoal filtration units. The bounding closure time is based on a high radiation in the air intake signal. Per Assumption 3.19, this analysis will assume manual initiation of the filters rather than credit the DBA or high radiation signals.

5.4.1. Emergency Core Coolant Systems

The Emergency core cooling system (ECCS) is provided to limit fuel cladding temperature to less than the limits set forth in 10CFR50.46 in the event of a loss-of-coolant accident (LOCA):

- ECCS provides for continuity of core cooling over the complete range of postulated break sizes in the RCPB;
- ECCS is diverse, reliable, and redundant; and
- Operation of the ECCS is initiated automatically when required, regardless of the availability of offsite power supplies and the normal generating system of the station.

ECCS is designed to maintain fuel cladding below the temperature limit in 10CFR50.46 in the event of a breach in the reactor coolant pressure boundary that results in a loss of reactor coolant, and consists of the following injection sub-systems:

- High Pressure Core Spray (HPCS),
- Low Pressure Core Spray (LPCS), and
- Three trains of Low Pressure Coolant Injection (LPCI).

The HPCS, LPCS, and LPCI pumps are all located on the 70' elevation of the auxiliary building. Each is located in a watertight cubicle and are physically separated from each other to prevent common-cause failures. The piping for the LPCS and LPCI systems is located within the auxiliary building. Following a postulated accident these systems use the suppression pool as their water source for injection into the RPV. HPCS also uses the suppression pool as its safety related water source, however, it is normally aligned to draw water from the Condensate Storage Tank (CST). HPCS automatically transfers to the suppression pool upon either a high level alarm from the suppression pool or a low water level alarm from the CST. All systems may be powered by a safety-related diesel generator and will have full flow prior to 2 minutes post accident.

5.4.2. Hydrogen Mixing

The drywell hydrogen purge system is designed to dilute the hydrogen produced following a degraded core event and subsequently released into the drywell to less than 4% by volume. The zirconium-water reaction which is assumed to occur in the reactor core during some SA scenarios results in a higher hydrogen concentration in the drywell than in the primary containment in the short term after the design basis LOCA. The hydrogen mixing system uses the larger, essentially hydrogen-free containment atmosphere as a source of air to dilute the drywell atmosphere. This tends to equalize the hydrogen concentration in the drywell and containment. The hydrogen mixing system consists of two independent trains located in the containment. Each train is capable of transporting 100% of the design flow. Plant emergency procedures require actuation of the hydrogen mixing system when the drywell hydrogen concentration reaches a minimum detectable level and the RPV pressure drops below 30 psig. Discussions with operations personnel indicated that the earliest system initiation would be expected would be 30 minutes following the onset of an accident.

When the hydrogen mixing system is activated, the drywell atmosphere will be in direct communication with the containment atmosphere. Containment air will be drawn into the drywell and drywell atmosphere will be exhausted into containment. This forced mixing dilutes the hydrogen, steam, and air mixture in the drywell; and increases the containment hydrogen concentration. This forced mixing and recirculation further redistributes the gases in containment. Each of the hydrogen mixing fans has a design flow rate of 600 cfm (Reference I.26).

6 EVENT PHENOMENOLOGY

6.1 Radionuclide Transport Within Containment

Since all activity is initially deposited into the drywell, the transport phenomena between the drywell and containment can have a significant impact on calculated doses. There are several transport mechanisms between the drywell and containment. During the onset of the event the drywell is at a sufficiently higher pressure to cause a blowdown into the containment. This can occur through either suppression pool vent flow or through drywell bypass leakage.

Regulatory Guide 1.183, Appendix A, Section 3.7 states:

> *"For BWRs with Mark III containments, the leakage from the drywell into the primary containment should be based on the steaming rate of the heated reactor core, with no credit for core debris relocation. This leakage should be assumed during the two hour period between the initial blowdown and termination of the fuel radioactivity release (gap and early in-vessel release phases). After two hours, the radioactivity is assumed to be uniformly distributed throughout the drywell and the primary containment."*

After the initial blowdown steam begins to condense in the drywell which ultimately becomes a vacuum relative to both the containment and atmosphere. Since RBS does not have drywell vacuum breakers, containment analyses demonstrate that this condition would continue until the hydrogen mixing system is placed in service. These containment analyses do not credit this system since use of the system depends upon Operations evaluating the hydrogen concentration within the drywell. However, it would clearly be placed in service should fuel damage of the magnitude assumed in this analysis occur (i.e., the hydrogen generated would easily exceed the threshold which would require Operations to place the system in service). Note that the AST fuel damage assumptions generate more hydrogen than that assumed for USAR Section 6.2.5 hydrogen analysis (which is greater than that calculated in the ECCS analysis in USAR Section 15.6 and 6.3).

A drywell/containment pressure analysis which assumed hydrogen mixing operation could not be identified. In lieu of performing a detailed analysis, an evaluation is performed to develop an event progression which results in calculated doses which are reasonable yet conservative. This evaluation, which is summarized below, reflects insights from a number of inputs including sensitivity studies (Reference I.9), current plant analyses, and the specific leakage paths assumed in this analysis. It should be noted that the model used in that Reference I.9 analysis was not identical to the model developed in this analysis. A number of informal "sensitivity studies" were performed specifically to support development of this model. Note that no suppression pool scrubbing is credited per Regulatory Guide 1.183, Appendix A, Section 3.5. In the event progression described below, the time frame is based upon analysis chronology rather than event chronology. This difference between the two chronologies is that the event time zero is at the initiation of the break, whereas the analysis time zero begins at the point at which fuel damage occurs (121 seconds after the start of the event).

<u>Analysis Time Frame: 0 – 23 minutes:</u>

During this time frame MSIV leakage (from the drywell), SCB (from containment), and primary containment leakage is occurring. Review indicated that MSIV leakage is the most significant contributor since (1) it is unfiltered, (2) it has more conservative dispersion factors, and (3) it originates from the drywell which is a significantly smaller volume. The blowdown analysis assumptions documented in Reference I.19 reasonably represents what would be expected during this time frame. However, since flow from the containment to the drywell will not significantly impact MSIV doses (since the activity transfer would be negligible with respect to the activity already in the drywell) and would be non-conservative with respect to secondary containment bypass and primary and secondary containment leakage releases, the flow during the time frame that the drywell is at a vacuum will not be modeled (i.e., no flow will be assumed from the containment to the drywell).

<u>Drywell to Containment Flow:</u>

-121 sec. – 0 sec.: Flow not modeled since no fuel damage occurs prior to this time.

0 sec. – 463 sec.: Reference I.19, page 189 provides containment and drywell pressure response curves for Power Uprate conditions. During this time period the average containment pressure is 17.48 psia and the average drywell pressure is 19.96. Assuming a drywell temperature of 230°F (at 120 seconds) and 100% steam flow yields a density of 18.718 lbs/cu. ft. (Reference II.12). Thus, the flow can be calculated as follows:

$$\dot{m} = \frac{A}{\sqrt{k}}\sqrt{\frac{2g_c\Delta p}{\upsilon}}$$

$$\dot{m} = (1.0ft^2)\sqrt{\frac{2(32.2\,{}^{ft-lbm}/_{s^2-lbf})(2.5psid)}{18.718\,{}^{ft^3}/_{lbm}}}\left(144\,{}^{in^2}/_{ft^2}\right) = 422.3\,{}^{lbm}/_{sec}$$

$$\dot{v} = \dot{m}\upsilon\left(60\,{}^{sec}/_{min}\right) = 422.3\,{}^{lbm}/_{sec}\times 18.718\,{}^{ft^3}/_{lbm}\times 60 = 4.74\times10^5\ cfm \approx 4.7\times10^5\ cfm$$

Note that this approach is considered to be the "best-estimate" approach since there are competing leakage paths, SCB and L_a from containment and MSIV leakage from the drywell. Past experience (in both TID and AST analyses) indicates that the final doses are not sensitive to minor changes in this parameter.

463 sec. – 23 minutes: No flow is modeled since the drywell pressure is negative with respect to containment.

Containment to Drywell Flow:

-121 sec. – 23 min.: No flow modeled.

Analysis Time Frame: 23 minutes – 1.9 hours:

During this time frame the airborne contributors are SCB and L_a which are both assumed to originate from primary containment. It will be assumed that hydrogen mixing is in operation at its design flow rate of 600 cfm (Reference I.27). However, as discussed above the P/T containment curves did not model operation of this system. Since these curves could artificially hold activity in the drywell (where it would not be released to the atmosphere) other assumptions not based on the P/T curves will be applied. Once the hydrogen mixing system is started one would expect the containment and drywell pressures to equalize very quickly.

Grand Gulf performed a MELCOR analysis which calculated a steaming rate of 3,000 cfm (Reference II.11). The GGNS AST submittal states that a similar number was also reported in the Perry SER. This value would be expected to be conservative for RBS since both GGNS and Perry have a higher core thermal power. Both plants are BWR 6's like River Bend, therefore, a bypass value of 3,000 cfm will be assumed from 23 minutes (25 minutes actual) to 1.9 hours. With the additional 600 cfm assumed to account for hydrogen mixing, the total flow rate from the drywell to containment is 3,600 cfm. A flow of 600 cfm will also be modeled from containment to the drywell to account for hydrogen mixing. Therefore, the following values will be used for hydrogen mixing flow rates:

Drywell to Containment Flow: 3,600 cfm.

Containment to Drywell Flow: 600 cfm.

Analysis Time Frame: 1.9 hours – 30 days:

During this time frame a very high mixing rate ($1.0x10^7$ cfm) will be assumed to meet Regulatory Guide 1.183, Appendix A, Section 3.7 assumptions. The high mixing rate is assumed at 1.9 hours to ensure the atmospheres are adequately mixed beginning at 2 hours. Regulatory Guide 1.183, Appendix A, Section 3.7 requires that the drywell and containment be homogenized at 2 hours. To ensure this assumption is met a very high mixing rate is assumed beginning at 1.9 hours.

6.2 Dose Contributors

RBS assumes that there are four contributors to off-site dose:

MSIV Leakage:

As discussed above, River Bend currently has the MS-PLCS system which will pressurize the main steam lines and main steam line drains and effectively eliminate leakage once the system is fully operational 25 minutes (23 minutes AST) post-accident. For the lines where both isolation valves close the pressure between the valves will exceed the drywell and RPV pressure.

Per Assumption 3.9, both isolation valves in three of the four steam lines close, and that pressure between the valves is sufficient to eliminate leakage until MS-PLCS is initiated. However, one of the isolation valves in the remaining steam line is assumed to fail to close, thus allowing leakage up to the point that MSPLCS is assumed to initiate.

Per Assumption 3.9, this calculation will use an MSIV leakage rate of 150 scfh @ P_a. To convert to containment peak accident conditions,

$$L_{MSIV} = \left(\frac{150\,\text{scfh}}{60\,\frac{\text{min}}{\text{hr}}}\right) \times \left(\frac{459.67\,°R + 330\,°F}{459.67\,°R + 60\,°F}\right) \times \left(\frac{14.696\,\text{psi}}{14.696\,\text{psi} + 7.6\,\text{psi}}\right) = 2.52\,\text{cfm} @ P_a$$

Primary Containment Leakage Rate (La) and Annulus Bypass Leakage:

Per Assumption 3.6 the analysis will use a value of 0.325 volume % per day for containment leakage. During the Positive Pressure Period (PPP) this leakage is assumed to be directed to the environment with no credit being taken for holdup, decay, or filtration by secondary containment. After the PPP, containment leakage is assumed to be directed to the annulus for the duration of the event. As such, it is treated by SGTS prior to release to the environment. Annulus bypass leakage was a subset of L_a and was considered to be leakage which was not released to the annulus. However, sensitivity studies indicate that off-site and MCR doses are insensitive to the annulus bypass leakage rate (Assumption 3.8) when the leakage is filtered. As such, all containment leakage (including that which was previously assumed to be Annulus Bypass leakage) will be released to the annulus prior to being released to the environment.

Containment leakage depends upon containment pressure and will be reduced at 24 hours as allowed by Regulatory Guide 1.183, Appendix A, Section 3.7. Based on Reference I.19, the containment pressure and temperature values 24 hours post-accident are roughly 16.8 psia and 100°F, respectively. As flow rate is proportional to the square root of the differential pressure the reduction in flow rate may be estimated as (assuming all other parameters remain constant),

$$\frac{L_{24hr}}{L_a} = \frac{\sqrt{16.8 - 14.7}}{\sqrt{7.6}} = 0.536 \Rightarrow 0.55$$

Therefore, this analysis will reduce the flow rates to 55% of the Technical Specification allowable value.

$$L_a = 0.325\,{}^{\text{vol\%}}\!/_{\text{day}}$$

$$L_{a,24hrs+} = 0.325\,{}^{\text{vol\%}}\!/_{\text{day}} \times 55\% = 0.1788\,{}^{\text{vol\%}}\!/_{\text{day}}$$

Secondary Containment Bypass (SCB) Leakage:

Secondary Containment Bypass leakage is leakage in addition to L_a. These paths could potentially allow leakage to bypass secondary containment. Therefore, any releases would not be treated by an ESF filtration system prior to being released to the environment.

Per Assumption 3.7 a SCB leakage rate of 580,000 cc/hr (0.341 cfm) @ P_a. Since these SCB leakage paths also depend upon containment pressure, this leakage rate will also be reduced to 55% of the TS allowable values beginning 24 hours post-accident.

$$SCB_{24} = 580{,}000\,{}^{\text{cc}}\!/_{\text{hr}} \times 55\% = 319{,}000\,{}^{\text{cc}}\!/_{\text{hr}} = 0.188\,\text{cfm}$$

Engineered Safety Features (ESF) Liquid Leakage:

Regulatory Guide 1.183, Appendix A, Section 5 states the ESF systems that recirculate sump water (i.e., suppression pool water for RBS) are assumed to leak during their operation. Per Assumption 3.10, the leakage rate assumed in this analysis is 60 gph, or 1 gpm. This leakage is assumed to occur within the Auxiliary Building and continues for the duration of the event. However, during the PPP this leakage is directed to the atmosphere with no credit taken for retention in the auxiliary building. Following the PPP the leakage will be released to the auxiliary building and eventually processed by SGTS prior to its release to the environment. All available ECCS pumps will be in operation with their operational flow before the onset of core damage (i.e., 2 minutes), therefore, this leakage is assumed to occur for the duration of the event.

Regulatory Guide 1.183, Appendix A, Section 5.5 states that if the temperature of the leakage is less than 212 °F, the amount of iodine that becomes airborne should be 10% of the total iodine activity in leaked fluid. A review of the containment response to the design basis accident (Reference I.19) indicates that the peak suppression pool temperature will not exceed 212 °F. Therefore, a flash fraction of 10% will be used in this analysis.

6.3 Removal Mechanisms

6.3.1. Natural Deposition

Regulatory Guide 1.183, Appendix A, Section 3.2 allows for the reduction in airborne radioactivity in the containment by natural deposition within the containment to be credited. RBS will credit natural deposition within the drywell only.

Particulate Iodines:

RADTRAD contains several options with respect to the natural deposition of particulate iodines. The model chosen for this analysis is the Power's Model (Reference II.10). Sensitivity studies indicate that the Power's Model with a 10% confidence interval yields the most conservative results (i.e., the least amount of deposition).

Elemental Iodine:

The elemental iodine coefficient to be used in this analysis will be based on guidance found in SRP 6.5.2. Specifically, the iodine removal rate constant for a particular compartment "n" will be based on the following formula:

$$\lambda_n = k_g\left(\frac{A}{V}\right) = \left(16.18\,\frac{\text{ft}}{\text{hr}}\right)\times\left(\frac{1.47\times10^4\ \text{ft}^2}{2.36\times10^5\ \text{ft}^3}\right) = 1.01$$

Where: λ_n = Removal rate constant due to surface deposition,

k_g = This is the average mass transfer coefficient, and is taken as 0.137 cm/sec (16.18 ft/hr) based on Page 17 of Reference II.17.

A = Surface area for wall deposition. The area calculation is based upon dimensions for the drywell based from Reference I.18. The height is based on a SP high water level of 20' (Elevation 90' 0"). The area to be used in this analysis will be the wall surface area of each building. Other surfaces, such as the biological shield wall for the drywell and the drywell outer surface for containment, will conservatively be neglected. The area is determined as:

= π x D x H

= π x (69.0 ft) x (158.0 ft – 90.0 ft)

= $1.47\text{x}10^4$ ft^2

V = Volume of the contained gas, which is the drywell volume from above, or $2.36\text{x}10^5$ ft^3.

6.3.2. Sprays:

Regulatory Guide 1.183, Appendix A, Section 3.3 allows for the reduction in airborne radioactivity in the containment by containment spray systems to be credited. However, the RBS design does not employ containment sprays.

6.3.3. Suppression Pool Scrubbing

Regulatory Guide 1.183, Appendix A, Section 3.5 states that suppression pool scrubbing should not be credited. Therefore, this analysis will not credit suppression pool scrubbing.

6.3.4. Filtration

Regulatory Guide 1.183, Section 4.2.4 states that the credit may be taken for engineered safety features that mitigate radioactive material in the control room. Examples of such engineered safety features are control room isolation or pressurization, or intake or recirculation filters. The RBS design includes the control room fresh air system which is a safety-related system that filters both intake and recirculated air (Reference I.32).

Regulatory Guide 1.183, Appendix A, Section 3.4 states that the reduction in the amount of radioactive material in containment by in-containment recirculation filter systems may be taken into account provided that these systems meet the guidance of Regulatory Guide 1.52 and Generic Letter 99-02. The RBS design does not incorporate in-containment recirculation filters.

Regulatory Guide 1.183, Appendix A, Section 4.4 states that the reduction in the amount of radioactive material released from the secondary containment because of ESF filter systems may be taken into account provided that these systems meet the guidance of Regulatory Guide 1.52 and Generic Letter 99-02. The RBS design includes the standby gas treatment system which filters air taken from the annulus and the auxiliary building (Reference I.31).

River Bend has committed to GL 99-02 in that the testing acceptance criteria used will be 50% of the available margin in the relevant safety analyses (Reference II.20).

Note that although all systems are currently designed such that a LOCA signal will automatically start the systems, filtration by SGTS will not be credited for the first 30 minutes (Assumptions 3.13 and 3.16).

6.4 Source Term – Core Source Term, Release Phases, and Timing

Source term estimates under severe accident conditions became of particular interest following the accident at Three Mile Island (TMI) due to the fact that the observed concentrations of iodine were significantly lower than those predicted using the TID methodology. In the early 1980s, the NRC initiated a major research effort with the ultimate goal to better understand fission product releases and transport under SA conditions for light water reactors. The document, NUREG-1465 *Accident Source Terms for Light-Water Nuclear Power Plants*, provides a summary of the extensive research by the NRC.

The AST dose methodology takes advantage of the significant amount of knowledge gained as a result of these various SA scenarios researched by the NRC. Specifically, several of the assumptions prescribed by the previous LOCA dose methodology guidance (Reference II.1) were found to be extremely conservative. Therefore, the NRC has incorporated the more realistic assumptions in its AST guidance found in Regulatory Guide 1.183. Application of AST at RBS has been approved by the NRC (Reference I.30).

6.4.1. Core Source Term

GE provided a generic core source term as part of power uprate project (Reference I.23) and recommended its use at River Bend Station. This source term had previously been used in several dose evaluations at RBS. However, the RADTRAD code has a default inventory which contains 60 isotopes. Table 3-1 below lists the inventories. A direct comparison shows that the source terms are generally consistent. The source term used in this analysis will be based on the GE Task Report 31.1 except for those isotopes which are not found in TR 31.1. For those 10 isotopes the RADTRAD default inventory value will be retained since it is inherently conservative to include the isotopes (Co-58 & 60, Np-239, Pu-239, 240, &241, Am-241, and Cm-242 & 244). A copy of the nuclide inventory file is contained on the attached CD (TR31_1.NIF).

BWR Core Nuclide Inventories

AST Group	Isotope	Halflife (sec)	RADTRAD Concentration (Ci/WMt)	GE TR 31.1 Concentration (Ci/WMt)
1	Kr-85	3.38E+08	2.51E+02	3.02E+02
1	Kr-85m	1.61E+04	9.11E+03	6.73E+03
1	Kr-87	4.58E+03	1.66E+04	1.29E+04
1	Kr-88	1.02E+04	2.24E+04	1.83E+04
1	Xe-133	4.53E+05	5.43E+04	5.53E+04
1	Xe-135	3.27E+04	1.29E+04	7.15E+03
2	I-131	6.95E+05	2.58E+04	2.63E+04
2	I-132	8.21E+03	3.79E+04	3.85E+04
2	I-133	7.49E+04	5.42E+04	5.50E+04
2	I-134	3.16E+03	5.93E+04	6.06E+04
2	I-135	2.38E+04	5.10E+04	5.19E+04
3	Rb-86	1.61E+06	1.40E+01	4.70E+01
3	Cs-134	6.51E+07	4.23E+03	5.36E+03

BWR Core Nuclide Inventories

AST Group	Isotope	Halflife (sec)	RADTRAD Concentration (Ci/WMt)	GE TR 31.1 Concentration (Ci/WMt)
3	Cs-136	1.13E+06	1.13E+03	1.18E+03
3	Cs-137	9.51E+08	2.53E+03	3.32E+03
4	Sb-127	3.33E+05	2.32E+03	2.28E+03
4	Sb-129	1.52E+04	8.07E+03	8.08E+03
4	Te-127	3.37E+04	2.25E+03	2.25E+03
4	Te-127m	9.42E+06	3.03E+02	3.41E+02
4	Te-129	4.18E+03	7.57E+03	7.60E+03
4	Te-129m	2.90E+06	1.99E+03	2.06E+03
4	Te-131m	1.08E+05	3.82E+03	3.73E+03
4	Te-132	2.82E+05	3.74E+04	3.79E+04
5	Sr-89	4.36E+06	2.77E+04	2.47E+04
5	Sr-90	9.19E+08	1.96E+03	2.58E+03
5	Sr-91	3.42E+04	3.60E+04	3.16E+04
5	Sr-92	9.76E+03	3.77E+04	3.37E+04
6	Ba-139	5.03E+03	4.99E+04	4.93E+04
6	Ba-140	1.10E+06	4.93E+04	4.75E+04
7	Co-58	6.12E+06	1.53E+02	Not listed
7	Co-60	1.66E+08	1.83E+02	Not listed
7	Mo-99	2.38E+05	4.86E+04	5.01E+04
7	Tc-99m	2.17E+04	4.20E+04	4.32E+04
7	Ru-103	3.39E+06	3.69E+04	4.24E+04
7	Ru-105	1.60E+04	2.46E+04	2.99E+04
7	Ru-106	3.22E+07	1.00E+04	1.51E+04
7	Rh-105	1.27E+05	1.84E+04	2.52E+04
8	Ce-141	2.81E+06	4.47E+04	4.40E+04
8	Ce-143	1.19E+05	4.36E+04	4.15E+04
8	Ce-144	2.46E+07	2.90E+04	3.53E+04
8	Np-239	2.03E+05	5.68E+05	Not listed
8	Pu-238	2.77E+09	3.95E+01	Not listed
8	Pu-239	7.59E+11	1.00E+01	Not listed
8	Pu-240	2.06E+11	1.25E+01	Not listed
8	Pu-241	4.54E+08	2.16E+03	Not listed
9	Y-90	2.30E+05	2.10E+03	2.79E+03
9	Y-91	5.06E+06	3.39E+04	3.22E+04
9	Y-92	1.27E+04	3.78E+04	3.39E+04
9	Y-93	3.67E+04	4.30E+04	3.91E+04
9	Zr-95	5.53E+06	4.46E+04	4.42E+04
9	Zr-97	6.08E+04	4.59E+04	4.54E+04
9	Nb-95	3.04E+06	4.22E+04	4.42E+04
9	La-140	1.45E+05	5.03E+04	5.03E+04
9	La-141	1.41E+04	4.64E+04	4.44E+04
9	La-142	5.55E+03	4.47E+04	4.34E+04
9	Pr-143	1.17E+06	4.26E+04	4.11E+04
9	Nd-147	9.49E+05	1.91E+04	1.81E+04
9	Am-241	1.36E+10	2.19E+00	Not listed
9	Cm-242	1.41E+07	5.79E+02	Not listed
9	Cm-244	5.72E+08	3.13E+01	Not listed

6.4.2. Release Fractions and Timing

Per Regulatory Guide 1.183, only the coolant, gap, and early in-vessel phases are required to be evaluated in design basis accident applications.

Isotopes of similar chemical properties are grouped for convenience. The groupings to be used in this evaluation are taken from Regulatory Guide 1.183, Table 5 and are listed in the table below.

AST Radionuclide Groups

Group*	Title	Elements
1	Noble Gases	Xe, Kr
2	Halogens	I, Br
3	Alkali Metals	Cs, Rb
4	Tellurium Group	Te, Sb, Se
5/6	Barium, Strontium	Ba, Sr
7	Noble Metals	Ru, Rh, Pd, Mo, Tc, Co
8	Cerium Group	Ce, Pu, Np
9	Lanthanides	La, Zr, Nd, Eu, Nb, Pm, Pr, Sm, Y, Cm, Am

Note *: NUREG-1465 lists Ba and Sr as one group, however, the RADTRAD ST and DCF files treat them as separate groups. The group number listed above corresponds to the RADTRAD file.

As a result of the line break, there is an immediate release of reactor coolant into the drywell. NUREG-1465 estimates this phase's duration to last at least 30 seconds for a BWR. However, a spectrum of breaks was later evaluated by the BWR Owner's Group initiative (Reference II.5). The results of this study indicated that the earliest cladding perforation could potentially occur is 121 seconds following the line break. Regulatory Guide 1.183 credits a duration of two minutes. This analysis will use the 121 seconds as the time for onset of fuel cladding damage.

This gap activity release phase begins when the fuel cladding begins to fail. During this phase the fission gases contained in the plenum and between the fuel pellet and cladding are released. Typically, these gases include the noble gases, the halogens, and the alkali metals. The bulk of the fission products are retained in the fuel pellets. This phase continues until the fuel's bulk temperature has been raised to a point where significant amounts of fission products are released from the fuel (i.e., fuel melting commences).

During early in-vessel release phase, it is assumed that the fuel reaches sufficiently high temperature such that core geometry can no longer be maintained. The fuel is relocated to the bottom of the reactor pressure vessel. As result of the melting, a significant amount of the volatile fission products, as well as a small amount of the non-volatile fission products, are released to containment. This phase continues until the bottom of the RPV fails. Release duration varies based on the break scenario and reactor design. It is estimated that this phase lasts 1.5 hours for BWRs. This is the last phase for DBA applications.

The ex-vessel release phase begins with the complete failure of the RPV, thus, the molten core falls onto the containment floor. During this release phase a significant amount of the remaining volatile fission products are released. Also, the non-volatile fission products are released to a lesser extent. This phase continues until the core debris has cooled to a point where significant amounts of fission products are no longer released. During this phase, significant core-concrete interactions would take place, however, these type of interactions take many hours. Studies indicate that the majority of fission products (>90%) would be released within a two hour period for PWRs and a three hour period for BWRs with the exception of ruthenium and tellurium. Note that this phase need not be considered in Design Basis Accident applications.

The late in-vessel release phase also begins with the breach of the lower RPV, thus, it begins concurrently with the Ex-Vessel Phase. During this phase the radionuclides which plated-out in the reactor coolant system during earlier phases may re-volatize, become airborne, and be released into containment. After considering the uncertainty, studies indicate that ten hours is a reasonable estimate for this phase. Note that this phase need not be considered in Design Basis Accident applications.

Based upon the above, and the data in Regulatory Guide 1.183, Tables 1 and 4, the release fractions and timing are provided in the table below:

BWR Release Fractions & Timing

Group*	Description	Gap Release	Early In-Vessel	DBA Total
1	Noble Gases	0.05	0.95	1.00
2	Halogens**	0.05	0.25	0.30
3	Alkali Metals	0.05	0.20	0.25
4	Tellurium	0.00	0.05	0.05
5/6	Ba, Sr	0.00	0.02	0.02
7	Noble Metals	0.00	0.0025	0.0025
8	Cerium Grp.	0.00	0.0005	0.0005
9	Lanthanides	0.00	0.0002	0.0002
Duration (hr.)	-	*0.5*	*1.5*	*2.0*
Begin Time	-	*2 min.*	*30 min.*	-

Note *: NUREG-1465 lists Ba and Sr as one group, however, the RADTRAD ST and DCF files treat them as separate groups. The group number listed above corresponds to the RADTRAD file.

Note **: For liquid releases (ESF leakage) only the halogens are assumed to be released to the environment. Regulatory Guide 1.183 states that Noble Gases are not retained in Suppression Pool water. Also, the other groups are assumed to be retained in SP water since they are assumed to be particulates.

6.4.3. Chemical Fractions

Containment Leakage and Secondary Containment Bypass:

Regulatory Guide 1.183, Appendix A, Section 2 states that if the suppression pool pH is controlled above 7 then the chemical form of radioiodine released to the containment should be assumed to be 95% cesium iodine (CsI, a particulate or aerosol), 4.85% elemental iodine, and 0.15% organic iodine. An analysis of post-LOCA suppression pool pH (References I.7 and I.33) indicates that the suppression pool pH can be maintained above 7, thus the fractions above may be used in this analysis.

ESF Leakage:

The chemical fractions for liquid leakage differ from the airborne release fractions. Specifically, Regulatory Guide 1.183, Appendix A, Section 5.6 states that "The radioiodine that is postulated to be available for release [from liquid sources] is assumed to be 97% elemental and 3% organic."

6.5 Atmospheric Dispersion Factors

The atmospheric dispersion factors (X/Qs) are based on several release locations. For containment and secondary containment releases, the values are based on main plant stack where SGTS is released. SCB leakage is assumed to be released to either the fuel building or the turbine building, and MSIV leakage would clearly be released to the turbine building. The fuel building X/Q values are slightly more conservative for the MCR main air intake by ~5%, however, the values are less conservative for the remote intake by ~15%. Prior to Technical Specification Amendment 113 (Reference I.16) the fuel building was considered to be part of secondary containment. As such the building is designed to withstand a DBA and any releases into the building would be held up to some extent prior to actually being released to the atmosphere (even with the Fuel Building cask doors open). This holdup and dilution in the fuel building would easily account for a minor non-conservatism on the order of 5%. Additionally, the majority of release SCB paths lead to the turbine building. The feedwater lines are expected to be the most significant contributors and these lines traverse through the main steam tunnel to the turbine building. Based on all of these considerations the turbine building X/Q values will be used for the SCB releases.

6.5.1. Off-Site χ/Q Values

The off-site χ/Q values were developed in Reference I.13 and are summarized in the following table.

Off-Site X/Q Values

Release Point	EAB*	LPZ
SGTS/Containment		
0-2 hours	6.05E-4	7.49E-5
2-8 hours	6.05E-4	7.49E-5
8-24 hours	6.05E-4	5.02E-5
1-4 days	6.05E-4	2.10E-5
4-30 days	6.05E-4	6.13E-6
Turbine Building		
0-2 hours	7.51E-4	7.79E-5
2-8 hours	7.51E-4	7.79E-5
8-24 hours	7.51E-4	5.23E-5
1-4 days	7.51E-4	2.21E-5
4-30 days	7.51E-4	6.40E-6

Note *: The 0 – 2 hour values will be conservatively assumed to last for the duration of the accident to ensure the "maximum" 2 hour dose is calculated as required per Regulatory Guide 1.183.

6.5.2. Main Control Room χ/Q Values

River Bend Station's MCRFA system has dual air intakes which may be manually selected from the main control room. RBS's design meets the criteria set forth in Murphy & Campe (Reference II.6). Standard Review Plan Section 6.4 states that plants with manually selected dual air inlets may reduce the more favorable X/Q value by a factor of four to account for the relative probability that control room operators will select the appropriate intake based on the meteorological conditions present at the time of the accident.

Previously RBS has credited this allowance and applied it to both the actual air intake via the MCRFA system and the unfiltered inleakage. This was reasonable due to the fact that the unfiltered inleakage was assumed to occur through ingress and egress of the MCR, and all doors to the MCR are interior to Category I buildings (hence, the mixing affects in the building far outweighed any minor non-conservatisms by allowing the more favorable X/Q value to be used). However, the 300 cfm of unfiltered inleakage assumed in this analysis may not necessarily occur through areas interior to the building, therefore, blindly applying the SRP allowance may not be completely appropriate. Therefore, this analysis will utilize a flow weighted average of the applicable X/Q values. The main air intake X/Qs will be assumed to apply to the unfiltered inleakage since the MAI is located on the roof of the Control Building just above the MCR envelope. The MCRFA intake will utilize the credit allowed per SRP 6.4.

$$\chi/Q_{effective} = \frac{1700\text{cfm}\left(\frac{\chi/Q_{most-fav}}{4}\right) + 300\text{cfm}\left(\chi/Q_{MAI}\right)}{2000\text{cfm}}$$

where, $\chi/Q_{most\text{-}fav}$ = More favorable X/Q value (main air intake or remote air intake),

χ/Q_{MAI} = X/Q value corresponding to the main air intake, and

χ/Q_{eff} = The effective X/Q value to be used in the actual analysis.

The main control room local and remote air intake χ/Q values are obtained from Reference I.14. The calculation of the effective χ/Q values are provided in the following table.

Main Control Room Effective X/Q

Time Period	Main Air Intake	Remote Air Intake	More favorable	Effective
SGTS				
0 to 2 hours	1.09E-03	4.30E-04	4.30E-04	2.55E-04
2 to 8 hours	7.78E-04	3.53E-04	3.53E-04	1.92E-04
8 to 24 hours	3.44E-04	1.38E-04	1.38E-04	8.09E-05
1 to 4 days	2.46E-04	1.19E-04	1.19E-04	6.22E-05
4 to 30 days	2.18E-04	8.58E-05	8.58E-05	5.09E-05
Turbine Building				
0 to 2 hours	2.70E-03	2.85E-04	2.85E-04	4.66E-04
2 to 8 hours	2.23E-03	2.29E-04	2.29E-04	3.83E-04
8 to 24 hours	9.67E-04	1.03E-04	1.03E-04	1.67E-04
1 to 4 days	7.43E-04	7.38E-05	7.38E-05	1.27E-04
4 to 30 days	5.49E-04	5.13E-05	5.13E-05	9.33E-05

6.6 Dose Conversion Factors

Regulatory Guide 1.183, Section 4 states that the acceptance criteria for AST shall be based on the total effective dose equivalent (TEDE) criteria in lieu of the whole body and thyroid doses used previously in the TID methodology. TEDE is the sum of the deep dose equivalent (DDE) and the committed effective dose equivalent (CEDE).

Per Regulatory Guide 1.183, Section 4.1.2, the dose conversion factors to determine CEDE will be based on Table 2.1 of Federal Guidance Report 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion."

Per Regulatory Guide 1.183, Section 4.1.4, the dose conversion factors to determine DDE will be based on Table III.1 of Federal Guidance Report 12, "External Exposure to Radionuclides in Air, Water, and Soil."

Note that both the FGR 11 and 12 dose conversion factors are contained in a RADTRAD default file which was reviewed and verified prior to use. A copy of this file is included on the CD attached to this calculation.

6.7 Breathing Rates and Occupancy Factors

The breathing rates used for off-site receptors will be taken from Regulatory Guide 1.3, Section C.2.c, and Regulatory Guide 1.183, Section 4.1.3.

0 – 8 hours:	3.47E-4 m^3/sec.
8 – 24 hours:	1.75E-4 m^3/sec.
> 24 hours:	2.32E-4 m^3/sec.

The MCR operator breathing rate is taken from Regulatory Guide 1.183, Section 4.2.6, and Murphy & Campe (Reference II.6).

0 – 30 days: 3.47E-4 m^3/sec.

Both Regulatory Guide 1.183, Section 4.2.6, and Murphy & Campe allow for the use of "occupancy factors."

0 – 1 days:	1.0
1 – 4 days:	0.6
4 – 30 days:	0.4

6.8 Event Timing Summary

Based upon the information in the preceding sub-sections, the event timing is:

Event Timing

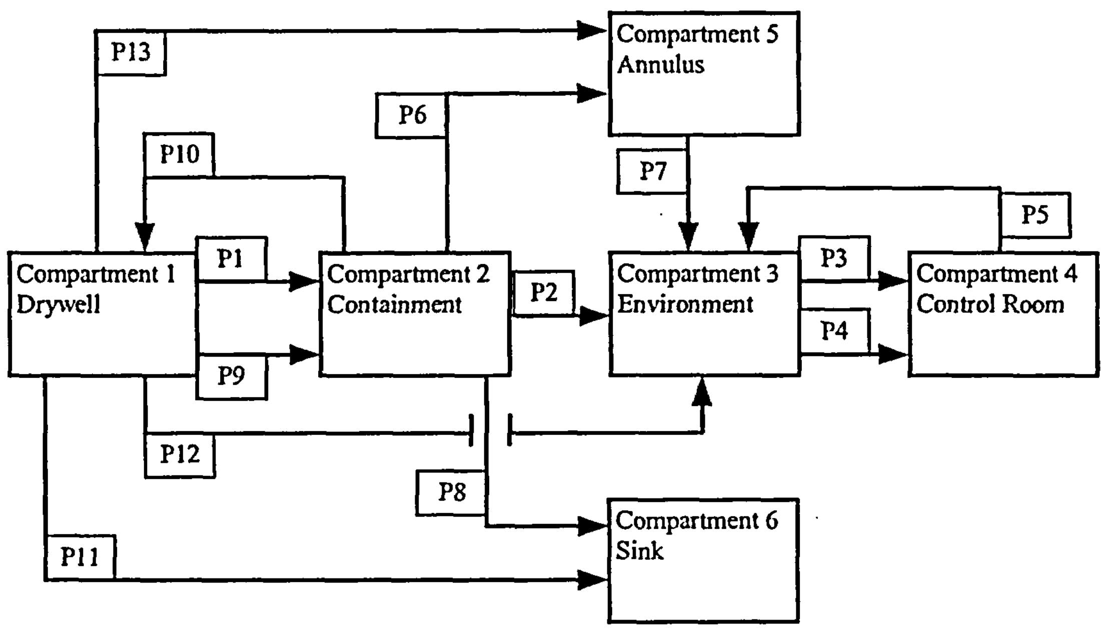
Event Time	Analysis Time	Event
0 sec	-121 sec.	DER of one of the two Recirculation Lines in the reactor occurs coincident with a SSE, and a Loss of Offsite Power. Consistent with the AST guidance, a release of all reactor coolant halogens is assumed.
0+ sec.	-121 sec.	LOCA signal from high drywell pressure occurs effectively instantaneously. Reactor low water level reached. All ECCS systems and associated emergency diesel generators are signaled to start. Main Control Room Ventilation Signaled to start.
0.2 sec.*	-120.8 sec.	Flow through the suppression pool vents begins.
1.1 sec.*	-119.9 sec.	Drywell peak pressure reached.
5.5 sec.*	-114.5 sec.	7 of 8 MSIVs are closed (one MSIV assumed to fail open)
10 sec.*	-111 sec.	2 of 3 EDG start (1 assumed to fail to start) and ready to load.
23 sec.*	-98 sec.	Top of Active Fuel Uncovered (USAR Figure 6.3-11)
27 sec.*	-94 sec.	Initiation of HPCS.
37 sec. *	-84 sec.	Initiation of LPCS and LPSI.
56 sec.*	-65 sec.	Low Pressure Core Spray flow begins (initiating ESF leakage)
66 sec.	-55 sec.	Main Control Room Ventilation System transfers to emergency mode (Note credited in actual analysis).
121 sec.	0 sec.	Failure of fuel cladding assumed to occur. This results in the release of gap activity. At this point, the containment is assumed to leak at L_a, ESF leakage of 1 gpm is assumed, and SCB leakage at proposed TS limit. **This is the point from which the analysis is started.**
293 sec.*	172 sec.	Vessel is re-flooded (Not in AST scenario which has no cooling).
352 sec.*	231 sec.	Suppression pool vent flow terminates.
584 sec.	463 sec.	Drywell pressure < Containment pressure. Suppression pool bypass flow assumed to terminate.
20 min.	18 min.	Main Control Room operators are assumed to transfer to the more favorable air intake based on wind conditions, initiate the Main Control Room Fresh Air Emergency Filters, initiate Main Steam Positive Leakage Control System, and initiate the SGTS system. See Assumptions 3.18, 3.19, 3.15, and 3.13.
25 min.	23 min.	MS-PLCS becomes fully operational terminating failed MSIV release.
30 min.	28 min.	Operator initiation of the hydrogen mixing system is assumed and Annulus and Auxiliary Building assumed to reach –0.25" w.g., therefore, secondary containment is established.
32 min.	30 min.	Core geometry is compromised in AST scenario – fuel melting begins. Early In-Vessel Release begins.
8 hours	8 hours	MCR and LPZ X/Q changed.
24 hours	24 hours	MCR and LPZ X/Q changed, Off-site breathing rate reduced, Containment and SCB leakage reduced to 55% of proposed TS allowable value, and MCR occupancy reduced
96 hours	96 hours	MCR and LPZ X/Q changed, Off-site breathing rate reduced, and MCR occupancy reduced.
30 days	30 days	End of Dose Calculation

Note *: Minor changes in these times will not have an appreciable affect the dose calculation.

7 DOSE CALCULATION MODELS

7.1 Primary and Secondary Containment Leakage Model Input Description

This model has 7 compartments and 13 pathways as shown in the diagram below:



All isotopes released are initially directed to the drywell and are transported elsewhere as discussed above. Releases via the MSIV and SCB leakage paths are directed to a "sink" and are evaluated in the secondary containment bypass model later in this calculation. The inputs for this model are described below:

7.1.1. Compartment Input Data

There are a total of six compartments in this model.

7.1.1.1. Compartment 1

Compartment Name: Drywell

Compartment Type: Other (3)

Volume (cu. ft.): $2.36x10^5$ ft^3 (Reference I.5)

Source Term Fraction: Per Section 6.1, all of the source term will be deposited into the drywell, thus this fraction will be 1.00.

Compartment Features: As discussed in Section 6.3.1 natural deposition will be assumed for this volume. The Power's Aerosol model at the 10^{th} percentile will be used for deposition of aerosols and a coefficient of 1.01 will be used for deposition of elemental iodine. Per Assumption 3.22, this mechanism is only credited for the first 24 hours of the event. The following table will be used for the elemental iodine deposition:

Time (hr.)	Removal Coefficient (hr^{-1})
0	1.01
24	0.0
720	0.0

Print Detailed Output: This option has no impact on the execution, but rather increases or decreases the amount of printed output. Detailed output is arbitrarily selected,

7.1.1.2. **Compartment 2**

Compartment Name: Containment

Compartment Type: Other (3)

Volume (cu. ft.): 1.19×10^6 ft^3 (Reference I.6)

Source Term Fraction: Per Section 6.1, all of the source term will be deposited into the drywell, thus this fraction will be 0.00.

Compartment Features: None of the compartment features have been selected for this compartment.

Print Detailed Output: This option has no impact on the execution, but rather increases or decreases the amount of printed output. Detailed output is arbitrarily selected,

7.1.1.3. **Compartment 3**

Compartment Name: Environment

Compartment Type: Environment (2)

Volume (cu. ft.): This input is not active for this compartment type.

Source Term Fraction: This input is not active for this compartment type.

Compartment Features: This input is not active for this compartment type.

Print Detailed Output: This option has no impact on the execution, but rather increases or decreases the amount of printed output. Detailed output is arbitrarily selected.

7.1.1.4. **Compartment 4**

Compartment Name: Control Room

Compartment Type: Control Room (1)

Volume (cu. ft.): The net free volume of this compartment is determined as follows:

From Reference I.3 the gross volume of the main control room below the suspended ceiling is 101,232 ft^3 and 96,757 ft^3 above the suspended ceiling. Within the control room 10,241 ft^3 of the gross volume is occupied by various pieces of equipment (panels, etc.). Additional free volume associated with the HVAC duct work is conservatively ignored (see Assumption 3.17). Summing the gross volumes and subtracting the volume occupied by equipment, yields a value for the net free volume of the main control room of 1.88×10^5 ft^3.

Source Term Fraction: Per Section 6.1, all of the source term will be deposited into the drywell, thus this fraction will be 0.00.

Compartment Features: Reference I.32 describes the control room fresh air system including the charcoal filtration system. Specifically, 2,000 cfm of control room air is recirculated through the operating filter train. Therefore, the "Recirculating Filter" compartment feature will be selected for this model.

Item 4.2.4 of Regulatory Guide 1.183 (Reference II.3) states that credit for engineered safety features that mitigate airborne radioactive material within the control room may assumed in the evaluation. River Bend has committed to GL 99-02 in that the testing acceptance criteria used will be 50% of the available margin in the relevant safety analyses. The test acceptance criterion for the filters is listed as a penetration depth of 1.0% found in Technical Specification 5.5.7.c (Reference II.7) which corresponds to an adsorption efficiency of 99 percent. For analysis purposes, the filters will be assumed to have an adsorption efficiency of 98 percent which accommodates the GL 99-02 requirement. Per Assumption 3.21 the HEPA filters have an efficiency of 99%.

Based upon the event timing information in Section 6.8, the control room operators will place the emergency filters in service 20 minutes into the event (18 minutes from start of the analysis). Thus, the following information will be entered for the filter efficiencies:

Time (hr.)	Iodine Filter Efficiencies (%)		
	Aerosol	Elemental	Organic
0.0	0	0	0
0.3	99	98	98
720	0	0	0

Print Detailed Output: This option has no impact on the execution, but rather increases or decreases the amount of printed output. Detailed output is arbitrarily selected.

7.1.1.5. Compartment 5

Compartment Name: Annulus

Compartment Type: Other (3)

Volume (cu. ft.): Per Assumption 3.5 the annulus volume is assumed to be 1.0 ft^3.

Source Term Fraction: Per Section 6.1, all of the source term will be deposited into the drywell, thus this fraction will be 0.00.

Compartment Features: None of the compartment features have been selected for this compartment.

Print Detailed Output: This option has no impact on the execution, but rather increases or decreases the amount of printed output. Detailed output is arbitrarily selected.

7.1.1.6. Compartment 6

Compartment Name: Sink

The sink compartment is a fictitious compartment required because the primary and secondary containment leakage release point location is different than the secondary containment bypass and MSIV leakage release point. The sink is used to limit double counting of the release inventory.

Compartment Type: Other (3)

Volume (cu. ft.): As this compartment is fictitious, an arbitrary value of 1.0×10^8 ft^3 will be selected.

Source Term Fraction: Per Section 6.1, all of the source term will be deposited into the drywell, thus this fraction will be 0.00.

Compartment Features: None of the compartment features have been selected for this compartment.

Print Detailed Output: This option has no impact on the execution, but rather increases or decreases the amount of printed output. Detailed output is arbitrarily de-selected.

7.1.2. Pathway Input Data

There are a total of thirteen pathways in this model.

7.1.2.1. Pathway 1:

From Compartment: Drywell (Node 1)

To Compartment: Containment (Node 2)

Pathway Name: Drywell Bypass to Containment

Transfer Mechanism: As described in Section 6.1 the maximum drywell bypass flow will be assumed for the duration of the positive drywell to containment pressure differential. The "Filter" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. The following table was developed using the information from Section 6.1 to describe the filter efficiency inputs.

	Flow Rate	Iodine Filter Efficiencies (%)		
Time (hr.)	(CFM)	Aerosol	Elemental	Organic
0	4.7E+05	0	0	0
0.1286	0.0	0	0	0
720	0.0	0	0	0

Active Pathway: Yes

7.1.2.2. Pathway 2:

From Compartment: Containment (Node 2)

To Compartment: Environment (Node 3)

Pathway Name: Containment Leakage - PPP

Transfer Mechanism: As described in Section 6.2 containment leakage is directed to the environment during the secondary containment positive pressure period. The "Air Leakage" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. The following table was developed using the information from Section 6.2 to describe the air leakage inputs.

Time (hr.)	Air Leakage Rate (volume %/day)
0	0.325
0.4667	0.0
720	0.0

Active Pathway: Yes

7.1.2.3. Pathway 3:

From Compartment: Environment (Node 3)

To Compartment: Control Room (Node 4)

Pathway Name: Control Room Air Intake

Transfer Mechanism: Reference I.32 describes the control room fresh air system including the charcoal filtration system. Specifically, air is drawn from either the local or remote air intake and filtered through the operating filter train. Therefore, the "Filter" transfer mechanism will be selected for this model.

Per Assumption 3.20, the intake flow is 1,700 cfm.

The event timing in Section 6.8 shows that the charcoal filters are placed into service at 18 minutes into the analysis.

Regulatory Guide 1.183, Section 4.2.4 states that credit for engineered safety features that mitigate airborne radioactive material within the control room may assumed in the evaluation. River Bend has committed to GL 99-02 in that the testing acceptance criteria used will be 50% of the available margin in the relevant safety analyses. The test acceptance criterion for the filters is listed as a penetration depth of 1.0% found in Technical Specification 5.5.7.c (Reference II.7) which corresponds to an adsorption efficiency of 99 percent. For analysis purposes, the filters will be assumed to have an adsorption efficiency of 98 percent which accommodates the GL 99-02 requirement. Per Assumption 3.21 the HEPA filters have an efficiency of 99%.

Based upon the event timing information in Section 6.8, the control room operators will place the emergency filters in service 20 minutes into the event (18 minutes from start of the analysis). Thus, the following information will be entered for the filter efficiencies:

Time (hr.)	Flow Rate (CFM)	Iodine Filter Efficiencies (%) Aerosol	Elemental	Organic
0	1,700	0	0	0
0.30	1,700	99	98	98
720	0.0	0	0	0

Active Pathway: Yes

7.1.2.4. **Pathway 4:**

From Compartment: Environment (Node 3)

To Compartment: Control Room (Node 4)

Pathway Name: Control Room Unfiltered Inleakage

Transfer Mechanism: Per Assumption 3.20, the unfiltered inleakage flow is 300 cfm. This flow is present for the duration of the event. The "Filter" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. As this is unfiltered inleakage, the filter efficiencies will be set to zero.

The following information will be entered for the filter efficiencies:

Time (hr.)	Flow Rate (CFM)	Iodine Filter Efficiencies (%) Aerosol	Elemental	Organic
0	300	0	0	0
720	0	0	0	0

Active Pathway: Yes

7.1.2.5. **Pathway 5:**

From Compartment: Control Room (Node 4)

To Compartment: Environment (Node 3)

Pathway Name: Control Room Discharge

Transfer Mechanism: Per Assumption 3.20, the discharge flow is 300 cfm. This flow is present for the duration of the event. The "Filter" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. The filter efficiencies will be set to zero.

The following information will be entered for the filter efficiencies:

	Flow Rate	Iodine Filter Efficiencies (%)		
Time (hr.)	(CFM)	Aerosol	Elemental	Organic
0	2,000	0	0	0
720	0	0	0	0

Active Pathway: Yes

7.1.2.6. Pathway 6:

From Compartment: Containment (Node 2)

To Compartment: Annulus (Node 5)

Pathway Name: Cont. Leakage - Annulus

Transfer Mechanism: As described in Section 6.2 containment leakage is directed to the environment following the secondary containment positive pressure period. The "Air Leakage" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. The following table was developed using the information from Section 6.2 to describe the air leakage inputs.

Time (hr.)	Air Leakage Rate (volume %/day)
0.0	0.0
0.4667	0.325
24	0.1788
720	0.0

Active Pathway: Yes

7.1.2.7. Pathway 7:

From Compartment: Annulus (Node 5)

To Compartment: Environment (Node 3)

Pathway Name: SGTS Flow - Annulus

Transfer Mechanism: The Standby Gas Treatment System (SGTS) is described in Section 5.3. This system filters post-LOCA air from the annulus and auxiliary building. Therefore, the "Filter" transfer mechanism is selected.

As discussed in Assumption 3.13, this analysis will assume that SGTS will be manually initiated. However, per SRP 6.2.3 filtration cannot be credited until the building pressure is below at least 0.25 inches of water gauge vacuum. Assumption 3.16 states that this positive pressure period is assumed to be 30 minutes from the start of the event, or 28 minutes from the start of the analysis as shown in Section 6.8.

Per Assumption 3.14, a flow rate of 2,500 cfm from the annulus will be used for this analysis.

Regulatory Guide 1.183, Appendix A, Section 4.4 states that the reduction in the amount of radioactive material released from the secondary containment because of ESF filter systems may be taken into account provided that these systems meet the guidance of Regulatory Guide 1.52 and Generic Letter 99-02. River Bend has committed to GL 99-02 in that the testing acceptance criteria used will be 50% of the available margin in the relevant safety analyses. The test acceptance criterion for the filters is listed as a penetration depth of 5.0% found in Technical Specification 5.5.7.c (Reference II.7) which corresponds to an adsorption efficiency of 95 percent. For analysis purposes, the filters will be assumed to have an adsorption efficiency of 90 percent which accommodates the GL 99-02 requirement. Per Assumption 3.21 the HEPA filters have an efficiency of 99%.

The following information will be entered for the filter efficiencies:

	Flow Rate	Iodine Filter Efficiencies (%)		
Time (hr.)	(CFM)	Aerosol	Elemental	Organic
0	0	0	0	0
0.4667	2,500	99	90	90
720	0	0	0	0

Active Pathway: Yes

7.1.2.8. **Pathway 8:**

From Compartment: Containment (Node 2)

To Compartment: Sink (Node 6)

As discussed above, Secondary Containment Bypass leakage has a different release point the containment leakage. Therefore, this leakage will be deposited to the sink volume in this model to avoid double counting in the dose calculation.

Pathway Name: Secondary Containment Bypass

Transfer Mechanism: Secondary Containment Bypass is described in Section 6.2. The "Filter" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. As this option is only used to specify the time-dependent flows, the filter efficiencies will be set to zero. The following table was developed using the information from Section 6.2 to describe the filter efficiency inputs.

	Flow Rate	Iodine Filter Efficiencies (%)		
Time (hr.)	(CFM)	Aerosol	Elemental	Organic
0.0	0.341	0	0	0
24	0.188	0	0	0
720	0.0	0	0	0

Active Pathway: Yes

7.1.2.9. **Pathway 9:**

From Compartment: Drywell (Node 1)

To Compartment: Containment (Node 2)

Pathway Name: H2 Mixing to Containment/Steaming

Transfer Mechanism: This path is described in Section 6.1. The "Filter" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. As this option is only used to specify time-dependent flows, the filter efficiencies will be set to zero. The following table was developed using the information from Section 6.1 to describe the filter efficiency inputs.

Time (hr.)	Flow Rate (CFM)	Iodine Filter Efficiencies (%) Aerosol	Elemental	Organic
0	0.0	0	0	0
0.3833	3,600	0	0	0
1.9	1.0×10^8	0	0	0
720	0.0	0	0	0

Active Pathway: Yes

7.1.2.10. Pathway 10:

From Compartment: Containment (Node 2)

To Compartment: Drywell (Node 1)

Pathway Name: Hydrogen Mixing to DW

Transfer Mechanism: This path is described in Section 6.1. The "Filter" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. As this option is only used to specify time-dependent flows, the filter efficiencies will be set to zero. The following table was developed using the information from Section 6.1 to describe the filter efficiency inputs.

Time (hr.)	Flow Rate (CFM)	Iodine Filter Efficiencies (%) Aerosol	Elemental	Organic
0	0.0	0	0	0
0.3833	600	0	0	0
1.9	1.0×10^8	0	0	0
720	0.0	0	0	0

Active Pathway: Yes

7.1.2.11. Pathway 11:

From Compartment: Drywell (Node 1)

To Compartment: Sink (Node 6)

As discussed above, MSIV leakage has a different release point the containment leakage. Therefore, this leakage will be deposited to the sink volume in this model to avoid double counting in the dose calculation

Pathway Name: MSIV Leakage (One failed MSIV)

Transfer Mechanism: The MSIV leakage path is described in Section 6.2. The "Filter" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. As this option is only used to specify the time-dependent flows, the filter efficiencies will be set to zero. The following table was developed using the information from Section 6.2 to describe the filter efficiency inputs.

Time (hr.)	Flow Rate (CFM)	Iodine Filter Efficiencies (%) Aerosol	Elemental	Organic
0	2.52	0	0	0
0.3833	0.0	0	0	0

720	0.0	0	0	0

Active Pathway: Yes

7.1.2.12. Pathway 12:

From Compartment: Drywell (Node 1)

To Compartment: Environment (Node 3)

Pathway Name: Drywell Leakage - PPP

Transfer Mechanism: As described in Section 6.2 containment leakage is directed to the environment during the secondary containment positive pressure period. The "Air Leakage" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. The following table was developed using the information from Section 6.2 to describe the air leakage inputs.

Time (hr.)	Air Leakage Rate (volume %/day)
0	0.325
0.4667	0.0
720.0	0.0

Active Pathway: Yes

7.1.2.13. Pathway 13:

From Compartment: Drywell (Node 1)

To Compartment: Annulus (Node 5)

Pathway Name: Drywell Leakage - Annulus

Transfer Mechanism: As described in Section 6.2 containment leakage is directed to the environment following the secondary containment positive pressure period. The "Air Leakage" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. The following table was developed using the information from Section 6.2 to describe the air leakage inputs.

Time (hr.)	Air Leakage Rate (volume %/day)
0	0.0
0.4667	0.325
24	0.1788
720	0.0

Active Pathway: Yes

7.1.3. Dose Point Input Data

There are three dose points, the exclusion area boundary (EAB), the low population zone (LPZ), and the main control room.

7.1.3.1. Location 1:

Name: EAB

In Compartment: Environment (Node 3)

χ/Q Values: The off-site atmospheric dispersion coefficients (χ/Q) values are described in Section 6.5.1. The following table was developed using this information:

Time (hr.)	χ/Q (sec/m^3)
0	6.05E-04
720	0.0

Breathing Rates: The breathing rate inputs are described in Section 6.7. The following table was developed using this information:

Time (hr.)	Breathing Rate (m^3/sec)
0	3.47E-04
8	1.75E-04
24	2.32E-04
720	0.0

Occupancy Factors: This option is not used for this dose point.

7.1.3.2. Location 2:

Name: LPZ

In Compartment: Environment (Node 3)

χ/Q Values: The off-site atmospheric dispersion coefficients (χ/Q) values are described in Section 6.5.1. The following table was developed using this information:

Time (hr.)	χ/Q (sec/m^3)
0	7.49E-5
8	5.02E-5
24	2.10E-5
96	6.13E-6
720	0.0

Breathing Rates: The breathing rate inputs are described in Section 6.7. The following table was developed using this information:

Time (hr.)	Breathing Rate (m^3/sec)
0	3.47E-04
8	1.75E-04
24	2.32E-04
720	0.0

Occupancy Factors: This option is not used for this dose point.

7.1.3.3. Location 3:

Name: Control Room

In Compartment: Control Room (Node 4)

χ/Q Values: The control room atmospheric dispersion coefficients (χ/Q) values are described in Section 6.5.2. The following table was developed using this information:

Time (hr.)	χ/Q (sec/m^3)
0	2.55E-04
2	1.92E-04
8	8.09E-05
24	6.22E-05
96	5.09E-05
720	0.0

Breathing Rates: The breathing rate inputs are described in Section 6.7. The following table was developed using this information:

Time (hr.)	Breathing Rate (m^3/sec)
0	3.47E-04
720	0.0

Occupancy Factors: The breathing rate inputs are described in Section 6.7. The following table was developed using this information:

Time (hr.)	Occupancy Factor
0	1.0
24	0.6
96	0.4
720	0.0

7.1.4. Source Term Input Data

Plant Power (MWth): The value of the reactor thermal power to be used here is 3100 MWth and is consistent with the rated thermal power of 3091 MWth in the RBS operating license (Reference II.7) including a power level uncertainty of 0.3% which was approved by the NRC in the SER for the Thermal Power Optimization project (Reference I.29).

NIF File: The nuclide inventory file is described in Section 6.4.1. The file name to be used is TR31_1.NIF.

Decay and Daughter Products: The option to calculate decay and include daughter products is selected

Iodine Chemical Fractions: The chemical fraction inputs for containment leakage model are described in Section 6.4.3. The values are the same as those in NUREG-1465 (Reference II.16).

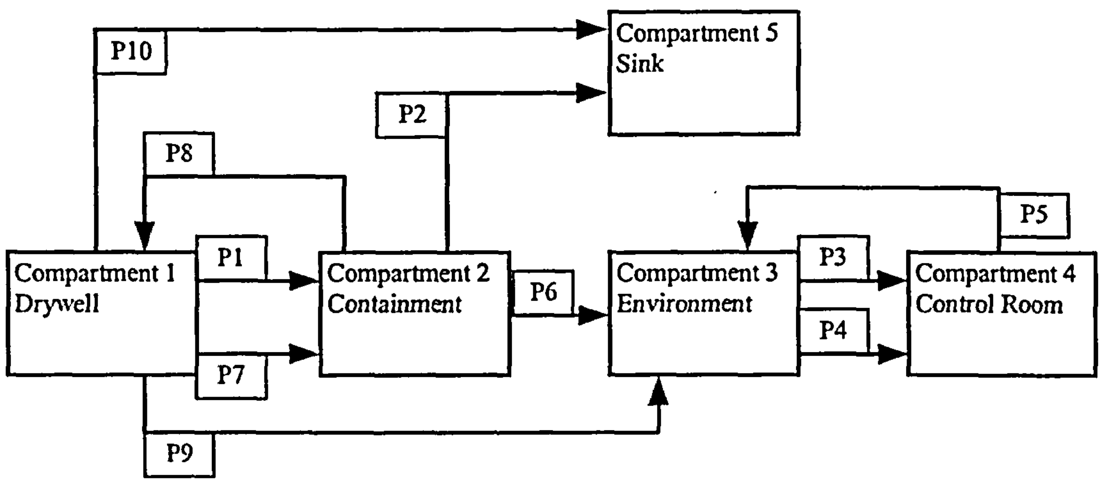
Delay Time (hours): A value of 0.0 is used for the delay time.

RFT File: The release fraction and timing file inputs are described in Section 6.4.2. The file name to be used is BWR_DBA.RFT (RADTRAD Default).

DCF File: The dose conversion file inputs are described in Section 6.6. The file name to be used is FGR11&12.INP (RADTRAD Default)

7.2 Secondary Containment Bypass Input Deck Description

This model has 5 compartments and 9 pathways diagram below:



This model is similar to the model developed in Section 7. All isotopes released are initially directed to the drywell and are transported elsewhere as discussed above. However, in this model releases via the MSIV and SCB leakage paths are environment rather than the sink and primary and secondary containment leakage is directed to the sink rather than the environment. The inputs for this model are described below:

7.2.1. Compartment Input Data

There are a total of six compartments in this model.

7.2.1.1. Compartment 1

Compartment Name: Drywell

Compartment Type: Other (3)

Volume (cu. ft.): 2.36×10^5 ft^3 (Reference I.5)

Source Term Fraction: Per Section 6.1, all of the source term will be deposited into the drywell, thus this fraction will be 1.00.

Compartment Features: As discussed in Section 6.3.1 natural deposition will be assumed for this volume. The Power's Aerosol model at the 10th percentile will be used for deposition of aerosols and a coefficient of 1.01 will be used for deposition of elemental iodine. Per Assumption 3.22, this mechanism is only credited for the first 24 hours of the event. The following table will be used for the elemental iodine deposition:

Time (hr.)	Removal Coefficient (hr^{-1})
0	1.01
24	0.0
720	0.0

Print Detailed Output: This option has no impact on the execution, but rather increases or decreases the amount of printed output. Detailed output is arbitrarily selected,

7.2.1.2. **Compartment 2**

Compartment Name: Containment

Compartment Type: Other (3)

Volume (cu. ft.): 1.19×10^6 ft^3 (Reference I.6)

Source Term Fraction: Per Section 6.1, all of the source term will be deposited into the drywell, thus this fraction will be 0.00.

Compartment Features: None of the compartment features have been selected for this compartment.

Print Detailed Output: This option has no impact on the execution, but rather increases or decreases the amount of printed output. Detailed output is arbitrarily selected,

7.2.1.3. **Compartment 3**

Compartment Name: Environment

Compartment Type: Environment (2)

Volume (cu. ft.): This input is not active for this compartment type.

Source Term Fraction: This input is not active for this compartment type.

Compartment Features: This input is not active for this compartment type.

Print Detailed Output: This option has no impact on the execution, but rather increases or decreases the amount of printed output. Detailed output is arbitrarily selected.

7.2.1.4. **Compartment 4**

Compartment Name: Control Room

Compartment Type: Control Room (1)

Volume (cu. ft.): The net free volume of this compartment is determined as follows:

From Reference I.3 the gross volume of the main control room below the suspended ceiling is 101,232 ft^3 and 96,757 ft^3 above the suspended ceiling. Within the control room 10,241 ft^3 of the gross volume is occupied by various pieces of equipment (panels, etc.). Additional free volume associated with the HVAC duct work is conservatively ignored (see Assumption 3.17). Summing the gross volumes and subtracting the volume occupied by equipment, yields a value for the net free volume of the main control room of 1.88×10^5 ft^3.

Source Term Fraction: Per Section 6.1, all of the source term will be deposited into the drywell, thus this fraction will be 0.00.

Compartment Features: Reference I.32 describes the control room fresh air system including the charcoal filtration system. Specifically, 2,000 cfm of control room air is recirculated through the operating filter train. Therefore, the "Recirculating Filter" compartment feature will be selected for this model.

Item 4.2.4 of Regulatory Guide 1.183 (Reference II.3) states that credit for engineered safety features that mitigate airborne radioactive material within the control room may assumed in the evaluation. River Bend has committed to GL 99-02 in that the testing acceptance criteria used will be 50% of the available margin in the relevant safety analyses. The test acceptance criterion for the filters is listed as a penetration depth of 1.0% found in Technical Specification 5.5.7.c (Reference II.7) which corresponds to an adsorption efficiency of 99 percent. For analysis purposes, the filters will be assumed to have an adsorption efficiency of

98 percent which accommodates the GL 99-02 requirement. Per Assumption 3.21 the HEPA filters have an efficiency of 99%.

Based upon the event timing information in Section 6.8, the control room operators will place the emergency filters in service 20 minutes into the event (18 minutes from start of the analysis). Thus, the following information will be entered for the filter efficiencies:

Time (hr.)	Iodine Filter Efficiencies (%)		
	Aerosol	Elemental	Organic
0 .0	0	0	0
0.3	99	98	98
720	0	0	0

Print Detailed Output: This option has no impact on the execution, but rather increases or decreases the amount of printed output. Detailed output is arbitrarily selected.

7.2.1.5. Compartment 5

Compartment Name: Sink

The sink compartment is a fictitious compartment required because the primary and secondary containment leakage release point location is different than the secondary containment bypass and MSIV leakage release point. The sink is used to limit double counting of the release inventory.

Compartment Type: Other (3)

Volume (cu. ft.): As this compartment is fictitious, an arbitrary value of 1.0×10^{8} ft^3 will be selected.

Source Term Fraction: Per Section 6.1, all of the source term will be deposited into the drywell, thus this fraction will be 0.00.

Compartment Features: None of the compartment features have been selected for this compartment.

Print Detailed Output: This option has no impact on the execution, but rather increases or decreases the amount of printed output. Detailed output is arbitrarily de-selected.

7.2.2. Pathway Input Data

There are a total of 10 pathways in this model.

7.2.2.1. Pathway 1:

From Compartment: Drywell (Node 1)

To Compartment: Containment (Node 2)

Pathway Name: Drywell Bypass to Containment

Transfer Mechanism: As described in Section 6.1 the maximum drywell bypass flow will be assumed for the duration of the positive drywell to containment pressure differential. The "Filter" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. The following table was developed using the information from Section 6.1 to describe the filter efficiency inputs.

Time (hr.)	Flow Rate (CFM)	Iodine Filter Efficiencies (%) Aerosol	Elemental	Organic
0.0	4.7E+05	0	0	0
0.1286	0.0	0	0	0
720	0.0	0	0	0

Active Pathway: Yes

7.2.2.2. **Pathway 2:**

From Compartment: Containment (Node 2)

To Compartment: Sink (Node 5)

As discussed above, Secondary Containment Bypass leakage has a different release point the containment leakage. Therefore, this leakage will be deposited to the sink volume in this model to avoid double counting in the dose calculation.

Pathway Name: Containment Leakage

Transfer Mechanism: The containment leakage for the duration of the event is described in Section 6.2. The "Air Leakage" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. The following table was developed using the information from Section 6.2 to describe the air leakage inputs.

Time (hr.)	Air Leakage Rate (volume %/day)
0	0.325
0.4667	0.325
24	0.1788
720	0.0

Active Pathway: Yes

7.2.2.3. **Pathway 3:**

From Compartment: Environment (Node 3)

To Compartment: Control Room (Node 4)

Pathway Name: Control Room Air Intake

Transfer Mechanism: Reference I.32 describes the control room fresh air system including the charcoal filtration system. Specifically, air is drawn from either the local or remote air intake and filtered through the operating filter train. Therefore, the "Filter" transfer mechanism will be selected for this model.

Per Assumption 3.20, the intake flow is 1,700 cfm.

The event timing in Section 6.8 shows that the charcoal filters are placed into service at 18 minutes into the analysis.

Regulatory Guide 1.183, Section 4.2.4 states that credit for engineered safety features that mitigate airborne radioactive material within the control room may assumed in the evaluation. River Bend has committed to GL 99-02 in that the testing acceptance criteria used will be 50% of the available margin in the relevant safety analyses. The test acceptance criterion for the filters is listed as a penetration depth of 1.0% found in Technical Specification 5.5.7.c (Reference II.7) which corresponds to an adsorption efficiency of 99 percent. For analysis purposes, the filters will be assumed to have an adsorption efficiency of 98 percent which accommodates the GL 99-02 requirement. Per Assumption 3.21 the HEPA filters have an efficiency of 99%.

Based upon the event timing information in Section 6.8, the control room operators will place the emergency filters in service 20 minutes into the event (18 minutes from start of the analysis). Thus, the following information will be entered for the filter efficiencies:

Time (hr.)	Flow Rate (CFM)	Iodine Filter Efficiencies (%) Aerosol	Elemental	Organic
0	1,700	0	0	0
0.3	1,700	99	98	98
720	0.0	0	0	0

Active Pathway: Yes

7.2.2.4. **Pathway 4:**

From Compartment: Environment (Node 3)

To Compartment: Control Room (Node 4)

Pathway Name: Control Room Unfiltered Inleakage

Transfer Mechanism: Per Assumption 3.20, the unfiltered inleakage flow is 300 cfm. This flow is present for the duration of the event. The "Filter" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. As this is unfiltered inleakage, the filter efficiencies will be set to zero.

The following information will be entered for the filter efficiencies:

Time (hr.)	Flow Rate (CFM)	Iodine Filter Efficiencies (%) Aerosol	Elemental	Organic
0	300	0	0	0
720	0	0	0	0

Active Pathway: Yes

7.2.2.5. **Pathway 5:**

From Compartment: Control Room (Node 4)

To Compartment: Environment (Node 3)

Pathway Name: Control Room Discharge

Transfer Mechanism: Per Assumption 3.20, the discharge flow is 2,000 cfm. This flow is present for the duration of the event. The "Filter" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. The filter efficiencies will be set to zero.

The following information will be entered for the filter efficiencies:

Time (hr.)	Flow Rate (CFM)	Iodine Filter Efficiencies (%) Aerosol	Elemental	Organic
0	2,000	0	0	0
720	0	0	0	0

Active Pathway: Yes

7.2.2.6. **Pathway 6:**

From Compartment: Containment (Node 2)

To Compartment: Environment (Node 3)

Pathway Name: Secondary Containment Bypass

Transfer Mechanism: Secondary Containment Bypass is described in Section 6.2. The "Filter" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. As this option is only used to specify the time-dependent flows, the filter efficiencies will be set to zero. The following table was developed using the information from Section 6.2 to describe the filter efficiency inputs.

	Flow Rate	Iodine Filter Efficiencies (%)		
Time (hr.)	(CFM)	Aerosol	Elemental	Organic
0.0	0.341	0	0	0
24	0.188	0	0	0
720	0.0	0	0	0

Active Pathway: Yes

7.2.2.7. **Pathway 7:**

From Compartment: Drywell (Node 1)

To Compartment: Containment (Node 2)

Pathway Name: Hydrogen Mixing to Containment/Steaming

Transfer Mechanism: As described in Section 6.1 the maximum drywell bypass flow will be assumed for the duration of the positive drywell to containment pressure differential. The "Filter" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. The following table was developed using the information from Section 6.1 to describe the filter efficiency inputs.

	Flow Rate	Iodine Filter Efficiencies (%)		
Time (hr.)	(CFM)	Aerosol	Elemental	Organic
0.0	0.0	0	0	0
0.3833	3,600	0	0	0
1.9	1.0×10^8	0	0	0
720	0.0	0	0	0

Active Pathway: Yes

7.2.2.8. **Pathway 8:**

From Compartment: Containment (Node 2)

To Compartment: Drywell (Node 1)

Pathway Name: Hydrogen Mixing to DW

Transfer Mechanism: As described in Section 6.1 the maximum drywell bypass flow will be assumed for the duration of the positive drywell to containment pressure differential. The "Filter" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. The following table was developed using the information from Section 6.1 to describe the filter efficiency inputs.

Time (hr.)	Flow Rate (CFM)	Iodine Filter Efficiencies (%) Aerosol	Elemental	Organic
0.0	0.0	0	0	0
0.3833	600	0	0	0
1.9	1.0×10^8	0	0	0
720	0.0	0	0	0

Active Pathway: Yes

7.2.2.9. **Pathway 9:**

From Compartment: Drywell (Node 1)

To Compartment: Environment (Node 3)

Pathway Name: MSIV Leakage (One failed MSIV)

Transfer Mechanism: The MSIV leakage path is described in Section 6.2. The "Filter" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. As this option is only used to specify the time-dependent flows, the filter efficiencies will be set to zero. The following table was developed using the information from Section 6.2 to describe the filter efficiency inputs.

Time (hr.)	Flow Rate (CFM)	Iodine Filter Efficiencies (%) Aerosol	Elemental	Organic
0.0	2.52	0	0	0
0.3833	0.0	0	0	0
720	0.0	0	0	0

Active Pathway: Yes

7.2.2.10. **Pathway 10:**

From Compartment: Drywell (Node 1)

To Compartment: Sink (Node 5)

As discussed above, Secondary Containment Bypass leakage has a different release point the containment leakage. Therefore, this leakage will be deposited to the sink volume in this model to avoid double counting in the dose calculation.

Pathway Name: Drywell Leakage (La)

Transfer Mechanism: As described in Section 6.2 containment leakage is directed to the environment following the secondary containment positive pressure period. The "Air Leakage" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. The following table was developed using the information from Section 6.2 to describe the air leakage inputs.

Time (hr.)	Air Leakage Rate (volume %/day)
0	0.325
24	0.1788
720	0.0

Active Pathway: Yes

7.2.3. **Dose Point Input Data**

There are three dose points, the exclusion area boundary (EAB), the low population zone (LPZ), and the main control room. The inputs are similar to those for the primary and secondary containment leakage model with the exception of the atmospheric dispersion coefficients.

7.2.3.1. **Location 1:**

Name: EAB

In Compartment: Environment (Node 3)

χ/Q Values: The off-site atmospheric dispersion coefficients (χ/Q) values are described in Section 6.5.1. The following table was developed using this information:

Time (hr.)	χ/Q (sec/m^3)
0	7.51E-04
720	0.0

Breathing Rates: The breathing rate inputs are described in Section 6.7. The following table was developed using this information:

Time (hr.)	Breathing Rate (m^3/sec)
0	3.47E-04
8	1.75E-04
24	2.32E-04
720	0.0

Occupancy Factors: This option is not used for this dose point.

7.2.3.2. **Location 2:**

Name: LPZ

In Compartment: Environment (Node 3)

χ/Q Values: The off-site atmospheric dispersion coefficients (χ/Q) values are described in Section 6.5.1. The following table was developed using this information:

Time (hr.)	χ/Q (sec/m^3)
0	7.79E-5
8	5.23E-5
24	2.21E-5
96	6.40E-6
720	0.0

Breathing Rates: The breathing rate inputs are described in Section 6.7. The following table was developed using this information:

Time (hr.)	Breathing Rate (m^3/sec)
0	3.47E-04
8	1.75E-04
24	2.32E-04
720	0.0

Occupancy Factors: This option is not used for this dose point.

7.2.3.3. Location 3:

Name: Control Room

In Compartment: Control Room (Node 4)

χ/Q Values: The control room atmospheric dispersion coefficients (χ/Q) values are described in Section 6.5.2. The following table was developed using this information:

Time (hr.)	χ/Q (sec/m^3)
0	4.66E-04
2	3.83E-04
8	1.67E-04
24	1.27E-04
96	9.33E-05
720	0.0

Breathing Rates: The breathing rate inputs are described in Section 6.7. The following table was developed using this information:

Time (hr.)	Breathing Rate (m^3/sec)
0	3.47E-04
720	0.0

Occupancy Factors: The breathing rate inputs are described in Section 6.7. The following table was developed using this information:

Time (hr.)	Occupancy Factor
0	1.0
24	0.6
96	0.4
720	0.0

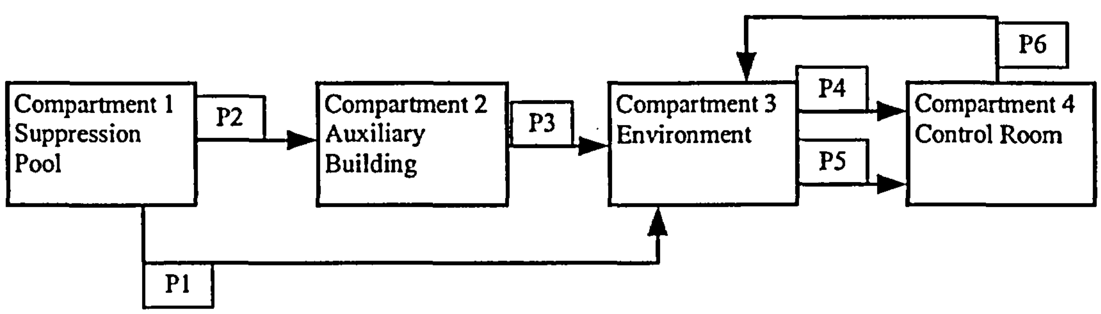
7.2.4. Source Term Input Data

Plant Power (MWth) The value of the reactor thermal power to be used here is 3100 MWth and is consistent with the rated thermal power of 3091 MWth in the RBS operating license

	(Reference II.7) including a power level uncertainty of 0.3% which was approved by the NRC in the SER for the Thermal Power Optimization project (Reference I.29).
NIF File:	The nuclide inventory file is described in Section 6.4.1. The file name to be used is TR31_1.NIF.
Decay and Daughter Products:	The option to calculate decay and include daughter products is selected
Iodine Chemical Fractions:	The chemical fraction inputs for containment leakage model are described in Section 6.4.3. The values are the same as those in NUREG-1465 (Reference II.16).
Delay Time (hours):	A value of 0.0 is used for the delay time.
RFT File	The release fraction and timing file inputs are described in Section 6.4.2. The file name to be used is BWR_DBA.RFT (RADTRAD Default).
DCF File:	The dose conversion file inputs are described in Section 6.6. The file name to be used is FGR11&12.INP (RADTRAD Default)

7.3 ESF Liquid Leakage Input Deck Description

This model has 5 compartments and 6 pathways.



7.3.1. Compartment Input Data

There are a total of six compartments in this model.

7.3.1.1. Compartment 1

Compartment Name:	Suppression Pool
Compartment Type:	Other (3)
Volume (cu. ft.):	The suppression pool design is described in Section 5.1. For this analysis, only the portion of the suppression pool outside the drywell wall will be credited. From Reference I.4, the gross volume of this portion of the suppression pool at minimum water level is 124,958 ft^3, of which 1,547 ft^3 is steel. Thus the net volume of this portion of the suppression pool is 123,411 ft^3 is water. Since a lower volume results in a higher concentration of radionuclides in the ESF leakage flow a suppression pool level value of 120,000 ft^3 will be used in this analysis for additional conservatism.
Source Term Fraction:	All of the source term will be deposited into the suppression pool, thus this fraction will be 1.00.
Compartment Features:	None of the compartment features have been selected for this compartment.
Print Detailed Output:	This option has no impact on the execution, but rather increases or decreases the amount of printed output. Detailed output is arbitrarily selected,

7.3.1.2. **Compartment 2**

Compartment Name: Auxiliary Building

Compartment Type: Other (3)

Volume (cu. ft.): Regulatory Guide 1.183, Appendix A, Section 4.4 states that credit of up to 50% mixing may be taken for dilution in secondary containment if adequate means for mixing may be demonstrated. The RBS design includes the SGTS system which is a safety-related system (Reference I.31) which is not a mixing system per see, yet the system does take suction directly or indirectly from every compartment in the auxiliary building thus providing a mixing arrangement. There the 50% mixing credit is applicable to auxiliary building. The auxiliary building free volume is 1.16E+06 ft^3 per Reference I.12. Therefore, the volume to be used for this compartment will be $5.8x10^5$ ft^3.

Source Term Fraction: Since all of the source term will be deposited into the suppression pool, thus this fraction will be 0.00.

Compartment Features: None of the compartment features have been selected for this compartment.

Print Detailed Output: This option has no impact on the execution, but rather increases or decreases the amount of printed output. Detailed output is arbitrarily selected.

7.3.1.3. **Compartment 3**

Compartment Name: Environment

Compartment Type: Environment (2)

Volume (cu. ft.): This input is not active for this compartment type.

Source Term Fraction: This input is not active for this compartment type.

Compartment Features: This input is not active for this compartment type.

Print Detailed Output: This option has no impact on the execution, but rather increases or decreases the amount of printed output. Detailed output is arbitrarily selected.

7.3.1.4. **Compartment 4**

Compartment Name: Control Room

Compartment Type: Control Room (1)

Volume (cu. ft.): The net free volume of this compartment is determined as follows:

From Reference I.3 the gross volume of the main control room below the suspended ceiling is 101,232 ft^3 and 96,757 ft^3 above the suspended ceiling. Within the control room 10,241 ft^3 of the gross volume is occupied by various pieces of equipment (panels, etc.). Additional free volume associated with the HVAC duct work is conservatively ignored (see Assumption 3.17). Summing the gross volumes and subtracting the volume occupied by equipment, yields a value for the net free volume of the main control room of $1.88x10^5$ ft^3.

Source Term Fraction: Since all of the source term will be deposited into the suppression pool, thus this fraction will be 0.00.

Compartment Features: Reference I.32 describes the control room fresh air system including the charcoal filtration system. Specifically, 2,000 cfm of control room air is recirculated through the operating filter train. Therefore, the "Recirculating Filter" compartment feature will be selected for this model.

Item 4.2.4 of Regulatory Guide 1.183 (Reference II.3) states that credit for engineered safety features that mitigate airborne radioactive material within the control room may assumed in the evaluation. River Bend has committed to GL 99-02 in that the testing acceptance criteria used will be 50% of the available margin in the relevant safety analyses. The test acceptance criterion for the filters is listed as a penetration depth of 1.0% found in Technical Specification 5.5.7.c (Reference II.7) which corresponds to an adsorption efficiency of 99 percent. For analysis purposes, the filters will be assumed to have an adsorption efficiency of 98 percent which accommodates the GL 99-02 requirement. Per Assumption 3.21 the HEPA filters have an efficiency of 99%.

Based upon the event timing information in Section 6.8, the control room operators will place the emergency filters in service 20 minutes into the event (18 minutes from start of the analysis). Thus, the following information will be entered for the filter efficiencies:

Time (hr.)	Iodine Filter Efficiencies (%)		
	Aerosol	Elemental	Organic
0 .0	0	0	0
0.3	99	98	98
720	0	0	0

Print Detailed Output: This option has no impact on the execution, but rather increases or decreases the amount of printed output. Detailed output is arbitrarily selected.

7.3.2. Pathway Input Data

There are a total of 10 pathways in this model.

7.3.2.1. Pathway 1:

From Compartment: Suppression Pool (Node 1)

To Compartment: Environment (Node 3)

Pathway Name: ESF Leakage - PPP

Transfer Mechanism: The ESF leakage is described in Section 6.2. During the secondary containment positive pressure period the leakage is assumed to go directly to the environment. As shown in the event timing in Section 6.8, the positive pressure period is assumed to end at 28 minutes into the analysis. As described in Section 6.2, the leakage rate is 1 gpm with a flash fraction of 10%. This translates into a leakage rate of 0.1337 cfm and aerosol, elemental, and organic filter effective efficiencies of 90%. The following table was developed using this information.

Time (hr.)	Flow Rate (CFM)	Iodine Filter Efficiencies (%)		
		Aerosol	Elemental	Organic
0.0	0.1337	90	90	90
0.4667	0.0	0	0	0
720	0.0	0	0	0

Active Pathway: Yes

7.3.2.2. Pathway 2:

From Compartment: Suppression Pool (Node 1)

To Compartment: Auxiliary Building (Node 2)

Pathway Name: ESF Leakage – Aux. Bldg.

Transfer Mechanism: The ESF leakage is described in Section 6.2. Following the secondary containment positive pressure period the leakage is assumed to go to the auxiliary building. As shown in the event timing in Section 6.8, the positive pressure period is assumed to end at 28 minutes into the analysis. As described in Section 6.2, the leakage rate is 1 gpm with a flash fraction of 10%. This translates into a leakage rate of 0.1337 cfm and aerosol, elemental, and organic filter effective efficiencies of 90%. The following table was developed using this information.

Time (hr.)	Flow Rate (CFM)	Iodine Filter Efficiencies (%) Aerosol	Elemental	Organic
0.0	0.0	0	0	0
0.4667	0.1337	90	90	90
720	0.0	0	0	0

Active Pathway: Yes

7.3.2.3. Pathway 3:

From Compartment: Auxiliary Building (Node 2)

To Compartment: Environment (Node 3)

Pathway Name: SGTS Flow – Aux. Bldg.

Transfer Mechanism: The Standby Gas Treatment System (SGTS) is described in Section 5.3. This system filters post-LOCA air from the annulus and auxiliary building. Therefore, the "Filter" transfer mechanism is selected.

As discussed in Assumption 3.13, this analysis will assume that SGTS will be manually initiated. However, per SRP 6.2.3 filtration cannot be credited until the building pressure is below at least 0.25 inches of water gauge vacuum. Assumption 3.16 states that this positive pressure period is assumed to be 30 minutes from the start of the event, or 28 minutes from the start of the analysis as shown in Section 6.8.

Per Assumption 3.14, a flow rate of 10,000 cfm from the auxiliary building will be used for this analysis.

Regulatory Guide 1.183, Appendix A, Section 4.4 states that the reduction in the amount of radioactive material released from the secondary containment because of ESF filter systems may be taken into account provided that these systems meet the guidance of Regulatory Guide 1.52 and Generic Letter 99-02. River Bend has committed to GL 99-02 in that the testing acceptance criteria used will be 50% of the available margin in the relevant safety analyses. The test acceptance criterion for the filters is listed as a penetration depth of 5.0% found in Technical Specification 5.5.7.c (Reference II.7) which corresponds to an adsorption efficiency of 95 percent. For analysis purposes, the filters will be assumed to have an adsorption efficiency of 90 percent which accommodates the GL 99-02 requirement. Per Assumption 3.21 the HEPA filters have an efficiency of 99%.

The following information will be entered for the filter efficiencies:

Time (hr.)	Flow Rate (CFM)	Iodine Filter Efficiencies (%) Aerosol	Elemental	Organic
0	0	0	0	0
0.4667	10,000	99	90	90
720	0	0	0	0

Active Pathway: Yes

7.3.2.4. Pathway 4:

From Compartment: Environment (Node 3)

To Compartment: Control Room (Node 4)

Pathway Name: MCR Air Intake

Transfer Mechanism: Reference I.32 describes the control room fresh air system including the charcoal filtration system. Specifically, air is drawn from either the local or remote air intake and filtered through the operating filter train. Therefore, the "Filter" transfer mechanism will be selected for this model.

Per Assumption 3.20, the intake flow is 1,700 cfm.

The event timing in Section 6.8 shows that the charcoal filters are placed into service at 18 minutes into the analysis.

Regulatory Guide 1.183, Section 4.2.4 states that credit for engineered safety features that mitigate airborne radioactive material within the control room may assumed in the evaluation. River Bend has committed to GL 99-02 in that the testing acceptance criteria used will be 50% of the available margin in the relevant safety analyses. The test acceptance criterion for the filters is listed as a penetration depth of 1.0% found in Technical Specification 5.5.7.c (Reference II.7) which corresponds to an adsorption efficiency of 99 percent. For analysis purposes, the filters will be assumed to have an adsorption efficiency of 98 percent which accommodates the GL 99-02 requirement. Per Assumption 3.21 the HEPA filters have an efficiency of 99%.

Based upon the event timing information in Section 6.8, the control room operators will place the emergency filters in service 20 minutes into the event (18 minutes from start of the analysis). Thus, the following information will be entered for the filter efficiencies:

	Flow Rate	Iodine Filter Efficiencies (%)		
Time (hr.)	(CFM)	Aerosol	Elemental	Organic
0	1,700	0	0	0
0.3	1,700	99	98	98
720	0.0	0	0	0

Active Pathway: Yes

7.3.2.5. Pathway 5:

From Compartment: Environment (Node 3)

To Compartment: Control Room (Node 4)

Pathway Name: Main Control Room Unfiltered Inleakage

Transfer Mechanism: Per Assumption 3.20, the unfiltered inleakage flow is 300 cfm. This flow is present for the duration of the event. The "Filter" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. As this is unfiltered inleakage, the filter efficiencies will be set to zero.

The following information will be entered for the filter efficiencies:

	Flow Rate	Iodine Filter Efficiencies (%)		
Time (hr.)	(CFM)	Aerosol	Elemental	Organic
0	300	0	0	0
720	0	0	0	0

Active Pathway: Yes

7.3.2.6. Pathway 6:

From Compartment: Control Room (Node 4)

To Compartment: Environment (Node 3)

Pathway Name: Main Control Room Discharge

Transfer Mechanism: Per Assumption 3.20, the discharge flow is 2,000 cfm. This flow is present for the duration of the event. The "Filter" transfer mechanism will be used as this allows the user to apply a time-dependent flow rate. The filter efficiencies will be set to zero.

The following information will be entered for the filter efficiencies:

	Flow Rate	Iodine Filter Efficiencies (%)		
Time (hr.)	(CFM)	Aerosol	Elemental	Organic
0	2,000	0	0	0
720	0	0	0	0

Active Pathway: Yes

7.3.3. Dose Point Input Data

There are three dose points, the exclusion area boundary (EAB), the low population zone (LPZ), and the main control room.

7.3.3.1. Location 1:

Name: EAB

In Compartment: Environment (Node 3)

χ/Q Values: The off-site atmospheric dispersion coefficients (χ/Q) values are described in Section 6.5.1. The following table was developed using this information:

Time (hr.)	χ/Q (sec/m^3)
0	6.05E-04
720	0.0

Breathing Rates: The breathing rate inputs are described in Section 6.7. The following table was developed using this information:

Time (hr.)	Breathing Rate (m^3/sec)
0	3.47E-04
8	1.75E-04
24	2.32E-04
720	0.0

Occupancy Factors: This option is not used for this dose point.

7.3.3.2. Location 2:

Name: LPZ

In Compartment: Environment (Node 3)

χ/Q Values: The off-site atmospheric dispersion coefficients (χ/Q) values are described in Section 6.5.1. The following table was developed using this information:

Time (hr.)	χ/Q (sec/m^3)
0	7.49E-5
8	5.02E-5
24	2.10E-5
96	6.13E-6
720	0.0

Breathing Rates: The breathing rate inputs are described in Section 6.7. The following table was developed using this information:

Time (hr.)	Breathing Rate (m^3/sec)
0	3.47E-04
8	1.75E-04
24	2.32E-04
720	0.0

Occupancy Factors: This option is not used for this dose point.

7.3.3.3. Location 3:

Name: Control Room

In Compartment: Control Room (Node 4)

χ/Q Values: The control room atmospheric dispersion coefficients (χ/Q) values are described in Section 6.5.2. The following table was developed using this information:

Time (hr.)	χ/Q (sec/m^3)
0	2.55E-04
2	1.92E-04
8	8.09E-05
24	6.22E-05
96	5.09E-05
720	0.0

Breathing Rates: The breathing rate inputs are described in Section 6.7. The following table was developed using this information:

Time (hr.)	Breathing Rate (m^3/sec)
0	3.47E-04
720	0.0

Occupancy Factors: The breathing rate inputs are described in Section 6.7. The following table was developed using this information:

Time (hr.)	Occupancy Factor
0	1.0
24	0.6
96	0.4
720	0.0

7.3.4. Source Term Input Data

Plant Power (MWth): The value of the reactor thermal power to be used here is 3100 MWth and is consistent with the rated thermal power of 3091 MWth in the RBS operating license (Reference II.7) including a power level uncertainty of 0.3% which was approved by the NRC in the SER for the Thermal Power Optimization project (Reference I.29).

NIF File: The nuclide inventory file is described in Section 6.4.1. The file name to be used is TR31_1.NIF.

Decay and Daughter Products: The option to calculate decay and include daughter products is selected

Iodine Chemical Fractions: The chemical fraction inputs for containment leakage model are described in Section 6.4.3 and are 0.00 for aerosols, 0.97 for elemental iodine and 0.03 for organic iodine.

Delay Time (hours): A value of 0.0 is used for the delay time.

RFT File: The core halogens (AST Group 2) are released directly to the suppression pool. Noble gases (Group 1) are neglected since they are not readily retained in water. All other AST groups are not included since they are retained in the water per Regulatory Guide 1.183, Appendix A, Section 5.3, and are not transported off-site. As such, the default release fraction file (BWR_DBA.RFT) was modified by setting the release fractions for all groups other than halogens to 0.0. The new release fraction file is BWR_1.RFT.

DCF File: The dose conversion file inputs are described in Section 6.6. The file name to be used is FGR11&12.INP (RADTRAD Default)

8 RESULTS

The table below contains the results of the input decks described above. The output files are contained on the attached CD.

AST LOCA Dose Results (REM TEDE)

Description	EAB	LPZ	MCR
LOCA_CON	3.7132E+00	1.9736E+00	4.2428E-01
LOCA_SCB	1.2262E+01	5.6080E+00	2.8331E+00
LOCA_ESF	3.3823E-01	5.6829E-01	1.5100E-01
Total*	**16.4**	**8.2**	**3.5**
Regulatory Limit	***25.0***	***25.0***	***5.0***

Note *: Results conservatively rounded up.

9 DISCUSSION/CONCLUSIONS

The calculated results are presented in the table above. The results meet the criteria set forth in 10CFR50.67.

Attachment A contains a list of the requirements of Regulatory Guide 1.183, Appendix A. This meets these requirements with two exceptions:

1. Section 5.2: Regulatory Guide 1.183, Appendix A, Section 3.8 states that ESF leakage should be taken as two times the sum of the simultaneous leakage from all components in the ESF recirculation systems above which the technical specifications would require declaring such systems inoperable. RBS does not have any technical specification requirements which can be directly tied to this assumption. The leakage rate assumed in this analysis is 1 gpm based on the initial licensing of the plant. Specifically, the RBS SER (NUREG-0989), Section 15.6.5, states that "The leak rate chosen for ESF equipment is that used by the staff in past evaluations; it represents the largest flow that could plausibly exist over the duration of the accident without discovery and isolation of this source." This value was used in the Amendment 98, 113, and 114 submittals.
2. Section 6.2: Regulatory Guide 1.183, Appendix A, Section 6.2 states that the Main Steam Isolation Valves should be assumed to leak at the technical specification maximum allowable value and be assumed to be released for the duration of the event. RBS has the MS-PLCS system which will pressurize the main steam lines (even with the failure of one MSIV) and terminate the leakage. Therefore, MSIV leakage is terminated 25 minutes into the event (20 minutes for the operators to manually start the system and 5 minutes for it to become fully operational).

ATTACHMENT A: CONFORMANCE TO REGULATORY GUIDE 1.183 ASSUMPTIONS

Regulatory Guide 1.183, Appendix A, provides guidance for applying AST assumptions to the DBA-LOCA analysis. This attachment documents the conformance of this analysis to the requirements of Regulatory Guide 1.183.

Source Term Assumptions

1. Acceptable assumptions regarding core inventory and the release of radionuclides from the fuel are provided in Regulatory Position 3 of this guide.

RBS Response: RBS complies with all of the requirements of Regulatory Position 3 as discussed below.

Regulatory Position 3 of Regulatory Guide 1.183 has several requirements:

3.1 Fission Product Inventory

The inventory of fission products in the reactor core and available for release to the containment should be based on the maximum full power operation of the core with, as a minimum, current licensed values for fuel enrichment, burnup, and assumed core thermal power equal to the current licensed rated thermal power times the ECCS evaluation uncertainty. The periods of irradiation should be of sufficient duration to allow the activity of dose significant radionuclides to reach equilibrium or to reach maximum values. ...

RBS Response: The source term used in this analysis is the GE generic BWR ST. GE Power Uprate Task Report 31.1 recommended the source term for use at RBS. The ST used is based on 102% of RTP. This analysis complies with these requirements in their entirety.

3.2 Release Fractions

The core inventory release fractions, by radionuclide groups, for gap and early in-vessel damage phases for DBA LOCAs are listed in Table 1 for BWRs ... These fractions are applied to the equilibrium core inventory described in Regulatory Position 3.1.

RBS Response: The values from Table 1 of Regulatory Guide 1.183 are used in this analysis. This analysis complies with these requirements in their entirety.

3.3 Timing of Release Phases

Table 4 tabulates the onset and duration of each sequential phase for DBA LOCAs at PWRs and BWRs. The specified onset is the time following the initiation of the accident (i.e., time = 0). The early in-vessel phase immediately follows the gap release phase. The activity released from the core during each release phase should be modeled as increasing in a linear fashion over the duration of the phase.

RBS Response: The values from Table 4 of Regulatory Guide 1.183 are assumed in this analysis. The RADTRAD computer code inherently treats the release as linear. Therefore, RBS complies with these requirements in their entirety.

3.4 Radionuclide Composition

Table 5 lists the elements in each radionuclide group that should be considered in design basis analyses.

RBS Response: RBS modified the RADTRAD BWR default nuclide inventory file to account for the values found in GE Power Uprate Task Report 31.1. As such all nuclides of concern were included in the analysis. RBS complies with this requirement in their entirety.

3.5 Chemical Form

Of the radioiodine released from the RCS to the containment in a postulated accident, 95% of the iodine released should be assumed to be cesium iodide, 4.85% elemental iodine, and 0.15% organic iodide. This includes releases from the gap and fuel pellets. With the exception of elemental and organic iodine and noble gases, fission products should be assumed to be in particulate form.

RBS Response: The chemical fractions prescribed in Section 3.5 were used in this analysis, therefore, RBS complies with this requirement in their entirety.

3.6 Fuel Damage in Non-LOCA DBAs

RBS Response: Not applicable to this analysis since this calculation evaluates a DBA-LOCA.

2. If the sump or suppression pool pH is controlled at values of 7 or greater, the chemical form of radioiodine released to the containment should be assumed to be 95% cesium iodide (CsI), 4.85 percent elemental iodine, and 0.15 percent organic iodide. Iodine species, including those from iodine re-evolution, for sump or suppression pool pH values less than 7 will be evaluated on a case-by-case basis. Evaluations of pH should consider the effect of acids and bases created during the LOCA event, e.g., radiolysis products. With the exception of elemental and organic iodine and noble gases, fission products should be assumed to be in particulate form.

*RBS Response: This calculation assumes that the pH of the suppression pool remains >7, thus, the chemical distribution prescribed above is used. The suppression pool pH analysis was performed by calculation G13.18.14.0*196. Therefore, RBS complies with these requirements in their entirety.*

Assumptions on Transport in Primary Containment

3. Acceptable assumptions related to the transport, reduction, and release of radioactive material in and from the primary containment in PWRs or the drywell in BWRs are as follows:

3.1 The radioactivity released from the fuel should be assumed to mix instantaneously and homogeneously throughout the free air volume of the primary containment in PWRs or the drywell in BWRs as it is released. This distribution should be adjusted if there are internal compartments that have limited ventilation exchange. The suppression pool free air volume may be included provided there is a mechanism to ensure mixing between the drywell to the wetwell. The release into the containment or drywell should be assumed to terminate at the end of the early in-vessel phase.

RBS Response: This requirement in inherently met through the use of the RADTRAD computer code. Specifically, RADTRAD assumes a homogeneous mixture throughout each node. The volume for the containment does not include the volume of the suppression pool. RBS complies with these requirements in their entirety.

3.2 Reduction in airborne radioactivity in the containment by natural deposition within the containment may be credited. Acceptable models for removal of iodine and aerosols are described in Chapter 6.5.2, "Containment Spray as a Fission Product Cleanup System," of the Standard Review Plan (SRP), NUREG-0800 and in NUREG/CR-6189, "A Simplified Model of Aerosol Removal by Natural Processes in Reactor Containments." The latter model is incorporated into the analysis code RADTRAD. The prior practice of deterministically assuming that a 50% plateout of iodine is released from the fuel is no longer acceptable to the NRC staff as it is inconsistent with the characteristics of the revised source terms.

RBS Response: Natural deposition of iodine is credited. The deposition of particulate iodine is based on the Power's Model with a 10% confidence interval which is based on NUREG-6189 methodology. The removal coefficient for elemental iodine is based on data obtained from NUREG/CR-0009.The practice of assuming 50% plateout of iodine is not employed. As such, RBS complies with these requirements.

3.3 Reduction in airborne radioactivity in the containment by containment spray systems that have been designed and are maintained in accordance with Chapter 6.5.2 of the SRP may be credited. Acceptable models for the removal of iodine and aerosols are described in Chapter 6.5.2 of the SRP and NUREG/CR-5966, "A Simplified Model of Aerosol Removal by Containment Sprays". This simplified model is incorporated into the analysis code RADTRAD.
The evaluation of the containment sprays should address areas within the primary containment that are not covered by the

spray drops. The mixing rate attributed to natural convection between sprayed and unsprayed regions of the containment building, provided that adequate flow exists between these regions, is assumed to be two turnovers of the unsprayed regions per hour, unless other rates are justified. The containment building atmosphere may be considered a single, well-mixed volume if the spray covers at least 90% of the volume and if adequate mixing of unsprayed compartments can be shown.
The SRP sets forth a maximum decontamination factor (DF) for elemental iodine based on the maximum iodine activity in the primary containment atmosphere when the sprays actuate, divided by the activity of iodine remaining at some time after decontamination. The SRP also states that the particulate iodine removal rate should be reduced by a factor of 10 when a DF of 50 is reached. The reduction in the removal rate is not required if the removal rate is based on the calculated time-dependent airborne aerosol mass. There is no specified maximum DF for aerosol removal by sprays. The maximum activity to be used in determining the DF is defined as the iodine activity in the columns labeled "Total" in Tables 1 and 2 of this guide multiplied by 0.05 for elemental iodine and by 0.95 for particulate iodine (i.e., aerosol treated as particulate in SRP methodology).

RBS Response: River Bend does not have containment sprays, therefore, none are credited in this analysis. This is not applicable to RBS.

3.4 Reduction in airborne radioactivity in the containment by in-containment recirculation filter systems may be credited if these systems meet the guidance of Regulatory Guide 1.52 and Generic Letter 99-02. The filter media loading caused by the increased aerosol release associated with the revised source term should be addressed.

RBS Response: River Bend does not have in-containment recirculation filters, therefore, none are credited in this analysis. This is not applicable to RBS.

3.5 Reduction in airborne radioactivity in the containment by suppression pool scrubbing in BWRs should generally not be credited. However, the staff may consider such reduction on an individual case basis. The evaluation should consider the relative timing of the blowdown and the fission product release from the fuel, the force driving the release through the pool, and the potential for any bypass of the suppression pool. Analyses should consider iodine re-evolution if the suppression pool liquid pH is not maintained greater than 7.

RBS Response: Suppression pool scrubbing is not credited, therefore, RBS complies with these requirements.

3.6 Reduction in airborne radioactivity in the containment by retention in ice condensers, or other engineering safety features not addressed above, should be evaluated on an individual case basis. See Section 6.5.4 of the SRP.

RBS Response: RBS does not have ice condensers. This is not applicable.

3.7 The primary containment (i.e., drywell for Mark I and II containment designs) should be assumed to leak at the peak pressure technical specification leak rate for the first 24 hours. ... For BWRs, leakage may be reduced after the first 24 hours, if supported by plant configuration and analyses, to a value not less than 50% of the technical specification leak rate. Leakage from subatmospheric containments is assumed to terminate when the containment is brought to and maintained at a subatmospheric condition as defined by technical specifications.

For BWRs with Mark III containments, the leakage from the drywell into the primary containment should be based on the steaming rate of the heated reactor core, with no credit for core debris relocation. This leakage should be assumed during the two-hour period between the initial blowdown and termination of the fuel radioactivity release (gap and early in-vessel release phases). After two hours, the radioactivity is assumed to be uniformly distributed throughout the drywell and the primary containment.

RBS Response: For the first 24 hours containment is assumed to leak at the proposed new technical specification leakage rate of 0.325 volume % per hour. After 24 hours this value is reduced to 55% of that value based on containment thermal hydraulic analyses. Prior to 30 minutes the steaming rate assumed is based on RBS analyses which demonstrate that the drywell reaches a vacuum roughly 8 minutes into the event due to condensing steam. The RBS analyses do not account for the operation of the hydrogen mixing system which is assumed to be initiated 30 minutes into the event. The steaming rate assumed at that time 3000 cfm based on the GGNS analysis as RBS does not have a site specific analysis. An additional

600 cfm is exchanged between the DW and containment to account for the hydrogen mixing system itself. At 1.9 hours a very high exchange rate (1E8) is assumed between the 2 nodes to homogenize both volumes. Based on this review it is concluded that RBS meets these requirements in their entirety.

3.8 If the primary containment is routinely purged during power operations, releases via the purge system prior to containment isolation should be analyzed and the resulting doses summed with the postulated doses from other release paths. The purge release evaluation should assume that 100% of the radionuclide inventory in the reactor coolant system liquid is released to the containment at the initiation of the LOCA. This inventory should be based on the technical specification reactor coolant system equilibrium activity. Iodine spikes need not be considered. If the purge system is not isolated before the onset of the gap release phase, the release fractions associated with the gap release and early in-vessel phases should be considered as applicable.

RBS Response: RBS is routinely purged during normal operations, however, the contribution to off-site and MCR doses due to the reactor coolant release phase was deemed to be negligible. First, RBS has two purge modes. The normal purge mode releases 7,000 scfm and the high volume purge releases 12,500 cfm. Both release modes are filtered. The containment purge is terminated immediately upon receipt of a LOCA signal. Other analyses have demonstrated that the dose contribution due to a puff release of all reactor coolant was not significant (<5% of the regulatory values). Since only a small fraction of the containment atmosphere would potentially be released it is clear that the dose consequences of the coolant phase are insignificant, and therefore, they are neglected.

Assumptions on Dual Containments

4. For facilities with dual containment systems, the acceptable assumptions related to the transport, reduction, and release of radioactive material in and from the secondary containment or enclosure buildings are as follows.

4.1 Leakage from the primary containment should be considered to be collected, processed by engineered safety feature (ESF) filters, if any, and released to the environment via the secondary containment exhaust system during periods in which the secondary containment has a negative pressure as defined in technical specifications. Credit for an elevated release should be assumed only if the point of physical release is more than two and one-half times the height of any adjacent structure.

RBS Response:
The positive pressure period used in this analysis was 30 minutes. Following the drawdown of secondary containment, leakage into the Annulus and Auxiliary Building is assumed to be processed by SGTS. The X/Q values used by this analysis assume ground level releases. Therefore, RBS complies with these requirements in their entirety.

4.2 Leakage from the primary containment is assumed to be released directly to the environment as a ground-level release during any period in which the secondary containment does not have a negative pressure as defined in technical specifications.

*RBS Response: This analysis does not credit holdup or filtration by secondary containment for the first 30 minutes of the event. Calculations G13.18.2.7*023_ADDA and ES-194_ADDA demonstrate that this assumption is valid. Specifically, those analyses demonstrate that the Annulus and Auxiliary Building will be ≤-0.25" w.g. within 30 minutes of the break even with manual initiation of SGTS 20 minutes into the event. Therefore, RBS complies with these requirements in their entirety.*

4.3 The effect of high wind speeds on the ability of the secondary containment to maintain a negative pressure should be evaluated on an individual case basis. The wind speed to be assumed is the 1-hour average value that is exceeded only 5% of the total number of hours in the data set. Ambient temperatures used in these assessments should be the 1-hour average value that is exceeded only 5% or 95% of the total numbers of hours in the data set, whichever is conservative for the intended use (e.g., if high temperatures are limiting, use those exceeded only 5%).

RBS Response: These potential affects were addressed during initial licensing of the plant. USAR Section 6.2.3 states " The secondary containment, in conjunction with the operation of the SGTS, is designed to achieve and maintain an external post-LOCA pressure of at least -1/2 in W.G. in the annulus and at least -1/4 in W.G. in the auxiliary building and the fuel building relative to the outside atmosphere, and prevents exfiltration at wind speeds less than or equal to

17.5 mph." *USAR Table 2.3-43 contains the hourly average wind speed data for 3/17/77 through 3/16/79. The Table shows only 69 hours out of 14050 hours for the 13-25 mph range, therefore, it is clear that secondary containment meets the wind speed requirements. Temperature induced differential pressures was addressed at RBS. It is not of significant concern at RBS due to that that the plant is located in the South. The analyses to support the drawdown requirements accounted for differential temperatures. Additionally, the differential pressure for secondary containment is typically significantly greater than the 0.5 and 0.25 required for the Annulus and Auxiliary Building, respectively. The bounding requirement for SGTS is the drawdown time, thus, the annulus and auxiliary building pressures easily exceed the minimum requirements by several inches water gauge. Based on this review it is clear that RBS meets these requirements in their entirety.*

4.4 Credit for dilution in the secondary containment may be allowed when adequate means to cause mixing can be demonstrated. Otherwise, the leakage from the primary containment should be assumed to be transported directly to exhaust systems without mixing. Credit for mixing, if found to be appropriate, should generally be limited to 50%. This evaluation should consider the magnitude of the containment leakage in relation to contiguous building volume or exhaust rate, the location of exhaust plenums relative to projected release locations, the recirculation ventilation systems, and internal walls and floors that impede stream flow between the release and the exhaust.

RBS Response: This analysis only credits 50% of the free air volume for both the annulus and the auxiliary buildings. This is consistent with all of the previous LOCA analyses. The annulus has the annulus mixing system which effectively dilutes the annulus atmosphere. The location and flow rates of the SGTS dampers for the auxiliary building, in addition to the unit coolers located in the aux. building, ensure that the dilution assumed in the analysis is appropriate. As such RBS complies with these requirements in their entirety.

4.5 Primary containment leakage that bypasses the secondary containment should be evaluated at the bypass leak rate incorporated in the technical specifications. If the bypass leakage is through water, e.g., via a filled piping run that is maintained full, credit for retention of iodine and aerosols may be considered on a case-by-case basis. Similarly, deposition of aerosol radioactivity in gas-filled lines may be considered on a case-by-case basis.

RBS Response: This analysis explicitly evaluates leakage that bypasses secondary containment via the secondary containment bypass (SCB) leakage term. SCB penetrations are tested in accordance with Appendix J and the site LLRT program. No credit is taken for retention in water filled lines. As such RBS complies with these requirements in their entirety.

4.6 Reduction in the amount of radioactive material released from the secondary containment because of ESF filter systems may be taken into account provided that these systems meet the guidance of Regulatory Guide 1.52 and Generic Letter 99-02.

RBS Response: Credit is taken for filtration by the SGT and MCRFA systems. These systems meet GL 99-02 and Regulatory Guide 1.52 assumptions. Therefore, RBS meets these requirements in their entirety.

Assumptions on ESF System Leakage

5. ESF systems that recirculate sump water outside of the primary containment are assumed to leak during their intended operation. This release source includes leakage through valve packing glands, pump shaft seals, flanged connections, and other similar components. This release source may also include leakage through valves isolating interfacing systems. The radiological consequences from the postulated leakage should be analyzed and combined with consequences postulated for other fission product release paths to determine the total calculated radiological consequences from the LOCA. The following assumptions are acceptable for evaluating the consequences of leakage from ESF components outside the primary containment for BWRs and PWRs.

5.1 With the exception of noble gases, all the fission products released from the fuel to the containment (as defined in Tables 1 and 2 of this guide) should be assumed to instantaneously and homogeneously mix in the primary containment sump water (in PWRs) or suppression pool (in BWRs) at the time of release from the core. In lieu of this deterministic approach, suitably conservative mechanistic models for the transport of airborne activity in containment to the sump water may be used. Note that many of the parameters that make spray and deposition models conservative with regard to containment airborne leakage are nonconservative with regard to the buildup of sump activity.

RBS Response: For the liquid leakage term (ESF leakage), all activity other than Noble Gases is released directly to the suppression pool as soon as it is released by the core. Therefore, RBS meets these requirements in their entirety.

5.2 The leakage should be taken as two times the sum of the simultaneous leakage from all components in the ESF recirculation systems above which the technical specifications, or licensee commitments to item III.D.1.1 of NUREG-0737, would require declaring such systems inoperable. The leakage should be assumed to start at the earliest time the recirculation flow occurs in these systems and end at the latest time the releases from these systems are terminated. Consideration should also be given to design leakage through valves isolating ESF recirculation systems from tanks vented to atmosphere , e.g., emergency core cooling system (ECCS) pump min-flow return to the refueling water storage tank..

RBS Response: RBS does not have any technical specification which is tied directly to this leakage term. This analysis assumes 1 gpm. This value is based on the RBS SER. It was considered by the NRC to be the maximum leakage that could "plausibly exist" without identification and isolation of the source. This leakage is assumed to be occurring at the onset of fuel damage and is assumed to last for the duration of the event. <u>This is considered an exception to Regulatory Guide 1.183 requirements.</u>

5.3 With the exception of iodine, all radioactive materials in the recirculating liquid should be assumed to be retained in the liquid phase.

RBS Response: This analysis assumes that only iodine is released to the environment as a result of ESF leakage. Therefore, RBS meets this requirement in its entirety.

5.4 If the temperature of the leakage exceeds 212°F, the fraction of total iodine in the liquid that becomes airborne should be assumed equal to the fraction of the leakage that flashes to vapor. This flash fraction, FF, should be determined using a constant enthalpy, h, process, based on the maximum time-dependent temperature of the sump water circulating outside the containment.

RBS Response: The maximum design temperate for the suppression pool is 185 °F, therefore, this is not applicable to RBS.

5.5 If the temperature of the leakage is less than 212°F or the calculated flash fraction is less than 10%, the amount of iodine that becomes airborne should be assumed to be 10% of the total iodine activity in the leaked fluid, unless a smaller amount can be justified based on the actual sump pH history and area ventilation.

RBS Response: The flash fraction for ESF leakage assumed in this analysis is 10%, therefore, RBS meets this requirement in its entirety.

5.6 The radioiodine that is postulated to be available for release to the environment is assumed to be 97% elemental and 3% organic. Reduction in release activity by dilution or holdup within buildings, or by ESF ventilation filtration systems, may be credited where applicable. Filter systems used in these applications should be evaluated against the guidance of Regulatory Guide 1.52 and Generic Letter 99-02.

RBS Response: This analysis assumes 97% elemental and 3% organic for iodines released as a result of ESF leakage. As discussed above, SGTS meets GL 99-02 and Regulatory Guide 1.52 requirements. Therefore, RBS meets these requirements in their entirety.

Assumptions on Main Steam Isolation Valve Leakage in BWRS

6. For BWRs, the main steam isolation valves (MSIVs) have design leakage that may result in a radioactivity release. The radiological consequences from postulated MSIV leakage should be analyzed and combined with consequences postulated for other fission product release paths to determine the total calculated radiological consequences from the LOCA. The following assumptions are acceptable for evaluating the consequences of MSIV leakage.

6.1 For the purpose of this analysis, the activity available for release via MSIV leakage should be assumed to be that activity determined to be in the drywell for evaluating containment leakage (see Regulatory Position 3). No credit should be assumed for activity reduction by the steam separators or by iodine partitioning in the reactor vessel.

RBS Response: The MSIV leakage term is assumed to be released directly from the drywell atmosphere. No credit is taken for activity reduction by the steam separators or by iodine partitioning in the reactor vessel. Therefore, RBS meets these requirements in their entirety.

6.2 All the MSIVs should be assumed to leak at the maximum leak rate above which the technical specifications would require declaring the MSIVs inoperable. The leakage should be assumed to continue for the duration of the accident. Postulated leakage may be reduced after the first 24 hours, if supported by site-specific analyses, to a value not less than 50% of the maximum leak rate.

RBS Response: The allowable leakage rate for each division of the MSIVs (and the drain line isolation valves) is 150 scfh at Pa. This analysis assumed a failure of 1 MSIV (in addition to the failure of one EDG). The leakage rate through the second MSIV is assumed to be 50 scfh rather than the total allowable leakage rate of 150 scfh. No leakage is assumed from the remainder of the MSLs. Attachment B demonstrates that the MSIVs close such that the pressure between the valves is significantly higher than containment for at least 2 hours. Note that the RELAP analysis was performed at pre-uprate operational conditions, however, engineering judgement and the results clearly support the assumption that no leakage would occur for the first 25 minutes. RBS has the Main Steam Positive Leakage Control System (MSPLCS). Division I pressurizes the volume between the MSIVs. Division II pressurizes the 98 valves. This system is assumed to be initiated 20 minutes into the event. It further assumes an additional 5 minutes for the system to fully pressurize. This the MSIV release is terminated 25 minutes into the event. This is considered an exception to Regulatory Guide 1.183 requirements.

6.3 Reduction of the amount of released radioactivity by deposition and plateout on steam system piping upstream of the outboard MSIVs may be credited, but the amount of reduction in concentration allowed will be evaluated on an individual case basis. Generally, the model should be based on the assumption of well-mixed volumes, but other models such as slug flow may be used if justified.

RBS Response: This analysis did not credit any deposition or plateout on the Main Steam piping. Therefore, RBS meets these requirements in their entirety.

6.4 In the absence of collection and treatment of releases by ESFs such as the MSIV leakage control system, or as described in paragraph 6.5 below, the MSIV leakage should be assumed to be released to the environment as an unprocessed, ground-level release. Holdup and dilution in the turbine building should not be assumed.

RBS Response: The MSIV leakage is assumed to be released from the turbine building as a unprocessed ground level release. It is terminated at 25 minutes when the MSPLCS

6.5 A reduction in MSIV releases that is due to holdup and deposition in main steam piping downstream of the MSIVs and in the main condenser, including the treatment of air ejector effluent by offgas systems, may be credited if the components and piping systems used in the release path are capable of performing their safety function during and following a safe shutdown earthquake (SSE). The amount of reduction allowed will be evaluated on an individual case basis.

RBS Response: This analysis did not credit any holdup or deposition in the main steam piping or the main condenser. Therefore, RBS meets these requirements in their entirety.

Assumption on Containment Purging

7. The radiological consequences from post-LOCA primary containment purging as a combustible gas or pressure control measure should be analyzed. If the installed containment purging capabilities are maintained for purposes of severe accident management and are not credited in any design basis analysis, radiological consequences need not be evaluated. If the primary containment purging is required within 30 days of the LOCA, the results of this analysis should be combined with consequences postulated for other fission product release paths to determine the total calculated radiological consequences from the LOCA. Reduction in the amount of radioactive material released via ESF filter systems may be taken into account provided that these systems meet the guidance in Regulatory Guide 1.52 (Ref. A-5) and Generic Letter 99-02 (Ref. A-6).

RBS Response: RBS does not require containment purging during a design basis event, therefore, this is not applicable to RBS.

ATTACHMENT B: CD AND FILE LOG

The following computer files were generated for this calculation and are stored on the attached CD-ROM.

File Name	Description	Application	Run Date
tr31_1.nif	Nuclide input file. This file is described in Section 6.4.1.	RADTRAD	9/15/03
bwr_dba.rft	Release fraction and timing file for the design basis event. This file is described in Section 6.4.2.	RADTRAD	9/15/03
bwr_i.rft	Release fraction and timing file for the design basis event. This file is described in Section 7.3.4.	RADTRAD	9/15/03
fgr11&12.inp	This is the file containing the dose conversion factors from Federal Guidance Reports 11 and 12. This is the default file the accompanied the program.	RADTRAD	9/15/03
loca_con.psf	Plant scenario file for the calculation of the contribution of the LOCA doses from primary and secondary containment leakage. This file is described in Section 7.1.	RADTRAD	9/15/03
loca_con.o0	Output file for the calculation of the contribution of the LOCA doses from primary and secondary containment leakage.	RADTRAD	9/15/03
loca_scb.psf	Plant scenario file for the calculation of the contribution of the LOCA doses from secondary containment bypass. This file is described in Section 7.2.	RADTRAD	9/15/03
loca_scb.o0	Output file for the calculation of the contribution of the LOCA doses from secondary containment bypass.	RADTRAD	9/15/03
loca_esf.psf	Plant scenario file for the calculation of the contribution of the LOCA doses from ESF leakage. This file is described in Section 7.3.	RADTRAD	9/15/03
loca_esf.o0	Output file for the calculation of the contribution of the LOCA doses from ESF leakage.	RADTRAD	9/15/03
calculation.doc	This document.	MS-WORD	10/01/03

Project File On CD-ROM