ADDITIONAL ATTACHMENTS TO
10-10-05 Letter: Supplement to Request for LAR Application of AST

Attachment 007 AST –.LM-0644 Rev 1 MSLB.

ATTACHMENT 1
Design Analysis Cover Sheet

Design Analysis (Major Revision) — **Last Page No.** [6] 17 / Att. B-1

Analysis No.: [1] LM-0644 — **Revision:** [2] 1

Title: [3] Reanalysis Of Main Steam Line Break (MSLB) Accident Using Alternative Source Terms

EC/ECR No.: [4] 04-00003 — **Revision:** [5] 0

Station(s): [7]	Limerick	**Component(s):** [14]
Unit No.: [8]	1	
Discipline: [9]	MEDC	
Descrip. Code/Keyword: [10]	H84 /AST, MSLB	
Safety/QA Class: [11]	SR	
System Code: [12]	VC & MS	
Structure: [13]		

CONTROLLED DOCUMENT REFERENCES [15]

Document No.:	From/To	Document No.:	From/To
Calculation LM-0641, Rev. 0	From		
Calculation LM-0311, Rev. 0	From		
Calculation LM-0642, Rev. 0	From		

Is this Design Analysis Safeguards Information? [16] Yes ☐ No ☒ — If yes, see SY-AA-101-106

Does this Design Analysis contain Unverified Assumptions? [17] Yes ☐ No ☒ — If yes, ATI/AR#:

This Design Analysis SUPERCEDES: [18] LM-0644, Rev. 0 in its entirety.

Description of Revision (list affected pages for partials): [19]

This revision incorporates responses to pertinent NRC Requests for Additional Information (RAIs) with respect to all Exelon Nuclear Station Alternative Source Term License Amendment Applications. A new total reactor water mass release from the break of 140,000 lbs is utilized as a bounding value from Standard Review Plan 15.6.4 for MSLB dose analysis purposes only for all Exelon Boiling Water Reactor plants. In addition, Cesium release from the main steam line as Cesium Iodine is included. Finally, additional assumptions from Regulatory Guide 1.183 are included to directly indicate conformance with this Regulatory Guide.

Preparer: [20] Harold Rothstein (Print Name) — Harold Rothstein (Sign Name) — 9/16/2005 (Date)

Method of Review: [21] Detailed Review ☒ — Alternate Calculations (attached) ☐ — Testing ☐

Reviewer: [22] Paul Reichert (Print Name) — Paul Reichert (Sign Name) — 9/16/2005 (Date)

Review Notes: [23] Independent review ☒ Peer review ☐
Independent 3rd Party reviews by D. Strawson (MPR), J. Johnson (S&L)

(For External Analyses Only)
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Is a Supplemental Review Required? [26] Yes ☐ No ☒ If yes, complete Attachment 3 — based on Independent 3rd Party Reviews.

Exelon Approver: [27] Elliott Flick (Print Name) — Elliott Flick (Sign Name) — 9/20/05 (Date)

CALCULATION TABLE OF CONTENTS

1.0 PURPOSE/OBJECTIVE

The purpose of this calculation is to determine the Control Room (CR), Exclusion Area Boundary (EAB), and Low Population Zone (LPZ) doses following a Main Steam Line Break (MSLB) Accident. This calculation is performed in accordance with Regulatory Guide (RG) 1.183 [Ref. 6] as described herein.

The principal attributes of this Revision 1 analysis compared to previous Revision 0 and prior analyses for this event under Standard Review Plan 15.6.4 guidance and 10CFR100 and 10CFR50, General Design Criterion 19 requirements are:

1. Doses are evaluated in terms of Total Effective Dose Equivalent (TEDE) and evaluated against 10CFR50.67 limits as modified by RG 1.183.
2. Noble gas releases are as previously analyzed and are not impacted by AST application.
3. Historically determined liquid reactor coolant and steam release continue to be the basis for the determination of the fact that no fuel damage results from an MSLB.
4. A simplified and more conservative basis is used for the determination of radionuclide releases based on a bounding reactor coolant blowdown value.
5. Cesium releases, as cesium iodide, are now considered in addition to iodine and noble gas release that have been historically assumed.

As per LGS UFSAR Section 15.6.4 [Ref. 1], this event involves the postulation that the largest steam line instantaneously and circumferentially breaks outside the primary containment at a location downstream of the outermost isolation valve, with this event representing the envelope evaluation of steam line failures outside primary containment. Closure of the Main Steam Isolation Valves (MSIVs) terminates the reactor coolant mass loss when the full closure is reached. No operator actions are assumed to be taken during the accident, and the radioactivity concentration inside the Control Room is considered the same as that just outside the intake (with a geometry factor applied for submersion doses) to address any degree of postulated unfiltered inleakage during the duration of the event.

The mass of coolant released during the MSLB is taken as a bounding value for all current Boiling Water Reactor (BWR) plants and for dose analysis purposes only of 140,000 pounds, as provided in Standard Review Plan 15.6.4, Paragraph III.2.a for a GESSAR-251 plant. This ensures that the discharge quantity and dose consequences are maximized, and that the releases should bound any other credible pipe break. As per UFSAR Section 15.6.4.4 and the Ref. 2 Calculation of Impact of Power Rerate on Main Steam Line Break Doses and Activities, a release of 88,333 pounds of reactor water and 20,452 pounds of steam applies, therefore the plant licensing basis mass release following a MSLB for consideration of the potential for fuel damage is the UFSAR Section 15.6.4 total of 108,785 lb of the primary coolant.

2.0 METHODOLOGY AND ACCEPTANCE CRITERIA

2.1 *General Description*

The radiological consequences resulting from a design basis MSLB accident to a person at the EAB; to a person at the LPZ; and to an operator in the Control Room following an MSLB accident were performed using a Microsoft EXCEL spreadsheet, provided as Attachment A.

2.2 *Source Term Model*

As noted in UFSAR Sections 15.6.4.2.1 and 15.6.4.3, no fuel damage is expected to result from a MSLB, as the core would be covered throughout the accident, and the temperature and pressure transients resulting as a consequence of the accident are insufficient to cause fuel damage. Therefore, the activity available for release from the break is that present in the reactor coolant and steam lines prior to the break, with two cases analyzed. Case 1 is for continued full power operation with a maximum equilibrium coolant concentration of 0.2 uCi/gm dose equivalent I-131 [Ref. 8]. Case 2 is for a maximum coolant concentration of 4.0 uCi/gm dose equivalent I-131, based on a pre-accident iodine spike caused by power changes. This accident source term basis meets the guidance in RG 1.183 for analysis of this event.

Inhalation Committed Effective Dose Equivalent (CEDE) Dose Conversion Factors (DCFs) from Federal Guidance Report (FGR) No. 11 [Ref. 3] and External Dose Equivalent (EDE) DCFs from FGR No. 12 [Ref. 4] are used.

2.3 *Release Model*

Noble gas releases are those historically determined to correspond to 0.35 Ci /sec offgas release rate after 30 minutes delay. These release quantities are taken from Ref. 1.

Iodine releases are determined based on a release of 140,000 lbs of reactor coolant with either 0.2 uCi/gm or 4.0 uCi/gm of I-131 dose equivalent activity per Technical Specification 3.4.5.

The iodine species released from the main steam line are assumed to be 95% CsI as an aerosol, 4.85% elemental, and 0.15% organic. Therefore, 95% of iodine releases have an atom equivalent cesium release. Cesium isotopic abundance is determined based on source terms developed for pH control for longer lived or stable isotope [Ref.11], and from ANSI/ANS-18.1-1999 [Ref.12] for shorter lived isotopes.

Releases are assumed to be instantaneous and no credit is taken for dilution in turbine building air.

2.4 *Dispersion Model*

2.4.1 EAB and LPZ

EAB and LPZ X/Q's are determined using the methodology in R.G. 1.5 [Ref. 5]. Specifically:

$$\frac{\chi}{Q} = \frac{0.0133}{\sigma_y u}$$

where

σ_y = horizontal standard deviation of the plume (meters)

u = wind velocity (meters/second)

Horizontal standard deviations are taken from the PAVAN outputs for the EAB and LPZ included in Rev. 0 of Calculation LM-0641 [Ref. 9]. Per R.G. 1.5, F stability and a 1 meter/sec wind speed are used.

2.4.2 Control Room

For control room dose calculations, the plume was modeled as a hemispherical volume, the dimensions of which are determined based on the portion of the liquid reactor coolant release that flashed to steam at atmospheric pressure. The activity of the cloud is based on the total mass of water released from the break. This assumption is conservative because it considers the maximum release of fission products.

Activity release is conservatively assumed to effectively occur at the Control Room intake elevation and, again conservatively, no credit is taken for plume buoyancy.

Although Control Room X/Q values do not apply to this calculation, equivalent X/Q's are developed in the spreadsheet contained in Attachment A.

2.5 ***Dose Model***

Dose models for both onsite and offsite meet R.G. 1.183 [Ref.6] requirements, providing results in units of Total Effective Dose Equivalent (TEDE). Dose conversion factors are based on Federal Guidance Reports 11 and 12 [Refs 3 & 4].

2.5.1 EAB and LPZ

Doses at the EAB and LPZ for the MSLB are based on the following formulas:

$$\text{Dose}_{\text{CEDE}}\ (\text{rem}) = \text{Release (Curies)} * \frac{\chi}{Q}(\text{sec/m}^3) * \text{Breathing Rate (m}^3\text{/sec)} * \text{Inhalation DCF (rem}_{\text{CEDE}}\text{/Ci inhaled)}$$

and

$$\text{Dose}_{\text{EDE}}\ (\text{rem}) = \text{Release (Curies)} * \frac{\chi}{Q}(\text{sec/m}^3) * \text{Submersion DCF (rem}_{\text{EDE}}\text{ - m}^3\text{/ Ci - sec)}$$

and finally,

$$\text{Dose}_{\text{TEDE}}\ (\text{rem}) = \text{Dose}_{\text{CEDE}}\ (\text{rem}) + \text{Dose}_{\text{EDE}}\ (\text{rem})$$

2.5.2 Control Room

CR operator doses are determined somewhat differently. Steam cloud concentrations are used, rather than X/Q times a curie release. No CR filter credit is taken and, therefore, for inhalation, a dose for a location outside of the CR is used. For cloud submersion, a geometry factor is used to credit the reduced plume size seen in the CR. This is a conservative implementation of RG 1.183 guidance. The formulas used are:

$$Dose_{CEDE}\ (rem) = Plume\ Concentration\ (Ci/m^3) * Transit\ Duration\ (sec) * Breathing\ Rate\ (m^3/sec) * Inhalation\ DCF\ (rem_{CEDE}/Ci\ inhaled)$$

and

$$Dose_{EDE}\ (rem) = Plume\ Concentration\ (Ci/m^3) * Transit\ Duration\ (sec) * Submersion\ DCF\ (rem_{EDE} - m^3/Ci - sec) * Geometry\ Factor$$

and finally,

$$Dose_{TEDE}\ (rem) = Dose_{CEDE}\ (rem) + Dose_{EDE}\ (rem)$$

2.6 *Acceptance Criteria*

Dose acceptance criteria are per 10CFR50.67 [Ref.7] and R.G. 1.183 [Ref. 6] guidance.

The following Table lists the regulatory limits for accidental dose to 1) a control room operator, 2) a person at the EAB, and 3) a person at the LPZ boundary.

Regulatory Dose Limits (Rem TEDE) per Refs. 6 and 7.

I-131 Dose Equivalent	CR (30 days)	EAB (2 hours)	LPZ (30 days
Normal Equilibrium	5	2.5	2.5
Iodine Spike	5	25	25

Direct conformance with the relevant guidance in Regulatory Guide 1.183 (e.g., the TEDE concept and the above limits) and in particular its assumptions provided in Appendix D "Assumptions for Evaluating the Radiological Consequences of a BWR Main Steam Line Break Accident" is provided by this analysis, as shown in the Conformance Matrix Table 2.1.

Table 2.1: Conformance with RG 1.183 Appendix D (Main Steam Line Break)

RG Section	RG Position	Limerick Analysis	Comments
1	Assumptions acceptable to the NRC staff regarding core inventory and the release of radionuclides from the fuel are provided in Regulatory Position 3 of this guide. The release from the breached fuel is based on Regulatory Position 3.2 of this guide and the estimate of the number of fuel rods breached.	Not Applicable	No fuel damage (as per Section 2.2), release estimate based on coolant activity.
2	If no or minimal fuel damage is postulated for the limiting event, the released activity should be the maximum coolant activity allowed by technical specification. The iodine concentration in the primary coolant is assumed to correspond to the following two cases in the nuclear steam supply system vendor's standard technical specifications.	Conforms	See 2.1 and 2.2 below
2.1	The concentration that is the maximum value (typically 4.0 μCi/gm DE I-131) permitted and corresponds to the conditions of an assumed pre-accident spike, and	Conforms	4.0 uCi/gm DE I-131 is a limit in Technical Specification (TS) 3.4.5 and is used in this analysis.
2.2	The concentration that is the maximum equilibrium value (typically 0.2 μCi/gm DE I-131) permitted for continued full power operation.	Conforms	0.2 uCi/gm DE I-131 is a limit in TS 3.4.5 and is used in this analysis.
3	The activity released from the fuel should be assumed to mix instantaneously and homogeneously in the reactor coolant. Noble gases should be assumed to enter the steam phase instantaneously.	Not Applicable	There is no activity released from the fuel as there is no fuel damage (as per Section 2.2).
4.1	The main steam line isolation valves (MSIV) should be assumed to close in the maximum time allowed by technical specifications.	Conforms	As a bounding mass release was used, the MSIV closure time was not used in the analysis. However, this closure time is considered in UFSAR Section 15.6.4 as 5.5 seconds, per the Technical Specification SR

Table 2.1: Conformance with RG 1.183 Appendix D (Main Steam Line Break)			
RG Section	**RG Position**	**Limerick Analysis**	**Comments**
			3.4.7 maximum allowed MSIV closure time of 5 seconds plus 0.5 seconds for instrument response.
4.2	The total mass of coolant released should be assumed to be that amount in the steam line and connecting lines at the time of the break plus the amount that passes through the valves prior to closure.	Conforms	A bounding value of 140,000 lbs of reactor coolant for a GESSAR-251 plant as provided in Standard Review Plan 15.6.4 is used for dose assessment. This bounds the RG Position total mass of coolant released.
4.3	All the radioactivity in the released coolant should be assumed to be released to the atmosphere instantaneously as a ground-level release. No credit should be assumed for plateout, holdup, or dilution within facility buildings.	Conforms	Release is assumed at ground level, with no credit taken for plateout, holdup or dilution within facility buildings, and the buoyancy effects of the steam neglected for conservatism. Activity releases considered are iodines, noble gases and cesium.
4.4	The iodine species released from the main steam line should be assumed to be 95% CsI as an aerosol, 4.85% elemental, and 0.15% organic.	Conforms	The subject values are used.

3.0 ASSUMPTIONS

3.1 *Activity Release and Transport*

- Iodine coolant activity isotopic distributions and Noble Gas activity releases are taken from Refs. 1 and 2.
- Cesium releases are based on the fact that a single cesium atom will accompany 95% of the released iodine atoms, and considering all of the iodine isotopes (including stable ones) from the End-of-Core condition per page B-14 of Ref. 11.
- Release from the break to the environment is assumed instantaneous. No holdup in the Turbine Building or dilution by mixing with Turbine Building air volume is credited.
- The steam cloud is assumed to consist of the portion of the liquid reactor coolant release that flashed to steam.
- The activity of the cloud is based on the total mass of water released from the break; i.e., the activity in water which does not flash to steam is conservatively added to the activity of the steam cloud.
- Buoyancy effect of the cloud was conservatively ignored.
- For the control room dose calculations,
  - The plume was modeled as a hemispherical volume. This is consistent with the assumption of no Turbine Building credit.
  - Dispersion of the activity of the plume was conservatively ignored.
  - The cloud was assumed to be carried away by a wind of speed 1 m/s. Credit is not taken for decay.

3.2 *Control Room*

- No credit was taken for the operation of the control room emergency filtration systems during the MSLB.
- Inhalation doses are determined based on concentrations at the intake, and exposures for the duration of plume traverse.
- External exposure doses are determined based on concentrations at the intake, exposures for the duration of plume traverse, and a geometry factor credit (Equation 1 of Ref. 6) based on the control room envelope volume of 126,000 cubic feet [Ref. 2]. As the LGS control room has no exterior walls or overlying structures that are less than 2 feet thick concrete, this cloud dose model is considered sufficient to eliminate separate consideration of the radiation shine from the external radioactive plume release.

4.0 DESIGN INPUT

4.1 *Mass Release Data*

- As stated in UFSAR Section 15.6.4.2.1, there is no fuel damage as a consequence of this accident. For this dose analysis, 140,000 lbs of reactor coolant is assumed to be released, which is more conservative than the 108,785 lb release in UFSAR Section 15.6.4.2.1.

4.2 *Iodine and Noble Gas Activity Release*

The MSLB Power Rerate Calculation [Ref. 2] provides the following concentrations of Iodine isotopes contained in the coolant:

Iodine Isotope	Activity (µCi/gm)
I-131	0.039
I-132	0.36
I-133	0.267
I-134	0.72
I-135	0.39

These are normalized to 0.2 uCi/gm for Case 1 and 4.0 uCi/gm for Case 2 in this calculation, as indicated in Section 6.3.

The UFSAR and MSLB Power Rerate Calculation [Refs. 1 and 2] provide the following Design Basis Accident releases for Noble Gases:

Noble Gas Isotope	Release Ci
Kr-83M	8.73E-02
Kr-85M	1.54E-01
Kr-85	5.97E-04
Kr-87	4.76E-01
Kr-88	4.88E-01
Kr-89	2.04
Xe-131M	4.87E-04
Xe-133M	7.30E-03
Xe-133	2.05E-01
Xe-135M	5.98E-01
Xe-135	5.52E-01
Xe-137	2.69
Xe-138	2.04

4.3 *Control Room Data*

- Control Room Envelope = 126,000 ft^3. [Ref. 1, Table 15.6-21 and Ref. 10]
- No Emergency Filtration Credit taken.

4.4 *EAB and LPZ Data*

- EAB Distance from Release, m 731 [Ref. 1, 9]
- LPZ Distance from Release, m 2043 [Ref. 1, 9]

5.0 REFERENCES

1. Limerick Generating Station Unit 1 & 2 UFSAR Section 15.6, Rev. 12.
2. LGS Design Analysis LM-0311, Rev. 0, "Impact of Power Rerate on Main Steam Line Break Doses and Activities".
3. Federal Guidance Report No. 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion", 1988.
4. Federal Guidance Report No. 12, "External Exposure to Radionuclides in Air, Water, and Soil", 1993.
5. Regulatory Guides 1.5, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Steam Line Break Accidents for Boiling Water Reactors," 3/10/71.
6. Regulatory Guide 1.183, "Alternative Radiological Source Terms For Evaluating Design Basis Accidents At Nuclear Power Reactors", July 2000.
7. 10 CFR Part 50.67, "Accident Source Term".
8. LGS Technical Specification Section 3.4.5, "Specific Activity".
9. LGS Design Analysis No. LM-0641, Rev. 0 "Calculation of Alternative Source Terms Onsite and Offsite X/Q Values".
10. LGS Calculation No. M-78-01, "Control Room Area – Room Volume", Rev. 6.
11. LGS Design Analysis No. LM-0642, Rev. 1 "Suppression Pool pH Calculation for Alternative Source Terms ".
12. American Nuclear Society Standard (ANS) 18.1-1999 "Radioactive Source Terms For Normal Operation of Light Water Reactors", Table 5.

6.0 CALCULATIONS

No fuel damage is expected for the limiting MSLB. As discussed in Section 2, two iodine concentrations are used (0.2 µCi/g and 4.0 µCi/g) [per Ref. 6] when determining the consequences of the main steam line break. All of the radioactivity in the released coolant is assumed to be released to the atmosphere instantaneously as a ground-level release. No credit is taken for plateout, holdup, or dilution within facility buildings.

The spreadsheets in Attachment A perform this analysis using data and formulations discussed above and shown in Attachment A. The following summarizes parameters and their treatment in the spreadsheet.

6.1 *Cloud Volumes, Masses, and Control Room Intake Transit Times*

The cloud is assumed to consist of the portion of the conservatively bounding liquid reactor coolant release that flashes to steam. The flashing fraction (FF) is derived as follows:

FF x (steam enthalpy at 212 F) + (1-FF) x (liquid enthalpy at 212 F) =
(liquid enthalpy at temperature of steam at reactor vessel outlet)

A 548 F vessel outlet temperature is used, with liquid enthalpy of 546.9 BTU/lb.
At 212 F, a steam enthalpy of 1150.5 BTU/lb and a liquid enthalpy of 180.17 BTU/lb are used (these enthalpies are taken from the ASME Steam Tables).

Substituting,

FF = (546.9 - 180.17) / [(1150.5 – 180.17)] = 0.378

For conservatism, a value of .40 or 40% is used.

As stated in Section 3.1, the cloud is assumed to consist of that portion of the liquid reactor coolant release that flashed to steam.

The mass of liquid water released	= 140,000 lb
Flashing fraction for calculating cloud volume	= 40%
The mass of water carrying activity into the cloud	= 140,000 lb
	= (140,000 lb)(453.59 g/lb)
	= 6.350E7 g
The mass of steam in the cloud	=40%*140,000 lb
	= 56,000 lb

The release is assumed to be a hemisphere with a uniform concentration. The cloud dimensions (based on 56,000 lb of steam at 14.7 psi and 212 °F, v_g = 26.799 ft^3/lb) were calculated as follows:

Volume = (56,000 lb)(26.799 ft^3/lb)
= 1,500,744 ft^3
= (1,500,744 ft^3)/(35.3 ft^3/m^3)
= 42,514 m^3

The volume of a hemisphere is $\pi d^3/12$. Thus, the diameter of the hemispherical cloud is 54.6 meters.

The period of time required for the cloud to pass over the control room intake, assuming a wind speed of 1 m/s is 54.6 s (=(54.6 m)/(1 m/s)). Therefore, at a wind speed of 1 m/s, the base of the hemispherical cloud will pass over the control room intake in 54.6 seconds.

6.2 ***Dispersion for Offsite Dose Assessment***

As discussed in Section 2.4.1 the following formulation was used for Offsite Dose X/Q assessment, with F Pasquill Stability and a 1 m/sec wind speed.

$$\frac{\chi}{Q} = \frac{0.0133}{\sigma_y u}$$

where

σ_y = horizontal standard deviation of the plume (meters)

u = wind velocity (meters/second)

As calculated in the PAVAN run in Ref. 9, at the 731 meter EAB distance σ_y is 27.9, and at the 2043 meter LPZ distance σ_y is 70.5. The resulting EAB and LPZ X/Qs are 4.77E-04 and 1.89E-04 sec/m^3, respectively.

6.3 ***Release Isotopics and Quantification***

The iodine, noble gas and cesium activity releases are given in Attachment A, which also determines resulting doses.

Noble gas releases are taken from the input in Section 4.2.

Iodine releases are based on reactor coolant isotopic distributions from Section 4.2, which are normalized based on FGR-11 CEDE dose conversion factors to obtain coolant concentrations corresponding to Case 1: 0.2 uCi/gm, and Case 2 4.0 uCi/gm, which are the TS 3.4.5 values. The resulting concentrations were multiplied by the 140,000 lbs of release converted to grams.

Cesium releases are based on the fact that a single cesium atom will accompany 95% of the released iodine atoms. The iodine isotopes (including stable ones) from the End-of-Core (EOC) condition per page B-14 of Ref. 11 are considered, with the total iodine moles calculated in Attachment A based on the ratio of the page B-14 total iodine gm-moles including I-127 and I-129 to the total on page B-14 of the radioactive iodine isotopes I-131 through I-135, times the total radioactive iodine moles for the activity releases for each of Cases 1 and 2. For Cs-133, Cs-134, Cs-135, and Cs-137, isotopic data (in Curies per Megawatt) for end of cycle conditions

from Ref. 11 were used. For shorter lived isotopes such as Cs-136 and Cs-138, the ratio of their concentration values in Reactor Water to that of Cs-137 in Ref. 12 is used to predict their relative concentrations. Releases reflect this distribution, with the molar fractions converted to curie quantities based on the isotope's decay constant. Cs-133, representing about 38% of the cesium, is stable.

6.4 *Dose Assessment*

Doses at the EAB and LPZ distances, and in the Control Room are calculated in Attachment A using the formulas in Section 2.5. Concentrations at the receptor locations are that in the steam plume for the Control Room or based on the release times the applicable X/Q for the EAB and LPZ.

Doses are calculated for inhalation (rem CEDE) and plume submersion (rem EDE) and totaled to yield rem TEDE. The breathing rate of 3.5E-04 m^3/sec is per RG 1.183 guidance.

The resulting calculated doses are in the spreadsheet and in the Summary and Conclusions Section below.

7.0 SUMMARY AND CONCLUSIONS

Accident doses from a design basis MSLB were calculated for the control room operator, a person at the EAB, and a person at the LPZ. Table 7.1 shows the CEDE and EDE contributions from iodines, noble gases and cesiums and the TEDE results are summarized in Table 7.2. The doses at the Control Room, EAB, and LPZ resulting from a postulated design basis MSLB are all below the regulatory limits.

TABLE 7.1

	CASE 1						CASE 2					
	Dose (rem CEDE) (Inhalation)			Dose (rem EDE) (External)			Dose (rem CEDE) (Inhalation)			Dose (rem EDE) (External)		
	CR	EAB	LPZ	CR	EAB	LPZ	CR	EAB	LPZ	CR	EAB	LPZ
Iodines	1.88E-01	6.97E-02	2.76E-02	4.38E-03	3.60E-02	1.42E-02	3.76E+00	1.39E+00	5.52E-01	8.75E-02	7.20E-01	2.85E-01
Cesiums	5.84E-03	2.17E-03	8.57E-04	3.51E-04	2.89E-03	1.14E-03	1.17E-01	4.33E-02	1.71E-02	7.03E-03	5.78E-02	2.29E-02
Noble Gases	N/A	N/A	N/A	4.45E-05	3.66E-04	1.45E-04	N/A	N/A	N/A	4.45E-05	3.66E-04	1.45E-04

TABLE 7.2

Location	Case 1 (normal equilibrium limit of 0.2 μCi) Dose (rem TEDE)	Case 2 (iodine spike limit of 4.0 μCi) Dose (rem TEDE)
LIMITS	CR: 5.0; EAB&LPZ: 2.5	CR: 5.0; EAB&LPZ: 25
EAB	1.11E-01	2.22E+00
LPZ	4.40E-02	8.77E-01
CR	1.98E-01	3.97E+00

8.0 OWNER'S ACCEPTANCE REVIEW CHECKLIST FOR EXTERNAL DESIGN ANALYSIS

DESIGN ANALYSIS NO. LM-0644 REV: 1

		Yes	No	N/A
1.	Do assumptions have sufficient rationale?	☑	☐	☐
2.	Are assumptions compatible with the way the plant is operated and with the licensing basis? (For AST)	☑	☐	☐
3.	Do the design inputs have sufficient rationale?	☑	☐	☐
4.	Are design inputs correct and reasonable?	☑	☐	☐
5.	Are design inputs compatible with the way the plant is operated and with the licensing basis? (For AST)	☑	☐	☐
6.	Are Engineering Judgments clearly documented and justified?	☑	☐	☐
7.	Are Engineering Judgments compatible with the way the plant is operated and with the licensing basis?	☑	☐	☐
8.	Do the results and conclusions satisfy the purpose and objective of the Design Analysis?	☑	☐	☐
9.	Are the results and conclusions compatible with the way the plant is operated and with the licensing basis? (For AST)	☑	☐	☐
10.	Does the Design Analysis include the applicable design basis documentation?	☑	☐	☐
11.	Have any limitations on the use of the results been identified and transmitted to the appropriate organizations? (AST Approval)	☑	☐	☐
12.	Are there any unverified assumptions?	☐	☑	☐
13.	Do all unverified assumptions have a tracking and closure mechanism in place?	☐	☐	☑
14.	Have all affected design analyses been documented on the Affected Documents List (ADL) for the associated Configuration Change?	☑	☐	☐
15.	Do the sources of inputs and analysis methodology used meet current technical requirements and regulatory commitments? (If the input sources or analysis methodology are based on an out-of-date methodology or code, additional reconciliation may be required if the site has since committed to a more recent code) (For AST)	☑	☐	☐
16.	Have vendor supporting technical documents and references (including GE DRFs) been reviewed when necessary?	☑	☐	☐

EXELON REVIEWER: T. J. Mscisz / [signature] DATE: 9/20/05
Print / Sign

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	LGS MSLB Dose Spreadsheet					Case 1:	Reactor Coolant at maximum value (DE I-131 of 0.2 uCi/cc) permitted for							
2							continued full power operation							
3	42,514	Volume of cloud (cubic meters)				Case 2:	Reactor Coolant at maximum value permitted (DE I-131 of 4.0 uCi/cc)							
4	6.35E+07	Mass of water in reactor coolant release (grams)					corresponding to an assumed pre-accident spike							
5	2.54E+07	Mass of steam release (grams)												
6	1	reactor coolant density when activity is measured (grams/cc)												
7	54.6	seconds for cloud to pass over CR intake for wind speed of 1 m/second												
8	126000	Volume of Control Room Envelope (cubic feet)												
9														
10	Halogens	Calc. LM-311							Case 1	Case 2				
11		Rev. 0							Release	Release				
12		Colant		Normalized	Case 1	Case 2	Case 1	Case 2	Cloud	Cloud		Case 1	Case 2	
13	Isotope	Activity	FGR 11	I-131 DE	Normalized	Normalized	Activity	Activity	Concentration	Concentration	Decay	Activity	Activity	
14		Concentration	DCF[1]	Activity	Activity	Activity	Release	Release			Constant	Release	Release	
15		uCi/gm	Rem/Ci	uCi/gm	uCi/gm	uCi/gm	Ci	Ci	Ci/m^3	Ci/m^3	1/seconds	moles	moles	
16	I-131	0.039	3.29E+04	3.90E-02	7.22E-02	1.44E+00	4.58E+00	9.17E+01	1.08E-04	2.16E-03	9.98E-07	2.82E-07	5.64E-06	
17	I-132	0.36	3.81E+02	4.17E-03	7.72E-03	1.54E-01	4.23E+01	8.46E+02	9.95E-04	1.99E-02	8.37E-05	3.10E-08	6.21E-07	
18	I-133	0.267	5.85E+03	4.74E-02	8.78E-02	1.76E+00	3.14E+01	6.28E+02	7.38E-04	1.48E-02	9.26E-06	2.08E-07	4.16E-06	
19	I-134	0.72	1.31E+02	2.87E-03	5.31E-03	1.06E-01	8.46E+01	1.69E+03	1.99E-03	3.98E-02	2.20E-04	2.37E-08	4.73E-07	
20	I-135	0.39	1.23E+03	1.46E-02	2.70E-02	5.40E-01	4.58E+01	9.17E+02	1.08E-03	2.16E-02	2.91E-05	9.67E-08	1.93E-06	
21				1.08E-01	2.00E-01	4.00E+00					Totals	6.42E-07	1.28E-05	
22					"non-spiked"	"spiked"								
23									Total moles with I-127 and I-129					
24									included from page B-14 of Ref. 11			2.37E-05	4.74E-04	
25														
26	Noble Gases							Iodine in Reactor Coolant Replacement Values for UFSAR						
27			Calc.		Case 1	Case 2		Sec. 15.6.4.5.1, adjusted to be 0.2 uCi/gm I-131 dose						
28			LM-311, Rev.		Release	Release				Activity				
29			0, Table 4		Cloud	Cloud			Isotope	(uCi/gm)				
30	Isotope		Activity		Concentration	Concentration			I-131	0.0722				
31			Release						I-132	0.666				
32			Ci		Ci/m^3	Ci/m^3			I-133	0.494				
33									I-134	1.33				
34	Kr-83M		8.73E-02		2.05E-06	2.05E-06			I-135	0.722				
35	Kr-85M		1.54E-01		3.62E-06	3.62E-06								
36	Kr-85		5.97E-04		1.40E-08	1.40E-08				Case 1	Case 2		Case 1	Case 2
37	Kr-87		4.76E-01		1.12E-05	1.12E-05				Activity	Activity	Decay	Activity	Activity
38	Kr-88		4.88E-01		1.15E-05	1.15E-05				Release	Release	Constant	Release	Release
39	Kr-89		2.04		4.80E-05	4.80E-05			Molar Frac.	moles	moles	1/seconds	curies	curies
40	Xe-131M		4.87E-04		1.15E-08	1.15E-08		Cs-134	4.4317%	9.98E-07	2.00E-05	1.07E-08	1.73E-01	3.46E+00
41	Xe-133M		7.30E-03		1.72E-07	1.72E-07		Cs-135	17.4506%	3.93E-06	7.86E-05	9.55E-15	6.11E-07	1.22E-05
42	Xe-133		2.05E-01		4.82E-06	4.82E-06		Cs-136	0.0120%	2.70E-09	5.40E-08	6.10E-07	2.68E-02	5.36E-01
43	Xe-135M		5.98E-01		1.41E-05	1.41E-05		CS-137	40.17%	9.05E-06	1.81E-04	7.28E-10	1.07E-01	2.14E+00
44	Xe-135		5.52E-01		1.30E-05	1.30E-05		Cs-138	0.0102%	2.30E-09	4.59E-08	3.59E-04	1.34E+01	2.68E+02
45	Xe-137		2.69		6.33E-05	6.33E-05		Totals	62.08%	1.40E-05	2.80E-04			
46	Xe-138		2.04		4.80E-05	4.80E-05		Balance is stable Cs-133						
47														

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
48	Inhalation Doses													
49			Curies Released				Case 1 Dose (rem CEDE)			Case 2 Dose (rem CEDE)				
50			to the Environment				(Inhalation)			(Inhalation)				
51	Isotope		Case 1	Case 2	DCF[1]	CR	EAB	LPZ	CR	EAB	LPZ			
52	I-131		4.58E+00	9.17E+01	3.29E+04	6.78E-02	2.52E-02	9.96E-03	1.36E+00	5.03E-01	1.99E-01			
53	I-132		4.23E+01	8.46E+02	3.81E+02	7.25E-03	2.69E-03	1.06E-03	1.45E-01	5.38E-02	2.13E-02			
54	I-133		3.14E+01	6.28E+02	5.85E+03	8.25E-02	3.06E-02	1.21E-02	1.65E+00	6.12E-01	2.42E-01			
55	I-134		8.46E+01	1.69E+03	1.31E+02	4.98E-03	1.85E-03	7.32E-04	9.97E-02	3.70E-02	1.46E-02			
56	I-135		4.58E+01	9.17E+02	1.23E+03	2.53E-02	9.41E-03	3.72E-03	5.07E-01	1.88E-01	7.45E-02			
57														
58	Cs-134		1.73E-01	3.46E+00	4.63E+04	3.60E-03	1.34E-03	5.29E-04	7.20E-02	2.67E-02	1.06E-02			
59	Cs-135		6.11E-07	1.22E-05	4.55E+03	1.25E-09	4.64E-10	1.84E-10	2.50E-08	9.28E-09	3.67E-09			
60	Cs-136		2.68E-02	5.36E-01	7.33E+03	8.83E-05	3.28E-05	1.30E-05	1.77E-03	6.55E-04	2.59E-04			
61	CS-137		1.07E-01	2.14E+00	3.19E+04	1.54E-03	5.71E-04	2.26E-04	3.08E-02	1.14E-02	4.52E-03			
62	Cs-138		1.34E+01	2.68E+02	1.01E+02	6.11E-04	2.27E-04	8.97E-05	1.22E-02	4.53E-03	1.79E-03			
63	**Sub-total (rem CEDE)**					**1.94E-01**	**7.19E-02**	**2.84E-02**	**3.87E+00**	**1.44E+00**	**5.69E-01**			
64														
65														
66			Curies Released				Case 1 Dose (rem EDE)			Case 2 Dose (rem EDE)				
67			to the Environment				(External)			(External)				
68	Isotope		Case 1	Case 2	DCF[2]	CR	EAB	LPZ	CR	EAB	LPZ			
69	I-131		4.58E+00	9.17E+01	6.73E-02	1.79E-05	1.47E-04	5.82E-05	3.58E-04	2.94E-03	1.16E-03			
70	I-132		4.23E+01	8.46E+02	4.14E-01	1.02E-03	8.36E-03	3.31E-03	2.03E-02	1.67E-01	6.62E-02			
71	I-133		3.14E+01	6.28E+02	1.09E-01	1.98E-04	1.63E-03	6.44E-04	3.96E-03	3.25E-02	1.29E-02			
72	I-134		8.46E+01	1.69E+03	4.81E-01	2.36E-03	1.94E-02	7.68E-03	4.72E-02	3.88E-01	1.54E-01			
73	I-135		4.58E+01	9.17E+02	2.95E-01	7.85E-04	6.45E-03	2.55E-03	1.57E-02	1.29E-01	5.11E-02			
74														
75	Cs-134		1.73E-01	3.46E+00	2.80E-01	2.81E-06	2.31E-05	9.15E-06	5.62E-05	4.62E-04	1.83E-04			
76	Cs-135		6.11E-07	1.22E-05	2.09E-06	7.41E-17	6.09E-16	2.41E-16	1.48E-15	1.22E-14	4.82E-15			
77	Cs-136		2.68E-02	5.36E-01	3.92E-01	6.10E-07	5.01E-06	1.98E-06	1.22E-05	1.00E-04	3.97E-05			
78	CS-137		1.07E-01	2.14E+00	2.86E-05	1.78E-10	1.46E-09	5.79E-10	3.56E-09	2.93E-08	1.16E-08			
79	Cs-138		1.34E+01	2.68E+02	4.48E-01	3.48E-04	2.86E-03	1.13E-03	6.96E-03	5.72E-02	2.26E-02			
80	**Sub-total (rem EDE)**					**4.73E-03**	**3.89E-02**	**1.54E-02**	**9.46E-02**	**7.78E-01**	**3.08E-01**			
81	**Iodine and Cesium Total (rem TEDE)**					**1.98E-01**	**1.11E-01**	**4.38E-02**	**3.97E+00**	**2.22E+00**	**8.77E-01**			
82														
83			Curies Released				Case 1 Dose (rem EDE)			Case 2 Dose (rem EDE)				
84			to the Environment				(External)			(External)				
85	Isotope		Case 1	Case 2	DCF[2]	CR	EAB	LPZ	CR	EAB	LPZ			
86	Kr-83M		8.73E-02	8.73E-02	5.55E-06	2.81E-11	2.31E-10	9.14E-11	2.81E-11	2.31E-10	9.14E-11			
87	Kr-85M		1.54E-01	1.54E-01	2.77E-02	2.47E-07	2.03E-06	8.04E-07	2.47E-07	2.03E-06	8.04E-07			
88	Kr-85		5.97E-04	5.97E-04	4.40E-04	1.52E-11	1.25E-10	4.96E-11	1.52E-11	1.25E-10	4.96E-11			
89	Kr-87		4.76E-01	4.76E-01	1.52E-01	4.21E-06	3.46E-05	1.37E-05	4.21E-06	3.46E-05	1.37E-05			
90	Kr-88		4.88E-01	4.88E-01	3.77E-01	1.07E-05	8.78E-05	3.47E-05	1.07E-05	8.78E-05	3.47E-05			
91	Kr-89		2.04	2.04E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			
92	Xe-131M		4.87E-04	4.87E-04	1.44E-03	4.06E-11	3.34E-10	1.32E-10	4.06E-11	3.34E-10	1.32E-10			
93	Xe-133M		7.30E-03	7.30E-03	5.07E-03	2.15E-09	1.76E-08	6.98E-09	2.15E-09	1.76E-08	6.98E-09			
94	Xe-133		2.05E-01	2.05E-01	5.77E-03	6.86E-08	5.64E-07	2.23E-07	6.86E-08	5.64E-07	2.23E-07			
95	Xe-135M		5.98E-01	5.98E-01	7.55E-02	2.62E-06	2.15E-05	8.52E-06	2.62E-06	2.15E-05	8.52E-06			
96	Xe-135		5.52E-01	5.52E-01	4.40E-02	1.41E-06	1.16E-05	4.59E-06	1.41E-06	1.16E-05	4.59E-06			
97	Xe-137		2.69	2.69E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			
98	Xe-138		2.04	2.04E+00	2.13E-01	2.53E-05	2.08E-04	8.22E-05	2.53E-05	2.08E-04	8.22E-05			
99	**Noble Gas Sub-total (rem EDE)**					**4.45E-05**	**3.66E-04**	**1.45E-04**	**4.45E-05**	**3.66E-04**	**1.45E-04**			
100														
101	**Overall Total (rem TEDE)**					**1.98E-01**	**1.11E-01**	**4.40E-02**	**3.97E+00**	**2.22E+00**	**8.77E-01**			
102														

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
103	[1]	Dose Conversion Factor (rem/Curie) from Federal Guidance Report (FGR) 11 per Reg. Guide 1.183												
104	[2]	Dose Conversion Factor (rem-m^3/Curie-second) from FGR 12 per Reg. Guide 1.183												
105	3.50E-04	Breathing rate (m^3/second) per Regulatory Guide 1.183 (without round-off)												
106	4.51E-02	Control Room Geometry Factor per Reg. Guide 1.183, Regulatory Position 4.2.7												
107	2.79E+01	EAB σ_y (meters) for F stability (taken from PAVAN runs in Ref. 9)												
108	7.050E+01	LPZ σ_y (meters) for F stability (taken from PAVAN runs in Ref. 9)												
109	1.00E+00	Wind Speed (m/s)												
110	4.77E-04	X/Q (seconds/m^3) at EA Boundary - 0-2 hours based on RG 1.5 methodology												
111	1.89E-04	X/Q (seconds/m^3) at Low Population Zone - 0-2 based on RG 1.5 methodology												
112														
113	Equivalent CR X/Q, based on (Curies Released)x(Equiv. X/Q)x(Breathing Rate)x(Dose Conversion Factor) = CEDE Dose													
114		Case 1		Case 1										
115	Isotope	Activity	FGR 11	Dose (rem CEDE)										
116		Release	DCF1	(Inhalation)	Equivalent X/Q									
117		Ci	Rem/Ci	CR	sec/m^3									
118	I-131	4.58E+00	3.29E+04	6.78E-02	1.28E-03									
119	I-132	4.23E+01	3.81E+02	7.25E-03	1.28E-03									
120	I-133	3.14E+01	5.85E+03	8.25E-02	1.28E-03									
121	I-134	8.46E+01	1.31E+02	4.98E-03	1.28E-03									
122	I-135	4.58E+01	1.23E+03	2.53E-02	1.28E-03									

	A	B	C	D	E
1	LGS MSLB Dose S				
2					
3	42514	Volume of cloud (cubic meters)			
4	63500000	Mass of water in reactor coolant r			
5	=56000*453.59	Mass of steam release (grams)			
6	1	reactor coolant density when activ			
7	54.6	seconds for cloud to pass over CF			
8	126000	Volume of Control Room Envelop			
9					
10	Halogens	Calc. LM-311			
11		Rev. 0			
12		Colant		Normalized	Case 1
13	Isotope	Activity	FGR 11	I-131 DE	Normalized
14		Concentration	DCF[1]	Activity	Activity
15		uCi/gm	Rem/Ci	uCi/gm	uCi/gm
16	I-131	0.039	32900	=C16*B16/C$16	=D16*0.2/D$21
17	I-132	0.36	381	=C17*B17/C$16	=D17*0.2/D$21
18	I-133	0.267	5846	=C18*B18/C$16	=D18*0.2/D$21
19	I-134	0.72	131	=C19*B19/C$16	=D19*0.2/D$21
20	I-135	0.39	1230	=C20*B20/C$16	=D20*0.2/D$21
21				=SUM(D16:D20)	=SUM(E16:E20)
22					"non-spiked"
23					
24					
25					
26	Noble Gases				
27			Calc.		Case 1
28			LM-311, Rev.		Release
29			0, Table 4		Cloud
30	Isotope		Activity		Concentration
31			Release		
32			Ci		Ci/m^3
33					
34	Kr-83M		0.0873		=$C34/$A$3
35	Kr-85M		0.154		=$C35/$A$3
36	Kr-85		0.000597		=$C36/$A$3
37	Kr-87		0.476		=$C37/$A$3
38	Kr-88		0.488		=$C38/$A$3
39	Kr-89		2.04		=$C39/$A$3
40	Xe-131M		0.000487		=$C40/$A$3
41	Xe-133M		0.0073		=$C41/$A$3
42	Xe-133		0.205		=$C42/$A$3
43	Xe-135M		0.598		=$C43/$A$3
44	Xe-135		0.552		=$C44/$A$3

	A	B	C	D	E
45	Xe-137		2.69		=$C45/$A$3
46	Xe-138		2.04		=$C46/$A$3
47					
48	Inhalation Doses				
49			Curies Released		
50			to the Environment		
51	Isotope		Case 1	Case 2	DCF[1]
52	I-131		=G16	=H16	32900
53	I-132		=G17	=H17	381
54	I-133		=G18	=H18	5846
55	I-134		=G19	=H19	131
56	I-135		=G20	=H20	1230
57					
58	Cs-134		=M40	=N40	=(3700000000000)*0.0000000125
59	Cs-135		=M41	=N41	=(3700000000000)*0.00000000123
60	Cs-136		=M42	=N42	=(3700000000000)*0.00000000198
61	CS-137		=M43	=N43	=(3700000000000)*0.00000000863
62	Cs-138		=M44	=N44	=(3700000000000)*0.0000000000274
63		**Sub-total (rem CEDE)**			
64					
65					
66			Curies Released		
67			to the Environment		
68	Isotope		Case 1	Case 2	DCF[2]
69	I-131		=C52	=D52	0.06734
70	I-132		=C53	=D53	0.4144
71	I-133		=C54	=D54	0.10878
72	I-134		=C55	=D55	0.481
73	I-135		=C56	=D56	0.29526
74					
75	Cs-134		=M40	=N40	=(3700000000000)*0.0000000000000757
76	Cs-135		=M41	=N41	=(3700000000000)*5.65E-19
77	Cs-136		=M42	=N42	=(3700000000000)*0.000000000000106
78	CS-137		=M43	=N43	=(3700000000000)*7.74E-18
79	Cs-138		=M44	=N44	=(3700000000000)*0.000000000000121
80		**Sub-total (rem EDE)**			
81	**Iodine and Cesium Tot**				
82					
83			Curies Released		
84			to the Environment		
85	Isotope		Case 1	Case 2	DCF[2]
86	Kr-83M		0.0873	0.0873	0.00000555
87	Kr-85M		0.154	0.154	0.027676
88	Kr-85		0.000597	0.000597	0.0004403
89	Kr-87		0.476	0.476	0.15244
90	Kr-88		0.488	0.488	0.3774
91	Kr-89		2.04	2.04	0

	A	B	C	D	E
92	Xe-131M		0.000487	0.000487	0.0014393
93	Xe-133M		0.0073	0.0073	0.005069
94	Xe-133		0.205	0.205	0.005772
95	Xe-135M		0.598	0.598	0.07548
96	Xe-135		0.552	0.552	0.04403
97	Xe-137		2.69	2.69	0
98	Xe-138		2.04	2.04	0.21349
99		**Noble Gas Sub-total (rem EDE)**			
100					
101	**Overall Total (rem TED**				
102					
103	[1]	Dose Conversion Factor (rem/Curie)			
104	[2]	Dose Conversion Factor (rem-m³/Cur			
105	0.00035	Breathing rate (m³/second) per Regul			
106	=($A$8^0.338)/1173	Control Room Geometry Factor per R			
107	27.9	EAB σ_y (meters) for F stability (taken			
108	70.5	LPZ σ_y (meters) for F stability (taken f			
109	1	Wind Speed (m/s)			
110	=0.0133/A$107/A$109	X/Q (seconds/m³) at EA Boundary - 0			
111	=0.0133/A$108/A$109	X/Q (seconds/m³) at Low Population			
112					
113	Equivalent CR X/Q, bas				
114		Case 1		Case 1	
115	Isotope	Activity	FGR 11	Dose (rem CEDE)	
116		Release	DCF1	(Inhalation)	Equivalent X/Q
117		Ci	Rem/Ci	CR	sec/m³
118	I-131	4.58358015752869	32900	0.0677843518149616	=D118/(B118*C118*$A$105)
119	I-132	42.3099706848802	381	0.00724596812013104	=D119/(B119*C119*$A$105)
120	I-133	31.3798949246195	5846	0.082459180601388	=D120/(B120*C120*$A$105)
121	I-134	84.6199413697604	131	0.00498279172565441	=D121/(B121*C121*$A$105)
122	I-135	45.8358015752869	1230	0.0253418701314294	=D122/(B122*C122*$A$105)

	F	G	H	I
1	Case 1:	Reactor Coolant at maximum value (DE I-131 of 0.2 uCi/cc) permitted for continued full power operation		
2				
3	Case 2:	Reactor Coolant at maximum value permitted (DE I-131 of 4.0 uCi/cc) corresponding to an assumed pre-accident spike		
4				
5				
6				
7				
8				
9				
10				Case 1
11				Release
12	Case 2	Case 1	Case 2	Cloud
13	Normalized	Activity	Activity	Concentration
14	Activity	Release	Release	
15	uCi/gm	Ci	Ci	Ci/m^3
16	=E16*20	=(C$16/C16)*E16*$A$4*0.000001	=(C$16/C16)*F16*$A$4*0.000001	=G16/$A$3
17	=E17*20	=(C$16/C17)*E17*$A$4*0.000001	=(C$16/C17)*F17*$A$4*0.000001	=G17/$A$3
18	=E18*20	=(C$16/C18)*E18*$A$4*0.000001	=(C$16/C18)*F18*$A$4*0.000001	=G18/$A$3
19	=E19*20	=(C$16/C19)*E19*$A$4*0.000001	=(C$16/C19)*F19*$A$4*0.000001	=G19/$A$3
20	=E20*20	=(C$16/C20)*E20*$A$4*0.000001	=(C$16/C20)*F20*$A$4*0.000001	=G20/$A$3
21	=SUM(F16:F20)			
22	"spiked"			
23				Total moles with I-127 and I-129
24				included from page B-14 of Ref. 11
25				
26			Iodine in Reactor Coolant Replacement Values for UFSAR Sec. 15.6.	
27	Case 2			
28	Release			
29	Cloud			Isotope
30	Concentration			I-131
31				I-132
32	Ci/m^3			I-133
33				I-134
34	=$C34/$A$3			I-135
35	=$C35/$A$3			
36	=$C36/$A$3			
37	=$C37/$A$3			
38	=$C38/$A$3			
39	=$C39/$A$3			Molar Frac.
40	=$C40/$A$3		Cs-134	0.044317152955112
41	=$C41/$A$3		Cs-135	0.174506296053598
42	=$C42/$A$3		Cs-136	0.000119942189253291
43	=$C43/$A$3		CS-137	0.401736793048373
44	=$C44/$A$3		Cs-138	0.000101901239392202

	F	G	H	I
45	=$C45/$A$3		Totals	=SUM(I40:I44)
46	=$C46/$A$3		Balance is stable Cs-133	
47				
48				
49		Case 1 Dose (rem CEDE)		
50		(Inhalation)		
51	CR	EAB	LPZ	CR
52	=I16*$E52*$A$105*$A$7	=C52*$E52*$A$105*$A$110	=C52*$E52*$A$105*$A$111	=J16*$E52*$A$105*$A$7
53	=I17*$E53*$A$105*$A$7	=C53*$E53*$A$105*$A$110	=C53*$E53*$A$105*$A$111	=J17*$E53*$A$105*$A$7
54	=I18*$E54*$A$105*$A$7	=C54*$E54*$A$105*$A$110	=C54*$E54*$A$105*$A$111	=J18*$E54*$A$105*$A$7
55	=I19*$E55*$A$105*$A$7	=C55*$E55*$A$105*$A$110	=C55*$E55*$A$105*$A$111	=J19*$E55*$A$105*$A$7
56	=I20*$E56*$A$105*$A$7	=C56*$E56*$A$105*$A$110	=C56*$E56*$A$105*$A$111	=J20*$E56*$A$105*$A$7
57				
58	=($C58/$A$3)*$E58*$A$105*$A$7	=C58*$E58*$A$105*$A$110	=C58*$E58*$A$105*$A$111	=($D58/$A$3)*$E58*$A$105*$A$7
59	=($C59/$A$3)*$E59*$A$105*$A$7	=C59*$E59*$A$105*$A$110	=C59*$E59*$A$105*$A$111	=($D59/$A$3)*$E59*$A$105*$A$7
60	=($C60/$A$3)*$E60*$A$105*$A$7	=C60*$E60*$A$105*$A$110	=C60*$E60*$A$105*$A$111	=($D60/$A$3)*$E60*$A$105*$A$7
61	=($C61/$A$3)*$E61*$A$105*$A$7	=C61*$E61*$A$105*$A$110	=C61*$E61*$A$105*$A$111	=($D61/$A$3)*$E61*$A$105*$A$7
62	=($C62/$A$3)*$E62*$A$105*$A$7	=C62*$E62*$A$105*$A$110	=C62*$E62*$A$105*$A$111	=($D62/$A$3)*$E62*$A$105*$A$7
63	**=SUM(F52:F62)**	**=SUM(G52:G62)**	**=SUM(H52:H62)**	**=SUM(I52:I62)**
64				
65				
66		Case 1 Dose (rem EDE)		
67		(External)		
68	CR	EAB	LPZ	CR
69	=I16*$E69*$A$106*$A$7	=C69*$E69*$A$110	=C69*$E69*$A$111	=J16*$E69*$A$106*$A$7
70	=I17*$E70*$A$106*$A$7	=C70*$E70*$A$110	=C70*$E70*$A$111	=J17*$E70*$A$106*$A$7
71	=I18*$E71*$A$106*$A$7	=C71*$E71*$A$110	=C71*$E71*$A$111	=J18*$E71*$A$106*$A$7
72	=I19*$E72*$A$106*$A$7	=C72*$E72*$A$110	=C72*$E72*$A$111	=J19*$E72*$A$106*$A$7
73	=I20*$E73*$A$106*$A$7	=C73*$E73*$A$110	=C73*$E73*$A$111	=J20*$E73*$A$106*$A$7
74				
75	=($C75/$A$3)*$E75*$A$106*$A$7	=C75*$E75*$A$110	=C75*$E75*$A$111	=($D75/$A$3)*$E75*$A$106*$A$7
76	=($C76/$A$3)*$E76*$A$106*$A$7	=C76*$E76*$A$110	=C76*$E76*$A$111	=($D76/$A$3)*$E76*$A$106*$A$7
77	=($C77/$A$3)*$E77*$A$106*$A$7	=C77*$E77*$A$110	=C77*$E77*$A$111	=($D77/$A$3)*$E77*$A$106*$A$7
78	=($C78/$A$3)*$E78*$A$106*$A$7	=C78*$E78*$A$110	=C78*$E78*$A$111	=($D78/$A$3)*$E78*$A$106*$A$7
79	=($C79/$A$3)*$E79*$A$106*$A$7	=C79*$E79*$A$110	=C79*$E79*$A$111	=($D79/$A$3)*$E79*$A$106*$A$7
80	**=SUM(F69:F79)**	**=SUM(G69:G79)**	**=SUM(H69:H79)**	**=SUM(I69:I79)**
81	**=SUM(F63+F80)**	**=SUM(G63+G80)**	**=SUM(H63+H80)**	**=SUM(I63+I80)**
82				
83		Case 1 Dose (rem EDE)		
84		(External)		
85	CR	EAB	LPZ	CR
86	=E34*$E86*$A$106*$A$7	=C86*$E86*$A$110	=C86*$E86*$A$111	=F34*$E86*$A$106*$A$7
87	=E35*$E87*$A$106*$A$7	=C87*$E87*$A$110	=C87*$E87*$A$111	=F35*$E87*$A$106*$A$7
88	=E36*$E88*$A$106*$A$7	=C88*$E88*$A$110	=C88*$E88*$A$111	=F36*$E88*$A$106*$A$7
89	=E37*$E89*$A$106*$A$7	=C89*$E89*$A$110	=C89*$E89*$A$111	=F37*$E89*$A$106*$A$7
90	=E38*$E90*$A$106*$A$7	=C90*$E90*$A$110	=C90*$E90*$A$111	=F38*$E90*$A$106*$A$7
91	=E39*$E91*$A$106*$A$7	=C91*$E91*$A$110	=C91*$E91*$A$111	=F39*$E91*$A$106*$A$7

	F	G	H	I
92	=E40*$E92*$A$106*$A$7	=C92*$E92*$A$110	=C92*$E92*$A$111	=F40*$E92*$A$106*$A$7
93	=E41*$E93*$A$106*$A$7	=C93*$E93*$A$110	=C93*$E93*$A$111	=F41*$E93*$A$106*$A$7
94	=E42*$E94*$A$106*$A$7	=C94*$E94*$A$110	=C94*$E94*$A$111	=F42*$E94*$A$106*$A$7
95	=E43*$E95*$A$106*$A$7	=C95*$E95*$A$110	=C95*$E95*$A$111	=F43*$E95*$A$106*$A$7
96	=E44*$E96*$A$106*$A$7	=C96*$E96*$A$110	=C96*$E96*$A$111	=F44*$E96*$A$106*$A$7
97	=E45*$E97*$A$106*$A$7	=C97*$E97*$A$110	=C97*$E97*$A$111	=F45*$E97*$A$106*$A$7
98	=E46*$E98*$A$106*$A$7	=C98*$E98*$A$110	=C98*$E98*$A$111	=F46*$E98*$A$106*$A$7
99	**=SUM(F86:F98)**	**=SUM(G86:G98)**	**=SUM(H86:H98)**	**=SUM(I86:I98)**
100				
101	**=SUM(F81+F99)**	**=SUM(G81+G99)**	**=SUM(H81+H99)**	**=SUM(I81+I99)**
102				
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	J	K	L	M
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9				
10	Case 2			
11	Release			
12	Cloud		Case 1	Case 2
13	Concentration	Decay	Activity	Activity
14		Constant	Release	Release
15	Ci/m³	1/seconds	moles	moles
16	=H16/$A$3	=LN(2)/(8.04*86400)	=G16*37000000000/$K16/6.023E+23	=H16*37000000000/$K16/6.023E+23
17	=H17/$A$3	=LN(2)/(2.3*3600)	=G17*37000000000/$K17/6.023E+23	=H17*37000000000/$K17/6.023E+23
18	=H18/$A$3	=LN(2)/(20.8*3600)	=G18*37000000000/$K18/6.023E+23	=H18*37000000000/$K18/6.023E+23
19	=H19/$A$3	=LN(2)/(52.6*60)	=G19*37000000000/$K19/6.023E+23	=H19*37000000000/$K19/6.023E+23
20	=H20/$A$3	=LN(2)/(6.61*3600)	=G20*37000000000/$K20/6.023E+23	=H20*37000000000/$K20/6.023E+23
21		Totals	=SUM(L16:L20)	=SUM(M16:M20)
22				
23				
24			=L21*(282.6/7.65)	=M21*(282.6/7.65)
25				
26	4.5.1, adjusted to be 0.2 uCi/gm I-131 dose equivalent			
27				
28	Activity			
29	(uCi/gm)			
30	=E16*C$16/C16			
31	=E17*C$16/C17			
32	=E18*C$16/C18			
33	=E19*C$16/C19			
34	=E20*C$16/C20			
35				
36	Case 1	Case 2		Case 1
37	Activity	Activity	Decay	Activity
38	Release	Release	Constant	Release
39	moles	moles	1/seconds	curies
40	=0.95*$I40*L$24	=0.95*$I40*M$24	=LN(2)/(2.062*86400*365.25)	=J40*6.023E+23*$L40/37000000000
41	=0.95*$I41*L$24	=0.95*$I41*M$24	=LN(2)/(2300000*86400*365.25)	=J41*6.023E+23*$L41/37000000000
42	=0.95*$I42*L$24	=0.95*$I42*M$24	=LN(2)/(13.16*86400)	=J42*6.023E+23*$L42/37000000000
43	=0.95*$I43*L$24	=0.95*$I43*M$24	=LN(2)/(30.17*86400*365.25)	=J43*6.023E+23*$L43/37000000000
44	=0.95*$I44*L$24	=0.95*$I44*M$24	=LN(2)/(32.2*60)	=J44*6.023E+23*$L44/37000000000

	J	K	L	M
45	=SUM(J40:J44)	=SUM(K40:K44)		
46				
47				
48				
49	Case 2 Dose (rem CEDE)			
50	(Inhalation)			
51	EAB	LPZ		
52	=D52*$E52*$A$105*$A$110	=D52*$E52*$A$105*$A$111		
53	=D53*$E53*$A$105*$A$110	=D53*$E53*$A$105*$A$111		
54	=D54*$E54*$A$105*$A$110	=D54*$E54*$A$105*$A$111		
55	=D55*$E55*$A$105*$A$110	=D55*$E55*$A$105*$A$111		
56	=D56*$E56*$A$105*$A$110	=D56*$E56*$A$105*$A$111		
57				
58	=E58*$D58*$A$105*$A$110	=E58*$D58*$A$105*$A$111		
59	=E59*$D59*$A$105*$A$110	=E59*$D59*$A$105*$A$111		
60	=E60*$D60*$A$105*$A$110	=E60*$D60*$A$105*$A$111		
61	=E61*$D61*$A$105*$A$110	=E61*$D61*$A$105*$A$111		
62	=E62*$D62*$A$105*$A$110	=E62*$D62*$A$105*$A$111		
63	**=SUM(J52:J62)**	**=SUM(K52:K62)**		
64				
65				
66	Case 2 Dose (rem EDE)			
67	(External)			
68	EAB	LPZ		
69	=D69*$E69*$A$110	=D69*$E69*$A$111		
70	=D70*$E70*$A$110	=D70*$E70*$A$111		
71	=D71*$E71*$A$110	=D71*$E71*$A$111		
72	=D72*$E72*$A$110	=D72*$E72*$A$111		
73	=D73*$E73*$A$110	=D73*$E73*$A$111		
74				
75	=D75*$E75*$A$110	=D75*$E75*$A$111		
76	=D76*$E76*$A$110	=D76*$E76*$A$111		
77	=D77*$E77*$A$110	=D77*$E77*$A$111		
78	=D78*$E78*$A$110	=D78*$E78*$A$111		
79	=D79*$E79*$A$110	=D79*$E79*$A$111		
80	**=SUM(J69:J79)**	**=SUM(K69:K79)**		
81	**=SUM(J63+J80)**	**=SUM(K63+K80)**		
82				
83	Case 2 Dose (rem EDE)			
84	(External)			
85	EAB	LPZ		
86	=D86*$E86*$A$110	=D86*$E86*$A$111		
87	=D87*$E87*$A$110	=D87*$E87*$A$111		
88	=D88*$E88*$A$110	=D88*$E88*$A$111		
89	=D89*$E89*$A$110	=D89*$E89*$A$111		
90	=D90*$E90*$A$110	=D90*$E90*$A$111		
91	=D91*$E91*$A$110	=D91*$E91*$A$111		

	J	K	L	M
92	=D92*$E92*$A$110	=D92*$E92*$A$111		
93	=D93*$E93*$A$110	=D93*$E93*$A$111		
94	=D94*$E94*$A$110	=D94*$E94*$A$111		
95	=D95*$E95*$A$110	=D95*$E95*$A$111		
96	=D96*$E96*$A$110	=D96*$E96*$A$111		
97	=D97*$E97*$A$110	=D97*$E97*$A$111		
98	=D98*$E98*$A$110	=D98*$E98*$A$111		
99	**=SUM(J86:J98)**	**=SUM(K86:K98)**		
100				
101	**=SUM(J81+J99)**	**=SUM(K81+K99)**		
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31	
32	
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35	
36	Case 2
37	Activity
38	Release
39	curies
40	=K40*6.023E+23*$L40/37000000000
41	=K41*6.023E+23*$L41/37000000000
42	=K42*6.023E+23*$L42/37000000000
43	=K43*6.023E+23*$L43/37000000000
44	=K44*6.023E+23*$L44/37000000000
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	A	B	C	D	E	F	G	H	I	J	K	L
1	**Limerick Beginning of Core Life (100 Effective Full Power Days) and End of Cycle (EOC) Cesium Isotope Quantities**											
2	**(Used for General Cs Molar Fraction Determination for AST)**											
3										***Decay***		
4		**100 EFPD**	**EOC**					**100 EFPD**	**EOC**	**Constant**	**100 EFPD**	**EOC**
5		**(grams)**	**(grams)**				**At. Mass**	**(gm-moles)**	**(gm-moles)**	**1/seconds**	**Ci**	**Ci**
6	Cs-133	1.025E+05	1.678E+05			Cs-133	132.9054	7.712E+02	1.263E+03	0.000E+00	0.000E+00	0.000E+00
7	Cs-134	1.031E+04	1.977E+04			Cs-134	133.9067	7.699E+01	1.476E+02	1.07E-08	1.335E+07	2.559E+07
8	Cs-135	4.502E+04	7.841E+04			Cs-135	134.9059	3.337E+02	5.812E+02	9.55E-15	5.188E+01	9.035E+01
9	Cs-137	1.087E+05	1.832E+05			Cs-137	136.9071	7.940E+02	1.338E+03	7.28E-10	9.410E+06	1.586E+07
10						Cs-136		2.37E-01	3.99E-01	6.10E-07	2.352E+06	3.964E+06
11						Cs-138		2.01E-01	3.39E-01	3.59E-04	1.176E+09	1.982E+09
12	**Total**	**2.665E+05**	**4.492E+05**					**1.976E+03**	**3.331E+03**			
13												
14	ANSI/ANS-18.1-1999 Relative Abundances in Reactor Water										**Molar Fraction**	
15		uCi/gram of	moles/gram of	ratio to						Cs-133	39.0219%	37.9218%
16		Reactor Cool	Reactor Coolant	Cs-137						Cs-134	3.8956%	4.4317%
17	Cs-134	3.00E-05	1.04E+08	2.56E-02						Cs-135	16.8848%	17.4506%
18	Cs-136	2.00E-05	1.21E+06	2.99E-04						Cs-137	40.1755%	40.1737%
19	Cs-137	8.00E-05	4.07E+09	1.00E+00						Cs-136	0.0120%	0.0120%
20	Cs-138	1.00E-02	1.03E+06	2.54E-04						Cs-138	0.0102%	0.0102%

	A	B	C	D	E	F	G	H	I
1	**Limerick Begin**								
2	**(Used for Gene**								
3									
4		**100 EFPD**	**EOC**					**100 EFPD**	**EOC**
5		**(grams)**	**(grams)**				**At. Mass**	**(gm-moles)**	**(gm-moles)**
6	Cs-133	102500	167800			Cs-133	132.9054	771.2	1263
7	Cs-134	10310	19770			Cs-134	133.9067	76.99	147.6
8	Cs-135	45020	78410			Cs-135	134.9059	333.7	581.2
9	Cs-137	108700	183200			Cs-137	136.9071	794	1338
10						Cs-136		=K10*37000000000/$J10/6.023E+23	=L10*37000000000/$J10/6.023E+23
11						Cs-138		=K11*37000000000/$J11/6.023E+23	=L11*37000000000/$J11/6.023E+23
12	**Total**	**=SUM(B6:B9)**	**=SUM(C6:C9)**					**=SUM(H6:H11)**	**=SUM(I6:I11)**
13									
14	ANSI/ANS-18.1								
15		uCi/gram of	moles/gram of	ratio to					
16		Reactor Coolant	Reactor Coolant	Cs-137					
17	Cs-134	0.00003	=B17*37000/J7	=C17/C$19					
18	Cs-136	0.00002	=B18*37000/J10	=C18/C$19					
19	Cs-137	0.00008	=B19*37000/J9	=C19/C$19					
20	Cs-138	0.01	=B20*37000/J11	=C20/C$19					

	J	K	L
1			
2			
3	**Decay**		
4	**Constant**	**100 EFPD**	**EOC**
5	**1/seconds**	**Ci**	**Ci**
6	0	=H6*$J6*6.023E+23/37000000000	=I6*$J6*6.023E+23/37000000000
7	=LN(2)/(2.062*86400*365.25)	=H7*$J7*6.023E+23/37000000000	=I7*$J7*6.023E+23/37000000000
8	=LN(2)/(2300000*86400*365.25)	=H8*$J8*6.023E+23/37000000000	=I8*$J8*6.023E+23/37000000000
9	=LN(2)/(30.17*86400*365.25)	=H9*$J9*6.023E+23/37000000000	=I9*$J9*6.023E+23/37000000000
10	=LN(2)/(13.16*86400)	=K$9*$B$18/$B$19	=L$9*$B$18/$B$19
11	=LN(2)/(32.2*60)	=K$9*$B$20/$B$19	=L$9*$B$20/$B$19
12			
13			
14		**Molar Fraction**	
15	Cs-133	=H6/H$12	=I6/I$12
16	Cs-134	=H7/H$12	=I7/I$12
17	Cs-135	=H8/H$12	=I8/I$12
18	Cs-137	=H9/H$12	=I9/I$12
19	Cs-136	=H10/H$12	=I10/I$12
20	Cs-138	=H11/H$12	=I11/I$12

Computer Disclosure Sheet

Discipline Nuclear

Client:: Exelon Corporation
Project: Limerick Generating Station AST

Date: September 2005
Job No.

Program(s) used	Rev No.	Rev Date	Calculation Set No.: LM-0644, Rev. 1
Attachment A spreadsheet		N/A	N/A
		Status	[ ] Prelim. [X] Final [ ] Void

WGI Prequalification [ ] Yes
[X] No

Run No. Description:

Analysis Description: Spreadsheet used to perform dose assessment for MSLB, as described in calculation.

The attached computer output has been reviewed, the input data checked,
And the results approved for release. Input criteria for this analysis were established.

By: H. Rothstein On: September 2005

Run by: H. Rothstein Harold Rothstein

Checked by: P. Reichert P. Reichert

Approved by: H. Rothstein Harold Rothstein

Remarks: WGI Form for Computer Software Control
This spreadsheet is relatively straight-forward and was hand checked. Attachment A includes the spreadsheet in both normal and formula display mode so it is completely documented.

ADDITIONAL ATTACHMENTS TO
10-10-05 Letter: Supplement to Request for LAR Application of AST

Attachment 008 AST –.LM-0644 Rev 1 MSLB Att A.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	LGS MSLB Dose Spreadsheet					Case 1:	Reactor Coolant at maximum value (DE I-131 of 0.2 uCi/cc) permitted for							
2							continued full power operation							
3	42,514	Volume of cloud (cubic meters)				Case 2:	Reactor Coolant at maximum value permitted (DE I-131 of 4.0 uCi/cc)							
4	6.35E+07	Mass of water in reactor coolant release (grams)					corresponding to an assumed pre-accident spike							
5	2.54E+07	Mass of steam release (grams)												
6	1	reactor coolant density when activity is measured (grams/cc)												
7	54.6	seconds for cloud to pass over CR intake for wind speed of 1 m/second												
8	126000	Volume of Control Room Envelope (cubic feet)												
9														
10	Halogens	Calc. LM-311							Case 1	Case 2				
11		Rev. 0							Release	Release				
12		Colant		Normalized	Case 1	Case 2	Case 1	Case 2	Cloud	Cloud		Case 1	Case 2	
13	Isotope	Activity	FGR 11	I-131 DE	Normalized	Normalized	Activity	Activity	Concentration	Concentration	Decay	Activity	Activity	
14		Concentration	DCF[1]	Activity	Activity	Activity	Release	Release			Constant	Release	Release	
15		uCi/gm	Rem/Ci	uCi/gm	uCi/gm	uCi/gm	Ci	Ci	Ci/m^3	Ci/m^3	1/seconds	moles	moles	
16	I-131	0.039	3.29E+04	3.90E-02	7.22E-02	1.44E+00	4.58E+00	9.17E+01	1.08E-04	2.16E-03	9.98E-07	2.82E-07	5.64E-06	
17	I-132	0.36	3.81E+02	4.17E-03	7.72E-03	1.54E-01	4.23E+01	8.46E+02	9.95E-04	1.99E-02	8.37E-05	3.10E-08	6.21E-07	
18	I-133	0.267	5.85E+03	4.74E-02	8.78E-02	1.76E+00	3.14E+01	6.28E+02	7.38E-04	1.48E-02	9.26E-06	2.08E-07	4.16E-06	
19	I-134	0.72	1.31E+02	2.87E-03	5.31E-03	1.06E-01	8.46E+01	1.69E+03	1.99E-03	3.98E-02	2.20E-04	2.37E-08	4.73E-07	
20	I-135	0.39	1.23E+03	1.46E-02	2.70E-02	5.40E-01	4.58E+01	9.17E+02	1.08E-03	2.16E-02	2.91E-05	9.67E-08	1.93E-06	
21				1.08E-01	2.00E-01	4.00E+00					Totals	6.42E-07	1.28E-05	
22					"non-spiked"	"spiked"								
23	Noble Gases							Iodine in Reactor Coolant Replacement Values for UFSAR						
24			Calc.		Case 1	Case 2		Sec. 15.6.4.5.1, adjusted to be 0.2 uCi/gm I-131 dose						
25			LM-311, Rev.		Release	Release				Activity				
26			0, Table 4		Cloud	Cloud			Isotope	(uCi/gm)				
27	Isotope		Activity		Concentration	Concentration			I-131	0.0722				
28			Release						I-132	0.666				
29			Ci		Ci/m^3	Ci/m^3			I-133	0.494				
30									I-134	1.33				
31	Kr-83M		8.73E-02		2.05E-06	2.05E-06			I-135	0.722				
32	Kr-85M		1.54E-01		3.62E-06	3.62E-06								
33	Kr-85		5.97E-04		1.40E-08	1.40E-08				Case 1	Case 2		Case 1	Case 2
34	Kr-87		4.76E-01		1.12E-05	1.12E-05				Activity	Activity	Decay	Activity	Activity
35	Kr-88		4.88E-01		1.15E-05	1.15E-05				Release	Release	Constant	Release	Release
36	Kr-89		2.04		4.80E-05	4.80E-05			Molar Frac.	moles	moles	1/seconds	curies	curies
37	Xe-131M		4.87E-04		1.15E-08	1.15E-08		Cs-134	4.4317%	2.70E-08	5.40E-07	1.07E-08	4.69E-03	9.37E-02
38	Xe-133M		7.30E-03		1.72E-07	1.72E-07		Cs-135	17.4506%	1.06E-07	2.13E-06	9.55E-15	1.65E-08	3.31E-07
39	Xe-133		2.05E-01		4.82E-06	4.82E-06		Cs-136	0.0120%	7.31E-11	1.46E-09	6.10E-07	7.26E-04	1.45E-02
40	Xe-135M		5.98E-01		1.41E-05	1.41E-05		CS-137	40.17%	2.45E-07	4.90E-06	7.28E-10	2.90E-03	5.81E-02
41	Xe-135		5.52E-01		1.30E-05	1.30E-05		Cs-138	0.0102%	6.21E-11	1.24E-09	3.59E-04	3.63E-01	7.26E+00
42	Xe-137		2.69		6.33E-05	6.33E-05		Totals	62.08%	3.79E-07	7.57E-06			
43	Xe-138		2.04		4.80E-05	4.80E-05		Balance is stable Cs-133						
44														

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
45	Inhalation Doses													
46		Curies Released				Case 1 Dose (rem CEDE)			Case 2 Dose (rem CEDE)					
47		to the Environment					(Inhalation)			(Inhalation)				
48	Isotope		Case 1	Case 2	DCF[1]	CR	EAB	LPZ	CR	EAB	LPZ			
49	I-131		4.58E+00	9.17E+01	3.29E+04	6.78E-02	2.52E-02	9.96E-03	1.36E+00	5.03E-01	1.99E-01			
50	I-132		4.23E+01	8.46E+02	3.81E+02	7.25E-03	2.69E-03	1.06E-03	1.45E-01	5.38E-02	2.13E-02			
51	I-133		3.14E+01	6.28E+02	5.85E+03	8.25E-02	3.06E-02	1.21E-02	1.65E+00	6.12E-01	2.42E-01			
52	I-134		8.46E+01	1.69E+03	1.31E+02	4.98E-03	1.85E-03	7.32E-04	9.97E-02	3.70E-02	1.46E-02			
53	I-135		4.58E+01	9.17E+02	1.23E+03	2.53E-02	9.41E-03	3.72E-03	5.07E-01	1.88E-01	7.45E-02			
54														
55	Cs-134		4.69E-03	9.37E-02	4.63E+04	9.74E-05	3.62E-05	1.43E-05	1.95E-03	7.23E-04	2.86E-04			
56	Cs-135		1.65E-08	3.31E-07	4.55E+03	3.38E-11	1.26E-11	4.97E-12	6.77E-10	2.51E-10	9.94E-11			
57	Cs-136		7.26E-04	1.45E-02	7.33E+03	2.39E-06	8.87E-07	3.51E-07	4.78E-05	1.77E-05	7.02E-06			
58	CS-137		2.90E-03	5.81E-02	3.19E+04	4.17E-05	1.55E-05	6.12E-06	8.33E-04	3.09E-04	1.22E-04			
59	Cs-138		3.63E-01	7.26E+00	1.01E+02	1.65E-05	6.14E-06	2.43E-06	3.31E-04	1.23E-04	4.86E-05			
60	**Sub-total (rem CEDE)**					**1.88E-01**	**6.98E-02**	**2.76E-02**	**3.76E+00**	**1.40E+00**	**5.52E-01**			
61														
62														
63			Curies Released			Case 1 Dose (rem EDE)			Case 2 Dose (rem EDE)					
64			to the Environment				(External)			(External)				
65	Isotope		Case 1	Case 2	DCF[2]	CR	EAB	LPZ	CR	EAB	LPZ			
66	I-131		4.58E+00	9.17E+01	6.73E-02	1.79E-05	1.47E-04	5.82E-05	3.58E-04	2.94E-03	1.16E-03			
67	I-132		4.23E+01	8.46E+02	4.14E-01	1.02E-03	8.36E-03	3.31E-03	2.03E-02	1.67E-01	6.62E-02			
68	I-133		3.14E+01	6.28E+02	1.09E-01	1.98E-04	1.63E-03	6.44E-04	3.96E-03	3.25E-02	1.29E-02			
69	I-134		8.46E+01	1.69E+03	4.81E-01	2.36E-03	1.94E-02	7.68E-03	4.72E-02	3.88E-01	1.54E-01			
70	I-135		4.58E+01	9.17E+02	2.95E-01	7.85E-04	6.45E-03	2.55E-03	1.57E-02	1.29E-01	5.11E-02			
71														
72	Cs-134		4.69E-03	9.37E-02	2.80E-01	7.61E-08	6.26E-07	2.48E-07	1.52E-06	1.25E-05	4.95E-06			
73	Cs-135		1.65E-08	3.31E-07	2.09E-06	2.00E-18	1.65E-17	6.52E-18	4.01E-17	3.30E-16	1.30E-16			
74	Cs-136		7.26E-04	1.45E-02	3.92E-01	1.65E-08	1.36E-07	5.37E-08	3.30E-07	2.71E-06	1.07E-06			
75	CS-137		2.90E-03	5.81E-02	2.86E-05	4.82E-12	3.96E-11	1.57E-11	9.64E-11	7.93E-10	3.14E-10			
76	Cs-138		3.63E-01	7.26E+00	4.48E-01	9.42E-06	7.74E-05	3.06E-05	1.88E-04	1.55E-03	6.13E-04			
77	**Sub-total (rem EDE)**					**4.39E-03**	**3.61E-02**	**1.43E-02**	**8.77E-02**	**7.21E-01**	**2.85E-01**			
78	**Iodine and Cesium Total (rem TEDE)**					**1.92E-01**	**1.06E-01**	**4.19E-02**	**3.85E+00**	**2.12E+00**	**8.38E-01**			
79														
80			Curies Released			Case 1 Dose (rem EDE)			Case 2 Dose (rem EDE)					
81			to the Environment				(External)			(External)				
82	Isotope		Case 1	Case 2	DCF[2]	CR	EAB	LPZ	CR	EAB	LPZ			
83	Kr-83M		8.73E-02	8.73E-02	5.55E-06	2.81E-11	2.31E-10	9.14E-11	2.81E-11	2.31E-10	9.14E-11			
84	Kr-85M		1.54E-01	1.54E-01	2.77E-02	2.47E-07	2.03E-06	8.04E-07	2.47E-07	2.03E-06	8.04E-07			
85	Kr-85		5.97E-04	5.97E-04	4.40E-04	1.52E-11	1.25E-10	4.96E-11	1.52E-11	1.25E-10	4.96E-11			
86	Kr-87		4.76E-01	4.76E-01	1.52E-01	4.21E-06	3.46E-05	1.37E-05	4.21E-06	3.46E-05	1.37E-05			
87	Kr-88		4.88E-01	4.88E-01	3.77E-01	1.07E-05	8.78E-05	3.47E-05	1.07E-05	8.78E-05	3.47E-05			
88	Kr-89		2.04	2.04E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			
89	Xe-131M		4.87E-04	4.87E-04	1.44E-03	4.06E-11	3.34E-10	1.32E-10	4.06E-11	3.34E-10	1.32E-10			
90	Xe-133M		7.30E-03	7.30E-03	5.07E-03	2.15E-09	1.76E-08	6.98E-09	2.15E-09	1.76E-08	6.98E-09			
91	Xe-133		2.05E-01	2.05E-01	5.77E-03	6.86E-08	5.64E-07	2.23E-07	6.86E-08	5.64E-07	2.23E-07			
92	Xe-135M		5.98E-01	5.98E-01	7.55E-02	2.62E-06	2.15E-05	8.52E-06	2.62E-06	2.15E-05	8.52E-06			
93	Xe-135		5.52E-01	5.52E-01	4.40E-02	1.41E-06	1.16E-05	4.59E-06	1.41E-06	1.16E-05	4.59E-06			
94	Xe-137		2.69	2.69E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			
95	Xe-138		2.04	2.04E+00	2.13E-01	2.53E-05	2.08E-04	8.22E-05	2.53E-05	2.08E-04	8.22E-05			
96	**Noble Gas Sub-total (rem EDE)**					**4.45E-05**	**3.66E-04**	**1.45E-04**	**4.45E-05**	**3.66E-04**	**1.45E-04**			
97														
98	**Overall Total (rem TEDE)**					**1.92E-01**	**1.06E-01**	**4.20E-02**	**3.85E+00**	**2.12E+00**	**8.38E-01**			
99														

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
100	[1]	Dose Conversion Factor (rem/Curie) from Federal Guidance Report (FGR) 11 per Reg. Guide 1.183												
101	[2]	Dose Conversion Factor (rem-m^3/Curie-second) from FGR 12 per Reg. Guide 1.183												
102	3.50E-04	Breathing rate (m^3/second) per Regulatory Guide 1.183 (without round-off)												
103	4.51E-02	Control Room Geometry Factor per Reg. Guide 1.183, Regulatory Position 4.2.7												
104	2.79E+01	EAB σ_y (meters) for F stability (taken from PAVAN runs in Ref. 9)												
105	7.050E+01	LPZ σ_y (meters) for F stability (taken from PAVAN runs in Ref. 9)												
106	1.00E+00	Wind Speed (m/s)												
107	4.77E-04	X/Q (seconds/m^3) at EA Boundary - 0-2 hours based on RG 1.5 methodology												
108	1.89E-04	X/Q (seconds/m^3) at Low Population Zone - 0-2 based on RG 1.5 methodology												
109														
110	Equivalent CR X/Q, based on (Curies Released)x(Equiv. X/Q)x(Breathing Rate)x(Dose Conversion Factor) = CEDE Dose													
111		Case 1		Case 1										
112	Isotope	Activity	FGR 11	Dose (rem CEDE)										
113		Release	DCF1	(Inhalation)	Equivalent X/Q									
114		Ci	Rem/Ci	CR	sec/m^3									
115	I-131	4.58E+00	3.29E+04	6.78E-02	1.28E-03									
116	I-132	4.23E+01	3.81E+02	7.25E-03	1.28E-03									
117	I-133	3.14E+01	5.85E+03	8.25E-02	1.28E-03									
118	I-134	8.46E+01	1.31E+02	4.98E-03	1.28E-03									
119	I-135	4.58E+01	1.23E+03	2.53E-02	1.28E-03									

	A	B	C	D	E
1	**LGS MSLB Dose S**				
2					
3	42514	Volume of cloud (cubic meters)			
4	63500000	Mass of water in reactor coolant r			
5	=56000*453.59	Mass of steam release (grams)			
6	1	reactor coolant density when activ			
7	54.6	seconds for cloud to pass over CF			
8	126000	Volume of Control Room Envelop			
9					
10	Halogens	Calc. LM-311			
11		Rev. 0			
12		Colant		Normalized	Case 1
13	Isotope	Activity	FGR 11	I-131 DE	Normalized
14		Concentration	DCF[1]	Activity	Activity
15		uCi/gm	Rem/Ci	uCi/gm	uCi/gm
16	I-131	0.039	32900	=C16*B16/C$16	=D16*0.2/D$21
17	I-132	0.36	381	=C17*B17/C$16	=D17*0.2/D$21
18	I-133	0.267	5846	=C18*B18/C$16	=D18*0.2/D$21
19	I-134	0.72	131	=C19*B19/C$16	=D19*0.2/D$21
20	I-135	0.39	1230	=C20*B20/C$16	=D20*0.2/D$21
21				=SUM(D16:D20)	=SUM(E16:E20)
22					"non-spiked"
23	Noble Gases				
24			Calc.		Case 1
25			LM-311, Rev.		Release
26			0, Table 4		Cloud
27	Isotope		Activity		Concentration
28			Release		
29			Ci		Ci/m^3
30					
31	Kr-83M		0.0873		=$C31/$A$3
32	Kr-85M		0.154		=$C32/$A$3
33	Kr-85		0.000597		=$C33/$A$3
34	Kr-87		0.476		=$C34/$A$3
35	Kr-88		0.488		=$C35/$A$3
36	Kr-89		2.04		=$C36/$A$3
37	Xe-131M		0.000487		=$C37/$A$3
38	Xe-133M		0.0073		=$C38/$A$3
39	Xe-133		0.205		=$C39/$A$3
40	Xe-135M		0.598		=$C40/$A$3
41	Xe-135		0.552		=$C41/$A$3
42	Xe-137		2.69		=$C42/$A$3
43	Xe-138		2.04		=$C43/$A$3
44					

	A	B	C	D	E
45	Inhalation Doses				
46			Curies Released		
47			to the Environment		
48	Isotope		Case 1	Case 2	DCF[1]
49	I-131		=G16	=H16	32900
50	I-132		=G17	=H17	381
51	I-133		=G18	=H18	5846
52	I-134		=G19	=H19	131
53	I-135		=G20	=H20	1230
54					
55	Cs-134		=M37	=N37	=(3700000000000)*0.0000000125
56	Cs-135		=M38	=N38	=(3700000000000)*0.00000000123
57	Cs-136		=M39	=N39	=(3700000000000)*0.00000000198
58	CS-137		=M40	=N40	=(3700000000000)*0.00000000863
59	Cs-138		=M41	=N41	=(3700000000000)*0.0000000000274
60		Sub-total (rem CEDE)			
61					
62					
63			Curies Released		
64			to the Environment		
65	Isotope		Case 1	Case 2	DCF[2]
66	I-131		=C49	=D49	0.06734
67	I-132		=C50	=D50	0.4144
68	I-133		=C51	=D51	0.10878
69	I-134		=C52	=D52	0.481
70	I-135		=C53	=D53	0.29526
71					
72	Cs-134		=M37	=N37	=(3700000000000)*0.000000000000075
73	Cs-135		=M38	=N38	=(3700000000000)*5.65E-19
74	Cs-136		=M39	=N39	=(3700000000000)*0.000000000000106
75	CS-137		=M40	=N40	=(3700000000000)*7.74E-18
76	Cs-138		=M41	=N41	=(3700000000000)*0.000000000000121
77		Sub-total (rem EDE)			
78	Iodine and Cesium To				
79					
80			Curies Released		
81			to the Environment		
82	Isotope		Case 1	Case 2	DCF[2]
83	Kr-83M		0.0873	0.0873	0.00000555
84	Kr-85M		0.154	0.154	0.027676
85	Kr-85		0.000597	0.000597	0.0004403
86	Kr-87		0.476	0.476	0.15244
87	Kr-88		0.488	0.488	0.3774
88	Kr-89		2.04	2.04	0
89	Xe-131M		0.000487	0.000487	0.0014393
90	Xe-133M		0.0073	0.0073	0.005069
91	Xe-133		0.205	0.205	0.005772

	A	B	C	D	E
92	Xe-135M		0.598	0.598	0.07548
93	Xe-135		0.552	0.552	0.04403
94	Xe-137		2.69	2.69	0
95	Xe-138		2.04	2.04	0.21349
96		**Noble Gas Sub-total (rem EDE)**			
97					
98	**Overall Total (rem TED**				
99					
100	1	Dose Conversion Factor (rem/Curie) f			
101	2	Dose Conversion Factor (rem-m^3/Cur			
102	0.00035	Breathing rate (m^3/second) per Regul			
103	=($A$8^0.338)/1173	Control Room Geometry Factor per R			
104	27.9	EAB σ_y (meters) for F stability (taken f			
105	70.5	LPZ σ_y (meters) for F stability (taken f			
106	1	Wind Speed (m/s)			
107	=0.0133/A$104/A$106	X/Q (seconds/m^3) at EA Boundary - 0			
108	=0.0133/A$105/A$106	X/Q (seconds/m^3) at Low Population Z			
109					
110	Equivalent CR X/Q, bas				
111		Case 1		Case 1	
112	Isotope	Activity	FGR 11	Dose (rem CEDE)	
113		Release	DCF1	(Inhalation)	Equivalent X/Q
114		Ci	Rem/Ci	CR	sec/m^3
115	I-131	4.58358015752869	32900	0.0677843518149616	=D115/(B115*C115*$A$102)
116	I-132	42.3099706848802	381	0.00724596812013104	=D116/(B116*C116*$A$102)
117	I-133	31.3798949246195	5846	0.082459180601388	=D117/(B117*C117*$A$102)
118	I-134	84.6199413697604	131	0.00498279172565441	=D118/(B118*C118*$A$102)
119	I-135	45.8358015752869	1230	0.0253418701314294	=D119/(B119*C119*$A$102)

	F	G	H	I
1	Case 1:	Reactor Coolant at maximum value (DE I-131 of 0.2 uCi/cc) permitted for continued full power operation		
2				
3	Case 2:	Reactor Coolant at maximum value permitted (DE I-131 of 4.0 uCi/cc) corresponding to an assumed pre-accident spike		
4				
5				
6				
7				
8				
9				
10				Case 1
11				Release
12	Case 2	Case 1	Case 2	Cloud
13	Normalized	Activity	Activity	Concentration
14	Activity	Release	Release	
15	uCi/gm	Ci	Ci	Ci/m3
16	=E16*20	=(C$16/C16)*E16*$A$4*0.000001	=(C$16/C16)*F16*$A$4*0.000001	=G16/$A$3
17	=E17*20	=(C$16/C17)*E17*$A$4*0.000001	=(C$16/C17)*F17*$A$4*0.000001	=G17/$A$3
18	=E18*20	=(C$16/C18)*E18*$A$4*0.000001	=(C$16/C18)*F18*$A$4*0.000001	=G18/$A$3
19	=E19*20	=(C$16/C19)*E19*$A$4*0.000001	=(C$16/C19)*F19*$A$4*0.000001	=G19/$A$3
20	=E20*20	=(C$16/C20)*E20*$A$4*0.000001	=(C$16/C20)*F20*$A$4*0.000001	=G20/$A$3
21	=SUM(F16:F20)			
22	"spiked"			
23			Iodine in Reactor Coolant Replacement Values for UFSAR Sec. 15.6	
24	Case 2			
25	Release			
26	Cloud			Isotope
27	Concentration			I-131
28				I-132
29	Ci/m3			I-133
30				I-134
31	=$C31/$A$3			I-135
32	=$C32/$A$3			
33	=$C33/$A$3			
34	=$C34/$A$3			
35	=$C35/$A$3			
36	=$C36/$A$3			Molar Frac.
37	=$C37/$A$3		Cs-134	0.044317152955112
38	=$C38/$A$3		Cs-135	0.174506296053598
39	=$C39/$A$3		Cs-136	0.000119942189253291
40	=$C40/$A$3		CS-137	0.401736793048373
41	=$C41/$A$3		Cs-138	0.000101901239392202
42	=$C42/$A$3		Totals	=SUM(I37:I41)
43	=$C43/$A$3			Balance is stable Cs-133
44				

	F	G	H	I
45				
46		Case 1 Dose (rem CEDE)		
47		(Inhalation)		
48	CR	EAB	LPZ	CR
49	=I16*$E49*$A$102*$A$7	=C49*$E49*$A$102*$A$107	=C49*$E49*$A$102*$A$108	=J16*$E49*$A$102*$A$7
50	=I17*$E50*$A$102*$A$7	=C50*$E50*$A$102*$A$107	=C50*$E50*$A$102*$A$108	=J17*$E50*$A$102*$A$7
51	=I18*$E51*$A$102*$A$7	=C51*$E51*$A$102*$A$107	=C51*$E51*$A$102*$A$108	=J18*$E51*$A$102*$A$7
52	=I19*$E52*$A$102*$A$7	=C52*$E52*$A$102*$A$107	=C52*$E52*$A$102*$A$108	=J19*$E52*$A$102*$A$7
53	=I20*$E53*$A$102*$A$7	=C53*$E53*$A$102*$A$107	=C53*$E53*$A$102*$A$108	=J20*$E53*$A$102*$A$7
54				
55	=($C55/$A$3)*$E55*$A$102*$A$7	=C55*$E55*$A$102*$A$107	=C55*$E55*$A$102*$A$108	=($D55/$A$3)*$E55*$A$102*$A$7
56	=($C56/$A$3)*$E56*$A$102*$A$7	=C56*$E56*$A$102*$A$107	=C56*$E56*$A$102*$A$108	=($D56/$A$3)*$E56*$A$102*$A$7
57	=($C57/$A$3)*$E57*$A$102*$A$7	=C57*$E57*$A$102*$A$107	=C57*$E57*$A$102*$A$108	=($D57/$A$3)*$E57*$A$102*$A$7
58	=($C58/$A$3)*$E58*$A$102*$A$7	=C58*$E58*$A$102*$A$107	=C58*$E58*$A$102*$A$108	=($D58/$A$3)*$E58*$A$102*$A$7
59	=($C59/$A$3)*$E59*$A$102*$A$7	=C59*$E59*$A$102*$A$107	=C59*$E59*$A$102*$A$108	=($D59/$A$3)*$E59*$A$102*$A$7
60	**=SUM(F49:F59)**	**=SUM(G49:G59)**	**=SUM(H49:H59)**	**=SUM(I49:I59)**
61				
62				
63		Case 1 Dose (rem EDE)		
64		(External)		
65	CR	EAB	LPZ	CR
66	=I16*$E66*$A$103*$A$7	=C66*$E66*$A$107	=C66*$E66*$A$108	=J16*$E66*$A$103*$A$7
67	=I17*$E67*$A$103*$A$7	=C67*$E67*$A$107	=C67*$E67*$A$108	=J17*$E67*$A$103*$A$7
68	=I18*$E68*$A$103*$A$7	=C68*$E68*$A$107	=C68*$E68*$A$108	=J18*$E68*$A$103*$A$7
69	=I19*$E69*$A$103*$A$7	=C69*$E69*$A$107	=C69*$E69*$A$108	=J19*$E69*$A$103*$A$7
70	=I20*$E70*$A$103*$A$7	=C70*$E70*$A$107	=C70*$E70*$A$108	=J20*$E70*$A$103*$A$7
71				
72	=($C72/$A$3)*$E72*$A$103*$A$7	=C72*$E72*$A$107	=C72*$E72*$A$108	=($D72/$A$3)*$E72*$A$103*$A$7
73	=($C73/$A$3)*$E73*$A$103*$A$7	=C73*$E73*$A$107	=C73*$E73*$A$108	=($D73/$A$3)*$E73*$A$103*$A$7
74	=($C74/$A$3)*$E74*$A$103*$A$7	=C74*$E74*$A$107	=C74*$E74*$A$108	=($D74/$A$3)*$E74*$A$103*$A$7
75	=($C75/$A$3)*$E75*$A$103*$A$7	=C75*$E75*$A$107	=C75*$E75*$A$108	=($D75/$A$3)*$E75*$A$103*$A$7
76	=($C76/$A$3)*$E76*$A$103*$A$7	=C76*$E76*$A$107	=C76*$E76*$A$108	=($D76/$A$3)*$E76*$A$103*$A$7
77	**=SUM(F66:F76)**	**=SUM(G66:G76)**	**=SUM(H66:H76)**	**=SUM(I66:I76)**
78	**=SUM(F60+F77)**	**=SUM(G60+G77)**	**=SUM(H60+H77)**	**=SUM(I60+I77)**
79				
80		Case 1 Dose (rem EDE)		
81		(External)		
82	CR	EAB	LPZ	CR
83	=E31*$E83*$A$103*$A$7	=C83*$E83*$A$107	=C83*$E83*$A$108	=F31*$E83*$A$103*$A$7
84	=E32*$E84*$A$103*$A$7	=C84*$E84*$A$107	=C84*$E84*$A$108	=F32*$E84*$A$103*$A$7
85	=E33*$E85*$A$103*$A$7	=C85*$E85*$A$107	=C85*$E85*$A$108	=F33*$E85*$A$103*$A$7
86	=E34*$E86*$A$103*$A$7	=C86*$E86*$A$107	=C86*$E86*$A$108	=F34*$E86*$A$103*$A$7
87	=E35*$E87*$A$103*$A$7	=C87*$E87*$A$107	=C87*$E87*$A$108	=F35*$E87*$A$103*$A$7
88	=E36*$E88*$A$103*$A$7	=C88*$E88*$A$107	=C88*$E88*$A$108	=F36*$E88*$A$103*$A$7
89	=E37*$E89*$A$103*$A$7	=C89*$E89*$A$107	=C89*$E89*$A$108	=F37*$E89*$A$103*$A$7
90	=E38*$E90*$A$103*$A$7	=C90*$E90*$A$107	=C90*$E90*$A$108	=F38*$E90*$A$103*$A$7
91	=E39*$E91*$A$103*$A$7	=C91*$E91*$A$107	=C91*$E91*$A$108	=F39*$E91*$A$103*$A$7

	F	G	H	I
92	=E40*$E92*$A$103*$A$7	=C92*$E92*$A$107	=C92*$E92*$A$108	=F40*$E92*$A$103*$A$7
93	=E41*$E93*$A$103*$A$7	=C93*$E93*$A$107	=C93*$E93*$A$108	=F41*$E93*$A$103*$A$7
94	=E42*$E94*$A$103*$A$7	=C94*$E94*$A$107	=C94*$E94*$A$108	=F42*$E94*$A$103*$A$7
95	=E43*$E95*$A$103*$A$7	=C95*$E95*$A$107	=C95*$E95*$A$108	=F43*$E95*$A$103*$A$7
96	**=SUM(F83:F95)**	**=SUM(G83:G95)**	**=SUM(H83:H95)**	**=SUM(I83:I95)**
97				
98	**=SUM(F78+F96)**	**=SUM(G78+G96)**	**=SUM(H78+H96)**	**=SUM(I78+I96)**
99				
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	J	K	L	M
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9				
10	Case 2			
11	Release			
12	Cloud		Case 1	Case 2
13	Concentration	Decay	Activity	Activity
14		Constant	Release	Release
15	Ci/m^3	1/seconds	moles	moles
16	=H16/$A$3	=LN(2)/(8.04*86400)	=G16*37000000000/$K16/6.023E+23	=H16*37000000000/$K16/6.023E+23
17	=H17/$A$3	=LN(2)/(2.3*3600)	=G17*37000000000/$K17/6.023E+23	=H17*37000000000/$K17/6.023E+23
18	=H18/$A$3	=LN(2)/(20.8*3600)	=G18*37000000000/$K18/6.023E+23	=H18*37000000000/$K18/6.023E+23
19	=H19/$A$3	=LN(2)/(52.6*60)	=G19*37000000000/$K19/6.023E+23	=H19*37000000000/$K19/6.023E+23
20	=H20/$A$3	=LN(2)/(6.61*3600)	=G20*37000000000/$K20/6.023E+23	=H20*37000000000/$K20/6.023E+23
21		Totals	=SUM(L16:L20)	=SUM(M16:M20)
22				
23	4.5.1, adjusted to be 0.2 uCi/gm I-131 dose equivalent			
24				
25	Activity			
26	(uCi/gm)			
27	=E16*C$16/C16			
28	=E17*C$16/C17			
29	=E18*C$16/C18			
30	=E19*C$16/C19			
31	=E20*C$16/C20			
32				
33	Case 1	Case 2		Case 1
34	Activity	Activity	Decay	Activity
35	Release	Release	Constant	Release
36	moles	moles	1/seconds	curies
37	=0.95*$I37*L$21	=0.95*$I37*M$21	=LN(2)/(2.062*86400*365.25)	=J37*6.023E+23*$L37/37000000000
38	=0.95*$I38*L$21	=0.95*$I38*M$21	=LN(2)/(2300000*86400*365.25)	=J38*6.023E+23*$L38/37000000000
39	=0.95*$I39*L$21	=0.95*$I39*M$21	=LN(2)/(13.16*86400)	=J39*6.023E+23*$L39/37000000000
40	=0.95*$I40*L$21	=0.95*$I40*M$21	=LN(2)/(30.17*86400*365.25)	=J40*6.023E+23*$L40/37000000000
41	=0.95*$I41*L$21	=0.95*$I41*M$21	=LN(2)/(32.2*60)	=J41*6.023E+23*$L41/37000000000
42	=SUM(J37:J41)	=SUM(K37:K41)		
43				
44				

	J	K	L	M
45				
46	Case 2 Dose (rem CEDE)			
47	(Inhalation)			
48	EAB	LPZ		
49	=D49*$E49*$A$102*$A$107	=D49*$E49*$A$102*$A$108		
50	=D50*$E50*$A$102*$A$107	=D50*$E50*$A$102*$A$108		
51	=D51*$E51*$A$102*$A$107	=D51*$E51*$A$102*$A$108		
52	=D52*$E52*$A$102*$A$107	=D52*$E52*$A$102*$A$108		
53	=D53*$E53*$A$102*$A$107	=D53*$E53*$A$102*$A$108		
54				
55	=E55*$D55*$A$102*$A$107	=E55*$D55*$A$102*$A$108		
56	=E56*$D56*$A$102*$A$107	=E56*$D56*$A$102*$A$108		
57	=E57*$D57*$A$102*$A$107	=E57*$D57*$A$102*$A$108		
58	=E58*$D58*$A$102*$A$107	=E58*$D58*$A$102*$A$108		
59	=E59*$D59*$A$102*$A$107	=E59*$D59*$A$102*$A$108		
60	**=SUM(J49:J59)**	**=SUM(K49:K59)**		
61				
62				
63	Case 2 Dose (rem EDE)			
64	(External)			
65	EAB	LPZ		
66	=D66*$E66*$A$107	=D66*$E66*$A$108		
67	=D67*$E67*$A$107	=D67*$E67*$A$108		
68	=D68*$E68*$A$107	=D68*$E68*$A$108		
69	=D69*$E69*$A$107	=D69*$E69*$A$108		
70	=D70*$E70*$A$107	=D70*$E70*$A$108		
71				
72	=D72*$E72*$A$107	=D72*$E72*$A$108		
73	=D73*$E73*$A$107	=D73*$E73*$A$108		
74	=D74*$E74*$A$107	=D74*$E74*$A$108		
75	=D75*$E75*$A$107	=D75*$E75*$A$108		
76	=D76*$E76*$A$107	=D76*$E76*$A$108		
77	**=SUM(J66:J76)**	**=SUM(K66:K76)**		
78	**=SUM(J60+J77)**	**=SUM(K60+K77)**		
79				
80	Case 2 Dose (rem EDE)			
81	(External)			
82	EAB	LPZ		
83	=D83*$E83*$A$107	=D83*$E83*$A$108		
84	=D84*$E84*$A$107	=D84*$E84*$A$108		
85	=D85*$E85*$A$107	=D85*$E85*$A$108		
86	=D86*$E86*$A$107	=D86*$E86*$A$108		
87	=D87*$E87*$A$107	=D87*$E87*$A$108		
88	=D88*$E88*$A$107	=D88*$E88*$A$108		
89	=D89*$E89*$A$107	=D89*$E89*$A$108		
90	=D90*$E90*$A$107	=D90*$E90*$A$108		
91	=D91*$E91*$A$107	=D91*$E91*$A$108		

	J	K	L	M
92	=D92*$E92*$A$107	=D92*$E92*$A$108		
93	=D93*$E93*$A$107	=D93*$E93*$A$108		
94	=D94*$E94*$A$107	=D94*$E94*$A$108		
95	=D95*$E95*$A$107	=D95*$E95*$A$108		
96	**=SUM(J83:J95)**	**=SUM(K83:K95)**		
97				
98	**=SUM(J78+J96)**	**=SUM(K78+K96)**		
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33	Case 2
34	Activity
35	Release
36	curies
37	=K37*6.023E+23*$L37/3700000000
38	=K38*6.023E+23*$L38/3700000000
39	=K39*6.023E+23*$L39/3700000000
40	=K40*6.023E+23*$L40/3700000000
41	=K41*6.023E+23*$L41/3700000000
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	A	B	C	D	E	F	G	H	I	J	K	L
1	**Limerick Beginning of Core Life (100 Effective Full Power Days) and End of Cycle (EOC) Cesium Isotope Quantities**											
2	**(Used for General Cs Molar Fraction Determination for AST)**											
3										**Decay**		
4		**100 EFPD**	**EOC**					**100 EFPD**	**EOC**	**Constant**	**100 EFPD**	**EOC**
5		**(grams)**	**(grams)**				**At. Mass**	**(gm-moles)**	**(gm-moles)**	**1/seconds**	**Ci**	**Ci**
6	Cs-133	1.025E+05	1.678E+05			Cs-133	132.9054	7.712E+02	1.263E+03	0.000E+00	0.000E+00	0.000E+00
7	Cs-134	1.031E+04	1.977E+04			Cs-134	133.9067	7.699E+01	1.476E+02	1.07E-08	1.335E+07	2.559E+07
8	Cs-135	4.502E+04	7.841E+04			Cs-135	134.9059	3.337E+02	5.812E+02	9.55E-15	5.188E+01	9.035E+01
9	Cs-137	1.087E+05	1.832E+05			Cs-137	136.9071	7.940E+02	1.338E+03	7.28E-10	9.410E+06	1.586E+07
10						Cs-136		2.37E-01	3.99E-01	6.10E-07	2.352E+06	3.964E+06
11						Cs-138		2.01E-01	3.39E-01	3.59E-04	1.176E+09	1.982E+09
12	**Total**	**2.665E+05**	**4.492E+05**					**1.976E+03**	**3.331E+03**			
13												
14	*ANSI/ANS-18.1-1999 Relative Abundances in Reactor Water*										**Molar Fraction**	
15		uCi/gram of	moles/gram of	ratio to						Cs-133	39.0219%	37.9218%
16		Reactor Coolε	Reactor Coolant	Cs-137						Cs-134	3.8956%	4.4317%
17	Cs-134	3.00E-05	1.04E+08	2.56E-02						Cs-135	16.8848%	17.4506%
18	Cs-136	2.00E-05	1.21E+06	2.99E-04						Cs-137	40.1755%	40.1737%
19	Cs-137	8.00E-05	4.07E+09	1.00E+00						Cs-136	0.0120%	0.0120%
20	Cs-138	1.00E-02	1.03E+06	2.54E-04						Cs-138	0.0102%	0.0102%

	A	B	C	D	E	F	G	H	I
1	**Limerick Begin**								
2	**(Used for Gene**								
3									
4		**100 EFPD**	**EOC**					**100 EFPD**	**EOC**
5		**(grams)**	**(grams)**				**At. Mass**	**(gm-moles)**	**(gm-moles)**
6	Cs-133	102500	167800			Cs-133	132.9054	771.2	1263
7	Cs-134	10310	19770			Cs-134	133.9067	76.99	147.6
8	Cs-135	45020	78410			Cs-135	134.9059	333.7	581.2
9	Cs-137	108700	183200			Cs-137	136.9071	794	1338
10						Cs-136		=K10*37000000000/$J10/6.023E+23	=L10*37000000000/$J10/6.023E+23
11						Cs-138		=K11*37000000000/$J11/6.023E+23	=L11*37000000000/$J11/6.023E+23
12	**Total**	**=SUM(B6:B9)**	**=SUM(C6:C9)**					**=SUM(H6:H11)**	**=SUM(I6:I11)**
13									
14	ANSI/ANS-18.1								
15		uCi/gram of	moles/gram of	ratio to					
16		Reactor Coolant	Reactor Coolant	Cs-137					
17	Cs-134	0.00003	=B17*37000/J7	=C17/C$19					
18	Cs-136	0.00002	=B18*37000/J10	=C18/C$19					
19	Cs-137	0.00008	=B19*37000/J9	=C19/C$19					
20	Cs-138	0.01	=B20*37000/J11	=C20/C$19					

	J	K	L
1			
2			
3	**Decay**		
4	**Constant**	**100 EFPD**	**EOC**
5	**1/seconds**	**Ci**	**Ci**
6	0	=H6*$J6*6.023E+23/37000000000	=I6*$J6*6.023E+23/37000000000
7	=LN(2)/(2.062*86400*365.25)	=H7*$J7*6.023E+23/37000000000	=I7*$J7*6.023E+23/37000000000
8	=LN(2)/(2300000*86400*365.25)	=H8*$J8*6.023E+23/37000000000	=I8*$J8*6.023E+23/37000000000
9	=LN(2)/(30.17*86400*365.25)	=H9*$J9*6.023E+23/37000000000	=I9*$J9*6.023E+23/37000000000
10	=LN(2)/(13.16*86400)	=K$9*$B$18/$B$19	=L$9*$B$18/$B$19
11	=LN(2)/(32.2*60)	=K$9*$B$20/$B$19	=L$9*$B$20/$B$19
12			
13			
14		**Molar Fraction**	
15	Cs-133	=H6/H$12	=I6/I$12
16	Cs-134	=H7/H$12	=I7/I$12
17	Cs-135	=H8/H$12	=I8/I$12
18	Cs-137	=H9/H$12	=I9/I$12
19	Cs-136	=H10/H$12	=I10/I$12
20	Cs-138	=H11/H$12	=I11/I$12