# ATTACHMENT 4

**Calculation QDC-0000-N-1266, Revision 2, "Re-analysis of Main Steam Line Break (MSLB) Accident Using Alternative Source Terms"**

**ATTACHMENT 1**
**Design Analysis Cover Sheet**

| | | | |
|---|---|---|---|
| **Design Analysis (Major Revision)** | | **Last Page No.** [6] 18 / Att. B-1 | |
| **Analysis No.:** [1] | QDC-0000-N-1266 | **Revision:** [2] | 4 |
| **Title:** [3] | Re-analysis of Main Steam Line Break (MSLB) Accident Using Alternative Source Terms | | |
| **EC/ECR No.:** [4] | 356379 | **Revision:** [5] | 0 |

| | | | |
|---|---|---|---|
| **Station(s):** [7] | Quad Cities | **Component(s):** [14] | |
| **Unit No.:** [8] | 1 & 2 | | |
| **Discipline:** [9] | N | | |
| **Descrip. Code/Keyword:** [10] | N01, R01, R02 /AST, MSLB | | |
| **Safety/QA Class:** [11] | SR | | |
| **System Code:** [12] | 00 | | |
| **Structure:** [13] | | | |

**CONTROLLED DOCUMENT REFERENCES** [15]

| Document No.: | From/To | Document No.: | From/To |
|---|---|---|---|
| QDC-0000-M-1408, R1 | From | GE-NE-A22-00103-64-01, R0 | From |
| QDC-0000-N-1020, R1 | 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] QDC-0000-N-1266, Rev. 3 in its entirety.

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

This revision corrects for the use of normalized values for activity releases for Iodine in column G on page A1 and formula page A4 of the calculation spreadsheet, with resulting changes in calculated doses as provided in the Summary and Conclusions section. A separate cell-by-cell independent check was also performed, as documented in Attachment B.

| | Print Name | Sign Name | Date |
|---|---|---|---|
| **Preparer:** [20] | Harold Rothstein | Harold Rothstein | 1/18/06 |

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

| | Print Name | Sign Name | Date |
|---|---|---|---|
| **Reviewer:** [22] | Paul Reichert | Paul Reichert | 1/18/06 |

**Review Notes:** [23] Independent review ☒ Peer review ☐
Independent Third Party review Performed by Nucore Corporation

(For External Analyses Only)

| | Print Name | Sign Name | Date |
|---|---|---|---|
| **External Approver:** [24] | Harold R. Rothstein | Harold Rothstein | 1/19/06 |
| **Exelon Reviewer:** [25] | T. J. Mscisz | T. Mscisz | 1/20/06 |

**Is a Supplemental Review Required?** [26] Yes ☐ No ☒ If yes, complete Attachment 3
Independent Third Party Review was Performed by NUCORE

| | Print Name | Sign Name | Date |
|---|---|---|---|
| **Exelon Approver:** [27] | E. Flick | Elliott Flick | 1/31/06 |

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 [Reference 6] as described herein.

The principal attributes of this analysis compared to those performed previously 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 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. Iodine releases are based on reactor coolant I-131 equivalent limitations in Technical Specifications for "Case 1" and a 20 times higher iodine spike limit for "Case 2".
6. Cesium releases, as cesium iodide, and noble gas release are now considered in addition to iodine that has been historically assumed.

As per Quad Cities - UFSAR [Ref. 8] Section 15.6.4, 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) to address any degree of postulated unfiltered inleakage during the duration of the event.

The mass of coolant released during the MSLB is taken for this dose calculation as a bounding maximized value for all current Boiling Water Reactor (BWR) plants of 140,000 pounds of water, as provided in Standard Review Plan 15.6.4, Paragraph III.2.a for a GESSAR-251 plant. This value bounds for dose calculation purposes the historic UFSAR values such as 55,000 pounds of steam and 45,000 pounds of water in UFSAR Section 15.6.4.5. This ensures that the discharge quantity and dose consequences are maximized, and that the releases should bound any other credible pipe break. Considering the release as all water maximizes the iodine (the primary dose contributor) release quantity compared to any actual release of steam, which would contain iodine quantities limited by the carryover fraction (typically 2%, as per Reference 10).

## 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*

No fuel damage is expected to result from a MSLB. 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 is consistent with the pre-AST MSLB analyses per Regulatory Guide 1.5 [Ref. 5], and meets the guidance in RG 1.183 for analysis of this event as well.

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 from the release fractions in Reference 2 and its Curie release formulation, corresponding to 100,000 uCi /sec off-gas emission after 30 minutes decay, per UFSAR Section 15.6.4.5, and for the Quad Cities Technical Specification value of 5.5 seconds MSIV closure time.

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.

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. 13], and from ANSI/ANS-18.1-1999 [Ref. 10] 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], that is also cited as a basis for evaluation in the Quad Cities – UFSAR (e.g., Section 15.6.4.5). Specifically:

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

where

$\sigma_y$ = 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 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. 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.

### 2.5 *Dose Model*

Dose models for both onsite and offsite are simplified and 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 1 & 0].

#### 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 rate. 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:

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

and

$$\text{Dose}_{\text{EDE}}\ (\text{rem}) = \text{Plume Concentration}\ (\text{Ci/m}^3) * \text{Transit Duration}\ (\text{sec}) * \text{Submersion DCF}\ (\text{rem}_{\text{EDE}} - \text{m}^3/\text{Ci - sec})$$

and finally,

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

## 2.6 *Acceptance Criteria*

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

The Table below 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. 7 and 6.

| 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 | Dresden/Quad Cities 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, 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 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 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 Technical Specification limit 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 | No fuel damage. |
| 4.1 | The main steam line isolation valves (MSIV) should be assumed to close in the maximum time allowed by technical specifications. | Conforms | An MSIV closure time of 5.5 seconds was assumed in the analysis. This is the Technical Specification 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 | Conforms | A bounding value of 140,000 lbs or reactor coolant is used |

| Table 2.1: Conformance with RG 1.183 Appendix D (Main Steam Line Break) | | | |
|---|---|---|---|
| RG Section | RG Position | Dresden/Quad Cities Analysis | Comments |
| | plus the amount that passes through the valves prior to closure. | | for dose assessment. |
| 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. |
| 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 the Quad Cities UFSAR [Ref. 8] Section 15.6.4.5.
- Noble Gas activity releases are taken from Reference 2.
- 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. This assumption is conservative because it considers the maximum release of fission products.
- 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. It is also reasonable for the more likely release paths through multiple large blowout panels situated around the Turbine Building Main Floor.
  - 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 maximum control room volume of 184,000 cubic feet [Ref. 11].

# 4.0 DESIGN INPUT

## 4.1 *Mass Release Data*

- As stated in UFSAR Section 15.6.4.3, there is no core uncovery and therefore no fuel damage as a consequence of this accident for the assumed releases. For this dose analysis, a conservative 140,000 pounds of primary coolant liquid is assumed to be released to maximize the iodine release, with a conservative fraction of this liquid flashing to steam.

## 4.2 *Iodine and Noble Gas Activity Release*

The MSLB noble gas release fractions listed in the second column below are provided in Table 3-1 of Reference 2. Using the formula below in this Reference for a 100,000 uCi /sec off-gas emission after 30 minutes decay, per UFSAR Section 15.6.4.5, and the Quad Cities Technical Specification value of 5.5 seconds MSIV closure time, the Curie releases in the third column below are obtained: Curies Released = Release fraction x 5.5 x 3 x 0.45,
where 0.45 is the offgas rate at the break, in Curies/second, corresponding to a 100,000 uCi /sec off-gas emission after 30 minutes decay, and 3 is nominally the ratio of NRC-assumed to design basis noble release rate.

| Noble Gas Isotope | Release Fraction | Curies Release |
|---|---|---|
| Kr-83M | 0.00936 | 6.95E-02 |
| Kr-85M | 0.0164 | 1.22E-01 |
| Kr-85 | 0.000064 | 4.75E-04 |
| Kr-87 | 0.0511 | 3.79E-01 |
| Kr-88 | 0.0524 | 3.89E-01 |
| Kr-89 | 0.218 | 1.62E+00 |
| Xe-131M | 0.0000523 | 3.88E-04 |
| Xe-133M | 0.000782 | 5.81E-03 |
| Xe-133 | 0.0219 | 1.63E-01 |
| Xe-135M | 0.0641 | 4.76E-01 |
| Xe-135 | 0.0592 | 4.40E-01 |
| Xe-137 | 0.288 | 2.14E+00 |
| Xe-138 | 0.218 | 1.62E+00 |

The relative mix of iodine isotopes in the reactor coolant at the onset of the accident, based on the Quad Cities UFSAR [Ref. 8] Section 15.6.4, is given below.

| Iodine Isotope | Activity (μCi/cc) |
|---|---|
| I-131 | 0.067 |
| I-132 | 0.38 |
| I-133 | 0.40 |
| I-134 | 0.53 |
| I-135 | 0.49 |

Release activities are calculated in Attachment A.

### 4.3 *Control Room Data*

- Control Room Emergency Zone Volume = 184,000 cubic feet [Ref. 11]

(the maximum volume above rather than the volume of the Control Room proper is utilized to maximize the calculated doses, which are proportional to geometry factor)

- No Emergency Filtration Credit taken.

### 4.4 *EAB and LPZ Data*

- EAB Distance from Release: 380 m [Quad Cities Tech Specs]
- LPZ Distance from Release,: 4,828 m [Quad Cities Tech Specs]

## 5.0 REFERENCES

1. Deleted.
2. NEDO-21143-1, "Radiological Accident Evaluation - The CONAC03 Code", General Electric Company, December, 1981.
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 Eexposure 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", January 1, 2001.
8. Quad Cities Nuclear Power Station UFSAR Rev. 7, Section 15.6.4.
9. Calculation QDC-0000-M-1408, Rev. 1 "Atmospheric Dispersion Factors (X/Qs) for Accident Release".
10. American Nuclear Society Standard (ANS) 18.1-1999 "Radioactive Source Terms For Normal Operation of Light Water Reactors", Table 5.
11. QDC-0000-N-1020, "Impact of Extended Power Uprate on Site Boundary and Control room Doses for LOCA and Non-LOCA Events", Revision 1.
12. Deleted.
13. PBAPS Calculation PM-1056, Rev. 1, "Suppression Pool pH Calculation for Alternative Source Terms".

## 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 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 the initial steam blowdown and that portion of the liquid reactor coolant release that flashed to steam.

| | |
|---|---|
| The mass 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) |
| | = 6.350E76 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 to 56,000 lb of steam at 14.7 psi and 212 °F, $v_g$ = 26.799 ft$^3$/lb) were calculated as follows:

$$\begin{aligned}\text{Volume} &= (56{,}000\ \text{lb})(26.799\ \text{ft}^3/\text{lb}) \\ &= 1{,}500{,}744\ \text{ft}^3 \\ &= (1{,}500{,}744\ \text{ft}^3)/(35.3\ \text{ft}^3/\text{m}^3) \\ &= 42{,}514\ \text{m}^3\end{aligned}$$

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

$\sigma_y$ = horizontal standard deviation of the plume (meters)

u = wind velocity (meters/second)

As calculated in the PAVAN run in Reference [9], at the 380 meter EAB distance $\sigma_y$ is 15.4, and at the 4828 meter LPZ distance $\sigma_y$ is 153. The resulting EAB and LPZ X/Qs are 8.64E-04 and 8.69E-05 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. 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. For Cs-133, Cs-134, Cs-135, and Cs-137, isotopic data (in Curies per Megawatt, and therefore generally applicable to similar BWRs such as Quad Cities +) for end of cycle conditions from Reference 13 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 Reference 10 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 3.47E-04 $m^3$/sec is per RG 1.183 guidance without the round-off.

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. The results are summarized in the Table below. The doses at the Control Room, EAB, and LPZ resulting from a postulated design basis MSLB do not exceed the regulatory limits.

| 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** | 0.167 | 3.32 |
| **LPZ** | 0.0168 | 0.335 |
| **CR** | 0.189 | 3.79 |

## 8.0 OWNER'S ACCEPTANCE REVIEW CHECKLIST FOR EXTERNAL DESIGN ANALYSIS

### DESIGN ANALYSIS NO. QDC-0000-N-1266 REV: 4

| | | 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? | ☑ | ☐ | ☐ |
| 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? | ☑ | ☐ | ☐ |
| 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? | ☑ | ☐ | ☐ |
| 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? | ☑ | ☐ | ☐ |
| 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) | ☑ | ☐ | ☐ |
| 16. | Have vendor supporting technical documents and references (including GE DRFs) been reviewed when necessary? | ☑ | ☐ | ☐ |

**EXELON REVIEWER:** T.J. Mscisz / [signature] **DATE:** 1/20/06

Print / Sign

| | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **Quad Cities 1&2 MSLB Dose Spreadsheet** | | | | | Case 1: | Reactor Coolant at maximum value (DE I-131 of 0.2 uCi/g) permitted | | | | | | |
| 2 | | | | | | | for continued full power operation | | | | | | |
| 3 | 42514 | Volume of cloud (cubic meters) | | | | Case 2: | Reactor Coolant at maximum value permitted (DE I-131 of 4.0 uCi/g) | | | | | | |
| 4 | 6.35E+07 | Mass of water in reactor coolant release (grams) | | | | | corresponding to an assumed pre-accident spike | | | | | | |
| 5 | 54.6 | seconds for cloud to pass over CR intake for wind speed of 1 m/second | | | | | | | | | | | |
| 6 | 184000 | Volume of Control Room Envelope (cubic feet) - maximum used for conservatism | | | | | | | | | | | |
| 7 | 140,000 | Mass of Liquid Water Released (lb) | | | | | | | | | | | |
| 8 | 40% | Flashing Fraction | | | | | | | | | | | |
| 9 | 56000 | Mass of Steam in the Cloud (lb) | | | | | | | | | | | |
| 10 | 26.799 | Vg ($ft^3$/lb) (based on 14.7 psi and 212F) | | | | | | | | | | | |
| 11 | Reactor coolant iodine distribution is assumed to be a 1 gm/cc specific gravity | | | | | | | | | | | | |
| 12 | | | | | | | | | Case 1 | Case 2 | | | |
| 13 | | | | | | | | | Release | Release | | | |
| 14 | | | | Normalized | Case 1 | Case 2 | Case 1 | Case 2 | Cloud | Cloud | | Case 1 | Case 2 |
| 15 | Isotope | Activity | FGR 11 | I-131 DE | Normalized | Normalized | Activity | Activity | Concentration | Concentratior | Decay | Activity | Activity |
| 16 | | Distribution | DCF[1] | Activity | Activity | Activity | Release | Release | | | Constant | Release | Release |
| 17 | | uCi/gm | Rem$_{CEDE}$/Ci | uCi/gm | uCi/gm | uCi/gm | Ci | Ci | Ci/m3 | Ci/m3 | 1/seconds | moles | moles |
| 18 | I-131 | 0.067 | 3.29E+04 | 6.70E-02 | 8.23E-02 | 1.65E+00 | 5.22E+00 | 1.04E+02 | 1.23E-04 | 2.46E-03 | 9.98E-07 | 3.22E-07 | 6.43E-06 |
| 19 | I-132 | 0.38 | 3.81E+02 | 4.40E-03 | 5.40E-03 | 1.08E-01 | 2.96E+01 | 5.93E+02 | 6.97E-04 | 1.39E-02 | 8.37E-05 | 2.17E-08 | 4.35E-07 |
| 20 | I-133 | 0.4 | 5.85E+03 | 7.11E-02 | 8.73E-02 | 1.75E+00 | 3.12E+01 | 6.24E+02 | 7.34E-04 | 1.47E-02 | 9.26E-06 | 2.07E-07 | 4.14E-06 |
| 21 | I-134 | 0.53 | 1.31E+02 | 2.11E-03 | 2.59E-03 | 5.18E-02 | 4.13E+01 | 8.26E+02 | 9.72E-04 | 1.94E-02 | 2.20E-04 | 1.16E-08 | 2.31E-07 |
| 22 | I-135 | 0.49 | 1.23E+03 | 1.83E-02 | 2.25E-02 | 4.50E-01 | 3.82E+01 | 7.64E+02 | 8.99E-04 | 1.80E-02 | 2.91E-05 | 8.06E-08 | 1.61E-06 |
| 23 | | | Totals | 1.63E-01 | 2.00E-01 | 4.00E+00 | | | | | Totals | 6.42E-07 | 1.28E-05 |
| 24 | | | | | "non-spiked" | "spiked" | | | | | | | |
| 25 | | NEDO- | NEDO- | NEDO- | | | | | | | | | |
| 26 | | 21143-1[3] | 21143-1[3] | 21143-1[3] | Case 1 | Case 2 | | | | | | | |
| 27 | | MSLB | Case 1 | Case 2 | Release | Release | | | | | | | |
| 28 | | Noble Gas | Activity | Activity | Cloud | Cloud | | | | | | | |
| 29 | | Release | Release | Release | Concentration | Concentration | | | | | | | |
| 30 | | Fractions | Ci | Ci | Ci/m3 | Ci/m3 | | | | | | | |
| 31 | Kr-83M | 0.00936 | 6.95E-02 | 6.95E-02 | 1.63E-06 | 1.63E-06 | | | Case 1 | Case 2 | | Case 1 | Case 2 |
| 32 | Kr-85M | 0.0164 | 1.22E-01 | 1.22E-01 | 2.86E-06 | 2.86E-06 | | | Activity | Activity | Decay | Activity | Activity |
| 33 | Kr-85 | 0.000064 | 4.75E-04 | 4.75E-04 | 1.12E-08 | 1.12E-08 | | | Release | Release | Constant | Release | Release |
| 34 | Kr-87 | 0.0511 | 3.79E-01 | 3.79E-01 | 8.92E-06 | 8.92E-06 | | Molar Frac. | moles | moles | 1/seconds | curies | curies |
| 35 | Kr-88 | 0.0524 | 3.89E-01 | 3.89E-01 | 9.15E-06 | 9.15E-06 | Cs-134 | 4.4317% | 2.70E-08 | 5.41E-07 | 1.07E-08 | 4.69E-03 | 9.38E-02 |
| 36 | Kr-89 | 0.218 | 1.62E+00 | 1.62E+00 | 3.81E-05 | 3.81E-05 | Cs-135 | 17.4506% | 1.06E-07 | 2.13E-06 | 9.55E-15 | 1.66E-08 | 3.31E-07 |
| 37 | Xe-131M | 0.0000523 | 3.88E-04 | 3.88E-04 | 9.13E-09 | 9.13E-09 | Cs-136 | 0.0120% | 7.32E-11 | 1.46E-09 | 6.10E-07 | 7.26E-04 | 1.45E-02 |
| 38 | Xe-133M | 0.000782 | 5.81E-03 | 5.81E-03 | 1.37E-07 | 1.37E-07 | CS-137 | 40.17% | 2.45E-07 | 4.90E-06 | 7.28E-10 | 2.91E-03 | 5.81E-02 |
| 39 | Xe-133 | 0.0219 | 1.63E-01 | 1.63E-01 | 3.82E-06 | 3.82E-06 | Cs-138 | 0.0102% | 6.22E-11 | 1.24E-09 | 3.59E-04 | 3.63E-01 | 7.26E+00 |
| 40 | Xe-135M | 0.0641 | 4.76E-01 | 4.76E-01 | 1.12E-05 | 1.12E-05 | Totals | 62.08% | 3.79E-07 | 7.58E-06 | | | |
| 41 | Xe-135 | 0.0592 | 4.40E-01 | 4.40E-01 | 1.03E-05 | 1.03E-05 | Balance is stable Cs-133 | | | | | | |
| 42 | Xe-137 | 0.288 | 2.14E+00 | 2.14E+00 | 5.03E-05 | 5.03E-05 | | | | | | | |
| 43 | Xe-138 | 0.218 | 1.62E+00 | 1.62E+00 | 3.81E-05 | 3.81E-05 | | | | | | | |
| 44 | | | | | | | | | | | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45 | | | Curies Released | | | Case 1 Dose (rem CEDE) | | | Case 2 Dose (rem CEDE) | | | | |
| 46 | | | to the Environment | | | | (Inhalation) | | | (Inhalation) | | | |
| 47 | Isotope | | Case 1 | Case 2 | DCF[1] | CR | EAB | LPZ | CR | EAB | LPZ | | |
| 48 | I-131 | | 5.22E+00 | 1.04E+02 | 3.29E+04 | 7.65E-02 | 5.15E-02 | 5.18E-03 | 1.53E+00 | 1.03E+00 | 1.04E-01 | | |
| 49 | I-132 | | 2.96E+01 | 5.93E+02 | 3.81E+02 | 5.03E-03 | 3.38E-03 | 3.40E-04 | 1.01E-01 | 6.77E-02 | 6.81E-03 | | |
| 50 | I-133 | | 3.12E+01 | 6.24E+02 | 5.85E+03 | 8.12E-02 | 5.46E-02 | 5.50E-03 | 1.62E+00 | 1.09E+00 | 1.10E-01 | | |
| 51 | I-134 | | 4.13E+01 | 8.26E+02 | 1.31E+02 | 2.41E-03 | 1.62E-03 | 1.63E-04 | 4.82E-02 | 3.24E-02 | 3.27E-03 | | |
| 52 | I-135 | | 3.82E+01 | 7.64E+02 | 1.23E+03 | 2.09E-02 | 1.41E-02 | 1.42E-03 | 4.18E-01 | 2.82E-01 | 2.83E-02 | | |
| 53 | | | | | | | | | | | | | |
| 54 | Cs-134 | | 4.69E-03 | 9.38E-02 | 4.63E+04 | 9.66E-05 | 6.50E-05 | 6.54E-06 | 1.93E-03 | 1.30E-03 | 1.31E-04 | | |
| 55 | Cs-135 | | 1.66E-08 | 3.31E-07 | 4.55E+03 | 3.36E-11 | 2.26E-11 | 2.27E-12 | 6.71E-10 | 4.52E-10 | 4.55E-11 | | |
| 56 | Cs-136 | | 7.26E-04 | 1.45E-02 | 7.33E+03 | 2.37E-06 | 1.59E-06 | 1.61E-07 | 4.74E-05 | 3.19E-05 | 3.21E-06 | | |
| 57 | CS-137 | | 2.91E-03 | 5.81E-02 | 3.19E+04 | 4.13E-05 | 2.78E-05 | 2.80E-06 | 8.26E-04 | 5.56E-04 | 5.60E-05 | | |
| 58 | Cs-138 | | 3.63E-01 | 7.26E+00 | 1.01E+02 | 1.64E-05 | 1.10E-05 | 1.11E-06 | 3.28E-04 | 2.21E-04 | 2.22E-05 | | |
| 59 | **Sub-total (rem CEDE)** | | | | | **1.86E-01** | **1.25E-01** | **1.26E-02** | **3.72E+00** | **2.51E+00** | **2.52E-01** | | |
| 60 | | | | | | | | | | | | | |
| 61 | | | Curies Released | | | Case 1 Dose (rem EDE) | | | Case 2 Dose (rem EDE) | | | | |
| 62 | | | to the Environment | | | | (External) | | | (External) | | | |
| 63 | isotope | | Case 1 | Case 2 | DCF[2] | CR | EAB | LPZ | CR | EAB | LPZ | | |
| 64 | I-131 | | 5.22E+00 | 1.04E+02 | 6.73E-02 | 2.32E-05 | 3.04E-04 | 3.06E-05 | 4.63E-04 | 6.08E-03 | 6.12E-04 | | |
| 65 | I-132 | | 2.96E+01 | 5.93E+02 | 4.14E-01 | 8.08E-04 | 1.06E-02 | 1.07E-03 | 1.62E-02 | 2.12E-01 | 2.13E-02 | | |
| 66 | I-133 | | 3.12E+01 | 6.24E+02 | 1.09E-01 | 2.23E-04 | 2.93E-03 | 2.95E-04 | 4.47E-03 | 5.86E-02 | 5.90E-03 | | |
| 67 | I-134 | | 4.13E+01 | 8.26E+02 | 4.81E-01 | 1.31E-03 | 1.72E-02 | 1.73E-03 | 2.62E-02 | 3.43E-01 | 3.46E-02 | | |
| 68 | I-135 | | 3.82E+01 | 7.64E+02 | 2.95E-01 | 7.43E-04 | 9.74E-03 | 9.80E-04 | 1.49E-02 | 1.95E-01 | 1.96E-02 | | |
| 69 | | | | | | | | | | | | | |
| 70 | Cs-134 | | 4.69E-03 | 9.38E-02 | 2.80E-01 | 8.65E-08 | 1.13E-06 | 1.14E-07 | 1.73E-06 | 2.27E-05 | 2.28E-06 | | |
| 71 | Cs-135 | | 1.66E-08 | 3.31E-07 | 2.09E-06 | 2.28E-18 | 2.99E-17 | 3.01E-18 | 4.56E-17 | 5.98E-16 | 6.02E-17 | | |
| 72 | Cs-136 | | 7.26E-04 | 1.45E-02 | 3.92E-01 | 1.88E-08 | 2.46E-07 | 2.48E-08 | 3.75E-07 | 4.92E-06 | 4.95E-07 | | |
| 73 | CS-137 | | 2.91E-03 | 5.81E-02 | 2.86E-05 | 5.48E-12 | 7.19E-11 | 7.23E-12 | 1.10E-10 | 1.44E-09 | 1.45E-10 | | |
| 74 | Cs-138 | | 3.63E-01 | 7.26E+00 | 4.48E-01 | 1.07E-05 | 1.40E-04 | 1.41E-05 | 2.14E-04 | 2.81E-03 | 2.83E-04 | | |
| 75 | | | | | | | | | | | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 76 | Sub-total (rem EDE) | | | | | 3.12E-03 | 4.09E-02 | 4.12E-03 | 6.23E-02 | 8.18E-01 | 8.23E-02 | | |
| 77 | Iodine and Cesium Total (rem TEDE) | | | | | 1.89E-01 | 1.66E-01 | 1.67E-02 | 3.79E+00 | 3.32E+00 | 3.35E-01 | | |
| 78 | | | Curies Released | | | Case 1 Dose (rem EDE) | | | Case 2 Dose (rem EDE) | | | | |
| 79 | | | to the Environment | | | | (External) | | | (External) | | | |
| 80 | | | Case 1 | Case 2 | DCF[2] | CR | EAB | LPZ | CR | EAB | LPZ | | |
| 81 | Kr-83M | | 6.95E-02 | 6.95E-02 | 5.55E-06 | 2.54E-11 | 3.33E-10 | 3.35E-11 | 2.54E-11 | 3.33E-10 | 3.35E-11 | | |
| 82 | Kr-85M | | 1.22E-01 | 1.22E-01 | 2.77E-02 | 2.22E-07 | 2.91E-06 | 2.93E-07 | 2.22E-07 | 2.91E-06 | 2.93E-07 | | |
| 83 | Kr-85 | | 4.75E-04 | 4.75E-04 | 4.40E-04 | 1.38E-11 | 1.81E-10 | 1.82E-11 | 1.38E-11 | 1.81E-10 | 1.82E-11 | | |
| 84 | Kr-87 | | 3.79E-01 | 3.79E-01 | 1.52E-01 | 3.81E-06 | 5.00E-05 | 5.03E-06 | 3.81E-06 | 5.00E-05 | 5.03E-06 | | |
| 85 | Kr-88 | | 3.89E-01 | 3.89E-01 | 3.77E-01 | 9.67E-06 | 1.27E-04 | 1.28E-05 | 9.67E-06 | 1.27E-04 | 1.28E-05 | | |
| 86 | Kr-89 | | 1.62E+00 | 1.62E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | | |
| 87 | Xe-131M | | 3.88E-04 | 3.88E-04 | 1.44E-03 | 3.68E-11 | 4.83E-10 | 4.86E-11 | 3.68E-11 | 4.83E-10 | 4.86E-11 | | |
| 88 | Xe-133M | | 5.81E-03 | 5.81E-03 | 5.07E-03 | 1.94E-09 | 2.54E-08 | 2.56E-09 | 1.94E-09 | 2.54E-08 | 2.56E-09 | | |
| 89 | Xe-133 | | 1.63E-01 | 1.63E-01 | 5.77E-03 | 6.18E-08 | 8.11E-07 | 8.16E-08 | 6.18E-08 | 8.11E-07 | 8.16E-08 | | |
| 90 | Xe-135M | | 4.76E-01 | 4.76E-01 | 7.55E-02 | 2.37E-06 | 3.10E-05 | 3.12E-06 | 2.37E-06 | 3.10E-05 | 3.12E-06 | | |
| 91 | Xe-135 | | 4.40E-01 | 4.40E-01 | 4.40E-02 | 1.27E-06 | 1.67E-05 | 1.68E-06 | 1.27E-06 | 1.67E-05 | 1.68E-06 | | |
| 92 | Xe-137 | | 2.14E+00 | 2.14E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | | |
| 93 | Xe-138 | | 1.62E+00 | 1.62E+00 | 2.13E-01 | 2.28E-05 | 2.98E-04 | 3.00E-05 | 2.28E-05 | 2.98E-04 | 3.00E-05 | | |
| 94 | Noble Gas Sub-total (rem EDE) | | | | | 4.02E-05 | 5.27E-04 | 5.30E-05 | 4.02E-05 | 5.27E-04 | 5.30E-05 | | |
| 95 | | | | | | | | | | | | | |
| 96 | Overall Total (rem TEDE) | | | | | 1.89E-01 | 1.67E-01 | 1.68E-02 | 3.79E+00 | 3.32E+00 | 3.35E-01 | | |
| 97 | | | | | | | | | | | | | |
| 98 | [1] | Dose Conversion Factor (rem/Curie) from Federal Guidance Report (FGR) 11 per Reg. Guide 1.183 | | | | | | | | | | | |
| 99 | [2] | Dose Conversion Factor (rem-$m^3$/Curie-second) from FGR 12 per Reg. Guide 1.183 | | | | | | | | | | | |
| 100 | [3] | From NEDO-21143-1, "Radiological Accident Evaluation - The CONAC03 Code", General Electric Company, December, 1981, | | | | | | | | | | | |
| 101 | | with its Table 3-1 ("SLBA Source Activities") Release Fractions and page 3-3 Ci conversion formula for a 0.1 Ci/sec design basis | | | | | | | | | | | |
| 102 | | offgas release rate and 5.5 second MSIV closure time, both of which apply | | | | | | | | | | | |
| 103 | 3.47E-04 | Breathing rate ($m^3$/second) per Regulatory Guide 1.183 (without round-off) | | | | | | | | | | | |
| 104 | 5.13E-02 | Control Room Geometry Factor per Reg. Guide 1.183, Regulatory Position 4.2.7 | | | | | | | | | | | |
| 105 | 1.54E+01 | EAB $\sigma_y$ (meters) for F stability, (taken from PAVAN runs in Calc. QDC-0000-M-1408, Rev. 1) | | | | | | | | | | | |
| 106 | 1.530E+02 | LPZ $\sigma_y$ (meters) for F stability, (taken from PAVAN runs in Calc. QDC-0000-M-1408, Rev. 1) | | | | | | | | | | | |
| 107 | 1.00E+00 | Wind Speed (m/s) | | | | | | | | | | | |
| 108 | 8.64E-04 | X/Q (seconds/$m^3$) at EA Boundary - 0-2 hours based on RG 1.5 methodology | | | | | | | | | | | |
| 109 | 8.69E-05 | X/Q (seconds/$m^3$) at Low Population Zone - 0-2 based on RG 1.5 methodology | | | | | | | | | | | |
| 110 | | | | | | | | | | | | | |

| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 1 | **Quad Cities 1&2 MSL** | | | | | Case 1: | Reactor Coolant at maximum value (D |
| 2 | | | | | | | |
| 3 | =(A9*A10)/35.3 | Volume of cloud (cubic meters) | | | | Case 2: | Reactor Coolant at maximum value pe |
| 4 | =A7*453.59 | Mass of water in reactor coolant r | | | | | |
| 5 | =(A3*12/PI())^(1/3) | seconds for cloud to pass over CF | | | | | |
| 6 | 184000 | Volume of Control Room Envelop | | | | | |
| 7 | 140000 | Mass of Liquid Water Released (lt | | | | | |
| 8 | 0.4 | Flashing Fraction | | | | | |
| 9 | =A7*A8 | Mass of Steam in the Cloud (lb) | | | | | |
| 10 | 26.799 | Vg ($ft^3$/lb) (based on 14.7 psi and | | | | | |
| 11 | Reactor coolant iodine dist | | | | | | |
| 12 | | | | | | | |
| 13 | | | | | | | |
| 14 | | | | Normalized | Case 1 | Case 2 | Case 1 |
| 15 | Isotope | Activity | FGR 11 | I-131 DE | Normalized | Normalized | Activity |
| 16 | | Distribution | DCF[1] | Activity | Activity | Activity | Release |
| 17 | | uCi/gm | $Rem_{CEDE}$/Ci | uCi/gm | uCi/gm | uCi/gm | Ci |
| 18 | I-131 | 0.067 | 32900 | =C18*B18/C$18 | =D18*0.2/D$23 | =E18*20 | =E18*$A$4*$C$18/C18/1000000 |
| 19 | I-132 | 0.38 | 381 | =C19*B19/C$18 | =D19*0.2/D$23 | =E19*20 | =E19*$A$4*$C$18/C19/1000000 |
| 20 | I-133 | 0.4 | 5846 | =C20*B20/C$18 | =D20*0.2/D$23 | =E20*20 | =E20*$A$4*$C$18/C20/1000000 |
| 21 | I-134 | 0.53 | 131 | =C21*B21/C$18 | =D21*0.2/D$23 | =E21*20 | =E21*$A$4*$C$18/C21/1000000 |
| 22 | I-135 | 0.49 | 1230 | =C22*B22/C$18 | =D22*0.2/D$23 | =E22*20 | =E22*$A$4*$C$18/C22/1000000 |
| 23 | | | Totals | =SUM(D18:D22) | =SUM(E18:E22) | =SUM(F18:F22) | |
| 24 | | | | | "non-spiked" | "spiked" | |
| 25 | | NEDO- | NEDO- | NEDO- | | | |
| 26 | | 21143-1[3] | 21143-1[3] | 21143-1[3] | Case 1 | Case 2 | |
| 27 | | MSLB | Case 1 | Case 2 | Release | Release | |
| 28 | | Noble Gas | Activity | Activity | Cloud | Cloud | |
| 29 | | Release | Release | Release | Concentration | Concentration | |
| 30 | | Fractions | Ci | Ci | Ci/m3 | Ci/m3 | |
| 31 | Kr-83M | 0.00936 | =$B31*5.5*3*0.45 | =$B31*5.5*3*0.45 | =C31/$A$3 | =D31/$A$3 | |
| 32 | Kr-85M | 0.0164 | =$B32*5.5*3*0.45 | =$B32*5.5*3*0.45 | =C32/$A$3 | =D32/$A$3 | |
| 33 | Kr-85 | 0.000064 | =$B33*5.5*3*0.45 | =$B33*5.5*3*0.45 | =C33/$A$3 | =D33/$A$3 | |
| 34 | Kr-87 | 0.0511 | =$B34*5.5*3*0.45 | =$B34*5.5*3*0.45 | =C34/$A$3 | =D34/$A$3 | |
| 35 | Kr-88 | 0.0524 | =$B35*5.5*3*0.45 | =$B35*5.5*3*0.45 | =C35/$A$3 | =D35/$A$3 | Cs-134 |
| 36 | Kr-89 | 0.218 | =$B36*5.5*3*0.45 | =$B36*5.5*3*0.45 | =C36/$A$3 | =D36/$A$3 | Cs-135 |
| 37 | Xe-131M | 0.0000523 | =$B37*5.5*3*0.45 | =$B37*5.5*3*0.45 | =C37/$A$3 | =D37/$A$3 | Cs-136 |
| 38 | Xe-133M | 0.000782 | =$B38*5.5*3*0.45 | =$B38*5.5*3*0.45 | =C38/$A$3 | =D38/$A$3 | CS-137 |
| 39 | Xe-133 | 0.0219 | =$B39*5.5*3*0.45 | =$B39*5.5*3*0.45 | =C39/$A$3 | =D39/$A$3 | Cs-138 |
| 40 | Xe-135M | 0.0641 | =$B40*5.5*3*0.45 | =$B40*5.5*3*0.45 | =C40/$A$3 | =D40/$A$3 | Totals |
| 41 | Xe-135 | 0.0592 | =$B41*5.5*3*0.45 | =$B41*5.5*3*0.45 | =C41/$A$3 | =D41/$A$3 | |
| 42 | Xe-137 | 0.288 | =$B42*5.5*3*0.45 | =$B42*5.5*3*0.45 | =C42/$A$3 | =D42/$A$3 | |
| 43 | Xe-138 | 0.218 | =$B43*5.5*3*0.45 | =$B43*5.5*3*0.45 | =C43/$A$3 | =D43/$A$3 | |
| 44 | | | | | | | |
| 45 | | | Curies Released | | | | Case 1 Dose (rem CEDE) |
| 46 | | | to the Environment | | | | (Inhalation) |
| 47 | Isotope | | Case 1 | Case 2 | DCF[1] | CR | EAB |
| 48 | I-131 | | =G18 | =H18 | 32900 | =I18*$E48*$A$103*$A$5 | =C48*$E48*$A$103*$A$108 |
| 49 | I-132 | | =G19 | =H19 | 381 | =I19*$E49*$A$103*$A$5 | =C49*$E49*$A$103*$A$108 |
| 50 | I-133 | | =G20 | =H20 | 5846 | =I20*$E50*$A$103*$A$5 | =C50*$E50*$A$103*$A$108 |
| 51 | I-134 | | =G21 | =H21 | 131 | =I21*$E51*$A$103*$A$5 | =C51*$E51*$A$103*$A$108 |
| 52 | I-135 | | =G22 | =H22 | 1230 | =I22*$E52*$A$103*$A$5 | =C52*$E52*$A$103*$A$108 |
| 53 | | | | | | | |
| 54 | Cs-134 | | =L35 | =M35 | =(3700000000000)*0.0000000125 | =($C54/$A$3)*$E54*$A$103*$A$5 | =C54*$E54*$A$103*$A$108 |
| 55 | Cs-135 | | =L36 | =M36 | =(3700000000000)*0.00000000123 | =($C55/$A$3)*$E55*$A$103*$A$5 | =C55*$E55*$A$103*$A$108 |
| 56 | Cs-136 | | =L37 | =M37 | =(3700000000000)*0.00000000198 | =($C56/$A$3)*$E56*$A$103*$A$5 | =C56*$E56*$A$103*$A$108 |
| 57 | CS-137 | | =L38 | =M38 | =(3700000000000)*0.00000000863 | =($C57/$A$3)*$E57*$A$103*$A$5 | =C57*$E57*$A$103*$A$108 |
| 58 | Cs-138 | | =L39 | =M39 | =(3700000000000)*0.0000000000274 | =($C58/$A$3)*$E58*$A$103*$A$5 | =C58*$E58*$A$103*$A$108 |

| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 59 | | Sub-total (rem CEDE) | | | | =SUM(F48:F58) | =SUM(G48:G58) |
| 60 | | | | | | | |
| 61 | | | Curies Released | | | | Case 1 Dose (rem EDE) |
| 62 | | | to the Environment | | | | (External) |
| 63 | Isotope | | Case 1 | Case 2 | DCF[2] | CR | EAB |
| 64 | I-131 | | =C48 | =D48 | 0.06734 | =I18*$E64*$A$104*$A$5 | =C64*$E64*$A$108 |
| 65 | I-132 | | =C49 | =D49 | 0.4144 | =I19*$E65*$A$104*$A$5 | =C65*$E65*$A$108 |
| 66 | I-133 | | =C50 | =D50 | 0.10878 | =I20*$E66*$A$104*$A$5 | =C66*$E66*$A$108 |
| 67 | I-134 | | =C51 | =D51 | 0.481 | =I21*$E67*$A$104*$A$5 | =C67*$E67*$A$108 |
| 68 | I-135 | | =C52 | =D52 | 0.29526 | =I22*$E68*$A$104*$A$5 | =C68*$E68*$A$108 |
| 69 | | | | | | | |
| 70 | Cs-134 | | =L35 | =M35 | =(3700000000000)*0.0000000000000757 | =($C70/$A$3)*$E70*$A$104*$A$5 | =C70*$E70*$A$108 |
| 71 | Cs-135 | | =L36 | =M36 | =(3700000000000)*5.65E-19 | =($C71/$A$3)*$E71*$A$104*$A$5 | =C71*$E71*$A$108 |
| 72 | Cs-136 | | =L37 | =M37 | =(3700000000000)*0.000000000000106 | =($C72/$A$3)*$E72*$A$104*$A$5 | =C72*$E72*$A$108 |
| 73 | CS-137 | | =L38 | =M38 | =(3700000000000)*7.74E-18 | =($C73/$A$3)*$E73*$A$104*$A$5 | =C73*$E73*$A$108 |
| 74 | Cs-138 | | =L39 | =M39 | =(3700000000000)*0.000000000000121 | =($C74/$A$3)*$E74*$A$104*$A$5 | =C74*$E74*$A$108 |
| 75 | | | | | | | |
| 76 | | Sub-total (rem EDE) | | | | =SUM(F64:F74) | =SUM(G64:G74) |
| 77 | Iodine and Cesium Total | | | | | =SUM(F59+F76) | =SUM(G59+G76) |
| 78 | | | Curies Released | | | | Case 1 Dose (rem EDE) |
| 79 | | | to the Environment | | | | (External) |
| 80 | | | Case 1 | Case 2 | DCF[2] | CR | EAB |
| 81 | Kr-83M | | =C31 | =D31 | 0.00000555 | =E31*$E81*$A$104*$A$5 | =C81*$E81*$A$108 |
| 82 | Kr-85M | | =C32 | =D32 | 0.027676 | =E32*$E82*$A$104*$A$5 | =C82*$E82*$A$108 |
| 83 | Kr-85 | | =C33 | =D33 | 0.0004403 | =E33*$E83*$A$104*$A$5 | =C83*$E83*$A$108 |
| 84 | Kr-87 | | =C34 | =D34 | 0.15244 | =E34*$E84*$A$104*$A$5 | =C84*$E84*$A$108 |
| 85 | Kr-88 | | =C35 | =D35 | 0.3774 | =E35*$E85*$A$104*$A$5 | =C85*$E85*$A$108 |
| 86 | Kr-89 | | =C36 | =D36 | 0 | =E36*$E86*$A$104*$A$5 | =C86*$E86*$A$108 |
| 87 | Xe-131M | | =C37 | =D37 | 0.0014393 | =E37*$E87*$A$104*$A$5 | =C87*$E87*$A$108 |
| 88 | Xe-133M | | =C38 | =D38 | 0.005069 | =E38*$E88*$A$104*$A$5 | =C88*$E88*$A$108 |
| 89 | Xe-133 | | =C39 | =D39 | 0.005772 | =E39*$E89*$A$104*$A$5 | =C89*$E89*$A$108 |
| 90 | Xe-135M | | =C40 | =D40 | 0.07548 | =E40*$E90*$A$104*$A$5 | =C90*$E90*$A$108 |
| 91 | Xe-135 | | =C41 | =D41 | 0.04403 | =E41*$E91*$A$104*$A$5 | =C91*$E91*$A$108 |
| 92 | Xe-137 | | =C42 | =D42 | 0 | =E42*$E92*$A$104*$A$5 | =C92*$E92*$A$108 |
| 93 | Xe-138 | | =C43 | =D43 | 0.21349 | =E43*$E93*$A$104*$A$5 | =C93*$E93*$A$108 |
| 94 | | Noble Gas Sub-total (rem EDE) | | | | =SUM(F81:F93) | =SUM(G81:G93) |
| 95 | | | | | | | |
| 96 | Overall Total (rem TEDE) | | | | | =SUM(F77+F94) | =SUM(G77+G94) |
| 97 | | | | | | | |
| 98 | [1] | Dose Conversion Factor (rem/Curie) f | | | | | |
| 99 | [2] | Dose Conversion Factor (rem-$m^3$/Cur | | | | | |
| 100 | [3] | From NEDO-21143-1, "Radiological A | | | | | |
| 101 | | with its Table 3-1 ("SLBA Source Acti | | | | | |
| 102 | | offgas release rate and 5.5 second M | | | | | |
| 103 | 0.000347 | Breathing rate ($m^3$/second) per Regul | | | | | |
| 104 | =($A$6^0.338)/1173 | Control Room Geometry Factor per R | | | | | |
| 105 | 15.4 | EAB $\sigma_y$ (meters) for F stability, (taken | | | | | |
| 106 | 153 | LPZ $\sigma_y$ (meters) for F stability, (taken | | | | | |
| 107 | 1 | Wind Speed (m/s) | | | | | |
| 108 | =0.0133/A$105/A$107 | X/Q (seconds/$m^3$) at EA Boundary - 0 | | | | | |
| 109 | =0.0133/A$106/A$107 | X/Q (seconds/$m^3$) at Low Population | | | | | |

| | H | I | J | K | L | M |
|---|---|---|---|---|---|---|
| 1 | E I-131 of 0.2 uCi/g) permitted for continued full power operation | | | | | |
| 2 | | | | | | |
| 3 | mitted (DE I-131 of 4.0 uCi/g) corresponding to an assumed pre-accident spike | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |
| 10 | | | | | | |
| 11 | | | | | | |
| 12 | | Case 1 | Case 2 | | | |
| 13 | | Release | Release | | | |
| 14 | Case 2 | Cloud | Cloud | | Case 1 | Case 2 |
| 15 | Activity | Concentration | Concentration | Decay | Activity | Activity |
| 16 | Release | | | Constant | Release | Release |
| 17 | Ci | Ci/m3 | Ci/m3 | 1/seconds | moles | moles |
| 18 | =G18*20 | =G18/$A$3 | =H18/$A$3 | =LN(2)/(8.04*86400) | =G18*37000000000/$K18/6.023E+23 | =H18*37000000000/$K18/6.023E+23 |
| 19 | =G19*20 | =G19/$A$3 | =H19/$A$3 | =LN(2)/(2.3*3600) | =G19*37000000000/$K19/6.023E+23 | =H19*37000000000/$K19/6.023E+23 |
| 20 | =G20*20 | =G20/$A$3 | =H20/$A$3 | =LN(2)/(20.8*3600) | =G20*37000000000/$K20/6.023E+23 | =H20*37000000000/$K20/6.023E+23 |
| 21 | =G21*20 | =G21/$A$3 | =H21/$A$3 | =LN(2)/(52.6*60) | =G21*37000000000/$K21/6.023E+23 | =H21*37000000000/$K21/6.023E+23 |
| 22 | =G22*20 | =G22/$A$3 | =H22/$A$3 | =LN(2)/(6.61*3600) | =G22*37000000000/$K22/6.023E+23 | =H22*37000000000/$K22/6.023E+23 |
| 23 | | | | Totals | =SUM(L18:L22) | =SUM(M18:M22) |
| 24 | | | | | | |
| 25 | | | | | | |
| 26 | | | | | | |
| 27 | | | | | | |
| 28 | | | | | | |
| 29 | | | | | | |
| 30 | | | | | | |
| 31 | | Case 1 | Case 2 | | Case 1 | Case 2 |
| 32 | | Activity | Activity | Decay | Activity | Activity |
| 33 | | Release | Release | Constant | Release | Release |
| 34 | Molar Frac. | moles | moles | 1/seconds | curies | curies |
| 35 | 0.044317152955112 | =0.95*$H35*L$23 | =0.95*$H35*M$23 | =LN(2)/(2.062*86400*365.25) | =I35*6.023E+23*$K35/37000000000 | =J35*6.023E+23*$K35/37000000000 |
| 36 | 0.174506296053598 | =0.95*$H36*L$23 | =0.95*$H36*M$23 | =LN(2)/(2300000*86400*365.25) | =I36*6.023E+23*$K36/37000000000 | =J36*6.023E+23*$K36/37000000000 |
| 37 | 0.000119942189253291 | =0.95*$H37*L$23 | =0.95*$H37*M$23 | =LN(2)/(13.16*86400) | =I37*6.023E+23*$K37/37000000000 | =J37*6.023E+23*$K37/37000000000 |
| 38 | 0.401736793048373 | =0.95*$H38*L$23 | =0.95*$H38*M$23 | =LN(2)/(30.17*86400*365.25) | =I38*6.023E+23*$K38/37000000000 | =J38*6.023E+23*$K38/37000000000 |
| 39 | 0.000101901239392202 | =0.95*$H39*L$23 | =0.95*$H39*M$23 | =LN(2)/(32.2*60) | =I39*6.023E+23*$K39/37000000000 | =J39*6.023E+23*$K39/37000000000 |
| 40 | =SUM(H35:H39) | =SUM(I35:I39) | =SUM(J35:J39) | | | |
| 41 | Balance is stable Cs-133 | | | | | |
| 42 | | | | | | |
| 43 | | | | | | |
| 44 | | | | | | |
| 45 | | | Case 2 Dose (rem CEDE) | | | |
| 46 | | | (Inhalation) | | | |
| 47 | LPZ | CR | EAB | LPZ | | |
| 48 | =C48*$E48*$A$103*$A$109 | =J18*$E48*$A$103*$A$5 | =D48*$E48*$A$103*$A$108 | =D48*$E48*$A$103*$A$109 | | |
| 49 | =C49*$E49*$A$103*$A$109 | =J19*$E49*$A$103*$A$5 | =D49*$E49*$A$103*$A$108 | =D49*$E49*$A$103*$A$109 | | |
| 50 | =C50*$E50*$A$103*$A$109 | =J20*$E50*$A$103*$A$5 | =D50*$E50*$A$103*$A$108 | =D50*$E50*$A$103*$A$109 | | |
| 51 | =C51*$E51*$A$103*$A$109 | =J21*$E51*$A$103*$A$5 | =D51*$E51*$A$103*$A$108 | =D51*$E51*$A$103*$A$109 | | |
| 52 | =C52*$E52*$A$103*$A$109 | =J22*$E52*$A$103*$A$5 | =D52*$E52*$A$103*$A$108 | =D52*$E52*$A$103*$A$109 | | |
| 53 | | | | | | |
| 54 | =C54*$E54*$A$103*$A$109 | =($D54/$A$3)*$E54*$A$103*$A$5 | =D54*$E54*$A$103*$A$108 | =D54*$E54*$A$103*$A$109 | | |
| 55 | =C55*$E55*$A$103*$A$109 | =($D55/$A$3)*$E55*$A$103*$A$5 | =D55*$E55*$A$103*$A$108 | =D55*$E55*$A$103*$A$109 | | |
| 56 | =C56*$E56*$A$103*$A$109 | =($D56/$A$3)*$E56*$A$103*$A$5 | =D56*$E56*$A$103*$A$108 | =D56*$E56*$A$103*$A$109 | | |
| 57 | =C57*$E57*$A$103*$A$109 | =($D57/$A$3)*$E57*$A$103*$A$5 | =D57*$E57*$A$103*$A$108 | =D57*$E57*$A$103*$A$109 | | |
| 58 | =C58*$E58*$A$103*$A$109 | =($D58/$A$3)*$E58*$A$103*$A$5 | =D58*$E58*$A$103*$A$108 | =D58*$E58*$A$103*$A$109 | | |

| | H | I | J | K | L | M |
|---|---|---|---|---|---|---|
| 59 | =SUM(H48:H58) | =SUM(I48:I58) | =SUM(J48:J58) | =SUM(K48:K58) | | |
| 60 | | | | | | |
| 61 | | | Case 2 Dose (rem EDE) | | | |
| 62 | | | (External) | | | |
| 63 | LPZ | CR | EAB | LPZ | | |
| 64 | =C64*$E64*$A$109 | =J18*$E64*$A$104*$A$5 | =D64*$E64*$A$108 | =D64*$E64*$A$109 | | |
| 65 | =C65*$E65*$A$109 | =J19*$E65*$A$104*$A$5 | =D65*$E65*$A$108 | =D65*$E65*$A$109 | | |
| 66 | =C66*$E66*$A$109 | =J20*$E66*$A$104*$A$5 | =D66*$E66*$A$108 | =D66*$E66*$A$109 | | |
| 67 | =C67*$E67*$A$109 | =J21*$E67*$A$104*$A$5 | =D67*$E67*$A$108 | =D67*$E67*$A$109 | | |
| 68 | =C68*$E68*$A$109 | =J22*$E68*$A$104*$A$5 | =D68*$E68*$A$108 | =D68*$E68*$A$109 | | |
| 69 | | | | | | |
| 70 | =C70*$E70*$A$109 | =($D70/$A$3)*$E70*$A$104*$A$5 | =D70*$E70*$A$108 | =D70*$E70*$A$109 | | |
| 71 | =C71*$E71*$A$109 | =($D71/$A$3)*$E71*$A$104*$A$5 | =D71*$E71*$A$108 | =D71*$E71*$A$109 | | |
| 72 | =C72*$E72*$A$109 | =($D72/$A$3)*$E72*$A$104*$A$5 | =D72*$E72*$A$108 | =D72*$E72*$A$109 | | |
| 73 | =C73*$E73*$A$109 | =($D73/$A$3)*$E73*$A$104*$A$5 | =D73*$E73*$A$108 | =D73*$E73*$A$109 | | |
| 74 | =C74*$E74*$A$109 | =($D74/$A$3)*$E74*$A$104*$A$5 | =D74*$E74*$A$108 | =D74*$E74*$A$109 | | |
| 75 | | | | | | |
| 76 | =SUM(H64:H74) | =SUM(I64:I74) | =SUM(J64:J74) | =SUM(K64:K74) | | |
| 77 | =SUM(H59+H76) | =SUM(I59+I76) | =SUM(J59+J76) | =SUM(K59+K76) | | |
| 78 | | | Case 2 Dose (rem EDE) | | | |
| 79 | | | (External) | | | |
| 80 | LPZ | CR | EAB | LPZ | | |
| 81 | =C81*$E81*$A$109 | =F31*$E81*$A$104*$A$5 | =D81*$E81*$A$108 | =D81*$E81*$A$109 | | |
| 82 | =C82*$E82*$A$109 | =F32*$E82*$A$104*$A$5 | =D82*$E82*$A$108 | =D82*$E82*$A$109 | | |
| 83 | =C83*$E83*$A$109 | =F33*$E83*$A$104*$A$5 | =D83*$E83*$A$108 | =D83*$E83*$A$109 | | |
| 84 | =C84*$E84*$A$109 | =F34*$E84*$A$104*$A$5 | =D84*$E84*$A$108 | =D84*$E84*$A$109 | | |
| 85 | =C85*$E85*$A$109 | =F35*$E85*$A$104*$A$5 | =D85*$E85*$A$108 | =D85*$E85*$A$109 | | |
| 86 | =C86*$E86*$A$109 | =F36*$E86*$A$104*$A$5 | =D86*$E86*$A$108 | =D86*$E86*$A$109 | | |
| 87 | =C87*$E87*$A$109 | =F37*$E87*$A$104*$A$5 | =D87*$E87*$A$108 | =D87*$E87*$A$109 | | |
| 88 | =C88*$E88*$A$109 | =F38*$E88*$A$104*$A$5 | =D88*$E88*$A$108 | =D88*$E88*$A$109 | | |
| 89 | =C89*$E89*$A$109 | =F39*$E89*$A$104*$A$5 | =D89*$E89*$A$108 | =D89*$E89*$A$109 | | |
| 90 | =C90*$E90*$A$109 | =F40*$E90*$A$104*$A$5 | =D90*$E90*$A$108 | =D90*$E90*$A$109 | | |
| 91 | =C91*$E91*$A$109 | =F41*$E91*$A$104*$A$5 | =D91*$E91*$A$108 | =D91*$E91*$A$109 | | |
| 92 | =C92*$E92*$A$109 | =F42*$E92*$A$104*$A$5 | =D92*$E92*$A$108 | =D92*$E92*$A$109 | | |
| 93 | =C93*$E93*$A$109 | =F43*$E93*$A$104*$A$5 | =D93*$E93*$A$108 | =D93*$E93*$A$109 | | |
| 94 | =SUM(H81:H93) | =SUM(I81:I93) | =SUM(J81:J93) | =SUM(K81:K93) | | |
| 95 | | | | | | |
| 96 | =SUM(H77+H94) | =SUM(I77+I94) | =SUM(J77+J94) | =SUM(K77+K94) | | |
| 97 | | | | | | |
| 98 | | | | | | |
| 99 | | | | | | |
| 100 | | | | | | |
| 101 | | | | | | |
| 102 | | | | | | |
| 103 | | | | | | |
| 104 | | | | | | |
| 105 | | | | | | |
| 106 | | | | | | |
| 107 | | | | | | |
| 108 | | | | | | |
| 109 | | | | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **Peach Bottom 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 | 132.91 | 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 | 133.91 | 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 | 134.91 | 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 | 136.91 | 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 Coolant | 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 |
|---|---|---|---|---|---|---|---|---|
| 1 | **Peach Bot** | | | | | | | |
| 2 | **(Used for (** | | | | | | | |
| 3 | | | | | | | | |
| 4 | | **100 EFPD** | **EOC** | | | | | **100 EFPD** |
| 5 | | **(grams)** | **(grams)** | | | | **At. Mass** | **(gm-moles)** |
| 6 | Cs-133 | 102500 | 167800 | | | Cs-133 | 132.9054 | 771.2 |
| 7 | Cs-134 | 10310 | 19770 | | | Cs-134 | 133.9067 | 76.99 |
| 8 | Cs-135 | 45020 | 78410 | | | Cs-135 | 134.9059 | 333.7 |
| 9 | Cs-137 | 108700 | 183200 | | | Cs-137 | 136.9071 | 794 |
| 10 | | | | | | Cs-136 | | =K10*37000000000/$J10/6.023E+23 |
| 11 | | | | | | Cs-138 | | =K11*37000000000/$J11/6.023E+23 |
| 12 | **Total** | **=SUM(B6:B9)** | **=SUM(C6:C9)** | | | | | **=SUM(H6:H11)** |
| 13 | | | | | | | | |
| 14 | ANSI/ANS- | | | | | | | |
| 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 | | | | |

| | I | J | K | L |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | **Decay** | | |
| 4 | **EOC** | **Constant** | **100 EFPD** | **EOC** |
| 5 | **(gm-moles)** | **1/seconds** | **Ci** | **Ci** |
| 6 | 1263 | 0 | =H6*$J6*6.023E+23/37000000000 | =I6*$J6*6.023E+23/37000000000 |
| 7 | 147.6 | =LN(2)/(2.062*86400*365.25) | =H7*$J7*6.023E+23/37000000000 | =I7*$J7*6.023E+23/37000000000 |
| 8 | 581.2 | =LN(2)/(2300000*86400*365.25) | =H8*$J8*6.023E+23/37000000000 | =I8*$J8*6.023E+23/37000000000 |
| 9 | 1338 | =LN(2)/(30.17*86400*365.25) | =H9*$J9*6.023E+23/37000000000 | =I9*$J9*6.023E+23/37000000000 |
| 10 | =L10*37000000000/$J10/6.023E+23 | =LN(2)/(13.16*86400) | =K$9*$B$18/$B$19 | =L$9*$B$18/$B$19 |
| 11 | =L11*37000000000/$J11/6.023E+23 | =LN(2)/(32.2*60) | =K$9*$B$20/$B$19 | =L$9*$B$20/$B$19 |
| 12 | **=SUM(I6:I11)** | | | |
| 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: Quad Cities Units 1&2 MSLB AST

Date: January 2006
Job No.

| Program(s) used | Rev No. | Rev Date |
|---|---|---|
| Attachment A spreadsheet | N/A | N/A |

Calculation Set No.: QDC-0000-N-1266, Rev. 4

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: On: January 2006

Run by: H. Rothstein H Rothstein

Checked by: P. Reichert P. Reichert

Separate cell-by-cell independent check by: A. Boatright Alvenia Boatright

Approved by: H. Rothstein H Rothstein

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