RAI Volume 2, Chapter 2.1.1.5, Second Set, Number 1

Provide the technical basis for the potential onsite public doses during normal operations, listed in SAR Table 1.8-28. Specifically, address the following:

a. Explain the basis for the public dose at the Warehouse and Non-Nuclear Facility location (17 mrem/yr) being significantly smaller than the dose at the Lower Muck Yard location (78 mrem/yr), even though the Warehouse location is at a similar distance from the Rail Car and Truck Buffer areas.

b. Clarify whether the dose rates on the external surfaces of the transportation casks in the buffer areas are based on 10 CFR 71.47 requirements (SAR Section 1.8.3.1.3). If not, provide the basis for these dose rates.

c. Provide the technical basis for not incorporating contributions from any single cask or TEV in transit, in developing the dose contour maps of BSC (2007am, section 7).

d. Explain how the 1.31 and 0.272 scaling factors were developed as referenced in BSC (2007am, Table 7).

e. Explain how the values in BSC (2007am, Table 7) were developed, including how the values in Column III represent the dose rate for 25 casks, and basis for not accounting for truck cask numbers (5) in column V. Also, provide a reference or describe the location and boundaries for the buffer areas.

1. RESPONSE

The dose rates on the external surfaces of the transportation casks are not based on 10 CFR 71.47. The potential onsite public doses during normal operations, listed in SAR Table 1.8-28, are calculated based on radiation sources contained in transportation casks in the railcar and truck buffer areas (Areas 33A and 33B) and contained in aging overpacks in the Aging Facility (Areas 17P and 17R). The buffer areas and the Aging Facility are conservatively assumed to be continuously at full capacity, which maximizes radiation sources and doses.

1.1 PUBLIC DOSE AT WAREHOUSE AND NON-NUCLEAR FACILITY

The public dose reported for the Warehouse and Non-Nuclear Facility (Area 230) listed in SAR Table 1.8-28 was inadvertently calculated at a dose receptor location outside of the facility. Revised coordinates have been developed to locate the dose receptor within the Warehouse and Non-Nuclear Facility at the shortest distance to the buffer areas. Figure 1 presents the locations of the original and revised receptor points for the Warehouse and Non-Nuclear Facility.

Figure 1 also provides a dose rate contour map surrounding the buffer areas and locations of the centers of the railcar and truck buffer areas. The dose rate contour lines are lines of constant dose rate (mrem/hr) based on a logarithmic scale (e.g., 10^{-2}, 10^{-3}). Using the contour map in Figure 1, the revised estimated annual onsite public dose for the Warehouse and Non-Nuclear Facility is

76 mrem. This value is estimated by interpolating between the dose rate contour lines surrounding the revised receptor point for the Warehouse and Non-Nuclear Facility. The onsite public doses are based upon an exposure time of 2,000 hours per year.

1.2 DOSE RATE AT EXTERNAL SURFACES OF TRANSPORTATION CASKS IN BUFFER AREAS

The FuelSolutions TS125 transportation cask is used as the representative transportation cask in the railcar and truck buffer areas (RAI 2.2.1.1.5-2-002). The FuelSolutions TS125 transportation cask has a design maximum external surface dose rate of 123 mrem/hr (Sisley 2002, Table 5.1-1).

1.3 SINGLE CASK, SITE TRANSPORTER, OR TRANSPORTATION AND EMPLACEMENT VEHICLE IN TRANSIT

The specific purpose of the dose contour map is to illustrate geologic repository operations area (GROA) external radiation levels due to radiation emitted from stationary sources within loaded casks or aging overpacks located at various areas within the GROA for estimation of the annual onsite public dose. Transient sources, such as a single transportation cask or transportation and emplacement vehicle or site transporter, only affect the radiation levels in their immediate vicinity during the brief period of transit; their impact on the estimated annual onsite public dose is small relative to the stationary sources. These areas are the aging pads (Area 17P and Area 17R), the railcar buffer area (Area 33A), and the truck buffer area (Area 33B). The total dose rates that determine the contours are the sum of contributions from only these areas (BSC 2007, Section 6.2). Dose rates from transient sources are addressed differently than stationary sources. Transient dose rates are described by dose rate curves that may be applied to any dose receptor location relative to the transient path.

1.4 DEVELOPMENT OF SCALING FACTORS

Although the FuelSolutions TS125 transportation cask is the representative transportation cask for the railcar and truck buffer areas, single-cask dose rates versus distance for the rail cask and the truck cask are developed based on existing distance attenuation results for the Transnuclear TN-32 dry storage cask. Transnuclear TN-32 cask distance attenuation results are developed for two cask geometries: (1) in a void and (2) with an air/ground interface. The Transnuclear TN-32 cask distance attenuation results represent the attenuation trend for other casks containing commercial spent nuclear fuel because primary gamma rays account for most of the external dose rates from a cask and the emitted gamma energy spectra for casks are similar to the Transnuclear TN-32 cask (BSC 2007, Section 3.2.4).

The Transnuclear TN-32 cask dose rate curves are normalized (scaled) to the FuelSolutions TS125 cask dose rates using scaling factors to account for differences between the two cask surface dose rates and the scattering effect of air and ground. Because the cask distance attenuation trends are similar, the ratio of the air/ground model results to the void model results will be equal for any cask, as shown by the relationship in Equation 1:

$$\frac{DR_{AG}^{TS125}(r)}{DR_{VD}^{TS125}(r)} = \frac{DR_{AG}^{TN32}(r)}{DR_{VD}^{TN32}(r)} \qquad \text{(Eq. 1)}$$

where

$DR_{AG}^{TS125}(r)$ = dose rate at distance *r* from one or multiple FuelSolutions TS125 casks in air over ground

$DR_{VD}^{TS125}(r)$ = dose rate at distance *r* from one or multiple FuelSolutions TS125 casks in a void

$DR_{AG}^{TN32}(r)$ = dose rate at distance *r* from a Transnuclear TN-32 cask in air over ground

$DR_{VD}^{TN32}(r)$ = dose rate at distance *r* from a Transnuclear TN-32 cask in a void.

Equation 1 states that for any cask, the dose effect of air and ground expressed as the ratio of dose rates with and without air and ground is equal to the corresponding ratio of the Transnuclear TN-32 cask.

From Equation 1,

$$\begin{aligned} DR_{AG}^{TS125}(r) &= \frac{DR_{AG}^{TN32}(r)}{DR_{VD}^{TN32}(r)} \times DR_{VD}^{TS125}(r) \\ &= \frac{DR_{VD}^{TS125}(r)}{DR_{VD}^{TN32}(r)} \times DR_{AG}^{TN32}(r) \qquad \text{(Eq. 2)} \\ &= F(r) \times DR_{AG}^{TN32}(r) \end{aligned}$$

where

F(r) = $\frac{DR_{VD}^{TS125}(r)}{DR_{VD}^{TN32}(r)}$, a scaling factor which is the ratio of dose rate from one or multiple FuelSolutions TS 125 casks to dose rate from a Transnuclear TN-32 cask at distance *r* in void.

Equation 2 is employed to develop Columns III and V in Table 7 of *GROA External Dose Rate Calculation* (BSC 2007). The information in Table 7 of the dose rate calculation (BSC 2007) is reproduced as Table 1. The values of $DR_{AG}^{TN32}(r)$ in Equation 2 are presented in Column II of Table 1. Equation 2 accounts for two effects: (1) adjusting the dose rates to be based on the FuelSolutions TS125 cask, and (2) including the attenuation and scattering effects of air and ground.

For the railcar buffer area (Area 33A), $DR_{AG}^{TS125}(r)$ is developed for the entire buffer area of 25 casks using FuelSolutions TS125 casks. A maximum scaling factor *F(r)* is selected from the ratios of dose rates from 25 FuelSolutions TS125 casks to dose rates from a Transnuclear TN-32 cask at several distances (20, 50, 100, 150, and 200 m) in a void (BSC 2007, Attachment II, file *Summary.xls*, worksheet *Staging*, cells I4 to I8). The scaling factors corresponding to these distances are 0.61, 1.01, 1.31, 1.24, and 1.19. The maximum scaling factor of 1.31 occurs at a distance of 100 m and is selected to provide conservative dose rates from the matrix of transportation casks in the railcar buffer area. Applying Equation 2, Table 1, Column III, is a product of 1.31 and Column II. As a simplification, the values in Table 1, Column III, are divided by 25 to obtain Column IV, the dose rates due to a single transportation cask in the railcar buffer area.

For the truck buffer area (Area 33B) $DR_{AG}^{TS125}(r)$ is estimated for a single FuelSolutions TS125 cask where *F(r)* is estimated from the ratios of dose rates from a FuelSolutions TS125 cask to dose rates from a Transnuclear TN-32 cask at several distances (20, 50, and 100 m) in a void (BSC 2007, Attachment II, file *Summary.xls*, worksheet *TN-32*, cells H27, H29, and H32). The scaling factors corresponding to these distances are 0.161, 0.267, and 0.272. The maximum scaling factor of 0.272 occurs at a distance of 100 m, which is selected to provide the conservative dose rates from a transportation cask in the truck buffer area. Applying Equation 2, Table 1, Column V, is a product of 0.272 and Column II. Column V dose rates are for a single transportation cask in the truck buffer area.

1.5 BASIS FOR DEVELOPMENT OF BUFFER AREA DOSE RATES

The buffer areas are conservatively assumed to be continuously at full capacity with 25 transportation casks in the railcar buffer area (Area 33A) and 5 in the truck buffer area (Area 33B). The dose rates from the centers of the buffer areas to dose receptor points in the GROA are developed in the following manner. Each transportation cask in the buffer areas is represented as a point source. For the railcar buffer area, 25 loaded railcars are located in 5 parallel columns as a 5-by-5 matrix with center-to-center separation distances of 10 m between columns and 30 m between casks in each column. Each column corresponds to a rail track. For the truck buffer area, 5 truck casks are located 15 m apart in a linear pattern. The dose rate from the railcar buffer area to a dose receptor is the sum of the dose rates from each of the 25 individual casks in the railcar buffer area. Similarly, the dose rate from the truck buffer area to a dose receptor is the sum of the dose rates from each of the 5 individual casks in the truck buffer area to the receptor. The single-cask dose rates versus distance for the rail cask and for the truck are not the same. For the railcar buffer area, because of the matrix arrangement, the rail casks are shielding each other (self-shielding) and effectively reduce the average-per-cask dose rate. For the truck buffer area,

because the casks are aligned in a linear pattern, self-shielding only occurs in the axial direction and is not included in the receptor dose estimation.

The development of scaling factors and generation of single-cask dose rate curves for the railcar and truck buffer areas are presented in Section 1.4 above. Table 1, Columns III, IV, and V are the result of that development. The dose rate values for single casks in Table 1, Columns IV and V are used to estimate the dose rate contributions to each GROA dose receptor location from each of the 25 individual casks in the railcar buffer area and 5 casks in the truck buffer area, respectively. Those individual cask dose rates are summed to determine the total dose rate at each receptor. The values in Table 1, Column III, represent the combined dose rate from all 25 casks in the railcar buffer area, but are only used to generate the single-cask dose rate curve for the railcar buffer area in Table 1, Column IV, after dividing by 25.

The individual dose rate contribution from each of the 5 casks in the truck buffer area is summed with the 25 casks in the railcar buffer area to obtain the total dose rate at a dose receptor. Table 1, Column V, provides the dose rate from a single cask in the truck buffer area.

The locations of the buffer areas in the GROA are identified in SAR Figure 1.2.1-2. The centers of the buffer areas used to distribute the transportation casks are indicated in Figure 1.

2. COMMITMENTS TO NRC

The DOE commits to update the license application as described in Section 3. The change will be included in a future license application update.

3. DESCRIPTION OF PROPOSED LA CHANGE

In SAR Table 1.8-28, change the entries for the hourly and annual total effective dose equivalent doses for the Warehouse and Non-Nuclear Receipt Facility to reflect updated values.

4. REFERENCES

BSC (Bechtel SAIC Company) 2007. *GROA External Dose Rate Calculation*. 000-PSA-MGR0-01300-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ENG.20071023.0003.

Sisley, S.E. 2002. “Transportation License Application for the FuelSolutions System (TAC No. L23311), Submittal of the FuelSolution Transportation SARs, Revision 3.” Letter from S.E. Sisley (BNFL) to the NRC, April 11, 2002, BFS/NRC 02-011, with enclosures. TIC: 255245.

Table 1. Dose Rates (mrem/hr) Versus Distance for Buffer Areas 33A (Railcar Buffer Area) and 33B (Truck Buffer Area)

Distance from Cask Axis (m)	TN-32 with Air/Ground (mrem/hr)	Buffer Area 33A (mrem/hr)	Single Cask in Buffer Area 33A (mrem/hr)	Single Cask in Buffer Area 33B (mrem/hr)
I	II	III	IV	V
5	1.88×10^{1}	2.47×10^{1}	9.88×10^{-1}	5.11
7	1.10×10^{1}	1.45×10^{1}	5.78×10^{-1}	2.99
10	5.92	7.78	3.11×10^{-1}	1.61
20	1.57	2.06	8.25×10^{-2}	4.27×10^{-1}
50	2.27×10^{-1}	2.98×10^{-1}	1.19×10^{-2}	6.17×10^{-2}
70	1.06×10^{-1}	1.39×10^{-1}	5.57×10^{-3}	2.88×10^{-2}
100	4.55×10^{-2}	5.98×10^{-2}	2.39×10^{-3}	1.24×10^{-2}
150	1.50×10^{-2}	1.97×10^{-2}	7.89×10^{-4}	4.08×10^{-3}
200	6.32×10^{-3}	8.31×10^{-3}	3.32×10^{-4}	1.72×10^{-3}
300	1.51×10^{-3}	1.98×10^{-3}	7.94×10^{-5}	4.11×10^{-4}
500	1.45×10^{-4}	1.91×10^{-4}	7.62×10^{-6}	3.94×10^{-5}
700	2.10×10^{-5}	2.76×10^{-5}	1.10×10^{-6}	5.71×10^{-6}
1000	1.60×10^{-6}	2.10×10^{-6}	8.41×10^{-8}	4.35×10^{-7}
1500	4.91×10^{-8}	6.46×10^{-8}	2.58×10^{-9}	1.34×10^{-8}
2000	1.51×10^{-9}	1.98×10^{-9}	7.93×10^{-11}	4.11×10^{-10}

NOTE: Information from Table 7 of BSC 2007.
Column II = Column III of BSC 2007, Table 3.
Column III = Column II × 1.31 (normalized to dose rate of buffer Area 33A). See Attachment II, file Summary.xls, worksheet "Staging."
Column IV = Column III ÷ 25 (scaled dose rate for 1 cask). See Attachment II, file Summary.xls, worksheet *Staging*. This column is used to generate dose rate contour due to buffer Area 33A.
Column V = Column II × 0.272 (normalized to dose rate of buffer area 33B). See Attachment II, file Summary.xls, worksheet "Staging." This column is used to generate dose rate contour due to buffer Area-33B.

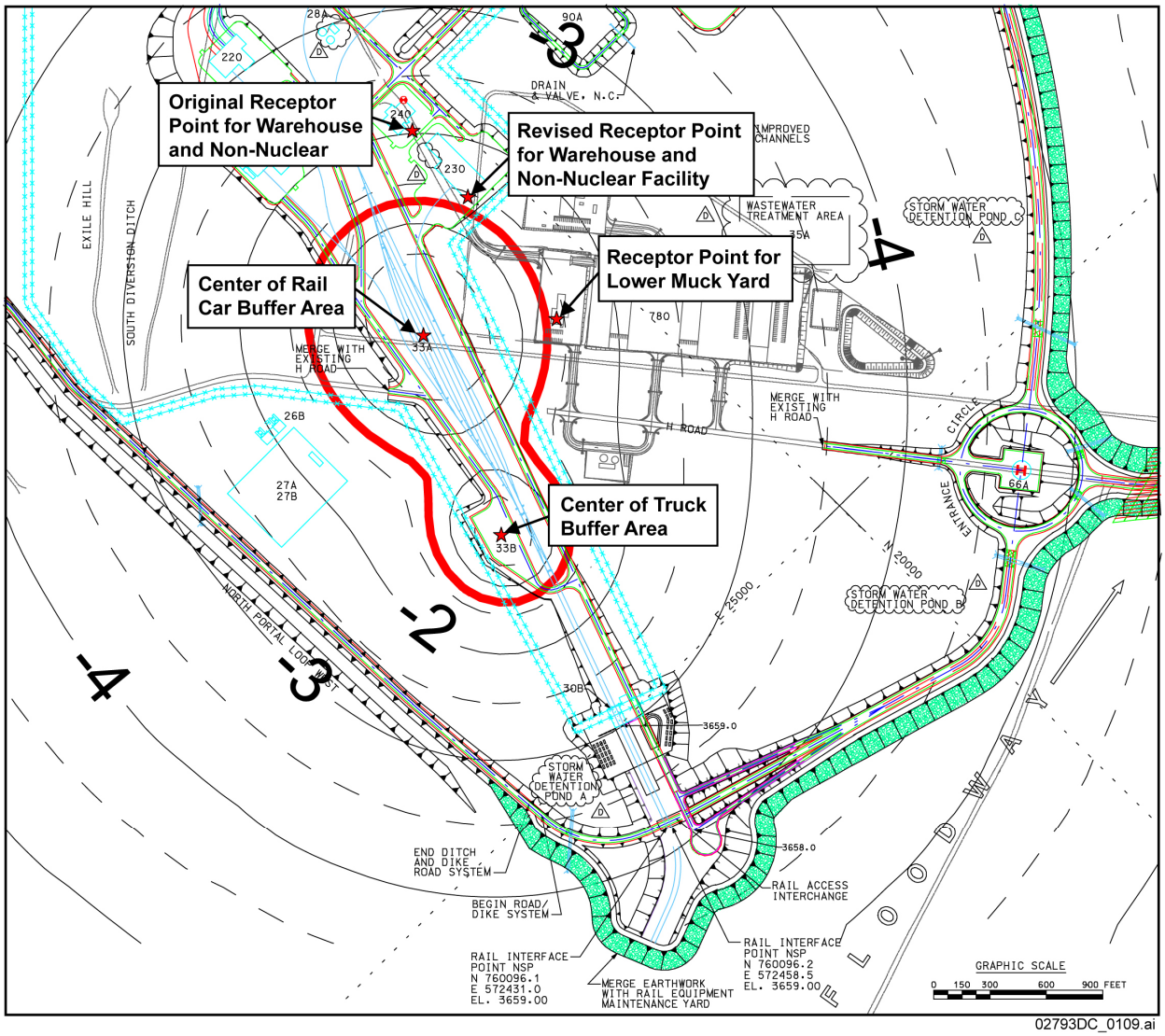

Figure 1. Buffer Area Dose Rate (mrem/hr) Contour Map in Log Scale

NOTE: The iso-dose-rate lines are based on a logarithmic scale (e.g., 10^{-1}, 10^{-2}, 10^{-3}) in mrem/hr. The thick red line corresponds to dose rate of 0.05 mrem/hr or 100 mrem per 2,000 hr.