RAI Volume 3, Chapter 2.2.1.3.13, First Set, Number 3, Supplemental Question 1:

> In the last paragraph of the RAI response, please provide clarification for the following statement "the Ashplume model calculates tephra mass deposition and waste mass deposition separately at the RMEI location, and dose is calculated based on the waste mass deposited, not the ratio of waste mass to tephra mass", which appears to conflict with the information given in *Redistribution of Tephra and Waste by Geomorphic Processes Following a Potential Volcanic Eruption at Yucca Mountain, Nevada* (SNL 2007), which on page 6-28 suggests that tephra thickness is used to calculate the mass of waste (Equations 6.3-16 and 6.3-17), and on page 6-29, states: "The concentration of waste, then, is simply given by the product of *ρ* * *dilutionfactoroutlet* and the ratio of the mass of waste and tephra mobilized from upstream (*fuelmobilized/ashmobilized*). The use of this average waste concentration from upstream assumes complete mixing of tephra and waste during transport." Also, the last statement in the RAI response "[t]herefore, performance assessment results for the volcanic ash exposure scenario are not sensitive to the ratio of waste contamination in tephra deposited directly at the RMEI location or in the catchment basin of Fortymile Wash" appears to conflict with the above.

1. SUPPLEMENTAL RESPONSE

In the Total System Performance Assessment (TSPA) volcanic eruption modeling case, waste concentration is calculated at the reasonably maximally exposed individual (RMEI) location separately for channels and inter-channel divides. The statements in the last paragraph of the original RAI response refer only to the channels. The inter-channel divides were not discussed in the original RAI response because no deposition of waste occurred on the inter-channel divides due to wind blowing away from the RMEI location in the selected realization. The following paragraphs clarify the discussion in the last paragraph of the original RAI response.

The initial waste concentration in channels at the RMEI location is defined in Equation 6.3-19 of *Redistribution of Tephra and Waste by Geomorphic Processes Following a Potential Volcanic Eruption at Yucca Mountain, Nevada* (SNL 2007):

$$fuelchannelinit = \left(\frac{fueldepositionRMEI}{scourdepthoutlet}\right) + \left(\rho * dilutionfactoroutlet * \frac{fuelmobilized}{ashmobilized}\right) \quad \text{(Eq. 6.3-19)}$$

where

fuelchannelinit	=	initial waste concentration in channels at the RMEI location (g/cm^3)
fueldepositionRMEI	=	direct waste deposition at the RMEI location (g/cm^2)
scourdepthoutlet	=	scour depth in channels at the RMEI location (cm)
ρ	=	tephra density (g/cm^3)
dilutionfactoroutlet	=	value of the dilution factor at the fan apex

fuelmobilized	=	total mass of mobilized waste (g)
ashmobilized	=	total mass of mobilized tephra (g).

The two terms on the right side of the equation represent contributions from direct deposition of waste on channels at the RMEI location and from redistribution of waste deposited upstream in the Fortymile Wash drainage basin. For direct deposition at the RMEI location, the ASHPLUME model calculates tephra mass deposition and waste mass deposition separately. Direct deposition occurs both in channels and on inter-channel divides. The contribution of direct deposition to the initial channel concentration at the RMEI location is described by the first term on the right side of Equation 6.3-19, *fueldepositionRMEI/scourdepthoutlet*, where *fueldepositionRMEI* is the waste mass deposition calculated by ASHPLUME for the RMEI location, and *scourdepthoutlet* is an input parameter representing the estimated scour depth in the channels at the RMEI location. This implies that the waste deposited directly on channels is assumed to be uniformly mixed with scour material in the channel from the surface down to the scour depth, and the contribution of direct deposition to the initial concentration in channels is dependent on the ratio of waste mass deposition and scour depth, not on the ratio of waste mass and ash mass deposited directly at the RMEI location.

The contribution to the initial concentration in channels at the RMEI location due to waste and ash redistributed from upstream is described by the second term on the right side of Equation 6.3-19, which is a function of the ratio *fuelmobilized/ashmobilized*, or the ratio of the total mass of mobilized waste and total mass of mobilized ash reaching the channels at the RMEI location. The ratio represents an average waste concentration from upstream and assumes complete mixing of tephra and waste during transport.

Because the sampled wind direction for the realization examined in the original RAI response was toward the northeast, away from the RMEI location, direct deposition on the inter-channel divides at the RMEI location was negligible, and was not discussed in the original RAI response. For realizations with wind blowing directly toward the RMEI location, direct deposition on divides would be greater, and the initial concentration on divides would be described by Equation 6.3-17 of the tephra redistribution report (SNL 2007):

$$fueldivideinit = \frac{fueldepositionRMEI}{primaryashthickness} \qquad \text{(Eq. 6.3-17)}$$

where

fueldivideinit	=	initial waste concentration on divides (g/cm^3)
fueldepositionRMEI	=	direct waste deposition at the RMEI location (g/cm^2)
primaryashthickness	=	tephra thickness on divides due to direct deposition at the RMEI location (cm).

The tephra thickness on divides is the direct deposition of tephra (g/cm^2) on divides divided by the tephra density (g/cm^3). According to this equation, the initial concentration on divides is a function of the ratio of waste mass and ash mass deposited directly at the RMEI location. However, for determining the concentration of waste in ash at the RMEI location in the TSPA volcanic eruption modeling case, the RMEI location is represented by a single point 18 km south of the repository. The initial concentration on divides at the RMEI location is calculated at that single, representative point only, and thus is not dependent on the spatial variation of the ratio of deposited waste and ash at the RMEI location. Justification for representing the RMEI location by a single point is provided in the response to RAI 3.2.2.1.3.13-004.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

SNL (Sandia National Laboratories) 2007. *Redistribution of Tephra and Waste by Geomorphic Processes Following a Potential Volcanic Eruption at Yucca Mountain, Nevada.* MDL-MGR-GS-000006 REV 00. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20071220.0004; LLR.20080423.0011.

RAI Volume 3, Chapter 2.2.1.3.13, First Set, Number 3, Supplemental Question 2:

> For the data provided and plotted in Table 1 and in Figure 1, respectively, is the amount of waste derived from the raw output of the Ashplume model, or for this particular realization, has the magma partitioning factor been applied. Also, how many waste packages are considered in this realization?

1. SUPPLEMENTAL RESPONSE

The data provided in Table 1 and plotted in Figure 1 of the original RAI response are derived from the output of the ASHPLUME model and are based on the mass in one repository-average waste package (i.e., a single waste package with radionuclide content equal to the average over all waste packages). For the purpose of demonstrating the variation in the ratio of waste mass to ash mass with distance from the vent, the magma partitioning factor was not applied to these results and radionuclide decay was not considered. For dose calculations within the TSPA model, scale factors representing the magma partitioning factor, number of waste packages hit, and radionuclide decay for each radionuclide considered are applied. The scale factors affect the magnitude of the waste/ash ratio, but not the relative shape of the ratio curves shown in Figure 1 of the original RAI response. The relative variation in the ratio is accurately represented in the figure.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

RAI Volume 3, Chapter 2.2.1.3.13, First Set, Number 3, Supplemental Question 3:

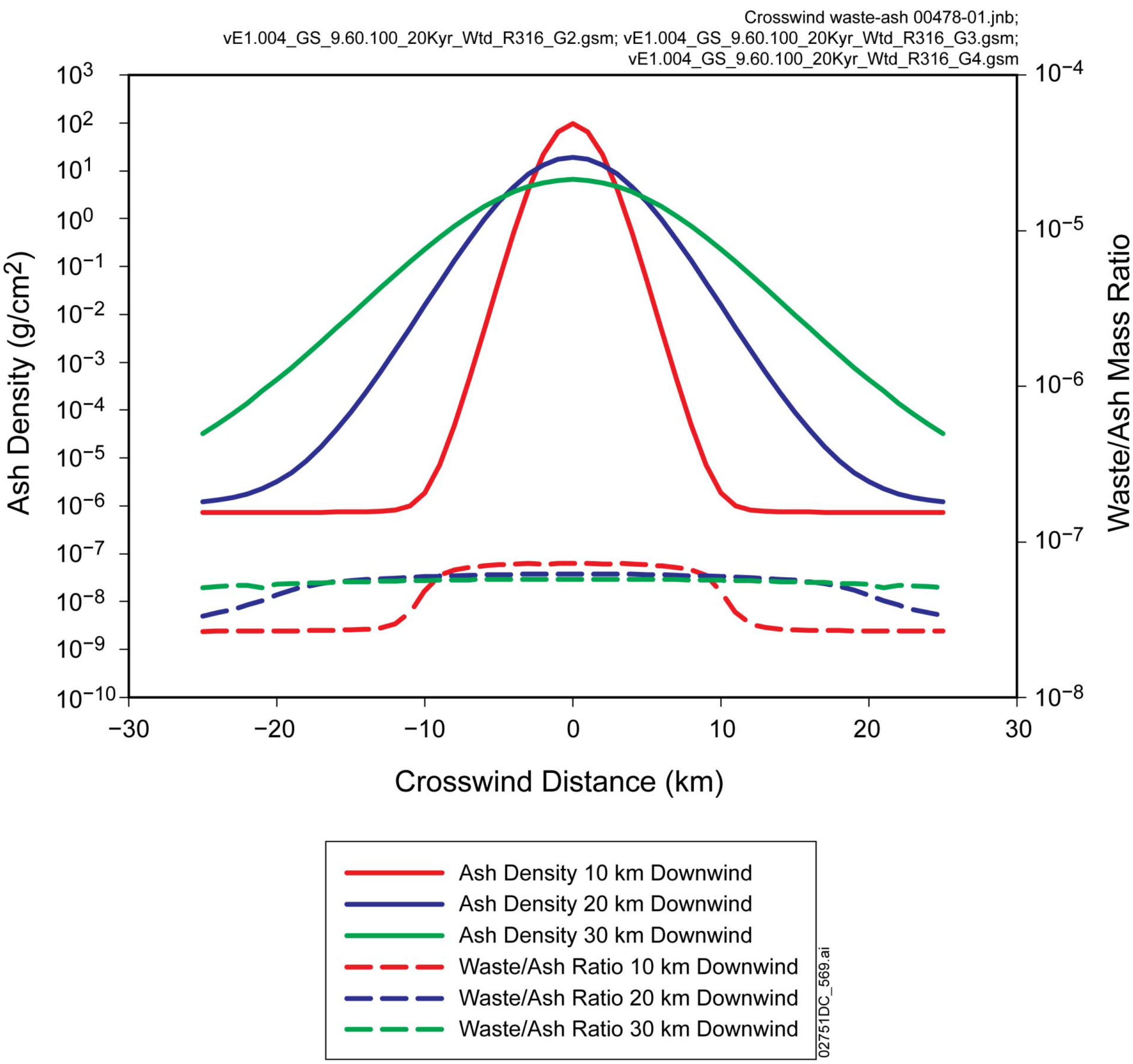
> In the model realization output shown in Figure 1 in the original response to RAI 3.2.2.1.3.13-003, the mass per unit area (ash density) along the dispersal axis is essentially the same 10, 20, and 30 km from the vent. This is not normal for tephra deposits, which will decrease in thickness (mass per unit area) over such distances, and requires an explanation. If this result is an artifact of using the sub-15 µm mean particle size (Table 1 in the response to RAI 3.2.2.1.3.13-003) for this particular realization, then justification for the use of such small particles sizes, which are not appropriate for the Suzuki model (Suzuki 1983), should be clarified. What proportion of realizations in TSPA used output from such small grain size tephra distribution? What proportion of realizations used a 30 µm mean particle size or less?

1. SUPPLEMENTAL RESPONSE

The mean tephra particle diameter for the TSPA volcanic eruption model is sampled from a log-triangular distribution with a minimum of 0.001 cm, mode of 0.01 cm, and maximum of 0.1 cm. Justification of this particle size distribution is discussed in *Characterize Eruptive Processes at Yucca Mountain, Nevada* (SNL 2007, Section 6.3.5.1). This distribution of particle sizes results in approximately 1.6% of realizations using a mean particle size less than 0.0015 cm and approximately 11.4% of realizations using a mean particle size less than 0.003 cm. As shown in Table 1 of the original RAI response, the mean particle size used for the realization selected for the demonstration of the variation of the waste/ash ratio, 0.001451 cm, was near the lower end of the mean particle size distribution.

The ash density along the dispersal axis is represented by the peak of the curves at crosswind distance equal to zero in Figure 1 of the original RAI response. The peak values of ash density shown in the figure vary from 0.1325 g/cm^2 at 10 km downwind, to 0.1931 g/cm^2 at 20 km downwind, to 0.1558 g/cm^2 at 30 km downwind. This variation represents an increase of 46% from 10 to 20 km followed by a decrease of 19% from 20 to 30 km. The amount of change in these peak values is not solely an artifact of the relatively small mean particle size. The ash density shown in the figure is influenced by particle size, but also by other eruptive parameters, including wind speed and eruption power.

A second realization, with a larger mean particle size, was selected for comparison to the data in the original RAI response. ASHPLUME parameters for realization 316 are shown in Supplemental Table 1 and the ash density and waste/ash ratio curves are plotted in Supplemental Figure 1. As shown in Supplemental Table 1, the mean ash particle diameter in this realization is 0.0251 cm. As with realization 5, the magma-partitioning and decay factors are not used for the supplemental results shown here. In realization 316, ash density decreases by an order of magnitude along the dispersal axis. Tephra concentrations for additional ASHPLUME realizations are shown in Figure 2 of the response to RAI 3.2.2.1.3.13-004. The variation in ash density along the dispersal axis is greater in realization 316 shown in Supplemental Figure 1 than in realization 5 shown in the original Figure 1 due to the larger mean ash particle size and differences in other eruption parameters shown in Supplemental Table 1. The waste/ash ratio shows similar relative variations in realizations 5 and 316. The magnitude of the ratio is significantly less in realization 316 than in realization 5 because the much longer eruption duration in realization 316 results in more erupted ash mass while the erupted waste mass remains constant.



Supplemental Figure 1. Ash Density and Waste/Ash Mass Ratio at Three Distances Downwind from the Volcanic Vent for Realization 316

Supplemental Table 1. ASHPLUME Parameter Values for Realization 316

ASHPLUME Parameter	Parameter Value Realization 316
Wind direction	60 degrees
Wind speed	1,185.0 cm/s
Mean ash particle diameter	0.0251 cm
Ash particle diameter standard deviation	0.5657 log(cm)
Minimum waste particle size	0.0001 cm
Mode waste particle size	0.0013 cm
Maximum waste particle size	0.2 cm
Beta	0.12439
Eruption power	9.95×10^9 Watts
Eruption duration	6.90×10^6 s
Eruption velocity	4,624 cm/s
Rhocut (waste incorporation ratio)	0
Number of waste packages	1

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

SNL (Sandia National Laboratories) 2007. *Characterize Eruptive Processes at Yucca Mountain, Nevada.* ANL-MGR-GS-000002 REV 03. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070301.0001; LLR.20080401.0273; DOC.20081001.0001.