Sandia's response to
NRC COMMENTS ON BTP - REVISION 7

Below are the NRC comments and Sandia's responses to those comments.

As a reminder, Sandia's scope was to rewrite the BTP for clarity and not to change any of the existing policies. Also, if the original 1995 BTP does not offer a justification for a policy, Sandia did not speculate on the justification for the policy. The rewrite for clarity is named Version A.

Sandia also drafted Version B, which offers a quantitative definition of "radiologically homogenous," and eliminates some of the guidance found in Version A.

During one of the Public Meetings on Blending, there was a request to clarify what types of facilities qualify as "a designed collection of homogeneous waste types from a number of sources within a licensee's facility, for purposes of operational efficiency or occupational dose reduction." Does NRC want Sandia to consider this request?

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Heath-1	General	This version is much easier to read than the original... you all did a great job of interpreting and clarifying it!	Thank you for providing enough hours to do this.
Heath-2	General	The BTP requires that the licensee measure the activity of certain items and/or specific radionuclides within the waste mixture, but it does not specify how the measurements need to be carried out (e.g., what does the confidence in the measurements need to be?). Should we provide guidance on this, or is there a section within 10 CFR 61 which we can reference?	Good comment. Text in Sections 4 and 8 of the BTP will be modified to highlight the fact that the NRC's 1983 Technical Position on Radioactive Waste Classification and Waste Form describes procedures acceptable to NRC staff for determining the presence and concentrations of the radionuclides listed in 61.55.
Heath-3	Sec. 5, para. 2	A representative density may be used, based on representative distribution of the waste. An example would be helpful here, just to clarify this point. How precise/accurate does the	This text was taken directly from the 1995 BTP. We are not sure why the BTP offers this option for a homogeneous waste type; as calculating a representative density by diving total mass by total container volume seems

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		representative distribution need to be if density is widely varied within the mixture?	easiest and gives the licensee the most leeway.
Heath-4	Sec. 8, Table C	If using the volume gives a lower concentration than the using the mass does, is the licensee required to use the more conservative concentration?	Tables 1 and 2 of 61.55 are expressed in curies / cubic meter, with the exception of the transuranics, which are expressed as nanocuries per gram. The licensee can not choose volume or mass, they must use the units specified in the 61.55 Tables.
Heath-5	Sec. 8, Table C	The singular and plural form of Volume and Mass are the same. I don't think we need the "es" ending.	Agreed, we'll correct. The one exception is that the original 1983 BTP is titled "Concentration Volumes and Masses."
Heath-6	Sec. 8, Table C	Solidified liquids is referred to as solidified mass in the right column. I think it would be good to be consistent here (e.g., 'mass of solidified liquid' in both columns). For the next row, 'mass of solidified ion-exchange resins' could be used. HIC should be spelled out when first used in Dewatered ion-exchange resins.	The columns have different purposes: the left column identifies the "waste type" and the right column gives guidance for how to measure the volume or mass for waste classification purposes. The first use of HICs will be spelled out.
Heath-7	Sec. 8, Table C	* indicates mixtures are subject to additional guidance, but does not specify the section of the guidance (it is the guidance in general or a specific section of the Position, if it is in general, aren't all mixtures subject to the Position in a general sense? why are we highlighting this particular waste type?)	Agreed, we'll correct. This footnote is there because the text of the BTP gives the generator 2 choices for how to calculate the volume of this waste type. The footnote has been edited to direct the reader to Section 5, where both methods of calculating the waste volume are provided.
Heath-8	Sec. 8, Table C	** indicates homogeneity should be maintained in the solidified mass, but does not indicate to what degree the radioactivity must be homogeneous	Agreed, and this is an important point. The 1995 BTP does not offer a quantitative definition of a homogenous waste. We have offered a straw man quantitative definition of a radiologically

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			homogeneous waste in Version B of the BTP rewrite.
Heath-9	Sec. 13, Ref. 2	2nd Reference - put a comma after Part 61	Agreed, we'll correct.
Heath-10	pg 14	should we define the term 'interstitial'?	Probably not; as the dictionaries definition works. Terms that have a definition unique to the BTP are defined in the Glossary of Terms in the front of the BTP rewrite.
Heath-11	Appendix, para. 9	Scenario 1 and 2 - suggest giving short names to these scenarios so they can be easily identified later in the text. The short names can be used as headings in bold or underlined.	This is a good idea. Short yet descriptive titles were difficult to identify. How about "Gamma Sealed Source Handling Scenario 1" and "Gamma Sealed Source Handling Scenario 2"?
Heath-12	Appendix, para. 16	double)) after steel plate.	The double)) is correct – but the sentence will be edited for better clarity.
Heath-13	Appendix, last sent.	the last sentence starting with "For example, " should be completed, or it should be part of the previous sentence.	Agreed – the sentence will be rewritten for clarity.
Heath-14	General	Should we have a glossary of terms for terms like "envelope of safety", "hot spot", "mixing", "sealed source", "discrete item", ...?	Agreed - there is a Definitions and Glossary of Terms section in the front of the BTP rewrite. Terms that have a special meaning in the context of the BTP are defined in that glossary. For example, classification-controlling radionuclides is a term unique to the BTP and a definition is offered in the front of the rewrite of the BTP.

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Esh-1	Title	Overall, very good job by SNL on this project.	Thank you

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Esh-2	Sec. 1, para.3	But it does explain how a licensee would determine under various scenarios whether they are meeting the concentration limits requirements, right?	Yes, for individual items, homogenous waste types and certain mixtures of items. It also sets bounds on encapsulation of individual items. "Alternative Provisions" are offered for other circumstances.
Esh-3	Sec. 5, para.1	It may be useful to clarify why these are examples of homogeneous waste. i.e. what is the underlying characteristic that makes them homogeneous? My guess is that they are likely to be uniformly distributed when exhumed under an intruder scenario.	Good comment. In general, Sandia is not using this Version A rewrite to speculate about the justification for the policies presented in the 1995 BTP, but in this case Sandia has added clarification to the Definitions Section and to the front of Section 5. Note that there are two related terms: "radiologically homogeneous waste" and "homogeneous waste type."
Esh-4	Fig. 2	Do all of the parts of the tree that have the "Classify per 10 CFR 61.55" boxes continue with the parts of the diagram listed in the lower right part of this figure (starting at node P)? If so, maybe those links should be provided. If not, hopefully the text explains why.	Good comment. Figure 1 as modified and the "end point" boxes were expanded to include encapsulation as an option.
Esh-5	Sec. 6.1, para.3.	Should this say can not be averaged because the concentrations are too high (> 1 mCi per item)?	Yes, text will be corrected.
Esh-6	Sec. 6.2, para.1.	Do we need dual units (English/metric)?	Probably not. Part 61 and the US rad waste industry use the mixed units of curies per cubic meter and nanocuries per gram. That said, we can easily present pure SI unit if the NRC wishes.
Esh-7	Table B footnote	Consider adding additional text to explain why this statement is true.	The 1995 BTP does not explain why Sr-90, Tc-99 and I-129 were excluded.
Esh-8	Sec. 9, para. 5, bullet 4.	Is this redundant with the bullet below?	Yes, text will be corrected.
Esh-9	Sec. 13, Ref. 3.	I don't know. Maybe Jake Philip (RES) would know.	

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Esh-10	Appendix, para. 10.	Should the calculations for footnote 4 be provided as an appendix? At a minimum we would want to ensure that NRC has copies of the calculations for our files to ensure transparency in the future.	Yes, see below.

<u>Sandia calculation of the specific activity of an infinite half-plane of Cs-137 at 500 years based on an initial disposal of Cs-137 at the upper Class C limit:</u>

For Cs-137, $t_{1/2}$ = 30 years and $\lambda = (\ln 2)/t_{1/2} = 0.6931/30 = 0.0231$, giving a decay factor of

$$e^{-\lambda t} = e^{-(.0231 \times 500)} = 9.64 \times 10^{-6}$$

Assuming an interstitial and cover mixing factor of 0.125 (factor of 8) and intrusion likelihood and mixing factor with lower activity waste of 0.10 (factor of 10), then:

$$(4600\ \text{Ci/m}^3 \times 10^6\ \text{pCi}\cdot\text{m}^3/\text{Ci}\cdot\text{cm}^3) \times (9.64 \times 10^{-6}) \times (0.125) \times (0.1) = 554\ \text{pCi/cm}^3$$

or, for a density of 1.6 g/cm^3,

$$\{554\ \text{pCi/cm}^3 \times (1\ \text{cm}^3/1.6\ \text{g})\} = 346\ \text{pCi/g.}$$

The 1995 BTP shows a slightly smaller decay factor of 9.4 x10^{-6}, which gives a source concentration of 540 pCi/cm^3 or 340 pCi/g. These values imply a half-life of 29.9 years

$$-\{\ln(2)/\ln(9.4\text{x}10^{-6})\} \times 500 = 29.9$$

which is within the roundoff error of the calculation.

<u>Sandia calculation of the dose to the intruder resulting from 2360 hours of exposure to an infinite half-plane of Cs-137 at 500 years at 554 pCi/cm^3:</u>

<u>500-year dose for infinite half-plane source:</u>

The FGR12 Dose Conversion Factor for Cs-137 evenly distributed in an infinite soil layer is 469.536 mrem·m^3/yr·µCi (or 460.192 if evenly distributed throughout 15 cm thick soil). [Source: http://www.iem-inc.com/tooldcf.html]. Changing units for the DCF gives:

$$(469.536\ \text{mrem-m}^3/\text{yr-}\mu\text{Ci})(10^6\ \mu\text{Ci/Ci}) = 4.69536 \times 10^8\ \text{mrem-m}^3/\text{yr-Ci}$$

This implies a dose for the 554 pCi/cm^3 source of:

$$\{554\ \text{pCi/cm}^3\}\{4.69536 \times 10^8\ \text{mrem-m}^3/\text{yr-Ci}\}\{10^{-12}\text{Ci/pCi}\}\{10^6\text{cm}^3/\text{m}^3\} =$$

$$2.6 \times 10^5\ \text{mrem/yr} = 260\ \text{rem/yr.}$$

If the exposure time is assumed to be only 2360 hours (rather than the 8760 in a 365 day year), the dose is

260 rem (2360/8760) = 70 rem.

The dose conversion factor for Cs-137 (from the Handbook of Health Physics and Radiological Health, 1996) is 2.85 x 10^{-19} Sv-m^3/sec-Bq. Converting units gives (for a 365 day year) for the DCF:

(2.85 x 10^{-19} Sv-m^3/sec-Bq)(10^2 rem/Sv)(3.7x10^{10}Bq/Ci) (10^3mrem/rem)(3.1536 x10^7 sec/yr) =

3.3255 x10^4 mrem-m^3/yr-Ci.

The dose for the 554 pCi/cm^3 source is then (for a 365 day year) is:

{554 pCi/cm^3}{3.3255 x10^4 mrem-m^3/yr-Ci}{10^{-12}Ci/pCi}{$10^6$$cm^3$/$m^3$} =

18.42 mrem/yr.

If the exposure time is assumed to be only 2360 hours, the dose is then:

18.42 (2360/8760) = 4.96 mrem.

These 1995 BTP gives a dose of 500 mrem, which is between the 7000 mrem and 4.96 mrem values calculated with these two DCFs. Therefore, it isn't clear what DCF was used for the 1995 BTP to derive the 500 mrem value.

<u>Sandia calculation supporting footnote 3 – which identifies the apparent typographical error in 1995 BTP;" Scenario 1 where the *un*shielded source would result in dose of 9.6 rem to the intruder:</u>

1995 Scenario: Exposure at 1 meter from a 30 Ci Cs-137 unencapsulated source, 500 years after disposal, 2360 hour/yr exposure period.

The dose to the intruder is calculated as follows:

Cs-137 has a half-life $t_{1/2}$ = 30 years. The equation for radioactive decay is

$$N = N_0 e^{-\lambda t}$$

Where

N = the number of atoms of Cs-137 at time t (the activity at time t)

$\mathbf{N_0}$ = the number of Cs-137 atoms at time t=0 (the initial activity: 30 curies)

$\lambda = (\ln 2)/t_{1/2} = 0.0231$

A 30 Ci Cs-137 source decayed for 500 years therefore has an activity of:

$$N = (30\ Ci)e^{-(0.0231\ yr\text{-}1)(500\ yr)} = (30\ Ci)(9.64 \times 10^{-6}) = 2.89 \times 10^{-4}\ Ci$$

Assuming the volume of the small source is 0.01 ft^3, or 2.83 x 10^{-4} m^3, the activity per unit volume at 500 years is thus

$$(2.89 \times 10^{-4}\ Ci)/(2.83 \times 10^{-4}\ m^3) = 1.02\ Ci/m^3.$$

Using the dose conversion factor from the Handbook of Health Physics and Radiological Health (1996) of 2.85 x 10^{-19} Sv-m^3/sec-Bq (or 3.3255 x10^4 mrem-m^3/yr-Ci, shown above), the effective dose equivalent with no shielding is:

$$(1.02\ Ci/m^3)(3.3255 \times 10^4\ mrem\text{-}m^3/yr\text{-}Ci) = 3.39 \times 10^4\ mrem/yr \text{ or } 33.9\ rem/yr.$$

For an exposure period of 2360 hours/yr, this corresponds (for a 365 day year of 8760 hr) to:

(33.9 rem/yr)(2360/8760) = 9.1 rem.

Explanation of footnote 4 and use of Microshield code:

The shielded dose was calculated using Microshield v. 7 for 15 inches (0.38 m) of concrete. The dose rate outside the 15 inches (0.38 m) of encapsulating concrete from a 289 μCi source at the center of the container was calculated to be 472 mrem over 2360 hours, or about 0.20 mrem/hour.