NTS RESUSPENSION ISSUES and COMMENTS MATRIX

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1	On page 12, Section 4.1.2 of the TBD, the following statement is made: *Therefore, dose reconstructions for individuals employed at NTS during the period from 1951 through December 31, 1992, but who do not qualify for inclusion in the SEC, can be performed using these data as appropriate.* We have a concern with this statement, because the TBD actually provides a protocol for reconstructing the internal doses from resuspension of radionuclides from January 1, 1963, through December 31, 1992.[2] This statement should be corrected.	NIOSH agrees that additional clarification should be added to ORAUT-TKBS-0008-4 (the NTS environmental TBD) to instruct dose reconstructors to include environmental inhalation and ingestion intakes as prescribed in Sections 4.2.1.2 and 4.2.2, respectively, beginning on January 1, 1963.
	We also have a concern with the following statement made in Appendix A of the TBD: *If an internal exposure was suspected, bioassay was performed. Managing radioactive material in the form of devices was episodic and limited to a few workers (e.g., radiation safety and industrial hygiene personnel, miners, and experimenters). These workers are identified on the rosters that were published before the event, and these workers are likely to have bioassay results in the DOE records.* It is our understanding that an SEC was granted in part because there was inadequate bioassay data and many employees were exposed in situations where there were no rosters, thereby precluding the ability to develop a coworker model. This topic was discussed thoroughly during the NTS WG meetings on October 29, 2008 (ABRWH 2008); April 23, 2009 (ABRWH	NIOSH agrees and will make the following change to the Attachment A text: *These workers are usually identified on the rosters that were published before the event, and these workers are likely to have bioassay results in the DOE records.*

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	2009a); and December 15, 2009 (ABRWH 2009b).	
2	A method for analyzing chronic environmental exposures associated with resuspension processes is provided for the time period beginning in January 1, 1963, approximately 6 months after the "last above ground test." Inspection of the Anspaugh et al. (2002) resuspension factor equation reveals that by 180 days after deposition, the resuspension factor drops down to about 5×10^{-9}/m. For earlier times, closer to the end of above-ground testing, the resuspension factors, according to the Anspaugh model, are orders of magnitude greater. SC&A believes that it is possible to back extrapolate the dose reconstruction to mid-1962, at the end of aboveground testing. Such calculations would be more complete and will likely reveal substantially higher doses from resuspension during that 6-month period. The intended time period of coverage for these calculations should be discussed and agreed upon with the members of the NTS WG. There is no reason that the important time period of July 1962 to December 31, 1962, is not included in the material in the TBD.	The evaluation report for SEC-00055 (SRDB Ref ID: 150574), which covers the time period of 1/27/51 – 12/31/62, specifically discusses the inability to reconstruct doses between the cessation of testing in July of 1962 and the end of that year. The last paragraph of section 4.5 states: *Above-ground testing at the NTS began on January 27, 1951, and concluded on July 17, 1962. NIOSH considers reconstruction of internal doses at the NTS feasible for periods after cessation of atmospheric testing beginning on January 1, 1963. During the period of atmospheric testing, the source term to which workers were exposed changed with each detonation, due mainly to re-suspension and mixing of fallout caused by the blast waves. After the final above-ground test, NIOSH considers the radiological source term to be sufficiently stable so as to allow assumptions adequate for dose reconstruction. The extension of the SEC period through December 31, 1962, approximately six months after the last atmospheric test, allows time for the stabilization of the source term and for decay of the shorter-lived radionuclides associated with the final atmospheric tests.* In addition, the ER for SEC-0084 (SRDB Ref ID: 77699) describes a model for the reconstruction of environmental internal doses beginning on 1/1/63. Thus, the ERs for the SECs are clear on the time period for which environmental doses can be reconstructed.

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	Further confusion on this point arises from the following statement on page 42 of the TBD under "Instruction to Dose Reconstructors:" *With the exception of cases that can be worked using the bounding assumption in ORAUT-OTIB-0018 (ORAUT 2005), environmental inhalation and ingestion intakes listed in Tables 4-7 and 4-11, respectively, shall be applied starting in 1964.* OTIB-0018 seems to be an inappropriate reference within the context of outdoor chronic exposures at the NTS. OTIB-0018 is more appropriately employed indoors at sites that have a comprehensive health physics and airborne monitoring program, which is not the case for the NTS.	The referenced exception does not infer that OTIB-0018 intakes would be applied instead of environmental intakes. OTIB-0018 intakes are typically applied as an efficiency method to obviate the need to assess negative (less than MDA) bioassay data for noncompensable cases. When OTIB-0018 intakes are applied, the addition of environmental intakes is unnecessary because the OTIB-0018 intakes envelope the environmental intakes.
3	It is important that the time period to be covered be carefully considered by the members of the NTS WG. SC&A believes that the logical time period to be covered is July 1962 through December 31, 1992.	**See response to Issue 2 above.**
	The method of environmental occupational dose reconstruction is strongly based upon measurements of the concentrations of Pu-239/240 in air samples starting in 1971. SC&A was originally concerned that the air-sampling locations were not representative of the locations where workers were exposed. We originally detailed these concerns in the Anspaugh report dated October 21, 2008 (Anspaugh 2008). At that time, these concerns were based on the assumption that our interest was in	NIOSH agrees with this observation.

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	"active environments" where operational activities were ongoing. However, within the context of using these air-sampling data as a means to characterize airborne Pu-239/240 concentrations during relatively quiescent conditions, referred to as chronic environmental exposure, these concerns are greatly diminished. It is important to note that the current scope of dose estimation from residual radioactivity is limited to environmental dose not associated with work activities. Exposure during work-related activities that disturb soil is not included within the scope of the TBD.	
4	The soil radionuclide inventory data collected in the 1980s by the Radionuclide Inventory and Distribution Program (RIDP) (Kordas and Anspaugh 1982; McArthur 1991) characterized soil contamination at the site during the 1980s. However, the TBD extrapolates back in time to derive the soil contamination levels that were present on January 1, 1963, so that doses could be reconstructed from the resuspension process during early years following the end of aboveground testing. One of the limitations of the back extrapolation process used in the TBD is there is evidence that some areas were decontaminated (McArthur 1991, p. 34) before the RIDP measurements were made. Also, significant contamination occurred in Areas 20 and 30 from Plowshare activities after 1963, and the Baneberry event in 1970 produced major contamination in Areas 8 and 12. These concerns need to be addressed in terms of the degree to which the TBD remains scientifically sound and claimant favorable, notwithstanding these events.	In order to assure that intakes and resultant doses from environmental intakes was not underestimated, NIOSH used the highest measurement of airborne plutonium to calculate reasonable intakes for all other years and all other areas. The highest measured airborne concentration measured in any area was in 1972 in Area 9 of 4.3×10^{-3} pCi/m^3. To determine the intake, exposure to this concentration was assumed to be 2,400 m^3 per year which resulted in a calculated intake of 0.381 Bq/yr. To determine bounding intakes for other radionuclides measured in the NTS soils but not measured by air sampling (e.g., Am-241, Pu-238, Co-60, Cs-137, Sr-90 and Eu-152, 154, and 155), the maximum ratio of these radionuclides to Pu-239 for all areas was used. These methods would mitigate the effects of decontamination venting in later years. In section 3.1 of the Resuspension Issue Status Report (Status Report on Resuspension Issues at the Nevada Test Site, Contract No. 211-2014-58081, Rev, S.Cohen & Associates, Vienna, VA, July 2015), on page 19, the following statement is made:

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		For example, by selecting the location and year with the highest annual average airborne plutonium concentration for the purposes of partial dose reconstruction, there is a level of assurance that reconstructed internal exposures are claimant favorable for all workers during those time periods, and also for earlier time periods where back-extrapolation was required. One could also argue that this strategy would be reasonable for earlier time periods and locations, even for locations that were cleaned-up prior to the commencement of the air-sampling program. In Section 3.1, on page 21 of the Resuspension Issue Status Report, the following statements appear: *The TBD acknowledges that the portion of the NTS where the RIDP data are provided is limited to only about one-third of the entire area of the NTS. However, the areas selected for the RIDP were those with measurable levels of contamination in soil above ubiquitous background. Hence, it certainly appears that a combination of the air-sampling data and the RIDP soil-inventory data can be used to assign chronic intakes of these nine radionuclides to workers. In addition, if high-end air-sampling and soil-inventory data are used, reconstructed doses associated with the chronic inhalation of these nine radionuclides would seem to be reasonably bounding. As presented in Table 4-6 of the TBD, this is, in fact, the approach adopted in the TBD to reconstruct radionuclide intake rates.* For these reasons, NIOSH believes the maximum intakes provided in Table 4-6 of the NTS environmental TBD to be scientifically sound

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		and claimant favorable even if specific consideration is given to decontamination activities and loss of containment incidents.
5	Derivation of the concentration of relatively short-lived radionuclides in soil for January 1, 1963, employed the Hicks' tables (Hicks 1982) for the Small Boy event that occurred on July 14, 1962. In fact, the contamination in soil on January 1, 1963, reflects fallout from numerous tests that resulted in surface contamination, such as the Sedan test on July 6, 1962, and Little Feller II on July 7, 1962, which occurred shortly before Small Boy, and Little Feller I that occurred after Small Boy on July 17, 1962. As such, NIOSH should address whether tests shortly before and after Small Boy on July 14, 1962, could also have contributed substantively to the fallout levels in soil derived for January 1, 1963. ——— In a related matter, the protocol used in the TBD to account for fractionation is overly simplistic and appears to rely primarily on the Small Boy event. NIOSH will need to demonstrate that the approach used to account for fractionation does not substantively underestimate doses.	Soil radionuclide concentrations corrected to 1963 (see Table 4-5 of the NTS environmental TBD) only included radionuclides that are persistent in the environment (e.g., Am-241, Pu-238, Co-60, Cs-137, Sr-90 and Eu-152, 154, and 155). These radionuclides would include those deposited as a result of all atmospheric test and loss of containment incidents prior to the 1980s. The persistent radionuclides deposited after January 1, 1963 were still decay corrected back to January 1, 1963 so their contribution to the soil concentrations corrected to January 1, 1963 would have been overestimated since these incident related radionuclides would not have existed in the environment on January 1, 1963. The same overestimate would occur for any persistent radionuclides deposited as a result of the Plowshare program. Thus the soil radionuclide concentrations corrected to January 1, 1963 likely represent overestimates of the actual soil concentrations present at the time. ——— In Section 3.4, page 25, of the NTS resuspension issues report, the following statement was made: *The Hicks' tables that were used by NIOSH to support the reconstruction of environmental exposures onsite were actually originally derived for the purpose of evaluating offsite exposures. As a result, the Hicks' tables understate the relative abundance of refractory elements onsite and overstate the presence of volatile elements.* In Section A.6, page 68, of the NTS environmental TBD, the process of adding the refractories back into the mix is discussed in some

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		detail. The discussion also includes a description of how the nearfield (i.e., NTS soils) was enriched with the refractories. Specifically, the NTS TBD states the following: *Because the Hicks data were developed to estimate offsite levels of fallout and resultant dose, fractionation effects were simulated in these data by the removal of a fraction of the refractory nuclides from the calculated abundances. In general, air drops were assumed to be unfractionated and offsite fallout from surface and cratering tests was assumed to have 0.4 of the refractory elements. For all other types of tests, offsite fallout was assumed to have 0.5 of the refractory elements present. Therefore, the refractory elements in the Hicks data must be adjusted to produce the best estimate of their enriched abundances in the onsite environment to which workers could have been exposed. Adjustment factors for each radionuclide were determined from data in Hicks (1984); this report provided relative abundances of radionuclides assuming no fraction, 50% fraction, and 90% fraction of refractory elements. From these data, ratios were developed for the 50% fractionation case (Table A-8). These ratios were used to deplete the refractory elements in the far-field (i.e., offsite) environment to estimate doses to offsite individuals. Therefore, to enrich the near-field (i.e., onsite) environment, the inverse of these ratios was applied to the Hicks SMALL BOY data (see below). These inverse ratios were applied twice because the Hicks SMALL BOY data were provided to estimate fallout in the offsite environment. The first application results in the data that represent no fractionation while the second application results in data that are enriched with refractory elements.*

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		NIOSH believes that the methods described above represent a reasonable treatment of refractories in the nearfield environment. However, NIOSH is continuing to research the methods used in the Hicks (1984) report for appropriateness for use in the NTS environmental TBD to assure that these methods are claimant favorable.
6	The levels of contamination observed in soil by the RIDP performed in the 1980s captured some contamination that occurred many years subsequent to the termination of aboveground testing. This is a concern that needs to be addressed, because the TBD is based on the assumption that all radionuclides observed in soil in the 1980s were as a result of aboveground testing that occurred in July 1962. However, some of the contamination was deposited many years later. NIOSH should explain how this affects the dose reconstruction process. ______ In a related manner, the TBD makes use of the Anspaugh equation to derive resuspension factors in order to calculate airborne mass loadings and associated intake rates after January 1, 1963. NIOSH needs to discuss how these resuspension factors might be affected if there are locations where soil contamination occurred well after January 1, 1963.	The persistent radionuclides deposited after January 1, 1963 were still decay corrected back to January 1, 1963 so their contribution to the soil concentrations corrected to January 1, 1963 would have been overestimated since these radionuclides would not have existed in the environment on January 1, 1963. The same overestimate would occur for any persistent radionuclides deposited as a result of the Plowshare program. Thus the soil radionuclide concentrations corrected to January 1, 1963 likely represent overestimates of the actual soil concentrations present at the time. ______ The resuspension factors derived from the Anspaugh equation were not used to calculate airborne mass loadings. Rather they were used to develop correction (normalization) factors that could be applied to intakes derived from the highest airborne concentration of Pu-239 measured at the NTS (i.e, Area 9, 1972). With the exception of the Plowshare program (which was conducted at a relatively small, remote area where personnel access would have been difficult) soil contamination occurring after 1963 was primarily

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		the result of loss of containment incidents. For each of these events, DOE attempted to identify all workers that had a potential for exposure to radioactive material. Those that were identified as having been possibly exposed were subjected to external and internal monitoring. In addition, except for operational activities, access to these newly contaminated areas was controlled. Therefore, estimating the potential exposure of individuals to airborne radioactive materials resuspended from the newly contaminated soils would involve the introduction of large uncertainties. However, NIOSH believes the use of high-end air-sampling data (i.e. the highest air sample concentrations ever measured at the NTS) and soil-inventory data in reconstructing environmental doses associated with the chronic inhalation of radioactive material provides reasonable assurance that the assigned intakes and resultant doses are not underestimated. Also, in section 5, page 29, of the resuspension issues report, the statement is made that ". . .a mass loading of 0.168 mg/m3 gives the same dose as the resuspension method, and (3) 1 mg/m^3 is reasonable and would be more claimant favorable." Table 7-1 of OCRWM (2003) provides ranges of mass loading factors for various conditions in the Armargosa Valley where the NTS is located. For inactive outdoor conditions, the table provides a triangular distribution with a minimum of 0.025 mg/m^3, a maximum of 0.100 mg/m^3 and a mode of 0.060 mg/m^3. These data do not support a mass loading of 1 mg/m^3 but do suggest that the implied mass loading factor of 1.68 mg/m^3 is sufficiently claimant favorable. OCRWM, 2003, (Office of Civilian Radioactive Waste Management), *Inhalation Exposure Input Parameters for the*

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		Biosphere Model, ANL-MGR-MD-000001 RREV 2 ICN 0, Yucca Mountain Project Office, Las Vegas, Nevada, June, 2003. [SRDB Ref. ID: 35535]
7	In order to prepare tables of doses to each organ and from each radionuclide as a function of time [which would have required an enormous number of Integrated Modules of Bioassay Analysis (IMBA) runs], NIOSH elected to prorate all doses based on the intake rate of Sr-90 beginning on January 1, 1963, and moving forward in time as the resuspension factors decline according to the Anspaugh equation and the radionuclide concentrations decline by radioactive decay. __________ A review of the methods used to perform these calculations, as provided in Appendix A of the TBD, reveals that errors have been made in its use of equation A-2, which could profoundly	In the NTS resuspension issues report in Section 3.5, page 26, the following statement is made: *There are two problems with this. The first is the implication that time zero is the time of the last detonation (i.e., July 1962), but this appears to be impossible, given that the authors show in their Table A-9 that the relative dose to the thyroid is the same as for 17 other organs. Due to the affinity of the thyroid for short-lived radioiodines, this cannot be correct.* It should be noted that Table A-9 does not provide relative doses. Rather, the table provides correction factor which when multiplied by the annual Sr-90 dose (to a particular organ) will account for short-lived fission and activation products. In other words, the correction factors given in Table A-9 are indicators of the relative importance of dose from Sr-90 (to a particular organ) to the total annual dose from short-lived fission and activation products. The reason the thyroid is grouped with the other 17 organs in Table A-9 is because the annual dose from the annual intakes of Sr-90 are similar for all 18 organs. The thyroid does not have an affinity for Sr-90. __________ In a related matter, the issues report also stated the following:

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	affect the dose fractions provided in Figures A-5 through A-11, and the doses calculated and reported in Tables 4-9, 4-14, and A-10.	*The second problem is the integration. The calculated value of 0.026 is obviously very different from 0.0000738.* The difference between these numbers is a factor of 365. The factor of 0.0000738 is actually the average dose for one day – not one year as stated in the NTS environmental TBD. This will be corrected in the next TBD revision. However, it should be noted that the integration of equation A-2 from Figure A-2 is not used in any way to calculate doses. The slope of the lines shown in Figures A-2, A-3 and A-4 of the NTS environmental TBD are what were used to demonstrate the relative importance of the lung dose from Sr-90 to the total dose from short-lived fission and activation products. The lower the slope, the lower the relative dose from Sr-90 when compared to the total dose from short-lived fission and activation products. The slope of the trend lines that predict the relative importance of 90Sr dose was determined to be 0.0001x for STORAX SMALL BOY, 0.0002x for STORAX LITTLE FELLER I (Figure A-3) and TEAPOT TURK (see Figure A-4). Because the slope of the trend line is directly proportional to the relative importance of the Sr-90 dose to total dose (i.e., the larger the slope, the larger the relative importance of Sr-90 dose), the tests with the smallest slopes result in the highest multiplicative correction factors for fission and activation products. Therefore, to ensure the organ dose from short-lived fission and activation products is not underestimated, the Hicks (1984) data for the STORAX SMALL BOY test were selected to be used to determine the fission and activation product dose correction factor. This assumption is justified by the fact that the test was very near the last atmospheric test (i.e., STORAX LITTLE FELLER I) and would therefore have been the

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		test most likely to produce the short-lived fission and activation product intakes for workers at NTS after 1962 (the period for which organ dose from environmental intakes is calculated).
8	A comparison of actual NIOSH dose reconstructions with the guidance provided in the TBD reveals that there are discrepancies and inconsistencies between the TBD guidance and the actual dose reconstructions. These inconsistencies need to be discussed with the WG.	Without having the case numbers which would allow for more specific reasons for the observed discrepancies and inconsistencies, NIOSH will attempt to explain some of the observations outlined in Table 5 of the NTS resuspension issues report. *1a. OTIB-0018 was utilized instead of environmental intakes when the NTS employment period coincided with employment at another site (LLNL, LANL, SNL etc.).* OTIB-0018 intakes are typically applied as an efficiency method to obviate the need to assess negative (less than MDA) bioassay data for noncompensable cases. When OTIB-0018 intakes are applied, the addition of environmental intakes is unnecessary because the OTIB-0018 intakes envelope the environmental intakes.

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		1b. OTIB-0018 was applied instead of environmental intakes when employment was at NTS and not another site. Project guidance does not require the addition of environmental intakes if OTIB-0018 intakes have been assigned (see response above). *2a. Some employment periods after 1963 were not assigned environmental intakes, because there was no dosimeter assigned to the EE for those periods.* Current practice includes applying environmental doses for all cases starting in 1963. However, when the second SEC was issued in 2012, the interpretation was that internal doses could not be assigned without bioassay data. Therefore, for the next couple of years, environmental intakes and resultant doses were not assigned. The interpretation of SEC was subsequently revised and environmental intakes were then assigned to all cases. Further, for the 611 cases evaluated under PER46, if employment was after 1962, environmental intakes and resultant doses were assigned. *2b. Lack of a dosimeter during certain employment periods after 1963 was not always used to preclude the assignment of environmental intakes.* See response to 1b above. *3. In some cases, OTIB-0018 was applied, but only for years after 1963.* This was true for some cases because of the interpretation of the SEC.

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		See response to 2a above. *4. Four cases assigned only 10% of the environmental intake values. Only one of the four cases specifically mentioned this in the DR Report. Two of the four cases had POC values that were less than 10%; the other two were above 45%.* Assignment of 10% of the environmental intakes is required for best estimates but not precluded for other cases. *5. Many cases did not evaluate ambient internal dose during NTS employment and cited the SEC and/or the lack of bioassay in the dose reconstruction report.* See response to 2a above. *6. One case assigned full environmental intakes from 1966–1989, although the EE's covered employment was only for a single day in 1971 and 1982.* This is an efficiency method that is employed because, currently, there is no way to truncate intakes when using the internal dose calculator (the CAD) tool. It should be noted that the resultant doses, even when the most claimant favorable assumptions are employed, are typically less than 0.010 rem which results in very small effect to the overall POC. *7. Several cases did not apply NTS environmental intakes and instead applied Tonopah Test Range (TTR) intake values, which are significantly lower than NTS intake rates (See Table 1). Not all of these observed cases had overlapping employment at*

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		NTS/TTR. Without reviewing the cases, it is difficult to comment on these inconsistencies. The current practice is to apply NTS environmental intakes during employments periods at the NTS and Tonopah Test Range (TTR) intakes for periods of employment at the test range. As an efficiency method, NTS intakes can be used in place of the TTR intakes for cases that do not require a best estimate. *9a. Some cases were not assigned environmental intakes, because the doses were deemed too low based on the short duration of covered employment.* This practice is generally applied when visits to the NTS are one or two days in duration. NIOSH believes that the effort to apply the short-term intakes is not warranted because the resultant doses are always much less than 0.001 rem. *9b. Some cases were assigned full years' worth of environmental intakes even though covered employment was of short duration.* This is an efficiency method that is used for cases that do not need a best estimate. As stated previously, even if the intakes are applied for a full year, the dose is usually less than 0.010 rem and has very little effect on the resultant POC.